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## **Engineering Ecological Modernization of Agriculture / Exploring the Potential of Tropical Biological Resources for Innovation / Towards a Bio-Economic Development of Caribbean Countries.**

Michel Naves, Valérie Angeon, Bérengère Merlot, Louis Fahrasmane,  
Jean-Louis Diman, Patrick Labbé, Patricia Traffond, Wilfredo Colòn, Harry  
Ozier-Lafontaine

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# CARIBBEAN FOOD CROPS SOCIETY

52

Fifty-second  
Annual Meeting 2016

Le Gosier, Guadeloupe  
Volume LII

MEETING HOST:





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**PROCEEDINGS**  
**OF THE**  
**52<sup>nd</sup> ANNUAL MEETING**

Caribbean Food Crops Society  
52<sup>nd</sup> Annual Meeting  
July 10 – July 16, 2016

Hosted by the  
Institut National de la Recherche Agronomique  
Centre Antilles-Guyane

Karibea Beach Resort - Pointe de la Verdure  
Guadeloupe FWI

**“Engineering Ecological Modernization of Agriculture / Exploring the Potential of  
Tropical Biological Resources for Innovation / Towards a Bio-Economic  
Development of Caribbean Countries”**

Edited by  
Michel Naves, Valérie Angeon, Bérengère Merlot, Louis Fahrasmane,  
Jean Louis Diman, Patrick Labbé, Patricia Traffond,  
Wilfredo Colon and Harry Ozier Lafontaine

Published by the Caribbean Food Crops Society





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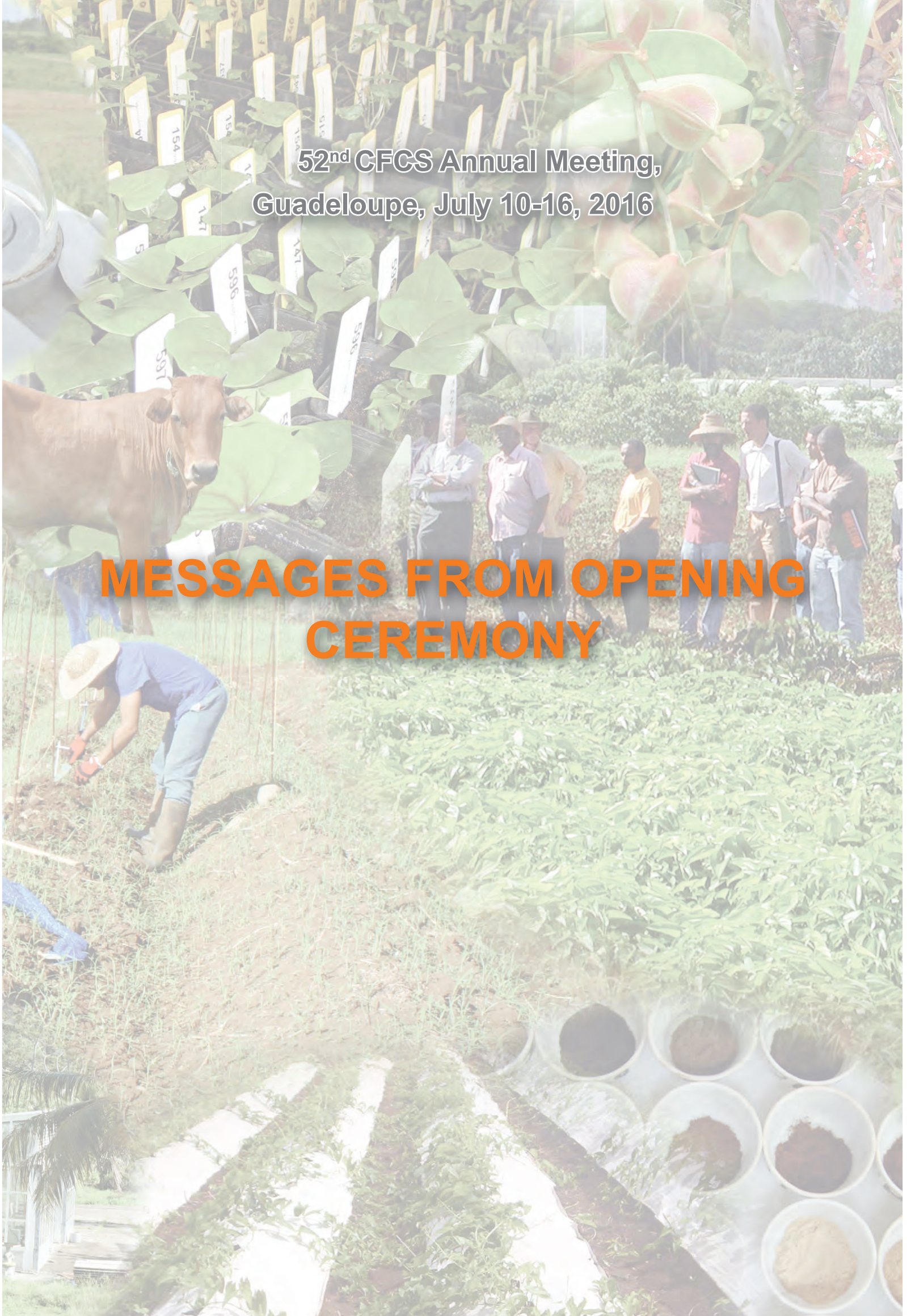
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Professor Clement Sankat, Pro Vice Chancellor & Campus Principal, The University of the West Indies, Trinidad and Tobago  
Mr. Carlos Robles, Commissioner, United States Virgin Islands Department of Agriculture, United States Virgin Islands





52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

**MESSAGES FROM OPENING  
CEREMONY**





## WELCOME REMARKS BY DR. HARRY OZIER-LAFONTAINE,

***Vice-President, CFCS 2016,***

*Directeur de Recherche, Président de Centre INRA*

*Délégué Régional Guadeloupe Guyane Martinique*

*Monsieur le Président du Conseil Régional,  
Madame la Présidente du Conseil Départemental,  
Monsieur le Président de la Chambre d'Agriculture de Guadeloupe,  
Monsieur le Préfet de Région ou son représentant,  
Monsieur le Président Directeur Général de l'Inra,  
Monsieur le Président de la CFCS, Mesdames,  
Messieurs les représentants des organismes internationaux et caribéens,  
Mesdames et Messieurs les élus et représentants de l'Etat,  
Mesdames et Messieurs en vos grades et qualités*

Chers collègues

C'est un immense honneur pour la Guadeloupe et les organisateurs de ce congrès, de vous accueillir pour cette 52<sup>ème</sup> édition de la CFCS dans ce complexe du Karibea Beach Resort de la commune du Gosier.

Le thème retenu cette année est :

### **Engineering Ecological Modernization of Agriculture / Exploring the Potential of Tropical Biological Resources for Innovation / Towards a Bio-Economic Development of Caribbean Countries**

Le choix de ce thème n'est pas innocent, et cherche à répondre aux enjeux majeurs que nos agricultures doivent relever pour permettre à nos sociétés de mieux s'épanouir face au changement global que nous expérimentons tous à l'échelle planétaire et singulièrement dans notre espace caribéen :

- le changement climatique et ses conséquences au regard de la vulnérabilité des petites économies insulaires, soulignée lors de la préparation de Rio+20 (conséquences sur la production et les moyens de production)
- l'accroissement de la population et la montée de l'insécurité (criminalité, terrorisme)
- la dépendance alimentaire accrue de nombreuses régions de la Caraïbe (+ de 80% pour la Guadeloupe)
- la dépendance aux énergies fossiles dans un contexte de raréfaction
- la régression tragique du foncier agricole, le mitage des terres agricoles et le déplacement des équilibres villes/campagnes
- le constat de l'inadéquation du modèle de production conventionnelle intensive (crise de la chlordécone sur les sols bananiers : 8000 ha en Guadeloupe)
- etc.

Nous n'avons pas d'autre choix, et c'est une véritable urgence, que de nous lancer dans la transition agroécologique et énergétique, en lien avec les nouveaux défis adressés par l'émergence de la bioéconomie : 5<sup>ème</sup> hot spot de biodiversité à l'échelle mondiale, la Caraïbe est aussi un haut lieu de l'agrobiodiversité, façonnée par son histoire entre la période amérindienne, la colonisation et la période moderne, ce qui nous confère un potentiel important en matière de valorisation sociale et économique.

C'est donc le défi majeur que cherche à relever ce congrès qui rassemble aujourd'hui plus de 250 participants de la Grande Caraïbe, de l'Europe et des Amériques :

- Par ingénierie, nous entendons produire des connaissances pour l'action et l'innovation au profit de la modernisation écologique et énergétique, et ce, en prenant les dispositions requises pour aménager et accompagner la transition.
- Par la valorisation des bioressources, nous entendons poser le cadre à la fois technologique mais aussi politique d'une stratégie caribéenne en faveur de l'essor de la bioéconomie dans cette région

qui ne peut se construire de manière isolée.

C'est réellement dans ce concept de « Science impliquée » que nous avons conçu ce congrès en équilibrant les sessions scientifiques et techniques avec 2 forums/ateliers :

- le premier, le Farmer's Forum, à destination des professionnels de l'agriculture sur le thème de l'innovation (50 professionnels y participent),
- le second, le Policy Maker's Forum, à destination des décideurs politiques de la Guadeloupe et de la Grande Caraïbe (CARICOM, FAO, OECS).

Ce sont donc les orientations résolument prises pour positionner ce 52<sup>ème</sup> Congrès de la CFCS comme pivot pour les projections des 20 prochaines années. La CFCS, est, je le rappelle, l'une des sociétés les plus actives dans le domaine de l'intégration régionale caribéenne, et je tiens à féliciter son Président, le Dr Wilfredo Colon et tout le Bureau de la CFCS pour l'impulsion qu'ils lui donnent. Nous inscrivons également ce 52<sup>ème</sup> congrès au titre des 70 ans de l'Inra, qui se positionne dans le peloton de tête des 3 grands organismes mondiaux les plus influents en matière de recherche agronomique. Notre Président Directeur Général, Monsieur François Houllier, nous fait aujourd'hui l'honneur de sa présence pour l'ouverture de ce congrès, et nous fera état des orientations stratégiques de l'Inra et de l'impact de ses recherches.

Je ne saurais conclure sans remercier chaleureusement tous les partenaires qui nous ont soutenus activement dans la construction de ce projet et qui font de la Guadeloupe durant cette semaine, l'une des vitrines de la Caraïbe en matière de modernisation écologique et énergétique du secteur agricole, au profit du développement social et économique. Je tiens aussi à féliciter tout particulièrement mes collègues du Comité d'Organisation Local, du Comité de Pilotage, de la Commission Scientifique et Technique et de la Commission Logistique et organisationnelle, qui ont fait un travail remarquable pour aboutir à cette programmation et à ce niveau de cohérence.

Je vous souhaite à tous de fructueux échanges et un excellent 52<sup>ème</sup> Congrès de la CFCS !

## WELCOME REMARKS BY MR. ARY CHALUS,

### *Président du Conseil Régional*

Grace à l'INRA Antilles-Guyane, la Guadeloupe peut s'enorgueillir de recevoir, du 10 au 16 juillet, le 52<sup>ème</sup> Congrès International de la Caribbean Food Crops Society.

Le thème retenu pour cette 52<sup>ème</sup> édition, « Cap sur l'Agroécologie et la Bio Economie dans le Caraïbe » est non seulement d'actualité mais surtout en parfait accord avec notre volonté d'impulser une politique agricole durable, respectueuse de l'environnement et source de développement économique.

L'agriculture est une priorité régionale!

L'agriculture a été, et doit redevenir, un secteur stratégique. Dans notre projet politique, c'est un élément incontournable si l'on veut développer durablement la Guadeloupe. Bien structurée, l'activité agricole contribue à gérer nos ressources naturelles et ce, au cœur de nos territoires. Nous avons pu constater la grande qualité et la diversité des cultures maraîchères, arboricoles, horticoles et des produits d'élevage mis en œuvre par nos agriculteurs.

En effet ; nous disposons d'une faune et d'une flore exceptionnelle ; notre biodiversité représente l'un des leviers de développement les plus puissants que nous ayons à porter de main.

L'agriculture Caribéenne semble donc bien armée pour faire face à cet immense défi : nourrir nos populations tout en préservant nos ressources naturelles pour les générations futures.

L'utilisation des plantes, au titre de produits alimentaires (agro-transformés ou pas), d'huiles essentielles, de cosmétiques ou de médicaments, avec la reconnaissance de la pharmacopée ultramarine, constitue un pilier majeur pour le développement économique de nombreuses entreprises en Guadeloupe.

L'agriculture est un secteur pourvoyeur d'emplois, surtout si l'on tient compte des potentialités de développement. Et ce d'autant que nous importons plus de 80% de notre alimentation. C'est notre responsabilité à tous d'œuvrer à réduire significativement ce chiffre!

Aussi et sans renier nos filières d'exportations, nous souhaitons, au côté d'une agriculture conquérante à l'export, une agriculture au service de l'alimentation des Guadeloupéens : c'est d'abord bon pour la santé et c'est aussi un formidable levier pour l'emploi local.

C'est donc tout naturellement que le secteur agricole est au centre du projet de croissance verte et bleue que nous portons. Nous nous engageons à avoir des rencontres permanentes et récurrentes avec tous les acteurs. Qu'il s'agisse des chercheurs de l'INRA, du CIRAD ou de l'Université, des représentants de la chambre d'agriculture, des melonniers, du collectif assofwi ou de l'UGPBAN, nos discussions portent toujours sur le développement durable de nos filières agricoles. La Région Guadeloupe, que nous voulons stratégique, doit être garante, aux côtés des agriculteurs, de la cohérence et de la soutenabilité de la production agricole.

Grâce à vos travaux de recherches et à l'abnégation de nos agriculteurs, la Région Guadeloupe pourra consolider le travail d'innovation et de conquête de nouveau marché amorcé par nos entreprises agricoles pour stimuler la création d'emplois grâce à une valorisation raisonnée et efficiente de notre biodiversité, marine et terrestre.

La Guadeloupe a été une puissance agricole, elle doit le redevenir!

## WELCOME REMARKS BY JOSETTE BOREL-LINCERTIN,

### *Présidente du Conseil Départemental*

Il revient à l'INRA des Antilles-Guyane d'organiser le 52<sup>ème</sup> congrès de la Caribbean Food Crops Society (CFCS).

Et, il est impossible qu'un tel événement se déroule en Guadeloupe avec la discrétion qui sied, d'ordinaire, aux séminaires scientifiques. D'une part, il s'agit d'une rencontre internationale d'une importance majeure dans la Caraïbe qui, au fil des décennies a acquis une véritable renommée. D'autre part, les sujets touchant à la manière dont sont produits les aliments destinés à la consommation humaine trouvent désormais un écho considérable dans l'opinion publique en général, et en particulier chez nous, qui sommes touchés par la pollution d'une partie de nos sols.

En mettant l'accent sur les enjeux et les conditions d'une modernisation écologique de nos agricultures, ce congrès crée l'événement et son intérêt va au-delà du périmètre strictement scientifique.

Le citoyen doit être un consommateur averti. Son intérêt est grandissant pour des pratiques agricoles saines respectant l'environnement. Celles, notamment, qui font face aux dérèglements climatiques en n'utilisant pas d'entrants chimiques et moins d'énergies fossiles.

Il doit aujourd'hui « consommer intelligent, équitable, éthique ou culturel » et avoir des garanties sur la manière dont la biodiversité est respectée, savoir si son sol et ses eaux ne sont pas contaminés par des pesticides, des OGM ou des engrais.

Depuis le rôle des abeilles jusqu'au poids des multinationales dans l'agriculture locale, il demande à être informé sur les multiples facettes des problématiques agricoles et environnementales.

Cet intérêt marqué de la population dynamise les chercheurs et les acteurs de l'agroécologie et de la bioéconomie, en les invitant à partager plus leurs connaissances et leurs pratiques.

La Guadeloupe est donc fière d'accueillir ce congrès scientifique international, que le Conseil Départemental se devait à plus d'un titre, de soutenir.

D'abord, parce qu'en étant propriétaire de la plus grande surface de foncier agricole, et en aidant l'installation des jeunes agriculteurs, nous sommes conscients de la place que nous pouvons occuper dans ces débats, en faveur d'une agriculture raisonnée et durable.

Ensuite, cela nous confère une responsabilité à l'égard des enjeux environnementaux, économiques et de santé publique, qui nécessitent que nous soyons mieux informés sur les alternatives existantes, afin de définir des orientations de politiques publiques agricoles et environnementales mieux adaptées.

A travers moi, c'est l'assemblée départementale qui souhaite un plein succès à la 52<sup>ème</sup> édition de la CFCS.



**WELCOME REMARKS BY JACQUES BILLANT,**  
*Préfet de Région Guadeloupe*  
**REPRÉSENTÉ PAR BERNARD FILS-LYCAON**  
*Délégué Régional à la Recherche et à la Technologie,*  
*Représentant de M. le préfet de région*

Monsieur le Président du centre INRA Antilles-Guyane,  
Monsieur le Président du conseil régional de la Guadeloupe,  
Madame la Présidente du conseil départemental de la Guadeloupe,  
Monsieur le Président de la chambre d'agriculture de Guadeloupe,  
Monsieur le Président Directeur Général de l'INRA,  
Monsieur le Président de la CFCS,  
Mesdames et Messieurs le représentants des organismes internationaux et caribéens,  
Mesdames et Messieurs les acteurs de la filière agricole,

Mesdames, Messieurs.

Permettez-moi, tout d'abord, de bien vouloir excuser Monsieur le préfet de la région Guadeloupe qui n'a pu se rendre disponible pour cette session d'ouverture de la 52<sup>ième</sup> conférence de la Caribbean Food Crops Society en Guadeloupe. En tant que Délégué Régional à la Recherche et à la Technologie pour la région Guadeloupe, il m'a chargé de le représenter, et de vous assurer de tout son intérêt et de celui des services de l'état traitant des problématiques de recherche, agriculture, environnement, développement économique, et coopération régionale pour cet événement majeur que constitue cette conférence, qui au fil du temps, a acquis une renommée incontestable.

Mes premiers mots seront pour remercier le bureau de la CFCS, le comité local d'organisation, et le centre INRA Antilles-Guyane pour avoir organisé cette conférence, cette année en Guadeloupe. Cela représente, je le sais, un travail considérable qui met à contribution tout un chacun soucieux d'aboutir à un succès partagé. Dans le contexte, d'une part, des 70 ans de l'INRA, et de la place incontestée de cet organisme de recherche français au niveau national et international en matière de productions de connaissances dans le domaine de l'agronomie, de l'alimentation et de l'environnement, et d'autre part, de la situation particulière du centre Antilles-Guyane, seul centre INRA situé en zone tropicale, je suis aussi certain que l'organisation de la conférence en Guadeloupe revêt une importance toute particulière aux yeux de l'ensemble de tout le personnel du centre INRA Antilles-Guyane.

En second lieu, je voudrais saluer tous les participants à cette conférence internationale. Elle constitue un événement majeur pour l'ensemble des partenaires caribéens, et au-delà, qui sont tous, j'en suis sûr, soucieux de développer, sur chacun de leurs territoires, une agriculture nouvelle répondant, certes, aux exigences du développement économique, mais :

- Qui soit plus respectueuse de l'environnement, et donc, mieux raisonnée que par le passé en matière d'utilisation de pesticides et fertilisants, par exemple ;
- Qui assure à la fois de meilleures protection et valorisation des ressources de notre biodiversité ;
- Qui permette de développer des innovations co-construites (et donc plus acceptées) par tous les acteurs de la filière, qu'il s'agisse de la recherche, des instituts techniques d'accompagnement, des chambres d'agriculture, des organisations professionnelles d'agriculteurs, et des agriculteurs eux-mêmes ; sans oublier d'ailleurs les consommateurs qui constituent également un poids considérable dans l'acceptation de celles-ci ;
- Qui permette d'assurer une formation initiale et continue motivantes et efficaces des acteurs du monde agricole, qui par leur labeur, restent au centre du dispositif ;
- Qui permette de restituer aux agriculteurs toute leur juste place dans l'ensemble de la société pour les services qu'ils rendent à leurs concitoyens tant en matière de suffisance alimentaire que de survie de nos milieux ruraux, si importants pour nos équilibres de vie.

Cette conférence, par les échanges qu'elle permet entre tous les acteurs de la grande Caraïbe, est capitale pour aboutir rapidement à des propositions nouvelles, des organisations nouvelles, des innovations acceptées par tous, des changements de paradigme en matière de politiques publiques d'innovation, tout cela dans un important contexte d'économies insulaires fragiles, et de défis mondiaux universels que constituent le besoin de développement économique, le besoin d'une suffisance alimentaire, le réchauffement climatique, et les pollutions diverses qui affectent l'environnement et les Hommes.

Ces progressions intéressent évidemment chaque territoire individuellement, mais elles doivent être partagées entre les territoires pour les rendre encore plus pertinentes en terme de développement de tout le bassin caribéen.

Le programme de cette conférence est dense. Lors des trois sessions programmées, de nombreux thèmes seront naturellement traités au regard des enjeux cités précédemment : transition agro écologique, économie circulaire, petite agriculture familiale, agro transformations et bioéconomie, tout cela dans un contexte de coopération régionale et d'implication de tous les acteurs de la filière. Je m'en réjouis.

De surcroit, dans un contexte où toutes ces choses très importantes sont du ressort de tous les acteurs de nos sociétés, je veux saluer l'initiative prise par les organisateurs, qui consiste, au-delà des traditionnelles présentations scientifiques communes à toutes les conférences scientifiques, à avoir organisé des forums, en particulier destinés aux professionnels et aux décideurs politiques. Cela me paraît en effet vraiment pertinent afin qu'ils soient mieux informés des réalités et contraintes scientifiques, techniques et économiques, et qu'ils co-définissent, ensemble, les priorités de demain, les organisations collectives qu'il convient de mettre en place, et les moyens publics qu'il convient d'y affecter.

Je termine donc ces quelques mots en souhaitant à tous les invités de la conférence un excellent séjour en Guadeloupe, et en vous souhaitant à Toutes et à Tous d'excellents travaux. J'ai la conviction qu'ils aboutiront à des options de développement durable pour l'ensemble de nos territoires, et je rappelle que des outils tels que le Fonds de Coopération Régionale et le programmes INTERREG sont là pour vous accompagner dans vos efforts de coopération régionale. Merci de votre attention.

**WELCOME REMARKS BY PATRICK SELLIN,**  
*Président de la Chambre d'Agriculture de la Guadeloupe*

Aujourd'hui, le contexte mondial de l'agriculture évolue en permanence. Assurer la sécurité alimentaire d'une population croissante, les changements climatiques et la préservation du milieu naturel sont autant de facteurs que nos agriculteurs doivent intégrer dans leurs systèmes de production. La Chambre d'Agriculture de la Guadeloupe, dans sa mission de développement agricole, oriente les exploitants agricoles vers l'Agro écologie.

Ce 52eme congrès de la CFCS (Caribbean Food Crops Society) permettra d'aborder à l'échelle caribéenne les enjeux de l'agroécologie afin d'intensifier les échanges et transferts d'expériences innovantes entre nos îles. La modernisation de l'agriculture, dans son cadre écologique, est indispensable pour assurer la pérennité de nos productions locales ; et faire face à la concurrence des grandes puissances.

La compagnie consulaire apporte toute sa contribution à la réussite de cet évènement international, et particulièrement à la création du réseau caribéen des systèmes innovants (Living-Labs Caribéen Réseau : LLCB) et de l'observatoire Caribéen de la Biodiversité Agricoles et des pratiques (OCABA).

## WELCOME REMARKS BY FRANÇOIS HOULLIER,

*Président Directeur Général de l'INRA*

Monsieur le Président du Conseil Régional,  
Madame la Présidente du Conseil Départemental,  
Monsieur le Président de la Chambre d'Agriculture de Guadeloupe,  
Monsieur le Préfet de Région ou son représentant,  
Monsieur le Président de la Société Caraïbienne des cultures alimentaires (Caribbean Food Crop Society, CFCS), Mesdames, Messieurs les représentants des organismes internationaux et caraïbens,  
Mesdames et Messieurs les élus et représentants de l'Etat,  
Monsieur le Président du centre Inra Antilles-Guyane

Chères et Chers collègues

CFCS : Cette société a été créée pour contribuer au développement du secteur agricole, à la sécurité alimentaire et à la préservation de l'environnement dans les îles et pays des Caraïbes.

Cette année, le thème du congrès porte sur la modernisation écologique de l'agriculture et sur l'exploration du potentiel des ressources biologiques tropicales pour l'innovation et pour le développement de la bioéconomie de la région des Caraïbes.

**Agroécologie et Bioéconomie**, voici deux concepts complémentaires qui sont au cœur des réflexions sur le devenir de l'agriculture et de l'élevage.

Dans la sphère scientifique, l'agroécologie, peut être définie par la convergence de l'agronomie, science des localités, et de l'écologie, qui s'attache à la connaissance des principes généraux qui régissent le fonctionnement et l'évolution des êtres vivants dans leur milieu et les interactions qu'ils entretiennent entre eux. L'agroécologie s'intéresse à la manière de produire des biens alimentaires et aux services environnementaux associés aux activités et milieux agricoles. Elle porte sur les régulations et les ressources naturelles — les sols, la biodiversité —, sur le bouclage des cycles biogéochimiques — le recouplage des productions animales et végétales. Elle considère l'agriculture et l'élevage à la bonne échelle — celle des paysages ou des territoires —, et tient compte des contextes physiques, écologiques ou humains. L'agroécologie traite ainsi des performances productives, économiques, sanitaires et environnementales de l'agriculture et de l'élevage. Elle traite aussi de leurs performances sociales, puisqu'elle suppose aussi des savoir-faire particuliers, un investissement dans l'observation, dans la formation, dans le conseil. C'est sous cet angle de la combinaison des performances de l'agriculture qu'elle a été inscrite dans la loi.

L'autre concept, celui de la bioéconomie, est plus récent. Il date du tout début des années 2000. Au sens large, la bioéconomie peut être définie comme l'économie des ressources et processus naturels considérés depuis la production primaire de biomasse jusqu'à ses divers usages — pour l'alimentation, l'énergie, la chimie, les matériaux. La bioéconomie concerne aussi bien la manière de produire que les cascades de transformation, d'usage et de recyclage de la biomasse. Elle porte aussi sur les complémentarités entre les différents usages de la biomasse et des ressources naturelles nécessaires à sa production. Elle comporte ainsi des dimensions biotechnologiques et systémiques. D'une certaine façon, la bioéconomie inclut l'agroécologie en lui ajoutant une dimension verticale et circulaire.

Agroécologie et bioéconomie ont en commun de considérer des systèmes. Toutes deux ont été mises en avant dans le rapport de la mission Agriculture-innovation 2025. Plusieurs projets ont ainsi été proposés :

### **Agroécologie :**

- développer des recherches sur la biologie des sols
- améliorer la fertilité des sols et atténuer le changement climatique (4/1000)
- développer et promouvoir une gestion intégrée de l'eau
- développer un portail de services climatiques
- développer des outils de diagnostic sanitaire rapide sur le terrain
- soutenir la R&D sur le biocontrôle des bio-agresseurs des plantes et des animaux dans une logique de prévention autant, si ce n'est plus, que de soin

### **Bioéconomie :**

- contribuer à l'autonomie protéique de la France et de l'Europe
- amplifier la recherche en technologie et en ingénierie des procédés de transformation de la biomasse
- promouvoir la biologie des systèmes et la biologie de synthèse
- structurer la recherche pour et sur la bioéconomie

### **Agroécologie et bioéconomie à l'Inra**

L'Inra a été pionnier dans le secteur de l'agroécologie,

- en investissant depuis près de vingt ans dans des expérimentations système à long terme
- en créant dès 2005 un dispositif dédié à l'agroécologie à Dijon
- en en faisant une priorité de ses orientations 2010-2020 avec l'ambition de nourrir le concept d'agroécologie par des connaissances et savoir-faire nouveaux

Elle est présente dans les identifiants de plusieurs centres de l'Inra et au cœur des priorités scientifiques de plusieurs départements : EA et PHASE au premier chef, mais aussi BAP et GA sur les questions de génétique et de sélection, SPE et SA pour ce qui concerne la santé végétale ou animale, ou encore MIA et SAD pour les aspects de modélisation ou pour l'étude des transitions vers de nouveaux systèmes production.

En tant qu'interdiscipline émergente, l'agroécologie est mobilisée par les différentes priorités thématiques du document d'orientation 2016-2025 qui est en cours de finalisation. Elle est naturellement très présente dans les 3 priorités suivantes :

- Des agricultures diversifiées et multiperformantes
- La lutte contre le changement climatique, sous les deux facettes de l'adaptation et de l'atténuation
- La complémentarité, la transformation et l'usage des bioressources

En tant que concept englobant, la bioéconomie recouvre l'ensemble de ces priorités ainsi que celles dédiées aux systèmes alimentaires, à la sécurité alimentaire ou aux ressources forestières. Cependant, le concept de bioéconomie percole également au sein des sciences humaines et sociales qui sont portés par deux départements de l'Inra, le département Sciences pour l'Action et le Développement et le département « Sciences Sociales, Agriculture et Alimentation, Espace et Environnement ».

Du fait de sa largeur et de son caractère récent, le concept de bioéconomie n'est pas — encore — incarné par des structures ou des instruments particuliers. L'idée de créer des démonstrateurs ou de créer un centre interdisciplinaire fait cependant son chemin !

Je voudrais ajouter que ces deux concepts s'appliquent également sur notre centre des Caraïbes. Je citerai

- Le pôle scientifique « Agroécologie des systèmes multi-espèces »
- Le dispositif de recherche/formation/innovation en partenariat (DP1) sur les stratégies agroécologiques pour des produits de qualité ou le DP5 sur l'écologie des forêts tropicales

Pour conclure ces deux notions trouvent leur déclinaison dans la recherche au sein de notre institut mais plus globalement à l'échelle régionale et mondiale. Je vous souhaite un congrès intéressant ici en Guadeloupe !

**INAUGURATION AND REMARKS BY DR. WILFREDO COLÓN,  
Chair and CEO, CFCS**

Good morning ladies and gentlemen, I am Dr. Wilfredo Colón, Chair of the Caribbean Food Crops Society. It is a great honor and privilege to be here today to officially inaugurate our 52nd Annual Meeting of the CFCS.

First of all, I want to ask everyone to stand so we can have a minute of silence to honor Dr. Richard Harrison, our representative from Jamaica. Dr. Harrison worked at the Rural Agricultural Development Authority (RADA), of the Jamaican Ministry of Agriculture & Lands. Upon retirement he occupied the position of Chair of RADA.

Thank you.

I want now to recognize the members of the head table:

1. Dr. Harry Ozier-Lafontaine President of the CFCS for 2015 - 2016,
2. the Honorable President of the Regional Council of Guadeloupe, Mr. Ary Chalus
3. the Honorable President of the Departmental Council of Guadeloupe, Mrs. Josette Borel-Lincertin
4. the Honorable President of the Chamber of Agriculture of Guadeloupe, Mr. Patrick Sellin
5. the Honorable Prefect of the Regional Council of Guadeloupe, Mr. Jacques Billant
6. the Honorable President of Inra, Mr. François Houllier

I also want to recognize the members of the Local Organizing Committee who worked diligently and energetically to make this meeting possible.

1. Dr. Harry Ozier-Lafontaine
2. Mr. Jean-Louis Diman
3. Mrs. Patricia Traffond
4. Mr. Patrick Labbe
5. Dr. Michel Naves

In addition I want to present and recognize the Members of the Board of the CFCS. I want to start with:

1. Vice Chair: Dr. Harry Ozier-La Fontaine, INRA, Guadeloupe,
2. Secretary: Mr. Jean-Louis Diman, INRA, Guadeloupe,
3. Treasurer: Dr. Alberto J. Beale, University of Puerto Rico,
4. Past President 2015: Dr. Henry Ori, Anton de Kon University, Suriname

Our Regional Representatives from:

- a. English Caribbean
  - a. Mr. Kwame García, University of the Virgin Islands
  - b. Mr. Barton Clarke, CARDI, Trinidad and Tobago
- b. Spanish Caribbean
  - a. Mr. Rafael Pérez Duvergé, IDIAF, Dominican Republic
  - b. Mr. Jerry Dupuy, Private Sector, Dominican Republic
- c. Dr. Wilfredo Colón, Puerto Rico
- c. French Caribbean
  - a. Dr. Isabelle Jean Baptiste, AMADEPA, Martinique
  - b. Mr. Marceau Farant, INRA, Guadeloupe
  - c. Dr. Harry Ozier-La Fontaine, INRA, Guadeloupe
- d. Dutch region
  - a. Dr. Lydia Ori, Anton de Kon University, Suriname

President of our Advisory Committee:

- a. Dr. Edward Evans, IFAS, University of Florida, USA

Ladies and gentlemen by the power invested in me as the Chair of the Board and Chief Operating Officer of the Caribbean Food Crops Society I officially declare inaugurated our 52nd Annual Meeting. Please let's give ourselves a round of applause to convene our most sincere appreciation for our noble and generous dedication to ensure the success of this meeting.

Now please bear with me a few brief remarks.

I want to recognize the Miguel and Aurora Lugo CFCS Student Scholars, Class of 2016, these are:

1. Ms. Nakisha Mark, Department of Food Production, The University of the West Indies, St. Augustine, Trinidad and Tobago. The title of her talk will be, Creating Value in the Agricultural Sector Through Innovative and Sustainable Chemistry-Utilization of Waste Biomass for the Production of Chemicals and Fuels.
2. Ms. Alida Cederboom, Faculty of Technology, Anton de Kom University of Suriname, Paramaribo, Suriname. The title of her talk will be, The Extraction of Pectin from Grapefruit *Citrus parasidi* and Passion fruit *Passiflora edulis flavicarpa* peels using the direct boiling extraction method
3. Ms. Yara I. Rosado-Rivera, Department of Agro-Environmental Sciences, University of Puerto Rico, Mayaguez Campus. The title of her talk will be, In Vitro and in vivo Evaluation of Conventional and Organic Pesticides to Manage Foliar Diseases of Yam (*Discorea alata* L.) in Puerto Rico.
4. Mr. Jacky Paul, AgroParisTech School and INRA ASTRO research unit, Guadeloupe. He will present two papers, an oral presentation titled, Factors affecting compost adoption in French West Indies and a poster presentation titled, Composting and organic fertilization in Guadeloupe: conditions for the emergence of a waste recycling industry in agriculture.

Please let's give them a round of applause to indicate our appreciation for them being selected as members of the Class of 2016.

Just this year, the International Food Policy Research Institute (IFPRI), published a report titled, Agricultural

Research in Latin America and the Caribbean A Cross-Country Analysis of Institutions, Investment, and Capacities.

However, they left out key regional research organizations that are actively involved in agricultural research in

the Caribbean Region, such as:

- INRA Guadeloupe, Martinique and French Guiana
- CIRAD also in the French West Indies
- University of Puerto Rico, Agricultural Experiment Station
- University of the Virgin Islands, Agricultural Experiment Station
- University of Florida, Agricultural Experiment Station
- INCA, Cuba
- Others

I wrote to the authors and informed them that they should visit our website (Caribbean Food Crop Society) and

access our proceeding which highlight regional research activities for the last 50 years.

This study highlighted that the focus of the research in tropical regions is mainly on bananas, coffee and sugarcane. In the Anglophone Caribbean research was shown to be focused on tubers (64%), vegetables (8%) and fruits (4%). The study did not identify any major efforts on research dealing with cropping systems.



There lies the importance of this year's theme: Engineering Ecological Modernization of Agriculture/ Exploring the Potential of Tropical Biological Resources for Innovation/Towards a Bio-Economic Development of Caribbean Countries.

This theme was crafted by the scientist of the French National Institute for Agricultural Research, and the territorial legislative bodies, the Guadeloupe Regional and Departmental Councils; Chamber of Agriculture, Network of Innovation and Agricultural Transfer (RITA), Pôle Synergîle of Competitiveness, schooled at Capenergies, and the Institute of Franco-Caribbean Cooperation (ICFC), specifically focused on the Caribbean Basin.

This theme is categorized in the larger and broader concept of green economy, which according to the United

Nations Environmental Program (2012) refers to one that generates increasing prosperity while maintaining the natural systems that sustain our societies and our economies.

The Caribbean Basin offers a diverse and rich tapestry of natural resources and agroecosystems. It has mountain ranges that reach up to 3,000 meters above sea level with ecosystems that receive more than 5000 mm and as little as 254 mm of rain annually. This region is exposed to the major tropical storms and hurricanes and has felt the effects of global climate change and globalization.

Our agriculture models rely more on plantation or cash crops and small animal production. In the recent past as well as in the present, the region has depended heavily on food imports to satisfy its food security requirements.

We definitely need to look at other food production models that are resilient when faced with global climate changes and sustainable for the benefits of our future generations.

We started to include this topic as a one day symposium in 2011 in our meeting in Barbados. We then organized a follow up meeting in Mexico 2012. In 2013 in Trinidad and Tobago we held an agroecology technical session.

This time around the LOC has brought this topic to the forefront of the CFCS annual meetings posing key questions, such as: What are we doing to develop alternate food production practices? What are the best practices in the region? Which regional projects can be replicated? Which regional projects are cost effective?

This is a theme that will be part of the CFCS discussion and evaluation for years to come.

We are already planning to continue this discussion in our 53rd annual meeting to be held in Puerto Rico in 2017.

Finally, it is our mission to be an independent professional organization with interdisciplinary orientation and

membership, which fosters communication between persons capable of contributing to the development of science, technology, and production of food crops and animals in the countries of the Caribbean Basin. For over 50 years we have fostered a regional scientific and cultural fellowship which all of you will enjoy and partake of during this week.

*Merci beaucoup*

*Muchas gracias*

*Thank you very much*

*Veel dank*

*Mesi anpil*

*Danki altamente*









52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

# Plenary introduction session

**KEYNOTE ADDRESS**



## TRACKING INNOVATION CROPPING SYSTEMS DESIGNED BY FARMERS

*J.M. Meynard, INRA, France, meynard@grignon.inra.fr*

### **Abstract:**

Farmers are very inventive, but their innovations often remain confined to their farm, or to small local networks. And the interest they might have for farmers other than their inventors is seldom analyzed. Tracking on-farm innovations aims at finding technical or organizational innovations designed by farmers, to characterize their agronomic, economic and environmental performance and analyze the conditions in which this performance is expressed. The talk presents the various stages of this tracking approach, applied to innovative cropping systems, basing on a variety of recent works, in France, Argentine, Burkina Faso and China: (1) Defining what we are looking for; (2) Identifying innovative systems; (3) Describing and characterizing innovative systems; (4) Assessing innovative systems; (5) Specifying the conditions for the success of innovative systems.

The results of the tracking are aimed not only at the farmers, but at their advisors and researchers too: (i) Innovative and effective cropping systems, which can be a source of inspiration for farmers; (ii) Confirmation of the interest of a principle for reasoning cropping systems; (iii) Innovative practices, analyzed within a systemic framework, which can serve as bricks for the design of new systems; (iv) Questions to be looked into more thoroughly by experimentation. Compared to traditional approaches in agronomy, tracking innovative cropping systems provides a double break: break with a top-down approach, where agricultural R & D is regarded as the only source of innovation: by mobilizing the innovative capacities of farmers, tracking increases our collective capacity to invent new practices or new cropping systems, by using not only technical and scientific knowledge, but also the empirical knowledge, that is so rich in agriculture. And break with the primacy given to experimentation, as a source for the production of knowledge and the assessment of innovations.

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Farmers are very inventive, but their innovations often remain confined to their farm, or to small local networks. And the interest they might have for farmers other than their inventors is seldom analyzed. Tracking on-farm innovations aims at finding technical or organizational innovations designed by farmers, to characterize their agronomic, economic and environmental performance and analyze the conditions in which this performance is expressed. Then the results of this analysis could be shared with other farmers, in participatory design processes. The talk presents the various stages of this tracking approach, applied to innovative cropping systems, basing on a variety of recent works, in France, Argentine, Burkina Faso and China.

### **Step 1: Defining what we are looking for**

We are interested here in cropping systems, or in crop management, in other words, consistent combinations of practices. We want them to be innovative, that is to say different from what most people know, and more particularly of course, different from what the tracking initiator knows. Generally, they will be innovative because their inventors have developed them in response to original aims. In the tracking studies, we found 3 main ways of defining what we are looking for :

1. We are looking for systems that are more sustainable than the dominant systems in a given region: a precondition to tracking is the characterization of the “dominant” systems .
2. We are looking for combinations of practices, which enable a problem to be controlled: For example, how to reduce pesticides? How to control weeds in organic farming?
3. We want to know more about a practice that is not indexed in the literature and not well-known by the experts: its interest for producers, its implementation methods, its insertion in the cropping systems...

### **Step 2: Identifying innovative systems.**

This is not easy, because really innovative systems are rare. The most usual method of identifying them is based on an exploration of the networks of actors: we ask the people involved if they know producers developing systems that correspond to the tracking objective, or failing this, if they can indicate other actors likely to know such producers. Gradually, we identify the innovative producers and their systems. An important choice is that of the “network heads”, the people to be approached first: it is essential to choose a variety of them, in order to multiply the networks explored; if we stay in the networks we know, we will only find the innovations we know. Even those that we have advised! It is also possible to sort innovative systems through a database, with a performance indicator. This method depends on the quality of the database, and on the criteria it contains.

### **Step 3: Describing and characterizing innovative systems.**

This involves describing the practices and the context in which they are implemented, then analyzing how consistent they are with the farmer's satisfaction criteria. The survey begins with a presentation to the farmer of our objectives, explaining that we propose to shed light on his practices, so that other farmers can take inspiration from them. The very large majority of farmers accept the principle of the study: they consider that the sharing of experience between farmers is not only normal, but desirable.

After a rapid collection of general information about the farm, the survey concentrates on the cropping system that has been identified as innovative. Initially, we endeavor to record practices (crop successions, intercrops, varieties, dates of intervention, inputs, equipment used ...); we are interested not only in the usual practices, but also in alternatives associated with particular events. Then we ask the farmer about his satisfaction criteria, that is to say the results he expects from the implementation of his practices. We use the producer's satisfaction criteria to clarify the agronomic logic of the cropping system: which satisfaction criteria explain which practice? According to the farmer, what practices are determining for the satisfaction of a criterion?

### **Step 4: Assessing innovative systems**

The interest an innovative system will have for other producers depends on its performance: what criteria will this performance be judged on? The scientific literature offers us many sets of indicators exploring the economic, ecological and social dimensions of sustainability. But these sets of indicators generally don't integrate important producers' satisfaction criteria. There is a special question on the assessment using farmers' personal criteria: How to communicate the result of the assessment to other farmers? On the basis of different examples, we show how to create indicators with farmers' satisfaction criteria.

### **Step 5: Specifying the conditions for the success of innovative systems:**

We call "conditions for success" the agronomic, economic and social conditions, which must be combined for the desired performances to be achieved. Analysis of the conditions for success is essential to use the result of tracking in other farms: what could be remobilized? Where?

The analysis of the conditions for success is based on the agronomic logic of the cropping systems and their assessment (previous steps). The expression of the conditions for success can refer to characteristics of the soil or climate, or to characteristics of the farm. It would appear essential to compare the systems of several producers to consolidate the characterization of the conditions for success: Convergence between several producers satisfied with the same innovation is an interesting sign of the robustness of this innovation. Conversely, differences in cropping system for similar satisfaction criteria, or differences in satisfaction for the same cropping system, help to perceive the limits of an innovative system.

### **Conclusion**

The results of the tracking are of different kinds, and are aimed not only at the farmers, but at their advisors and researchers too: (i) Innovative and effective cropping systems, which can be a source of inspiration for farmers; (ii) Confirmation of the interest of a principle for reasoning cropping systems; (iii) Innovative practices, analyzed within a systemic framework, which can serve as bricks for the design of new systems; (iv) Questions to be looked into more thoroughly by experimentation

Compared to traditional approaches in agronomy, tracking innovative cropping systems provides a double break:

- (i) break with a top-down approach, where agricultural R & D is regarded as the only source of innovation: by mobilizing the innovative capacities of farmers, tracking increases our collective capacity to invent new practices or new cropping systems, by using not only technical and scientific knowledge, but also the empirical knowledge, that is so rich in agriculture;
- (ii) break with the primacy given to experimentation, as a source for the production of knowledge and the assessment of innovations.

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## OPERATIONS ET PLATES-FORMES DE TRANSFERT DE TECHNOLOGIE EN PROXIMITÉ : OUTILS CLÉS POUR STIMULER UN DÉVELOPPEMENT LOCAL.

## OPERATIONS AND TECHNOLOGY TRANSFER PLATFORMS IN VICINITY: KEY TOOLS TO ENHANCE LOCAL DEVELOPMENT.

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**Keywords:** technology transfer, development, Caribbean, innovation

### Abstract

Many are the components of the geographical area of the Caribbean (islands, islets, islands, archipelagos, Continental, isthmique) overdrive are issues, when dealt with the development of food production or non-food, based on local resources. Those last are very diverse in terms of type of organs, properties to kept, availability in cultivated areas or the wild, at very different strata of the canopy or underground. Their optimal use is subject to the consideration of time in terms of moment and delay *i.e.* optimal physiological stage of harvest and / or short deadlines to be respected in handling due to rapid changes in hot and humid tropical climate.

Therefore, skills to integrate the various dimensions of the biological object of interest, the resource, are more essential than the standard tools offered by technology vendors. It is crucial to shape *ad hoc* equipments, by negotiating near suppliers in a firm and precise manner. Otherwise we run the risk of receiving means made for another world.

In a presentation by several voices, let you share stories of success or not, about operations or technology transfers involving the implementation of technological platforms, obtained under different conditions. The aim is to highlight how it is appropriate to control the platform pilot study phase of the development process, of innovation, to bring about success.

- ✓ INRA: Transfer by experimentation platform on industrial site.
- ✓ PHYTOBÔKAZ: Natural resources and innovation: At the heart of biodiversity in the Caribbean.
- ✓ MINATCHY: Industrial technological innovation in the insular Caribbean. Need for adaptation, flexibility and to be rustic.
- ✓ PARM: Transfer of innovative technology for company development. Caribfruits (Petal's fruit).

**Mots-clés :** Transfert technologique, développement, Caraïbes, innovation

### Résumé

Multipliées sont les questions, quand est abordé le développement de productions alimentaires ou non-alimentaire à base des ressources locales. Car ces dernières sont très diverses en termes de typologie d'organes, de propriétés d'intérêt à préserver, de disponibilité dans des espaces cultivés ou non, à des strates très variables du couvert végétal ou du sous-sol. Leur valorisation optimale est soumise à la prise en compte du temps en termes de moment et de délais *i. e.* stade physiologique optimale de récolte et/ou délais de manipulation courts à respecter du fait d'une évolution rapide sous climat tropical chaud et humide.

C'est pourquoi, les compétences à intégrer les diverses dimensions de l'objet biologique d'intérêt, de la ressource, sont primordiales aux outils-types proposés par les fournisseurs de technologie. Il est déterminant de façonner des équipements *ad hoc*, en négociant près des fournisseurs de manière ferme et pointue des besoins et des fonctions. Autrement on prend le risque de recevoir des moyens faits pour un autre monde.

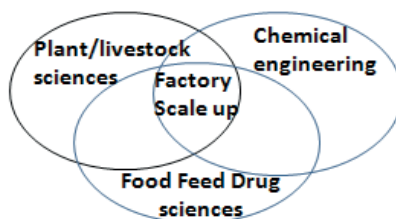
Dans une présentation à plusieurs voix nous allons vous faire partager des succès stories, d'opérations ou de transferts de technologie impliquant la mise en œuvre de plates formes technologiques, obtenues dans des conditions différentes. L'objectif est de mettre en évidence combien il est aussi opportun de maîtriser la phase d'étude de plateforme pilote du processus de développement, d'innovation, pour provoquer le succès.

- ✓ INRA: Transfert par expérimentation plate-forme sur site industriel.
- ✓ PHYTOBÔKAZ: Ressources naturelles et innovation : Au cœur de la biodiversité des Caraïbes.
- ✓ MINATCHY: La difficulté de l'innovation technologique industrielle en milieu caribéen insulaire: une nécessité d'adaptation, de souplesse, de rusticité.
- ✓ PARM: Le transfert d'une technologie innovante au service du développement de l'entreprise Caribfruits (Petal's de fruits).

### Contexte du travail d'expérimentation pilote

Le développement socio-économique d'un espace, d'une région, s'appuie sur des richesses naturelles de cet espace et/ou de l'apport d'externalités qui donnent lieu localement à l'émergence de savoir-faire qui peuvent alors eux aussi devenir des facteurs de développement (. De nos jours, les attentes sociales, qu'elles soient collectives ou individuelles, sont caractérisées par un nombre croissant d'arguments qualitatifs, qui font que la fourniture de biens et de services, nécessite de la part des fournisseurs le plus grand soin. Aussi, des réglementations nationales, quelques fois supranationales viennent encadrer la fourniture de biens et de services, dans un monde où les barrières commerciales ont été progressivement abaissées. De ce fait la concurrence est devenue un peu partout, de plus en plus forte, d'où pour durer, l'impérieuse nécessité pour les producteurs de biens et de services, de faire miroiter aux consommateurs d'éventuelles qualités que présentent leurs produits. La construction de cette qualité et de la compétitivité, ainsi que l'innovation amènent les opérateurs économiques à avoir recours à une panoplie d'outils, de moyens.

Pour l'exploitation et la valorisation des ressources biologiques naturelles, que ce soit à des fins alimentaires ou non-alimentaires, il apparaît nécessaire de mener des études expérimentales, dites pilotes, intégrant plusieurs disciplines scientifiques, techniques, et mêmes socio-économiques, en fonction de l'ampleur du projet d'exploitation. Cette démarche pluridisciplinaire expérimentale constitue une intersection de taille variable (Factory scale up), un point de croisement, qui peut être pris en considération dès l'échelle domestique, et progressivement amplifié quand on se situe dans des problématiques d'échelle industrielle (**Figure 1**). L'expérimentation pilote a pour objet d'établir des connaissances, de disposer de préséries, permettant l'élaboration de produits de qualité contrôlée en fonction des quantités de matières premières mises en œuvre simultanément. Il y a des effets de masse qu'il faut maîtriser et valoriser.



**Figure 1.**Principales disciplines contribuant aux démarches pilotes de plates-formes expérimentale.

Le pilote d'expérimentation fixe ou mobile correspond à une opération, un traitement, à étudier dans un itinéraire de transformations. La plate-forme d'expérimentation est une structure avec des services et des annexes (eaux froide et chaude, air comprimé, courants faible et fort, internet, métrologie, enceintes froides, congélation, ...). Des compétences humaines techniques et de l'ingénierie sont associées au sein de surfaces conditionnées sur lesquelles peuvent être positionnés serait-ce occasionnellement un ou des pilotes, permettant de prendre en considération des itinéraires de transformation complexes qui peuvent être continus sur des périodes longues.

### Intégration en amont de la filière de transformation des outils d'expérimentation pilote

C'est grâce à des opérations de type pilote, à des études sur plate-forme d'expérimentation de proximité, que peuvent être élaborés des produits de qualité, durable et compétitifs. L'optimisation de la qualité des produits biologiques transformés nécessite bien souvent des outils spécifiques de manipulation adaptés au plus près de chaque matière première. La prise en compte précise du stade physiologique de développement de la ressource biologique est un aspect d'importance, car la teneur en composés d'intérêt de la matière première en est très souvent dépendante. Aussi, en fonction des quantités manipulées de matière première et/ou des délais de traitement après récolte, des itinéraires adaptés sont à définir pour optimiser la qualité du produit final.

Pour valoriser au mieux les propriétés des ressources étudiées, les outils de plate forme en proximité sont avantageux, dans la mesure où des traitements et des délais d'approche ne viendront pas modifier en aucune façon ou très peu la ressource considérée. Il apparaît donc que le contexte géographique a un poids considérable et spécifique sur la ressource. Les compétences humaines, techniciens et ingénieurs, doivent être en mesure de discuter avec les fournisseurs de technologie pour obtenir pas nécessairement des équipements standards des opérations du génie chimique, mais des équipements répondant au plus près aux problématiques, aux challenges propres aux ressources prises en considérations et aux quantités manipulées. Trop souvent les fournisseurs proposent « des marteaux pour écraser une fourmi ».

### Expériences locales en milieux Caribéen.

Dans notre démarche à quatre voix autour d'expériences de développement expérimental avec des pilotes et/ou des plates-formes, dans le contexte Caribéen, nous voulons mettre l'accent sur l'importance de cette phase dans le développement en diverses situations.

#### 1. Expérience de plate-forme sur site industriel, en continu, sur période longue.

La digestion méthanique est un processus naturel, domestiqué à partir du 19<sup>e</sup> siècle. On retrouve les premières traces d'utilisation de biogaz dans le Moyen-Orient antique, pour le chauffage d'eau de bain. En 1776, Volta en France a fait le constat de la relation entre la production de gaz et la matière organique en décomposition (gaz des marais). La première unité de production de biogaz a été construite dans une léproserie en Inde en 1869. Le développement de la microbiologie



a permis dans les années 1930, l'identification de bactéries anaérobies comme agents de la fermentation méthanique, et la compréhension des conditions qui occasionnent cette fermentation. C'est dans les fermes que la fermentation méthanique a été le plus souvent mise œuvre pour fournir du gaz pour la cuisson et l'éclairage, jusqu'à l'après seconde guerre. La digestion anaérobie est très présente dans les mangroves.

La fermentation méthanique ou digestion anaérobie, tout en produisant du biogaz combustible, a un effet dépolluant sur des substrats solides ou liquides contenant donc de la matière organique polluante. C'est dans le domaine de la dépollution et de la protection de l'environnement que la digestion anaérobie a conquis ses lettres de noblesse. Dépolluer les eaux issues des lignes de production industrielle en transformant cette pollution en source d'énergie réutilisée a été considérablement développé.

La taille croissante des rhumeries au cours des années 60 et 70 en a fait des sources de plus en plus importantes d'effluents polluants. La réglementation en matière d'environnement, ainsi que le respect de la qualité de l'air respiré par les habitants proches des distilleries ont généré la nécessité de dépolluer les vinasses, résidus de la distillation des milieux fermentés en rhumerie. L'étude par des chercheurs de l'INRA, à partir de 1979, de la capacité de l'environnement à digérer la pollution des vinasses par différentes voies, avait conduit à la conclusion que la digestion méthanique en réacteur était le procédé le plus efficace. Des études pilotes ont alors été lancées au début des années 80. L'INRA, et un fournisseur de technologie ont étudié la digestion méthanique des vinasses de rhumerie afin de les dépolluer tout en produisant de l'énergie, du biogaz, utilisable au sein même de l'unité de traitement pour satisfaire à des besoins en énergie pour la distillation, ou pour produire de l'électricité réinjectée dans le réseau EDF.

Il y avait des besoins de connaissances liées aux substrats (vinasse de mélasse et vinasse de jus de canne), à un inoculum, et aux paramètres physiques de conduite du processus:

- composition quantitative et qualitative des vinasses en charge polluante (DCO),
- écosystème source d'inoculum,
- taille de réacteur pour absorber les débits importants des distilleries,
- matériaux servant de support de fixation des bactéries, au sein du fermenteur,
- des paramètres opératoires adéquats pour assurer l'équilibre et la permanence de la digestion méthanique sur une campagne de production (6 mois/an) et sa reprise à la campagne suivante.

Pour arriver à déterminer et maîtriser ces données industrielles, des outils pilotes avec des cuves de 15 m<sup>3</sup> ont été nécessaires, implantés directement sur les sites industriels, ce qui était une impérieuse nécessité, afin de disposer du substrat en quantité suffisante à flux continu, avec la chaleur qui la caractérise au sortir de la distillation. Différentes sources d'inoculum ont été étudiées (mangrove, lagunes, sédiments), ainsi que leur capacité à être multiplié et activé. Des campagnes d'étude s'étalant sur 2 ans avec un arrêt et un redémarrage ont été entreprises.

Les données accumulées ont permis de dimensionner l'outil industriel. Un digesteur de 1 700 m<sup>3</sup> a été mis en place en 1986 sur le site de Bonne-Mère. Le système dépolluait les vinasses à 65 %, en fournissant 60% de l'énergie nécessaire au fonctionnement de la distillation. La rusticité de fonctionnement du système ont fait qu'il a fonctionné pratiquement sans intervention pendant 5 ans, au bout desquels le système a ralenti considérablement. L'industriel a alors recommencé à rejeter les effluents polluants dans la Grand Rivière à Goyave. Des troubles publics de protestation contre la pollution du milieu naturel ont conduit à des barrages sur la route nationale passant sur le pont de Laboucan. Les autorités en charge de l'environnement ont fait des interventions. Il n'y pas eu d'alternative à la digestion méthanique. Cela a conduit à la réactivation du fermenteur de 1 700 m<sup>3</sup>, et à la mise en place d'un deuxième pour pouvoir traiter un volume d'effluent qui avait entre temps augmenté. Depuis 2005 l'unité de Bonne Mère traite par digestion méthanique et un traitement complémentaire ses vinasses en donnant satisfaction à la réglementation en matière d'environnement et la paix sociale est revenue sur le pont de Laboucan.

Sur vinasse de jus de canne l'itinéraire a été le même d'étude a été parallèle, mais spécifique avec un substrat plus facilement biodégradable, jusqu'à 98% de dépollution. L'unité de Boulogne dépollue ses vinasses par cette voie et réinjecte l'énergie produite sur le réseau EDF, car la combustion de sa bagasse lui fournit son compte d'énergie.

## 2. PHYTOBOKAZ



**VIRAPIC**

**STIMULE LES DÉFENSES NATURELLES**  
 Agit sur le stress et la fatigue.  
 -  
 Herbe à pic, *Neuroleena lobata*.



**STIMULATE THE BODY'S NATURAL DEFENCES**  
 Fight against stress and fatigue.  
 -  
 Zebocpek, *Neuroleena lobata*.

**BANULINE**

**PRÉBIOTIQUE**  
**RÉGULARISE LE SYSTÈME DIGESTIF**  
 Confort digestif. Anti-oxydant. Alcalinisant.  
 -  
 Banane, *Musa paradisiaca*.



**PREBIOTIC**  
**BALANCE THE DIGESTIVE SYSTEM**  
 Digestive comfort. Anti-oxidant. Alkalinizing agent.  
 -  
 Banana, *Musa paradisiaca*.

**BIOVEN**

**PROBLÈMES CIRCULATOIRES**  
 Facilite le retour du sang veineux et favorise le drainage lymphatique. Tonifie en cas de jambes lourdes.  
 -  
 Herbe Charpentier, *Justicia pectoralis*.



**BLOOD CIRCULATION**  
 Promoting lymphatic drainage and the return of the blood into the veins. Tones heavy legs.  
 -  
 Carpenter's grass, *Justicia pectoralis*.

**HUILE DE GALBA**

**ANTI-ÂGE - ANTI-OXYDANT, FORTIFIE CHEVEUX ET CUIR CHEVELU**  
 -  
 Galba, *Calophyllum calaba*.



**ANTI-AGING - ANTI-OXYDANT, STRENGTHEN HAIR AND SCALP**  
 -  
 Galba, *Calophyllum calaba*.

**RUMAGO**

**SOULAGE LES DOULEURS MUSCULAIRES ET ARTICULAIRES**  
 Apaise en cas de douleurs en saison froide et après l'effort.  
 -  
 Herbe Charpentier, Gommier rouge (*Bursaria simaruba*).



**MUSCLES AND JOINTS WELFARE**  
 Soothing and relaxing after exercising or during the cold season.  
 -  
 Carpenter's grass, Red gumbo limbo (*Bursaria simaruba*).

**TITREZO**

**LISSE LES CAPITORS**



**SMOOTHES AND TONES UP THE SKIN**



## PRESENTATION DE L'ENTREPRISE

Notre entreprise PHYTOBÔKAZ [PHYT, plantes et ÔBOKAZ signifiant «autour de la maison »] est née en 2005, de l'association entre Henry JOSEPH (Pharmacien et Dr en pharmacognosie) et son ancien professeur, Paul BOURGEOIS, chimiste à la retraite.

Le laboratoire Phytobôkaz fabrique des compléments alimentaires et des phytocosmétiques. Les matières premières naturelles nécessaires aux besoins de l'entreprise sont puisées au cœur de la biodiversité de la Guadeloupe. La conception de nos produits suit un itinéraire technique précis de la plante au produit fini, que nous avons dû mettre en place pour assurer un développement harmonieux de la faune, de la flore et de l'Homme avec notre unité de production.

Il s'agit d'un concept innovant d'agroécologie, d'agroforesterie et d'agro-transformation liant le développement de notre laboratoire et le maintien de la biodiversité de façon concomitante. Le projet était de produire des plantes oléagineuses (galbas, cocotiers, calebassiers, avocatiers) en comprenant le fonctionnement de chacune de ces espèces, les interconnexions trophiques faune / flore et les adaptations humaines à effectuer, afin d'optimiser le développement de notre entreprise tout en préservant la biodiversité.



## UN PROJET VISIONNAIRE

Au cours de ces prochaines années, les ressources carbonées de la chimie française seront de plus en plus végétales. 80% de la biodiversité de la France se trouvent en Outre-Mer, pourtant il n'y a pratiquement pas d'exemples de valorisation au niveau industriel de cette richesse en harmonie avec la nature sur ces mêmes territoires.

Dès 2005, PHYTOBÔKAZ a été une entreprise pionnière afin de répondre aux exigences de la transition énergétique et écologique. Notre caractère insulaire, avec des écosystèmes fragiles, le fort taux de chômage chez nos jeunes, nous ont poussés à aller vers d'autres modèles de développement endogènes, en passant par ce que nous avons d'original et de spécifique : notre biodiversité. Selon nous, la valorisation l'Or vert de la Guadeloupe dans le respect de son environnement, à travers ce projet permet, et permettra de penser et de produire autrement, tout en créant de véritables filières vertes, avec des retombées sociales et économiques indispensables à notre région insulaire. Ce d'autant que l'archipel de la Guadeloupe fait partie des *hotspots* de biodiversité, définis comme zone de réserve mondiale de biosphère. Il est donc capital de préserver ce trésor de la forêt primaire pour les générations futures et d'élaborer des zones de reforestation « utiles » tout en se développant industriellement. C'est le pari que nous avons fait.

## UNITE EXPERIMENTALE INNOVANTE D'AGROECOLOGIE, D'AGROFORESTERIE ET D'AGROTRANSFORMATION EN GUADELOUPE

Les fondateurs de Phytobôkaz, étant tous deux amoureux de la nature, mais également conscients de révolution de l'Or Vert, ont créé un concept de valorisation de la Biodiversité des Outre-Mer, à travers la création d'une filière oléagineuse. La composition chimique exceptionnelle de certaines de ces huiles ainsi que leurs propriétés que nous avons mises en lumière, laisse présager un très bel avenir cosmétique voire de santé en termes d'applications.

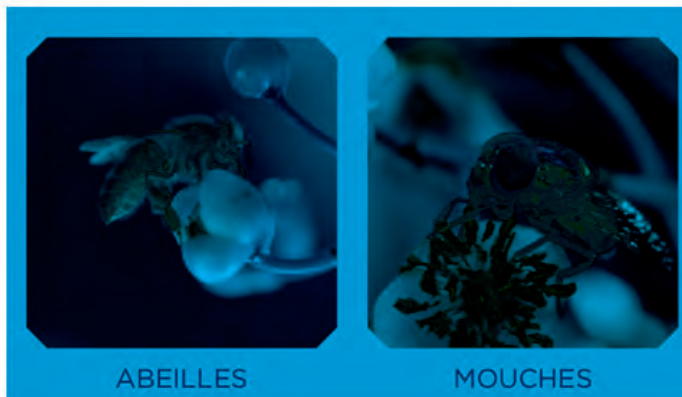
Notre démarche a consisté à imiter le fonctionnement de la forêt tropicale pour concevoir un ensemble agro-écologique durable et utile. Ainsi, nous avons recréé tout un **éco-système** interdépendant qui vit sur notre plantation alternée de Galbas, de calebassiers, de cocotiers et d'avocaters, des oléagineux que nous avons sélectionnés. Les abeilles, les mouches, d'autres insectes, les chauves-souris et les hommes interviennent à différents stades de la chaîne allant de la plantation aux produits finis: les huiles. Notre concept, intègre également des innovations en termes d'outil de récolte des noix de Galba respectueux de notre écosystème, et d'outil d'**écalage** et de conservation des noix afin de préserver les propriétés organoleptiques et pharmacologiques de l'huile. Notre unité d'agroécologie, d'agroforesterie et d'agro-transformation est opérationnelle depuis maintenant deux ans.

**PRESERVATION DE LA BIODIVERSITE ET DE L'ECO-SYSTEME**

Cette notion complexe qu'est la biodiversité qui inclut à la fois des aspects taxonomiques, fonctionnels et spatiaux de la diversité des êtres vivants dans un même lieu nous passionne. Nous pensons écologie, phytosociologie, écosystème avant de mettre en culture les plantes utilisées dans notre entreprise. Notre unité d'agroforesterie est pour nous un très bon cas d'école, car nous oublions souvent que le fruit est le résultat de la fécondation d'une fleur. En mettant 18 ruches à proximité des champs et en bannissant tout pesticide afin de préserver les abeilles, le résultat en termes de fructification est spectaculaire et en évolution d'années en années.

Nos observations complémentaires et photographies sur l'éthologie des chauves-souris font ressortir que le mâle dominant est seul à avoir accès à un harem de femelles dans les arbres de Galba. Ceci oblige les mâles non dominants à cueillir les fruits et s'installer, ailleurs, sur d'autres arbres à proximité, que nous appelons des perchoirs ou mangeoires. Ceci nous a incité à étudier les caractéristiques des meilleures mangeoires et leurs implantations précises au milieu du champ de Galba afin de réduire la dispersion des fruits hors draps de récolte et éviter des pertes trop importantes. De plus, l'association des Galbas avec d'autres plantes oléagineuses utilisées à PHYTOBÔKAZ assurent ainsi d'autres réseaux trophiques à la faune: nectars de fleurs de calebassiers pour les chauves-souris et pollen des cocotiers et avocaters pour les abeilles.

Ainsi, nous avons pu constater un impact sur la **biodiversité animale** grâce à une augmentation des populations de chauves-souris. Ceci se traduit par une augmentation de la quantité de noix récoltées d'une année à l'autre mais également la colonisation de l'écosystème créé, par de nouvelles espèces d'oiseaux, d'anolis (petits lézards), d'insectes (pollinisateurs, etc).



Nous avons eu également un impact sur la **biodiversité végétale** et le paysage, grâce à la reforestation visible sur la parcelle. Une autre image de l'agriculture antillaise se construit, plus propre, plus nuancée et se fond au paysage déjà luxuriant de la forêt guadeloupéenne jadis nommée «île d'émeraude».



## IMPACT ENVIRONNEMENTAL, SOCIO-ECONOMIQUE ET CULTUREL

Avec la fin programmée du pétrole dans une quarantaine d'années et de la pétrochimie, nous devons d'ores et déjà penser à des contenants durables, comme alternatives aux sacs et aux couverts en plastique.

Cela a conduit notre entreprise au niveau socio-économique et culturel, à tisser des passerelles avec le monde associatif notamment avec l'association « On Pannyé On Kwi ». Il s'agit d'une entreprise d'insertion dont l'activité consiste en la fabrication d'objets éco-conçus dans le cadre de la mise en place d'un atelier de vannerie pour la protection de l'environnement et la dépollution de nos territoires. Celle-ci se fait par la gestion des déchets à la source par l'usage des paniers et des kwis (calebasses coupées en deux). Pour ce faire l'association travaille à partir de matières premières 100% naturelles issues de notre biodiversité, comme des lianes et des bambous pour la fabrication des paniers. Puis elle récupère les calebasses de nos plantations et les débarrasse de leur pulpe et noix et fabrique des objets éco-conçus. Notre entreprise récupère ensuite les noix pour en faire de l'huile de calebasse. Grâce à cette complémentarité de nos activités dans des disciplines totalement différentes nous créons des emplois tout en pérennisant la tradition et un savoir-faire ancestral toujours dans un souci de protection de notre environnement.

## L'AVENIR VU PAR NOTRE JEUNESSE

Phytobôkaz accompagne et encourage de jeunes chercheurs dont les travaux, mettant en avant la flore guadeloupéenne pour la plupart, donne un souffle d'espoir quant à l'avenir de la biodiversité.

Ils ont tenu à partager leur vision de l'avenir et leur ambition pour valoriser notre biodiversité.

**3. L'innovation technologique industrielle en milieu caribéen insulaire: une nécessité d'adaptation, de souplesse, de rusticité.**

Selon les données de l'INSEE (2013), en Guadeloupe et en Martinique, l'industrie agroalimentaire (IAA) de la Guadeloupe et de la Martinique a un poids relativement faible dans l'économie locale : 2 % de la richesse produite contre 8 % pour la totalité de l'industrie.

Cependant, les établissements de l'IAA représentent des acteurs non négligeables au niveau de l'emploi : 5 700 salariés répartis équitablement sur les deux îles. Les IAA représentent 33 % en Guadeloupe et 31 % en Martinique du total des emplois industriels.

C'est également un secteur dynamique, puisqu'entre 2006 et 2010, le nombre d'établissements relatifs aux IAA augmente de 25 % aux Antilles (notamment en Guadeloupe + 35%), alors qu'il est en baisse au niveau de la France hexagonale.

L'industrie agro-alimentaire est dominée par l'industrie de la canne à sucre qui exporte 45% de sa production vers la France, qui absorbe notamment les trois quarts des exportations de rhum.

La vitalité de l'industrie agroalimentaire en Guadeloupe et en Martinique est donc fortement liée à la demande locale mais aussi à la demande mondiale via les échanges avec l'hexagone et l'Europe.

A part cette filière canne, le secteur de l'agro-transformation industriel est bien souvent déconnecté de l'agriculture, car de nombreuses structures importent les matières premières agricoles pour les transformer, les formuler ou les emballer sur place. C'est le cas pour bon nombre d'industries de jus de confitures, de café, etc...

Pour les entreprises qui développent la transformation des produits locaux, deux cas de figure peuvent être distingués :

- l'utilisation de produits agricoles cultivés en quantité suffisante
- ou alors la valorisation de produits issus de la biodiversité, pour lesquels il est nécessaire de construire toute une filière depuis les itinéraires techniques pour la mise en culture, jusqu'à la mise au point de technologies de transformation adaptées à cette matière non conventionnelle.

La pérennité de ces entreprises est donc dépendante de la disponibilité et du prix de la matière première, de l'adaptation de technologies correctement dimensionnées par rapport au contexte du marché local et aussi de l'environnement technologique.

On le voit donc, sur ce secteur fortement concurrentiel, l'innovation technologique est extrêmement importante. Cette innovation se heurte cependant à des difficultés, notamment en l'absence d'outils techniques dédiés, comme c'est le cas en Guadeloupe.

Dans un passé récent, des travaux de recherche et développement ont été menés en collaboration avec des structures délocalisées qui disposaient des outils pilotes, mais les projets n'ont pas abouti à la création d'activités industrielles. Deux exemples seront évoqués : la mise au point du pur-jus de banane et la valorisation de l'ambrette.

Le pur-jus de banane a été développé à l'Unité Expérimentale de Pech-Rouge de l'INRA à Gruissan (Aude) qui disposait de l'ensemble des outils nécessaires pour mener à bien cette expérimentation. Ce pur-jus de banane est un produit nouveau sans sucre ni eau ajoutés. Il s'agit d'une réussite technique, mais avec un environnement technologique très lourd, qui est difficilement transposable dans le contexte industriel de la Guadeloupe.

L'industrie des jus est en effet une industrie de volume où la marge est réalisée sur les quantités vendues, or le marché local est restreint. Les industriels de la place importent généralement des pulpes de fruits qu'ils formulent, hormis un seul projet récent concernant le jus de canne microfiltré.

De plus, le produit comporte une valeur ajoutée alimentaire, insuffisante pour couvrir les coûts notamment de main d'œuvre qui constituent une part importante du coût de revient.

Enfin, les opérations unitaires nécessaires à la fabrication d'un jus sont nombreuses (préparation, extraction, formulation, stabilisation, conditionnement) et donc nécessitent un niveau d'investissement initial d'emblée très conséquent.

Ainsi un programme de recherche délocalisé a été mené, hors contexte, sans tenir compte des caractéristiques de l'environnement technologique local. Or, le projet était destiné en priorité à la valorisation de la transformation de la banane de Guadeloupe, compte-tenu des difficultés sur le marché du frais liées, entre autres, à la disparition des protections douanières pour l'accès au marché européen.

Un autre exemple, est celui de la valorisation de l'ambrette, dont le nom scientifique est *Abelmoschus moschatus*, qui est une plante de la même famille que le gombo et la groseille pays. La plante existe aux Antilles à l'état sauvage, elle est originaire de l'Inde.

Elle produit des graines qui contiennent de l'huile essentielle, utilisée en parfumerie pour son caractère musqué et la fixation des parfums. Elle a été exploitée au début du siècle en Martinique pour son odeur musquée caractéristique (Saint Pierre - musée du Volcan), mais le développement de la chimie organique et des muscs de synthèse (musc ambrette) a entraîné la disparition des muscs naturels (animaux et végétaux).

En juillet 85, la directive 95/34/CE de l'Union européenne interdit l'utilisation du musc de synthèse, 4-ter-Butyl-3-méthoxy-2,6-dinitrotoluène.

Une société, sise en Guadeloupe, y a donc vu l'opportunité de valoriser l'ambrette et a monté un programme de recherche et développement avec le soutien de l'ANVAR (Agence Nationale de Valorisation de la Recherche).

Il s'est agi de réaliser des essais aux champs pour déterminer les schémas culturaux et identifier les ravageurs et le programme a également porté sur la validation industrielle des procédés d'extraction de l'huile essentielle.

#### Parmi les résultats obtenus :

- l'identification des maladies et ravageurs liés à la culture de l'ambrette en Guadeloupe
- le recensement de la biodiversité de l'ambrette guadeloupéenne
- la définition d'un schéma cultural compatible avec une intensification de la production et un mode de culture « écologique »
- l'amélioration des méthodes d'extraction d'huile
- des tests et l'adaptation d'outillage industriel
- Le volet technologique portait sur la mise au point d'une technologie zéro déchets, visant une valorisation intégrale de la graine en trois composantes :
  - L'huile essentielle pour la parfumerie
  - L'huile végétale pour la cosmétique
  - Le tourteau d'Ambrette pour l'alimentation animale, comme source de protéines.

Les fonds à mobiliser pour ce volet de recherche ont été particulièrement lourds et la délocalisation des expérimentations a également été nécessaire avec l'identification de prestataires pouvant réaliser les opérations et conduire les différents essais.

Ce type de schéma entraîne une absence de maîtrise du savoir-faire et constitue un danger pour la propriété intellectuelle, la plus value technologique étant apportée par des prestataires extérieurs.

Il est donc nécessaire de réfléchir à des modalités d'innovation technologique pouvant être mises en oeuvre *in situ*. Cela nécessite des adaptations, car souvent les technologies spécifiques pour traiter la biodiversité locale, correctement dimensionnées n'existent pas. Il faut également faire preuve de souplesse et de rusticité pour garantir un fonctionnement et une maintenance plus aisée des appareillages utilisés.

Ce ne sont pas des schémas habituels pour nous, chercheurs antillais, qui sommes habitués à évoluer dans un environnement technologique poussé (centres de recherche et universités équipés grâce à des programmes européens de financement), où chaque problème a sa solution technologique théorique, mais qui dans notre contexte local n'est pas gage de succès et de création d'activité pérenne.

Il existe pourtant des exemples d'innovations technologiques réussis alliant adaptation/souplesse/polyvalence/rusticité. Ils sont évoqués par Louis Fährasmane, Henry Joseph et Kathia Rochefort.



#### 4. Pôle Agroalimentaire Régional de la Martinique



### Le PARM, Levier pour le développement et l'innovation du secteur agroalimentaire

**Le PARM (Pôle Agroalimentaire Régional Martinique)** développe ses activités comme partenaire du développement et de l'innovation auprès des entreprises et des filières du secteur agroalimentaire depuis 2003 sur le territoire.

L'enjeu est de permettre la mise à disposition d'un outil performant et opérationnel pour accompagner la création de valeur ajoutée aux productions de l'agriculture, de l'élevage et de la pêche, mais aussi d'appuyer les entreprises du tissu économique pour qu'elles maintiennent leurs parts de marché et créent de l'activité en Martinique.

**L'objectif du PARM est de contribuer au développement économique du secteur agroalimentaire.**

Le PARM est récemment labellisé en qualité de CRT (Centre de Ressources technologiques) par le MESR. Cette labellisation constitue une reconnaissance des activités du PARM pour son professionnalisme dans la conduite du transfert de technologie aux TPE et PME.

C'est aussi une reconnaissance de la qualité des activités de recherche développement menées en collaboration avec les professionnels et les organismes de recherche.

L'enjeu essentiel du PARM, étant de faire en sorte que les retombées des projets de recherche bénéficient au développement et à l'innovation du secteur agroalimentaire en Martinique.

**Ses modalités d'intervention auprès du secteur agroalimentaire sont diversifiées :**

- Des actions collectives d'assistance aux filières et aux entreprises,
- Des actions d'animation : diffusion de veille réglementaire, scientifique et technique et appui technique au secteur,
- Des programmes R&D collaboratifs,
- L'accompagnement de projets innovants,
- Des prestations privées sous contrat de confidentialité.



[www.parm.asso.fr](http://www.parm.asso.fr)



Pour stimuler l'innovation des TPE et PME en Martinique, le PARM met à disposition ses compétences, son expertise et ses ressources technologiques pour accompagner les entreprises sur toutes les étapes du processus de l'innovation, de l'idée à la commercialisation.



## CARIB'FRUITS - le transfert d'une technologie innovante

La friture sous vide est une technologie brevetée, sous licence d'exploitation, présentée par le PARM aux entreprises de transformation de fruits et de légumes, lors d'un atelier de démonstration, organisé en 2007.

**SUCCESS  
STORY**

Séduite par cette technologie innovante, l'entreprise CARIB'FRUIT décide d'élargir sa gamme de produits en proposant des pétales de fruits séchés. Le PARM est intervenu sur :

- la mise au point de gammes de fruits séchés et de pétales de fruits (friture sous vide)
- le dimensionnement atelier et conseil équipements
- les essais et le lancement de la production
- la validation couple / produit emballage



L'entreprise CARIB'FRUIT produit des pétales de fruits, produit innovant obtenu par la technologie de la friture sous vide depuis 2010. Elle bénéficie du support technologique du PARM afin de poursuivre la diversification de son offre produit.

Ces pétales sont élaborés sans additif, sans colorant et sans conservateur à partir de fruits et légumes frais et restituent couleur et saveur du fruit.

La gamme de produits, présente aussi à l'export, a été élue "SIAL Innovation 2012" et se positionne sur l'axe naturalité / plaisir.

*Make  
me  
Fruit*



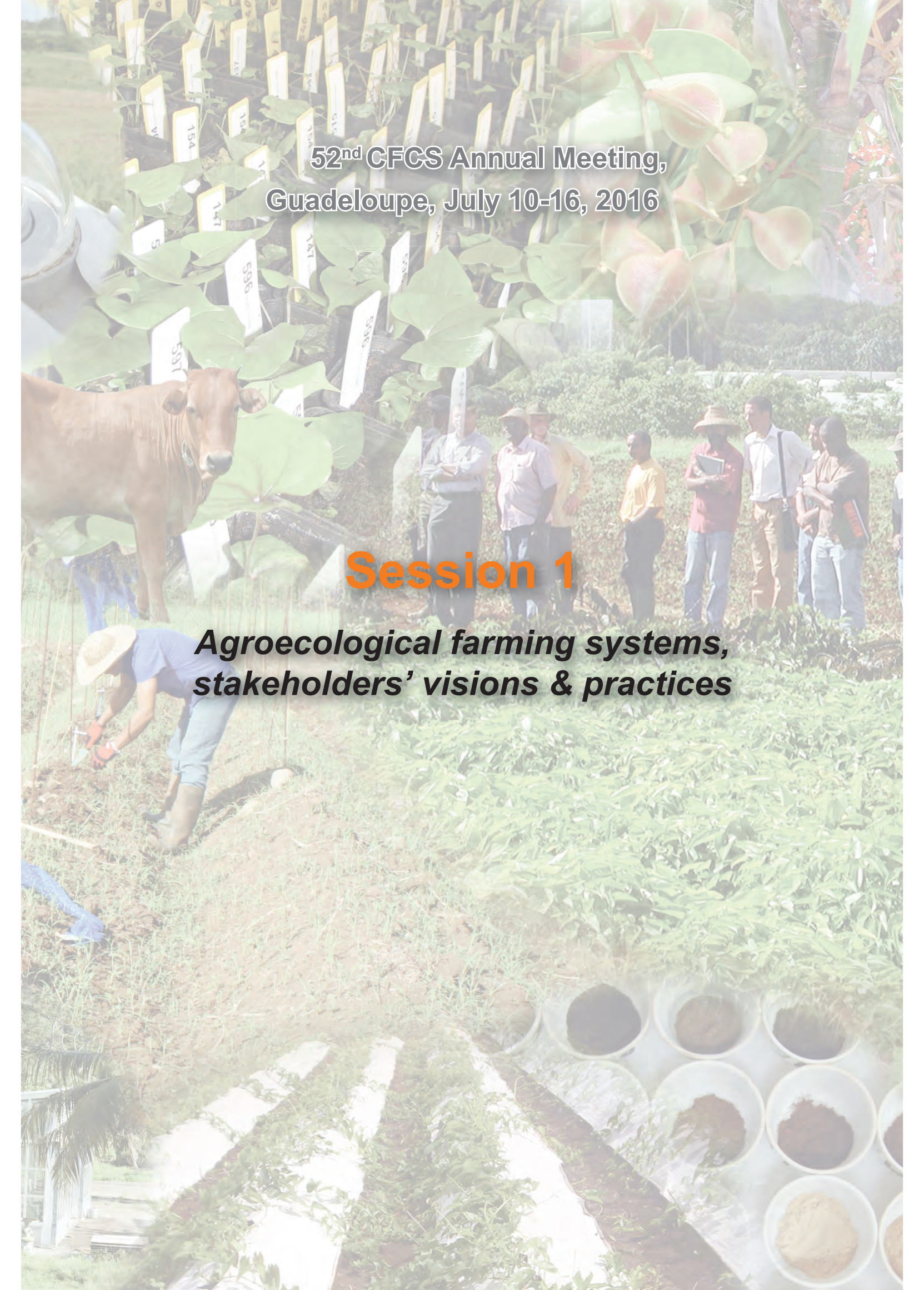




52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

## Session 1

*Agroecological farming systems,  
stakeholders' visions & practices*





## INTRODUCTION AND REPORT OF SESSION 1:

### AGROECOLOGICAL FARMING SYSTEMS, STAKEHOLDERS' VISIONS & PRACTICES

*M. Naves<sup>1</sup>, M. Chave<sup>2</sup>, P. Chopin<sup>2</sup>, L. Penet<sup>2</sup>*

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In the context of global changes, feeding a growing population and ensuring food security whilst protecting ecosystems and natural resources (energy, water, phosphate, biodiversity) are crucial priorities. Agroecological farming systems (ie. adaptive and/or biologically diversified farming systems) offer promises worldwide and particularly in the Caribbean which possess assets for their implementation. Enhancing domestic and ordinary biodiversity (animal, plant, microbial) offers new strategies to promote economically and environmentally efficient agriculture.

In agro-ecological farming systems, farmers have to manage uncertain and complex interactions through management practices to provide diverse ecological services (food and other products, soil fertility, biological regulations). Designing and managing innovative farming systems that take into account different spatial and temporal scales is at stake. Creating and strengthening agricultural innovation networks to enable interactions between partners (researchers, farmers, regional authorities, development and transfer organizations, public or private funders) is a key issue for the success of the agroecological transition.

The communications presented in this session tackle as well conceptual, methodological or technical issues, to answer the questions raised by the agroecological transition. The presentations are organized in order to illustrate different aspects of agroecological practices.

During the congress, a total of 34 oral presentations and 12 posters were presented in this session (3 presentations and 6 posters were missing). The oral communications were grouped in five thematic sessions, organized each in sequences of 3 or 4 presentations one after another, and followed by 15 to 20 minutes of questions and discussion, the speakers being invited to stay in the table of presentation for the discussion. This timing aimed at allowing a well-balanced display of the oral presentations, while letting the time for exchanges between participants. It allowed particularly rich debates and exchanges of experience on certain concepts or concrete examples that are presented in the following chapters.

A first thematic chapter concerns the knowledge of the pests and diseases of the vegetable and animal productions (reporter M. Naves, INRA; moderator M. Farant, CFCS), with 7 oral presentations, distributed in two sequences. This session make an inventory of the situation of different pathogens or parasites of the plants and the animals in the Caribbean, illustrated by various examples. It put forward in particular the increasing difficulty to manage these sanitary problems, as well as the acceleration of the rhythm of appearance of new pathologies, pointing out various causes:

- The climate change, with a strong incidence on the evolution of the pathogens;
- The appearance of resistance to pesticides which is also a key factor of the worsening of the sanitary problems
- The incomplete or biased perception of the sanitary situation by the producers or the actors of the sectors, and the management strategies to be adopted.

The following chapter extends the discussions about the sustainable sanitary management of the plants and the animals (reporter M. Naves, INRA; moderator C. Serra, IDIAF), with 4 oral presentations and 3 posters. These communications illustrate the concepts linked to the integrated control of pests and diseases, in plants and animals. Two communications presented promising results concerning the integrated control of *Bemisia* in tomato, by means of auxiliary insects or biopesticides. A presentation approaches also the case of the animal production sector, with the interaction between nutrition and parasitism in small ruminants. Finally the last presentation draw an interesting conceptual framework of the integrated management and its main determiners, illustrated by two examples on the implementation of bioprotection measures against *Ralstonia* in vegetables, and on the integrated control of the internal parasitism in small ruminants.

The following chapter approaches the theme of the valuation of the genetic resources within the framework of sustainable production systems (reporter L. Penet, Inra; moderator G. Anaïs, CFCS), with 9 oral presentations distributed in two sequences, and 3 posters. Various aspects attached to this theme are illustrated, concerning the characterization, the conservation, the genetic improvement and the exploitation of the local genetic resources. The first presentation presented collections and objectives of the BRC Tropical Plants, while the following one showed the diversity of the varieties of yams cultivated by the farmers and their differences of tolerance in the anthracnose. Other original characteristics of the local resources are also illustrated (longevity of Creole goat, tolerance to hydric stress in manioc). The possibilities of selection of adapted plant material were discussed concerning the sweet potato and the banana plantains, in particular through the use of the selection assisted by markers in banana. Finally, the valuation of the local resources was illustrated

## **Paper presented at the 52<sup>nd</sup> CFCS Annual Meeting, Guadeloupe, July 10-16, 2016.**

by the example of the development of a niche market for the Creole pork in Martinique. These various presentations emphasized the wealth of the agricultural biodiversity in the Caribbean, and the possibilities of its valuation.

In continuation, the question of the control of the biological processes on a agroecological perspective is approached (reporter: L. Ori, AdeKUS; moderator Mr. Naves, INRA), with 9 oral presentations distributed in two sequences, and 4 posters. These presentations mainly concerned the control of soil fertility, through alternative solutions of organic fertilization, such as the use of gulfweeds (2 presentations), composting of plant residues (2 presentations) or the use of mycorrhiza (2 presentations). Two methodological papers approach also the development of phyto-toxicity tests to evaluate various byproducts of waste recycling, and the use of an isotopic method to estimate the potential of carbon retention in tropical acid soils. Finally, a presentation concerns the use of probiotics to improve the food of dairy cows in Trinidad.

Finally, the last thematic chapter deals with the theme of the design and the engineering of innovative production systems in the Caribbean (reporter: JL. Diman, INRA; moderator F. Lopez, UWI), with 5 oral presentations and 2 posters illustrating the integration of knowledges approached in the previous sessions, in a holistic approach of the production systems. Various examples were presented, within the framework of annual cultures in Florida, or with a diversity of animal breeding systems following the agroecology principles in the Caribbean, or of innovative systems of agroforestry, combining the preservation of the biodiversity and the agroindustrial valuation of local oleaginous plants. The valuation of the local agricultural resources was revisited finally, through the example of the implementation of the participative plant selection in Cuba, or the question of the choice of the animal breed in mixed farming systems in the tropics. These various presentations illustrate how the principles of the agroecology could be put into practices, based on disciplinary knowledge, within the framework of environment-friendly and sustainable production systems, while being efficient and economically profitable. This sub-session allows approaching various key points for the development of innovations on agroecological production systems, answering perfectly the objective of this congress to establish a solid base of knowledge for the ecological intensification of the production systems in the Caribbean.

The organization of the sequences of presentations followed by discussion, also allowed particularly rich and promising exchanges for the participants, answering another objective of the congress to strengthen the regional integration of the searches led in the region. Finally, by mixing at the same time presentations of the plant and animal domains, it enriched the discussions thanks to exchanges of experience between these two domains.



PESTS AND DISEASES AND THEIR PERCEPTION IN CROP AND ANIMAL PRODUCTION  
DISEASES AND DISORDERS AFFECTING PITAYA IN SOUTH FLORIDA

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**Keywords:** Pitaya, Dragonfruit, Anthracnose, Stem and fruit canker, Stem and fruit rot.

**Abstract:**

Vine, climbing cacti in the genera *Hylocereus* and *Selenicereus* produce fruit known variously as pitaya, pitahaya, dragonfruit or strawberry pear. These fruit are very popular in the specialty tropical fruit market and commercial production of *Hylocereus undatus* and *H. polyrhizus* has increased steadily over the past decade, but not without challenges from diseases and disorders. Anthracnose was one of the first major diseases mostly affecting the ribs of vines, but capable of rotting the entire vine column of pitaya. This disease is most important when plants are young and newly established, but has not been an issue on fruit. A newly reported and emerging disease is stem and fruit canker caused by *Neoscytalidium dimidiatum*. Stem and fruit canker has been reported in most production areas and disease incidence has reached levels as high as 70% on the fruit. *Bipolaris cactivora* is another fungal pathogen that causes stem and fruit rot and like *N. dimidiatum* mostly affects the fruit. Cankers and fruit rot have currently been the most economically important diseases, but other recent challenges such as a sooty mold affecting young flowers and developing fruit and the occurrence of *Cactus Virus X* may become more troublesome for pitaya growers in the future.

**Introduction**

Pitaya, commonly known as dragon fruit, is a columnar, climbing cactus species (genus *Hylocereus*) native to the tropical forest region of Mexico and Central America and widely grown in tropical and subtropical areas (Mizrahi et al., 1997). It is distributed through tropical and subtropical America, south Florida, Caribbean, Hawaii, Asia and Australia, Taiwan, Vietnam, Malaysia and Israel (Crane and Balerdi, 2005). In Florida, in 2006 less than 50 acres were planted but in 2010, production had grown six-fold and it was estimated around 320 acres (Evans et al., 2010). The objective of this report is to present all the diseases affecting pitaya in south Florida.

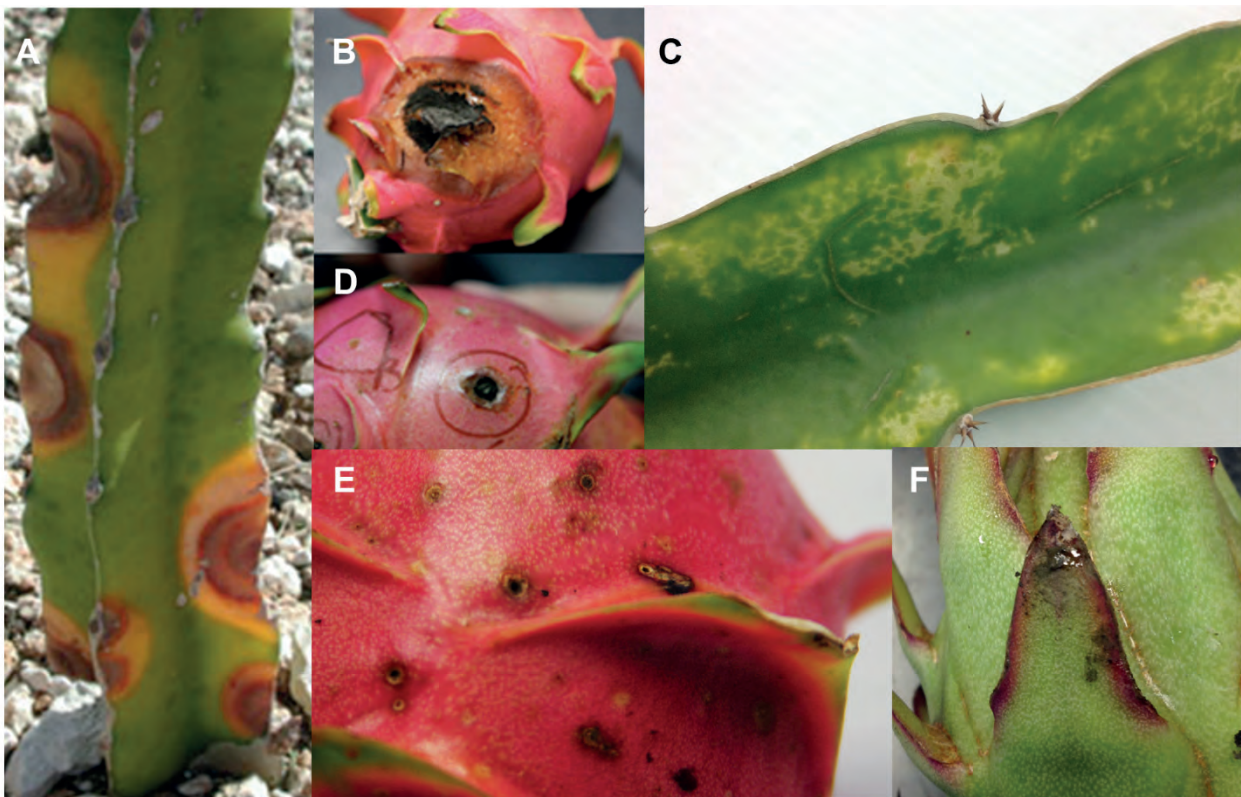
**Materials and methods**

All material used was collected from pitaya samples submitted to the Florida Extension Plant Diagnostic Clinic in Homestead, FL, USA. Symptomatic lesions from fungal diseases were surface-disinfected with 70% ethanol (20 s) followed by 10% bleach (1 min), and distilled sterile water prior to sectioning into 0.5 cm and plated at 25°C for 7 days on acidified potato dextrose agar (APDA) medium (Difco PDA; Becton, Dickson and Company, Sparks, MD). Compound and dissecting microscopes were used for morphological and cultural characteristics. To determine molecular characteristics DNA was extracted from cultures of fungi on APDA using the CTAB method described by Daire et al. (1997) and conventional PCR targeting internal transcribed spacer (ITS) regions using primers ITS 1 and ITS 4 and glyceraldehyde-3-phosphate dehydrogenase (GPD) using *gpd1* and *gpd2* were performed to accurately identify the isolates to species level. ITS and GPD primers used were described previously by White et al. (1990) and Berbee et al. (1999), respectively. Amplicons were sequenced by Eurofins, Louisville, KY, USA. Sequences obtained were submitted to GenBank database (<http://www.ncbi.nlm.nih.gov/genbank/>). For new diseases Koch's postulates was completed as described (Palmateer et al., 2007; Tarnowski et al., 2010; Sanahuja et al., 2016). Virus suspect plants were submitted to Agdia Inc. (Elkhart, IN, USA) for virus detection and identification.

**Results and discussion**

Several new and newly emerging diseases have affected pitaya production over the past decade. In December 2004, reddish brown lesions with conspicuous chlorotic haloes developed concentrically on the edges of vine ribs. Lesion centers became white and coalesced to rot much of the vine column, and in severe cases, only the vascular column in the vine center was not diseased (Fig. 1A). Salmon-colored spores and waxy, subepidermal acervuli, typically with setae and simple, short, erect conidiophores, were observed in lesion centers. *Colletotrichum gloeosporioides* was isolated from all samples. Colonies produced abundant conidia that were hyaline, one celled, straight, cylindrical, and averaged 14.7 (12.5 to 17.5)  $\mu\text{m} \times 5.0$  (3.8 to 7.5)  $\mu\text{m}$  (Bailey and Jeger, 1992). Cultural and morphological characteristics of isolates matched those for *C. gloeosporioides* except for appressoria and hyphopodia (Bailey and Jeger, 1992, Du, 2005); pitaya isolates had a spherical rather than lobed hyphopodia reported for *C. gloeosporioides* and averaged 10.9 (8.5 to 12.7)  $\times$  9.1 (7.1 to 10.3)  $\mu\text{m}$ . ITS sequences for the pitaya isolates were nearly identical (98% homology) to those for *C. gloeosporioides* isolates occurring on *Euphorium thymifolia* in Thailand (GenBank Accession No. AY266393). Koch's postulates were completed for two isolates of *C. gloeosporioides* and inoculated plants developed the same symptoms as samples were submitted (Palmateer et al., 2007; Palmateer and Ploetz, 2006). This disease has been already reported on pitaya in Japan (Taba et al., 2006), Korea (Kim et al., 2000) and Brazil (Takahashi et al., 2008).

In July 2009, flowers and fruit were discovered with an uncharacterized rot. Small, circular, light brown, depressed lesions expanded to form large areas of rot on flowers and fruit (Fig. 1B and 1D) (Tarnowski et al., 2010). The lesions produced large amounts of dark fungal spores. ITS and GPD DNA sequences from the isolates alignment with other isolates sequences of *Bipolaris* species. Conidia from the dark, blackish brown colonies were formed at the tips of pale golden brown, straight to flexuous conidiophores, averaged  $184 (99 \text{ to } 313) \mu\text{m} \times 6 (3 \text{ to } 8) \mu\text{m}$  and slightly swollen at the apex and base. Conidia were pale-to-medium golden brown, smooth and clavate with a protuberant hilum, averaged  $40 (24 \text{ to } 51) \mu\text{m} \times 10 (9 \text{ to } 13) \mu\text{m}$ , and two to four distoseptate (Tarnowski et al., 2010). The isolates closely match descriptions of *Bipolaris cactivora*, although isolates from pitaya had smaller conidia (30 to 65  $\mu\text{m}$ ) than previously reported. Conidial characteristics from a *B. cactivora* herbarium specimen BPI 431621 (U.S. National Fungus Collections) closely matched (averaged  $36 (29 \text{ to } 50) \mu\text{m} \times 9 (8 \text{ to } 11) \mu\text{m}$ , two to four distoseptate) our isolates. ITS (GenBank Accession No. HM598677 and HM598679) sequences aligned most closely (99.7% homology) with another *B. cactivora* isolate from China (GU390882), and both ITS and *gpd* (GenBank Accession Nos. HM598680–HM598682) sequences indicate a close relationship to *Bipolaris indica*. (Tarnowski et al., 2010). Koch's postulate was completed for the isolate *B. cactivora* and inoculated plants developed the same symptoms as the samples submitted previously (Tarnowski et al., 2010). The same pathogen causes stem rot of the Cactaceae in Europe and the United States (Durbin et al., 1955) and a fruit rot on pitaya in Japan (Taba et al., 2007). In Florida, it has been reported as causing a leaf spot on *Portulaca oleracea* (Alfieri et al., 1984).



**Figure 1.** Symptoms of different diseases affecting pitaya.

A) Anthracnose lesions caused by *Colletotrichum gloeosporioides* on *Hylocereus undatus*; B and D) *Bipolaris cactivora* causing fruit rot on *Hylocereus undatus*; C) Potexvirus, *Cactus Virus X* causing chlorosis, speckling and mottling on the columnar stem of *Hylocereus undatus*; E) *Neoscytalidium dimidiatum* causing fruit canker on *Hylocereus undatus*; and F) Sooty mold, *Cladosporium cladosporioides* colonizing sugars on the fruit surface of *Hylocereus undatus*.

In July 2015, symptomatic pitaya fruit developed small cankers that appeared as sunken orangish brown spots (Fig. 1E). Dark gray to black aerial mycelium grew on APDA and colonies produced abundant conidia in arthric chains that were dark brown, cylindrical to round with zero to one-septa and averaged  $9.29 (6 \text{ to } 20) \mu\text{m} \times 5.93 (4 \text{ to } 10) \mu\text{m}$  (Crous et al., 2006). Genomic DNA was extracted from ITS was amplified and the PCR product was sequenced. The resulting sequence was deposited in GenBank (Accession No. KT803701). Based on morphological characteristics and the ITS sequence region, the pathogen was identified as *Neoscytalidium dimidiatum*. A BLAST search exhibited 97% nucleotide identity with an isolate of *N. dimidiatum* that caused pitaya canker disease in China (Accession No. JX524168). Koch's postulate was completed for the isolate *N. dimidiatum* and inoculated plants developed the same symptoms. This disease has been reported in Taiwan (Chuang et al., 2012), Malaysia (Mohd et al., 2013) and China (Lan and He, 2012). It is important to note that *Hylocereus polyrhizus* was also include in the pathogenicity test and it is also susceptible to *N. dimidiatum*. Disease incidence in several local fields has been as high as 70% and appears to be more severe on fruit than stems.

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Most recently, the potexvirus, *Cactus Virus X* causing chlorosis, speckling and mottling on stems (Fig. 1C), and *Cladosporium cladosporioides* causing sooty mold on fruit (Fig. 1F) have been issues for commercial production and dooryard plantings.

Sooty mold is not a plant pathogen but grow on surfaces where honeydew deposits accumulate. Honeydew is a sweet, sticky liquid that plant-sucking insects excrete as they ingest large quantities of sap from a plant.

With the increase of pitaya production in south Florida cphad been increased during the last year and this provides new pathogens to stablished in the area. Therefore, it is required an effective disease management strategy for all these diseases since very few fungicides are currently labeled for use on pitaya in Florida and these diseases has been a serious issue for pitaya growers in south Florida (Palmateer et al., 2007, Tarnowski et al., 2010, Sanahuja et al., 2016).

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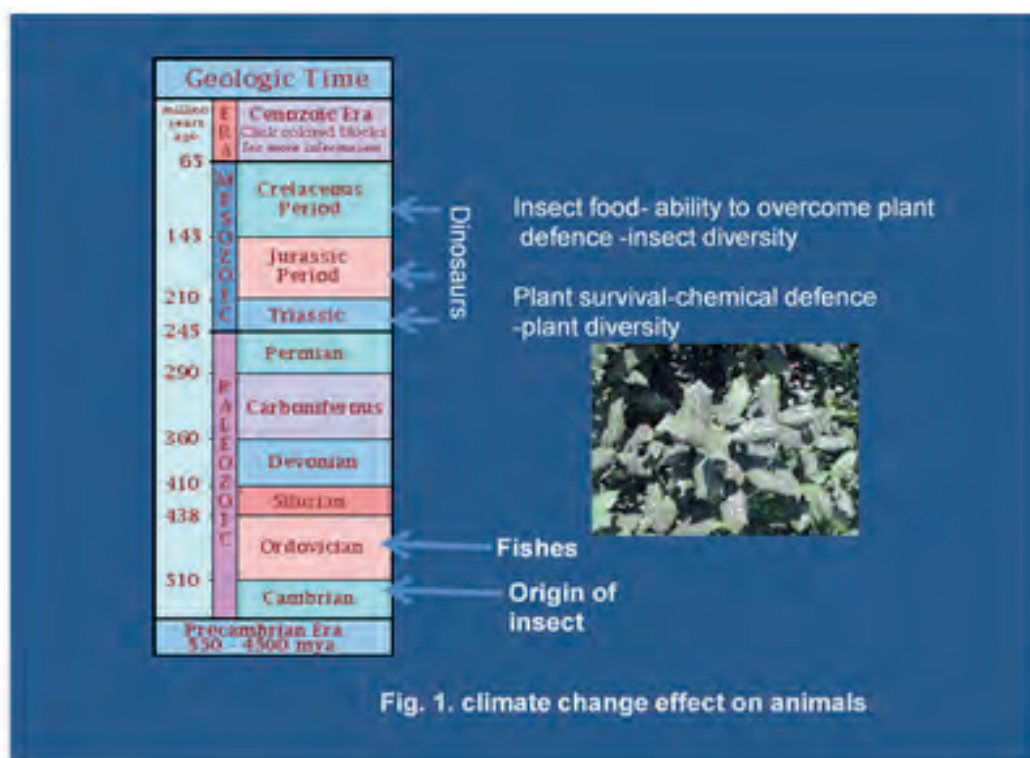
**CLIMATE CHANGE AND ITS EFFECT ON BIOLOGY OF MELON THRIPS, *THRIPS PALMI* KARNY, AND COMMON BLOSSOM THRIPS, *FRANKLINIELLA SCHULTZEI* TRYBOM, (THYSANOPTERA: THRIPIDAE)**

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Environmental factors are most important parameters for the living worlds to continue their biological processes. Insects are the most diversified group that show effects of environment on their life history. Insects originated almost about 510 million years ago in the Cambrian period. They used terrestrial plants as their prime source of foods beginning from their origin. During the last 400 million years, global climate changed several times which favored some lives to flourish and destroyed some vast group of lives due to their less flexibility in complying with the climate change (Fig. 1).



Insects continued to co-evolve with plants; and progressed into winged form in about 299 to 356 million years ago (Carboniferous period). Another climate change during the Permian period 252 – 299 million years ago cause insects to go through additional changes to adapt with more challenging environments. This time, individual development was through several metamorphic stages allowing greater adaptability: egg, larva, pupa and adults. Insects existed in the Permian period gave rise to the modern insect fauna, although the largest event of their extinction also occurred during the Permian. This event led to the development of the modern insects with wide range of adaptability.

The phenomenon of climate change is a slow and continuous process which becomes consistently noticeable only after a long time period. The effects of climate change be enhanced by interfering with the natural phenomena, such as by adding pollutants, toxic chemicals, deforestation, disrupting food chain for human interest, and many other factors.

Earth’s environment comprises of two major components-biotic and abiotic. The biotic environment is dependent on the abiotic or physical environment. Earth’s atmosphere is a primary component of the physical environment, which assures proper maintenance of the biotic environment. Earth atmosphere includes various gases which can be divided into two components- (i) greenhouse gases (GHG) and (ii) non greenhouse gases. Greenhouse gases absorb and emit infrared radiation and plays direct role in “airborne fraction” (AF) which ultimately causes global warming. The most abundant GHG include, in order, Water vapor (H<sub>2</sub>O), Carbon dioxide (CO<sub>2</sub>), Methane (CH<sub>4</sub>), Nitrous oxide (N<sub>2</sub>O), Ozone (O<sub>3</sub>) and Chlorofluorocarbons (CFCs). Non-greenhouse gases (second component of atmosphere) include nitrogen (N<sub>2</sub>), oxygen (O<sub>2</sub>), and argon (Ar) and they are nearly unaffected by infrared radiation.



Carbon dioxide plays a major influence (at least 73%) on warming the greenhouse gases followed by methane, nitrous oxide and other gases. Atmospheric CO<sub>2</sub> concentrations have been increasing at an astonishing rate because of human activities, such as rapid exploration fossil fuels and deforestation. Global CO<sub>2</sub> concentrations in the atmosphere increased from 270 ppm in preindustrial age to the present 381 ppm. This is a 41% increase during the last 150 years. Hence, most of the current research studies on insects address the effects of carbon dioxide on their life history parameters.

Thrips can be considered an example of a good group of insects to study for climate change. They are very small (ca. 1 mm) and efficient in adapting to their environment. Melon thrips (*Thrips palmi* Karny) and common blossom thrips (*Frankliniella schultzei* Trybom), are two species of this group. Our present study will focus on various biological aspects of these two thrips. Melon thrips which is an economically important invasive pest of all vegetable crops grown in the southern Florida. Although native to Sumatra, this thrips is widely distributed, and has dispersed to many countries in Asia, Africa, Central America, Oceania, and Europe.



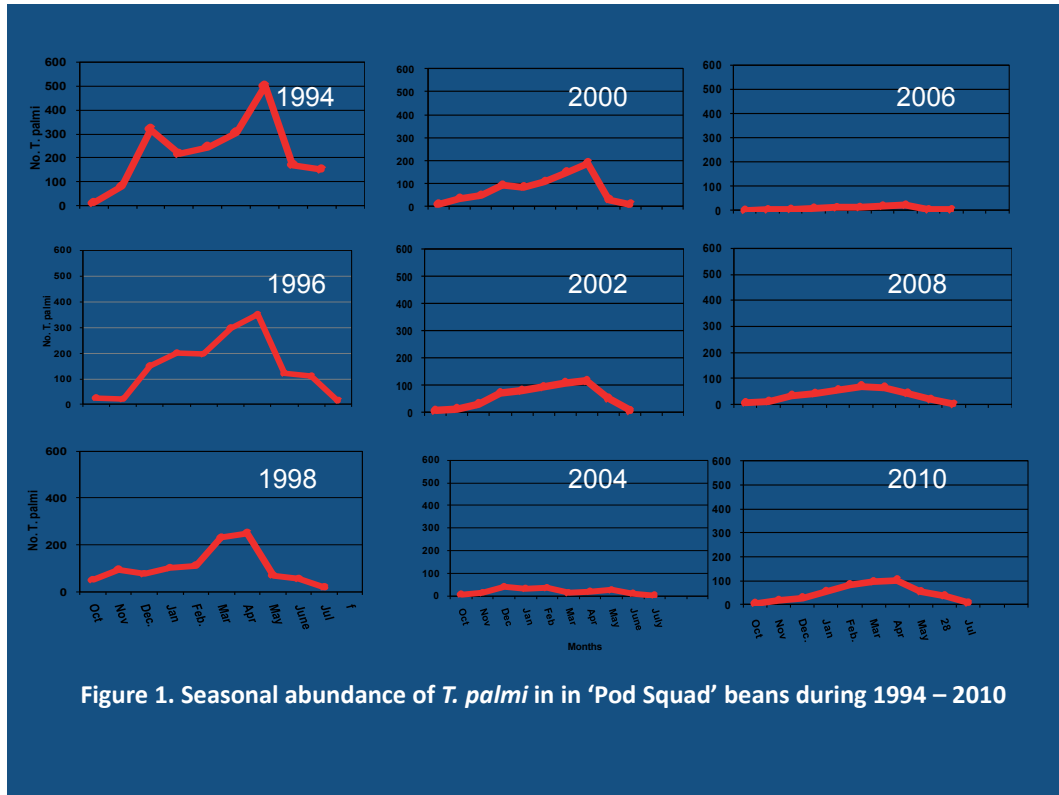
Fig. 2. Defoliation of 'Pod Squad' bean by *Thrips palmi*, 1992

Melon thrips has a short generation time consisting of 13-18 days which is the total of egg, larva, pre-pupa, pupa, and adult stages. Adult life span lasts for 10 – 30 days depending on temperature. During the life time, a female lays up to 200 eggs. Because of the short generation time, high reproductive rate, and polyphagous habits, this thrips is an excellent candidate for studying its biology in relation to various abiotic factors, such as, temperature, rainfall, solar radiation, and greenhouse gases, specifically CO<sub>2</sub>.

Since its invasion of Florida in 1990, we have been studying melon thrips seasonal abundance on various vegetable crops, and their within field distributions and management programs to document the effects of climate change on its biology and behavior. In southern Florida, melon thrips arrives in the vegetable fields at the beginning of growing season in September–October, when their density is typically 2-5 thrips/bean leaf, they reach peak density during February–April with 100 -300 thrips/bean leaf. Abundance of melon thrips decreases significantly after May because of reduced vegetable production and increasing rainfall. Melon thrips population showed decreasing trend as year progressed from 1990 to onward because of improved management programs (insecticides), and biotic (predators) and abiotic environmental factors (rainfall, temperature). Melon thrips abundance became very low (1-4/10 bean leaves) in 2006 because of using spinosad (SpinTor, Dow AgroSciences) and other effective insecticides. However, melon thrips populations began increasing after 2006 because of sole reliance on few insecticides; they are presently considered an economic pests of all vegetable crops.

Common blossom thrips (*Frankliniella schultzei* Trybom) was first recorded in 1992, and became economic pest of cucumber, tomato and pepper in 2008. In 2012, it was recorded to transmit tospoviruses in tomato plants; and in 2014, a serious outbreak of this tospoviruses in tomato plants transmitted by common blossom thrips occurred in Miami-Dade County, FL.

In our presentation, we will provide data on temperature, rainfall, and solar radiation, which will be correlated with the population dynamics of melon thrips and common blossom thrips. Our information on biology, vegetable hosts and management of melon thrips will be considered as baseline data to determine effects of climate on thrips populations.



## CHARACTERIZATION OF COLLETOTRICHUM SPECIES AFFECTING YAM (*DIOSCOREA SPP.*) CROP IN PUERTO RICO

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**Keywords :** Dioscorea spp. Colletotrichum, yam

### **Abstract :**

Yam anthracnose, caused by *Colletotrichum gloeosporioides*, is widely distributed in most yam-producing areas worldwide, causing losses of up to 90 % in the most palatable species *Dioscorea alata* and *D. rotundata*. The objective of this research was to characterize other species of this fungus affecting yam crop around the island. Twenty-two isolates of *Colletotrichum* spp. were obtained from the yam germplasm collection and private farms. Single-spore isolates were used for morphological and pathogenic characterization. DNA was extracted from isolates, and the genes ITS, GAPDH and TUB2 were amplified and sequenced. All isolates were pathogenic to yam on detached leaf assay resembling anthracnose symptoms closely similar to those observed on naturally infected yam. Sequences obtained from these isolates had 97-100 % percentage of similarity with GenBank sequences. Based on morphological and molecular characterization nine species different of *Colletotrichum gloeosporioides* were identified. These species were *C. ignotum*, *C. tropicale*, *C. aoteora*, *C. truncatum*, *C. alatae*, *C. fructicola*, *C. theobromicola*, *C. siamense* and *C. cliviae*. Also, one isolate of *Colletotrichum gloeosporioides* was identified. Some of the identified species were pathogenic on *D. rotundata* previously reported as tolerant/resistant species of yam in Puerto Rico. ITS region was unable to separate some of these species in different clades, resulting  $\beta$ -tubulin and GAPDH the most discriminate genes to separate *Colletotrichum* species. These results are of significant importance to establish reliable control measures to increase yam production in the region. To our knowledge, this is the first report of these nine species causing anthracnose on the leaves of yam in Puerto Rico.

## RESISTANCE TO PESTICIDES IN SELECTED POPULATIONS OF WHITEFLIES, *BEMISIA TABACI* (GENNADIUS, 1889) (HEMIPTERA: ALEYRODIDAE) IN DOMINICAN AGRICULTURAL AREAS

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**Keywords:** insecticide, resistance, populations, lethal concentration, factor of resistance.

### Abstract

It was intended to identify resistances in whitefly populations against pesticides used in the country and the degree of the same, using the species *B. tabaci* as a subject of study. A bioassay was conducted to evaluate insecticides of different chemical groups. Six colonies of *B. tabaci* from locations of five provinces (Azua, Peravia, La Vega, Santiago, Santo Domingo) were established in the Center for Agricultural Technology of the IDIAF in Los Alcarrizos-Pantoja, along with a population considered as a more susceptible check (National District). From each population 10 adults / Petri dish were exposed using aqueous dilutions (x0, x0.1, x1, x10, x100, x1000) of the respective recommended average dose for each insecticide. The corrected mortality of individuals were determined and plotted and probit analysis were performed to determine the lethal concentration for 50% of the population (CL50) and resistance factors (FR), comparing the effects of the used doses in each insecticide with the more susceptible population. The results showed differences between the reaction of populations exposed to each active ingredient. The FR were also highly variable from no significant factors (x7 for carbosulfan (carbamate) in Peravia) to some highly resistant (x206 and x326 for fipronil + imidacloprid (phenyl pyrazole + neonicotinoid) in Santiago and Santo Domingo, respectively and x488 for endosulfan (organochlorine) in Santo Domingo. In general, the active ingredient with the lowest RF was abamectin (macrocyclic lactone). It was also noted, that the RF against  $\lambda$ -cyhalothrin (pyrethroid) were quite similar to the RF against dimethoate (organophosphate).

### Introduction

For the first time in the Dominican Republic, it was intended to identify resistances in pest populations against insecticides which have been widely used in the country and the degree of the same. Initial field tests carried out in different localities with yellow sticky traps for each active ingredient (a.i.) on which different doses had been applied, showed differences in the amount of trapped whiteflies in relation of the a.i., doses and localities. A bioassay was conducted using different populations of the species *B. tabaci* as a subject of study to evaluate insecticides of different chemical groups.

### Materials y methods

Six colonies of *B. tabaci* from locations of five provinces (Azua, Peravia, La Vega, Santiago, Santo Domingo) were established in the Center for Agricultural Technology (CENTA) of the IDIAF in Los Alcarrizos-Pantoja, along with a population considered as a more susceptible check (National District, D.N.). From each population 10 adults / Petri dish were exposed using aqueous dilutions (x0, x0.1, x1, x10, x100, x1000) of the respective recommended average dose for each insecticide. The corrected mortality of individuals were determined and plotted and probit analysis were performed to determine the lethal concentration for 50% of the population (LC50) and resistance factors (FR), comparing the effects of the used doses in each insecticide with the more susceptible population.

### Main results

The results of the LC50 concentrations showed significant differences between the reactions of populations exposed to each active ingredient. The FR were also highly variable from no significant factors (x7 for carbosulfan (carbamate) in Peravia) to some highly resistant (x206 and x326 for fipronil + imidacloprid (phenyl pyrazole + neonicotinoid) in Santiago and Santo Domingo, respectively and x488 for endosulfan (organochlorine) in Santo Domingo. In general, the active ingredient with the lowest RF was abamectin (macrocyclic lactone). It was also noted, that the RF against  $\lambda$ -cyhalothrin (pyrethroid) were quite similar to the RF against dimethoate (organophosphate).

### Conclusions

- The simple experimental methodology used following Cahill *et al.* (1995) showed its effectiveness.
- The resistance factors (FR) determined for different insecticides for each of the *B. tabaci* populations still have to be considered as too low, as the urban population used as check, as no susceptible population is available in the country, resulted with a slight resistance to the pyrethroid.
- The low efficiency of several for many years widely used a.i., some nowadays only allowed for restricted uses, has been attributed to acquired resistance of populations of key pests; a low quality of several generic insecticides with expired patents sold in the country and used in the study must also be considered.



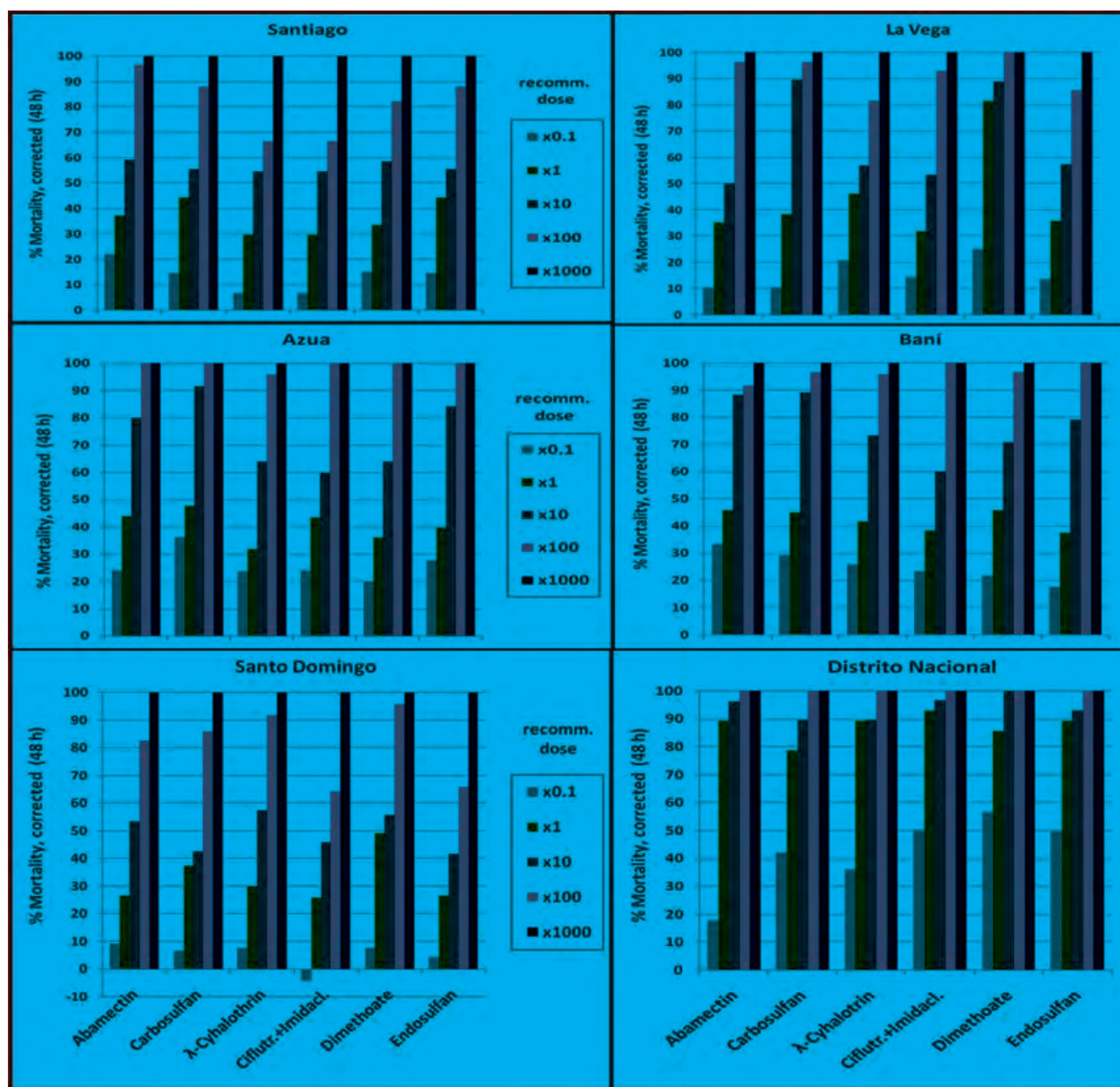


Figure 1. Graphical representation of mortalities evaluated for each active ingredient in relation to the factors of the recommended average doses and province as obtained in the bioassay.

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## DISEASE PERCEPTION AND MANAGEMENT STRATEGIES BY PRODUCERS: EXAMPLE OF ANTHRACNOSE ON WATER YAMS (*DIOSCOREA ALATA*) IN GUADELOUPE

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**Keywords** Anthracnose disease, *Dioscorea alata*, disease management, disease perception, yams

### Abstract

Perception of disease and its impact on cropping practices are two important issues faced by farmers, especially in the current context of climate change which may potentially increase disease risk. Our study explored the diversity of yam cropping systems in Guadeloupe via interviewing farmers, how producers and international yam research scientists perceived anthracnose disease, and how this perception was relating to producers risk management strategies. We found that disease perception by producers is quite similar to that of yam scientists, and both demonstrate similar perception of a hierarchy of factors leading to anthracnose epidemics. We found that three different yam production strategies coexisted regionally, with different profiles regarding perception of disease management. Here, we explore the conceptual niche of factors perceived as impacting epidemics.

### Materials and methods :

We designed a questionnaire about perception of anthracnose disease on yams and impact of agronomic factors on epidemics (on a 5 levels scale ranging from strongly decrease disease incidence to strongly increase disease incidence in the fields). Seventy eight yam producers were interviewed. Early results (Penet et al, 2016) demonstrated that disease perception by producers is quite similar to that of yam scientists, and both demonstrate similar perception of a hierarchy of factors leading to anthracnose epidemics. We found that three different yam production strategies coexisted regionally, with slightly different profiles regarding perception of disease management. Farmers growing yam crops more intensively were also more risk prone, while the other groups usually coopted practices to prevent anthracnose. Here, we explored how perception of agronomic and landscape factors is conceptualized and fit into different conceptual niches via a Principal Component Analysis.

### Main results :

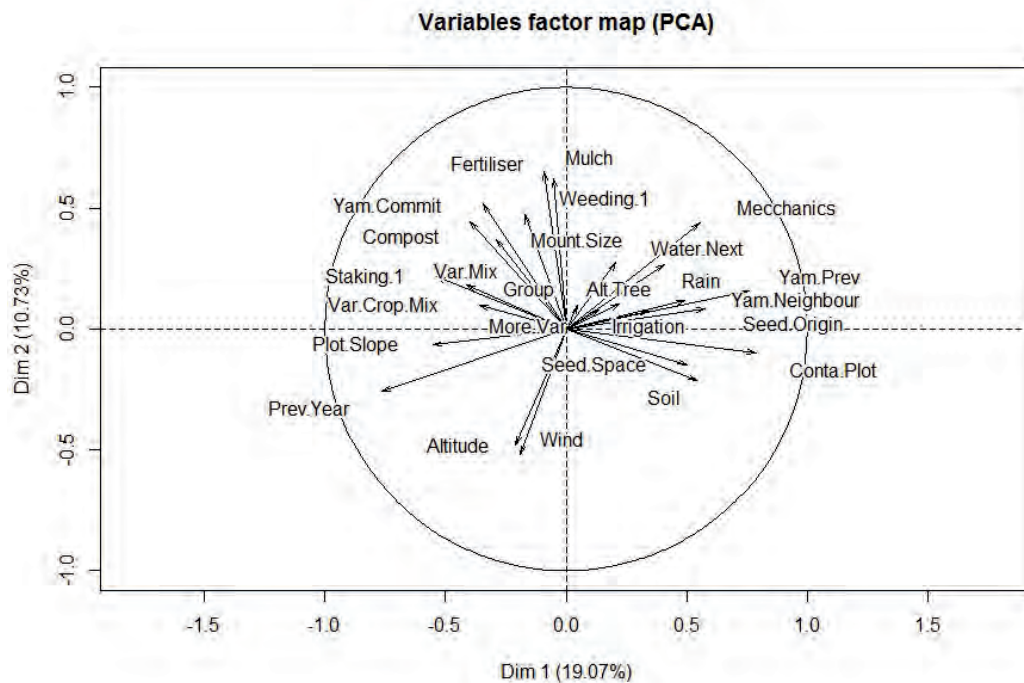
The relative impact of agronomic and landscape factors segregated most of the ‘concept space’ (Figure 1), even though the variation explained by the combined two first axes of the PCA was moderate (ca. 30%). Interestingly, these factors tended to segregate rather harmoniously in different sets grouping general families of factors:

- higher left quadrant essentially grouped agronomic factors *sensu stricto*,
- grossly higher right quadrant grouping factors centering yam, crop neighborhood (alternative host and other yam plots) and humidity factors (pond or river next to the plot, rain, irrigation), to the exception of the more agronomical ‘farm mechanization’ covariate (Mechanics),
- bottom quadrants grouping soil and topological factors (to the exception of Prev. Year, which represent the impact of the nature of the previous crop).

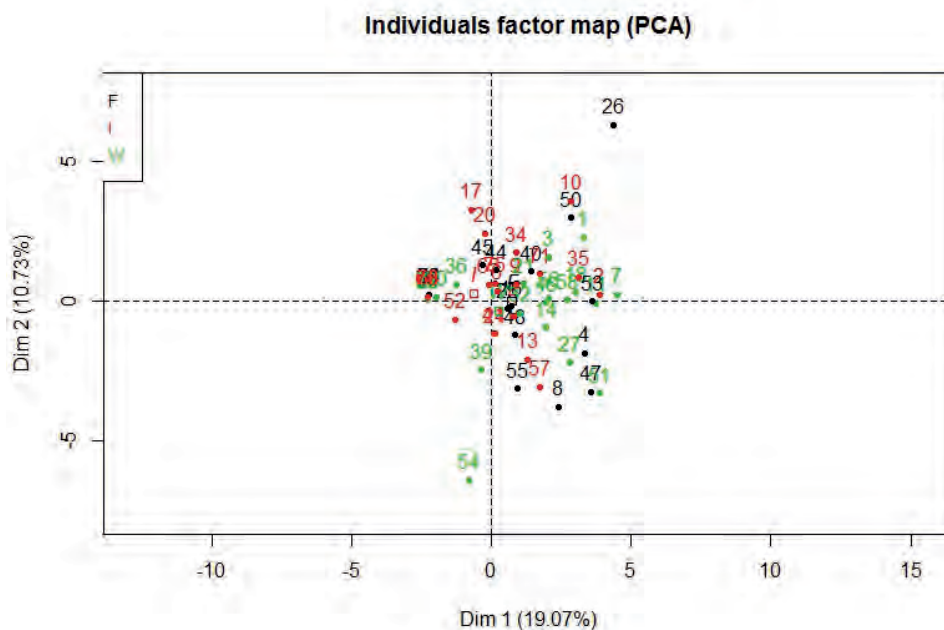
Yam producers in Guadeloupe can be grouped into three main cropping strategies, ranging from an ‘Intensive labor’ group closer to traditional yam production, an ‘Intermediate’ group similar in plot size but growing less varieties, and a ‘Financially interested’ group with more intensive producers, often relying on irrigation and being financially less constrained than the other producers (Penet et al, 2016). These different groups of producers, which differ in the way they grow yams, apparently do not differ in their perception of factors impacting anthracnose epidemics, since their ranges span throughout the PCA concept space in an intermingled fashion (Figure 2). There seems to be a trend for the ‘Intermediate’ group to have a greater focus on agronomic factors, while the ‘Intensive Labor’ group demonstrate a pattern toward a more plant based approach to disease factors, but overall there is an important admixture of disease conceptualization within Guadeloupean producers.

### Conclusion :

Perception of factors impacting epidemics of yam anthracnose are similar among different producers groups, suggesting that while they consider cropping system strategies differently their choice are not driven by the disease.



**Figure 1.** Vector map of covariates in the Principal Component Analysis.



**Figure 2.** Principal Component Analysis distribution of yam producers (‘Work intensive’ group --in green, ‘Intermediate’ group --in red, and ‘Financially interested’ group --in black) according to their perception of factors influencing anthracnose epidemics.

**Bibliographic references:**

L. Penet, E. Barthe, A. Alleyne, J.M. Blazy (2016) Disease risk perception and diversity of management strategies by farmers: The case of anthracnose caused by *Colletotrichum gloeosporioides* on water yams (*Dioscorea alata*) in Guadeloupe, Crop Protection, 88, pages 7-17. ISSN 0261-2194, <http://dx.doi.org/10.1016/j.cropro.2016.05.005>.

**Authors’ notification:** The main storyline and results have been published in Crop Science. You can access a free pdf reprint using the following link until July, 16th 2016 at <http://authors.elsevier.com/a/1T6i1xPFYX5vm>

## CAN THE MARKET INFORMATION SYSTEM HELP YOU TO UNDERSTAND THE INCIDENCE OF DISEASES? THE CASE OF SECHIAM EDULE (CHAYOTE, CHO CHO, CHRISTOPHENE) IN TRINIDAD

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**Keywords:** Christophene, Chayote, Market Information, Price Formation, Market Arrivals, Regression Analysis

### Abstract

Christophene is used as a vegetable in various cuisines and cultures, basically as a filler and not related to any special recipe or festival that creates shocks on the demand side. Cultivation in Trinidad has been concentrated in the foothills of the Northern Range and has been challenged by the Gummy Stem Blight disease. Farmers have retained fruits from their fields for seedling cultivation and have been using the same overhead table trellis technology for more than 50 years. This study assumed that demand remained constant (*ceteris paribus*) throughout the period of the study. Market Information analysis was used as an indirect approach to understand the supply side issues alongside a parallel disease investigation. The study found that higher wholesale market prices coincided with the months of higher rainfall (possibly greater disease prevalence) and lower wholesale market prices coincided with the drier months of the year. There was a strong correlation between rainfall and market arrivals. Price formation was positively influenced by previous month's price and negatively by current market arrivals. It was therefore concluded that rainfall (field moisture and humidity) may have led to favorable conditions for the Gummy Stem Blight disease, and thus lowered yields (market supply) which was ultimately reflected in higher market prices. The study also suggested that modification of field technology that can reduce field moisture and humidity such as vertical trellis should be investigated to determine whether it will reduce disease incidence and thus lower variations in market prices.

### Materials and methods

Time series data on deliveries to the Trinidad Northern Wholesale Market and wholesale prices of christophene were collected for the period of 2006 to 2015 from the NAMIS database. The data was logged and linear regression equations were developed to study (i) the factors that influence production (or market arrivals) and (ii) the influence of arrivals and other factors on prices. The data on production, market arrivals and prices of christophene were analysed using the average monthly modal prices and monthly data on climatic factors including rainfall.

### Main results

The dependent variable,  $Y_t$ , data for marketable yields or market arrivals of Christophene in wholesale market was regressed against current and lagged rainfall, and current and lagged prices. It was expected that the price will provide incentives to the producers to increase the level of production if it is remunerative. It was observed however, that market arrival was not related to price. In the case of market arrivals, the level of production at different times of the year stands independent of price. The current price, lagged (previous year) price and lagged rainfall were not significant. The regression analysis indicated that only current rainfall had a negative and significant correlation with christophene volumes harvested measured by deliveries or market arrivals (Table 1).

Linear regression equations were estimated to study the nature of relationship between prices and market arrivals (Table 2). The regression analysis indicated that the lagged price of christophene had a positive and significant correlation with current prices and negative and significant with market arrivals. It was observed that the lagged price of christophene gave high response and explained higher variation indicating that the lagged price of christophene is an important factor in determining the current price than the market arrivals. Similar findings were reported by Sharma (2011) and Kanungo (2015) for other vegetables. Volumes (market arrivals) were negatively correlated and significant indicating that high volumes translated into lower prices and low volumes into higher prices. This is a typical supply relationship.

### Conclusion

The analysis shows the influence of climatic factors on production volumes and deliveries to the market, also referred to as "market arrivals". There is also an influence of previous month's prices and market arrivals on price formation. The analysis shows that the market arrival has a great impact on price formation; shown by the significant inverse relationship between market arrival and price. Given the high perishability of christophene and the lack of storage and the subsistence system of production - characterized by low income resource poor farmers, they will be unwilling to carry over the crop even a week after harvesting. The study also suggested that farmers can target months of higher rainfall to grow the crop under protected agriculture structures in order to benefit from higher prices.



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These findings have important implications for policy makers in terms of (i) modification of agronomic technology to minimize diseases and stabilize production and (ii) accuracy and reliability of market information for traders in the marketplace. Modification of field technology that can reduce field moisture and humidity such as vertical trellis should be investigated to determine whether it can reduce disease incidence and thus lower variations in market prices.

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## Regression analysis

The following functional relationship was estimated:

$$\text{Production} = f(\text{rainfall}, U) \dots \dots \dots (1)$$

$$\text{Price} = f(\text{deliveries}, \text{previous market prices}, U) \dots \dots \dots (2)$$

In order to examine the nature of relationship between marketable yield or arrivals (dependent variable) and rainfall (independent variable), the following model was used in linear form:

$$Y_t = f(R_{t=0}, R_{t-1}, P_{t=0}, P_{t-1\text{mth}}) \dots \dots \dots (3)$$

Where:

$Y_t$  = marketable yields or current arrivals of christophene in wholesale market

$R_{t=0}$  = current rainfall

$R_{t-1}$  = rainfall lagged 1 month

In order to examine the nature of relationship between market prices (dependent variable) and market arrivals and lagged prices (independent variables), the following model was used in linear form:

$$P_t = f(P_{t-1}, Y_t) \dots \dots \dots (4)$$

Where

$P_t$  = current price,

$P_{t-1}$  = lagged price and

$Y_t$  = current arrivals of christophene in selected markets

Volumes (market arrivals) was negatively correlated and significant indicating that high volumes translated into lower prices and low volumes into higher prices. This is a typical supply relationship.

**Table 1: Results Variables Influencing Christophene Production in Trinidad and Tobago**

Dependent Variable: LOG(CRIS\_VOL)

Method: Robust Least Squares

Date: 05/06/16 Time: 21:07

Sample (adjusted): 2006M02 2015M12

Included observations: 119 after adjustments

Method: MM-estimation

S settings: tuning=1.547645, breakdown=0.5, trials=200, subsmpl=3,  
refine=2, compare=5

M settings: weight=Bisquare, tuning=4.684

Random number generator: rng=kn, seed=1577040679

Huber Type I Standard Errors & Covariance

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	10.76884	0.215332	50.01052	0.0000
LOG(RAIN)	-0.169871	0.046120	-3.683203	0.0002
LOG(RAIN(-1))	0.031436	0.046274	0.679339	0.4969

Robust Statistics

R-squared	0.100597	Adjusted R-squared	0.085090
Rw-squared	0.146498	Adjust Rw-squared	0.146498
Akaike info criterion	123.6312	Schwarz criterion	133.1219
Deviance	13.71441	Scale	0.339789
Rn-squared statistic	15.33706	Prob(Rn-squared stat.)	0.000467

Non-robust Statistics

Mean dependent var	10.12005	S.D. dependent var	0.414892
S.E. of regression	0.387411	Sum squared resid	17.41011

\* Significant at 1% level of significance

\*\* Significant at 5% level of significance

\*\*\* Significant at 10% level of significance

**Table 2: Results of Regression - Christophene Wholesale Market Price Formation**

Dependent Variable: LOG(CRIS\_P)  
 Method: Robust Least Squares  
 Date: 05/06/16 Time: 21:04  
 Sample (adjusted): 2006M02 2015M12  
 Included observations: 119 after adjustments  
 Method: MM-estimation  
 S settings: tuning=1.547645, breakdown=0.5, trials=200, subsmpl=3, refine=2, compare=5  
 M settings: weight=Bisquare, tuning=4.684  
 Random number generator: rng=kn, seed=1258528637  
 Huber Type I Standard Errors & Covariance

Variable	Coefficient	Std. Error	z-Statistic	Prob.
C	7.468861	0.956872	7.805500	0.0000
LOG(CRIS_P(-1))	0.496279	0.063031	7.873538	0.0000
LOG(CRIS_VOL)	-0.617789	0.085741	-7.205280	0.0000

Robust Statistics

R-squared	0.619599	Adjusted R-squared	0.613040
Rw-squared	0.726550	Adjust Rw-squared	0.726550
Akaike info criterion	100.0528	Schwarz criterion	109.8222
Deviance	10.13096	Scale	0.325730
Rn-squared statistic	242.6742	Prob(Rn-squared stat.)	0.000000

Non-robust Statistics

Mean dependent var	2.402751	S.D. dependent var	0.559302
S.E. of regression	0.311472	Sum squared resid	11.25372

- \* Significant at 1% level of significance
- \*\* Significant at 5% level of significance
- \*\*\* Significant at 10% level of significance



Appendices

Appendix Table 1: Christophene Wholesale Market Prices and Monthly Average Rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
2006	4.57	5.45	4.77	7.42	9.36	14.70	17.32	15.33	13.79	10.50	14.72	7.33	10.44
2007	3.30	4.47	4.66	6.90	12.07	19.63	12.09	9.11	11.84	12.93	11.51	6.09	9.55
2008	5.39	4.00	3.38	3.16	7.19	12.78	22.76	15.24	14.50	14.06	15.29	14.65	11.03
2009	4.82	3.93	6.06	4.07	11.41	10.20	15.40	15.13	16.47	14.48	11.79	9.22	10.25
2010	4.68	6.43	14.37	24.52	27.88	33.83	25.39	25.20	14.08	10.00	9.96	12.13	17.37
2011	5.57	3.53	3.88	4.37	8.53	14.02	23.10	15.04	15.39	18.17	13.75	14.37	11.64
2012	9.43	6.61	6.05	7.36	9.48	14.64	16.58	14.53	16.59	19.15	20.55	16.91	13.16
2013	10.26	5.62	7.92	13.03	19.15	20.63	14.22	10.93	15.70	20.60	19.92	14.75	14.39
2014	7.57	6.09	6.46	9.85	13.55	12.18	21.72	15.71	10.63	19.39	22.24	21.82	13.93
2015	6.87	8.11	5.45	6.42	7.91	20.65	23.35	13.42	18.13	27.47	25.48	15.05	14.86
Average Price \$TT/kg	6.25	5.42	6.30	8.71	12.65	17.33	19.19	14.96	14.71	16.68	16.52	13.23	12.66
Rainfall	85.07	48.77	58.56	57.59	92.67	170.57	190.69	205.20	152.20	194.59	186.18	178.24	

r= 0.90

Appendix Table 2: Christophene Wholesale Market Prices and Monthly Rainfall (mm)

Rainfall (mm)	Year	Month	Wholesale Market Prices (\$TT/kg)
107.44	2006	1	4.57
71.1	2006	2	5.45
31.06	2006	3	4.77
35.56	2006	4	7.42
48.58	2006	5	9.36
187.2	2006	6	14.70
259.86	2006	7	17.32
202.64	2006	8	15.33
127.78	2006	9	13.79
255.62	2006	10	10.50
169.94	2006	11	14.72
184.82	2006	12	7.33
68.1	2007	1	3.30
37.52	2007	2	4.47
51.64	2007	3	4.66
31.54	2007	4	6.90
47.66	2007	5	12.07
189.96	2007	6	19.63
154.9	2007	7	12.09
232.84	2007	8	9.11
134.48	2007	9	11.84
236.1	2007	10	12.93
102.96	2007	11	11.51
334.26	2007	12	6.09

<b>Appendix Table 2: Christophene Wholesale Market Prices and Monthly Rainfall (mm)</b>			
<b>Rainfall (mm)</b>	<b>Year</b>	<b>Month</b>	<b>Wholesale Market Prices (\$TT/kg)</b>
53.62	2008	3	3.38
50.3	2008	4	3.16
27.34	2008	5	7.19
174.14	2008	6	12.78
199.16	2008	7	22.76
185.84	2008	8	15.24
166.06	2008	9	14.50
273.04	2008	10	14.06
141.78	2008	11	15.29
116.94	2008	12	14.65
120.16	2009	1	4.82
37.86	2009	2	3.93
34.76	2009	3	6.06
47.5	2009	4	4.07
58.6	2009	5	11.41
93.96	2009	6	10.20
240.18	2009	7	15.40
163.46	2009	8	15.13
105.36	2009	9	16.47
124.1	2009	10	14.48
159	2009	11	11.79
77.26	2009	12	9.22
28.56	2010	1	4.68
5.92	2010	2	6.43
40.3	2010	3	14.37
76.66	2010	4	24.52
171.16	2010	5	27.88
178.48	2010	6	33.83
259.86	2010	7	25.39
347.28	2010	8	25.20
272.94	2010	9	14.08
108.42	2010	10	10.00
259.34	2010	11	9.96
160.52	2010	12	12.13
182.78	2011	1	5.57
66.7	2011	2	3.53
48.64	2011	3	3.88
72.82	2011	4	4.37
109.82	2011	5	8.53
171.52	2011	6	14.02
172.78	2011	7	23.10
143.74	2011	8	15.04
192.88	2011	9	15.39
243.7	2011	10	18.17
330.02	2011	11	13.75
187.96	2011	12	14.37
15.16	2012	1	9.43
66.56	2012	2	6.61
149.92	2012	3	6.05

<b>Appendix Table 2: Christophene Wholesale Market Prices and Monthly Rainfall (mm)</b>			
<b>Rainfall (mm)</b>	<b>Year</b>	<b>Month</b>	<b>Wholesale Market Prices (\$TT/kg)</b>
88.72	2012	4	7.36
185.56	2012	5	9.48
198.76	2012	6	14.64
48.06	2012	7	16.58
160.62	2012	8	14.53
65.88	2012	9	16.59
121.14	2012	10	19.15
140.22	2012	11	20.55
185.94	2012	12	16.91

**BIOLOGY AND EFFECTS OF SELECTED PESTICIDES ON A PREDATORY BEETLE, *THALASSA MONTENZUMAE* A POTENTIAL BIOCONTROL AGENT OF CROTON SCALE, *PHALACROCOCCUS HOWERTONI* IN SOUTH FLORIDA**

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**Keywords:** *Thalassa montezumae*, Predatory Beetle, Biology, Pesticidal Effects, Biological Control

**Abstract.** A new species of soft scale, *Phalacrocooccus howertoni* Hodges & Hodgson (Hemiptera: Coccidae), first reported on croton in South Florida in 2008, has spread throughout the state and presents a high risk to other areas. It is an established pest of croton plants in production and landscape and, due to its polyphagous nature and high reproductive capacity, it is a pest of more than 72 known tropical and subtropical ornamental plants, fruit trees and environmentally important mangrove trees. Little is known about its biology and population dynamics and there are currently no recommended biological control measures for this pest; however, a predatory beetle, *Thalassa montezumae* Mulsant (Coleoptera: Coccinellidae), has been found feeding on *P. howertoni* and could be a potential biological control agent. Thus, laboratory studies were conducted to determine the life cycle, longevity, survival rate, fecundity and other biological parameters of *T. montezumae*. The life cycle is holometabolous with four larval instars, a prepupal/pupal stage, and adults. Average developmental time from egg to adult was 34 days and the survival rate from egg to adult was 72.9%. Lifetime fecundity was  $274.2 \pm 13.93$  eggs per female with an average oviposition period of  $18.3 \pm 0.48$  days. Fourth instars *T. montezumae* consumed a mean of  $21.28 \pm 1.47$  second-stage nymphs of *Phalacrocooccus howertoni*,  $14.36 \pm 0.98$  third-stage nymphs, and  $14.56 \pm 0.82$  adults. Each adult *Thalassa montezumae* fed on a mean number of  $157.30 \pm 7.64$  *P. howertoni* (all stages) with an average of  $212.00 \pm 2.48$  second-stage nymphs,  $162.69 \pm 1.70$  third-stage nymphs, and  $94.27 \pm 1.76$  adults. There were no significant differences in the number of eggs hatched from female beetles that were fed second or third instars or adult scales. The effect of commonly used bifenthrin and imidacloprid insecticides on *T. montezumae* were studied by exposing the beetles to insecticide treated scales (*P. howertoni*) and leaves. Both systemic and contact insecticides caused mortality to adult and immature stages of the beetle. There was no significant difference in mortality between the imidacloprid foliar treatment and bifenthrin. In addition, there was less mortality recorded when imidacloprid was applied as a systemic in the form of drench formulation.

**Materials and methods**

**Biology of *Thalassa montezumae*.** The Biology of *T. montezumae* was determined by evaluating individuals reared from eggs to adults feeding on various stages of *P. howertoni* in plastic Petri dishes (90 x 10 mm) lined with filter paper. Beetle eggs were collected for the first three days of oviposition and were transferred to new Petri dishes. These eggs were placed in an incubator at a constant temperature of  $27^\circ \pm 2^\circ\text{C}$ , RH of 60%, and a photoperiod of 11:13 (L:D). Time of hatch and development from egg to adult were followed through daily observation using a microscope (Leica Z-12 stereoscope 10X oculars) to record each molt. Once an egg hatched, the 1<sup>st</sup> instars were placed individually into Petri dishes to monitor for molting. A total of 451 first instars were evaluated. The number of days to each instar, emergence rate, percent survival, and number of adult females and males emerged were recorded. The development time which is the number of days until hatching and survival were also recorded.

**Indirect Contact – Treated Leaves. Adult Beetles.** A total of 20 clean plants free of croton scales and any other insect pests were divided into two groups (10 plants each). One group was sprayed with bifenthrin (Talstar P<sup>TM</sup>); the other group was not treated (control). The bifenthrin was prepared according to the label rate for ornamental trees (0.16 oz/gal). The 10 treated 46 plants were sprayed with a handheld pressure sprayer (Flomaster Premium gallon sprayer) to provide full coverage of each plant. Leaves were removed from treated and control plants 24 hours after treatment and three leaves each were placed in individual petri dishes with an adult beetle. Beetle mortality was determined 24 and 48 h after exposure. The beetles were determined to be dead when they did not move when poked with forceps. The procedure was repeated with new beetles and fresh leaves two, three and seven days after treatment. The entire experiment was repeated a week later. A second experiment was done using a total of eight plants that were divided into two groups (four plants each) from which treated leaves were removed as in the previous experiment. The first group of plants received a foliar application of imidacloprid (Merit 75 WP<sup>TM</sup>) and was prepared according to the label rate for ornamentals and trees (0.25 tsp/2.5 gal). The final solution was 0.5 gal which was used to thoroughly cover the four plants. The second group of four plants served as the control. Ten beetles were individually placed in petri dishes (one per dish) and exposed to treated leaves; another 10 beetles in individual dishes were used as the control. Beetle mortality was determined 24 and 48 h after exposure, and the procedure was repeated with fresh beetles and leaves two, three and seven days after treatment and replicated a week later as previously described. A third experiment evaluated a soil drench application of imidacloprid. Eight clean plants were divided into two groups (four plants each). Four plants were drenched with imidacloprid (Merit



75 WP) and four received no insecticide but were drenched with water. The imidacloprid solution was prepared according to the label rate of 0.7-1.4 teaspoon per foot height. Each plant measured approximately one foot. A total of 2.25 g of imidacloprid was mixed with 2 liters of water in a plastic bottle. Each plant received a total of 200 ml of solution that was applied to each pot by pouring over the soil surface. Each pot was slowly drenched with the insecticide solution in a way to prevent dripping from the bottom of the pots. The control plants were drenched with the same amount of water. Leaves were removed and placed in petri dishes, one adult per plate, and examined 24 hours after treatment. This was repeated 2, 3 and 7 days after treatment with fresh beetles and fresh leaves, and replicated a week later.

**Second and Third Instar Beetle Larvae.** The three experiments described for adults were repeated using second and third instar beetles. All other procedures were the same.

**Indirect Contact – Treated Scales.** A total of 10 plants infested with different stages of croton scale were divided into two groups (five plants each). The first group was sprayed with bifenthrin (Talstar P) and second group (control) was treated with water only. The bifenthrin solution was prepared according to the label rate (0.16 oz/gal) for ornamental trees as described above. This test was repeated one week later with a new set of plants. A second experiment was done with imidacloprid (Merit 75 WP), using the above-mentioned protocol and rate for trees and ornamentals. A third experiment used the drench method of application of imidacloprid (Merit 75 WP) following the same protocol previously described. Scales were removed from either control or treated plant three hours after treatment, and were placed in petri dishes with one adult beetle each; the experiment was repeated with second and third instar beetle larvae. Monitoring was done at 3, 6, 12, 18, 24 and 48 hours to determine if the beetles had died after exposure to the treated scales. This test was repeated one week later with a new set of plants.

**Statistical Analysis.** Statistical analysis was carried out using SAS 9.1 (SAS, 1996). Average mortality data were collected for each test. The data from the initial and repeated tests (T1) and (T2) were combined because there were no differences between the results of the two tests. ANOVA was used to analyze the data to determine the effect of insecticide exposure and method of application on the predatory beetle. Response of adult *T. montezumae* to two different insecticides was subjected to Probit analysis using the POLO program (Russell et al. 1977). The responses were considered not significant if the 90% confidence limits at the LT50 overlapped. A likelihood ratio test of equality of parallelism was run to determine whether the regression lines were parallel (Robertson and Priesler 1992).

### Main results

**Biology of *Thalassa montezumae*** *Thalassa montezumae* has a holometabolous life cycle that includes four larval instars (Figure 1). Under laboratory conditions, they can complete their life cycle in 28 to 37 days (Table 1). At a constant temperature of 27±2°C on a diet of *P. howertoni*, the mean duration of each stage was as follows: egg 8.2 days, first instar 4.7 days, second instar 2.8 days, third instar 2.8 days, fourth instar 6.3 days, and pupae 9.3 days. Development from egg to adult was 34 days on average.

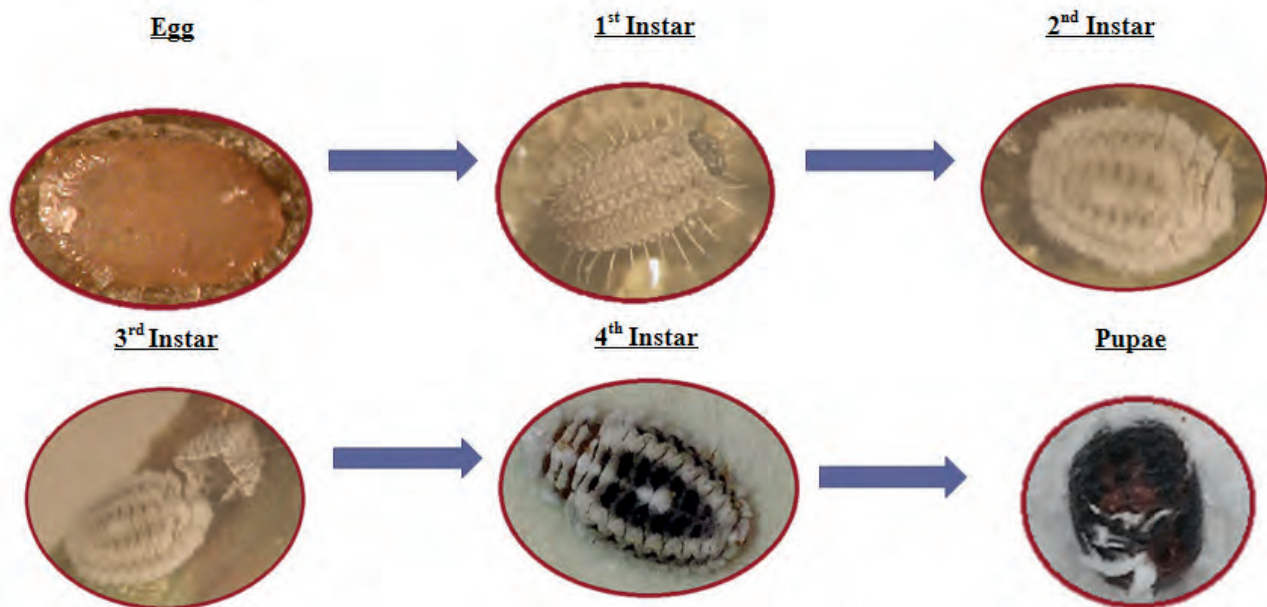


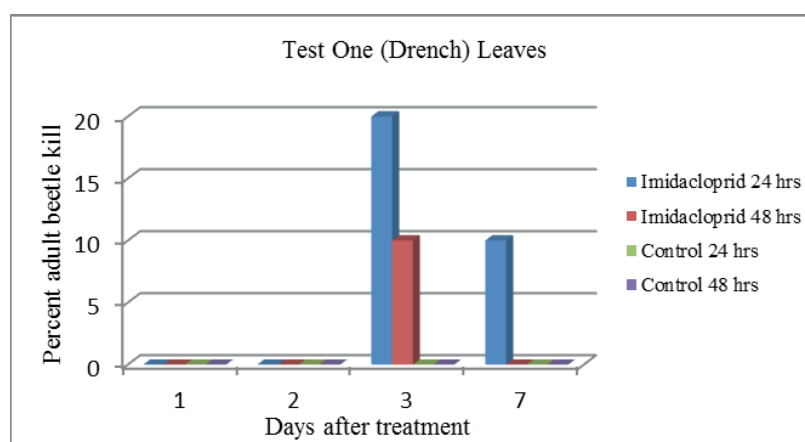
Figure 1. Immature Stages of *T. montezumae*. Photo by Netalie L. Francis.

Growth Stage	n	Minimum (days)	Maximum (days)	Mean±SEM (days)	Survival (%) from egg
Egg	542	7	9	8.2±0.18	-
1 <sup>st</sup> instar	451	4	5	4.7±0.11	83.2
2 <sup>nd</sup> instar	431	2	3	2.8±0.10	79.5
3 <sup>rd</sup> instar	409	2	3	2.8±0.09	75.4
4 <sup>th</sup> instar	400	5	7	6.3±0.16	73.8
Pupa	400	8	10	9.3±0.16	73.8
Egg to adult	395	28	37	34.0±0.74	72.9
Female Longevity	-	-	-	-	-
Male Longevity	-	-	-	-	-

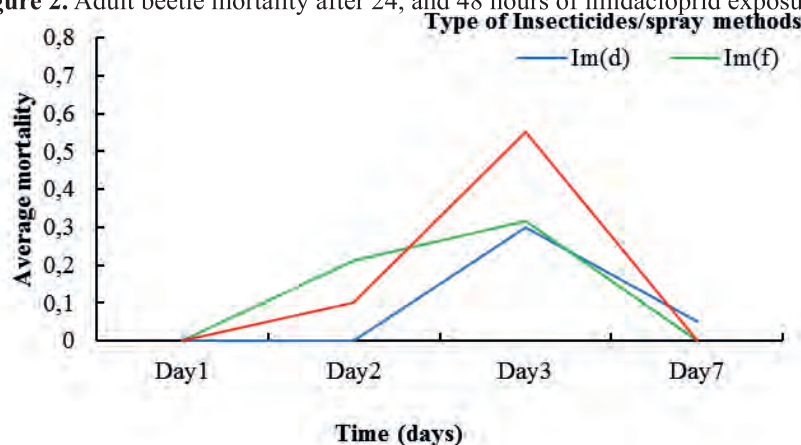
<sup>a</sup>Number of *Thalassa montezumae* tested.

**Table 1.** The longevity (days) and survival (%) of different growth stages of *T. montezumae* under laboratory conditions.

**Insecticide Exposure to *T. montezumae* on Treated Leaves.** Mortality of adult beetles exposed to croton leaves treated with imidacloprid drench, imidacloprid foliar and bifenthrin foliar are summarized in Figure 2. There was no mortality in controls, and mortality was highest for beetles placed on treated leaves the first day after foliar treatments. Fewer beetles died on leaves collected on day two and three, and there was no mortality on day seven. This is in contrast to the imidacloprid drench formulation where there was no mortality until day three (20%) and another 5% of beetles died on leaves at day seven (Fig. 2). There was no significant difference between the two foliar treatments (imidacloprid and bifenthrin) ( $F = 1.359$ ;  $df = 1,158$ ;  $P = 0.245$ ), but the difference between the two imidacloprid formulations (drench and foliar) on larval mortality was significant ( $F = 8.954$ ;  $df = 1,158$ ;  $P = 0.003$ ) [Figure 3].



**Figure 2.** Adult beetle mortality after 24, and 48 hours of imidacloprid exposure.



**Figure 3.** Mortality of second/third instar beetle that was exposed leaves treated with imidacloprid (drench and foliar) and bifenthrin (foliar) insecticides.

## Conclusion

*Phalacrocooccus howertoni*, sometimes called the croton scale, is an invasive pest which was first found in 2008 in South Florida. Since its discovery, it has spread to many more counties in Florida, particularly those along the coast. The most commonly infested hosts in the South Florida landscape include croton (*Codiaeum variegatum*), gumbolimbo (*Bursera simaruba*), firebush (*Hamelia patens*), lignum vitae (*Guajacum santum*), avocado (*Persea americana*), carambola (*Averrhoa carambola*), guava (*Psidium guajava*), and mango (*Mangifera indica*) (Mannion and Hodges, 2010). We surveyed several sites in Homestead and Key Biscayne in South Florida and found that gumbo limbo appeared to be the most common host for *P. howertoni*, which is consistent with surveys by the Florida Department of Agriculture and Consumer Services (FDACS) Division of Plant Industry (DPI) database. A potential biological control agent, the coccinellid beetle *Thalassa montezumae*, was found in Florida in 2009 feeding on *P. howertoni*. Because of its potential importance as a biological control agent, we first determined its biology. Under laboratory conditions, development from egg to adult required 34 days and adult males lived an average of 122 days while females lived a little longer (137 days). Females oviposited for approximately three weeks laying an average of 274 eggs. Females were larger than males, but there was no significant difference between males and females when choosing a stage of prey. The second instar nymph was the stage of *P. howertoni* fed upon most by all stages of *T. montezumae*, and the stage of scale fed upon by adults in experiments did not significantly affect female fecundity. Effects of the insecticides bifenthrin (contact) and imidacloprid (contact and systemic formulations) on *T. montezumae* were studied by exposing beetles indirectly to insecticide treated leaves or to *P. howertoni* scales collected from treated plants. Foliar formulations of bifenthrin killed 50% of adult beetles and imidacloprid killed 40% one day after application to leaves; numbers of dead beetles declined at two and three days, and seven days after application there was no mortality. In comparison, a drench formulation of imidacloprid resulted in 20% mortality after three days but only 5% mortality after seven. However, when fed scales that had fed on the leaves, mortality was slightly higher (20%) for the drench after two days than for the foliar applications (5% each); the significance of this result needs further study as total numbers were too low for meaningful comparison. In addition to problems such as insect resistance and environmental and food contamination, pesticides can lead to a reduction in populations of natural enemies (Garratt and Kennedy, 2006). One objective of this study concerned protection of the natural enemy *T. montezumae*. At minimum, the data suggest that there should be a four day delay between the application of the insecticides studied and the introduction of the predatory beetle *T. montezumae* in an IPM program.

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**THE FLORIDA ENTOMOLOGICAL SOCIETY (FES)**

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FES was founded 1916 with the present charter dating from 1965. Members come from universities, government agencies, industry, pest control companies, and include researchers, extension agents, teachers, students, consultants, and hobbyists. They come from Florida, other regions of the USA and many foreign countries. Much emphasis is placed on student participation by providing scholarships, mini research grants, achievement awards, and special membership opportunities. The Florida Entomologist, first on the internet, is the official journal of the Society published quarterly and covers all disciplines of entomology although with New World emphasis. Annual meetings are held in Florida or elsewhere in the Caribbean to provide opportunities for professional information exchange, consideration of societal matters, and fellowship. Meetings are considered public forum for all people interested in entomology and other related sciences. Our membership is greatly anticipating a joint meeting with the Caribbean Food Crop Society in Puerto Rico, July 2017!



**INTEGRATED MANAGEMENT OF PEST AND DISEASES IN CROP AND ANIMAL PRODUCTION  
INTEGRATED PEST MANAGEMENT OF THE SOUTHERN GREEN STINK BUG, *NEZARA VIRIDULA* ON TOMATO CROP USING TRAP AND REFUGE CROPS IN NORTH FLORIDA**

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**Keywords:** Southern Green Stinkbug, *Nezara viridula*, IPM, Trap Crops, Refuge Crop, North Florida.

**Abstract.**

The Southern Green Stink bug, *Nezara viridula* (L.) (Hemiptera: Pentatomidae) is a serious insect pest of tomato crop in tropical and sub-tropical countries. This stinkbug is difficult to control with currently available insecticides. In this study we investigated the potential use of three trap crops and three varieties of refuge crops in an Integrated Pest Management (IPM) strategy for *N. viridula* on tomatoes during two growing seasons. The experimental trap crops were striped sunflower (*Helianthus annuus*), wild game feed sorghum, (*Sorghum bicolor*); brow top millet (*Panicum ramosum*) in 2014 and pearl millet (*Pennisetum glaucum*) in 2015. The refuge crops were three varieties of sweet alyssum (*Lobularia maritima*) (carpet of snow, royal carpet and tall white). Among the three trap crops, the number of stink bugs collected from the wild game feed sorghum exceeded the cumulative number from sunflower and none were collected from either species of millet. Sorghum attracted a statistically significant higher number of adults compared to other trap crops, however, both sunflower and sorghum served as host plants for *N. viridula*. In addition, 82% of stink bugs collected from sorghum were parasitized by *Trichopoda pennipes* (Fabricius), a natural enemy of late instar nymphs and adult stages of *N. viridula*. Although fewer stinkbugs were found on sunflower, this trap crop was found to be a good source of other natural enemies and pollinators, and also attracted a significantly higher number of the brown stinkbug *Euschistus servus* (Say) [another hemipteran pest]. While this study demonstrated the effectiveness of sorghum to attract *N. viridula*. Therefore, sorghum could be planted with another trap crop preferably sunflower to increase effectiveness of the preventive control strategy. Among refuge crops, all varieties of *Lobularia maritima* attracted natural enemies. The carpet of snow variety attracted the greatest diversity of natural enemies of insect pests. The tall white variety was also very effective in attracting *Geocoris punctipes* (Say) in tomato crop. The population of *N. viridula* was significantly lower in the experimental plots than in the control, indicating that trap cropping and refuge cropping may be effective management tools for *N. viridula* in a tomato cropping system. The results of this field study confirmed the potential of selected trap crops and refuge crops for IPM of *N. viridula* on tomato crops in north Florida.

**Materials and methods**

Tomato crop, trap crops and refuge crops were planted at the Center for Viticulture and Small Fruits Research in Tallahassee, FL. Trap crops and refuge crops were selected based on previous studies (Tillman, 2006; Franket et al. 2008; Mizell, 2008, 2015; Majumdar, 2014) and recommendations from collaborators from the USDA, Agricultural Research Station in Tallahassee, FL (Legaspi and Miller, 2013; personal communication). All seeds were purchased from Gramlings (Tallahassee, FL), Johnny's Seed (Ft. Myers, FL) and Harris Seeds (Paul Road Rochester, NY). Trap crops, refuge crops and main vegetable crops (Table 1) were planted in 60 ft. (18.2 m) rows.

Common Name	Family	Scientific Name	Collection Method/Tool*
Tomato var: marglobe	Solanaceae	<i>Solanum lycopersicum</i>	Handpicked
Striped sunflower	Asteraceae	<i>Helianthus annuus</i>	Sweep Net/Aspirator
Brown top millet (2014)	Poaceae	<i>Panicum ramosum</i>	Sweep Net
Pearl millet (2015)	Poaceae	<i>Pennisetum glaucum</i>	Sweep Net
Wild game feed sorghum	Poaceae	<i>Sorghum bicolor</i>	Sweep Net
Sweet alyssum var.: carpet of snow, royal carpet, tall white	Brassicaceae	<i>Lobularia maritima</i>	Vacuum

\*Sweep net with handle from Bioquip: 15" diameter collapsible net, 12" net handle extension; Bioquip Aspirator with 9-dram clear styrene tubes and snap-on caps; Hand insect vacuum (Craftsman): 19.2 volt.

**Table 1.** Tomato crop, trap crops and refuge crops monitored, May to July 2014 & 2015.

Trap crop seeds were sown directly in the field approximately two weeks before the main crop in order to allow early start and good synchronization between plant species and arrival of insect pests and their natural enemies. Refuge crops and main crops were sown in seedling trays and transplanted to the experimental plots. Proper fertilization and irrigation were provided to promote suitable plant establishment. Plants were fertilized with 20:20:20 NPK throughout the season. Drip irrigation was provided twice per day depending on the needs of crops, one hour in the morning and one hour in the night. Data were collected during the two summer cropping seasons.

**Sampling and monitoring procedure.** Within the total research plot of 300 tomato plants, 30 plants were randomly chosen for each sampling date, representing 10 % of the total plants. For each of the three treatment blocks of trap crops (sunflower, millet and sorghum), five plants per block were randomly sampled on each sampling date. For refuge crops (carpet of snow, royal carpet, and tall white), each of the treatment blocks was vacuum-sampled for 20 seconds on each sampling date. Samples were collected weekly from May to July 2014. The entire procedure was repeated in 2015. Adults of *N. viridula* on the main crop, trap crops, and control were collected and recorded. Also, natural enemies on the refuge crops were collected and recorded. Temperature, rainfall, and relative humidity data were recorded from a local weather channel on each sample date. Sampling continued until all tomatoes were harvested.

**Major pests and natural enemies present on cultivated crops.** In summer 2014 and 2015, tomato trap crops (sunflower, sorghum and millet) and refuge crop (sweet alyssum) were cultivated to know the presence or absence of insect pests and natural enemies. Insects were collected every week and brought into the laboratory where they were identified.

**Preventative control strategy for *Nezara viridula*.** Three trap crops were assessed for their attractiveness to *N. viridula* in an experimental field using tomato as a major/commercial crop from May to July 2014 and 2015. The three trap crops were also compared to each other regarding their attractiveness to *N. viridula*. The first experiment was conducted using the following three trap crops: striped sunflower WGF sorghum and brown top millet (Table 1). For the second growing season brown top millet was replaced with pearl millet because the first season's results were less informative. All trap crops were tested for their ability to attract *N. viridula* and other major stink bugs. We compared the abundance of *N. viridula* on trap crops and the main crop (tomato).

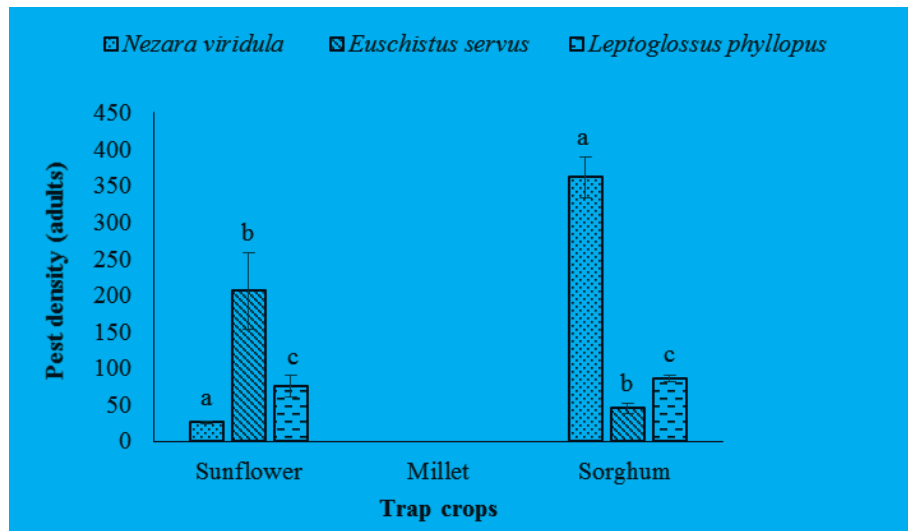
**Conservation of beneficial species.** The second experiment was conducted to compare the abundance of natural enemies and the different insect species attracted to the three varieties of *Lobularia maritima* (carpet of snow, royal carpet, and tall white varieties).

**Statistical analyses.** Data on number of insect pest and natural enemies for each trap and refuge crop were subjected to Analysis of Variance (ANOVA) and treatment means were separated using Tukey's HSD Test (SAS Institute, 2013). Multiple linear regressions were also used to determine if the variables: *Geocoris punctipes*, time, precipitation, temperature and humidity influenced the population density of *Nezara viridula*. For all statistical tests,  $\alpha = 0.05$ .

## Main results

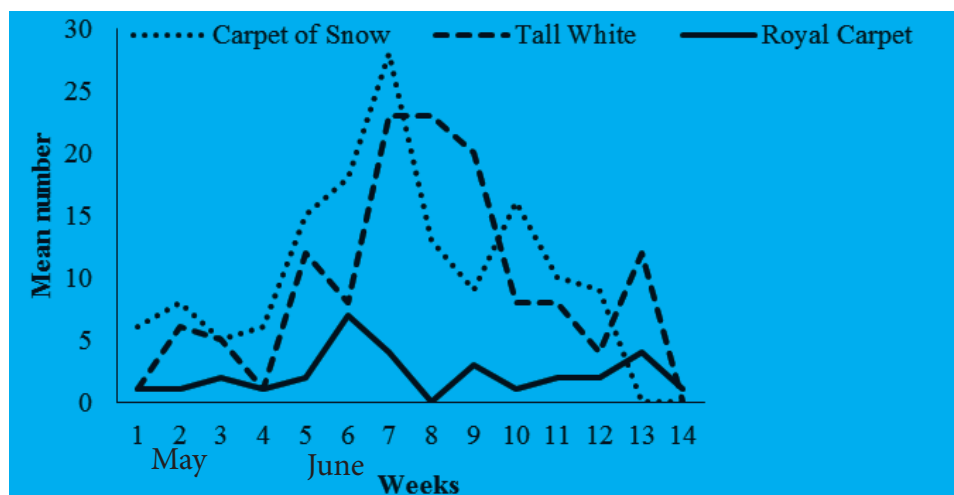
**Major insect pests and natural enemies present on cultivated crops.** Six insect pests found in this study were identified to species and two were identified to genus. Three species of natural enemies (one parasitoid and two predators) were also identified. In addition, one species of parasitoid was identified to order (Hymenoptera) and four species were recorded to families in the orders Diptera, Coleoptera, Hemiptera representing one species in each. Among the insect pests were southern green stink bug, *Nezara viridula*; brown stink bug, *Euschistus servus*; leaf footed bug, *Leptoglossus phyllopus* and tachinid wasp, *Trichopoda pennipes* were collected. For refuge crops the following were collected, big eyed bug, *Geocoris punctipes*; minute pirate bug, *Orius insidiosus*, ladybird beetles (Coccinellidae), assassin bugs (Reduviidae), damsel bugs (Nabidae), hoverflies (Syrphidae) and spiders. However, the pest most frequently recovered throughout the season were southern green stink bug, brown stink bug and leaf footed bug and among the natural enemies, big eyed bug was the dominant predator found throughout the season.

**Preventative control strategies for *Nezara viridula*.** Two major species of stinkbug and one species of leaf-footed bug were the most common on sunflower and sorghum trap crops. These were *Nezara viridula*, *Euschistus servus* and *Leptoglossus phyllopus*. Over the two-year period of study, the highest number of *N. viridula* were recorded on sorghum (362 adults) as compared to sunflower (26 adults) and millet (0 adults) (Fig. 1). In this study, significantly more *N. viridula* were recorded in sorghum (93%) than in sunflower (7%). This study confirmed that sorghum is a suitable trap crop for *N. viridula* and results are in agreement with other studies in cotton where sorghum reduced the need for insecticide applications for *N. viridula* (Rea et al. 2002; Tillman and Mullinix, 2003).



**Figure 1.** Comparison of three insect species caught (Mean±SE) per trap crop (May-July 2014 and 2015).

**Conservation of beneficial species.** The big eyed bug, *Geocoris punctipes* was the most dominant natural enemy found on all three varieties of sweet alyssum (*Lobularia maritima*). Other natural enemies included the minute pirate bug (*Orius insidiosus*), a hymenopteran parasitoid, and predators such as hover flies, spiders, ladybird beetles, assassin bugs and damsel bugs. The highest number of *G. punctipes* (143 specimens) were recorded on the carpet of snow variety followed by tall white (131)) and royal carpet (31). All three refuge crops attracted *G. punctipes* but carpet of snow and tall white are recommended over royal carpet (Fig. 2) because more natural enemies were attracted to these two variety. In addition to *G. punctipes*, *O. insidiosus*, and other parasitoid and predators were found on all three variety of sweet alyssum.



**Figure 2.** Total number of *Geocoris punctipes* collected from three refuge crops (2014 and 2015).

### Conclusion

In both the 2014 and 2015 study periods, *N. viridula* adults strongly preferred sorghum to tomatoes because the density of *N. viridula* adults was higher in sorghum when compared to tomatoes (control). Compared with the control tomato fields, density of *N. viridula* adults was much lower in tomato fields with sorghum trap crops demonstrating that the sorghum was serving as a suitable trap crop for *N. viridula*. This suggests the possibility of using sorghum as a trap crop for tomatoes. Mizell et al. 2008 recommended a variety of different flower and crop species (triticale, sorghum, millet, buckwheat, and sunflower) throughout the season to control native stink bug populations in the southern coastal plain. Trap cropping may be an effective management tool for several stink bug species in an organic agroecosystem. Both sunflower and sorghum serves as host plants for *Nezara viridula*. Therefore, this crop has great potential to be used in integrated pest management for *N. viridula* on tomato crops in north Florida.

Carpet of snow was very effective in attracting *G. punctipes* and other natural enemies in tomato fields. All varieties of *L. maritima* attracted natural enemies; however carpet of snow was the most effective followed by tall white which was also very effective in attracting *G. punctipes* in tomato crop. Natural enemies showed preference for the flowers that had white blooms; carpet of snow and tall white. According to Colley and Luna (2000) flower color may influence choice. Cowgill (1989) surveyed wild plants on farmlands and noted that white and yellow flowers were particularly attractive to natural enemies. Our results are consistent with previous reports on attractiveness of insects to flower colors. While this study demonstrated the attractiveness of sorghum to *N. viridula*, we recommend that sorghum could be planted with another trap crop preferably sunflower for the management of *N. viridula*. Trap cropping along with other methods such as habitat management for natural enemies may be an effective IPM management tool for *N. viridula* in tomato cropping system.

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**BIOLOGICAL CONTROL OF WHITEFLIES IN TOMATO: LESSONS FROM GREENHOUSE TO OPEN FIELD**

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**Abstract:**

Biological control on Tomato is a special problem worldwide because of incompatibility with available predaceous mites and prevalence of whitefly-borne viruses. The plant bugs *Nesidiocoris tenuis* and *Macrolophus pygmaeus* are well adapted to tomato and used successfully to control whiteflies in European greenhouse production, but are not permitted for release in North America because they can also damage plants. Nevertheless, *N. tenuis* found its way into the US, and is now present in southern Florida and Texas, allowing us to establish colonies and do some preliminary open field trials. We found *N. tenuis* to be very vagile, rapidly dispersing out of the tomato crop, but we were able to hold it by intercropping with sesame which is a preferred host plant. The result was excellent control of whitefly on tomato with the majority of plant damage restricted to sesame. We are now determining the required proportion of sesame in the plant population in order to obtain satisfactory results.

## MANAGING WHITEFLY (*BEMISIA TABACI*) ON GREENHOUSE TOMATO WITH BIOPESTICIDES

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**Keywords :** Sweetpotato Whitefly, Bemisia tabaci, Greenhouse Tomato, Biopesticides

### **Abstract :**

The US Environmental Protection Agency (EPA) defines Biopesticides as certain types of pesticides derived from natural materials such as animals, plants, bacteria, and certain minerals. There are many benefits associated with biopesticides: they are inherently less toxic when compared to conventional chemistries; are narrow spectrum in efficacy, generally affecting only the target pest and closely related organisms; are typically at low risk for resistance and are generally compatible with pollinators and biocontrol. In 2014, the IR-4 Program, which is the entity that helps procure registration of sustainable pest management tools for specialty crop growers, via its Biopesticides and Organic Support Program, identified whitefly control on greenhouse (GH) tomato as a priority need during a stakeholder led national workshop. In 2015 two studies were conducted in Florida and Georgia whose objectives were to evaluate a selected group of biopesticides for efficacy and phytotoxicity on GH tomatoes for control of whiteflies. This presentation will highlight the results of these studies.

### **Materials and methods :**

The efficacy of nine biological pesticides for control of SPW on greenhouse-grown tomato was compared to Sivanto and a non-treated check at the locations in Georgia and Florida. Each treatment was replicated 4 times and each replicate consisted of 4-5 tomato plants enclosed in mesh covered cages. All cages were arranged on greenhouse benches in a RCB design. The plants were hand watered and liquid fertilized as needed. The treatments were as follows: (1) Non-treated control, (2) Agri-Colle at 3 liters per acre, (3) EPL-1001 at 135 oz per acre, (4) Botanigard ES at 1 qt per acre, (5) PFR 97 at 28 oz per acre, (6) MBI 203 at 12 qt per acre, (7) MBI 206 at 8 qt per acre, (8) Requiem Prime at 3 qt per acre, (9) Mycotrol O at 1 qt per acre, (10) M-Pede at 2% v:v, and (11) Sivanto at 14 oz per acre.

Plants were infested from laboratory SPW colonies at both locations. Treatments were applied to the plants outside their cages using a hand-held sprayer with a spray wand outfitted with a nozzle containing a 45° core and a no. 4 disc. The sprayer was pressurized by CO<sub>2</sub> to 40 psi and calibrated to wet the leaf surfaces thoroughly without excessive run-off. Sampling was performed over a period of 3-4 weeks and consisted of ten leaflets per plot, selected randomly from the middle one third strata of the plants. Samples were transported to the laboratory where SPW were counted on the lower leaf surfaces with the aid of a stereo microscope.

### **Main results :**

In the FL trial, all treatments resulted in lower total nymphal densities than the UTC, however treatments of Sivanto and PFR-97 resulted in the lowest densities. In the GA trial, a number of biopesticides such as Agri-colle, EPL-1001, Requiem, Mycotrol, and M-pede were comparable with the conventional standard Sivanto in reducing immature populations.

The effects of biopesticides on eggcounts were not all that clear and no significant differences from the non-treated control were obvious.

### **Conclusion :**

This study suggests that a handful of biopesticides could be useful for whitefly management under certain conditions, particularly when virus management is not a concern. Several applications might also be necessary to notice substantial effects on whitefly populations.

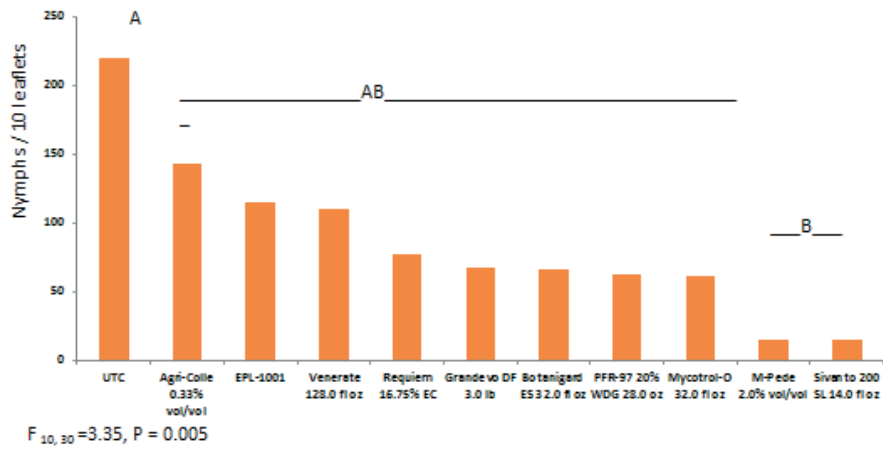


## Methods



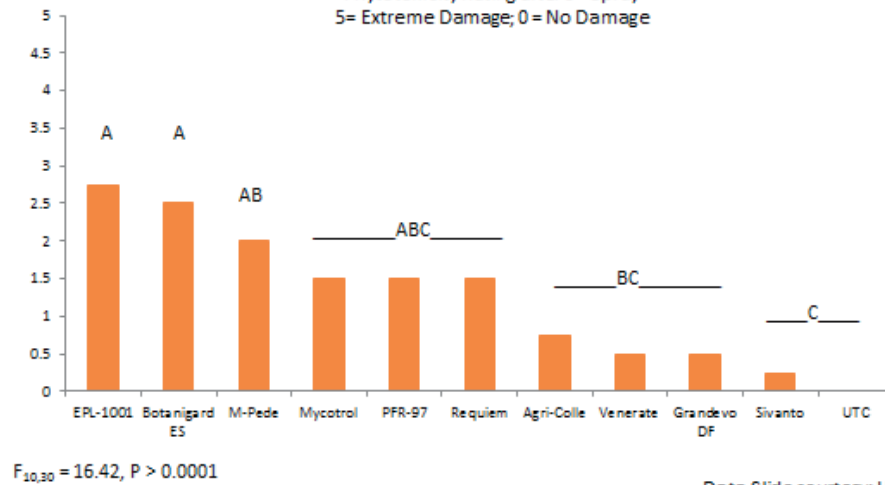
Michelle Samuel-Foo, Hugh Smith and Babu Srinivasan

IR4 Biopesticide Study: Control of Whiteflies on Greenhouse Tomato  
Total nymphs after third weekly spray  
Sivanto was sprayed week 1 and week 3



Michelle Samuel-Foo, Hugh Smith and Babu Srinivasan

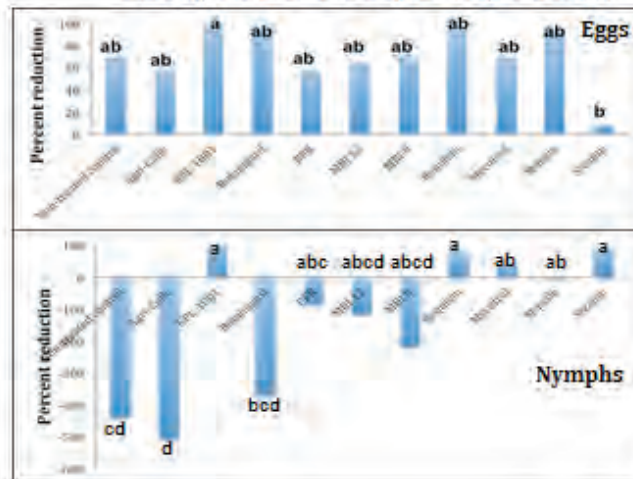
IR4 Biopesticide study: Control of Whiteflies in Greenhouse Tomato  
Phytotoxicity Rating after 3<sup>rd</sup> Spray  
5= Extreme Damage; 0= No Damage



Data Slide courtesy: Hugh Smith

Michelle Samuel-Foo, Hugh Smith and Babu Srinivasan

Bar graph representing whitefly eggs and immatures after treatment with various biopesticides. The bars represent percent reduction from pretreatment counts. Bars with negative percentage values represent an increase from the pretreatment count



Data Slide courtesy: Babu Srinivasan

Michelle Samuel-Foo, Hugh Smith and Babu Srinivasan



## Fungal Entomopathogens

Mycotrol (*Beauveria bassiana*)



PFR-97 (*Paecilomyces fumosoroseus*)



Michelle Samuel-Foo, Hugh Smith and Babu Srinivasan



## INTERACTIONS NUTRITION PARASITISME GASTRO-INTESTINAL ET ALICAMENTS. REVUE DE LA LITTÉRATURE

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**Mots clés :** Interaction nutrition parasitisme, alicaments, légumineuses

### **Résumé :**

La lutte intégrée contre le parasitisme gastro-intestinal est une démarche alternative à l'utilisation exclusive de molécules de synthèse. Cette dernière conduit en effet au développement de résistances chez les parasites lorsqu'elle est utilisée comme seul moyen de contrôle. La phytothérapie est une composante de la lutte intégrée. De plus, certaines ressources végétales sont classées comme alicaments car ce sont des aliments contenant des substances aux propriétés médicamenteuses. Certains feuillages riches en protéines et tannins condensés, entre autres certaines légumineuses, sont des alicaments qui ont une double actions contre les parasites. D'une part, ils renforcent la résilience et la résistance des animaux via l'apport de protéines. Les tanins condensés contenus dans ces ressources protègent partiellement les protéines contre leur dégradation dans le rumen et en conséquence contribuent à l'augmentation du flux intestinal de protéines by pass qui contribuent à accroître la résistance des animaux via le renforcement de leur système immunitaire. Le profil optimal des acides aminés pour les réponses immunitaires qui pourrait être différent de celui requis pour les fonctions de production doit encore être précisé. L'une des conséquences de cette hypothèse pourrait être qu'indépendamment du niveau d'apport de protéines by pass des ressources, l'identification du profil devrait aussi être déterminé pour analyser l'efficacité des ressources alicamentaires. D'autre part, les tanins, en plus de leur action protectrice sur les protéines, contrôlent directement différents stades de développement des parasites. Leur action dépend à la fois de leur teneur et de leur profil dans la ration. La littérature scientifique fait état de nombreux résultats sur les teneurs en tannins condensés des ressources. Elle est par contre beaucoup plus pauvre sur la caractérisation du profil des tannins condensés. La connaissance du profil des tannins condensés permettrait de mieux caractériser les ressources alicamentaires et d'optimiser leur mode d'utilisation.

### **Introduction**

En zone tropicale humide, le parasitisme gastro-intestinal est une pathologie majeure des petits ruminants pouvant entraîner jusqu'à 100% de mortalité chez les jeunes avant le sevrage et de très faibles croissances en post sevrage au pâturage. L'utilisation massive d'anthelminthiques chimiques comme unique moyen de lutte est à l'origine d'une résistance des strongles à la plus part des molécules chimiques de synthèse rendant ainsi cette stratégie de lutte de moins en moins efficace. Face à cette impasse, la lutte intégrée contre les strongles gastro-intestinaux se met progressivement en place. Elle combine la lutte chimique, la gestion des pâturages, la nutrition, la phytothérapie, la génétique. La nutrition et la phytothérapie sont souvent associées via l'ingestion de certains alicaments. L'objectif de cette short note est de présenter la diversité des ressources alicamentaires ainsi que leur modalités d'action.

### **Résultats**

Les alicaments sont des ressources végétales contenant des métabolites secondaires leur conférant une activité médicamenteuse. La valeur nutritionnelle des alicaments varie avec leur profil en métabolites primaires. Elle augmente avec leur teneur en protéines et diminue avec celle de glucides pariétaux. Des coproduits de culture tels les feuilles et stipes de bananier qui contiennent des teneurs élevées en fibres et des faibles teneurs en protéines sont des fourrages de qualité moyenne mais une activité anthelminthique (Marie-Magdeleine et al, 2010a). D'autres aliments tels les feuilles de manioc, de pois, de leucaena sont moins riches fibres alors quelles ont des teneurs élevées en protéines fourrage (Marie-Magdeleine et al, 2010b). Différents métabolites secondaires sont à l'origine des activités anthelminthiques des alicaments: flavonoïdes, tannins, lactones, sesquiterpènes, acide cinnamique. La littérature rapporte une variabilité significative de l'activité anthelminthique intra ressources alicamentaire. Cette variabilité est partiellement expliquée par la quantité et la qualité des métabolites secondaires qu'ils contiennent. Cette variabilité est sous l'influence de facteurs génétiques (espèce, variété...), environnementaux (climat, sol, âge...) et technologique (récolte, conservation). Certains alicaments, au rang desquels figurent les légumineuses riches tannins condensés, ont deux modalités d'actions. D'une part, les tannins condensés ont une action directe sur les strongles pathogènes à différents stades de leur développement. Chez les petits ruminants infestés, l'ingestion d'aliments contenant des tannins condensés s'accompagne : 1) d'une réduction du taux de développement en larves L3 des œufs excrétés; 2) une réduction du taux d'installation des larves L3 dans la caillette ; 3) une réduction de l'excrétion d'œufs liée a une moins de femelles adultes dans la caillette et/ou a une moindre fertilité. D'une part, ils renforcent la résilience et la résistance des animaux via l'apport de protéines. Le parasitisme augmente les besoins protéines pour faire face à la réparation des tissus endommagés et aux réponses immunitaires qui mobilisent

des acides aminés. L'apport de protéines augmente donc la résistance face aux strongles gastro-intestinaux et se traduit par une réduction de la charge parasitaire et l'excrétion d'oeufs (Houdijk, 2012). Les feuillages riches en protéines et en tannins condensés contribuent à la résilience des animaux infestés en augmentant l'apport de protéines by pass. En effet, les tanins condensés protègent partiellement les protéines contre leur dégradation dans le rumen et en conséquence contribuent à l'augmentation du flux intestinal de protéines by pass.

### **Perspective de recherches et conclusions**

La littérature scientifique rapporte de nombreuses données sur la teneur en tannins condensés de ressources tropicales. Les concentrations en tannins condensés doivent être supérieures à 2% pour avoir une activité anthelminthique. Quand ces concentrations sont supérieures à 5% leur consommation s'accompagne d'effets antinutritionnels. Cependant au-delà de ces seuils, les réponses animales sont variables en fonction de la nature des tannins. Des progrès dans la caractérisation des tannins est indispensable pour expliquer les différences observées pour une même teneur de TC. La connaissance du profil des tannins condensés devrait permettre d'affiner les connaissances sur les modalités d'action.

Les réponses animales sont aussi variables pour un même niveau d'apport de protéines. Les profils d'acides aminés requis pour optimiser les fonctions de production et fonctions immunitaires pourraient être différents. Un rapport élevé entre les protéines by pass / protéines digestibles dans le rumen élevé favoriserait davantage la réponse immunitaire. Des travaux complémentaires doivent permettre de : 1) préciser le profil optimal pour les réponses immunitaires ; 2) caractériser la diversité protéique des ressources alicamentaires tropicales.

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## AGROECOLOGICAL ENGINEERING AND CROP AND LIVESTOCK HEALTH. CASE STUDIES IN THE FRENCH WEST INDIES.

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**Keywords :** biocontrol, integrated control of health, crop, livestock, tropical environment

### Abstract :

Current crop and livestock farming strategies based on elite varieties and breeds and intensive use of chemicals (pesticides, medicines) suffer from major limitations. Production losses, alteration of natural resources, loss of biodiversity, risk to human health, and vulnerability of the agrosystems dependent on polluted resources are part of the numerous undesirable side effects. The solutions derived from the paradigm of eradication of pathogens have shown their limits. The considerable variability and adaptability among pathogen strains results in emerging resistance and replacement of susceptible with resistant strains in many pathogen species. When extremely aggressive emergent pests or resistance breakage occur, no more food production is possible. Novel approaches and methods are needed to encourage diseases management. The development of an ecological engineering approach that combines nested multi-scale levers is necessary. Mobilizing ecological interactions, largely unexplored, is a key issue to design new health management options. Thus, it fits in with the ‘smart’ (FAO 2011) approach required for the agroecological transition. We analyze how to enhance ecological interactions for crop and animal health. Based on a conceptual grid (Chave, 2015; Chave and Angeon, 2014), we show that consistent strategies for mobilizing ecological interactions rely on a complex activation of key levers at different spatial scales. We apply this analytical grid to two case studies relating to plant and animal health in the French West Indies. These areas face strong challenging diseases for which most of the conventional solutions requiring the use of chemicals barely function. By applying an analytical grid that constitutes the ABCs of ecological regulation to crop and livestock health, we point out strategic choices lead in the French West Indies to cope with diseases. We show how new multi-scale approaches are implemented to identify solutions to enhance ecological interactions for crop and livestock health.

### Materials and methods :

The suggested conceptual framework constitutes the ABCs of biological regulation (Chave and Angeon, 2014). It takes advantage of ecological interactions by increasing ecosystem services and reducing disservices. It originally derives from crop health management (Chave et al. 2014), but it can also aid the comprehension of sustainable animal production (Botreau et al. 2014) as, in both animal and crop systems, the use of biodiversity is the cornerstone of agroecological principles. The grid tackles the key levers used to engineer beneficial or damaging interactions. It defines 6 main levers that appear to be key determinants of agroecological innovative practices.

### Main results :

Two case studies are considered to discuss agroecological protection strategies.

The first one deals with the biocontrol of plants diseases (i.e. the soil bacteria *Ralstonia solanacearum*) in the French West Indies. *R. solanacearum* is one of the world’s most important phytopathogenic bacteria due to its lethality, persistence in soil, wide host range and broad geographic distribution. A new pathogenic variant of *R. solanacearum* was detected in 1999, first in Martinique (Wicker et al. 2009). No resistance was effective for controlling this extremely aggressive new strain (Lebeau et al. 2011). As the use of methyl bromide has been banned for years, one promising approach was to encourage agroecological management. Multifunctional practices harnessing rhizosphere bioprotection were explored to overcome the limitations of conventional protection strategies. Integrating interacting species with strong ability to recruit beneficial microorganisms (i.e. arbuscular mycorrhizal fungi) or secrete toxic compounds in mixed cropping systems is a key issue. Harnessing these natural processes may also avoid the problem of pathogens quickly evolving resistance. Based on functional biodiversity management, numerous agroecological practices, such soil amendments (with compost or plant extract) and mixed cropping systems, also help to control soil diseases (Chave 2015). Breeding crop cultivars which capitalize on plant-microbiome interactions or associating plants and biocontrol agents early in their life offers innovative ways to contribute to disease-suppressive agroecosystems design (Chave et al. 2014). Beyond the practices themselves, it is their combination that is likely to produce synergies for an integrated bioprotection against soil-borne pests.

The second case study explores management strategies for integrated parasitic control. Gastrointestinal parasitism is probably the most widespread disease in grazing small ruminants in the tropics. Half a century of suppressive drenching has resulted sooner or later in the selection of parasite strains resisting to the chemicals employed, and in increasing production losses. Some small ruminant farmers are already facing multi-resistant parasites with no more chemical solution (Mahieu, Ferré et al. 2014). Integrated management must be thought at the whole small ruminant farming system, as a combination of strengthening the animal immune responses (through choice of parasite resistant breed, selection, suitable nutrition, vaccine policy when available), grazing management according to the parasite epidemiology, herbivore species associations, use of forage or plant with anthelmintic properties, and finally management of the residual efficacy of chemical anthelmintic using targeted selective treatments and managing the parasite population at the farm level (Mahieu 2014).

**Conclusion :**

Agriculture has to shift from a simplifying industrial approach to an ecological approach, that enhances complex and non-linear interactions between living organisms and that leaves room for the farmer initiative. From these examples, we showed agroecological systems offer a wide diversity of levers of actions. Different actors implement the key levers depending on their area of action. Identifying a set of potential solutions in order to guide the stakeholders' choices to explore new combinations of levers, depending on their agrosystem and territorial contexts is a key issue to implement the agroecological transition.

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## VALUATION OF LOCAL GENETIC RESOURCES FOR SUSTAINABLE PRODUCTION SYSTEMS THE TROPICAL PLANT BIOLOGICAL RESOURCE CENTER OF THE FRENCH WEST INDIES: SERVING AGRICULTURE AND RESEARCH THROUGHOUT THE CARIB- BEAN.

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**Keywords:** Plant germplasm - Genetic resources - Viral diagnostic - Sanitation - Banana - Mango tree - Pineapple - Sugarcane - Yam - Information system.

### Abstract

Plant genetic resources are instrumental in the adaptation of agriculture to social and environmental change. They are the backbone of research and breeding programs aimed at the development and transfer of new crop varieties best suited to consumers' needs and tastes and to new farming systems. To this aim, plant germplasm collections have been constituted worldwide. Securing such collections requires substantial human and financial investments that can prove difficult to maintain on the long run for small countries and territories such as most Caribbean countries.

In Guadeloupe and Martinique, INRA and CIRAD have constituted large plant germplasm collections of tropical crops over several decades. They joined forces in 2010 to create the Tropical Plant Biological Resource Center of the French West Indies (CRB-PT), which is affiliated to both institutions. In this paper, we describe CRB-PT's collections, services provided to end users and research programs as well as scientific and technical networking strategy.

### Materials and methods

CRB-PT maintains collections of bananas (365 accessions), yams (481 accessions) [1], sugarcane (426 accessions), pineapple (526 accessions) and mango trees (90 accessions) [2] that cover a large part of the worldwide genetic diversity [1, 2]. These collections are conserved *ex situ* under field conditions in one location in Martinique (pineapple) and four locations in Guadeloupe, and also *in vitro*.

Within the past 6 years, CRB-PT has focused its efforts on:

1. The development of an information system allowing end users to gather information on conserved germplasm
2. The implementation of quality assurance measures regarding the traceability, introduction, conservation and distribution of conserved plant germplasm
3. The characterization of viruses infecting its germplasm collections, in order to develop appropriate diagnostic tools and implement them in sanitation programs allowing the distribution of certified virus-free plant material

These efforts were shared with other tropical BRCs and with French research groups working on plant viruses.

### Main results

Funding from the French group of scientific interest IBiSA (*Infrastructures in biology, health and agronomy*) allowed the establishment and coordination of the Inter-TROP network [3]. This network started in 2010 and involves several French tropical BRCs from Guadeloupe, Martinique, French Guyana, Réunion, Corsica and Montpellier.

It led to the development of common quality assurance and computer tools operating under open source software. These tools are now used by the curators of the 14 germplasm collections scattered among the 6 participating BRCs, for managing data related to each conserved accession (passport, taxonomy, biological characteristics). In addition, a common portal was developed, providing public access to detailed information for accessions conserved in all 6 BRCs and allowing the ordering of plant material [4].

The tropical plant BRC of the French West Indies also plays a key role in research programs. It has provided tuber, leaf, pollen, root tip samples and whole plants to local, national and international research groups, to extension officers and end users in Guadeloupe, to a conservation center in Fiji and to tissue culture companies. In order to better serve end users, the tropical plant BRC increases its collections on a regular basis through the importation of additional accessions, in accordance with current regulations.

A specific standard developed for agronomic BRCs, NF S 96-900, was used to develop quality assurance. The implementation of a quality management involving a tracking system of flaws led the certification of the tropical plant BRC –the second BRC to be certified in France-. This certification has been renewed every year since 2014.

the tropical plant BRC coordinated the SafePGR project [5], funded by French national research agency (ANR) and several European outermost regions under the Era-Net program NetBiome. This project involved research groups from the University of the Azores, the University of Madeira, CIRAD in Guadeloupe, Réunion and Montpellier and INRA in Bordeaux and in Guadeloupe. The aim of this project was to run extensive searches of viruses infecting banana, garlic, sugarcane, sweet potato, vanilla and yam accessions conserved in Guadeloupe, Réunion, Azores and Madeira BRCs, using molecular approaches including next generation sequencing (NGS). Based on the extensive molecular characterization of these viruses, including the discovery of 21 new virus species, specific diagnostic tools were developed and implemented for sanitation programs, leading to certified virus-free planting material: to date, 25 yam accessions free of the 9 virus species known to infect this crop are available from the tropical plant BRC. Additional virus-free material will be produced in the coming years.

### **Conclusion**

The Tropical Plant Biological Resource Center of the French West Indies is eager up to provide plant material to end users throughout the Caribbean region, in order to help promote crop diversification and selection programs and more generally to share knowledge with all Caribbean countries and territories. Feedback from end users is appreciated so that the benefits of crop diversification can be shared.

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## VARIETAL DYNAMICS IN YAM PRODUCERS FROM GUADELOUPE AND IMPACT OF ANTHRACNOSE DISEASE

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### Keywords

#### Abstract

Loss of agrobiodiversity mediated by varietal legacy is an important concern, translating as crop species being at risk for genetic erosion, while loss of genetic resources may deplete material available for future breeding strategies. We explored varietal dynamics in the Guadeloupean agricultural yam system. Interviewing farmers about the varieties cultivated in the past compared to their current varieties demonstrated that no dramatic loss of varieties occurred in the two to three latest decades, and changes in variety frequency mostly affected former widespread varieties while frequency of uncommon varieties demonstrated some stability in cultivation frequency. Varietal dynamics nevertheless reflected strong sub-regional trends, and socio-economic impacts such as age of producers or in farm crop diversity. Recurrent epidemics of anthracnose since its historical start in the 70s did not change varietal turnover too strongly, but resulted into transition from *Dioscorea alata* to less susceptible species or into a decrease of yam cultivation especially for farmers with financial dissatisfaction.

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## LONGEVITY, AN ADAPTATION TRAIT OF CREOLE GOATS TO TROPICAL CLIMATE

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**Keywords:** local breed, adaptation, tropical, longevity, goat

### Abstract:

The importance of longevity as an economically trait gives a picture of the flock efficiency and adaptation in a particular environment. A study was conducted in the experimental herd of Creole goats at INRA in Guadeloupe in order to test environmental (year and season at first kidding, age at first kidding and weight at first mating as well as genetic (index of resistance, sire) factors that affect longevity of does. Lifetime data set of 387 Creole does, reared at pasture all year long, was recorded over a period of 11 years (2001-2012). Does were bred for reproduction at 11 months of age. Three mating periods were organized per year, corresponding to 3 climatic seasons, using buck effect. Data were analyzed using survival models (Survival Kit 6.1). The average age for culling was 5.03 years. The culling rate was higher for goats between 2 and 3 years (17 and 24%) and then gradually decreased. Year and season at first kidding did not have a long term influence on does' longevity; neither does age at first kidding. In contrast, weight at first mating had a significant effect and it can be recommended to farmers to mate primiparous goats heavier than 17 kg. Heritability was estimated to 0.16 allowing some genetic progress. No significant correlation was shown with the genetic breeding value of resistance to gastrointestinal parasitism. This study gave indications to breeders to improve their female flock management and increase does' longevity.

### Introduction:

Profitability of meat goat farming systems is largely dependent of the amount of meat produced by does and so by their longevity. However, this trait is largely influenced by culling and replacement policies of breeder arbitration to maintain the best flock structure. Longevity is also determined by adaptation of reproductive females in tropical low input systems.

### Materials and methods:

Longevity data were provided by INRA-Gardel, located in Guadeloupe, in the French-West Indies. Lifetime data set was collected from 387 Creole does with their first kidding between June 2001 and November 2012. Longevity was defined as time in days from first kidding to death or culling. A lifetime record was considered to be completed (uncensored) if does were either died or culled for any reason. Censored records were represented does being sold, exported or still in the flock at the end of the study. For a complete description of survival analysis theory, see Kalbflesch and Prentice (1980) or Klein and Moeschberger (1997).

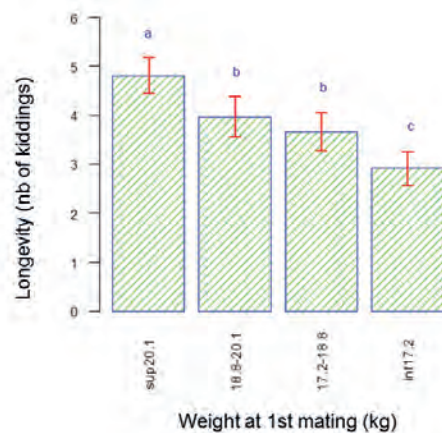
### Model selection.

The fixed effects of year and season at first kidding, age at first kidding and weight at first mating as well as genetic index of resistance to gastrointestinal parasitism were tested using likelihood ratio tests. Only significant effects were included in the final model. The baseline hazard function was initially stratified per level of each effect to choose a model appears to fit the data well. The need for different baselines (Cox ou Weibull) can be assessed using graphical tests. The sire variance was estimated using a Bayesian approach (Ducrocq and Casella, 1996). All computation were done using the software Survival Kit version 6.1 (Ducrocq and Sölkner, 1998) and some analyses were conducted in R-2.15.3.

### Main results:

Year and season at first kidding did not have a long term influence on does' longevity; neither does the age at first kidding. It reflects the good adaptation of Creole does to their environment and the absence of seasonality in this local breed. In contrast, the significant influence of weight at first mating on longevity ( $P < 0.001$ ) indicates that the heaviest is the does at first mating the longest will be its productive lifetime (Figure 1). Yearling females should reach a minimum live weight of 17 kilograms to be mated, at least 60-65 % of their adult body weight. This minimum weight allows them to ensure the successive reproductions coping with environmental variations and stresses for themselves and their litters. One additional year of longevity results in 18 kilograms weaned kids per year/per doe. Furthermore, heritability estimate of longevity is 0.16, indicating available genetic variability for selection. This estimation confirms similar results of Vatankhah (2013;  $h^2 = 0.01-0.09$  from different linear models and  $h^2 = 0.08-0.55$  from animal and sire models) and Rogers et al. (2004;  $h^2 = 0.14$ ) in sheep and cattle production. Otherwise, no significant relationship between breeding value of resistance to gastrointestinal parasitism and does' longevity was shown. So the 2 traits are independent and breeding for enhanced resistance will not affect does' longevity.





**Figure 1:** Relationship between longevity and weight at first mating

**Conclusion:**

The present study demonstrates the genetic basis of longevity in goats which is an original result regarding the literature. It leads to practical conclusions concerning farmers' flock management to enhance productivity of Creole does. Longevity of Creole does reflects also adaptation of the breed to harsh tropical climate of which management practices must take advantage.

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## THE TRINIDAD AND TOBAGO BUFFALYPSO: HISTORY AND PERSPECTIVE

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**Keywords:** Buffalypso, *bosBubalis*, Water Buffalo, Tuberculosis, Zebu, breed, species, hereditary characteristics, inter-fertile, Trinidad, Caroni

### Abstract

**Background to Buffalypso Breeding:** The water buffalo *Bos bubalis*, a type of wild oxen often referred to as “buffalo”, are multifunctional animals used for draught power, meat and milk. When compared to other farm animals there are two main characteristics making them outstanding :- 1) capacity to work in hot, marshy or flooded areas and 2) the ability to survive on low planes of nutrition unsuitable for other livestock. Buffaloes are not indigenous to the Caribbean and not regarded as an important in the agricultural sector, however, it can be utilised as a source of milk and draught power and with development a primary source of meat (buffalo beef), which can be produced locally and may reduce costs of meat production when compared to rearing of imported breeds of beef cattle. Thirty Jaffarabadi buffaloes were imported to Trinidad by Caroni Limited between the period 1900-1905, to replace the Zebu as draught animals. The herd of Buffalo was presumed to be immune to Tuberculosis, which had become rampant among the Zebu herd. Additionally other animals were imported from India with historical records of 16 Buffaloes in 1931, 2 Bulls in 1938 and 18 animals in 1949, there may have also been unrecorded importations of animals. Due to these importations, buffalo population increased and had a great presence in the sugarcane growing areas of Central and South Trinidad. Breeds present in 1964 were Murrah, Jaffaradadi, Nagpuri, Surti, Ravi, Nelli and Bhadwari. There were no buffalo beef breeds present worldwide up to this era, however, Bennet (1964) suggested that there may have been a complete admixture of breeding (through interbreeding), by this time since initial importation in the fifty year period (1905-1964) it was extremely difficult to find pure-bred strains of any buffalo as a result of inter-breeding and cross-breeding. A new breeding programme was adopted with the objective of creating a breed for suited needs, mainly beef production – the Buffalypso.

### Problem:

In 1905, Caroni 1975 Limited found the need to replace its Zebu (Brahana Indian Cattle) herd with a breed that could provide the main function of draught power, with same or even higher productivity if possible to achieve labour efficiency and economic feasibility. This was due to the present herds of Zebu becoming infected with Tuberculosis. The disease had spread due to unsanitary conditions of housing, this was generally not seen as a problem until the outbreak of the disease. Water Buffaloes were imported from India as they were known to be resistant to the disease and provided the same suitability (if not greater) as the Zebu, these animals were also better adapted to tropical climates as they were used in farming systems mainly for draught power in India and Pakistan. Animals would give optimum output during the rainy season as they have a predilection for water, however they are not heat tolerant and suffered distress after prolonged periods of exposure to intense sunlight during the dry season and required protection from direct exposure. With improvements made in housing facilities (to reduce the possibility of disease outbreaks as previously occurred), there was the realisation that with improved management practices and diligent breeding systems that the buffalo could be exploited as a meat and milk producer. Caroni Limited saw this as an opportunity that would increase their profits and diversify their sugar production industry. Up to this time there had not been any developed beef buffalo breed present worldwide or any local beef cattle breed present. Most members of the *Bos bubalis* species are not inter-fertile, making hybridisation of a suited breed a difficult task. Characteristics such as high birth rate, rapid growth and early maturity, efficiency in food conversion, high fertility rate and percentage of carcass weight consisting of saleable meat were traits selected for the development of the new breed.

### Material and methods:

Buffaloes convert poor quality rations into remarkable muscle growth, they can adapt to hostile environments and show positive response to good management practices. Wendover (1968) stated “the buffalo was admirably suited for meat production where extensive husbandry systems prevailed, concentrate feed costs high, pastures were of low quality and capital scarce. Under more intensive systems, the seasonability of breeding and poor yield of meat would not favour the adoption of the animal as a meat producer.” Characteristics identified for the use of water buffalo for meat production were as follows: 1) High birth weight, rapid growth and early maturity, 2) Efficiency in food conversion, 3) High fertility rates and 4) Good carcasses characteristics (Table 1). Desai (1965) concluded that birth weight is a highly heritable trait among buffaloes –  $0.733 + 0.182$ , in Trinidad at Caroni Ltd, Livestock, average birth weight for buffalo calves was 60 lbs. Of significant importance was the buffalo ability to thrive successfully on poor pastures, in a comparison by Shute (1966) done in Trinidad between Jamaica Red Poll, Brahman cattle and buffaloes after grazing for 10 weeks on poor pastures the cattle had made no liveweight gain and had lost body condition whereas the buffalo gained ½ lb / day and

visual appearance being sleek and plump, this led to the conclusion that buffaloes can survive in conditions that the cattle could not, making it an important factor to develop a beef buffalo breed that did not necessarily require high input costs of imported feed. Information on fertility rates of buffalo are not scientifically conclusive and are the subject of hypothetical guesses, Osborn (1965) observed that out of 130 buffaloes, 82% calved during the July/December period, this had serious implications in choosing buffalo for beef production as low fertility rates became apparent. Trinidad buffaloes showed high feed conversion ratios on diets composed of bagasse, molasses and grass, Trinidad buffaloes showed significant weight gain against buffaloes from other regions across the world (Table 2), at 6 months old Trinidad buffaloes weighed 429 lbs with the closest region being Italy at 383 lbs (a 10% difference) at 12 months old the Trinidad buffalo had a 13% greater difference than the Italian buffalo. Carcass comparisons to other buffalo breeds (Table 3) shows superior beef quality compared to beef of other animals produced under local conditions with important noticeability on lower fat content, leading to higher nutritional value (protein content of 18-20%).

**Caroni Buffalypso Project:** Buffalo herds were used for draught power for hauling sugar cane to the production factories, the company opted for mechanisation for transport in the early 1960's, as such the buffaloes were placed at the company's Esperanza location (Central Trinidad) which was considered unsuitable for sugar cane production. They were to be raised for beef production based on 1) capacity to utilise poor quality fodder, 2) resistance to disease, 3) tolerance to tropical climatic conditions and 4) the animals' ability to survive under poor conditions. The project began with 78 yearlings in 1963, number of herd increased to 262 by 1971 and by 1978 there were higher numbers in breeding stock (Table 4a, 4b). Varieties of *Bos bubalis* with selected traits which could be inter-bred were identified. Many cross-breeds already existed, however a distinct breed with all preferred strains still did not exist, as such, a new structured breeding approach was taken. Bennet (1964) suggested there may have been an admixture of breeding (through interbreeding) and the possibility existed of evolving a new breed in Trinidad – the Buffalypso. Research by Dr. Stephen Bennet (1964) proved that many varieties were inter-fertile and this became the basis of a breeding programme. Desirable characteristics to develop a new breed of beef buffalo were selected for the development of the new breed. Five breeds of Indian origin were used to begin this breeding programme. These breeds differed in physical and hereditary characteristics. Notable characteristics of these foundation stock breeds were, 1) Murrah – shapely and clean cut head in females but coarse and heavy in bulls, face is fine without white markings and with nostrils inside apart, neck is long and thin in females but thick and massive in males, well developed chests short and straight legs, average weight of 1,000 lbs for females and 1,200 lbs for males, well developed udder, broad hips and drooping quarters – efficient milk producers in India, 2) Surti – black or brown colour, medium length, sickle shaped horns, directed downward and backward then turn upward to form a hook, straight back and low on legs, high butterfat content in milk, 3) Jaffarabadi – longer body than Murrah and not as compact, loosely knit frame massive head and neck, large body weighing up to 3,000 lbs 4) Nelli – Prominent eyes especially in females, animals are the basis of the Pakistani dairy herd, 5) Bhadawari – medium sized with wedge-shaped bodies, small, light head bulges out between the horn, well developed chest, stout legs and black hooves. The pure-bred animals were interbred and cross bred with admixture stock already considered to have the features desired, the cross-bred progeny was selected for conformation of desired characteristics, the breed resulting from these crosses is now referred to as the Buffalypso, this breed now possesses the characteristics of a new breed suited for beef production.

#### **Results:**

The breeding programme led to the development of the buffalypso breed; this can be considered successful as it satisfied the objectives of the project – create a fast growing beef buffalo breed (Table 5.), also resulting was a significant increase in population (Table 6.). The program suggested that production would increase and the breed would be maintained with typical characteristics preserved in offspring with a dual purpose animal (beef and milk). However it has primarily been used for beef production since. Notable achievements of breeding have been 1) Weaning weight of animals reared under severe conditions for 6 – 7 months was 750 lbs, 2) Animals reared over 30 months with minimal concentrate weighed between 1,232 – 1,344 lbs 3) Mature bulls weigh over 2,000 lbs 4) Average weight of 6-8 months old animals was 431 lbs 5) Average weight of 2 year old steers was 987 lbs, emphasising its suitability as a beef buffalo breed.

#### **Conclusion:**

Caroni (1975) Limited replaced its Zebu stock with Water Buffalo for the intended purposes of draught animals and eventually saleable beef commodities, through the breeding programme one such breed was successfully created, which is now the only beef buffalo breed that exists worldwide. Bennet (1972) states – this type of animal was desirable as it provides the maximum amount of meat when slaughtered, the animal grows quickly, is heavy, compact strong for working and is an excellent beef animal. Greater emphasis can be placed on such a prolific breed within the Caribbean for beef production, supported by low cost of production and high turnover (of both saleable meat and time to be produced considered). Bennet (1972) described the breed as: “The buffalypso is reddish brown or copper colored with a white star on the forehead being permissible. The skin is light and thin. It has a broad head and a face with prominent, intelligent looking eyes and horns which grow backwards and curl upwards – but not as tightly as those of the Murrah. The body is

low (short-legged) and compact with a straight top line, standing on well-turned thighs and buttocks which twists carrying well down the inside of the leg.” However, today, very few animals are now maintained on the islands of Trinidad and Tobago, considerations by stakeholders in the beef industry should be made to improve stocks and quality of the breed with eventual non-dependency on costly rearing of foreign beef cattle breeds for beef production in Trinidad and the Caribbean.

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**Appendix**  
**Tables**

Bone	16.23%
Muscle	64.81%
Fat	18.96%

**Table 1.** Analysis of the carcass of buffaloes in 1968  
(Wendover – The Water Buffalo as a meat producer, D.T.A. UWI 1968)

Age (Months)	Liveweight (lbs)					
	India	Italy	Egypt	Trinidad	Esperanza (Trinidad)	
					Bulls	Heifers
6	300	383	300	429	404	422
9	380	450	340	557	464	430
12	475	570	400	658	533	498
15	550	675	500	-	637	587

**Table 2.** Age and weight gain in Buffaloes in Selected Countries  
(Bennet – Trinidad (1964); Rife – India (1959); Maymond – Italy (1955); Ahamed and Tantany – Egypt (1954))

Breed	Lean % of Carcass	Fat % of Carcass	Bone % of Carcass
Male Buffalo *	68.81	18.96	16.23
Female Buffalo *	68.25	13.52	18.2



Hereford **	57.1	28.5	12.1
Sorthorn **	55.1	30.4	12.1
Friesan **	60	24.5	13
Zebu Steers ***	58.6	27.2	14.2

**Table 3.** Lean, Fat and Bone % of Carcass in Various Breeds  
(\* Shute (1961); \*\*Callow (1961); \*\*\*Ledger + Hutchinson (1962))

Bulls	5
Breeding Cows	100
Calves (weaning)	70
Heifers (9-24 months)	25
Heifers (24-36 months)	9
Bulls (9-24 months)	8
Steers (9-24 months)	17
Steers(24-36 months)	13
Cull Cows	15
Total	262

**Table 4a.** Breakdown of Initial Caroni herd placed at Esperanza  
(Appraisal of Caroni Buffalypso Project. Agricultural Planning Course – 1971)

Heifer calves	61
Bull Calves	56
Breeding bulls	8
Breeding cows	247
2 yr. heifers	26
Yearling heifers	10
Total	408
Breeding Animals (Breeding bulls + Breeding Cows)	255

**Table 4b.** Caroni herd at March 1978  
(Caroni Livestock Office Records – 1979)

Age (Months)	Live weight (lbs)	
	Bulls	Heifers
6	404	422
9	464	430
12	533	498
15	637	587

**Table 5.** Buffaloes – Live weight with age (Trinidad)  
(Wendover – The Water Buffalo as a meat producer, D.T.A. UWI 1968)

Year	Estimated Population
1947/1948	4 000
1951/1952	4 000
1960/1961	5 000
1964/1965	6 000

## RESEARCH FRAMEWORK FOR THE DEVELOPMENT OF CREOLE PIG'S NICHE MARKET IN MARTINIQUE: A HOLISTIC APPROACH

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*The authors thank pig farmers Duventru, Nino, Montluc and Audinay and the PNRM staff for stimulating discussions and their assistance, and contribution in the project.*

**Keywords :** local breed, natural park, Martinique, pig

### Abstract

The Creole pig has always been part of the rural and suburban landscape of Martinique. Currently, this breed is not integrated into a research and conservation program. The Natural Park of Martinique Region (PNRM) has the objective to maintain and valorize the genetic heritage of Martinique's Creole pig and develop a niche business. Based on PNRM knowledge, some Creole pigs live freely in the mountains in the North, in the South coast and in a few disparate traditional breeders located in the countryside. It is essential to carry out an inventory of the local pig population to propose a scheme for conservation and economic development. In order to favour the appropriation of the Creole pig niche, the PNRM, as a decision maker, acts in a systemic and holistic way by considering the whole Martinican territory and the pig sub-sector: producers involved in the COOPMAR pig farmers' cooperative, researchers of INRA (FWI), the food chain and at least (in a second phase) the consumers and the Martinican society. First of all, the pig farmers are involved (private family farms and specialised pig producers). Researchers and technicians from PNRM and INRA-URZ (Animal production research unit) and INRA-PTEA (Tropical platform in animal experimentation) are performing experimental studies both in controlled conditions and in farms, in order to: i) determine phenotypic and genetic characteristics of Martinique's Creole pigs in comparison with other pig breeds from the Caribbean area; ii) help at designing genetic management to maintain the population and avoiding inbreeding; iii) help at defining feeding management by a) establishing, at the whole territorial food chain, an inventory of co or by-products available for pig feeding; b) implementing experimental studies in technology for conservation; c) implementing feeding and growing experiments and finally iv) help at defining eco-friendly production systems a) aiming at generate an adequate revenue and b) focusing on ecosystem services such as meat quality, socio-cultural services and circular economy.

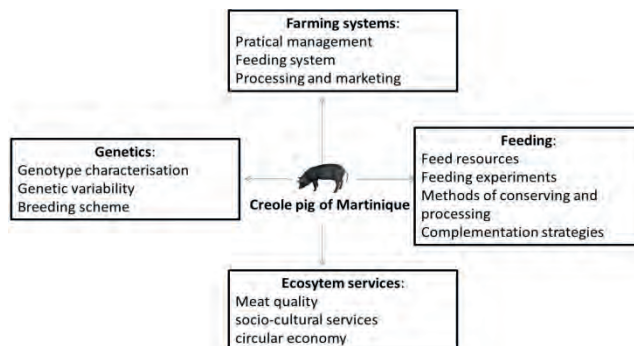
### INTRODUCTION

The local pig of Martinique, often call "black pig" or "plank pig" or "wild pig" has been an element of the rural and peri-urban landscape from many years (Létang 2013). He had played a relatively important part in the economy of subsistence or small-scale farmers. However, the small black pigs are now very rare throughout formal production units, due to indiscriminate breeding with imported exotic breeds due to the development of intensive pig systems with purchased industrial feed. Currently, the local pig of Martinique is not integrated into a research and conservation program. The Natural Park of Martinique Region (PNRM) has the objective to maintain and valorize the genetic heritage of Martinique's biodiversity. The PNRM's medium term objective is to maintain the Creole pig population and to develop a niche business. Since 1970s, INRA has performed studies to characterize the Creole pig breed of Guadeloupe. Studies have been performed on morphologic characteristics (Barrau 1978; Lauvergne and Canope 2000), growing performance (Canope and Raynaud 1982; Renaudeau et al. 2003), reproductive performance (Gourdine et al. 2006), carcass and meat qualities (Deprès et al. 1992; Renaudeau et al. 2005b; Renaudeau and Mourot 2007) and heat adaptation (Gourdine et al. 2007; Renaudeau et al. 2005a; Renaudeau et al. 2006). Based on PNRM knowledge, some Creole pigs live freely in the mountains in the North, in the South coast and in a few disparate traditional breeders located in the countryside (Seychelle, 2015). It is essential to carry out an inventory of the local pig population to propose a scheme for conservation and economic development (Audinay 2014, personal communication). The research project aims at i) determining phenotypic and genetic characteristics of Martinique's Creole pigs in comparison with other pig breeds from the Caribbean area; ii) designing genetic management to maintain the population and avoiding inbreeding; iii) defining feeding management by a) establishing, at the whole territorial food chain, an inventory of co or by-products available for pig feeding; b) implementing experimental studies in technology for conservation; c) implementing feeding and growing experiments and finally iv) defining eco-friendly production systems a) aiming at generate an adequate revenue and b) focusing on ecosystem services such as meat quality, socio-cultural services and circular economy. The objective of this paper is to present the one-year research project (February 2016 – February 2017) on the Creole pig of Martinique which lay stress on the genetic part (i and ii) and the feeding resources inventory part.

## MATERIAL AND METHODS

### 1. THE HOLISTIC APPROACH

The PNRM, as a decision maker, acts in a systemic and holistic way. Different stakeholders characterized by different skills are involved in the project, including apart from PNRM, the National Institute for Agricultural Research (INRA), pig farmers' cooperative (COOPMAR), Regional Chamber of Agriculture of Martinique, and farmers. A schematic presentation of the project is described in Figure 1. The project can be divided in experiments implementing by INRA (genetic and feeding analysis) and research actions managed by INRA (conception and evaluation of farming systems and evaluation of ecosystem services). Table 1 summarizes the “rules” of each stakeholder.



Acronym	Description	Contributions
PNRM	The Natural Park of Martinique Region	Decision maker Capture of freely pigs
Rurality - Multiservices	Engineering	Coordinator Management of meeting between partners Administrative tasks Surveys on farmers and feed resources
INRA-URZ	National Institute for Agricultural Research Animal Production Unit Research	Scientific expertise (Farming systems, genetics, nutrition, technological processes) Technical expertise (Pig production) Experiments
COOPMAR	Pig farmers' cooperative of Martinique	Technical expertise Following of farming systems for farmers belonging to the cooperative
CA Martinique	Regional Chamber of Agriculture of Martinique	Technical expertise Following of farming systems for private farmers not belonging to the cooperative Implementing the herd book of the Creole pig of Martinique
Farmers		Implementing breeding schemes and feeding management

**Tableau 1.** Description of the contribution of each partner in the project

### 2. GENETIC ANALYSIS

Based on literature on management of inbreeding (De Rochambeau and Chavalet, 1985 ; Rydhmer et al., 2010), the genetic researches aim at obtaining a minimum of 10 boars and 40 sows (5 sire lines and 5 dam lines) for the founder population. To achieve these goals, farm surveys and blood samples collection on more than 50 animals that phenotypically look like Creole pig breed are needed. The following process is implemented: i) serologic tests to check any sanitary problems (classical swine fever; brucellosis; Aujeszky's disease; porcine reproductive and respiratory syndrome virus); ii) genotyping of blood samples with the Illumina's porcine SNP60 BeadChip (Ramos et al., 2009) and analysis of genetic variability and genetic distances between pigs and other Creole pig population; iii) choice of founders based on genetic analysis; iv) serologic tests (pre-quarantine and quarantine); v) Implementation of the breeding scheme. with the following rules: a) maintain sire and dam lines: each boar and each sow will be replaced by one of their son or daughter; b) Movement of boars: a boar of one farm will be mated with females of another farm; c) The number of boars used each year is as large as possible and the renewal rate is fast.

### 3. FEEDING RESOURCES INVENTORY

Agricultural wastes (such as grade-outs, return from food factories) can represent a large amount of organic matter which can be turned into animal feed, especially for omnivore monogastrics (San Martin et al., 2016). INRA will be able to propose technological processes to prevent and preserve from the development of dangerous germs such as *Clostridium*, while keeping or increasing the energy or protein contents to satisfy the nutritional requirements of animal. A survey was then established to assess the origin and the availability of wastes in quantity, in quality and frequency.

## RESULTS AND DISCUSSION

### 1. CHARACTERISTICS OF THE LOCAL PIG OF MARTINIQUE : PRELIMINARY RESULTS

Until now, blood samples of a total of 26 pigs (around one third of the targeted number of samples) from 5 farms (Figure 2) were collected. These animals showed phenotypes which are commonly observed in well-known Creole pigs. Most of them are living outdoors. Serological analysis showed that all animals were negative by both classical swine fever; brucellosis; Aujeszky's disease; porcine reproductive and respiratory syndrome virus. To our very knowledge, the local pig of Martinique is not yet genetically characterized at the opposite of other Caribbean regions such as in Cuba (Velázquez et al. 1998), Mexico (Sarabia et al. 2011) or Guadeloupe (Canope and Raynaud 1981).

Nevertheless, based on the historical background of the Caribbean area and South America and the well characterized local pig populations in these countries (Burgos-Paz et al. 2013), there are very few doubts that the local pig of Martinique is from Creole types. Moreover, phenotypes of local pigs observed in different farms of the Martinique's territory, argue for this Creole appurtenance.



Figure 2– Geographical location of animals collected

### 2. INTERACTIONS BETWEEN PARTNERS : TRUST AND COMMITMENTS ARE THE KEY OF THE SUCCESS

The interactions between various stakeholders involved in the project are formalized in several meetings through a technical committee (on average one per two months) where protocols are discussed, revisited and collective decisions are taken. Commitments and trust between each other are the main keys for the success of the project. The success of the genetic and feeding managements is closely related with the economic development of the niche market for which linkages are needed by considering the whole Martinique territory (Figure 3).

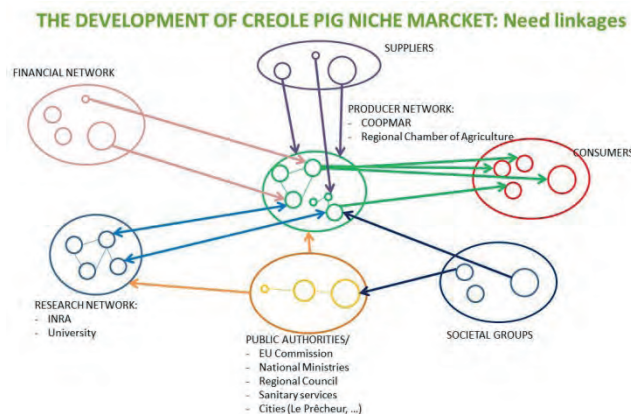


Figure 3– Schematic representations of interactions between stakeholders for the development of the Creole pig niche market (adapted from Geels et al, 2002)

**ACKNOWLEDGMENTS:** The financial support of the PNRM and the Martinique Territorial Community are gratefully acknowledged.



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## PRELIMINARY ASSESSMENT OF LOCAL CASSAVA VARIETIES FOR TOLERANCE TO WATER STRESS CONDITIONS IN TRINIDAD AND TOBAGO

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**Keywords :** cassava, water stress tolerance

### Abstract :

Cassava (*Manihot esculenta*, Crantz) shows wide adaptation to adverse climatic conditions and is well known for its inherent tolerance to stresses such as drought. With increasing occurrences of drought, there is a need to evaluate local varieties for tolerance to such conditions. This study assessed and compared five popular cassava varieties in Trinidad and Tobago grown in pots over an eight-month period under two watering regimes. Watering regimes consisted of 4 L of water per plant every other day (regime 1) and 2 L of water per plant every other day (regime 2). Varieties assessed were the Butterstick, Maracas Blackstick, Maracas Bluestick, Mmex 59 and Pickney Muma. The experiment was arranged in a Completely Randomized Design with 4 replications per variety. Parameters measured at harvest were leaf and stem fresh weight; total Fresh and fresh marketable root weight and total and marketable number of roots. Marketable roots were defined as follows: diameter > 2cm; length >15 cm. No significant differences were observed among the varieties and treatments for leaf fresh weight. Significant variety x treatment ( $p < 0.05$ ) interactions were observed for total fresh root weight; total number of roots and number of marketable roots. Maracas Bluestick yielded total fresh root weight of  $1,500.0 \pm 120.7$  g per plant under water regime 1 compared to  $925.0 \pm 120.7$  g under water regime 2. Comparative values for the other 4 varieties regimes 1 and 2, respectively were Butterstick ( $633.3 \pm 139.4$  and  $550 \pm 120.7$ ); Maracas Blackstick ( $458.7 \pm 120.7$  and  $725 \pm 120.7$ ); Mmex 59 ( $787.5 \pm 120.7$  and  $543.7 \pm 120.7$ ) and Pickney Muma ( $337.5 \pm 120.7$  and  $368.7 \pm 120.7$ ). Maracas BlueStick had Total Root number of  $9.8 \pm 1.19$  per plant under regime 1 compared to  $5.3 \pm 1.19$  under water regime 2. Comparative values for the other 4 varieties regimes 1 and 2, respectively were Butterstick ( $7.0 \pm 1.37$  and  $6.5 \pm 1.19$ ); Maracas Blackstick ( $5.5 \pm 1.19$  and  $9.5 \pm 1.19$ ); Mmex 59 ( $7.0 \pm 1.19$  and  $4.3 \pm 1.19$ ) and Pickney Muma ( $4.8 \pm 1.19$  and  $6.5 \pm 1.19$ ). Maracas BlueStick had marketable Root number of  $7.3 \pm 0.89$  per plant under regime 1 compared to  $4.0 \pm 0.89$  under water regime 2. Comparative values for the other 4 varieties regimes 1 and 2, respectively were Butterstick ( $5.3 \pm 1.03$  and  $3.8 \pm 0.89$ ); Maracas Blackstick ( $3.0 \pm 0.89$  and  $5.5 \pm 0.89$ ); Mmex 59 ( $4.3 \pm 0.89$  and  $3.3 \pm 0.89$ ) and Pickney Muma ( $1.5 \pm 0.89$  and  $4.3 \pm 0.89$ ).

### Materials and methods

The experiment was conducted in pots at the Sugarcane Feeds Centre (SFC), in Central Trinidad  $10^{\circ}31'15.52''$  N and  $61^{\circ}21'47.9''$  W under clear polyethylene greenhouse plastic (6 mil thickness) to allow for sunlight and exclude rainfall. The experiment consisted of popular varieties grown in Trinidad and Tobago: Butterstick, Maracas Blackstick, Maracas Bluestick, Mmex 59 and Pickney Muma. Plants were arranged in a completely randomized design consisting of the following treatments:

- 4 L of water every other day provided to the plants for the entire duration of the experiment (regime 1)
- 4 L of water every other day provided to the plants until 4 months after planting (MAP) and 2 L of water every other day for the remaining four months of the experiment (regime 2)

There were 4 replications per variety and each plot consisted of 1 plant per plot.

Cassava cuttings (20-30 cm long) were planted in pots (approximately 23 US gallons) filled with soil from the Sugarcane Feeds Centre (SFC) on June 4, 2015. Soil tests indicated that the soil was highly acidic (pH of 4.45), had low levels of K (20.79 mg/kg) and moderate levels of P (41.63 mg/kg). The water holding capacity of the soil was 10%. Limestone was applied to neutralize the pH during soil preparation. The cassava was fertilized at rate of 25 g per pot /100kg N per hectare of 12:12:17 +2 after plant establishment.

Data collection (plant height, leaf length and width) began at 1 MAP and continued until 8 MAP when the plants were harvested. The following parameters were collected at harvest: total fresh weight of leaves, total fresh weight of stems, total and marketable fresh root weight and total and marketable number of roots. The plants were harvested in February 2016.

Data analysis was done using Genstat Eighteenth Edition computer software.

## Main results

### Pre-harvest

Variety differences were observed for plant height, leaf length and leaf width. However, there did not appear to be any effect on these parameters due to the water treatments.

### Harvest

No significant difference was observed among the varieties for fresh leaf weights.

Significant variety x treatment ( $p < 0.05$ ) interactions were observed for total fresh root weight; total number of roots and total number of marketable roots. Maracas Bluestick yielded total fresh root weight of  $1,500.0 \pm 120.7$  g per plant under water regime 1 compared to  $925.0 \pm 120.7$  g under water regime 2. Comparative values for the other 4 varieties regimes 1 and 2, respectively were Butterstick ( $633.3 \pm 139.4$  and  $550 \pm 120.7$ ); Maracas Blackstick ( $458.7 \pm 120.7$  and  $725 \pm 120.7$ ); Mmex 59 ( $787.5 \pm 120.7$  and  $543.7 \pm 120.7$ ) and Pickney Muma ( $337.5 \pm 120.7$  and  $368.7 \pm 120.7$ ).

Maracas BlueStick had Total Root number of  $9.8 \pm 1.19$  per plant under regime 1 compared to  $5.3 \pm 1.19$  under water regime 2. Comparative values for the other 4 varieties regimes 1 and 2, respectively were Butterstick ( $7.0 \pm 1.37$  and  $6.5 \pm 1.19$ ); Maracas Blackstick ( $5.5 \pm 1.19$  and  $9.5 \pm 1.19$ ); Mmex 59 ( $7.0 \pm 1.19$  and  $4.3 \pm 1.19$ ) and Pickney Muma ( $4.8 \pm 1.19$  and  $6.5 \pm 1.19$ ).

Maracas BlueStick had marketable Root number of  $7.3 \pm 0.89$  per plant under regime 1 compared to  $4.0 \pm 0.89$  under water regime 2. Comparative values for the other 4 varieties regimes 1 and 2, respectively were Butterstick ( $5.3 \pm 1.03$  and  $3.8 \pm 0.89$ ); Maracas Blackstick ( $3.0 \pm 0.89$  and  $5.5 \pm 0.89$ ); Mmex 59 ( $4.3 \pm 0.89$  and  $3.3 \pm 0.89$ ) and Pickney Muma ( $1.5 \pm 0.89$  and  $4.3 \pm 0.89$ ).

Significant differences ( $p < 0.05$ ) were observed among varieties for total fresh marketable root weight and total number of roots. Marketable fresh root weight of Maracas Bluestick for both regimes 1 and 2 was significantly higher than for the other 4 varieties.

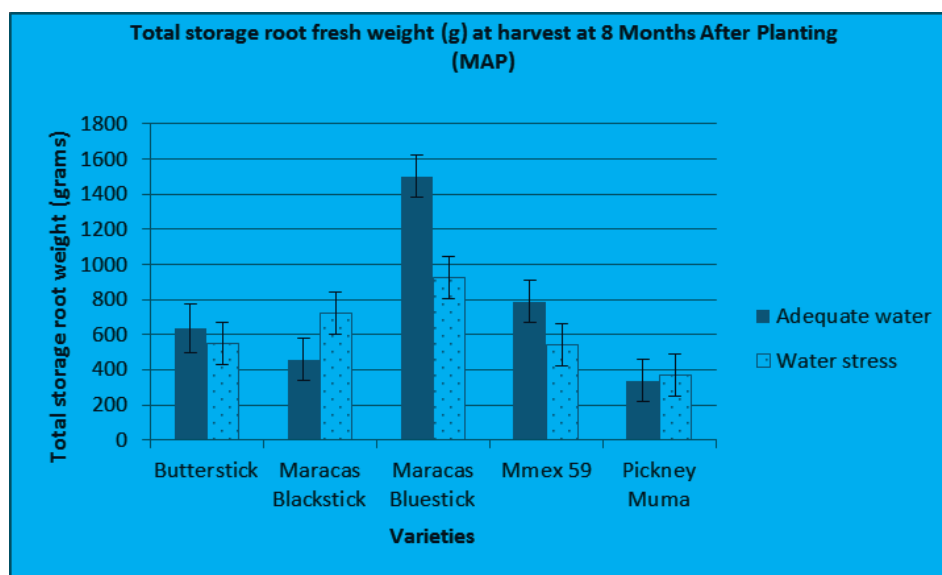
### Conclusion :

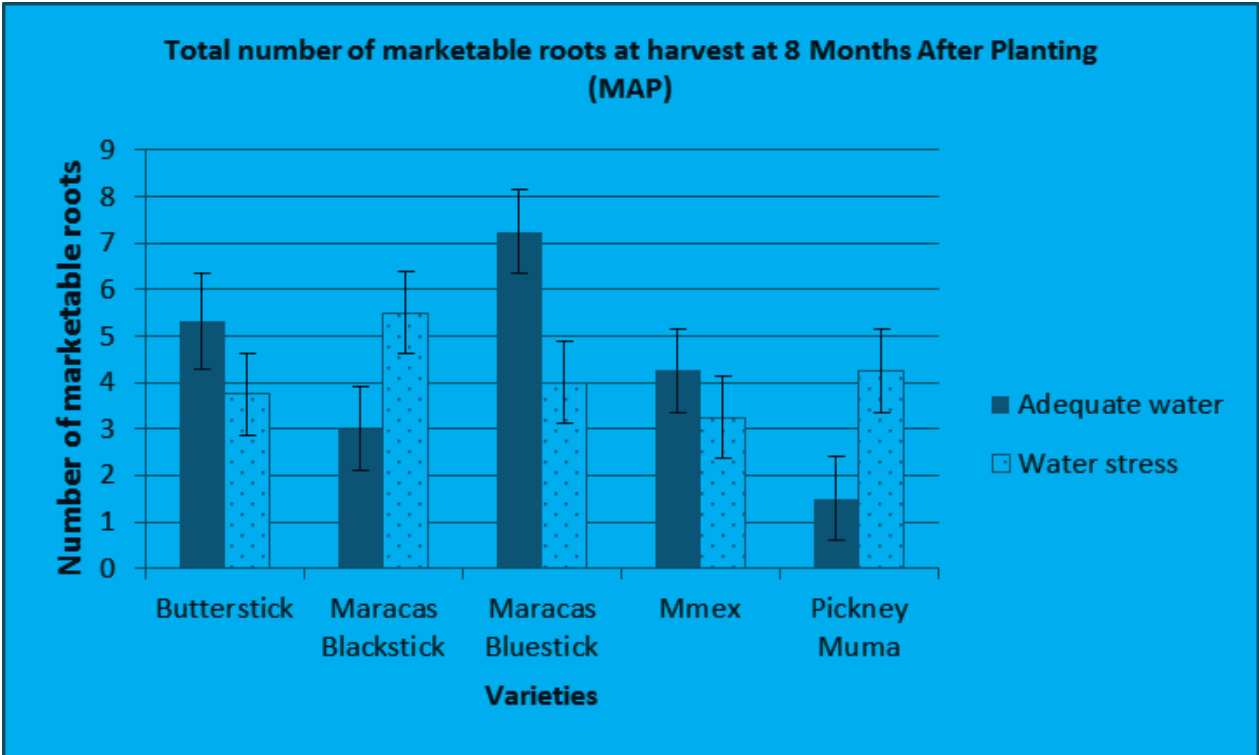
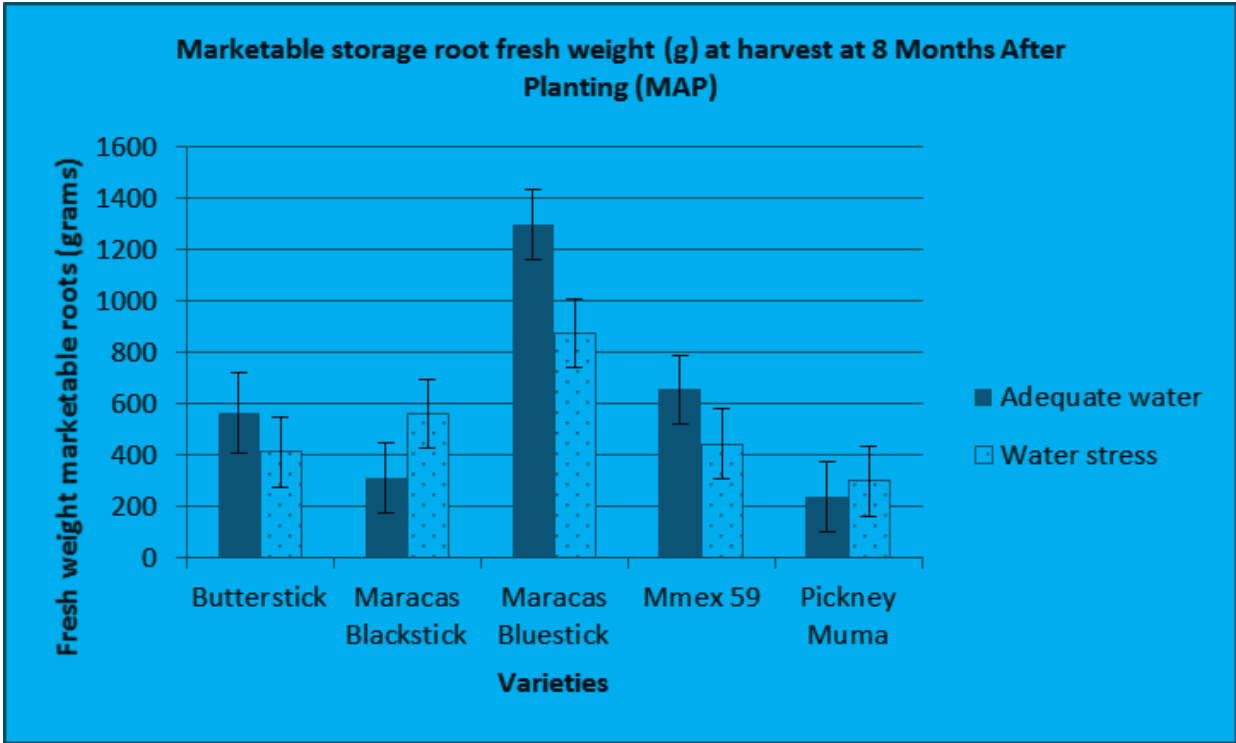
Based on the performance of Maracas Bluestick under water regime 2 (water stress), it is concluded that the variety has the potential for good production in areas prone to drought (water stress). The next step would be field evaluations to assess the varieties under field conditions.

**Acknowledgement:** The support of the Intra-ACP Agriculture Policy Programme funded by the European Union under the 10th EDF facility for the study is highly acknowledged.

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## BREEDING TO DEVELOP A PURPLE SWEETPOTATO FOR THE VIRGIN ISLANDS

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**Keywords :** Ipomoea batatas, tuberous roots, Caribbean

### **Abstract :**

Limited work has focused on the nutritionally beneficial purple-fleshed sweetpotato in the Caribbean. Purple-fleshed sweetpotatoes are an excellent source of bioflavonoids and antioxidants. Cultivars of purple-fleshed sweetpotato are common in Asia but seldom grown in the west. These Asian cultivars set tuberous roots along the stem length where they root. The objective of this work was to introgress the purple-fleshed characteristic into highly productive early bearing (90-105 days) lines. The purple-fleshed line 'VIP' was used in reciprocal crosses with 'Bonita', 'Liberty', 'Mojave' and 'Ruddy'. From hand pollination of these hexaploid plants, 179 seedlings were obtained with a skin color ranging from white to deep burgundy. After the first field trial, 60 were selected for further evaluation based on early tuberous root shape and set, weevil tolerance and soluble sugar content. Continued evaluation will reduce selection down to 20 which further scrutiny to narrow selection to the top five.

### **Materials and methods :**

The purple-fleshed sweetpotato line 'VIP' was used in reciprocal crosses with 'Bonita', 'Liberty', 'Mojave' and 'Ruddy'. From hand pollination of these hexaploid plants, 179 seedlings were obtained with a skin color ranging from white to deep burgundy. Seedlings were scored for weevil damage at 90 and 120 days. A refractometer was used to determine the soluble sugar content from freshly squeezed tuberous root pieces at harvest and one week later after curing.

### **Main results :**

A wide range of sweetpotato types were obtained. These included negative attributes as very hairy roots with minimal tuberous root development, deep eyes, irregular tuberous root shape and high susceptibility to sweetpotato weevils. Positive attributes included 80% marketable tuberous roots in 90 days, shallow eyes, evenly curved oblong shape, soluble sugar content at or above 10 after one week post-harvest curing and purple flesh and minimal weevil damage at 120 days. Tuberous root skin color varied and ranged from creamy white to deep crimson burgundy (Figure 1). Tuberous root development ranged from few to above ten with the larger set resulting in smaller roots. The preference was for 5 to 7 marketable roots per plant. Screening over over winter versus summer allowed for evaluation of photoperiod response to tuberous root development.

### **Conclusion :**

Developing an improved purple flesh productive sweetpotato requires multiple crosses to obtain the desired characteristics that are needed for production in the Caribbean. Screening of seedlings over the winter and summer season allows to select for early-bearing day neutral lines. The sweetpotato weevil is a common pest, however selecting for deeper tuberous root set impart better resistance.



**Figure 1.** Range in sweetpotato skin color from breeding.



## EVALUATION OF BANANA AND PLANTAIN (*MUSA* SPP.) ACCESSIONS TOLERANT TO BLACK SIGATOKA DISEASE IN DOMINICA, GUYANA, ST. LUCIA AND ST. VINCENT AND THE GRENADINES.

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### Abstract

Banana and plantain (*Musa* spp) are important foreign exchange earners in Guyana and the Windward Islands of the Caribbean. Black Sigatoka Disease (BSD) also referred to as black leaf streak disease is one of the most destructive diseases of banana and plantain and is present within the region. In Guyana within two years following its introduction in 2008, the industry was totally decimated, recording a 100% decline, turning the country to a net banana importer. Also, from 2009 – 2012 the disease spread in the Windward Islands causing as much as 100% decrease in the export of banana. The disease is caused by the ascomycete fungus, *Mycosphaerella fijiensis* (anamorph *Pseudocercospora fijiensis*) and is aggressive, challenging to control and results in enormous crop damage if left uncontrolled. In an effort to develop an integrated management approach to the disease the Caribbean Agricultural Research and Development Institute (CARDI) with financial assistance from the Caribbean Development Bank (CDB) is evaluating five FHIA banana and plantain accessions and eight IITA plantain accessions for tolerance to BSD. The evaluation is presently conducted in four Caribbean countries, Dominica, Guyana, St Lucia and St Vincent and the Grenadines. In each country, four distinct agro-ecological zones were selected for the trial evaluation blocks and using a randomized block design, four blocks were established in each country. Five FHIA accessions: FHIA-01, FHIA-03, FHIA-18, FHIA-21 and FHIA-23 are being evaluated in Dominica, St Lucia and St Vincent and the Grenadines whereas, plantain accessions: PITA-17, PITA-21, PITA-22, PITA-23, PITA-24 and PITA-26 are to be evaluated in Guyana for tolerance to the disease. Cavendish are used as regional controls and as borders rows to increase disease pressure. The disease parameters evaluated are youngest leaf spotted (YLS), disease development time (DDT), leaf emission rate (LER), disease severity at 6 months, bunch emergence and harvest, and index of standing leaves. Agronomic data; days from planting to flowering, bunch weight, number of hands in bunch, average weight of hands and average number of fingers per hand and bunch, as well as organoleptic characteristics of both cooked and ripe fruits are also evaluated. The early data collection, of the FHIA only accessions, show trends in the disease tolerance and agronomic performance as well as their adaptability in the different agro-ecological zone. The trends indicate better disease tolerance of FHIA varieties with higher leaf counts before, at bunching and at harvest. The organoleptic test shows a preference to FHIA 03 and FHIA 21.

**Keywords:** Black Sigatoka, *Mycosphaerella fijiensis*, FHIA, banana, plantain, *Musa* spp., disease tolerance

### MATERIALS AND METHODS

#### Reference cultivars

Five FHIA: FHIA-01, FHIA-03, FHIA-18, FHIA-21; FHIA-23, and three Cavendish: Grande Naine, Jaffa and Williams varieties are being evaluated in Dominica, St. Lucia and St. Vincent and the Grenadines where a BSD susceptible Cavendish variety was used as border rows. In Guyana seven plantain accessions: PITA-17, PITA-21, PITA-22, PITA-23, PITA-24 and PITA-26 are to be evaluated for tolerance to the disease. The accessions were received, as tissue culture material, from Bioversity International and the International Institute of Tropical Agriculture (IITA). The received accessions were multiplied in sufficient quantities at the Orange Hill Plant Tissue Culture Laboratory in St. Vincent and the Grenadines and shipped to the participating countries as tissue culture material where they were weaned and hardened prior to field establishment according to protocols developed by Mc Donald and Chien-Ying (2006, unpublished).

#### Establishment of blocks and experimental design

Using the INIBAP Technical Guidelines 6 (Carlier et al., 2002), the experiment was a randomized complete block design with nine clones per plot. Each plot was bordered by a susceptible Cavendish variety (Williams or Grande Naine). Experimental blocks were established in areas where there was sufficient presence of the pathogen. In each of the three participating countries (Dominica, St. Lucia, St. Vincent and the Grenadines) four experimental blocks were established each in a distinct agro-ecological zone. Evaluation blocks were established between May 2015 and January 2016.

#### Agronomic practices

The trial is being managed according to the local agronomic practices recommended by the Banana Growers Manual -A Guide to Successful Banana Production in the Windward Islands (WIBDECO, 2007). All management practices were applied uniformly and no fungicides were applied. The data are being collected on the mother plant and first sucker.

## **Data collected**

### *Disease evolution data*

Using the INIBAP technical guidelines 6 the following parameters are being recorded: disease development time (DDT), youngest leaf spotted (YLS), leaf emission rate (LER), disease severity, infection index, agronomic data, fruit characteristics, number of standing leaves (NSL) index of non-spotted leaves (INSL), and environmental data. Powers (2016 unpublished), nondestructive volume of the banana cone was recorded. Number of standing leaves (NSL) and index of no-spotted leaves (INSL) was recorded using the corresponding field forms in INIBAP Technical Guidelines 7 (Carlier et al., 2003), and all other parameters, were recorded using the appropriate field forms in INIBAP Technical Guidelines 6 (Carlier et al., 2002).

### *Agronomic data*

The agronomic data recorded at bunch emergence were time from planting to shooting, height of pseudostem, height of following sucker and number of functional leaves. At harvest number of functional leaves, plant crop cycle, girth of pseudostem, weight of bunch, number of hands in bunch, number of fruits and weight of fruits were recorded at harvest. Number of functional leaves was also recorded at six months.

### *Organoleptic tests*

Organoleptic tests will be conducted on the FHIA accessions. In Dominica, preliminary tests were conducted on FHIA 03, 18, 21 and 23. Samples were cooked and offered to the public. Evaluation forms were completed by participating individuals, guided by INIBAP Technical Guidelines 4 (Dadzie, 1998).

## **Statistical analysis**

All data from all participating countries are being analyzed at CARDI Headquarters, Trinidad using the Genstat 18.1 statistical software.

## **Results**

The results presented are from data collected in St Vincent during 2015 – 2016 and Dominica during 2016. The preliminary data shows trends in the growth of the accessions, their disease tolerance and consumer taste preference.

At all locations FHIA 18, FHIA 03 and FHIA 21 seemed to performed better than the other BSD tolerant accessions with regards to growth as measured by Powers (2016 unpublished), nondestructive volume of the banana cone as well as to disease development data. However, these parameters will be further viewed together with days to harvest and yield to determine plant productivity. Presently, FHIA varieties as compared to the Cavendish varieties present higher leaf count, before and after bunching, a measure of higher tolerance to the disease. Performance trends have also been observed in the different agro-ecological zones where higher altitude present longer days to bunch.

The organoleptic tests indicated a consumer preference for FHIA 03 and FHIA 21. Consumers generally agreed that they would consider growing both accessions and would substitute them for the traditionally available accessions. However, FHIA 18 did not receive such a favorable response.

## **Discussion**

The preliminary results have indicated that BSD tolerant varieties are performing better than Cavendish varieties with relation to leaf count and disease tolerance. Two potential accessions, FHIA 03 and FHIA 21 seem to be presented for further consideration. However, the BSD evaluation trial is on-going.

## **Acknowledgements**

The authors wish to thank the Governments of Dominica, St. Lucia, St. Vincent and Guyana for recognizing the need for this research, requesting the required funding and for supporting its implementation. Also they wish to thank Bioversity International and IITA for providing the black Sigatoka disease tolerant accessions and the Orange Hill Plant Tissue Culture Laboratory in St. Vincent and the Grenadines for multiplying the reference accessions in sufficient quantities for use in the evaluation. The Caribbean Development Bank (CDB) is acknowledged for providing the necessary funding under Grant No. GA 163 REG and the Caribbean Agricultural Research and Development Institute (CARDI) for implementation of the project. Thank you to all other collaborators, stakeholders, support institutions who contributed to the implementation of this project.

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## HOW MARKER-ASSISTED BREEDING OF *MUSA BALBISIANA* GENITORS DEVOID OF INFECTIOUS ENDOGENOUS BANANA STREAK VIRUS SEQUENCES CONTRIBUTES TO PESTICIDE-FREE AGROECOLOGICAL BANANA FARMING SYSTEMS

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**Keywords:** *Musa*; Endogenous viral element; Banana streak virus; infectious alleles; marker-assisted breeding

### Abstract

Breeding new interspecific banana hybrid varieties with pests and disease resistance characters is instrumental for the development of pesticide-free agroecological banana farming systems. Such breeding relies on the combined use of *Musa acuminata* and *M. balbisiana* parents. Unfortunately, infectious alleles of endogenous Banana streak virus (eBSV) sequences are present in the genome of *M. balbisiana* genitors. Upon activation by biotic and abiotic stresses, these infectious eBSVs lead to spontaneous infections by several species of Banana streak virus (BSV) in interspecific hybrids harbouring both *M. acuminata* and *M. balbisiana* genomes.

In this work, we show that *M. balbisiana* diploid genitors available for breeding host at least one infectious eBSV. We also show how we segregated infectious and non-infectious eBSV alleles in seedy *M. balbisiana* diploids through self-pollination or chromosome doubling of haploid lines. We report on the successful breeding of *M. balbisiana* diploid genitors devoid of all infectious eBSV alleles following self-pollination and on the potential of breeding additional *M. balbisiana* diploid genitors free of infectious eBSVs by crossing parents displaying complementary eBSV patterns. This work paves the way to the safe use of *M. balbisiana* genitors for breeding banana interspecific hybrid varieties with no risk of activation of infectious eBSVs.

### Materials and methods

Plants used in this study originated from the open-field *Musa* collection of the Guadeloupe Biological Resources Center of Tropical Plant (CRB-PT) at Station de Neufchâteau, Capesterre Belle-Eau, Guadeloupe, French West Indies. Haploid lines were created from male flower buds of PKW and their ploidy was assessed by flow cytometry [1]. Their homozygosity was assessed by the analysis of simple sequence repeats (SSR). Selfed-progenies were created by self-pollination followed by embryo rescue and their ploidy was assessed by flow cytometry. Interspecific and intraspecific crosses were performed similarly to self-pollination except that male and female flowers originated from separate plants. Progenies were conserved under insect-proof greenhouse conditions and placed under maximized abiotic stress conditions favoring the expression of infectious eBSV alleles when required. eBSV allelic genotyping was assessed for eBSOLV, eBSGFV and eBSIMV by PCR-based screening and Southern blot hybridization [2, 3]. Virus indexing was performed by immunocapture PCR (IC-PCR) [4].

### Main results

PCR-based screening and Southern blot showed that all analyzed seedy *M. balbisiana* diploids harbor at least one infectious eBSV: ‘Pisang Klutuk’, ‘Pisang Batu’, ‘Klue Tani’ and model species PKW share the same eBSV allelic patterns, whereas other *M. balbisiana* diploids ‘Lal Velchi’, ‘Singapuri’, ‘Cameroun’, ‘Butuhan’ and ‘Honduras’ displayed modified eBSV allelic patterns for either one, two or all three eBSVs (eBSOLV, eBSGFV and eBSIMV).

eBSV modified alleles of ‘Cameroun’ and ‘Honduras’ were characterized. We showed that the modified eBSGFV allele of ‘Cameroun’ is infectious whereas its modified eBSOLV allele is not. Likewise, we showed that the modified eBSGFV allele of ‘Honduras’ is non-infectious.

For the first time, segregation of eBSOLV and eBSGFV alleles was achieved experimentally by chromosome doubling of haploid lines for model species ‘PKW’ and by self-pollination for diploids ‘Pisang Batu’ and ‘Klue Tani’, leading to improved *M. balbisiana* genitors devoid of some infectious eBSVs. Likewise, improved diploids ‘Honduras’ genitors devoid of all infectious eBSVs were obtained following self-pollination.

## Conclusions

All *M. balbisiana* diploids analyzed harboured infectious eBSVs, confirming previous observations [5] and confirming also the fact no *M. balbisiana* genitor devoid of infectious eBSVs is currently available..

We achieved the first experimental segregation of eBSV alleles in several seedy *M. balbisiana* diploid genitors harbouring both infectious and non-infectious eBSV alleles, following chromosome doubling of haploid lines or self-pollination, leading to the first improved *M. balbisiana* genitors devoid of all infectious eBSV alleles. These results pave the way to the safe use of *M. balbisiana* genitors for breeding much needed improved interspecific banana hybrids with no risk of activating infectious eBSVs. They add to a recently reported complementary approach also resulting in the segregation of eBSVs [6]

The approach described in our work is now being used for creating additional *M. balbisiana* genitors devoid of infectious eBSVs by crossing diploid *M. balbisiana* parents with improved *M. balbisiana* diploid ‘Honduras’ devoid of all infectious eBSVs [7]. This approach will be extended to more diploid *M. balbisiana* parents with potential for breeding interspecific hybrids.

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## MANAGEMENT OF BIOLOGICAL PROCESSES IN AGRO ECOLOGICAL PERSPECTIVE MULCHING EFFECTS OF FRESH SARGASSUM SEAWEED ON SOIL PROPERTIES AND PLANT GROWTH

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**Keywords :** SOLVITA, chlorophyll index, SPAD, plant height, number of leaves

### **Abstract :**

Mulch application of Sargassum seaweed (*Sargassum* spp.) to soil can help to reduce beach contamination in the Caribbean Region while providing beneficial horticultural effects. This study investigated the effects of fresh Sargassum mulch on soil properties and plant growth in a test crop of tomato (*Solanum lycopersicum* L. 'HA 3019'). Fresh Sargassum material (washed and unwashed) was applied as mulches (0, 5 and 8cm thick) to small field plots one week after transplanting of 3-week-old seedlings. The mulch material was raked away from the plots after three weeks exposure. Observations on soil moisture, electrical conductivity, pH and biological activity, and plant growth were made at 1 to 2-week intervals over a 6-week period with additional soil measurements after 10 weeks. Soil biological activity (respiration) was increased by the Sargassum mulch with values being similar for the 5cm and 8cm mulch layers. Soil moisture content, pH and electrical conductivity (EC) were increased as the mulch layer increased and EC values were only marginally reduced by Sargassum washing. An increase in plant growth compared to the control treatment was noted only in the washed Sargassum treatments. Potential benefits of Sargassum seaweed mulches on soil properties and plant growth can be nullified due to soil salinization effects.

### **Materials and methods :**

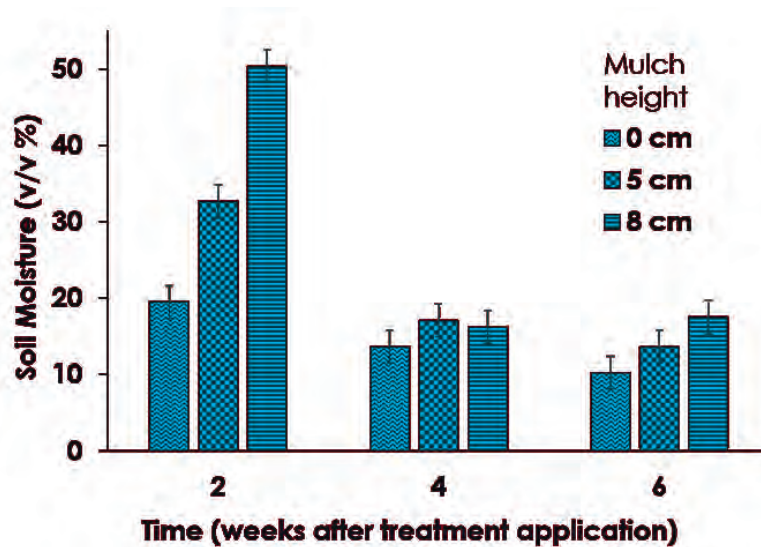
This study was established in a heavy clay soil at the Cave Hill Campus of the University of the West Indies. The soil was prepared to a fine tilth and beds (1m wide) were formed incorporating a pre-plant fertilizer (NPK+Mg 12:12:17:2, 200 kg ha<sup>-1</sup>). Two rows of tomato seedlings (3-week-old) were established on each bed with a spacing of 45cm between and 40 cm within rows.

Fresh Sargassum seaweed was collected from Long Beach, Christ Church, Barbados, at high tide on the 9th November, 2015. It was removed from the shore line and placed into sacks for transport to the UWI Cave Hill campus for preparation and application. A split-plot design (5 replications) was used with mulch washing (washed, unwashed) as the main plots and mulch height (0, 5, 8 cm) as sub-plots. Washing of the Sargassum seaweed was done using a garden hose aimed at each sack for 15 minutes. Mulch treatments were applied 1 week after transplanting of seedlings and each sub-plot (0.72 m<sup>2</sup>) contained 4 plants. The fresh mulch material applied was estimated at 10 and 15 t ha<sup>-1</sup> for the 5cm and 8cm mulch heights, respectively. The mulch material was raked away from the plots into the furrows after three weeks exposure.

Observations were made at 1 to 2-week intervals over a 6-week period with additional soil measurements after 10 weeks. Plant growth was assessed by observing height and leaf number, and leaf greenness was determined for the first fully expanded leaf from the apex using a chlorophyll index meter (SPAD 502 Plus, Konica Minolta Sensing Inc., Japan). Soil moisture content was determined directly in field plots using a soil moisture probe (CS620, Campbell Scientific, USA). Soil samples (top 10cm) from each plot were dried for 24h at 40°C, ground and sieved using a 2 mm sieve. Soil pH and electrical conductivity were determined with probes (IQ170, IQ Scientific Instruments, USA) using a 1:2.5 soil/water ratio. Soil respiration was determined using the CO<sub>2</sub>-Burst method (SOLVITA, Woods End Laboratories Inc., USA).

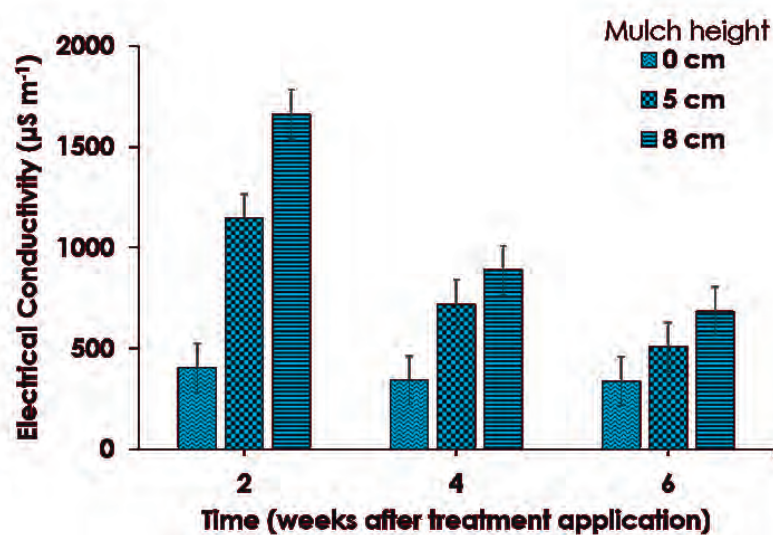
### **Main results :**

At two weeks after treatment application, soil moisture content was significantly increased by the mulch treatments and was 1.5 and 2.5 times greater in plots with the 5cm and 8cm mulch treatments, respectively, compared to Control plots (Figure 1). Differences in soil moisture content between treatments were largely nullified by the removal of the mulch material after three weeks.



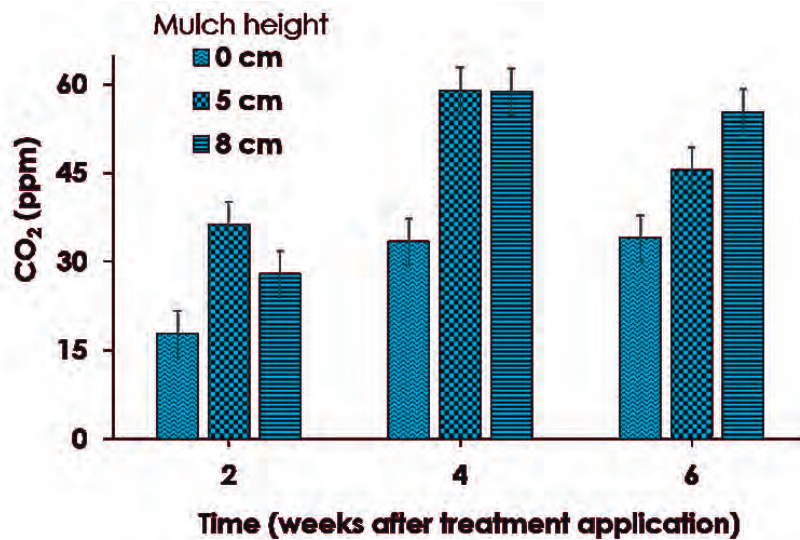
**Figure 1:** Effect of Sargassum mulch height on Soil Moisture Content at different times after treatment application. Mulch treatments were removed after 3 weeks.

Soil electrical conductivity was greatly increased by the mulch treatments with values going above  $1600 \mu\text{S m}^{-1}$  for the 8cm mulch treatment at two weeks after treatment application (Figure 2). Values declined over time, however, differences between the mulch treated and Control plots persisted after the mulch material was removed. Although soil electrical conductivity values were consistently lower for washed compared to unwashed Sargassum mulch treatments, the effect was not significant (data not shown).



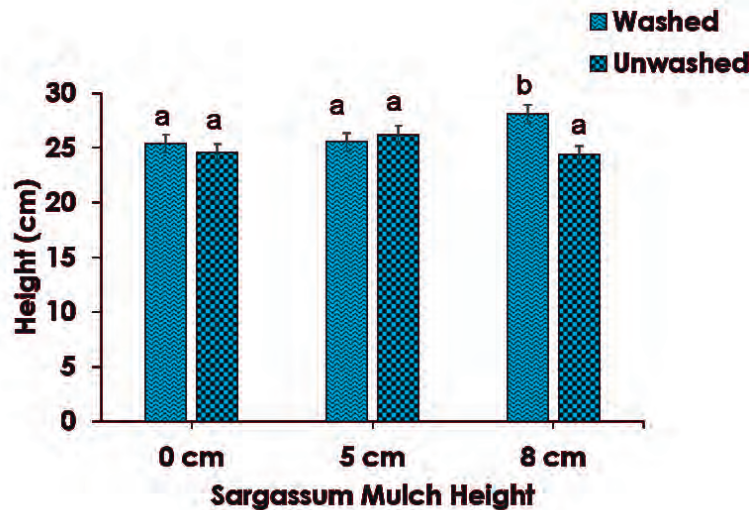
**Figure 2:** Effect of Sargassum mulch height on Soil Electrical Conductivity at different times after treatment application. Mulch treatments were removed after 3 weeks (indicated by arrow).

Soil respiration was increased by the mulch treatments after two weeks, and the effects became greater at 4 weeks after treatment application with similar values observed for the 5cm and 8cm mulch treatments (Figure 3). Increased soil respiration was observed in mulch treated plots even when soil moisture content was similar across all treatments. Soil respiration increased in Control plots over time indicating that possible beneficial effects of the mulch treatments can spill over into nearby non-treated plots.



**Figure 3:** Effect of Sargassum mulch height on soil respiration measured as SOLVITA Soil CO<sub>2</sub> release at different times after treatment application. Mulch treatments were removed after 3 weeks (indicated by arrow).

Plant height over the 6-week period was significantly increased by the 8cm washed mulch treatment, however, no corresponding effect was observed for the unwashed Sargassum mulch treatment (Figure 4).



**Figure 4:** Effect of Sargassum mulch height and washing treatments on height of tomato plants averaged over a 6-week period.

**Conclusion :**

Soil moisture content and biological activity were greatly enhanced by the use of Sargassum seaweed mulches. The large effect on soil respiration occurred under increased salinity conditions and continued even after the mulch was removed and soil moisture levels fell. Liquid extracts of seaweeds have been shown to promote germination and growth of tomato (Hernandez-Herrera et al. 2014). Data on plant growth suggest that the benefits of Sargassum seaweed mulches may be counteracted due to the direct effects of increased soil salinity on plants. Washing of the fresh Sargassum seaweed appeared to be of very limited benefit for reducing the soil salinization effect.

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## POTENTIAL FOR USE OF SARGASSUM MULCH IN SWEET POTATO PRODUCTION

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**Keywords :** light interception, SPAD, Soil pH

### Abstract :

Practical uses for Sargassum are sought regionally as our coastlines continue to be flooded by sargassum blooms floating ashore. This study investigated the potential benefits of Sargassum (*Sargassum spp.*) mulch in sweet potato production at Golden Ridge, St. George, Barbados, during a drought period (November 2015-March 2016). Treatment consisted of combinations of two cultivars of sweet potato ('E' and 'CBS 32', main-plots) and washed/unwashed Sargassum mulches (sub-plots) of different ages (approximately 4 weeks old and fresh, sub-sub-plots) with four replications. Sargassum mulch was applied to the furrows of plots (6m<sup>2</sup>) four weeks after planting at a rate of 10 t ha<sup>-1</sup> and yield, growth and soil parameters were monitored at periodic intervals. Yield (t ha<sup>-1</sup>) was highest for the 4-weeks old Sargassum mulch treatment, and the number of marketable tubers was highest for the unwashed 4-weeks old Sargassum treatment. The number of tubers with *Euscepes postfaciatus* (Scarabee) pest damage was decreased by the Sargassum mulch treatments especially for the 4-weeks old unwashed Sargassum. Vine growth was taller for cultivar 'E' and for the washed Sargassum treatments. Chlorophyll indices were higher in 'CBS 32' than in cultivar 'E' and were lower in Sargassum treated plots. Moisture content in the top 10cm of soil was consistently low and greater in plots of cultivar 'E' than in those of 'CBS 32'. There appears to be some potential for the use of aged Sargassum mulches for improving growth, pest management and yields of sweet potato and further investigations are needed.

### Materials and methods :

The experiment was set up on a field approximately half hectare large at Golden Ridge, St. George in Barbados. Sugarcane was previously grown on the field for many years. Yellow Brown Soils and adequate rainfall are common to the Golden Ridge area (Nazeer 2011) but the experiment was conducted during a drought period of November 2015 to March 2016 with no irrigation available.

A split-split plot design was used with main-plots of cultivars 'E' and 'CBS 32', sub-plots of washed and unwashed Sargassum and sub-sub plots of two different ages of Sargassum, fresh and four weeks old. The field was harrowed then furrowed and single beds were moulded approximately 1.68 m apart. No fertiliser was applied to the field. Sweet potato vine slips were planted 0.46 m apart on the beds.

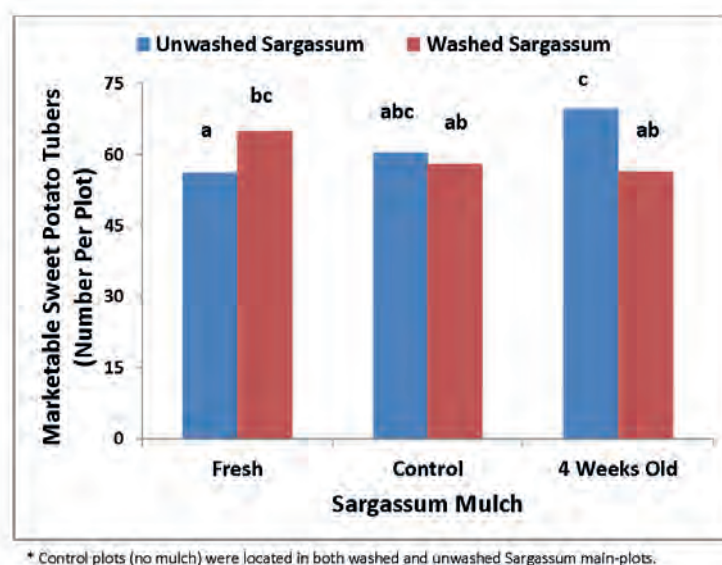
Sargassum was collected from the Skeetes Bay Beach, St. Philip located on the East Coast of Barbados, weighed and washed at a facility on the beach and transported to the field where it was applied in the furrows at a rate of 10 t ha<sup>-1</sup> at four weeks after planting. Each plot was approximately 6m<sup>2</sup>. Treatments consisted of fresh washed and fresh unwashed Sargassum as well as four week old washed and unwashed Sargassum. Controls in the washed and unwashed sub-plots were also established. The field was manually weeded once throughout the experiment and an organic insecticide, NewBT 2X WP was applied at a rate of 2 tsp/3.78 l shortly after weeding. Rat baits were placed in the field as needed at approximately one month before harvesting.

Throughout the experiment, growth parameters were measured at 1 to 3 week intervals. Soil moisture was measured using a 10 cm probe (CS620, Campbell Scientific, USA). Plant heights were measured using a rising disc technique, leaf chlorophyll index was measured (SPAD, Spectrum Technologies Inc., USA) on the first fully developed leaf of plants within the sample plots. Additionally, light interception (LI1500, LI-COR, USA) was measured at two locations in each plot. At harvest, tuber mass was determined for marketable and unmarketable tubers using an electronic scale. The number of tubers per plant was also recorded and a damage assessment rating scale (Lawrence, Bohac et al. 1999) was used to determine pest and other damages. Statistical analyses of ANOVA, REML, Repeated Measures ANOVA, Repeated Measures REML and Chi-square were done using IBM SPSS Statistics 23 and GenStat 17<sup>th</sup> Edition.

### Main results :

Yield was highest for the unwashed 4-weeks old Sargassum mulch treatment with 25.15 t ha<sup>-1</sup> as shown in Table 1 (P=0.018). Similarly, the number of marketable tubers was highest for the unwashed 4-weeks old Sargassum treatment (Fig. 1) with 69.62 tubers (P=0.012). The number of tubers with *Euscepes postfaciatus* (Scarabee) pest damage was decreased by the Sargassum mulch treatments especially for the 4-weeks old unwashed Sargassum (P=0.001). Vine growth was taller for cultivar 'E' (P<0.001) with average height recorded at 227.4 cm compared to 'CBS 32' recorded at 197.5cm. Plants were also taller for the washed Sargassum treatments, 217.1 cm compared to the unwashed Sargassum treatments, 207.8 cm (P=0.049). Chlorophyll indices were higher in 'CBS 32' than in cultivar 'E' and were lower in Sargassum treated plots (P<0.001). Moisture content in the top 10cm of soil was consistently low overall because of the drought conditions but was greater (P=0.010) in plots of cultivar 'E', 3.9% than in those of 'CBS 32', 3.5%.





**Figure 1.** Wash and Age of Sargassum Interaction Effects on Number of Marketable Sweet Potato Tubers

Sargassum	Sargassum Washing Treatment	
	Washed	Unwashed
Control	22.71 ab	20.28 a
Fresh Sargassum	22.63 ab	21.09a
4-week old Sargassum	21.69 ab	25.15b

**Table 1.** Effects of Wash and Age of Sargassum Treatment Interactions on Yield of Sweet Potatoes

**Conclusion :**

The Sargassum mulch appeared to have some effects on the growth of sweet potato vines. The four weeks old unwashed Sargassum was most influential on yield, increasing the tonnes produced per hectare as well as the number of marketable tubers. This may be as a result of growth hormones found in the Sargassum that can stimulate root development (Sangha, Kelloway et al. 2014). The pest damage from Scarabee decreased with the same treatment which suggests that something in the Sargassum is deterring the weevils. This may be linked to the salt content given the treatment was unwashed but further investigation needs to be carried out. Varietal effects were observed showing that cultivar ‘E’ is a higher rising vine than cultivar ‘CBS 32’ while ‘CBS 32’ continually produced more leaves with greater chlorophyll indices than cultivar ‘E’. Chlorophyll indices were not increased by the application of Sargassum mulches. The drought conditions under which this experiment was carried out resulted in very low moisture levels in the soil but cultivar ‘E’ was able to keep more moisture in the soil. This cultivar produced taller plants but leaves were also wider, which may suggest that it covers the ground more efficiently to retain moisture. The results of this study showed potential benefits of Sargassum as a mulch in sweet potato cultivation but further work is needed to determine mulch effects with different cultivars on varying soils under non-drought conditions.

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## FERTIGATING LETTUCE (*LACTUCA SATIVA* L.) USING COMPOST TEA

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**Keywords:** Compost Tea, Lettuce, Application Rate, Root Architecture, Nutrient Partitioning

### **Abstract:**

Crop nutrient management is a critical component of productivity and quality. Commercial horticulture has relied almost exclusively on inorganic nutrient sources to satisfy plant nutritional requirements. Compost tea represents a sustainable alternative technology but its use has not been extensively researched. A factorial experiment was conducted subjecting lettuce plants to four increasing concentrations of compost tea; 0, 5, 10 and 20 % (m/v) applied at either 100 or 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup>, for 30 days. At the end of the trial, measurements were made of leaf area (LA), yield, shoot and root dry mass (DM), root to shoot ratio, and nitrogen (N) and phosphorus (P) contents of shoots and roots. Compost tea concentration significantly ( $P < 0.05$ ) affected all growth indices showing a similar pattern. Increasing concentration up to 10 % (m/v), positively improved growth and yield above the control. Increasing further to 20 % (m/v) reduced LA, yield and dry mass. For these variables, applying compost tea at 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup> resulted in a better response. Increasing concentration of compost tea showed a directly proportional relationship to shoot and root N content. However, the effect was non-significant for P. Yield and shoot DM were affected by the combination of compost tea concentration and application rate. Similar patterns of increasing yield were seen for increasing concentration within both rates however, the differences were significant for all concentrations at the higher application rate. Application of 200 cm<sup>3</sup>, 5 % compost tea resulted in the greatest yield, shoot and root DM. In addition to root DM, root surface area was significantly correlated with yield and shoot DM. Compost tea used at appropriate concentrations improved root growth and lettuce productivity.

### **Materials and methods:**

Repeated trials were conducted in an open ventilated greenhouse located at the UWI St. Augustine campus, Trinidad and Tobago (10.644276 °N, -61.401714 °W) over two months. Mean maximum and minimum temperature were 33 and 24 °C respectively, at a corresponding relative humidity of 65 and 95 %. Lettuce was grown in Promix (Sunshine Professional Growing Mix #15/LC15<sup>®</sup>, Sun Gro Horticulture, British Columbia, Canada) and fertigated with compost tea. Compost tea was made from cattle manure and corn straw composted using a rotary drum in-vessel system for two months. Three concentrations were tested consisting 5, 10 and 20 % m/v, with corresponding compost to water ratios of 1:20, 1:10 and 1:5 respectively. A control treatment was included where water substituted for the compost tea. Aerated extracts were prepared as described by Pant et al. (2009) and used as the only source of nutrients. Selected properties of the compost teas are displayed in Table 1. pH and EC were measured using an Eijkelkamp pH/mV/EC meter (Agriearch Equipment 2G Giesbeck, the Netherlands). NH<sub>4</sub><sup>+</sup> and NO<sub>3</sub><sup>-</sup> were determined via steam distillation (Bremner, 1996) and P by the ascorbic acid method (Kuo, 1996). Compost teas were applied at 100 or 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup>. Compost tea concentration and rate were combined in a factorial design with each treatment replicated five times. Treatments were arranged in a completely randomised layout.

Compost teas were applied as a drench treatment to 'Trinity Iceberg' lettuce using a 0.001 m<sup>3</sup> hand held spray can calibrated to deliver 100 cm<sup>3</sup> after 20 seconds, using a fine spray nozzle. In addition to the compost teas plants also received 100 cm<sup>3</sup> of water daily to minimise water stress. Plants were harvested whole including roots, after four weeks. Prior to harvesting, LA was measured using image analysis (Xiao, 2005). Adhering root media was removed by washing under running water and final rinsing with distilled water. Roots were separated from shoots and fresh weights recorded. Dry weights were determined after oven drying at 65 °C for 48 hrs. Subsequently, lettuce shoots and roots were ground to pass a 0.5 mm sieve using a Wiley mill (Glen Creston Ltd., Middlesex, UK). Milled samples were digested with H<sub>2</sub>SO<sub>4</sub>-Salicylic acid-H<sub>2</sub>O<sub>2</sub> formulation (Temminghoff and Houba, 2004), followed by N determination using steam distillation (Bremner, 1996) and P determination by the ascorbic acid method (Kuo, 1996). The trial was immediately repeated. At the end of the second growth period plants were harvested and treated in a similar manner to that explained for trial 1.

Data were analysed statistically by GLM ANOVA, examining main and interactive factor effects, using Minitab 17 Statistical Software (Minitab Inc. PA, USA). Means of all plant parameters for significant treatment effects were statistically separated using Tukey's multiple range test. Significance was defined at  $P < 0.05$ . Data is presented for trial 1 only.

**Main results:**

Measured chemical properties showed distinct relationships to compost tea strength. pH, EC and  $\text{NH}_4^+$  content increased with increasing compost tea concentration, whilst P and  $\text{NO}_3^-$  showed an inverse relationship (Table 1). Increases in extract pH and EC are likely associated with increasing content of mineralised elements from greater amounts of compost. This efficiency was not apparent with available P and  $\text{NO}_3^-$ . Notably they are both anions and their concentration in the compost may not be related to CEC, also Eghball (2002) stated that 85 % of P in composted manures are present in available form. Extraction efficiency decreased with increasing concentration and may be related to the extent of saturation which decreased with increasing amount of compost in the tea.

Concentration	pH	EC	P	$\text{NH}_4^+$	$\text{NO}_3^-$
% (m/v)		dS m <sup>-1</sup>	← mg kg <sup>-1</sup> →		
0	7.22	0.62	1.13	0	2.06
5	6.66	4.70	864	0	13.1
10	7.33	5.39	439	5.49	7.55
20	7.52	8.49	166	121	6.86

**Table 1.** Selected properties of compost teas

**Yield and Productivity**

Lettuce yield and corresponding shoot DM was affected by the combination of compost tea concentration and application rate. Inclusion of compost tea increased yield relative to the control for concentrations up to 10 % (m/v), at the low application rate (Figure 1). Further increases in tea concentration to 20 % (m/v) resulted in a significantly ( $P < 0.05$ ) lower yield compared to other treatments. Increasing application rate to 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup> significantly increased yield, doubling the yield for some treatments. The increase in the control treatment clearly indicates that although plants received supplemental irrigation, this amount did not satisfy their requirements, which may have limited growth at the low application rate. At this rate, inclusion of compost tea did not have a significant stimulating effect on yield, which is likely associated with lower amounts of available nutrients in addition to water deficits. The 5 % (m/v) tea treatment applied at the high rate produced lettuce with a significantly greater yield than all other treatments. This clearly demonstrated the influence of compost tea strength on plant performance. Pant et al. (2012) reported similar positive influences of compost tea on pat choi yield. The decline in yield at compost tea concentrations > 5 % m/v may be associated with elevated EC levels and resultant phytotoxicity. Andriolo et al. (2005) investigating the effects of salinity on lettuce yield under hydroponic conditions showed a similar positive effect of EC on yield with maximum yield associated with a solution EC of 1.93 dS m<sup>-1</sup>. They further reported a 16.5 % decrease in yield as solution EC increased from 1.93 - 4.72 dS m<sup>-1</sup>. EC for the 5 % (m/v) compost tea treatment was similar to the highest EC reported by Andriolo et al. (2005). The superior performance in this study may be related to genotype differences and environmental conditions, especially the fact that a chemically active solid medium was used, which can influence rhizosphere EC. Under experimental conditions lettuce tolerated compost tea with an EC threshold of approximately 5 dS m<sup>-1</sup>. Lazcano and Dominguez (2011) noted that use of vermicompost tea reduces the probability of phytotoxic effects arising from elevated EC and specific ions concentrations. However, this study showed the contrary. Shoot dry matter was less responsive to compost tea concentration compared to yield but followed a similar pattern (Figure 2). The lesser response can be explained by the influence of salinity on water uptake by plants.

Productivity variables including LA and root DM were significantly affected by compost tea concentration and application rate. Regardless of the variable, similar trends were observed. Compost tea treated plants performed superior to control plants, except at a concentration of 20 % (m/v) (Table 2). At that concentration all variables were negatively affected, with values lower than the control. Interestingly, root to shoot ratio was not affected by compost tea concentration alluding to a non-differential response between roots and shoots among tea concentration. However, application rate significantly affected all measures variables. Except for root to shoot ratio all other variables were greater at 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup>. Shalhevet et al. (1995) stated that root growth is almost always less affected than shoot growth by increasing salinity so that root to shoot ratio generally increases.

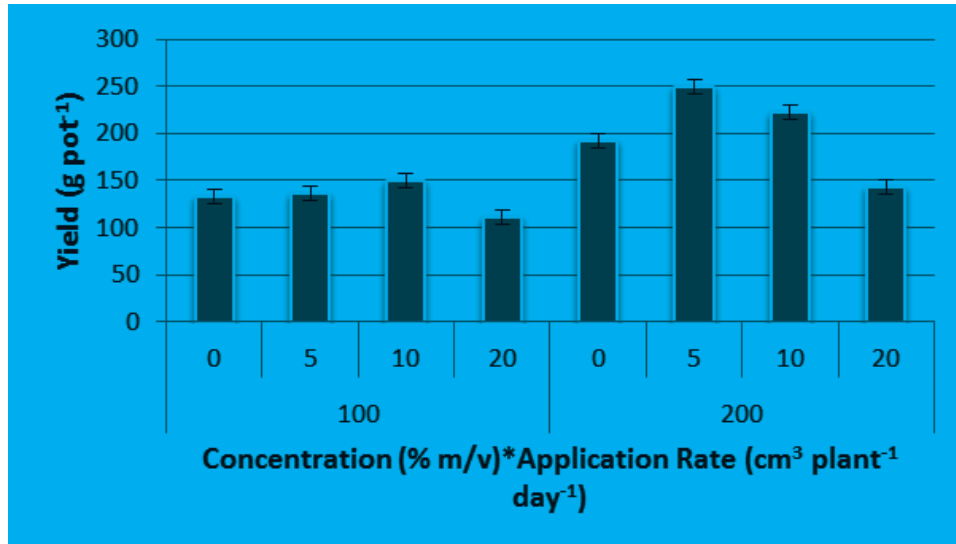


Figure 1 Combinatory effects of compost tea concentration and application rate on lettuce yield.

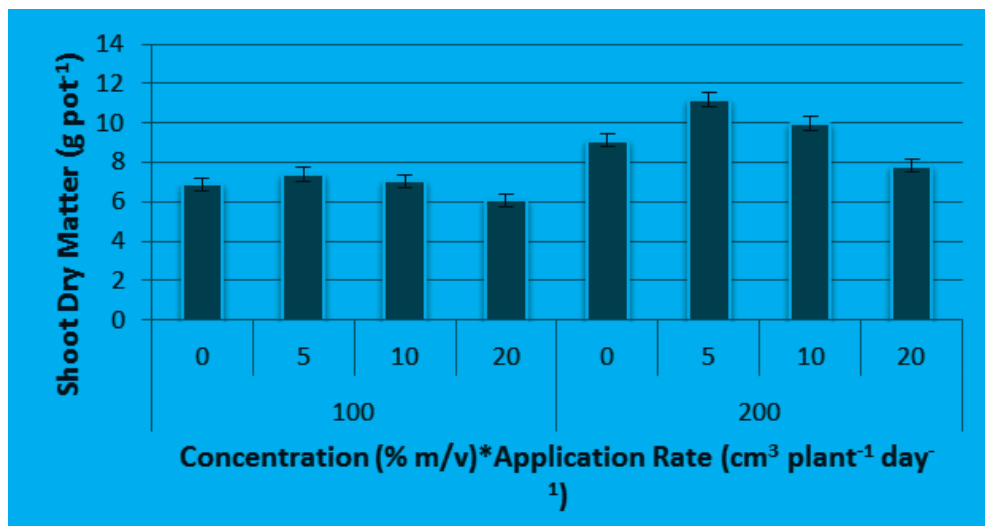


Figure 2 Combinatory effects of compost tea concentration and application rate on lettuce shoot dry matter.

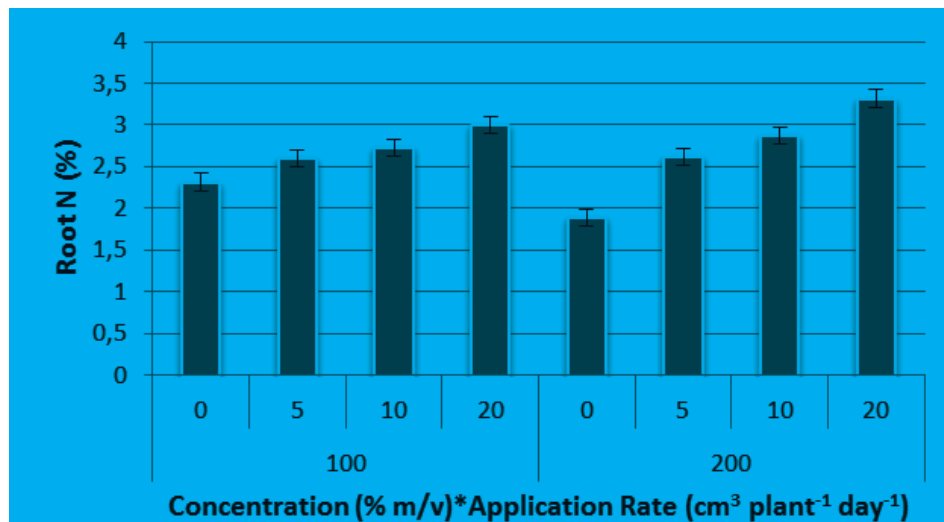


Figure 3 Combinatory effects of compost tea concentration and application rate on lettuce root nitrogen.

Treatment	Leaf Area	Yield	SDM	RDM	R/S Ratio	Shoot N	Root N	Shoot P	Root P
	cm <sup>2</sup>	← g pot <sup>-1</sup> →				← % →			
Concentration									
0	882.5ab	163.1b	7.99b	1.78ab	0.228	4.19c	2.10c	0.346	1.04
5	978.1a	193.1a	9.29a	2.11a	0.23	4.72b	2.60b	0.431	0.978
10	977.9a	186.1a	8.50ab	2.16a	0.256	4.70b	2.80b	0.367	0.921
20	799.1b	127.6c	6.95c	1.50b	0.227	5.48a	3.16a	0.444	1.09
					NS <sup>†</sup>			NS	NS
Rate									
100	837.6b	133.1b	6.85b	1.74b	0.257a	4.88	2.66	0.443a	1.02
200	981.3a	201.8a	9.52a	2.04a	0.214b	4.67	2.67	0.351b	0.992
						NS	NS		NS

**Table 2** Effects of compost tea concentration (% m/v) and application rate (cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup>) on lettuce productivity and nutritional quality

### *Nutrient Partitioning*

Root N was the sole variable significantly ( $P < 0.05$ ) affected by the interaction between compost tea concentration and application rate. Increasing concentration of compost tea resulted in increasing content of root N. Greater root N was present for all concentrations at the lower application rate, except for 20 % (m/v). Lower contents of root N at similar tea concentrations for the high application rate may be associated with greater N loss. Increased volume of water may have contributed to greater leaching of soluble N, especially for lower concentrations which had greater contents of NO<sub>3</sub><sup>-</sup> relative to NH<sub>4</sub><sup>+</sup> (Table 1). Additionally, greater yield and shoot dry matter at 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup> may have contributed to greater N assimilation in shoots relative to roots. Root N content may be associated with compost tea NH<sub>4</sub><sup>+</sup> content, which was greatest at 20 % (m/v). Wang and Shen (2012) noted improved root architectural traits with increasing NH<sub>4</sub><sup>+</sup> content in hydroponic solutions. In this regard reduced yield and SDM for compost tea concentrations of 20 % (m/v) is not likely due to nutrient imbalances but associated with solution EC.

Shoot and root N were significantly ( $P < 0.05$ ) affected by compost tea concentration. N content increased with increasing concentration of compost tea. According to Hartz et al. (2007) shoot N content for all treatments except the control were within the sufficiency range. This finding supports that of Lazcano and Dominguez (2011) who reported a non-significant effect of application dose on tissue nutrient content, but opposes other works (Hargreaves et al., 2008; Reeve et al., 2010). Neither shoot nor root N was affected by application rate, which supports the notion that plants received an adequate amount of nutrient and were not limited by shortfalls in nutrient availability. Compared to plant N, P content and partitioning was non-significantly influenced by experimental treatments. This result supports the preposition that compost tea has a greater influence on N uptake, probably through actions of other biochemical compounds. While shoot P was greater at the lower application rate, N was unaffected. Improved P uptake may be associated with greater root to shoot ratio and root surface area (data not shown). Radin and Warman (2010) reported that doubling the application rate of compost tea had no significant effect on tissue nutrient content. A similar response was observed in this study.

### **Conclusion:**

Compost tea concentration and application rate both influenced lettuce yield and productivity. Application of 200 cm<sup>3</sup> plant<sup>-1</sup> day<sup>-1</sup> of 5 % (m/v) compost tea resulted in the greatest yield and dry matter, but not the greater tissue nutrient content. The highest concentration of compost at either rate produced phytotoxic effects in lettuce lowering yield and dry mass. EC of the compost tea was the variable most related to plant performance. Lettuce nutrient content increased proportionally with compost tea concentration in both roots and shoot. Shoot N content was within the sufficiency range for all treatments accept the control. Tissue P content was unaffected by tea concentration. Compost tea showed a greater effect on N uptake and assimilation. Its use as a primary or supplementary nutrient source is encouraged for horticultural crops.

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## FACTORS AFFECTING COMPOST ADOPTION IN FRENCH WEST INDIES

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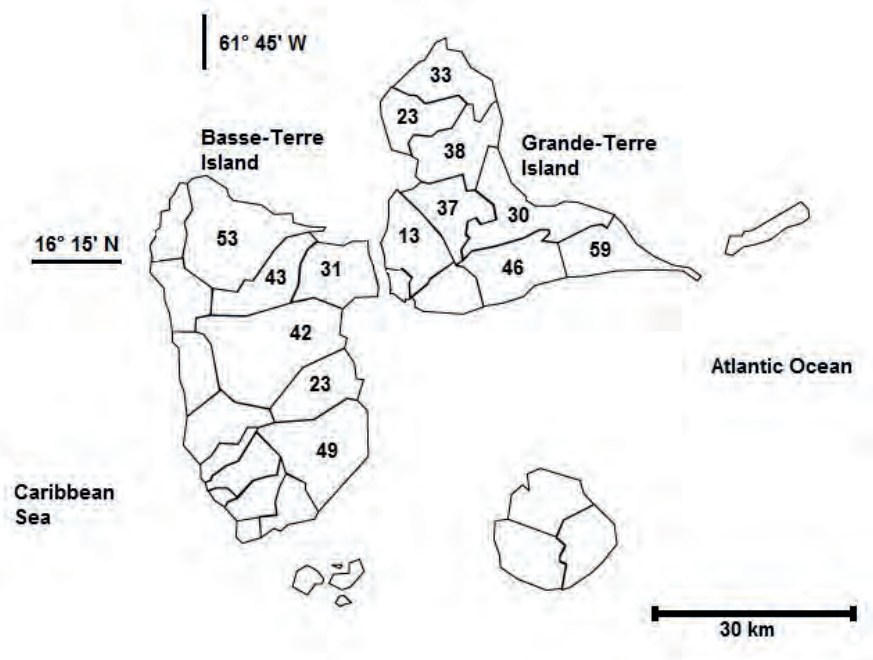
**Keywords :** survey; adoption; compost; logit model; French West Indies

### Abstract :

In French West Indies, local authorities have proposed composting as a sustainable practice for recycling organic wastes, as well as for orientating farmer towards the use of organic amendments to fertilize degraded tropical soils. The aim of this study was to identify the determinants of compost adoption in Guadeloupe (French West Indies). The study was based on a survey of 520 farmers covering a wide range of agro-ecological regions and cropping systems. Fourteen biophysical and socio-economic variables were used to explain compost adoption with a logit regression model. The logit model was used to simulate the effect of the analysed variables on adoption under different agricultural scenarios, and to propose the implementation of Agri-Environmental Schemes promoting the use of composts under tropical conditions.

### Materials and methods :

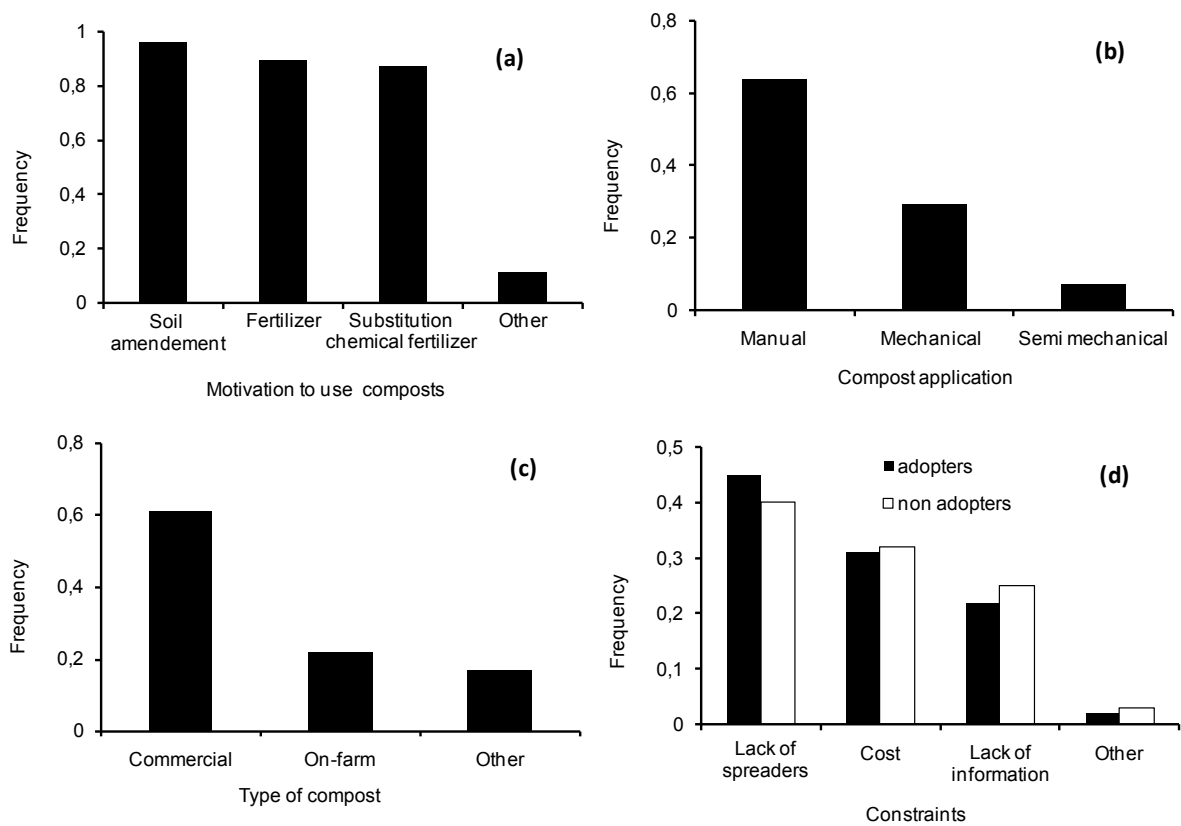
The study was carried out in Guadeloupe, which is made of two main islands (Basse-Terre and Grande-Terre) and several smaller islands, which provides a good representation of the spatial variability of agriculture in the Caribbean (Figure 1). Data was collected through a survey performed on a sample of 520 farmers covering a wide range of agro-ecological regions and cropping systems, which represented 7% of the total population of farmers and 17% of the agricultural area of Guadeloupe. Only the islands of Basse-Terre and Grande-Terre with an important agricultural activity were analysed during this study. The survey was made by a team of three trained enumerators through face-to-face interviews with the farmers. Farmers were selected randomly from a database covering all the territory, where 279 were located in Grande-Terre and 241 in Basse-Terre. The sample was stratified to cover all the diversity observed in Guadeloupe, both in terms of agro-ecological conditions (pedoclimatic conditions and nature of the farming system) and economic resources of farmers (farm size). The questionnaire was made of two parts. The aim of the first part was to identify the reasons for using (or not using) composts, and the perception of barriers to adoption and potential incentives for facilitating adoption. The second part consisted in describing the farmer's socio-economic profile as well as the farm structure and the nature of the farming system in terms of crops and livestock. The variables collected in this second part were used to characterize of the farmer types reported by Chopin et al. (2015) for Guadeloupe. Fourteen biophysical and socio-economic variables were selected to explain compost adoption with a logit regression model. The logit model was then used to simulate the effect of the analysed variables on adoption under different agricultural scenarios



**Figure 1.** The archipelago of Guadeloupe in the Caribbean region. Numbers indicate the number of farmers surveyed in each municipality.

**Main results :**

The survey indicated that 96 farmers use composts, which represented an adoption rate of 18%. Adoption is significantly higher in Basse-Terre (27%) than in Grande-Terre (11%). The amended area is highest for banana systems followed by vegetable and tuber crops (Table 1). The amended area of sugarcane is low. The amended area for orchard, melon, pineapple and grasslands represent only 4% of the total amended area. Most of adopters declared that they apply composts as organic amendment, as fertilizer and to substitute chemical fertilizers in order to reduce pollution risks (Fig. 2a). Other motivations were minor in this study; e.g. organic farming, waste recycling. Near 60% of the adopters apply composts manually (Fig. 2b) and use commercial composts (Fig. 2c). Only 22% of the adopters declared to produce their composts on farm, which are mainly made with green wastes blended with poultry litter or pig manure. The question about the main constraints in compost utilization was asked to both adopters and non-adopters farmers and the results obtained are presented in Fig. 2d. It is interesting to note that farmers showed the same perception of these constraints regardless compost adoption. In this way, the arduousness of the manual application was the main constraint highlighted by farmers, followed by the cost of the practice (product, transport and application) and the lack of available information about compost quality and its effect on the crops and the soil.



**Figure 2.** Results of the survey performed on a network of 520 farmers: (a) motivations to use composts, (b) type of compost application, (c) type of compost used by farmers, and (d) constraints found by farmers to use composts. Although only adopters were questioned for (a), (b) and (c), the question about the constraints in (d) was asked to both adopters and non adopters farmers.

Crop	Cultivated area	Amended area	
	ha	ha	%
Banana	657	261	40
Vegetable crops	433	91	21
Tuber crops	118	22	19
Sugarcane	2659	83	3
Orchard	44	7	16
Melon	53	3	6
Pineapple	63	2	3
Grasslands	1260	7	1
Total	5287	476	9

**Table 1.** Cultivated and amended area for the crops involved in the survey performed for this study.

The results of the econometric model revealed that adoption of compost is mainly determined by the nature of cropping system at the farm level. Although banana, vegetable and tuber crops affected positively the adoption rate, sugarcane affected it negatively. Farmer experience, education and information also affected positively the adoption rate but their effect was less compared with that of the cropping system. Farmer's age and livestock activity had a slight negative effect on compost adoption.

#### **Conclusion :**

The relatively small rate of compost adoption found in this study was mostly associated to the low use of compost in the dominant sugarcane systems and to several socio-economic factors such as the high cost of the practice, the weak level of farmer education and the lack of professional organisations in some production sectors. Several action levers should be combined to increase the global adoption rate and the specific rate in sugarcane. First, it appears that specific compost like organic fertilizer rich in nutrients and cheaper than chemical fertilizers could be adopted by sugarcane planters. Second, current Agri-Environmental Schemes should be improved to adapt them to the specific requirements of small and large farms. This concerns principally subsidies to peasant associations to purchase spreaders adapted to different cropping systems to be used by memberships. This could reduce labour costs and motivate farmers to join farmer's associations, which is essential to develop effective dissemination channels. Also, the installation of a composting platform in the Basse-Terre Island, having the highest number of adopters, would contribute to the reduction of transportation cost, mainly for smallholder farmers. Third, on-farm composting should be further promoted for smallholder farmers cultivating high value vegetable and tuber crops for the local market. In this case, Agri-Environmental Schemes could be proposed to compensate the cost of transportation from the source of supply of raw materials (e.g. manure) to the farm. Finally, research has an important role to play to propose proper raw material blends and composting procedures, such as vermicomposting, able to produce high quality composts under tropical conditions.

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## DEVELOPMENT OF A PHYTOTOXICITY BIOASSAY FOR SOIL AMENDMENT PRODUCTS FROM ORGANIC WASTE RECYCLING

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**Keywords :** chlorophyll index, SPAD, plant height, number of leaves, root length

### Abstract :

A germination bioassay was developed to screen for potential phytotoxicity of soil amendment products from organic waste recycling. In phase 1 of the study, nine soil amendment products were applied as mulches on 3- to 5-week-old tomato seedlings (*Solanum lycopersicum* L. 'HA3019') planted in 4L pots. Plant growth was reduced by the less mature mulch materials. Using lettuce (*Lactuca sativa* L. 'New Red Fire') as the test species, a laboratory germination test was developed in phase 2 with aqueous extracts from a non-phytotoxic (safe) and a phytotoxic product identified in phase 1. Extracts were obtained by soaking 10g of air-dried product in 90 mL distilled water for 24h at 25°C. Diluted extracts (0, 25, 50, 75 and 100%) were applied to lettuce seeds sown on filter paper in petri-dishes and germination was monitored for 5 days, confirming the results from phase 1. In phase 3, the bioassay developed in phase 2 was used to test three previously untested local products and one imported product. Two of the local products were comparable to the imported product. Results obtained in phase 3 were confirmed using the mulch test as described in phase 1. Hence, the germination bioassay can be a useful tool for quality control in the production of 'safe' soil amendment products from organic waste recycling.

### Materials and methods :

In phase 1, tomato seedlings were transplanted into 4L plastic pots containing a 1:1 sand/soil ratio with the soil medium filled to 5cm below the rim of the pot. A soluble fertilizer (NPK 24:8:16 Scotts Miracle-Gro Products, USA) was applied at 3 g L<sup>-1</sup> to all pots within 1 week after transplanting. Ten mulch treatments were applied after 1 week as follows: Vermiculite (VC, Control), Coconut and wood chips (CW) and Plant and Tree Clippings (PC) applied at product ages of 3 months (CW1, PC1), 8 months (CW2, PC2) and final product (CW3, PC3), and Coconut and Green Waste (CG) applied at product ages of 3 weeks (CG1), 3 months (CG2) and 8 months (CG3). A randomized block design was used with 4 replications and observations on plant height, number of leaves and leaf greenness (SPAD, Spectrum Technologies Inc., USA) were made at 3-day intervals over a 3-week period.

Air-dried samples (10g) of a 'safe' and a phytotoxic product identified from phase 1 were extracted in 90 mL of distilled water in phase 2. Three replicates of each sample were placed in filter paper pouches or directly in the water and extraction time was 24h or 48h. Each sample extract was diluted to 25, 50, 75 and 100% strength and used in the germination test with lettuce seeds. Fifty seeds were sown on filter paper moistened with extract or distilled water in a covered petri-dish (diameter: 9 cm). Seed germination was monitored daily and root elongation was measured after 5 days. In phase 3, germination tests were conducted on three local products and one imported product with direct placement of samples in distilled water and an extraction time of 24h.

### Main results :

Tomato leaf production in phase 1 was significantly reduced compared to the Control (VC) in treatments CG1, CW1 and CW2 at 15 days after mulch application and in almost all mulch treatments after 21 days (Table 1). Over the 3-week period, the average plant height was also significantly reduced for treatments CG1 and CW1 (data not shown). Phytotoxicity tests are likely to be conducted on products that are close to maturity, therefore products CW2 and CW3 were selected as the phytotoxic and non-phytotoxic products, respectively, to be tested in phase 2.

Root elongation and germination tests have been used previously to test for phytotoxicity, with lettuce seeds showing high sensitivity (Di Salvatore, Carafa, and Carrat<sup>1</sup> 2008). No significant differences in germination of lettuce seeds were observed in mulch extracts obtained at different extraction times (24h and 48h), and with or without the placement of the mulch sample in filter pouches (data not shown). Root elongation of lettuce seedlings was reduced with the extract from the phytotoxic product (CW2) but not with that from the non-phytotoxic product (CW3, Figure 1), compared to the Control seeds moistened with distilled water. Lettuce seed germination was reduced more for the phytotoxic product (CW2, data not shown). In phase 3 of the study, lettuce seed germination was reduced for one local product (Table 2), and this product also reduced tomato plant growth when applied as a mulch (Figure 2). Root elongation appeared to have been promoted by extracts from the soil amendment products tested in phase 3 (data not shown).



Day	Mulch Treatment									
	CG1	CG2	CG3	CW1	CW2	CW3	PC1	PC2	PC3	VC
9	10.00	12.00	10.75	10.75	9.75	11.25	10.50	11.25	10.25	11.25
12	10.00*	12.00	11.50	11.00	10.50	12.00	10.75	12.00	10.50	11.75
15	10.50*	13.00	12.50	11.00*	11.00*	13.00	11.50	12.00	12.00	12.75
18	11.25*	13.00	13.25	12.25	11.50*	13.00	13.00	13.00	12.25	13.75
21	13.25*	13.33*	13.50*	13.00*	12.50*	13.00*	13.75	13.50*	12.50*	15.50

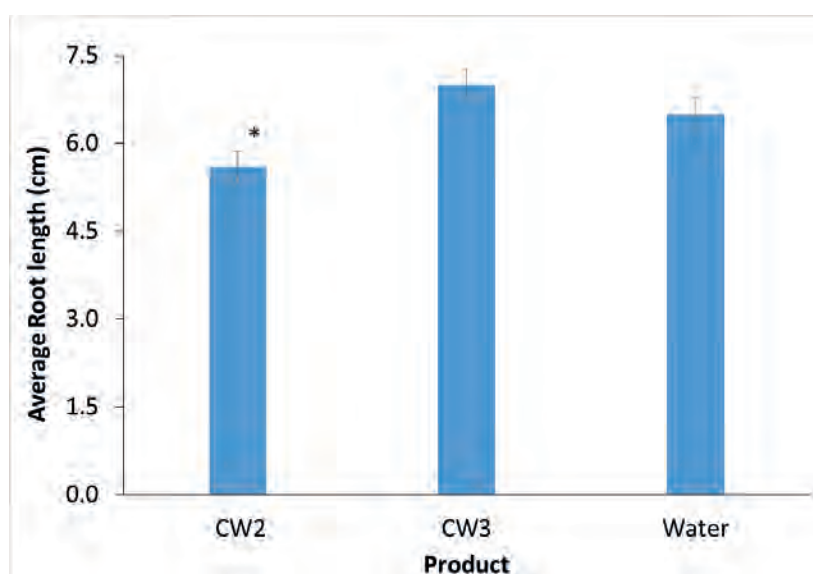
\* Values significantly different from the corresponding Control (VC) value at the 5% significance level by the LSD test (SE= 0.582 LSD= 1.657).

**Table 1.** Leaf production in potted tomato seedlings at various times following mulch application of Coconut and Green Waste (CG), Coconut and Wood (CW), and Plant and Tree Clippings (PC) at 3 product development stages (1 indicates the least and 3 the most mature).

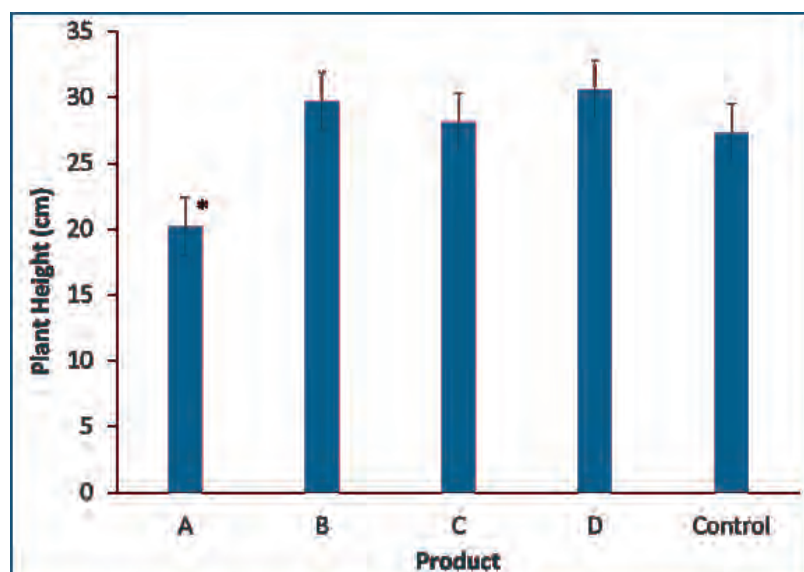
Product Extract	Extract Concentration (%)				
	0	25	50	75	100
A		98.7	98.0	86.7	62.7*
B		99.3	100.0	100.0	100.0
C		100.0	100.0	100.0	100.0
D		99.3	99.3	98.0	98.0
Distilled water	99.3				

\* Value significantly different from the corresponding Control value at the 5% significance level by the LSD test.

**Table 2.** Germination percentage of lettuce seeds after 5 days in various concentrations of four product extracts (A, B, C and D) compared to the Control (water).



**Figure 1.** Root elongation of lettuce seedlings germinated in extracts of products CW2 and CW3 compared to the Control treatment (water). \* Value significantly different from the corresponding Control value at the 5% significance level by the LSD test.



**Figure 2.** Height of potted tomato plants at 3 weeks after mulch application of four soil amendment/mulch products (Local: A, B, C; Imported: D) compared to the Control (Vermiculite). \* Value significantly different from the corresponding Control value at the 5% significance level by the LSD test.

**Conclusion :**

The lettuce seed germination bioassay appeared to be a simple, rapid and relatively low-cost method for the testing of soil amendment products and mulches for phytotoxicity prior to public release for sale. Better quality control of soil amendment products on the market is likely to improve the utilization of these products by farmers for soil protection and improvement.

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Di Salvatore, M, AM Carafa, and G Carrat<sup>1</sup>. 2008. "Assessment of heavy metals phytotoxicity using seed germination and root elongation tests: A comparison of two growth substrates." *Chemosphere* 73 (9):1461-1464.

## EVALUATING THE EFFECT OF VESICULAR – ARBUSCULAR MYCORRHIZAE ON TOMATO PLANT GROWTH AND PRODUCTION

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**Keywords:** Tomato, bio fertilizer, VAM, sustainability, fruit production

### Abstract

Tomato is one of the most popular vegetables in the world. Therefore, for improvement in crop productivity in Suriname and most other countries, excessive application of pesticides and synthetic fertilizers is used. These result in gradual depletion of soil fertility and microbial diversity. Conventionally managed soils are found to exhibit a poorer micro flora and a lower biological activity than organically managed soils. Recently much attention is paid to organic cultivation and the use of bio fertilizers as a supplement for chemical fertilizers. VAM fungi have the potential to improve the sustainability of tomato production by improving yield and quality. Therefore, the aim of the study was to evaluate the effect of two different concentrations of commercially available vesicular - arbuscular mycorrhiza on the plant growth and fruit production of two tomato varieties (*Lycopersicon esculentum* Mill.) in the greenhouse. The experiment was set up as a randomized factorial block design with two independent factors and consisted of six treatments and three replications. The factors were two tomato varieties: hybrid 61 and hybrid 501 and two concentrations of VAM namely 2.5 and 10 g. VAM/plant. Biomass was determined two times, at bloom initiation and at the end of the experiment. The growth parameters were measured once per week. The production was recorded only for the first two harvest times. Data was statistically analyzed using three-way ANOVA. The results of this experiment showed that the VAM fungi had a positive influence ( $p < 0.05$ ) on the production for both varieties of tomatoes. And it also resulted in earlier reproduction. There was no significant difference in production ( $p > 0.05$ ) between the two concentrations of VAM inoculum used.

### Material and methods

The experiment was set up as a randomized factorial block design with two independent factors. The factors to test the efficiency of VAM inoculum on the growth and production of tomato plants were: -Tomato variety (Tomato hybrid 61 and Tomato hybrid 501); - Concentration VAM inoculant (2.5 and 10 g. of VAM inoculum per plant). Three weeks after germination, the seedlings were transplanted for the implementation of the experiment in the greenhouse at ICCA. Before transplanting the soiled plant pots were irrigated and plant holes were made in the growth medium. During transplanting the concentration of VAM inoculant, purchased from Bio Organics, was applied to the plant.

The experiment consisted of six treatments and three replications:

- Blanco treatment tomato hybrid 61 (CV1)
- Blanco treatment tomato hybrid 501 (CV2)
- Plants inoculated with 2.5 g of VAM fungi, tomato hybrid 61 (T1V1)
- Plants inoculated with 2.5 g of VAM fungi, tomato hybrid 501 (T1V2)
- Plants inoculated with 10 g of VAM fungi, tomato hybrid 61 (T2V1)
- Plants inoculated with 10 g of VAM fungi, tomato hybrid 501 (T2V2)

To evaluate the effect of VAM fungi on the growth and production of the tomato plants, the following was observed and measured:

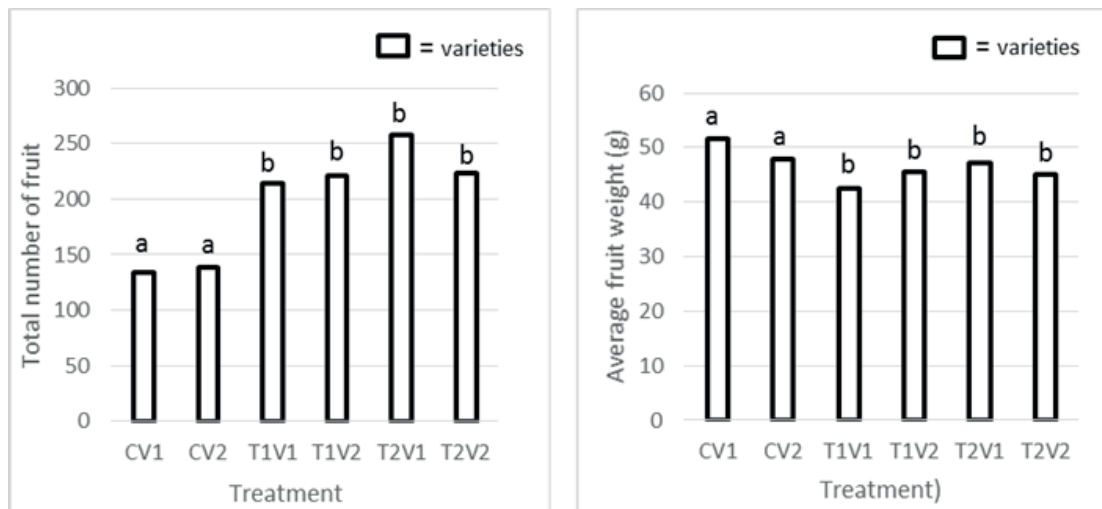
- The biomass at bloom initiation and in the end of the experiment
- The nitrogen and phosphorus content in the shoots at bloom initiation and in the end of the experiment
- The growth parameters
- The production was recorded only for the first two harvests

Data was statically analyzed using a three –way ANOVA followed by Duncan's Multiple range test.

### Results

The results of the plant growth in a low fertile soil revealed that the plants performed well, though they were not fertilized. The Nitrogen and Phosphorus content are crucial for VAM symbiosis, which is characterized by nutrient exchange between the symbiotic partners. The results showed that in both cases there was a significant difference between the control plants and the treated plants ( $p < 0.05$ ). The N and P content in the tissue of the treated plants was higher than of the control plants.

The results of this experiment showed that the VAM fungi had a positive influence ( $p < 0.05$ ) on the production for both varieties of tomatoes. And it also resulted in earlier reproduction. There was no significant difference in production ( $p > 0.05$ ) between the two concentrations of VAM inoculum used. The treated plants had a higher production, but a lower average fruit weight. More fruits may mean, less nutrients for each fruit, which decreases fruit weight per plant.



**Figure 1** Total number of fruits and average fruit weight. Different letters & color indicate significant different values according to the Duncan's Multiple range test ( $P < 0.05$ )

### Conclusions:

From this research there can be concluded that:

- The VAM fungi had a positive effect on the growth and development
- Tomato hybrid 61, inoculated with 2.5 g/plant had the highest biomass production and N and P content
- Tomato hybrid 501, inoculated with 10 g/plant had the highest biomass production and N and P content in their tissue
- The inoculum had positive influence on the production for both tomato varieties
- The inoculum resulted in early reproduction
- There was no significant difference in production between the two concentrations of inoculum used.
- The recommended dose of 2.5 g VAM inoculum per plant is enough to significantly increase production

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## HOW TO FOSTER MYCORRHIZA? FROM BRAKES TO LEVERS

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**Keywords:** agroecology, innovation, participatory design, natural regulations

### Introduction

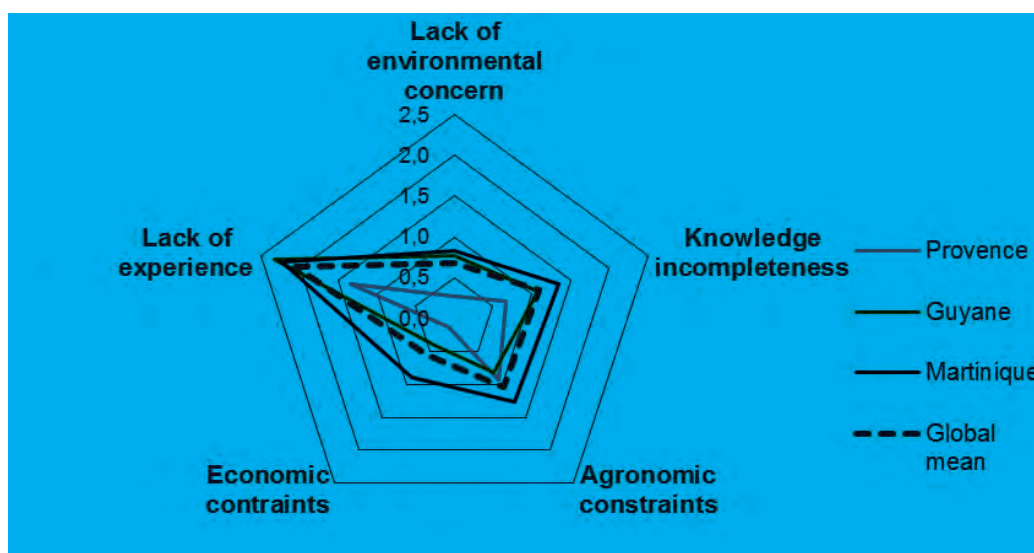
Agroecology aims to design economically and environmentally efficient cropping systems, based on the exploitation of natural regulations. Arbuscular mycorrhiza (symbiosis between roots and soil fungi) are of growing interest for such an ecologization of agriculture, as they are likely to provide ecosystem services and enhance crop health and productivity, reducing the use of chemicals. Agroecology no longer offers one-stop solutions but calls for a diversity of solutions that leaves the choice to farmers to build their own trade-offs, relying to some extent on their empirical knowledge, scientific knowledge and available products. An innovative design strategy was experienced with horticulture producers to collectively build strategies to foster mycorrhiza.

### Material and methods

We implemented a participatory approach to identify brakes and levers to foster mycorrhiza in horticultural fields (Chave et Angeon, 2015). In different areas (Martinique, French Guiana and Provence) researchers, technical advisers and farmers were involved in an innovative design strategy aimed at sharing knowledge on “How to enhance and benefit from mycorrhizas?”. Different types of brakes were identified and compared between the 3 case studies. Statistical data were subjected to analysis of variance (ANOVA) and compared using Student test ( $P < 0.05$ ). A set of levers was analyzed as the result of the agronomic propositions stressed by farmers. Following Hatchuel et al. (2009), these propositions were gathered in a hierarchical tree starting from an initial concept (Le Masson et al., 2006): “Mycorrhiza valorization” which was divided in 3 sub-concepts: *i.* fungi propagules production, *ii.* plant-arbuscular fungi association and *iii.* mycorrhizal networks densification.

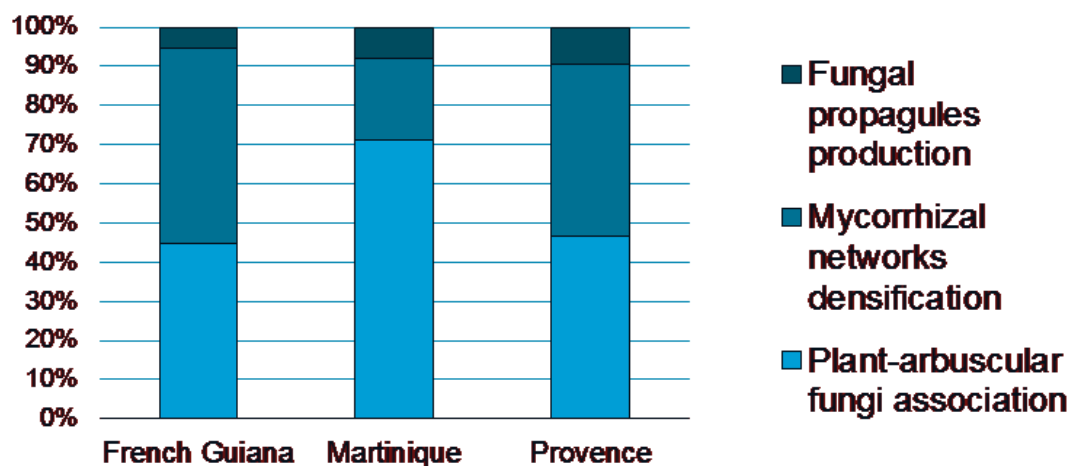
### Main results

In the three case studies, 5 brakes were identified and classified following the same order by the farmers: the lack of experience (difficulty in exchanging practical knowledge), agronomic constraints, knowledge incompleteness, economic constraints and lack of environmental concern. Nevertheless, the 5 brakes do not appear with the same intensity among the 3 territories. The lack of experience, knowledge incompleteness and economic constraints are significantly different in Provence compared to the others ( $P < 0.05$ ; Student Test) (figure 1). In French Guiana and Provence, most of the farmers' propositions rely on the sub-concept *iii.* mycorrhizal networks densification via mycorrhizal-friendly practices (inputs and tillage decrease) although in Martinique farmer's favor the sub-concept *ii.* plant-arbuscular fungi association in mixed cropping systems including mycorrhizal plants (*legumes*, *alliaceae*). Moreover, collective actions were proposed in Martinique and French Guiana. Farmers suggested that they would like to experiment native strains production through mycorrhizal crops cultivation (sub-concept *i.* fungi propagules production).



**Figure 1.** Types of brakes identified by farmers exploring the concept of « mycorrhizae valorization ».





**Figure 2.** Levers proposed by farmers of the three regions classified by sub-concepts of the initial concept « mycorrhizae valorization ».

### Conclusion

The participatory approach favored the whole exploration of the concept tree “Mycorrhiza valorization”. The collective local dynamics resulted in research-action projects to implement and assess effective solutions embedded in the ecological and organisational properties of the studied agrosystems.

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## APPLYING C-13 TECHNIQUES IN EXPLORING THE CARBON SEQUESTRATION POTENTIAL OF LIMED ACID SOILS FROM TRINIDAD

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**Keywords :** Carbon dioxide emissions, carbon sequestration, C-13, aglime, acid soils

### Abstract :

Carbon dioxide (CO<sub>2</sub>) accounts for the largest proportion (74%) of total greenhouse gas (GHG) emissions globally, with agricultural activities contributing approximately 25% of this gas. Opportunities to reduce the emissions in the sector can therefore contribute significantly to mitigating global climate change. Ag-lime is used extensively to alleviate problems of soil acidity and the potential for this material to contribute to C sequestration in soils is gaining interest among researchers. A laboratory experiment using C-13 isotopic labelling techniques was therefore established to answer the following questions: 1) Is there a potential for sequestering C using ag-lime in Trinidad acid soils? 2) Does enhancing soil microbial respiration by applying labile organic amendments enhance the C sequestration potential of ag-lime? 3) Are lime-derived C (LDC) estimates from non-isotopic difference technique comparable to that from the C-13 isotopic labelling technique? The results ascertained for the study showed significant (P<0.05) differences between the LDC estimates from the two techniques with the non-isotopic techniques yielding higher estimates. Over the 32-day experiment, between 16.4 to 85.4% of the ag-lime C was released as CO<sub>2</sub> with values being lower for the Piarco soil. The LDC in the CO<sub>2</sub> was also significantly (P<0.05) lower for the poultry litter treatments comparison to the other organic amendments for the Piarco soil but not the Nariva soil. This effect may not have been as a result of an enhancement of the carbon sequestration potential of the ag-lime due to an elevation in soil microbial respiration since the LDC in the glucose-amended soils did not differ significantly from the no-amendment control soils.

### Materials and methods :

The two acid soils (Nariva series, Typic Hydraquents and Piarco series, Aquoxic Tropudults) used in the experiment were incubated in 1L media bottles in a laboratory at 25°C. The soils were amended with varying combinations of C-13 labelled (5.91% C-13 atoms) ag-lime (0%w/w and 0.230% w/w), organic amendments (0%w/w, 1% w/w poultry litter, 1%w/w corn stover, and 1% w/w glucose) at 100% soil water holding capacity (WHC) to give a total of 16 treatments with three replicates. Gas samples were taken 12 times over the 32 day experiment. At each sampling, a 30mL sample was taken for C-13 analysis on a Picarro G1101-i isotopic CO<sub>2</sub> analyser while a 20mL sample was taken for total CO<sub>2</sub> quantification by Gas Chromatography. Statistical analyses (ANOVAs) were done to identify significant main and interactive effects.

### Main results :

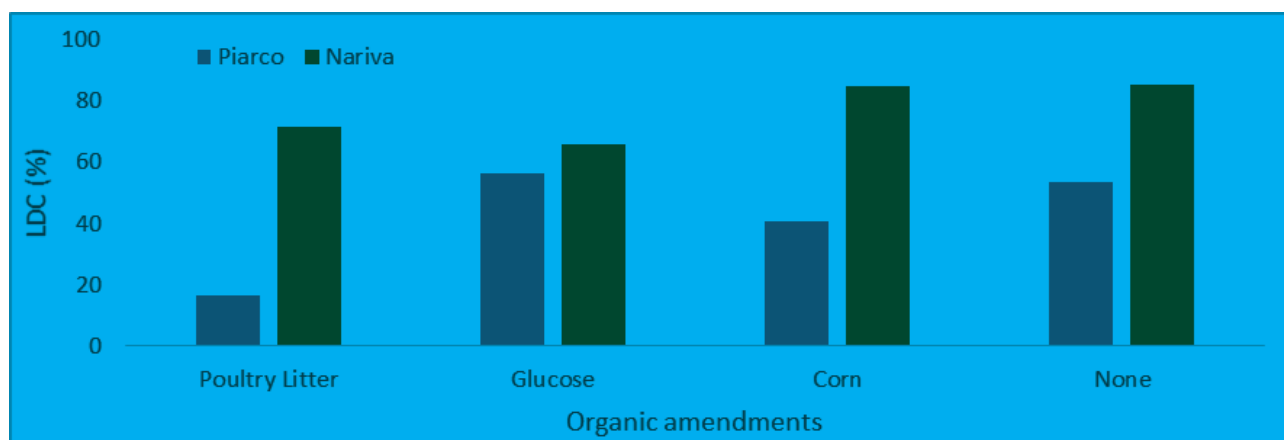
There was a significant effect of the organic amendment on the lime-derived C in the CO<sub>2</sub> emissions (LDC) between the two soils based on the C-13 technique (Figure 1). For the Piarco soil, the LDC was significantly lower for poultry litter compared to all other organic amendment, which however, was not the case for the Nariva soil. The LDC for the glucose amended soils did not differ significantly from the control soils even though this amendment had the greatest emissions (data not shown). The glucose-treated soils had higher emissions than all other organic treatments in the order glucose > corn stover > poultry litter = control. Figure 2 shows that while the LDC values were comparable for both the C-13 and difference methods, for the Nariva soil the values for the difference method was double that for the isotope technique.

### Conclusion :

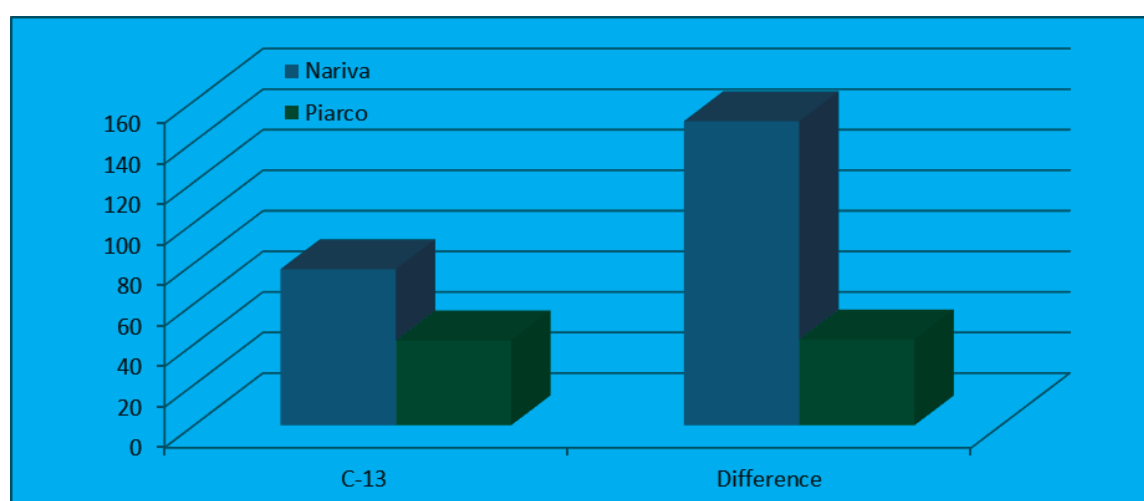
It is likely that the reduction in the percentage of C released from lime for the poultry litter and corn treatments was independent of any enhancement of microbial respiration following the application of these amendments and the cause may be chemical in nature (Ahmad et al. 2014; Tamir et al. 2013).

The priming effect of aglime on soil respiration may have been much more significant for the Nariva soil than it was for the Piarco soil and indicate an important limitation with the difference method in making conclusions about LDC for some soils.

On the basis of the C balance between the quantity of C applied and what is lost as CO<sub>2</sub>, the results provide some evidence of carbon sequestration in limed acid soils although confirmation of the exact amount will be made when the soils are analysed at the end of the experiment.



**Figure 1.** Effect of organic amendments on the lime-derived C in the CO<sub>2</sub> emitted (LDC) for the two soils.



**Figure 2.** The interaction between soil type and estimation method on LDC

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## PRELIMINARY OBSERVATIONS ON MILK COMPOSITION DUE TO THE INCLUSION OF SOLID PROBIOTIC INTO A DAIRY FEED IN COWS - A CASE STUDY

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**Keywords :** Celmanac milk composition, solid non fat, Druminske score

### Abstract :

The purpose of this study was to investigate the effect on milk composition of the inclusion of a fixed amount of solid prebiotic celmanac into a dairy feed before milking in lactating cows. Fourteen lactating cows, 3-4 mo lactating, were randomly equal in terms of approximate days into lactation, and allocated to one of two treatment groups: Control no Supplementation and Celmanax supplemented. Milk samples were collected every 7 days for approximately 8 weeks and sent to the lab for milk composition analysis and Draminski score testing. Cows supplemented with Celmanax had a higher ( $p<0.05$ ) butter fat content (2.91%) when compared to the control (2.48%). SNF, protein & lactose percentages were lower ( $p<0.05$ ) than the control Milk fat, SNF, or lactose percentages were not affected by treatment ( $P>.01$ ) In conclusion, butterfat percentage was higher for cows supplemented with Celmanax than supplemented cows.

### Materials and methods :

Fourteen, 3-4 months into lactation cows were randomly, equal in terms of approximate days into lactation, and allocated to one of two treatment groups: Control no Supplementation and Celmanax supplemented. Cows were allowed 2 kg of 18% dairy ration to which was added 25 gm solid Celmanax each day before twice a day milking. Milk samples were collected every 7 days for approximately 8 weeks and analysed for milk composition and Draminski score testing. Composition of the milk from individual goats were analysed using a Lactoscan SP (Nova Zagora, 8900).

### Main results :

Cows supplemented with Celmanax had a higher ( $p<0.05$ ) butter fat content (2.91%) when compared to the control (2.48%). Solid Non-Fat was higher ( $p<0.05$ ) for the control group of cows (8.1%) when compared to Celmanax treated cows (7.63%). Celmanax treated cows had a lower ( $p<0.05$ ) milk density (27.4%) when compared with the control group (29.4%). Similarly, protein was lower ( $p<0.05$ ) for the Celmanax supplemented group (2.75%) when compared with the control group of cows (2.95%) (Table 1). Cows supplemented with Celmanax had significantly lower lactose content (4.19%) when compared to the control group (4.43%). The percent water was highest ( $p<0.05$ ) in the Celmanax treated group of cows (7.56%) and lowest in the control group of animals. Similarly, the milk temperature was significantly higher for cows given Celmanax (29%). In contrast, the milk freezing point was higher ( $p<0.05$ ) for cows in the control group (0.51%) when compared to the Celmanax supplemented group (0.48%). The milk salt levels was highest ( $p<0.05$ ) for the control group of cows (0.66%) whereas milk conductivity was highest for the Celmanax supplemented group (5.64%). The Draminski score was lowest ( $p<0.05$ ) among the Celmanax supplemented group (424) when compared to the control group (442).

Milk Composition (%)											
Treat.	Fat	SNF	Dens.	Prot.	Lactose	Water	Temp	FP	Salt	C	DS
Celmanx	2.91 <sup>a</sup>	7.63 <sup>a</sup>	27.4 <sup>a</sup>	2.75 <sup>a</sup>	4.19 <sup>a</sup>	7.56 <sup>a</sup>	29 <sup>a</sup>	0.48 <sup>a</sup>	0.62 <sup>a</sup>	5.64 <sup>a</sup>	424 <sup>a</sup>
Control	2.48 <sup>b</sup>	8.1 <sup>b</sup>	29.4 <sup>b</sup>	2.95 <sup>b</sup>	4.43 <sup>b</sup>	3.57 <sup>b</sup>	27 <sup>b</sup>	0.51 <sup>b</sup>	0.66 <sup>b</sup>	5.28 <sup>b</sup>	442 <sup>b</sup>
SEM	0.104	0.033	0.170	0.011	0.018	0.308	0.078	0.002	0.002	0.038	3.19

<sup>ab</sup>Means in the same column within a parameter with different superscripts differ significantly;  $p<0.05$

SNF – Solid Non Fat, Dens – Density, Prot – Protein, Temp – Temperature, FP – Freezing Point, C – Conductivity, DS – Draminski Score

**Table 1:** The effect of Celmanax on the milk composition of dairy cows

**Conclusion :**

Celmanac supplementation resulted in a higher butterfat content as reported by Nocek et al. (2011). Druminsky scores did not indicate the presence of subclinical mastitis in these cows.

**Bibliographic references :**

J.E. Nocek, Ph.D., M.G. Holt, and J. Oppy (2011) Effects of supplementation with yeast culture and enzymatically hydrolyzed yeast on performance of early lactation dairy cattle. *Journal of Dairy Science* Vol. 94 No. 8



## INNOVATING AGROECOLOGICAL FARMING SYSTEMS IN THE CARIBBEAN IMPLEMENTING CROPPING SYSTEMS TO IMPROVE SUSTAINABLE AGRICULTURE IN TROPICS AND SUBTROPICS

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**Keywords :** cover crop, crop rotation, nematodes, sunn hemp, sustainability

### Abstract :

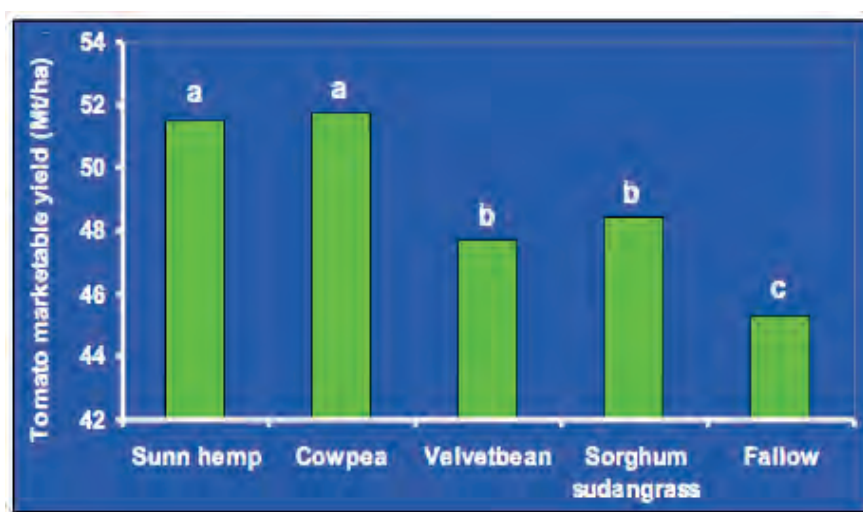
Under tropical and sub-tropical climates, a sustainable development of agriculture is challenging because of the pest pressure with favorable weather conditions. Implementation of appropriate cropping systems including growing cover crops and crop rotation plays a critical role, which can break up the food chain and life cycles of field pests. Some field trials have demonstrated that among all tested summer cover crops, sunn hemp (*Crotalaria juncea* L. cv. Tropic sun) can grow vigorously during the rainy summer, cover the land quickly and densely, and it can produce a large quantity of biomass in two to three months. More importantly, sunn hemp can suppress soil root-knot nematodes via releasing some nematicides through its roots and through the decomposition of plant residues. Therefore, growing cover crop sunn hemp during the crop off season and rotating with valuable vegetable crops in the growing season has become a promising cropping system under the subtropical climate. Such a result may have a potential to be implemented in Caribbean countries to improve the sustainable development of agriculture.

### Materials and methods :

A number of summer cover crops were tested in field trials under subtropical climate in Homestead, Florida, U.S.A. The cover crops are sunn hemp (*Crotalaria juncea* L. cv. 'Tropical Sun'), velvetbean (*Mucuna deeringiana* 'Bort.' Merr.), cowpea (*Vigna unguiculata* L. cv. 'Iron Clay'), sorghum sudangrass (*S. bicolor* X *S. bicolor* var. *sudanense* 'Piper' Stapf.), and Japanese millet (*Echinochloa esculenta* 'A. Braun') vs. fallow. The seeding rates were 25 lb/ac for sunn hemp and sorghum sudangrass, 20 lb/ac for velvetbean and cowpea, and 15 lb/ac for Japanese millet. All these cover crops were planted in May or June, flail-mowed and incorporated into the soil in August. The land was prepared, i.e., disked and formed beds to grow vegetables, such as tomatoes and okra, etc. Crop yield and quality were recorded and evaluated with different treatments. Soil samples were collected for nutrient analyses and nematode assay.

### Main results :

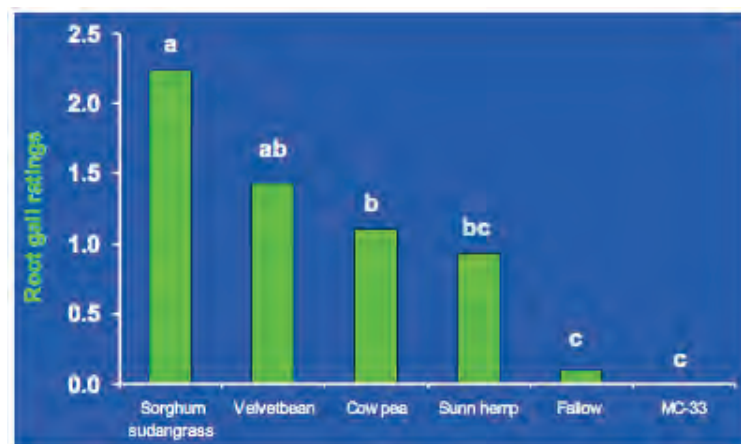
Vegetable yields were increased with all cover crops grown as compared to the fallow, especially with sunn hemp and cowpea (Figure 1). Okra yield was improved significantly as well by growing cover crops, especially by velvet bean (Table 1). Moreover, sunn hemp can suppress soil nematodes effectively. For instance, the rate of root galls after growing sunn hemp was statistically insignificant difference as compared with the treatments of fallow or methyl bromide (Figure 2).



**Figure 1.** Tomato marketable yields affected by growing cover crops.

Cover crops	Okra fruit yield (kg/ha)	Okra biomass (kg/ha)
Velvet bean	10,024.5 <sup>a</sup>	252.7 <sup>bc</sup>
Sunn hemp	8,370.1 <sup>ab</sup>	603.1 <sup>a</sup>
Sorghum sudangrass	7,536.7 <sup>b</sup>	330.1 <sup>b</sup>
Fallow	6,256.8 <sup>c</sup>	232.3 <sup>c</sup>

**Table 1.** Okra fruit yield and biomass with cover crops vs. fallow



**Figure 2.** Soil root-knot nematodes suppressed by various cover crops.

**Conclusion :**

Incorporating summer cover crops into the cropping system for commercial vegetable production has shown a great potential for a sustainable development of agriculture in the tropical and subtropical regions. Some cover crops, especially sunn hemp, can grow fast and accumulate a large quantity of biomass, it can suppress weeds and nematodes to reduce the input of agrochemicals, which are critical components of the sustainability in agriculture.

## AGROECOLOGICAL PRACTICES AND ECOLOGICAL SERVICES IN THE FIELDS OF TROPICAL LIVESTOCK FARMING SYSTEM: A CARIBBEAN PERSPECTIVE

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**Keywords :** agroecology, biodiversity, ecoservices, livestock system, Tropics

### Abstract :

With the crisis of global change, and particularly severe energy and food shortages throughout the tropical regions, agroecological (AE) systems are drawing renewed attention as an efficient alternative to modern intensive models of production. There is a pressing need to focus on the functions of animal and livestock farming systems (LFS), and characterize their potential contributions, whether positive or negative, to the sustainability of the system. A multidisciplinary approach is necessary to address such complex problems. The purpose of the work described here was to highlight solutions to minimize inputs while maximizing ecosystem services, by describing some success stories through diverse case studies of several systems in the Caribbean and Latin America. These were analyzed at different levels: animal/function, farm/family, and territory/society. We produced a set of rules that help to increase the efficiency of tropical systems: (i) choose the best-suited genotypes, while enhancing population biodiversity, (ii) match the farming system to the available resources, feed and by-products, (iii) steer the whole farming system through reproduction management with no hormonal treatment, while facilitating system reproducibility and increasing performances, (iv) control health constraints instead of nihilizing risks, and implement an integrated management design to reduce chemical treatments or increase the use of nutraceuticals, and (v) mitigate climate constraints by using soft techniques. In the second part, the animal and LFS ecoservices are studied. The Tosoly farm of Columbia is conceived as a totally integrated crop-livestock system additionally allowing the production of energy at the farm level. Thus it epitomizes the positive impact that livestock can exert upon the environment. The case study of Haiti indicates how AE can help in designing a pro-poor sustainable system. It concerns an entire milk sector built all over the country on the basis of micro-units of milk production and processing. Finally, the socio-cultural functions of animals or systems in this region are described.

### Materials and methods :

The main objectives of the paper is to demonstrate that in the Caribbean region the concept of shifting paradigm - i.e. towards an AE transition- is not an empty word. On the contrary, many husbandry practices at the farm/territory levels or even so many studies at the animal/function levels have been addressing the AE transition objectives for more than 20 years in the Tropics (see reviews of [1], [9], [2] and [12]). Studies are disseminated all over the R&D teams working in the Caribbean region ([8], [3]). We gather some of our major issues and results owing to a multidisciplinary approach ([3]). This review paper is based upon the methodology of livestock farming system concept and systemic approach that we have already described ([2]).

### Main results :

Given that animal production results from complex and diverse biological processes it appears important to describe first the general on going framework (Figure 1). The different study cases are recombined owing to the systemic framework but can be unfold as followed.

1. A combined set of practices (Figure 1, Table 1) through a) matching resources and genotypes to the environment ([3], [5], [19]); b) implementing a genetic policy according to the prevalent LFS of the region ([3], [19]); c) building feeding strategies ([16],[5]) through i) optimising all available biomasses even by ii) developing an efficient circular economy.
2. Addressing the environmental limits by soft and integrated practices (Figure 1, Table 1) by :a) setting up climate mitigation ([21] and [17]); b) piloting the system by means of reproduction management ([18] and [7] and c) implementing an integrated control of parasitism constraints ([17],[6] and [16])instead of nihilizing the risks.

The LFS are well-known to be multifunctional (see reviews of [2] and [19]). This is not only built upon the multi-objectives of the farmer but also on multi-physiological functions of the animals. The following chapters are built upon:

- Case studies in different regions and at different levels (Table 1, 2) a) at the animal/function level (examples are i) dual purpose cows and poultry, ii) multi-objectives for genetic policy ([11] and [10]);b) at the farm/family level (examples are the food/feed/fuel system of TOSOLY ([20]) in Colombia or ii) biomass-Cuba projects and c) at the territory/society level (examples are the Haitian Lèt Agogo experiences ([13] and [12]) that is totally a pro-poor successful story ([4]).
- The description of some of ecoservices of tropical animal or LFS (Table 2, [2]). Their diversity is demonstrated through domesticated animals or neo-tropical wildlife animals (NTWA).

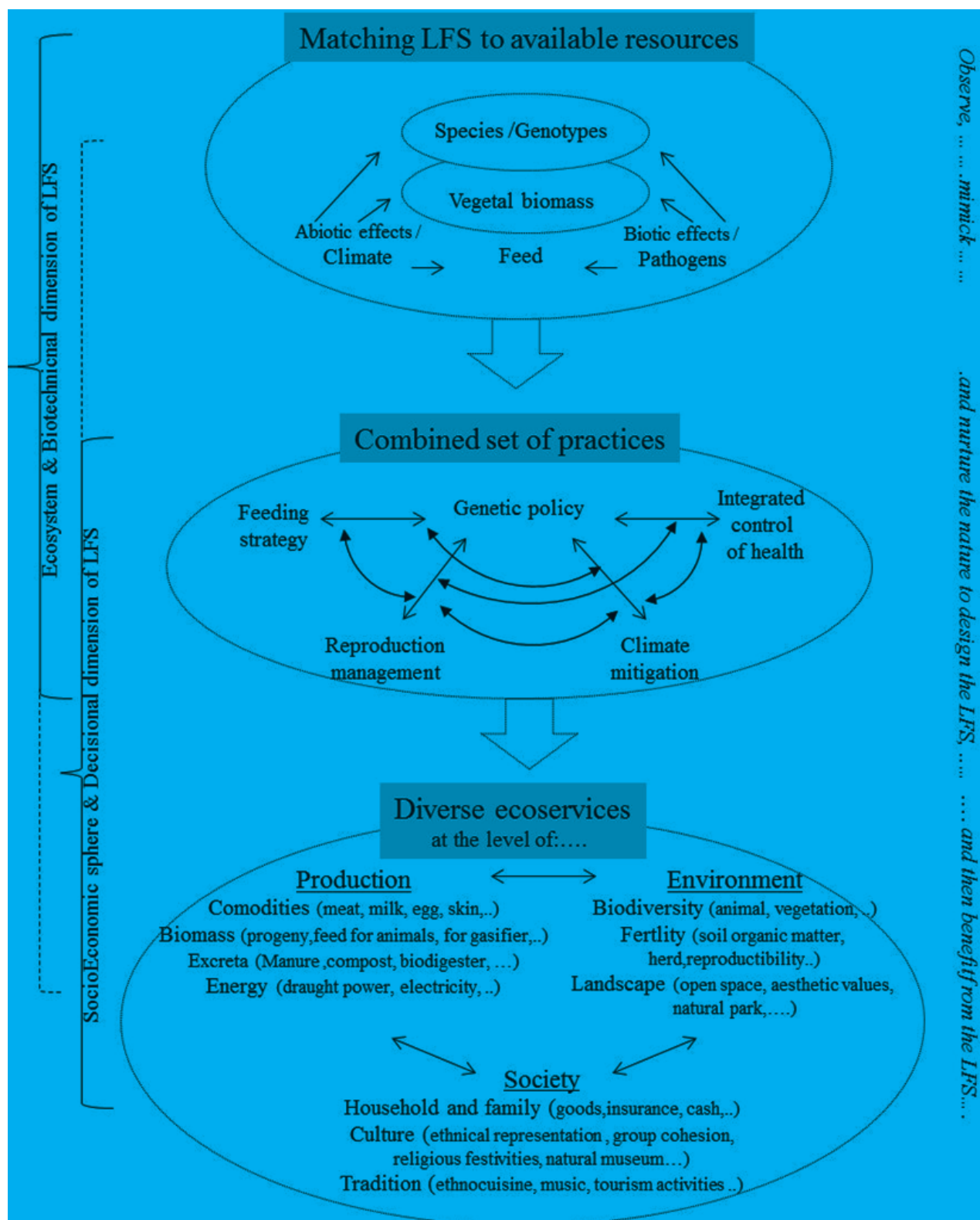


Figure 1. Main principles and practices for designing agroecological livestock farming system (LFS) in the Caribbean and provisioning of ecoservices.

Items	Observations	Actions	Benefice/ Ecoservice	Case study	Future
Vegetal biomass 1a	Diversity (space, time, ecological, chemical), Adaptation, Multi value.	Use, Combination, Mixed diet,	Reduced costs and toxicity	Tosoly Haiti NTAW/ Cuba, Guadeloupe Mexico	Resource seasonality, Nutrient allocation, Different biological functions in competition or complementary, Production of pellets at farm level, Up-scaling of energy production.
Feeding strategy 1d	Feed costs, High technicality, Feeding behavior of animals.	No maximising the performances, Use for many species Fractionating the feeds, Dual purpose system.	Cycling residuals & excreta, Increased efficiency, Qualitative goods		
Species and genotypes 1b	Diversity, adaptation, multi function (physiology, ecoservices,...)	Use of excreta for gasifier, Combining functions, No maximising performances.	Biodiversity, Soil fertility, Food security, Energy production, Pro-poor, Cultural function	Tosoly Haiti NTAW/ Cuba, Guadeloupe Mexico	
Genetic policy 1c	Given 1a&b and abiotic and biotic factors.				
Climate mitigation 2a	Effects of temperature, humidity, wind.	Reducing abiotic effects habitat, 1d & 1c	Improving welfare, Increased output	NTAW/ Guadeloupe	Improve housing, Breeding program for acclimation,
Reproductive management 2b	Effect of photoperiod.	Use of photo stimulation.	Increased output, Improved herd management,	NTAW/ Guadeloupe Mexico	Increased energy consumption (solved by Tosoly concept ?)
Integrated control of health 2c	Ecophysiology of pathogens, Animal functions Farmer practices	Techniques towards animals, environment & pathogens. 1d & 1c	Reduced input, Integration, Cycling, Increased efficiency	Tosoly/ Cuba, Guadeloupe Mexico	Up-scaling at the farmer level, Study of neutraceuticals.

**Table 1** Livestock farming systems (LFS) in the Caribbean, interactions between practices (1a to 2c) and comparison of the different case studies through the concept of agroecology



Items	Regions	References (n)
<u>Economic contributions</u>		
Marginalized sector / poor population	Central America	5 ref
	Latin America	6 ref
Small-holder farmers	Latin America	5 ref
Household consumption and income	Central America	3 ref
Cash reserve	Central America	3 ref
	Latin America	5 ref
<u>Non food commodities</u>		
Supplying manure.	Latin America	8 ref
Draft animals	Central America	5 ref
	Latin America	3 ref
Positive effects upon environment	Latin America	6 ref
Insurance against ecological risks (protection against crop failure)	Central America	1 ref
Landscapes, aesthetic functions	Central America	5 ref
	Latin America	6 ref
Socio-cultural linkages	Central America	2 ref
	Latin America	3 ref
<u>Special niche market</u>		
Goat meat	Central America	6 ref
	Latin America	3 ref
Goats target religious festivities	Central America	3 ref
Buffalypso milk	Central America	3 ref
Pekari (+ rodent) meat	Central America	10 ref
	Latin America	16 ref
Goat (sheep) skins	Central America	4 ref

**Table 2** Some examples of socio-economic roles of domesticated and neo-tropical mammals in different regions (Garcia 2005; Alexandre et al., 2013 reviewed in Alexandre et al., 2014)

## Conclusion :

As a conclusion we notify that improving the current systems and practices is an urgent need, particularly in the context of small farmer natural resource management systems, which predominate in tropical developing countries. Based on the different case studies developed for different species and at different scales: (i) animal/physiology, (ii) plot/field, (iii) agroecosystem/farm, and (iv) territory/society, and on the food system approach, we can prescribe a set of rules in a multi-circular process that could help to reduce the use of external inputs, and increase the efficiency of the animals and systems.

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## UN SYSTEME D'AGROECOLOGIE ET D'AGROFORESTERIE INNOVANT EN GUADELOUPE- PHYTOBOKAZ

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**Keywords :** Agroécologie, Agroforesterie, Phytobokaz, Oleagineux, Interaction Trophique

### **Abstract**

Le laboratoire Phytobôkaz fabrique des compléments alimentaires et des phytocosmétiques. Les matières premières naturelles nécessaires aux besoins de l'entreprise sont puisées au cœur de la biodiversité de la Guadeloupe. La conception de nos produits suit un itinéraire technique précis de la plante au produit fini, que nous avons dû mettre en place pour assurer un développement harmonieux de la faune, de la flore et de l'Homme avec notre unité de production.

Il s'agit d'un concept innovant d'agroécologie, d'agroforesterie et d'agro- transformation liant le développement de notre laboratoire et le maintien de la biodiversité de façon concomitante. Le projet était de produire des plantes oléagineuses (galbas, cocotiers, calebassiers, avocatiers) en comprenant le fonctionnement de chacune de ces espèces, les interconnexions trophiques faune / flore et les adaptations humaines à effectuer, afin d'optimiser le développement de notre entreprise tout en préservant la biodiversité.

## METHODOLOGY OF PARTICIPATORY PLANT BREEDING (PPB) IN CUBA

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**Keywords:** Improvement, field experimentation, agricultural fairs.

### **Abstract**

The methodology is supported on the basis of the experience acquired by a group of researchers, farmers and technicians from Cuba in the implementation of Participatory Plant Breeding. The proposal presents a number of methodological considerations with the necessary flexibility to allow proper application of the method and follows a logical sequence of activities to be executed in a manner that facilitates their implementation in various contexts in which it is of interest to apply. Its implementation, as such, is a learning process in action for all actors involved in it; also enables participants to understand the scale of the needs of the producers and breeding programs and dissemination of varieties in terms of the real interest of these. The methodology has 4 main phases: 1) diagnosis, 2) Collection of plant genetic resources, 3) Establishment of demonstration plots and development diversity fairs and 4) farmer experimentation. Besides the four basic stages of Participatory Plant Breeding in Cuba other tools that allowed the PPB constitute a successful process were used, these tools are: action learning as interest Schools Farmers Festivals innovation, exchange visits and retreats, capacity building of students on stage in local innovation and creation of local seed banks.

### **Stages of the methodology. PPB methodology in Cuba has four phases or stages (3):**

1) Diagnosis, 2) Collection of plant genetic resources, 3) Establishments demonstration plots and development diversity fairs and 4) Peasant Experimentation.

#### **Stage 1. Diagnosis:**

The diagnosis is the initial stage of the methodology and establish essentially it allows producers according to the socio-economic characterization and biophysics of production systems and determine relationships leadership presented in each locality. This gives key arguments to meet the entry points Participatory Plant Breeding in communities and producers from this stage begin to feel an active part of the systematization of community knowledge.

#### **Stage 2. Collection of plant genetic resources:**

Collecting plant genetic resources is one of the most important stages of the process, this work provides the opportunity to learn and collect the diversity managed by local systems in order to facilitate access to these participating communities, the formal system of plant breeding, other communities and producer groups.

#### **Stage 3. Establishment of demonstration plots and development of diversity fairs.**

The diversity collected in the previous phase focuses on demonstration plots, which can be located on land belonging to public institutions, private institutions grounds or on the grounds of the producers themselves.

##### **Diversity fairs**

A diversity fair is only those meetings of producers, breeders, makers politicians, conservatives gene banks and leaders of peasant organizations, among others, made in fields previously prepared for such purposes, pursue the fundamental purpose of contributing to through participatory selection of accessions to maintaining and increasing biodiversity of species and accessions of crops of economic interest to producers, so that the needs of family consumption and marketing revenue as new resources are met.

#### **Stage 4. peasant Experimentation.**

The main goals of farmer experimentation are:

Determine the level of adaptation in the farms of the producers themselves at the fair selected varieties; Select at the farm level best response varieties have under their conditions; Find alternatives based on increasing diversity allow them to obtain better yields and lower production costs, reducing the incidence of pests and diseases; Seek joint alternatives between technicians and producers that allow new varieties or acquire technologies to increase their production and profits; Recognize the knowledge and ability of producers in terms of experimentation and diversity management and Establish new producer associations united around diversity and experimentation.

In addition to the four basic stages of Participatory Plant Breeding in Cuba other tools that allowed the FP constituted a successful process were used, these tools are:

1. Learning in action as interest
2. Schools producers
3. Innovation Festival
4. Exchange visits
5. stays on farms
6. Capacity building of students in local innovation scenarios
7. Creating local seed banks

#### **Conclusion:**

Farmer experimentation for the selection of materials more adapted to the specific conditions of farms and management achieves increased efficiency, measured in increasing the performance of their plots in the sufficiency of animal feed of high quality, the satisfaction of their tastes and eating habits, all of which results in an improvement of the life of the farmer and his family. Farmer experimentation for the selection of materials more adapted to the specific conditions of farms and management achieves increased efficiency, measured in increasing the performance of their plots in the sufficiency of animal feed of high quality, the satisfaction of their tastes and eating habits, all of which results in an improvement of the life of the farmer and his family. The FP has achieved the awakening of local innovation in the areas of intervention, influence on raising yields based on the increase of agricultural biodiversity in species and varieties. It has managed to significantly increase performance through the FP under low-input agriculture on farms where their farmers have selected the most suitable materials. The process is a source of learning for farmers, technicians, extension workers. Knowledge production, selection criteria and increased innovation capacity of farmers and livestock producers. Increased self-esteem of local farmers and food producers for recognition of their capacity for analysis and experimentation, self-organization at the local level for the realization of common goals, its convening power and relationships with other local actors and the possibility to participate in the formulation and implementation of projects of local transformation. The increasing incorporation of women to the extent that perceived benefits for herself and her family and their farming systems, social recognition of their abilities

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## WHICH ANIMAL DO FARMERS NEED FOR TROPICAL MIXED FARMING SYSTEMS IN THE CARIBBEAN?

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**Keywords :** mixed farming systems, tropical, agroecology, adaptation, efficiency

### **Abstract :**

In the Global South, improvement of agricultural outputs is eagerly awaited. While by 2050, its population will double areas devoted to agriculture will decrease exacerbating undernutrition of the poor. Unfortunately, the demand for fresh locally-produced meat products is not satisfied yet in the tropics. So, efficiency in animal productions is essential to allow coverage of protein nutritional needs of people, both in quality and quantity. In the Caribbean territories mixed farming systems are the most common farming systems (about 80%) and can constitute a solution to reach food sovereignty in such limited and isolated spaces. Lessons to be learned from these systems involve improving animal performance while respecting the natural balance with environment and maintaining the multi-functionality of plants and animals. Firstly, the natural (or selected) comfort zone of animal and plants must fit with the farm conditions, insuring thereby animal survival and welfare. Enhancement of adaptation to stresses (biotic, abiotic and socio-economic) in species or animal genotypes is a key element implying their equilibrium with the farm environment. This approach underpins for the farmer an integrated management of animal health, nutrition, genetics, reproduction, in close relationship with other compartments of the farming system. Secondly, animal adaptation may be completed by resilience ability within systems. Animals have to produce although facing stresses. Finally, the animal must be efficient that is to say must reconcile physiological functions of production, reproduction with adaptation functions. This optimization leads to decreased inputs and to overall efficiency of mixed farming systems at the end. The aim of the breeder is to choose the animal producing the best balance between output-reproduction-adaptation, at the individual or the flock scale combining genetic and physiological diversity. The underlying idea is to give to humans and animals their right place in the food chain taking into account the farmers' skills and wills. This idea is included in the agroecological approach and may give guidelines for food sovereignty worldwide.



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**Posters**





INTEGRATED MANAGEMENT OF DISEASES IN CROP AND ANIMAL PRODUCTION

**INVITRO AND INVIVO EVALUATION OF CONVENTIONAL AND ORGANIC PESTICIDES TO MANAGE FOLIAR DISEASES OF YAM (*DIOSCOREA ALATA* L.) IN PUERTO RICO**

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**Keywords :** Yams, anthracnose, fungicides

**Abstract :**

Yam (*Dioscorea alata* L.), a member of the Dioscoreaceae family, is one of the most demanded root crops in Puerto Rico. One of the main constraints on yam production are the losses caused by *Colletotrichum gloesporioides* Penz, the causal agent of anthracnose disease. On susceptible yam cultivars, the disease affects leaves, vines and tubers, resulting in vine dieback, defoliation, and tuber dry rot. Currently in Puerto Rico, Quadris® is the only registered product to manage this disease. The relative lack of research on disease management practices on yam in Puerto Rico is an issue that needs to be addressed to provide more reliable information to local farmers. Thus, the objective of this research was to investigate the potential disease control obtained with OMRI certified materials and conventional fungicides against *Colletotrichum* spp. *in vitro* and *in vivo*. The field research was conducted at the Agricultural Experimental Station of Isabela, Puerto Rico using a randomized complete block design with four replications and ten treatments (Non-treated plants, Quadris®, Fontelis™, Chlorothalonil 720, Trilogy®, Switch® 62.5WG, Kocide® 3000, Kphite® 7LP, and two rates of Regalia®). The same treatments were evaluated *in vitro* using a colorimetric assay, which uses the absorbance (OD450) of cultures in a microtiter plate to assess mycelial growth. *In vitro* studies showed that Chlorothalonil 720 and Switch® 62.5WG provided >50% inhibition of mycelial growth of *C. alatae* and *C. gloesporioides* at all concentrations tested. In field experiments, the most effective fungicide for managing anthracnose disease and improving the yields of yam was Switch® 62.5WG. None of the OMRI certified materials (Trilogy® and Regalia®) and conventional fungicides provided a significant reduction in disease severity. Given the limited data regarding the efficacy of disease-control products available for yam farmers, our results reported here provide an extensive evaluation of products that may have the potential for managing anthracnose disease in yam.

## IMPROVED DIAGNOSIS TOOLS FOR THE DETECTION OF YAM VIRUS IN THE SANITATION PROCESS AND UNVEIL VIRUS-FREE ACCESSIONS FOR PRODUCERS' EXCHANGE

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**Mots clés :** Yams, viruses, sanitation, viral diagnosis.

### Abstract:

French West Indies Biological Resources Centre for Tropical Plants (CRB-PT) maintains several germplasm collections of tropical crops and wild relatives, including a collection of more than 450 yam accessions (*Dioscorea spp*) in vitroculture. The purpose of this Centre is to conserve this biodiversity and distribute virus-free germplasm to end users.

To this aim, virus populations infecting conserved accessions have been characterized and the diversity of intra and inter-species highlighted through the SafePGR project. Thus, three new virus generi have been found out (Ampelovirus, Macluravirus and Sadwavivirus) besides those existing (Badnavirus [1], Potyvirus [2] and Potexvirus [3]). Efficient extraction method and appropriate detection tools have been created and/or optimized, then implemented for an initial diagnosis of the *in vitro* collection. Prevalence shown that more than 75% of yam accessions are infected by Potyvirus, 80% of *D. alata*, the most cultivated yam, are infected by the new yam virus Ampelovirus and Macluravirus are only present in *D. alata*.

Only 14 accessions remained free of viruses, but the majority of the collection contained one, two or more of viruses, so the necessity to sanitize the infected germplasm. The sanitation process consists to submit shoots to thermotherapy at 34°C, then in excising apical meristem to obtain the regeneration of a new plant, expecting to be free of viruses. Using optimized detection tools, each new plant is diagnosed for the six viral generi.

Up to now, the sanitation process leads to the achievement of 8 accessions completely virus-free. The development and yield of this improved plant material have to be evaluated by comparison of infected and sanitized accessions.

### Materials and methods:

Through SafePGR project, successful, effective and sensitive techniques have been implemented to detect new and already known yam viruses. Total nucleic acids (tNAs) of high quality were first extracted with silica powder and all RNA viruses were detected from the same cDNA by RT-PCR method. Five viral generi, included 3 new ones (Ampelovirus, Macluravirus and Sadwavivirus), and 3 distinct species of Potyvirus (YMV and YMMV) and Potexvirus (YVX) were indexed. As Badnavirus is integrated in yam genome [4], this DNA virus was detected by using antibody in immunocapture-PCR. These new detection methods were tested on *in vitro* yam collection of CRB-PT to perform initial diagnosis of yam germplasm. Thus, 275 accessions were indexed, including 73 *Dioscorea alata*, 47 *D. cayenensis-rotundata* and 150 *D. trifida*. Based on this work, a set of 15 accessions was chosen to undergo a cycle of sanitation consisting in thermotherapy and apical meristem culture. The viral status of each generated meriplant was checked with detection methods listed above.

### Main results :

The collection indexation showed that the *D. trifida*, species which is native to the central tropical America, is particularly sensitive to viral infections, as already known, with a high prevalence for Potyvirus (81%), Badnavirus (46%) and Potexvirus (22%) compared to other species. *D. alata* presents the highest rate of contamination by the Ampelovirus (80 %) and is also the only species infected by Macluravirus. The Sadwavivirus prevalence is equivalent for all the yam species.

The sanitation process was performed on 46 *D. trifida*, 10 *D. alata* and 5 *D. cayenensis-rotundata* and we obtained 8 accessions completely virus-free, whatever their initial contamination. The rates of sanitation depend on the virus, for instance 16 % for YMMV (Potyvirus), 56% for YMV (Potyvirus) or 100 % for Macluravirus.

### Conclusion :

We succeed to implement the sanitation on *in vitro* yam collection of the CRB-PT thank to efficient and reliable viral detection methods. 8 accessions have already been sanitized but the efficiency strongly depends on the considered virus. Macluravirus, which infects only *D. alata* with a low prevalence, are removed quite easily (100% of sanitation) and the Potyvirus YMV, which leads the strongest loss of yield in yam, has fortunately a good sanitation rate (56%). Conversely, the Potyvirus YMMV, that infects 72% of yam collection, preferentially remains in plants with a sanitation rate of 16%. However, the sanitation rates could depend on yam species, but our sets of accessions for sanitation mainly contain the American species, *D. trifida*.



The sanitation of yam germplasm is a complicated and time-consuming process and several cycles are necessary to obtain a complete sanitation.

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## AN ANALYSIS OF RECENT OCCURRENCES OF RABIES IN TRINIDAD

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**Keywords :** Rabies, Desmodus rotundus, Artibeus, Bats, Public Health, Trinidad

### Abstract :

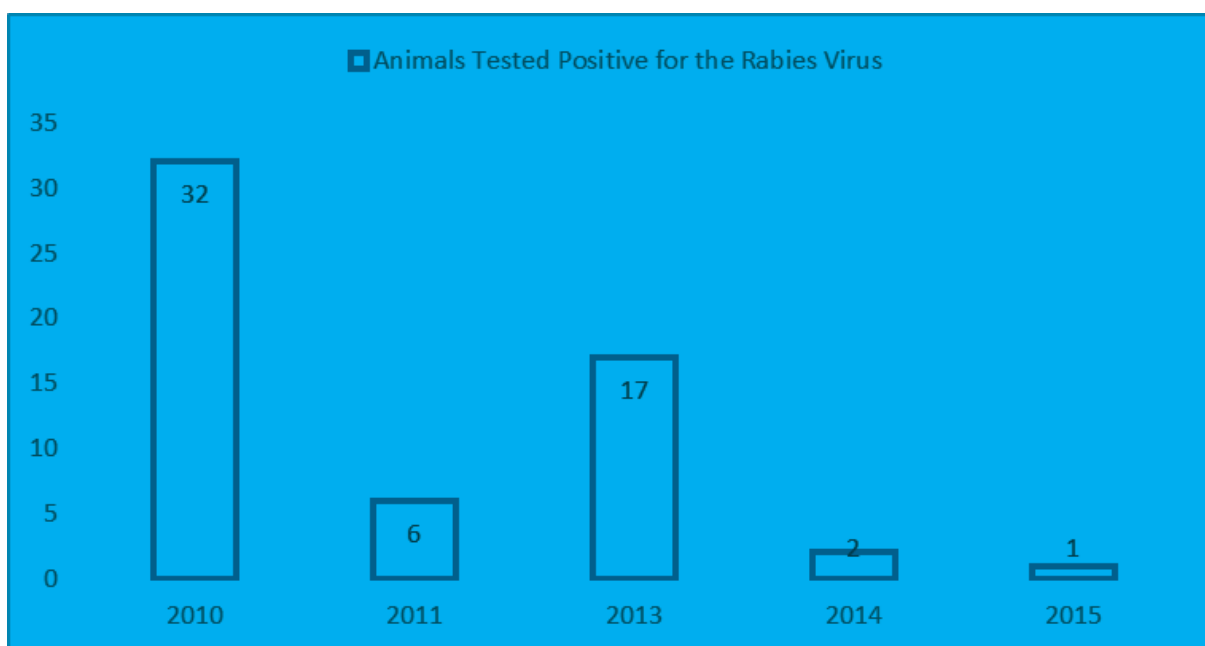
Rabies is a viral, zoonotic disease that is of great public health concern. Paralytic rabies first reared its head in Trinidad among cattle in 1925. The disease swiftly became an epidemic and resulted in the unfortunate deaths of humans, and thousands of livestock. More recently, animal rabies cases have occurred between the years of 2010 and 2015. Data obtained from the Veterinary Diagnostic Laboratory, Ministry of Agriculture, Land and Fisheries, showed that a total of 62 positive animal cases were identified during the five year period. The data was analyzed to ascertain any patterns in the distribution of the virus. The largest number of cases occurred in 2010, with 32 positive cases of rabies being recorded. The records also show that the disease was most prevalent among cattle, as well as in the southwestern area of Trinidad.

### Materials and methods :

Data obtained from the Veterinary Diagnostic Laboratory, Animal Production and Health Division, Ministry of Agriculture, Land and Fisheries, regarding the isolation of the rabies virus in Trinidad during the period 2010 to 2015 was analyzed.

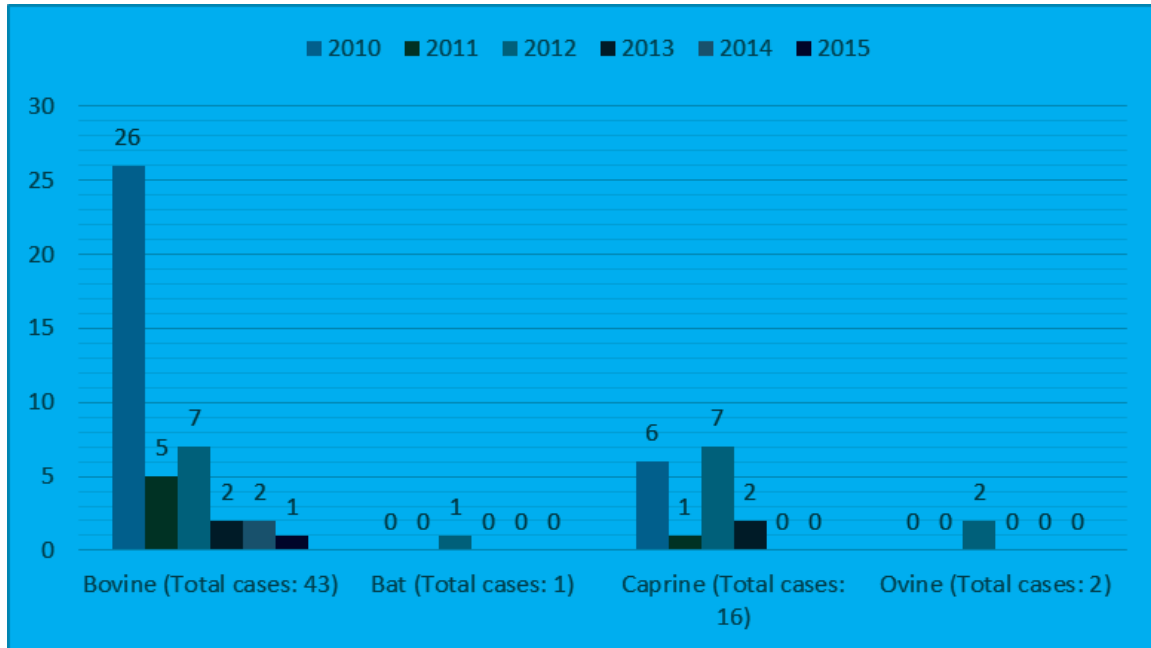
### Main results :

62 positive cases of the rabies virus occurred in Trinidad from 2010 to 2015. The largest annual number of positive animal cases for the past 5 years was 32, which occurred in 2010 with a subsequent decline in cases observed up until 2015 (Fig 1).



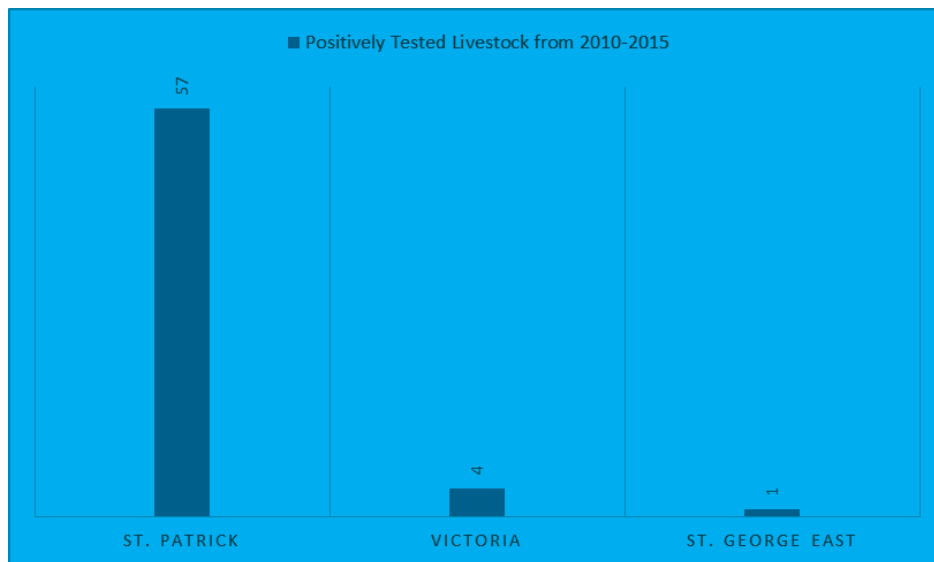
**Figure 1:** The Occurrence of Rabies in Trinidad's Livestock from 2010 – 2015

The majority (43) of positive cases were recorded from cattle, while 16 cases occurred in goats and 2 cases occurred in sheep. Only one bat was found to be rabid from 2010 to 2015 (Fig 2). It should be noted that porcine, canine, and, equine species were also tested but proved to be negative.



**Figure 2:** The Prevalence of Rabies Cases by Animal Species from 2010 – 2015

The majority (61) of positive cases occurred in the southern region of Trinidad, with 57 of these cases being restricted to the southwestern county of St. Patrick (Fig 3).



**Figure 3:** The geographic distribution of Rabies Cases in Trinidad from 2010 – 2015

**Conclusion :**

A pattern was seen in the geographic, and species distribution of rabies cases from 2010 to 2015. Most rabies cases were identified in cattle, while the disease was primarily restricted to County St. Patrick in the southwestern area Trinidad.

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## ANAPLASMOSIS AS AN ENDEMIC DISEASE IN SOUTH TRINIDAD, TRINIDAD AND TOBAGO, W. I.

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**Keywords:** Anaplasmosis, Ticks, Ruminant, Tropical livestock, Caribbean agriculture

### Abstract

Anaplasmosis is caused by bacteria of the *Anaplasma* spp. occurs in most parts of the world. Ticks like *Dermacentor andersoni* and *Boophilus microphilus* are unique biological vectors that carry *A. marginale* in their tissues and can infect large and small ruminants when feeding at subsequent molts or stages of their life cycles. This disease affects production and results in large losses to farmers. Data provided by the St Patrick Animal Health Office of the Ministry of Agriculture, Land and Fisheries indicated a general decline in the incidence of Anaplasmosis from 2004 to 2014. This decrease can possibly be attributed to a number of factors including veterinary interventions, tick surveillance, improvements in animal husbandry and attention to host species.

### Introduction

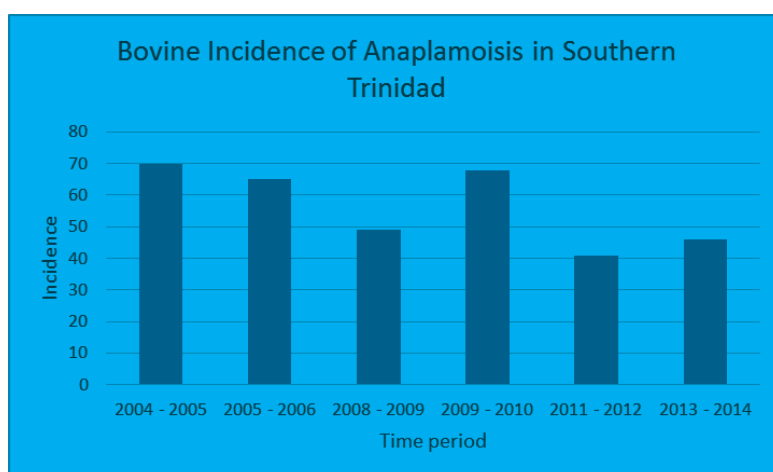
Diseases affecting food animals in the Caribbean are of significant concern as it impacts on food quality and safety and ultimately food security for the region. Anaplasmosis caused by bacteria of the *Anaplasma* spp. occurs in most parts of the world (Oie 2012). Ruminants that recover from acute infection remain persistently infected and are protected from clinical disease, serving as reservoirs for mechanical transmission and biological transmission by ticks (Guglielmone 1995; Corrier 1977). The incubation time for the disease is 3-4 weeks on average. Ticks like *Dermacentor andersoni* and *Boophilus microphilus* are unique biological vectors that carry *A. marginale* in their tissues and can infect large and small ruminants when feeding at subsequent molts or stages of their life cycles (Alamzán et al. 2008). Anaplasmosis is characterized by progressive anemia due to extravascular destruction of infected and uninfected erythrocytes. Animals with per acute infections succumb within a few hours of the onset of clinical signs. Acutely infected animals lose condition rapidly and milk production falls. Loss of appetite, coordination, breathlessness under exertion and a rapidly bounding pulse are usually evident in the late stages. Pregnant cows may abort. Surviving cattle convalesce over several weeks, during which hematologic parameters gradually return to normal (Thompson et al. 1978; De Wall 2000). Tetracycline antibiotics and imidocarb are currently used for treatment. Cattle may be sterilized by treatment with these drugs and remain immune to severe Anaplasmosis subsequently for at least 8 months.

### Methods

Data provided by the St Patrick Animal Health Office Station of the Ministry of Agriculture, Lands and Fisheries for suspect cases of Anaplasmosis that responded to treatment in South Trinidad were analyzed for the years 2004 to 2014.

### Results

There were 70 suspect cases of Anaplasmosis in bovines in South Trinidad in 2004. In 2014, there were only 46 suspect cases, showing a 37% decline in the suspected incidence of Anaplasmosis.



**Figure 1** Reported cases of Anaplasmosis in bovine for South Trinidad during the period 2004 to 2014



## Discussion

There was a general decline in the incidence of Anaplasmosis from 2004 to 2014. Improvements in Farmer's husbandry practices could have led to this decrease in confirmed cases as farmers have educated themselves through the use of the internet and as such, are engaging in practices to improve conditions on their farms. Modified housing for large and small ruminants and improved diets can also have contributed to the decline (Wormser et al. 2006; da Silva and da Fonseca 2014; Kocan, Fuente, and Blouin 2007; De La Fuente et al. 2006). Anaplasmosis is spread by a one host tick, *Boophilus spp.* hence breaking the life cycle by resting of the pastures is probably a major factor in reduction of the disease. Additionally tethering restricts free grazing which will decrease the chances of finding ticks or tick eggs in pastures. The access and use of ascaricides has assisted in preventing and treating the vectors. Vaccination has been an economical and effective way to control bovine Anaplasmosis (Sainz et al. 2015; Brown 2014).

Improvements in the veterinary services in South Trinidad may also have been negatively correlated with the decrease in Anaplasmosis. Improved techniques, farmer education, tick surveillance and distribution of drugs are some of the factors that may have impacted on the decline of the disease. These efforts help to preserve the biological and ecological landscape of agriculture in the Caribbean (Camus and Barre 1995; Parola and Raoult 2001; Grzeszczuk 2006; Alonso et al. 1992).

Novel policies on animal importation implemented by policy makers to reduce the entry of diseased or tick infested animal may also have contributed to the decline of cases of Anaplasmosis. Animals are held at the point of entry and fully examined by quarantine officers before given clearance.

## Conclusion

Confirmed cases of Anaplasmosis in county St. Patrick, Trinidad and Tobago were limited to Bovine Anaplasmosis. No cases were reported for sheep and goat. This suggests that sheep and goats may have some form of resistance to the disease. The confirmed cases of the disease decreased from by 37% from 2004 to 2014 in cattle, possibly through improved management practices and veterinary services.

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## EVALUATION OF INFESTATION LEVEL OF CATTLE BY THE TICK *RHIPICEPHALUS MICROPLUS* IN NEW CALEDONIA

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**Keywords :** cattle ticks, susceptibility, resistance, survey

### Abstract :

The cattle ticks represent a particularly important danger for ruminant production, because of the losses which they cause directly, or because of the infectious diseases with which they are associated. In New Caledonia, as in other tropical regions, the tick *Rhipicephalus microplus* represents a real plague, leading to very important losses in cattle herds. Moreover, since a few years, the efficiency of acaricide treatments classically used marks time and resistance of the parasites becomes widespread. So, the development of alternative methods of control of the infestation by the ticks is nowadays essential. Among these, the identification of more resistant lineages of cattle to the ticks, or the culling of the most sensitive animals, are interesting tools to decrease the impact of the ticks in the herds. The evaluation of the level of individual infestation represents therefore a particularly interesting tool for the herd survey. An assessment grid of the individual infestation by the ticks in the cattle raised in New Caledonia was worked out, and applied periodically for more than a year, in 4 herds, on a total of about 600 animals. This semi quantitative grid allows a relatively fast and precise evaluation of the level of infestation, by taking into account the number of engorged females and the importance of the infestation by the immature stages. The number of engorged females on one side of the body is either counted, or estimated according to a classification in 5 or 7 classes (from 0 to more than 100 ticks), according to the ease of the observation of the ticks on the animals. For the immature stages, the observations are realized in three physical locations of preferential infestation by the ticks (tail, perineum, neck), following a classification in 4 classes in each location. Finally, these notes are combined in a score of degree of infestation, which varies in a continuous way from 0 to more than 100. This score follows a Poisson distribution, the most common statistical distribution in parasitism phenomena. The individual evaluation of the level of infestation of the animals can be useful within a research program but also for the breeders, as a management tool of the herd. Various applications are in progress on the field in New Caledonia. First of all, the evaluation of the infestation by the breeders to identify the most infested individuals is a useful management tool. It allows estimating if all or part of the herd must be treated, and, after several counting, to identify animals most regularly infested in order to cull them first. Previous studies also demonstrated that the culling of the most sensitive animals allowed reducing by 7 the global infestation of the herd in 15 years. The identification of resistant lineages of cattle to the ticks requires a more important implication of the breeders with the realization of regular counting and the follow-up of the genealogies of animals. Such a study started in New Caledonia, on about 300 individuals of known filiation. Finally this method allows to compare the degree of infestation of the animals of various breeds and to estimate their behavior against ticks in a given context. The method tested in New Caledonia is operational. Its application in the herds represents a usable additional tool in alternative strategies of fight against the ticks. It also interests the breeders in the tropical regions who face the danger of the tick *Rhipicephalus microplus*.

### Introduction

The ticks of the cattle represent a danger particularly important for herbivores, because of the losses which they cause directly, or by the diseases with which they are associated. In New Caledonia, as in other tropical regions, the tick *Rhipicephalus microplus* causes very heavy direct losses in the cattle herds. Since a few years, the efficiency of the current acaricides decreases, and the phenomena of resistance of the parasites to the products become widespread. So, the implementation of alternative methods of control of the infestation by the ticks is today essential. Among these, culling of the most sensitive individuals and the identification of more resistant lineages of cattle are interesting tools to decrease the impact of the ticks (Hue and al ., 2014). The evaluation of the individual level of infestation is then a tool of particularly useful follow-up. A notation grid of the individual infestation level of the cattle by the ticks was worked out, and is applied for more than a year, in four herds in New Caledonia.

### Material and methods

This semi quantitative grid allows a relatively precise evaluation of the infestation, by taking into account the number of engorged females, and the intensity of the infestation by the immature stages. The number of engorged females on one side of the body is either counted exactly, or estimated according to a classification in 5 classes (0 ; ]0 ;20] ; ]20 ;50] ; ]50 ;100] ; >100) or 7 classes (0 ; ]0 ;10] ; ]10 ;20] ; ]20 ;30] ; ]30 ;50] ; ]50 ;100] ; >100), according to the ease of the observation of the ticks on the animals. A score of adult stage infestation is then assigned, corresponding to the number of adult ticks counted, or to the median value of the class of infestation. For the immature stages, the observations are realized in three physical locations of preferential infestation by the ticks (tie of the tail, perineum, neck), following a

notation in 5 classes in every location (0 ; 1 ; 2 ; 3 ; 4). A score of infestation by the immature stages is assigned, which is the sum of the scores attributed at each of the three locations, multiplied by 10. In the end, average of both scores is calculated to establish an average score of degree of infestation, which varies in a continuous way from 0 to more than 100. In total, we obtain 882 scores of infestation, on 454 individuals (from 1 to 8 observations by animal), observed during 28 visits, between August, 2014 and April, 2016. They animals belong mainly to the breed Limousine (419 notations on 211 individuals) and Charolais (363 notations on 163 individuals), but also in other bovine breeds. Besides, we obtain the filiations of 151 cattle Limousin and 156 cattle Charolais. The final scores underwent a log transformation, with the aim of the realization of variance analyses, by means of the procedures GLM and MIXED of the software SAS ®. The models included the direct effects of the herd, the season, the breed, the sex, the age, and the random effect of the father of the animal.

### Main Results

This evaluation grid may have various applications in New Caledonia. First of all, the evaluation of the infestation by the breeders themselves is a tool particularly interesting for the management of the herds, because it allows to assess if all or part of the herd have to be treated against the ticks. The realized notations show that the average score of infestation of a herd can vary from 3 to 92 (average 29 +/-23). Furthermore, 13 % of the individuals carry 39 % of the parasitic load of the herd, while 9 % are not infested.

The application of this grid also allows identifying animals most regularly infested, in order to cull them first. Indeed, on all the measures, the repeatability is about 0.42, what shows that these measures are a good indicator of the sensibility of animals. An Australian study showed that the reform of the most sensitive animals allowed to reduce by 7 the global infestation of the herd in 15 years (Frisch and al., 2001).

Besides, analyses intra breed, for Limousine and Charolais animals, showed that the random effect of the sire is very significant ( $p < 0.0001$ ), with an average level of infestation varying, between the extreme “families”, from 1 to 40 in Limousin breed, and from 10 to 80 in Charolais. These first results give encouraging perspectives for the selection of animals onto this criterion.

This method also allows to compare the degree of infestation of various breeds and to estimate their level of sensitivity or resistance against the ticks in a given context. On a small studied sample (168 animals of 8 races), the breeds Charolais and Limousine appear the most sensitive breeds, with levels of infestation respectively 6.7 times higher and 3.4 times higher than the Brahman breed, which is the most resistant. Droughtmaster and Senepol breeds present levels of infestations 1.5 times higher than Brahman. The breeds Belmont Red, Santa Gertrudis, and the crossing Brahman x Limousin, presents intermediate levels, 2.6 times higher than Brahman (table 1).

breed	Ln(score+1)	Std Err	Score	Diff. <sup>1</sup>
Brahman	1.80	0.23	6.0	a
Senepol	2.22	0.27	9.2	ab
Droughtmaster	2.24	0.34	9.4	abc
Belmont Red	2.65	0.31	14.2	abc
Bramousin	2.71	0.49	15.1	abcd
Santa Gertrudis	2.88	0.27	17.8	bcd
Limousin	3.01	0.16	20.3	cd
Charolais	3.71	0.30	40.8	d

<sup>1</sup> Different letters indicate a significant difference between breed ( $p < 0.01$ )

**Table 1:** Level of infestation according to the breed

### Conclusions

The method raised and tested in New Caledonia is operational. Its application must be pursued to validate the first results. It represents however an easily usable tool in cattle management, as an alternative strategy for the control of tick infestation, in tropical regions confronted with the tick *Rhipicephalus microplus*.

*The authors thank the heads of the farms and the technicians of the stations of the Chambre d'Agriculture and of Port Laguerre, the herd of the UPRA-NC and the farm Moglia for their availability and their implication during surveys.*

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## VALUATION OF LOCAL GENETIC RESOURCES FOR SUSTAINABLE PRODUCTION SYSTEMS DEVELOPMENT OF THE BUFFALYPSO BREED BY CARONI 1975 LIMITED IN TRINIDAD AND TOBAGO – A REVIEW

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**Keywords:** Buffalypso, *bosBubalis*, Water Buffalo, Tuberculosis, Zebu, breed, species, characteristics, inter-fertile, Trinidad, Caroni

### **Abstract:**

In 1949 Dr. Steve Bennet and Mr. T. Porteous began the development of the Buffalypso breed for Caroni (1975) Limited in Trinidad. The name from the breed came was determined as: Buffalo from Trinidad, Land of Calypso – Buffalypso. Bennet's work was inspired by studies performed by Mac Lachlan which pointed out 7 highlights : 1) Buffaloes from India were genus *Bos buballis*, 2) They were widely used for work and production of ghee (a milk fat formulation used by Indian cultures for food production), 3) In 1949 the last Murrah buffaloes were imported from India , 4) These buffaloes thrived well on high fibre grass and were well adapted to hot, humid tropical conditions, as in the Caribbean region, 5) Buffalo milk had 7-12% butter fat and took half as much milk to produce 1 lb of butter as conventional breeds, 6) Buffaloes had a preference to European tastes (Italy) and 7) Buffaloes were easier to break in then the Zebu currently used by Caroni, tuberculosis tests were performed in 1949 on the Zebu herd (500 animals tested) and it was discovered that there was a 30% infection rate. To ensure development of a suitable breed for beef buffalo and a healthy working herd, the disease had to be eradicated, a two-pronged approach to combat the disease was taken 1) elimination of animals that showed positive to the tuberculosis tests and 2) improving sanitary conditions of the herd. With the introduction of this programme the disease was eventually eradicated by 1958. Concrete floors were laid down introduced and animals were fed via racks and mangers, coconut meal were fed by creeps to nursing calves, tuberculin tests were regularly performed and diseased animals were slaughtered. Breeding programmes used led to the only beef animal ever developed from various strains - The Buffalypso.

### **Background to Buffalypso Breeding:**

The introduction of new health standards in buffalo breeding led to an over-production of buffaloes, this resulted in buffaloes being used for beef production. As a result Caroni Limited had aspirations to develop a breeding programme which aimed at producing a breed of buffalo suited for beef production. They gave this charge to Dr. Steve Bennet who in 1949 began the breeding programme to develop such a breed. The fundamental philosophy used by Dr. Bennet for the breeding programme was that the adaptability of these animals to tropical conditions indicated that with selective breeding the animals may easily find their way in the field of beef production and to a lesser extent dairy production, thus allowing great economic potential and increased profits for Caroni (1975) Limited and farmers who would rear the breed.

### **Method:**

Four desired characteristics were of importance of developing the new breed: 1) Straighter top lines of animals, 2) Broder loins and rumps to ensure maximum meat production, 3) Transfer of weight from the front quarters (where there was tractive strength and larger muscles) to the hind quarters and 4) Horns with small tight curls (to prevent injury to other animals and humans alike). This met the criteria for such a breed in Trinidad, to provide sustainable production of a non-imported breed for beef and milk production, which would allow products to be cheaper and with high weight gain/yr , a quick turnover in stock for production. This would lead to the objectives being met: beef being readily available on the market to consumers and a high profit margin for producers and farmers alike. The breed thrives on poor pastures and rough conditions making it cheaper to rear and produce.

Selection work was done in the Caroni herd until 1973, then extended to collaborating farms. Buffalypsos prominent physical features are: 1) small flat horns growing backwards, upwards and inwards with slightly pointed tips, 2) three colours of animals: black, brown and albinoid and 3) meat well distributed to the hind quarters.

Two major drawbacks to beef cattle production by Caroni Limited and farmers alike were 1) a deep litter, zero-grazed system was used for production and 2) animals were fed by placing feed (mainly sugarcane trash and grass) on the floors of pens. The deep litter system was used to facilitate collection for buffalo manure and feed that was not consumed to apply to sugarcane fields, that was seldom collected during the year.

### **Results:**

Diets composed of molasses and fresh chopped sugarcane/sugarcane silage/sugarcane bagasse ranging between 73-78% of total diet DM the following were observed for meat characteristics and characteristics of milk from cows at Aripo Livestock station were as follows:



Buffalo meat is well marbled and noted as being very delicious to eat, there are no major differences by viewing cattle beef and buffalo beef, hence there is no drawback in this egger to being placed on the markets for sale and consumption by consumers, sensory evaluations performed using different types of beef showed that buffalo meat commanded excellent consumer acceptance, these results are presented in the following table:

**Health and Reproduction:**

Observations done on reproduction and health in 2004, showed the following Heifers exposed to bulls at 350kg body weight at 21 months old showed 75 % pregnancy ratios, there were no observed abortions with less than 1% still births, no dystocia was observed. The breed is resistant to major infectious diseases including ecto and endo parasites (ticks) and tick borne diseases and foot and mouth diseases.

**Future**

There are only 5,000 Buffaloes in Trinidad, only half of which are Buffalypso breed. There are no conservation methods employed for the breed. The breed has been exported to other countries including USA, Colombia, Mexico and Venezuela. To preserve biodiversity of traits that may be important for further development and for food security the Buaffalypso breed needs to be preserved and further breeding research should be supported.

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	Tobago Local Steer	Water Buffalo	Imported Frozen Meat
Colour of Meat	6.6	7	6.9
Colour of Fat	5.5	6.4	6.1
Texture	7.4	7.4	7.3
Taste	7.8	8	7.5
General Acceptability	7.3	7.8	7.5
% Overall Acceptance	69.3	76.6	70.7

**Table 1 :** Gourmet Card Scores for Types of Beef (Each Score out of 10)

	Characteristic Observed	Performance
<b>Meat:</b>	Average Daily Gain	0.5 kg/day
	Feed Conversion Efficiencies - DMI/kg - ADG/kg	7.31 - 10.04 Kg
	Dressing Percentage (DP)	55-58%
	REA	68-86cm <sup>2</sup>
	DP - Slaughtered Animals , 14-20 months old	48 - 51%
	Heifer performance between weights of 150-250kg	0.7kg/day
<b>Milk</b>	Fat	7.15%
	Protein	4.03%
	Solids Non Fat	8.84%
	Total Solids	16.97%
	Calcium	0.23%
	Ash	0.85%
	Lactose	5.60%

**Table 2** Observations performed on Buffalypso Breed



**Plate 1.** Classic  
1950's



Buffalo Herd, circa

**Plate 2.** Buffalo Herd



Present Day





## SMALL SCALE OUTDOOR PIG SYSTEMS IN THE TROPICS: IMPACTS ON THE SOIL, THE PHYSIOLOGICAL AND THE ZOOTECNICAL RESPONSES OF FATTENING PIGS:

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With the collaboration of Georges Magdeleine (farmer in a mixed farming system).

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**Keywords:** agroecology, pig, outdoor system, sweet potatoes

### Abstract:

To our knowledge, there are few references on the pig production integrated into a mixed farming- system. In which farmers try to minimize inputs (in particular on feed purchase d). Feeding is one of the most important elements of the production cost. It is even more the case in tropical small countries, where the cost of the raw material included also the cost of transports. Farmers in these countries are looking for alternative solutions to reduce or replace the utilization of industrial concentrates, by the use of local resources (e.g. roots and tubers, sugar cane, banana). The main objective of this study was to compare fattening pigs' systems (outdoor vs. indoor, local vs. industrial feedings, local vs. exotic breeds). We performed two trials on a total of 54 fattening pigs, reared either in outdoor in a sweet potatoes field (n=18) or indoor with diet based on sweet potatoes (n=18) or indoor with industrial concentrates (n= 18). Our results show that the growth is significantly affected by the production system. The outdoor animals have a growth rate of 240 g/d, against 360 and 580 g/d for the indoor pigs fed with local or industrial feed, respectively (P < 0.001). Our findings on the physiological responses (blood profiles) highlighted the best adaptation of the local breed (Creole pig) when they passed from indoor to outdoor system. Indeed, adaptive hematologic response is faster in Creole pigs than in the exotic breed (Large White pigs). Unlike Creole pigs, the arrival of exotic pigs in outdoor conditions caused firstly a weakening of the hematologic status suggesting that Large White pigs are stressed by the change. Regarding the interaction between digging activities of pigs with macrofauna, in our experimental conditions (gradual discovery of plots and grazing period of 28 days), it seems that the presence of pigs on the plots (manure) is beneficial to soil macrofauna and thus the quality of the land from the farmer for future planting. The alternative systems (outdoor and/or diet based on local resources), although less powerful in a zootechnical point of view, should suit to mixed farmers who are looking for an economic gain on animal production by using crop residues and minimizing human interventions. These studies are the beginning of trials that aimed at meeting mixed farmers requirements in terms of techno-economic references on outdoor pig systems and alternatives to preserve and develop a niche market for the local pig breed.

### INTRODUCTION

In tropical and subtropical regions, pork production is based on a variety of farming systems (Robinson et al., 2011). These farms are situated between two extremes. The first extreme is specialized industrial and landless farms with high pig density and a limited number of selected commercial breeds or lines with high genetic potential for high growth and reproduction. The second extreme is small family farms with indigenous and/or crossbreeds reared in low input conditions. In simplified terms, there are two opposing logics of production. In industrial systems: “Do to” maximize the pig output/input ratio vs in non-conventional systems : “Do with” the available biomass from the farm or neighbouring farms to limit inputs (Gourdine et al., 2011). These two logics are clearly not mutually exclusive, and it can in some cases support each other. To our best knowledge, little is published on outdoor pig production in small scale farms in tropical humid conditions. As feed is the most costly element in the production, farmers are looking for alternative solutions to replace totally or partially industrial concentrate, via the use of local resources. Sweet potato (*Ipomea batatas*), by its appetite, nutritional qualities and its place in tropical agriculture could be an interesting alternative (Régner C. 2011). Our first studies presented in this paper aimed at characterizing feeding behavior and activities, growth rate and physiological response of growing pigs and their impacts on the soil quality, when they are raised in an outdoor system with a sweet potato field.

### MATERIAL AND METHODS

#### *Experimental design*

We performed two trials on a total of 54 fattening pigs, reared either in outdoor in a sweet potatoes field (n=18) or indoor with diet based on sweet potatoes (n=18) or indoor with industrial concentrates (n= 18). In the first trial, 30 pigs, 15 exotic Large White pigs (LW) and 15 local Creole pigs (CR) were used. In the second trial, 24 pigs, 12 LW and 12 CR were used. The first experiment was conducted in the farm of Mr Georges Magdeleine. The second experiment was conducted at the experimental facilities of INRA in Guadeloupe. Experiments began when pigs were 87 days of age. Three groups

with an average live body weight of 30 kg were defined. Each experiment period was about 28 days, with 4 days for adaptation to the new conditions. The 3 groups corresponded to 3 farming conditions. First, a conventional system with industrial concentrates as diet (CSC): pigs were reared in 2 pens in a semi-open building. Each pen was equipped with nipple drinkers and animals had free access to water and were fed ad libitum with commercial diet presented as pellets and formulated to meet the nutritional requirements of growing pigs according to the standard recommendations. Second, an outdoor system (OSP) on a sweet potatoes field (4.7m<sup>2</sup>/d/pig). OSP pigs had to feed themselves with the sweet potatoes leaves and tubers. Forty-seven tuber samples were collected (0.5m<sup>2</sup>/19m<sup>2</sup>) in order to evaluate the available amount of sweet potatoes. According to these results, the estimated available amount of sweet potatoes was in average 6 kg per day per animal. Thus, animals were considered as having an ad libitum access to sweet potatoes, which means having an ad libitum energy feed intake. Nevertheless, the forty-seven leaves samples collected have shown a lack of protein in the feed ration: in average 1.2 kg of leaves were available per day per animal. Therefore, pigs were given soybean meal as supplementation, at the end of the afternoon (around 17:00 h). The provided amount was calculated in order to fulfill the nutritional requirements to achieve theoretically a growth rate of 500 g/day for CR and 800 g/day for LW. In order to study outdoor behavior of each breed, LW and CR were reared separately. Third, a CSP system in a semi-open building with similar feed allowance than in OSP conditions. CSP pigs had an ad libitum access to sweet potatoes tuber and the same average amount of sweet potatoes leaves that available on the OSP daily piece of field. Similarly to pigs in OSP, CSP pigs were given soybean meal as supplementation at the end of the afternoon (around 17:00 h). LW and CR were bred separately in order to evaluate feed intake and its effect on growth performances according to the breed.

### Measurements

In OSP conditions, rainfall level was daily registered. Humidity and ambient temperature were recorded twice a day: in the morning (06:00h) and at the end of the afternoon (17:00h). In indoor conditions (CSC and CSP) ambient temperature and humidity have been recorded automatically every 15 minutes.

Pigs were weighed at the beginning (d-4) and the end (d-1) of the adaptation period as well as at the middle (d11) and end of the experiment (d25). At the end of the study, back fat thickness of all pigs was measured. Four values were recorded with an ultra-sonic device (Honda, HS 1500): on both sides at 6.5 cm of the spine at back- and shoulder-level. Average of these four values was calculated for statistical analysis. Body and skin temperatures (three measurements: back, side and skull) have been recorded for all pigs at the beginning (d-4) and the end (d-1) of the adaptation period as well as at the middle (d11) and end of the experiment (d25). Every three days the skin temperature of outdoor pigs (SEP) was registered twice a day in three points: back, side and skull. Measurements were performed in the morning (between 6:00 and 10:00) and at the end of the afternoon (around 17:00h).

Pigs' outdoor behavior was studied twice, at the middle and the end of the experiment (d7 and d19). During 24 continuous hours, every 5 minutes physical activity, feeding behavior and position of each pig in the field area was registered. Data collected were used to estimate the covered distance in 24h for each pig. In the second trial, blood samples were collected at the before adaptation (d-4), one day after adaptation (d1), at the middle of the experiment (d11) and at the end (d22). Blood samples were used to determine hematology characteristics of pigs. A total of 20 samples of macrofauna were collected (10 before the presence of pig and 10 after their departure) by detecting macrofauna in samples of 20 cm<sup>3</sup> of soil.

### Statistical analyses

Non-parametric Kruskal-Wallis tests were used for non-repeated data and variance analysis were performed for repeated data (body temperatures) using the R software. The effects of system (S) and breed (B) were tested. Differences in means of outdoor behavior parameters between LW and CR were tested for significance using a  $\chi^2$  test.

## RESULTS AND DISCUSSION

Our results show that the growth is significantly affected by the production system. The outdoor animals had a growth rate of 240 g/d, against 360 and 580 g/d for the indoor pigs fed with local or industrial feed, respectively (Table 1; P <0.001). The discrepancy between OSP and CSP pigs could be explained by a more important physical activity in outdoor conditions.

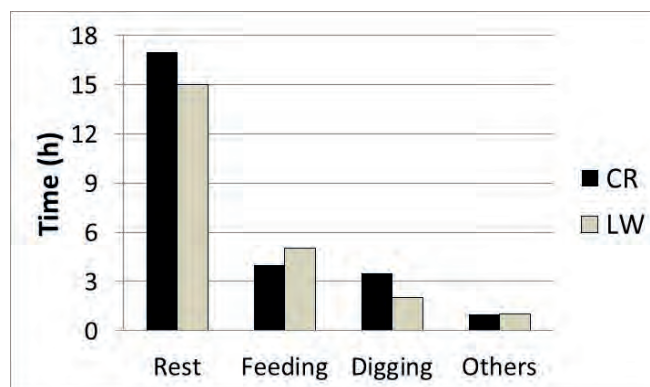


Figure 1—Effect of breed on outdoor physical activities.

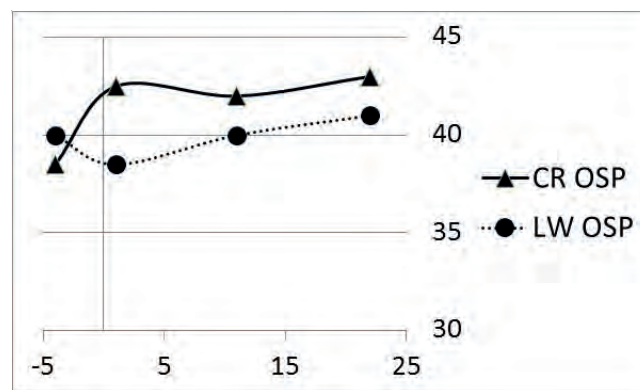


Based on Noblet (2005) study, we estimated that around 6% of the metabolizable energy of the OSP diet was used to cover requirements for adding physical activity in outdoor conditions. At the end of the experiments, CR pigs had higher backfat thickness than LW pigs. These results were in agreement with those obtained in indoor pigs of 45 kg by Renaudeau et al. (2005).

Breed	Creole			Large White			Significance
System	CSC	CSP	OSP	CSC	CSP	OSP	
Daily growth rate g/day	480 ± 50 <sup>a</sup>	340 ± 90 <sup>b</sup>	220 ± 40 <sup>c</sup>	680 ± 250 <sup>a</sup>	380 ± 50 <sup>b</sup>	260 ± 70 <sup>c</sup>	S***
Backfat thickness, mm	14 ± 2 <sup>a</sup>	9 ± 2 <sup>bc</sup>	15 ± 4 <sup>a</sup>	10 ± 2 <sup>b</sup>	8 ± 1 <sup>c</sup>	10 ± 2 <sup>b</sup>	B***, S*
Skin temperature, °C	35.4 <sup>a</sup>	35.0 <sup>b</sup>	37.5 <sup>c</sup>	36.2 <sup>d</sup>	35.6 <sup>a</sup>	38.0 <sup>c</sup>	B***, S***
Rectal temperature, °C	39.7 <sup>a</sup>	39.2 <sup>b</sup>	39.9 <sup>c</sup>	39.7 <sup>a</sup>	39.9 <sup>c</sup>	40.0 <sup>c</sup>	S*, B x S*

**Table 1.** Effects of system (S) and breed (B) on zootechnical performance and thermoregulatory responses; \*\*\* P<0.001 ; \* P<0.1

Outdoor pigs had greater body temperatures than indoor pigs. This is explained by an average difference in ambient temperature of + 1.5 °C between outdoor and semi-opened building. Skin temperatures were significantly affected by breed, with lowest values for CR animals. Our findings were in accordance with previous results on comparison between LW and CR growing pigs acclimation to hot environment (Renaudeau et al, 2007).

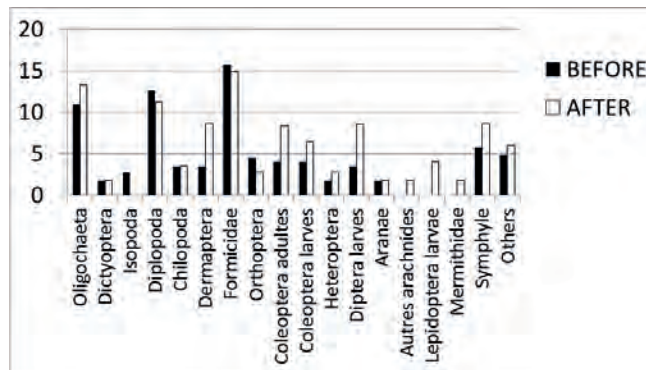


**Figure 2** – Effect of breed (CR vs LW) on hematocrit (%) before (d-4) and after (d1, d11 and d22) the outdoor conditions.

After 4 days of adaptation to outdoor conditions, OSP pigs were able to feed themselves by eating sweet potatoes leaves and by searching the tubers. Physical activities were found different between breed (Figure 1). LW pigs were found to be more active (40% of the time dedicated to physical activities) than CR pigs (30 %). Outdoor feeding behavior were also affected by breed with much more time dedicated for eating leaves in LW pigs and more eating time for tubers in CR pigs. In agreement with the study of Renaudeau et al (2005), ingestion time of soybean meal was more important in CR than in LW pigs. The breed's difference in outdoor behavior suggests that some differences occur between CR and LW in adaptation's strategies in outdoor conditions.

Our findings on the physiological responses (blood profiles; Figure 2) highlighted the best adaptation of the local breed (CR pig) when they passed from indoor to outdoor system. Indeed, adaptive hematologic response is faster in CR pigs than in the exotic breed (LW pigs). Unlike CR pigs, the arrival of exotic pigs in outdoor conditions caused firstly a weakening of the hematologic status suggesting that LW pigs are stressed by the change

Regarding the interaction between digging activities of pigs with macrofauna, in our experimental conditions (gradual discovery of plots and grazing period of 28 days), it seems that the presence of pigs on the plots (manure) is beneficial to soil macrofauna and thus the quality of the land from the farmer for future planting (Figure 3).



**Figure 3**—Effect of outdoor pigs activities on the density of the macrofauna (the density was expressed using the following formulae :  $\ln(\text{number of individuals} + 1)/\text{surface in m}^2$ ).

The alternative systems (outdoor and/or diet based on local resources), although less powerful in a zootechnical point of view, should suit to mixed farmers who are looking for an economic gain on animal production by using crop residues and minimizing human interventions. These studies are the beginning of trials that aimed at meeting mixed farmers requirements in terms of techno-economic references on outdoor pig systems and alternatives to preserve and develop a niche market for the local pig breed.

#### Aknowlegments

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## SAVOIRS INNOVANTS PAYSANS : LES ASSOCIATIONS CULTURALES TRADITIONNELLES DES HAUTS PLATEAUX DU CAMEROUN, UN MODÈLE POUR L'INTENSIFICATION AGROÉCOLOGIQUE

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**Mots-clés** : associations culturelles, agrobiodiversité, DER, services écosystémiques, changement climatique, mondialisation.

### Introduction

Les cultures associées multi-spécifiques et multi-étagées sont très répandues en région tropicale. Les hauts plateaux et montagnes de l'Ouest Cameroun offrent un exemple intéressant de la conceptualisation paysanne de ces associations. Cette région se caractérise par de nombreux microclimats, et des unités variées de paysages agro-géologiques qui expliquent la diversité des écosystèmes et des cultures pratiquées (tempérées à tropicales). Cette diversité induit un large éventail de situations agroécologiques, matérialisées par des associations culturelles élaborées de manière empirique par des paysan(ne)s. Quoique reconnues incontournables depuis les années 60 par certains chercheurs, elles sont restées considérées comme primitives et irrationnelles par les agronomes et financiers occidentaux jusque dans les années 90. Elles suscitent aujourd'hui un fort regain d'intérêt, comme alternative aux impasses environnementales de l'intensification conventionnelle monoculturelle. L'objectif de cet article est de présenter l'inventivité et le savoir-faire innovant des agriculteurs des Hauts Plateaux du Cameroun en matière d'adaptation des associations à différentes échelles - du billon au bassin versant -, en respect des gradients pédoclimatiques.

### Matériel et méthodes

Les Hauts Plateaux du Cameroun sont situés entre 700 et 2700m d'altitude (de 9° à 11°E et entre 5° à 6°N). Quatre provinces géoclimatiques sont définies selon un gradient altitudinal réglant les régimes thermiques et de précipitations, et créant une grande diversité d'agroécosystèmes. Huit situations pédoclimatiques très spécifiques ont été retenues pour étudier la typologie des associations culturelles. L'indicateur d'efficiency retenu est le Density Equivalent Ratio :  $DER = \frac{\text{Densité culture associée 1}}{\text{Densité culture pure 1} + \text{Densité culture associée 2}} + \frac{\text{Densité culture associée 2}}{\text{Densité culture pure 2} + \text{Densité culture associée 3}} + \dots$

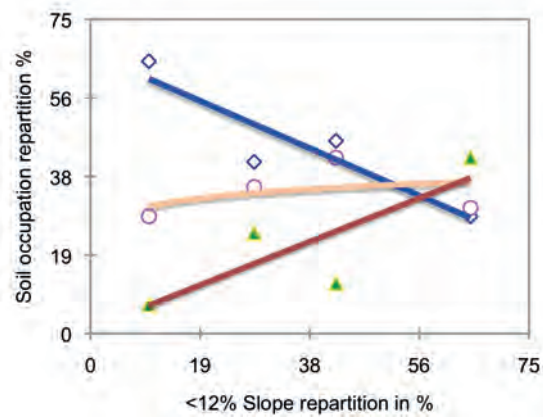
### Résultats et discussion

Les agriculteurs ont conceptualisé des associations spécifiques aux différentes échelles du billon, au champ jusqu'au bassin versant unitaire et selon les diverses conditions pédo-climatiques. Selon le type d'unité agro-écologique et de sa fertilité (position, pente), du nombre de rotations (épuiement), de l'éloignement de la case et des marchés. Le nombre des cultures varie ainsi que les espèces et variétés (Tableau 1).

Site	C%	CEC	Nombre d'espèces (+ si caféier)	DER
Fotensa	2,2	3	6	1,31
Dschang	4,2	4,3	11	1,04
Bafou	6,6	11,4	12 +	2,91

**Tableau 1.** Efficience d'associations culturelles sur 3 unités agroécologiques contrastées

Les caféiers sont introduits dans les cultures sur les unités les plus fertiles en général. Les paysans diminuent la densité des caféiers conseillée par les chercheurs. La fumure conseillée pour le café profite en partie aux cultures associées. Les champs/exploitations sont enserrés par des haies vives ou mortes qui fixent le sol, contrôlent le ruissellement, piègent et remontent en surface les nutriments. Les nombreux arbres jouent un rôle similaire sur le maintien de la fertilité. A l'échelle des éco-régions, trois systèmes agricoles dominant i) Jachère vs. Pâturage, ii) Cultures associées vivrières évolutives, iii) Cultures associées vivrières évolutives + Café. Elles sont implantées en respect des conditions pédoclimatiques et démographiques. Leur répartition dépend de l'importance des pentes inférieures à 12% caractéristiques des unités de paysage agro-géologiques. Le maraîchage irrigué est pratiqué dans les bas-fonds prioritairement. Sur chaque bassin versant, pour les zones à plus de 1800m (roches acides), 1800m (basalte), 1450m (granite) et 1400m (basalte) on constate une répartition spécifique selon la position sur le versant, outre celle observée selon l'altitude et l'unité agro-géologique (Fig. 1). Ces résultats agronomiques étonnants en absence de biocides et d'engrais de synthèse sont dus aux services écosystémiques (support, régulation, fourniture) gratuits que les plantes en association fournissent.



**Figure 1.** En haut de versant, la surface de la prairie et jachère diminue, alors que celle des cultures associées avec et sans caféiers avec la baisse de l'altitude



Rebord de plateau avec roche métamorphique (1400-900m)

### Conclusion

Après deux siècles d'exploitation intensive et ininterrompue dans l'Ouest Cameroun, malgré la forte densité démographique, l'agriculture multistratifiée traditionnelle reste encore largement excédentaire en produits vivriers. Ceci démontre que les cultures associées traditionnelles constituent un agroécosystème innovant et résilient par la très grande variété des combinaisons possibles pour un développement écologique alternatif face au changement climatique et démographique mais aussi à la « mondialisation ». Ces différentes associations représentent une alternative agroécologique remarquable qu'il faut veiller à maintenir. Leur amélioration technique et le souci de répondre aux exigences de la « mondialisation » obligent à combiner les savoirs traditionnels raisonnés, logiques, stratégiques, empiriques des paysan(ne)s avec les savoirs prédictifs et méthodologiques des chercheurs.

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## A YAM COLLABORATIVE SELECTION PLATFORM IN GUADELOUPE: A MODEL FOR EFFECTIVE MULTIPARTENARIAL AND PARTICIPATIVE PROGRAM

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**Keywords :** Yam selection, participative program, outreach & extension

### **Abstract :**

Since the early years of 2002, INRA and CIRAD in Guadeloupe have implemented complementary yam breeding programs to develop highly performant and locally well-adapted yam hybrids to fit both producers and consumer's requirements, yielding to nearly 20 pre-selected innovative cultivars.

In 2012, a multi-local, multi-partenarial and participative field plot network was implemented to achieve evaluation of cultivar performance at field scale in contrasted geographical and productive environments throughout Guadeloupe. During two to three crop cycles, several agronomic and qualitative indicators selected by producers were followed, registers and combined in a collaborative database. Once formatted, data will be used to develop computer-based decision tools to help growers and technical advisors with selection of best-adapted cultivars to specific growing production or final use.

Though this collaborative platform, various actors such as research scientists, breeders, technical advisors and producers have experimented and optimized effective yam breeding network to serve as a model for evaluation of any other tuber crops in Guadeloupe.

### **Materials and methods :**

Yam pre-selected cultivars were evaluated at the farm in 7 different contrasted yam-producing areas in Guadeloupe over 3 crop cycles, each approximately 10-to-12 months long. The list of cultivars, number of plants per cultivar (48), and distribution of cultivars within the experimental plot were pre-determined by the selection committee, and common to all experimental sites. Cultivation practices such as soil preparation, type and irrigation frequency, fertilization, choice for yam foliage support or associated crops were given free to each producer.

At each experimental site and for each crop cycle, several indicators were followed from planting to post-harvesting, as determined by the selection committee. Over 2 months after planting, number of germinated plants per cultivar was assessed bi-weekly and expressed as percent of germinated plants to assess germination rate and homogeneity. From 2 months after planting, foliage development rate per cultivar was determined by measuring weekly foliage soil covering in one-square-meter quadrats and expressed as quadrat total percent cover.

All along crop cycle, foliar diseases and disorders caused by anthracnose, curvularia or viruses were determined by evaluation of symptom intensity following a 1-to-5 scale.

At harvest and for each experimental site and each cultivar, number of yam tubers per harvested plant was determined and expressed as average number of plant tubers. Additionally, each harvested tuber was weighted individually and characterized regarding global shape and quality. Finally, weight and quality of lots of 7 tubers per cultivars were evaluated during 2 months after harvest to evaluate potential for post-harvest conservation.

At each crop cycle, several farm field-days were organized at selected experimental sites with producers and technical advisors located in the vicinity of the production site. Participants were invited to appreciate foliage development, cultivar estimated yield and tuber quality using evaluation sheets.

### **Main results :**

Over 3 crop-cycles and in 7 experimental sites, over 100.000 individual data were collected and combined. As for instance 8097, 8832 and 5103 yam individual tubers weights were collected in 2013, 2014 and 2015, respectively. All data are currently being processed to evaluate cultivar performance in contrasted and heterogeneous environments and determine if there are statistically significant cultivar-environment interactions. However preliminary results already suggest that yam cultivar variability within each experimental site is not significantly different to variability between experimental sites.



**Conclusion :**

Yam selection cultivars through multiple criteria analysis in contrasted geographic and pedoclimatic environments with various cultivation practices appears to be a complex and tremendous process. Thus, selection of a limited number of highly successful cultivars adapted to all yam production areas and markets in Guadeloupe seems not to be the preferred strategy. Indeed, feedbacks from yam evaluation field days have revealed that any of the evaluated cultivars could fit one's growers or consumer's requirements, indicating that expectation for a range of multiple and various cultivars is greater than for limited selected cultivars. Through continuous enhanced interactions within the collaborative platform between final consumers and growers, on one side, and yam breeders and actors of the selective process, on the other side, these results should help improving yam selection process in Guadeloupe to deliver cultivars best fitting local requirements.

MANAGEMENT OF BIOLOGICAL PROCESSES IN AGRO ECOLOGICAL PERSPECTIVE

GREENHOUSE EVALUATION OF SARGASSUM SEAWEED AS A POTTING MEDIUM FOR VEGETABLES

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**Keywords:** sargassum, sweet peppers, net photosynthesis rate PN, PAR, and stomatal conductance.

**Abstract**

The Sargassum seaweed [*Sargassum natans* and *S. fluitans*] can be classed as a perennial invasive weed problem in all the Caribbean islands. It has been shown to affect fisher-folks, sea bathers, and tourists. It is proving to be costly to remove; in addition to its offensive odour which hampers the clean-up operations. The University of Trinidad and Tobago at the BAFT campus is engaged in series of activities to find suitable uses of the seaweed as animal feed, and as soil medium and ameliorant. This study aimed at evaluating the suitability of the seaweed as a growing media for the production of sweet peppers [*Capsicum annuum* var. *annuum*] using different percentage of the weed (0, 25, 50 and 100%) with soil under greenhouse conditions. The crop growth and development and yield were monitored. The results indicated that the plant height [ $Y_{\text{pl ht}} = 16.6 + 0.3 \text{ DAT} - 0.11 \text{ TRT}$ ] and leaf number [ $Y_{\text{no.lvs}} = 0.90 + 1.04 \text{ DAT} - 0.206 \text{ TRT}$ ] increased as age of the crop increased, but decreased with the increase in percentage of seaweed/ soil mixture. A similar response was observed for the flower buds and fruits numbers and percentage soil mixture. The medium had no effect on the crop transpiration and net photosynthesis rate [PN], photosynthesis active radiation[PAR], and stomatal conductance. A nutrient analysis of the medium was also conducted.

**Introduction**

Seaweeds can be classed in groups based on their pigmentation; brown (*Phaeophyceae*), red (*Rhodophyceae*) and green (*Chlorophyceae*) (FAO, 2003). Sargassum seaweed has been a problem in the Caribbean earlier 2015, with large quantities washing ashore. There are mainly two species of Sargassum washing ashore in the Caribbean: *Sargassum natans* and *Sargassum fluitans*; both belonging to the class *Phaeophyceae* (Doyle and Franks, 2015). Mineral analysis of *S. natans* and *S. fluitans* powder, have shown the macronutrients: nitrogen to be  $6.36 \pm 0.2$  mg/100g, phosphorous  $96.5 \pm 2.12$  mg/100g, potassium  $28.0 \pm 0.74$  mg/100g, magnesium  $42.75 \pm 0.35$  mg/100g, and micronutrients, zinc  $0.05 \pm 0.0$  and iron  $8.7 \pm 0.28$  mg/100g (Oyesiku and Egunyomi, 2014). The nutrients present in the seaweed may not be adequate all together for plants; however it may be used as a biostimulant. The brown seaweed similar to what washed ashore on the East Coast of Trinidad comprises of 2,000 species and has been extracted and manufactured as a biostimulant or a biofertilizer (Khan et al, 2009). The definition of a plant biostimulant given by the European Biostimulants Industry Council is: 'Plant biostimulants contain substance(s) and/or micro-organisms whose function when applied to plants or the rhizosphere is to stimulate natural processes to enhance/benefit nutrient uptake, nutrient efficiency, tolerance to abiotic stress, and crop quality'.

The *Laminaria* and *Sargassum* seaweed families are the most commonly used in the manufacture of seaweed concentrate/ extract in the Northern Hemisphere, along with the species *Ascophyllum nodosum* (Stirk and Staden, 2006). The beneficial effects of plant growth by seaweed extracts are not only attributed to mineral nutrients alone, but presumably extend to plant growth regulators cytokinins (Khan, 2009) and betaines (Stirk and Staden, 2006). Some of the effects noted by application of seaweed extracts to plants are improved shoot and root growth, increased flowering, better yield, resistance to insect pests and enhance photosynthesis (Norrie and Keathley, 2006, Stirk and Staden 2006). Addition of seaweed to soil was also noted to affect physical soil properties, by increasing total pore volume and aggregate stability of the soil (Haslam and Hopkins, 1996).

From the literature reviewed, studies have mainly focused on seaweed extracts and not necessarily seaweed as a whole. With the large quantities of seaweed washing on shore and potentially damaging the tourism industry seasonally and hampering turtles from nesting, in the Caribbean; this study was undertaken to evaluate the likelihood a small scale farmer can utilize the whole seaweed with minimum preparation and record any benefits the seaweed provides presumably as a biostimulant.

**Materials and Method**

*Capsicum annuum* var. *annuum*, commonly known as Canape variety of sweet peppers were used in this experiment and grown in four variations of the potting media. The media were filled into buckets with a depth of 24.5 cm and 23.5cm diameter. The four media were: **1)** topsoil without seaweed [0%], **2)** topsoil with a 25% mulch layer of sargassum seaweed on 6 inches of soil **3)** 5 inches of 100% Sargassum seaweed **4)** 50/50 mixture of soil and Sargassum seaweed amounting to 6 inches. The seaweed was not washed before in order to preserve mineral content; the seaweed however was dried in direct sunlight and the sand shaken out.

The buckets had holes to the base to allow for proper drainage. 144 Canape seedlings at two weeks old were transplanted into each soil type (36 in each soil type). Guard rows were placed around the set up. Each soil type had 4 columns by 9 rows. During a period of 9 weeks, plant height, number of fruits, number of buds and flowers were recorded. Photosynthesis data were also recorded using the CI-340 Bioscience Photosynthesis System at 9 am once a week. On week 10 after two harvests, each plant was treated with 5 grams of 12-12-17 Blaukorn complex fertilizer at monthly intervals. Results were analyzed by regression analysis using Minitab v17.

## Results and Discussion

The number of leaves and plant height increased with time but decreased with the increase in percentage of seaweed. The number of fruits and buds showed no significant difference. The transpiration rate, net photosynthesis rate, photosynthesis active radiation and stomatal conductance showed no significant difference:

### *Results of statistical analysis*

#### Average plant height versus days after transplanting (DAT) and treatment (TRT)

$$Y_{pl\ ht} = 16.6 + 0.3\ DAT - 0.11\ TRT \quad R^2 = 76.8\%$$

#### Average number of leaves versus days after transplanting (DAT) and treatment (TRT)

$$Y_{no.lvs} = 0.90 + 1.04\ DAT - 0.206\ TRT \quad R^2 = 76.4\%$$

#### Average number of buds versus days after transplanting (DAT) and treatment (TRT)

$$Y_{nos\ buds} = 9.9 + 0.800\ DAT - 0.168\ TRT \quad R^2 = 18.2\%$$

#### Average number of fruits versus days after transplanting (DAT) and treatment (TRT)

$$Y_{nos\ fts} = -3.1 + 0.5\ DAT - 0.14\ TRT \quad R^2 = 18.2\%$$

#### Average fruit weight versus days after transplanting (DAT) and treatment (TRT)

$$\text{fruit wt.} = 164 - 1.75\ TRT + 0.873\ DAT$$

$$S = 125.158 \quad R\text{-Sq} = 24.9\% \quad R\text{-Sq(adj)} = 18.9\%$$

#### Transpiration rate (E) versus days after transplanting (DAT) and treatment (TRT)

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Table and figures

Treatment (% seaweed)	Days after transplanting	Average Plant height (cm)	Average Number of leaves	Average Number of flowers	Average number of buds	Average number of fruits
0	9	16.25	11	0	0	0
25	9	14.25	10	0	0	0
50	9	15.63	8	0	0	0
100	9	15.75	6	0	0	0
<b>Mean</b>		<b>15.47</b>	<b>9</b>	<b>0</b>	<b>0</b>	<b>0</b>
0	19	27.7	25	20	98	5
25	19	22.23	18	25	75	4
50	19	19.72	10	11	19	1
100	19	16.07	6	1	6	0
<b>Mean</b>		<b>21.43</b>	<b>15</b>	<b>14</b>	<b>50</b>	<b>3</b>
0	32	38.25	54	30	29	23
25	32	29.63	36	38	26	19
50	32	28.38	33	29	54	3
100	32	20.08	14	8	19	0
<b>Mean</b>		<b>29.08</b>	<b>34</b>	<b>26</b>	<b>32</b>	<b>11</b>
0	45	36.25	41	2	36	28
25	45	31.33	41	4	46	25
50	45	37.08	69	30	106	21
100	45	23.33	25	4	48	6
<b>Mean</b>		<b>31.99</b>	<b>44</b>	<b>10</b>	<b>59</b>	<b>20</b>

Table 1. Sweet pepper physical data for different treatments and days after transplanting

Treatment (% seaweed)	Days after transplanting	Average Weight (g)
0	59	525.00
25	59	487.25
50	59	75.00
100	59	0.00
<b>Mean</b>		<b>271.81</b>
0	79	12.83
25	79	36.96
50	79	241.60
100	79	52.65
<b>Mean</b>		<b>86.01</b>
0	106	200.02
25	106	343.08
50	106	239.27
100	106	120.00
<b>Mean</b>		<b>225.59</b>
0	131	303.61
25	131	313.02
50	131	172.55
100	131	78.77
<b>Mean</b>		<b>216.99</b>

Table 2. Sweet pepper harvest data for different treatments and days after transplanting

Treatment (% seaweed)	Days after transplanting	Transpiration rate (E)	Net photosynthesis rate (Pn)	Photosynthesis Active Radiation (PAR)	Stomatal conductance rate (C)
		mmol/m <sup>2</sup> /s	umol/m <sup>2</sup> /s	umol/m <sup>2</sup> /s	mmol/m <sup>2</sup> /s
0	15	2.78	0.82	41.5	282.07
25	15	3.23	1.54	70.53	351.58
50	15	0.3	0.29	216.48	15.89
100	15	0.19	0.21	439.5	7.18
<b>Mean</b>		<b>1.63</b>	<b>0.72</b>	<b>192.00</b>	<b>164.18</b>
0	27	1.24	3.57	147.2	144.36
25	27	1.58	8.33	581.47	115.83
50	27	5	-30.88	225.83	702.56
100	27	3.25	-35.78	199.73	288.78
<b>Mean</b>		<b>2.77</b>	<b>-13.69</b>	<b>288.56</b>	<b>312.88</b>
0	38	0.28	146.24	187.83	29.36
25	38	2.41	3.73	203.6	264.7
50	38	3.67	3.42	269.3	671.63
100	38	3.31	3.34	281.8	354.65
<b>Mean</b>		<b>2.42</b>	<b>39.18</b>	<b>235.63</b>	<b>330.09</b>
0	45	3.54	0.75	98.97	390.73
25	45	3.17	9.31	330.3	347.04
50	45	4.03	4.32	95.57	771.7
100	45	3.96	8.67	313.13	632.4
<b>Mean</b>		<b>3.68</b>	<b>5.76</b>	<b>209.49</b>	<b>535.47</b>
0	73	1.5	138.25	82.33	382.04
25	73	2.53	1.42	62	717.47
50	73	3.15	0.76	82.57	429.62
100	73	2.66	8.79	340.07	308.48
<b>Mean</b>		<b>2.46</b>	<b>37.31</b>	<b>141.74</b>	<b>459.40</b>

**Table 3.** Sweet pepper biological rates for different treatments and days after transplanting

Parameter	Reading
pH	
Electrical conductivity	
Nitrogen	
Phosphorous	
Potassium	
Calcium	
Magnesium	
Iron	

**Table 4.** Chemical analysis of Sargassum seaweed



## MULCHING EFFECT ON CAULIFLOWER (*BRASSICA OLERACEA* VAR. *BOTRYTIS*) PRODUCTION IN THE DRY SEASON IN TRINIDAD

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### Abstract

This study assessed the yield, growth measurements and weed control of eleven organic and three synthetic mulches during the dry season. The data obtained showed that the most beneficial mulches in terms of leaf area of the cauliflower were the synthetic Black Plastic, organic Coffee Hull and wood chips. The largest leaf area varied from the smallest by 3952.95 cm<sup>2</sup>.

The average fresh weight had a difference of 220 grams from the lowest and highest fresh weights. This could probably be attributed to the retardation of the evaporation of water from the soil. Saw and wood chips had the highest fresh weight as well as diameter size and these were also higher than the control.

In terms of diameter of the cauliflower, the synthetic saran netting, organic saw dust and wood chips displayed the largest value. The largest diameter varied by 4.4 cm from the smallest diameter. The synthetic mulches did not seem to follow any pattern in terms of diameter size.

The synthetic mulches appeared to discourage the growth of weeds better than the organic mulches although the clear plastic mulch did not perform as well as the black plastic; this can probably be attributed to the availability of sunlight to the weeds. The use of dried grass as a mulch encouraged the most growth of weeds. Horse manure, elephant grass, coconut coir, coconut leaves and dried grass had more weeds in terms of dry weight, than the control; which seems to suggest that these types of mulches encouraged their growth.

### Introduction

Mulching uses a material with different properties from the soil to create a barrier between the existing soil material and the atmosphere. Mulches can be either organic or synthetic. Organic mulches are derived from plant material, and over time decomposes into the soil; adding nutrients to the soil. Inorganic mulches, like plastics and stone do not break down and stays longer than organic mulch; however they don't add any nutrients to the soil over any period of time (Pranmanik, 2015). Mulching creates benefits, such as: conserving soil moisture, and modifying soil temperature (Pranmanik, 2015); plastic mulches can control weeds and deter insects (Ham et al, 1993). Mulches vary in their optical and thermal properties, so soil temperature (Ham et al. 1993) and soil moisture (Mahadeen, 2014) is varied based on the mulch used. The use of plastic mulched soil has resulted in early and increased yields, due to the increase heat of the soil, resulting in accelerated seed germination in some vegetables (Katan and DeVay, 1991).

### Objectives

To assess the yield, growth measurements and weed control of eleven organic and three synthetic mulches during the dry season.

### Materials and method

A plot of land, 31m x 2m, was rotovated, banked and installed with a drip irrigation system. The soil type was Piarco Fine Sand. The area was then subdivided into 15 plots (175cm x 110cm). Four-week old cauliflower seedlings (Whiteshot variety) were transplanted, 0.3m x 0.3m apart. The different mulches were administered to fifteen plots. Organic mulches included control, coconut coir, banana pseudostem, coffee husk, rice husk, horse manure, dry grass, coconut leaves, elephant grass, wood chips, cocoa pod and synthetic mulches used were black plastic, clear plastic and saran netting. At two-week intervals, the plants were sprayed with insecticides (Regent, Fastac, Pronto), and a fungicide (Acrobat, Mankozeb). Both the insecticide and fungicides were alternated. The irrigation system was turned on every other day for two hours. Five (5) grams of 12:24:12 fertilizer were applied to the seedlings at transplanting. At 2 weeks and 4 weeks after transplanting, 15 grams of 12: 12 17:2 fertilizer was then applied.

At four weeks after application of the mulches, two cauliflower plants were randomly selected and the number of leaves was recorded. Two fully grown cauliflower plants were sampled at harvest time and the diameter, the fresh weight and dry weight of the cauliflower were recorded. The leaf areas were attained using the CI202 laser leaf area meter. Also, grasses, broadleaf and sedges from each plot with different mulches were also collected and the dry weights were recorded.



Figure 1. Cauliflower grown in pseudostem mulch



Figure 2: Cauliflower grown in saw dust mulch



Figure 3: Cauliflower grown in clear plastic mulch

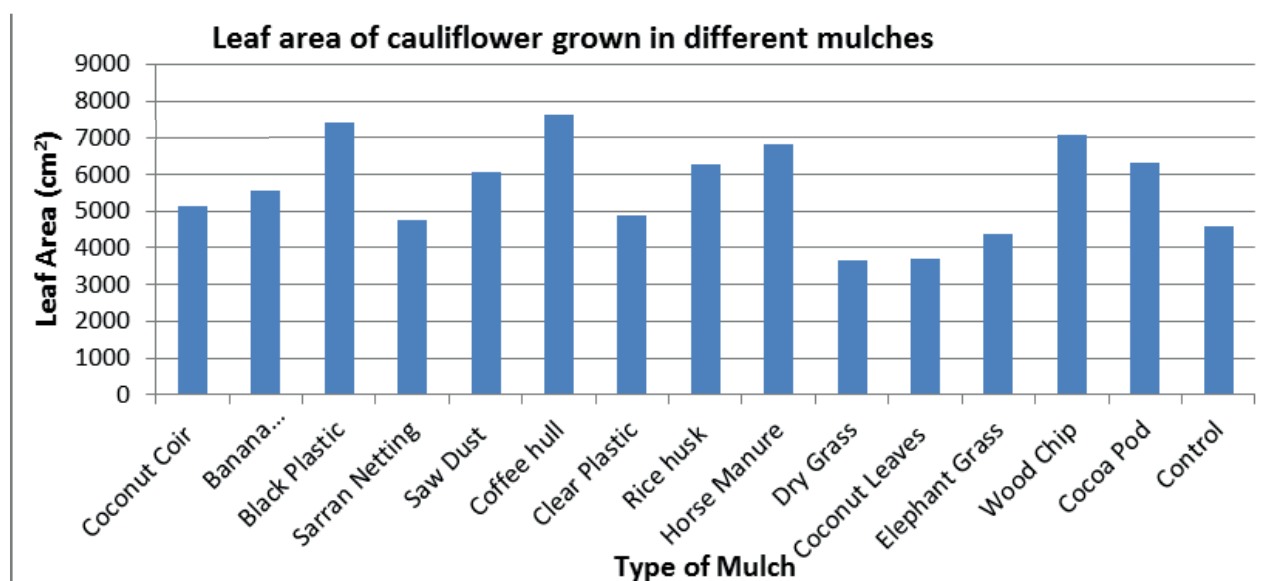
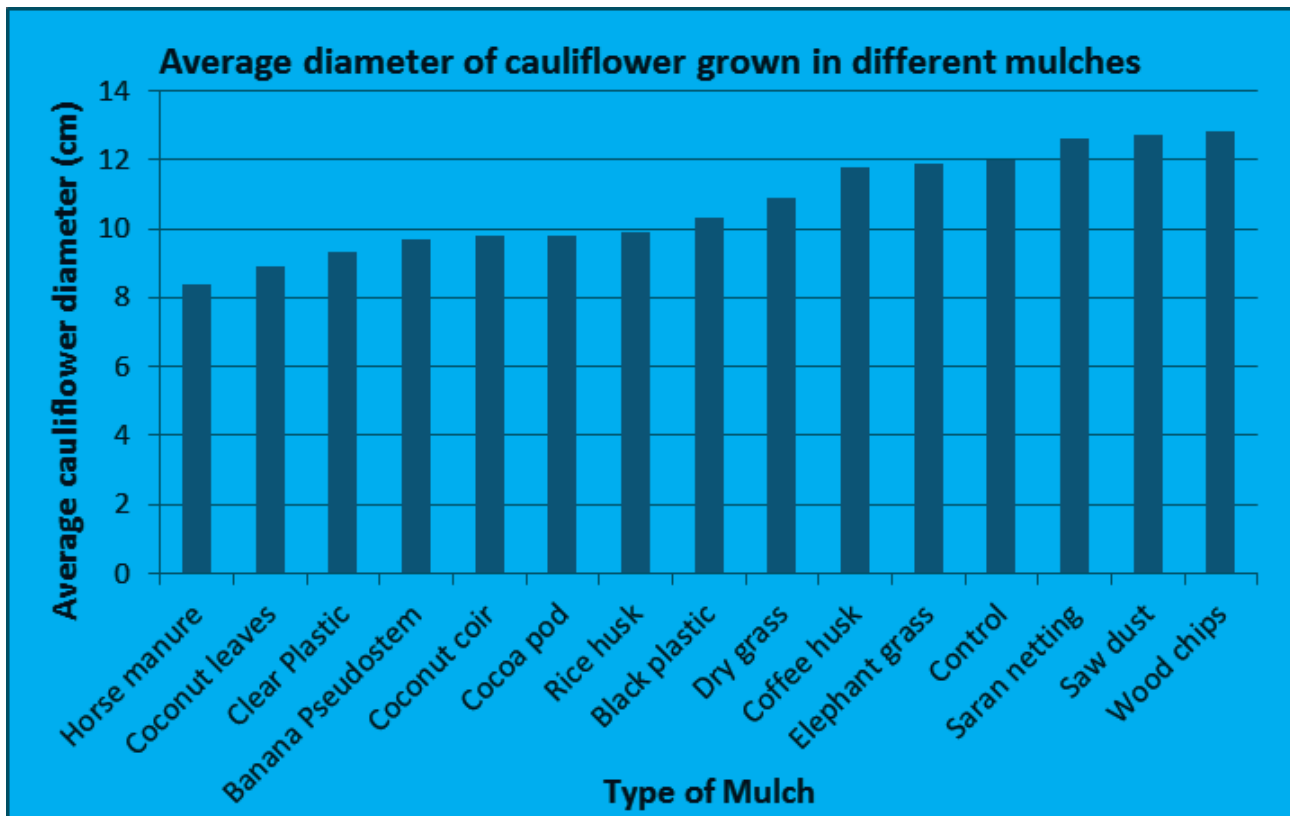


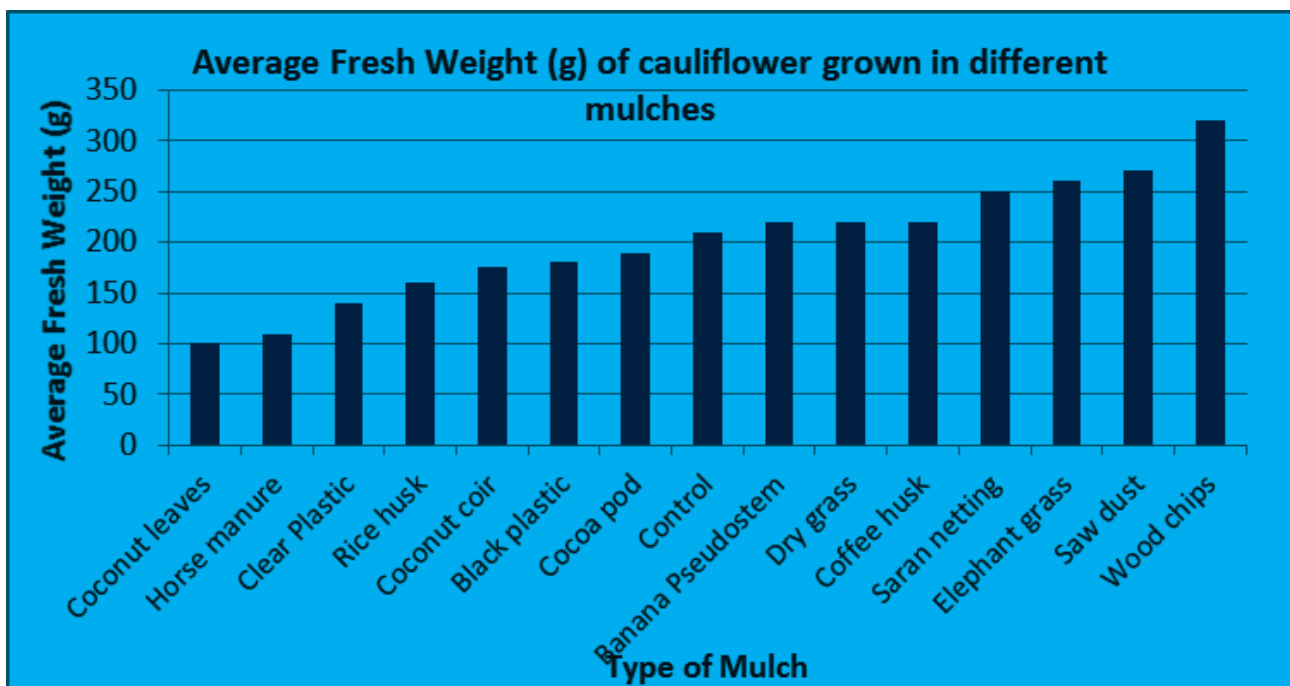
Figure 4. Average leaf area of cauliflower grown in different mulches

Figure 4, showed the most beneficial mulches in terms of leaf area of the cauliflower were the synthetic Black Plastic, and the organic Coffee Hull and wood chips. The largest leaf area varied from the smallest leaf area by 3952.95 cm<sup>2</sup>. The synthetic mulches did not seem to follow any pattern in terms of leaf area.



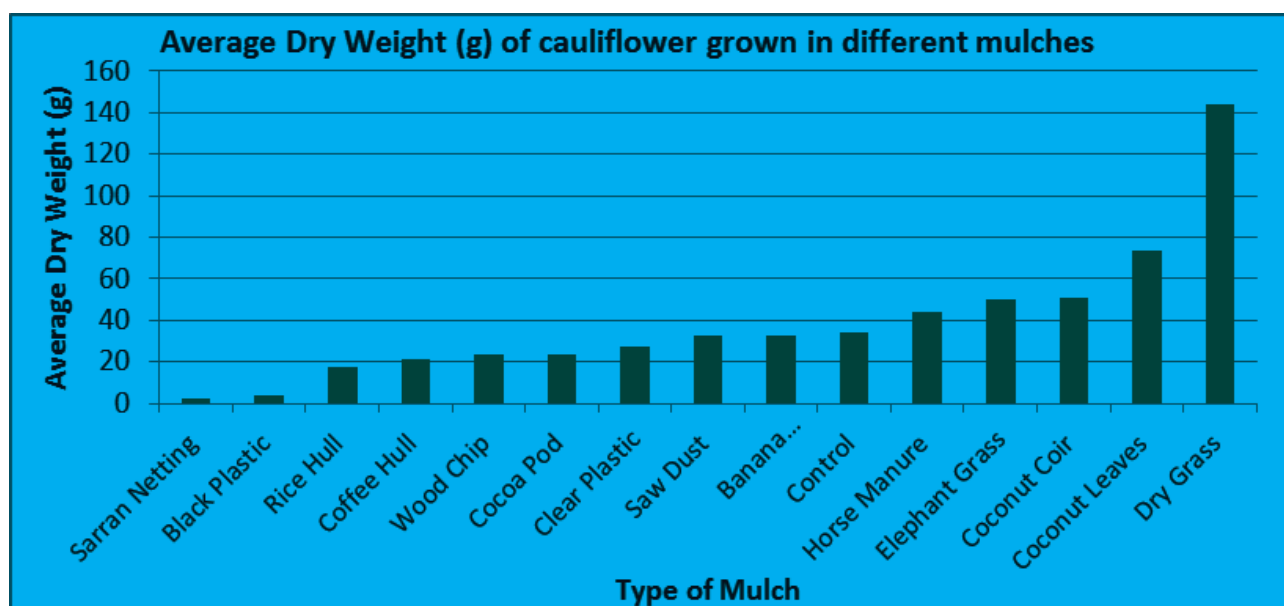
**Figure 5.** Average diameter of cauliflower grown in different mulches

Figure 5, showed the most beneficial mulches in terms of diameter of the cauliflower were the synthetic saran netting and the organic saw dust and wood chips. The largest diameter varied by 4.4 cm from the smallest diameter. The synthetic mulches did not seem to follow any pattern in terms of diameter size.



**Figure 6:** Average fresh weight (g) of cauliflower grown in different mulches

Figure 6 displays the average fresh weight (g) of cauliflower grown in the different mulch mediums. The average fresh weight had a difference of 220 grams from the lowest and highest weights. This could probably be attributed to the retardation of the evaporation of water from the soil. Saw and wood chips had the highest fresh weight as well as diameter size and these were also higher than the control.



**Figure 7:** Average dry weight (g) of cauliflower grown in different mulches

Referring to Figure 7, the synthetic mulches seemed to discourage the growth of weeds better than the organic mulches although the clear plastic mulch did not perform as well as the black plastic; this can properly be attributed to the availability of sunlight to the weeds. The use of dried grass as a mulch encouraged the most growth of weeds. Horse manure, elephant grass, coconut coir, coconut leaves and dried grass had more weeds in terms of dry weights, than the control; which seems to suggest that these types of mulches encouraged their growth.

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## COMPOSTING AND ORGANIC FERTILIZATION IN GUADELOUPE: CONDITIONS FOR THE EMERGENCE OF A WASTE RECYCLING INDUSTRY IN AGRICULTURE

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**Keywords :** bioeconomy; sustainable management of soils; eco-efficiency; recycling of waste; compost; public policies; choice experiment; experimental economics

### Abstract :

In French West Indies soil organic carbon (SOC) losses would be in the order of 5-10% since the early 90s, which is linked to agriculture intensification and the non-use of organic amendments. On the other hand, in Guadeloupe, the reduction and recycling of wastes become an important issue of sustainable development. The organic waste production is about 786 000 tons per year. Local authorities have proposed composting as a sustainable practice for recycling organic wastes as well as for orientating farmers towards the use of organic amendments. The basic assumption of this research is that composting can be an economic and ecological way to meet the needs of the proper treatment of organic waste and the needs of farmers in solutions for a sustainable fertilization of their soils. However, increasing supply, particularly for local industrial composts, means ensuring the existence of a strong and consistent demand. This raises the question of the conditions of adoption of compost by farmers in Guadeloupe. We propose an analysis of constraints to adoption to deliver various promotional levers of the use of composts. From an original economic approach, combining choice experiment, experimental economics and territorial modelling, the purpose of the research presented is to seek the economic, technical and organizational conditions of emergence of a sustainable waste recycling industry in agriculture.

### Materials and methods :

The proposed research approach is based on five complementary steps described below and in Figure 1.

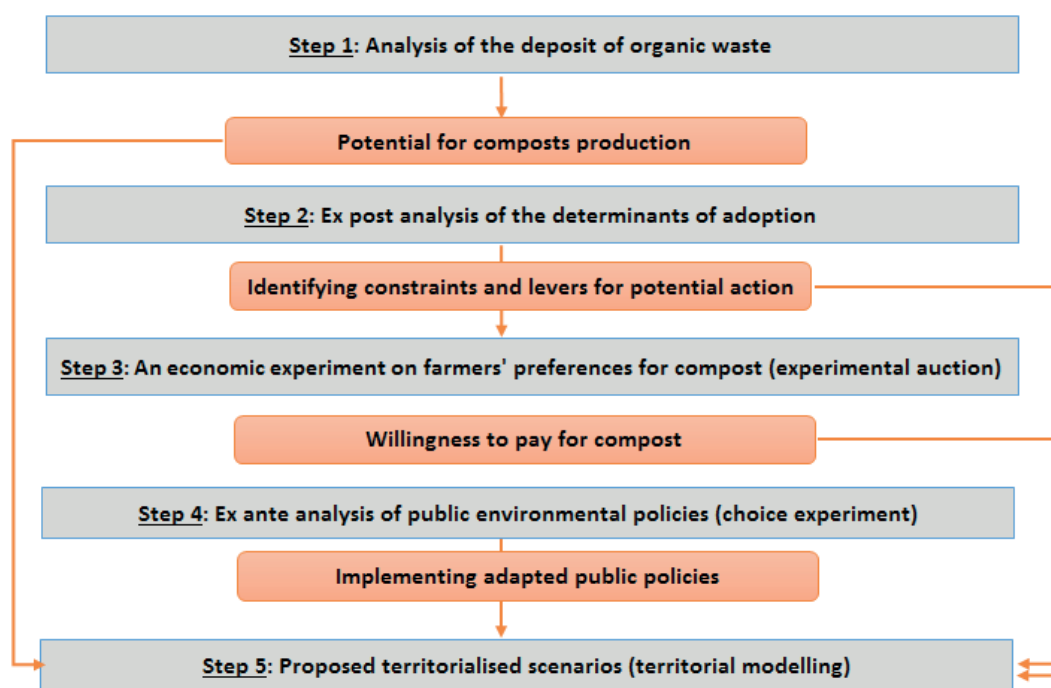


Figure 1. Research approach

1) The first step consisted in an analysis of potential for composts production based on a census of the actual amount of organic wastes. We distinguished several types of waste based on their current valorisation, ability to be used in compost production and availability for industrial processing of compost.

2) Then an ex post analysis of adoption of compost is done to identify the determinants of compost adoption in Guadeloupe (French West Indies), the reasons for using (or no-using) composts, the perception of barriers to adoption and potential incentives for facilitating adoption. To this end we surveyed through face-to-face interviews 520 farmers randomly selected from a database covering all the territory and a wide range of agro-ecological regions and cropping systems, which represented 7% of the total population of farmers and 17% of the agricultural area of Guadeloupe.



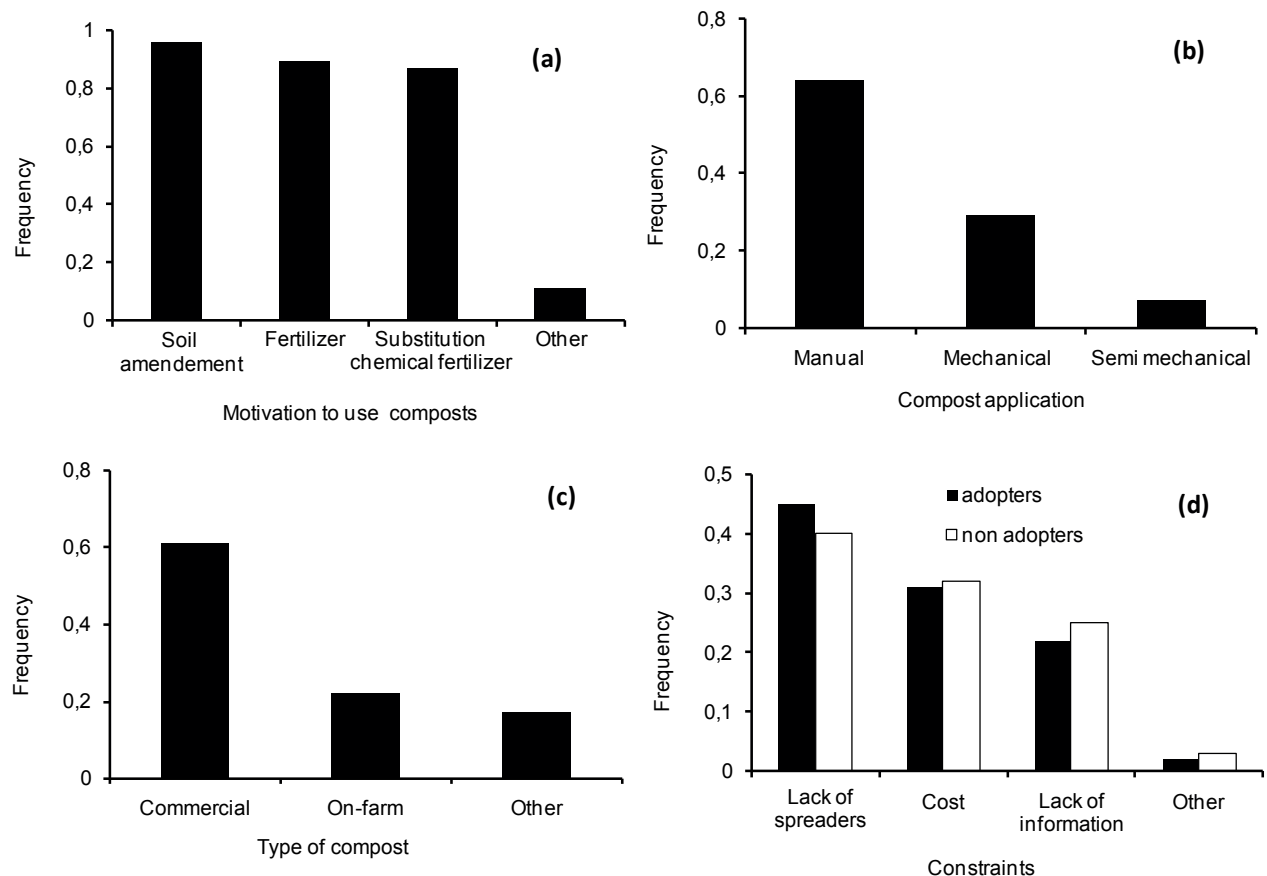
3) In the third step, an economic experiment on farmers' preferences for composts is made to measure farmers' willingness to pay for several types of compost. To analyse the impact of compost attributes on farmers' preferences, information about compost characteristics is gradually given for compost with an experimental auction mechanism. We tested several characteristics of compost likely to influence farmers' behaviour: (i) visual appearance, (ii) agronomic value, (iii) organic waste used and (iv) origin of the product (local or imported).

4) Then an ex ante analysis of public environmental policies to promote the adoption of compost is conducted with a 'Choice Experiment'. The aim is to guide public choice towards the definition of adapted public policies while taking into account the interests of farmers.

5) Finally we propose regional scenarios to summarise results of previous steps and to propose spatialized development scenarios of compost adoption in the agriculture sector of Guadeloupe.

**Main results :**

Our preliminary results indicated that the territory can potentially produce 80 000 tons of compost per year, which would recycle approximately 203 000 tons of organic waste per year. The survey indicated an adoption rate of 18%, which is mainly determined by the nature of cropping system at the farm level. The amended area was highest for banana systems followed by vegetable and tuber crops (Table 1). The amended area of sugarcane was low. The amended area for orchard, melon, pineapple and grasslands represented only 4% of the total amended area. Most of adopters declared that they apply composts as organic amendment, as fertilizer and to substitute chemical fertilizers in order to reduce pollution risks (Fig. 2a). Other motivations were minor in this study; e.g. organic farming, waste recycling. Near 60% of the adopters apply composts manually (Fig. 2b) and use commercial composts (Fig. 2c). Only 22% of farmers declared to produce their composts on farm, which are mainly based on green wastes blended with poultry litter or pig manure. The question about the main constraints involved in compost utilization was asked to both adopters and non-adopters farmers and the results obtained are presented in Fig. 2d. It is interesting to note that farmers showed the same perception of these constraints regardless compost adoption. In this way, the arduousness of the manual application was the main constraint highlighted by farmers, followed by the cost of the practice (product, transport and application) and the lack of available information about compost quality and its effect on the crops and the soil.



**Figure 2.** Results of the survey performed on a network of 520 farmers: (a) motivations to use composts, (b) type of compost application, (c) type of compost used by farmers, and (d) constraints found by farmers to use composts. Although only adopters were questioned for (a), (b) and (c), the question about the constraints in (d) was asked to both adopters and non adopters farmers.

Crop	Cultivated area	Amended area	
	ha	ha	%
Banana	657	261	40
Vegetable crops	433	91	21
Tuber crops	118	22	19
Sugarcane	2659	83	3
Orchard	44	7	16
Melon	53	3	6
Pineapple	63	2	3
Grasslands	1260	7	1
Total	5287	476	9

**Table 1.** Cultivated and amended area for the crops involved in the survey

### Conclusion :

Results obtained highlight various important factors (e.g. manual application, high cost of the practice and lack of available information about compost quality and its effect on the crops and the soil) which constitute significant barriers to the development of the use of composts by farmers. Several useful conclusions that provide insight on pathways to increase the adoption of compost in Guadeloupe emerge from activities carried out. Expected results concern: (i) willingness-to-pay of farmers for intrinsic characteristics of compost and information impact and (ii) analysis of the impact of the implementation of environmental public policies on the willingness of farmers to adopt compost.

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## INVESTIGATION ON ONE LOCAL EARTHWORM SPECIES IN SURINAME

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**Keywords:** Vermicomposting; *Amyntas cortices*; prostomium; clitellum; spermathecae.

### Abstract

Earthworms are essential soil organisms in maintaining soil fertility and thus are regarded as biological indicators of soil fertility. Earthworms are ecologically classified into epigeics, anecics and endogeics. However, only some species (epigeic and anecic) of earthworms are used for vermicomposting. The present investigations were carried out during the year 2014-2015 on local variety of earthworms hand sorted from Anton de Kom University of Suriname cattle fields for their feasibility to vermi-processing. Species identified belongs to family *Megascolecidae* and species *Amyntas corticis*, commonly known as black wriggler or crazy worm.

### Introduction

Approximately 4400 species have been identified in the world however few species are used in the process of vermicomposting. Broadly the earthworms are classified as soil dwelling and composting types. In Suriname little is known of earthworms and their application. Earthworms are soil macro-invertebrates that play a fundamental role in maintaining soil fertility by cycling of nutrients and decomposition of organic matter. They are terrestrial earthworms and scientifically classified under the phylum Annelida and class Oligochaeta. The earthworms are hermaphrodite, segmented worms, bilaterally symmetrical, with an external gland (clitellum) for producing the egg case (cocoon), a sensory lobe in front of the mouth (prostomium), and an anus at the end of the animal body, with a small number of bristles (setae) on each segment. Based on these features the earthworms can be taxonomically classified. In Suriname limited studies have been conducted on earthworm taxonomy hence this research focused on collection and identification of one earthworm species using taxonomic tools directing towards its feasibility for vermicomposting.

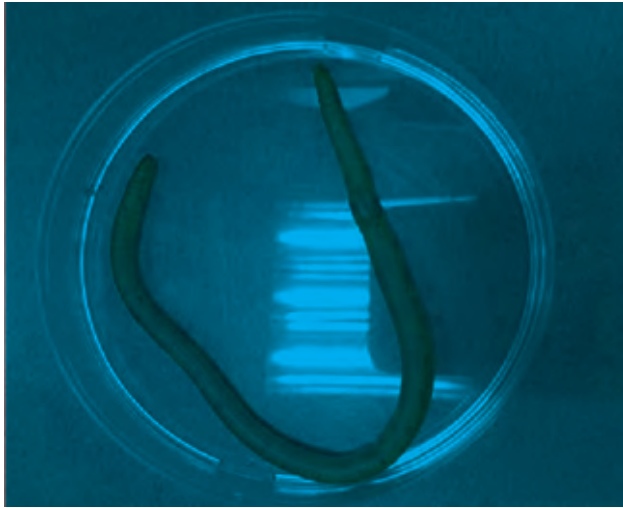
### Materials and Methods

The present research was carried out during the year 2014-2015 at the Anton de Kom University of Suriname, Paramaribo aiming on identification and classification of local available species of earthworm for the process of vermicomposting. The collection of earthworms was done in different parts of Paramaribo, Wanica and Para by organizing fieldtrips to dairy cattle and agriculture farms. In the dairy cattle farms the earthworms were collected from the heap of cow manure. The local - earthworms were collected from agricultural farms by digging the soil up to approximately 20 to 30 cm at places that showed earthworm activity, by observing the worm castings. Samples were taken from moist soils, gardens and agricultural fields. Digging of the earthworms was done carefully to avoid cutting or killing them. After visualizing the earthworms, the same were placed in a bucket. The locally collected worms were identified according to the morphology.

### Main Results

The species collected was identified to be *Amyntas corticis*, an exotic species to Suriname that basically feeds on soil (endogeic) and has no role in the process of vermiculture. *Amyntas corticis* (Kinberg, 1867) known as black wriggler, crazy worm or snake worm is the most widely distributed species of the pheretimoid earthworms and is found in many countries in east and southeast Asia, Australia, New Zealand, Europe, UK, USA, South America and South Africa according to Talavera

The black wriggler has a reddish-brownish dorsal pigmentation. They have a single female pore and small paired male pores. The black wriggler is found in human-influenced habitats and live in places that have arable land, pastures and forests up to a depth of 20 cm. or near the surface under litter or other decomposing organic material. They are capable of violent trashing movements, jumping and are very fast moving.



**Plate 1.** Colour of earthworm



**Plate 2.** Length of earthworm (in cm)

### **Conclusion**

The locally collected species from the agricultural fields in Suriname is confirmed to be *Amyntas cortices*, an endgiec exotic species that largely feeds on soil and does not play role in process of vermicomposting.

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## EFFECT OF EXOGENOUS ORGANIC MATTER ON SOIL BIODIVERSITY AND ECOSYSTEM SERVICES IN TOMATO PLANTATIONS

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**Keywords :** Chemical fertilizer, Compost, Vermicompost, Soil biodiversity, Ecosystem services, agronomic performance of tomatoes (*Solanum lycopersicum*).

### Abstract :

After the Green revolution, crop intensification and uses of chemical fertilizers and pesticides allowed the increase of agriculture productivity to respond to the expectation of a global food demand. However, these practices have negative side effects on the environment and human health. Consequently, to preserve the environment, the use of innovative practices is preconized nowadays. Among these alternatives practices, the use of compost and vermicompost is known to preserve soil diversity and fertility.

The objective of this study is to investigate the impact of chemical fertilizers, compost and vermicompost on key ecosystem services (primary production, nutrient recycling and decomposition of organic matter) provided by soil biodiversity in tomatoes (*Solanum lycopersicum*) plants.

### Materials and methods:

#### Experimental design

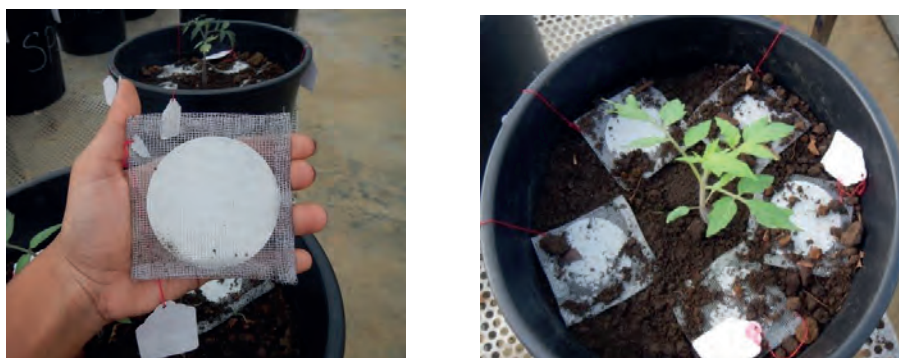
For this study, the variety of tomato plants used was *Solanum lycopersicum* cv. Heatmaster, because of its ability to resist in high temperature (35°C) and bacterial wilt. The seed were sowed in a mixture (V: V) of Ferralsol-Loam. After 3 weeks, tomato plants were transplanted in different type of growth medium. The soil used was a Ferralsol taking from the first fifteen centimetres of forest located near the INRA station (Domaine Duclos, Prise d'eau, Petit-Bourg). For this study, four different substrates were used: 1) T: soil forest + calcium; 2) SPE: soil forest + chemical fertilizers+ calcium ; 3) SPC : soil forest + compost+ calcium ; 4) SPV : soil forest + vermicompost+ calcium. Tomato plants (*Solanum lycopersicum* cv. Heatmaster) of 3 weeks old were transplanted in the each different treatment. This study was carried out in a greenhouse during 4 months.

#### Primary production

Leaf biomass have been determined 30 days after the experiment setting up, by weighting the aerial parts of plants dried out in an oven at 70° C during 72 hours.

#### Decomposition of organic matter

Organic matter decomposition was measured using the litterbags method (Figure 1). Five bags were installed at the soil surface of each pot and were randomly collected 7 days, 15 days, 30 days, 2 months and 4 months after the experiment setting up.



**Figure 1:** Litterbags (8,5 x 8,5 cm) with cellulose paper (Wattman, 7 cm) (Pictures C.Moulin).



**Soil chemical properties**

Total P, K were determined after soil mineralisation. Total P was measured colorimetrically according to the method proposed by Novozamsky et al. (1983), using a spectrophotometer. Total K was measured by atomic absorption spectrophotometry.

**Plant chemical properties**

The P and K content were determined from dry plant material (leaves and fruits). Total P was measured colorimetrically using a spectrophotometer and total K was measured by atomic absorption spectrophotometry.

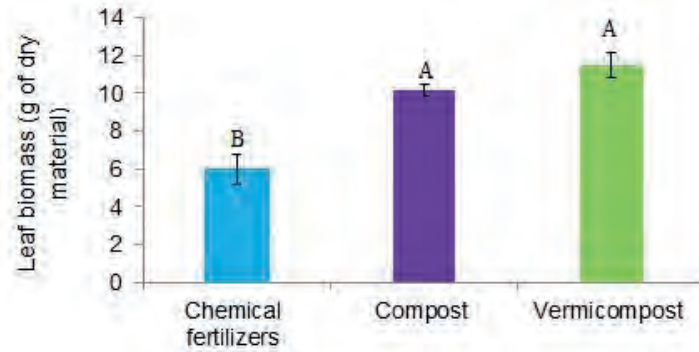
**Statistical analysis**

To compare the different variable among treatments, GLM were realised using XLSTAT software.

**Main results:**

**Primary production**

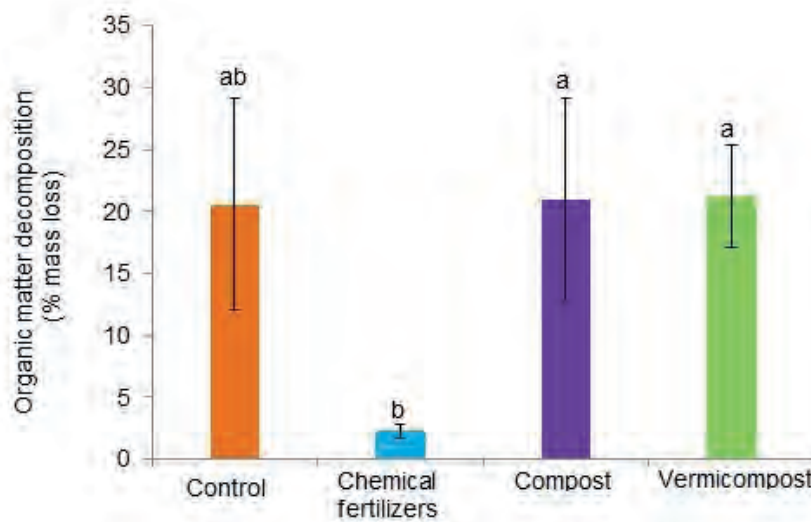
At 30 days, the leaf biomass was significantly higher for vermicompost ( $11.5 \pm 0.65$  g) and compost ( $10.18 \pm 0.28$  g) compared to chemical fertilizers ( $6.0 \pm 0.79$  g) (Figure 2). This difference of plant growth between treatments was probably due to the availability of soil nutrients in the organic treatments. However, the partitioning of dry matter among the different plant parts remained similar regardless of treatment (the leaves accounted for  $60 \pm 1\%$  of total dry matter of plants).



**Figure 2:** Leaf biomass in chemical fertilizers, compost and vermicompost at 30 days.

**Decomposition of organic matter**

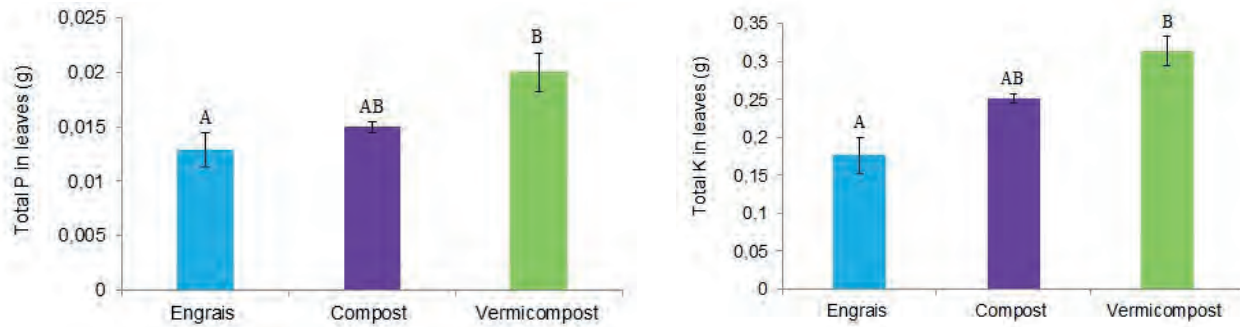
The decomposition of organic matter was significantly different among treatments (GLM,  $p= 0.04$ ). The decomposition was more important with vermicompost (21.3% of mass loss after 4 months) and compost (20.9% of mass loss after 4 months) compared to chemical fertilizers, (2.3% of mass loss after 4 months), Fig. 3. The biological activity was probably more efficient in these organic treatments.



**Figure 3:** Decomposition of organic matter in four different substrates at 4 months. The letters are indicating the difference between the treatments based on Tukey test.

### Soil chemical properties

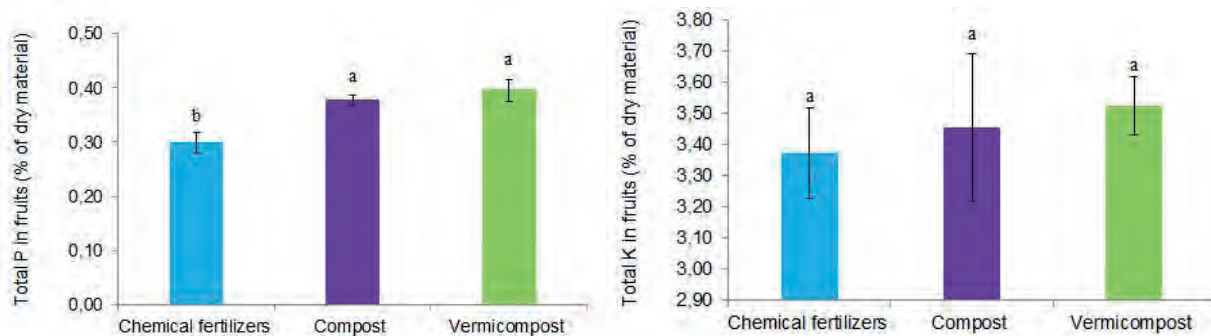
The soil P content was significantly higher for vermicompost compared to chemical fertilizers and compost (GLM,  $p=0.04$ ). However, the soil K amount was not different among treatments. Vermicompost increased the availability of P in soil due to earthworm activities (Loranger-Merciris et al. 2012).



**Figure 4:** Total P in leaves (on the left) and Total K in leaves (on the right) at 30 days for chemical fertilizers and organic fertilizers. The letters are indicating the difference between the treatments based on Tukey test.

### Plant chemical properties

The amount of P and K in leaves were higher for vermicompost compared to chemical fertilizers and compost (GLM,  $p=0.02$ ), Fig. 4. The amount of P in fruits was significantly higher for vermicompost and compost compared to chemical fertilizers (GLM,  $p=0.04$ ), Fig. 5. There was no significant differences between the treatments for K; however, we observed a slightly increase of K fruit content for the vermicompost (Figure 5). Plants had a tendency to use soil nutrients for their fruits production in organic fertilizers.



**Figure 5:** Total P (% of dry material) in fruits (on the left) and Total K in fruits (on the right) at 4 months for chemical fertilizers and organic fertilizers. The letters are indicating the difference between the treatments based on Tukey test.

### Conclusion :

In general, the availability of nutrients was not identical for all treatments based on the decomposition of organic matter. We observed that plants, which were treated with vermicompost and compost, had an easily access to nutrients especially for the P. These plants had a tendency to accumulate more nutrients in fruits compared to plants which were treated with chemical fertilizers.

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## EFFECTS OF A PHYTOSTIMULANT AMINO ACID FORMULATION ON BREADFRUIT PLANTS IN THE NURSERY

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**Keywords :** *Artocarpus altilis*; biostimulant; plant growth.

### **Abstract :**

The breadfruit (*Artocarpus altilis*) is generally propagated by root cuttings an emerging crop in Puerto Rico. Producing transplants from root cuttings is generally slow, and there is little information regarding the effects of practices that may help hasten their growth, such as fertilizers and phytostimulants. The objective of this research was to determine the effects of rates of a commercially available agricultural formulation of amino acids on the performance of breadfruit plants in the nursery. Rates of a phytostimulant with 6% free L-amino acids formulated for soil application (from BioIberica, Barcelona, Spain) was evaluated. Root cuttings of 15 cm in length and 2.5 cm in diameter, taken from a selected tree ('Ballester') were planted in plastic containers 20-cm in diameter and 30-cm tall, filled with a commercial peat moss substrate. When breadfruit shoots were 10 cm tall, the phytostimulant was applied as a substrate drench, using 200 ml of aqueous phytostimulant solution per plant. The aqueous phytostimulant solutions (treatments) were prepared at the rates of 0 (check), 1, 2, 3, or 4 ml of commercial formulation/L of water. The treatments were arranged in a completely randomized design with 7 replicates (plants). The phytostimulant solutions were applied 11 times at 14-day intervals. Stem diameter was not affected by phytostimulant rates. Leaf number, leaf area, shoot biomass, and root biomass had quadratic responses to phytostimulant rates. These results indicate that using agricultural amino acid formulations may help in hastening the growth of breadfruit plants in the nursery.

### **Materials and methods :**

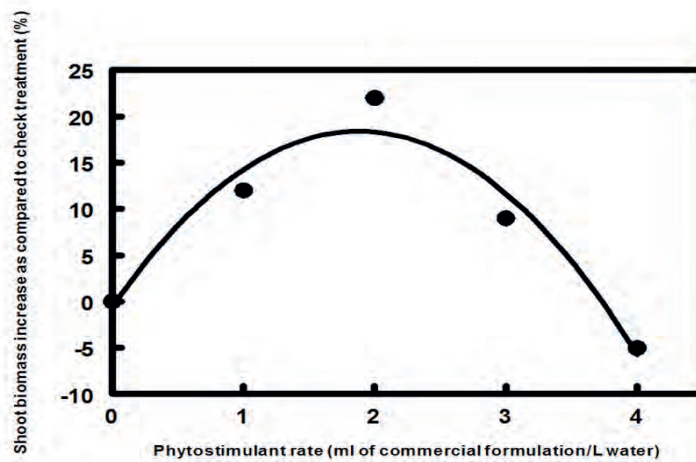
Root cuttings 15-cm in length and 2.5-cm in diameter, were taken from a selected breadfruit tree in a farm located in the municipality of Las Marias, Puerto Rico. The root cuttings were planted were in plastic containers 20-cm in diameter and 30-cm tall, filled with a commercially-available peat moss substrate. The containers were kept in a greenhouse and the substrate was irrigated daily.

The treatments were rates of a phytostimulant based on 6% free L-amino acids, commercially available and formulated for soil application, manufactured by BioIberica, Barcelona, Spain. The phytostimulant was applied as a substrate-drench, applying to each plant 200 ml of an aqueous solution of the phytostimulant. The aqueous solutions contained 0 (check), 1, 2, 3, or 4 ml of the commercial formulation per L of water. The treatments were first applied when breadfruit plants reached 10 cm in height and were repeated at 14-day intervals for a total of 11 applications. The treatments were arranged in a completely randomized design with 7 replicates, where one plant was a replicate. Stem diameter and height, as well as number of leaves and leaf area were evaluated every 2 weeks. Root and shoot biomass were determined destructively 22 weeks after first application of the treatments. Results were submitted to statistical analyses.

### **Main results :**

The treatments did not affect stem diameter. In contrast, stem height, leaf number, leaf area, shoot biomass, and root biomass by 22 weeks after first treatment application followed the same pattern of quadratic responses to phytostimulant rates, increasing until phytostimulant rate was 2 ml/L, and declining at higher phytostimulant rates (Figure 1).

This kind of response has been reported for other plants in nursery, greenhouse and field conditions (Flores Torres, 2013; Maini, 2006; Mancilla, 2000), showing that there is a limit to how much amino acid formulation may be applied and still obtain a favorable response from the crop, while at higher rates amino acids may have adverse effects on plants. The extent of such effects may be somewhat different depending on the target plant species, amino acid concentration in the formulation, and frequency and mode of application of the formulation, and among other factors.



**Figure 1.** Effect of a phytostimulant amino acid blend on shoot biomass of breadfruit in the nursery. Mayaguez, Puerto Rico, 2015.  $Y = -0.51 + 20.13x - 5.4x^2$ ;  $r^2 = 0.94$ . Similar effects were found for leaf area, leaf number, root biomass and stem height, and are not depicted in this article.

**Conclusion :**

These results show that the response of nursery-stage breadfruit plants to amino acid phytostimulants was rate-dependent. Agricultural amino acid formulations may help in hastening the growth of breadfruit plants in the nursery, when used within certain rates.

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## INNOVATING AGROECOLOGICAL FARMING SYSTEMS IN THE CARIBBEAN DESIGN AND FABRICATION OF UNDERCOVER VEGETABLE GREENHOUSE FOR UTILIZATION OF MICRO-IRRIGATION AND FUZZY LOGIC TECHNIQUES

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**Key words:** Screenhouses , solar radiation, irrigation systems, fuzzy logic control mechanisms

### **Abstract:**

Screenhouses reduce incoming solar radiation that crops receive. In a tropical country such as Trinidad and Tobago, this is an important consideration for effective plant growth. Additionally, screenhouses may provide protection from weather conditions and virus vector insects and birds. The Waterloo Research Campus, housed on the site of the former Caroni 1975 Limited Research Station, contains a repository of rice and sugar cane germplasm. In order to conduct experiments on a variety of germplasm over an extended period of time, whose results would be based on fuzzy logic systems, a screenhouse with a micro-irrigation system was designed and fabricated over a 6 week period in November 2015.

Permits and code changes may require that a grower construct a professionally engineered structure where previously a non-load rated greenhouse may have been allowed to be built. The specifications of such dictates the heights, truss support mechanisms, grow boxes dimensions that allows for crop protection and as such welding procedures for proper stabilization so that proper irrigation systems and fuzzy logic control mechanisms can be monitored. Within a budgeted time, availability of materials, least resources and manpower hours, the workflow of designing and building such a structure was done. In retrospect, it can be said that proper scheduling and execution of constructing the screen house was done within budgeted time and cost with minimum resources and to specifications.



**Photograph 1.**

Structure of green house  
without irrigation systems



**Photograph 2.**

Micro-irrigation system under  
construction



## HYDROPONIC PRODUCTION SYSTEMS FOR WATERCRESS (*NASTURTIIUM OFFICINALE* R. BR.)

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**Keywords:** hydroponic, recirculating, aeration, shade growth analysis, photosynthetic rate

### Abstract

Watercress is produced by small farmers who divert water from rivers into paddies to ensure a continuous flow. The objective of this study was to evaluate novel systems of production for optimal growth and yield. The two new hydroponic production systems: recirculating and continuous aeration under two levels of shade using four different planting media were evaluated in both open and green house conditions. The crop were treated to Blaukorn fertilizer (12:12:17) at three rates, and a growth analysis and photosynthetic rate conducted. After 2 weeks of growth, watercress stalks that were at and above 10cm were harvested. The watercress re-circulating system in shaded conditions has produced consistently higher average results versus the watercress in full sunlight, in terms of fresh weight- 11.89 g vs 4.94 g; dry weight- 0.83 g vs 0.49 g; stem length- 17.60 cm vs 10.68 cm and number of leaves- 17 vs 15. Also the visual appearance and texture of the watercress grown in shaded conditions in the re-circulating system is better than that of the watercress grown in full sunlight and resembles the watercress produced in large scale systems more closely.

### Introduction

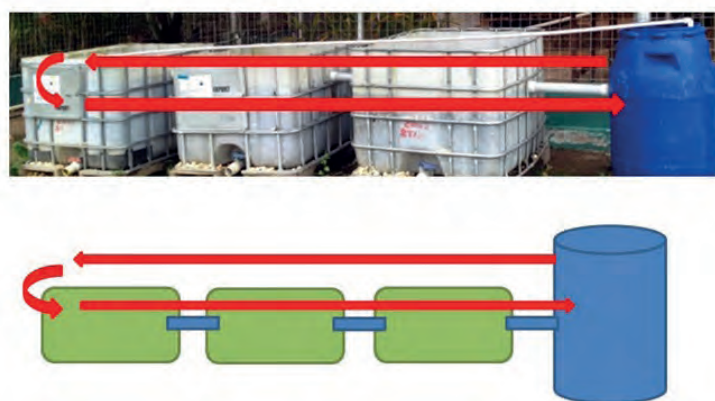
Watercress, *Nasturtium officinale* R. Br., is used in salads and are a source of vitamins A and C, niacin, ascorbic acid, thiamine, riboflavin, and iron (Stephens, 2015). Watercress needs to be grown in areas with ¼ to 2 inches of cool flowing water (McHugh et al., 1987); farmers in Trinidad usually plant watercress near a river, where the water can be diverted to create a stream throughout their plantation and then exit back into the river; thereby creating a continuous flow system. Water temperature also influences the growth of watercress; temperatures above 25.5° C cause poor or stunted growth. Nitrate content is another important factor for watercress growth; optimum growth is at about 4 ppm (McHugh et al., 1987). The discouraging factors highlighted by farmers into watercress production is the need for continuously flowing water and the danger of being bitten by poisonous coral water snakes that comes from the river.

### Materials and methods

#### Recirculating system design

Three containers each 91 x 22 cm was connected via 2” PVC pipe at the middle. Gravel was filled 15 cm away from the top of the containers. A pump was immersed into a 55 gallon barrel with a pipeline connection from the base to the top of the barrel and extended to the furthest container. An average of 42 pieces (498.54 g) of watercress stalks were placed in each container. This design was repeated twice, one in full sunlight and one in shaded conditions. Each week, Blaukorn fertilizer (12:12:17) was applied in accordance with the farmer’s rate, at 13.6 g for each 91 x 22 cm container.

After 2 weeks of growth, watercress stalks that were above 10cm (4 inches) were harvested and records were taken for stem length, number of leaves, fresh and dry weights. pH, temperature and electrical conductivity were also monitored. Nitrate and phosphate content were monitored at intervals before and hours after application of fertilizer.



**Figure 1.** Photo and diagram illustrating the recirculating system for watercress production

### Aerated system

A concrete brick trough was constructed under greenhouse conditions and was filled with water in which several air stones, connected to a pump, were immersed. These air stones served to continuously aerate the water within the trough. Two (2) gallon buckets were filled with different layers of planting mediums, namely; Promix, Promix-Soil, Promix-Sharp Sand, Sharp Sand-Promix, Promix-Sharp Sand-Promix, Sharp Sand-Promix-Sharp Sand. Two holes were drilled in each bucket approximately 4 inches below the top of the bucket, in order to allow water to flow into it. Watercress planting material was sourced from a nearby market place, leaves were trimmed and the stalks were cut into 4-5 inch pieces. Six stalks of watercress were secured into the planting material of each bucket. Each week, Blaukorn fertilizer (12:12:17) was applied in accordance with the farmer's rate, at 0.12grams for each 415.5cm<sup>2</sup> bucket. On a daily basis, pH, temperature, electrical conductivity and total dissolved solids were measured and recorded. Additionally, every 2 weeks, number of stems, stem length, number of leaves and dry and fresh weights were measured and recorded.



**Figure 2.** Photo displaying the continuously aerated system for watercress production utilizing different planting media under shade conditions

### Results and discussion

Days after planting	Average fresh weight for full sunlight condition (g)	Average fresh weight for shaded condition (g)
17	7.38	10.30
25	0.00	6.71
32	5.85	8.23
45	6.54	22.30
<i>Average</i>	<b>4.94</b>	<b>11.89</b>

Days after planting	Average dry weight for full sunlight condition (g)	Average dry weight for shaded condition (g)
17	0.80	0.77
25	0.00	0.47
32	0.55	0.62
45	0.59	1.45
<i>Average</i>	<b>0.49</b>	<b>0.83</b>

Days after planting	Average stem length for full sunlight condition (cm)	Average stem length for shaded condition (cm)
17	18.10	16.73
25	0.00	17.87
32	11.53	17.70
45	13.10	18.10
<i>Average</i>	<b>10.68</b>	<b>17.60</b>

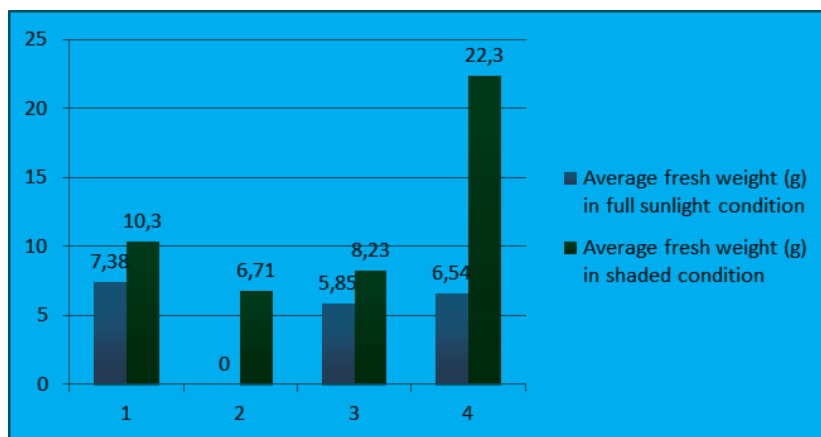
  

Days after planting	Average number of leaves for full sunlight condition	Average number of leaves for shaded condition
17	35	20
25	0	16
32	17	18
45	9	13
<i>Average</i>	<b>15</b>	<b>17</b>

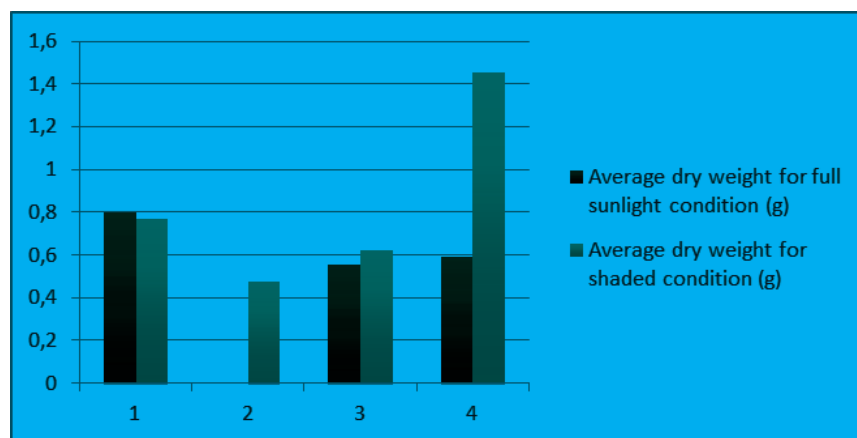
**Table 1:** Data from full sunlight conditions versus shaded conditions

	Temperature in full sunlight condition (°C)	Temperature in shaded condition (°C)
At 10am	27-29	30-31
At 2pm	30-32	34-36

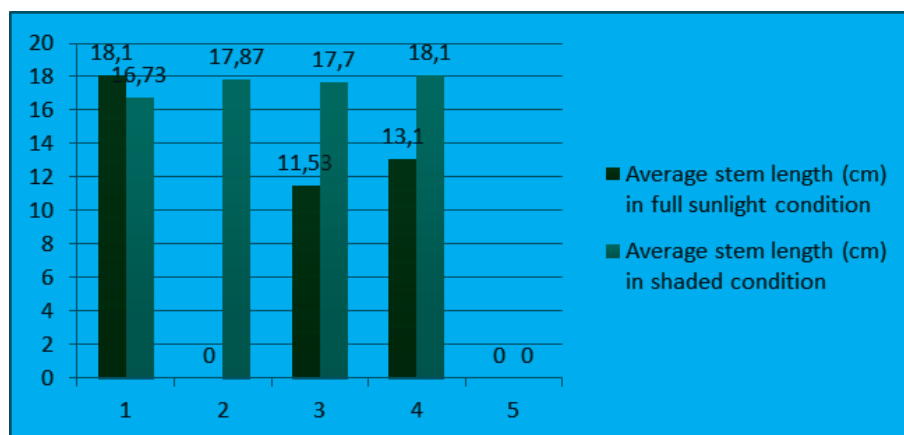
**Table 2:** Water temperature ranges in full sunlight and shaded conditions



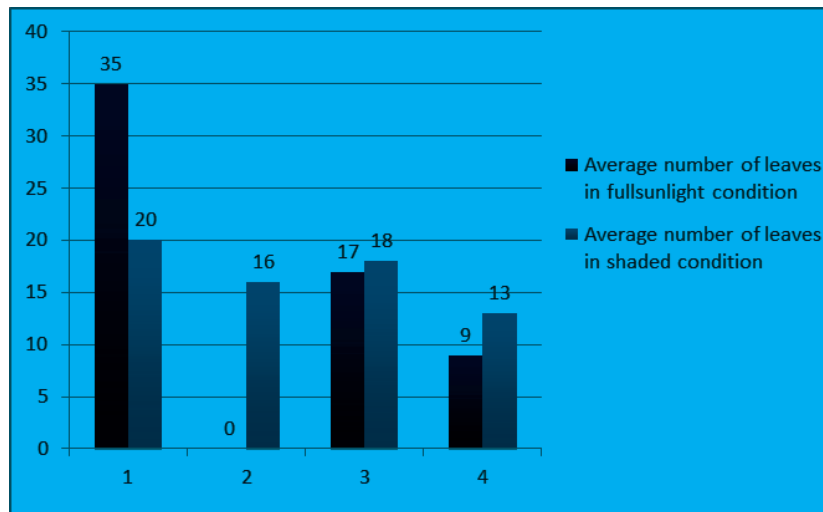
**Figure 3.** Bar chart of average fresh weights (g) in full sunlight versus shaded conditions



**Figure 4.** Bar chart of average dry weights (g) in full sunlight versus shaded conditions



**Figure 5.** Bar chart of average stem lengths (cm) in full sunlight versus shaded conditions

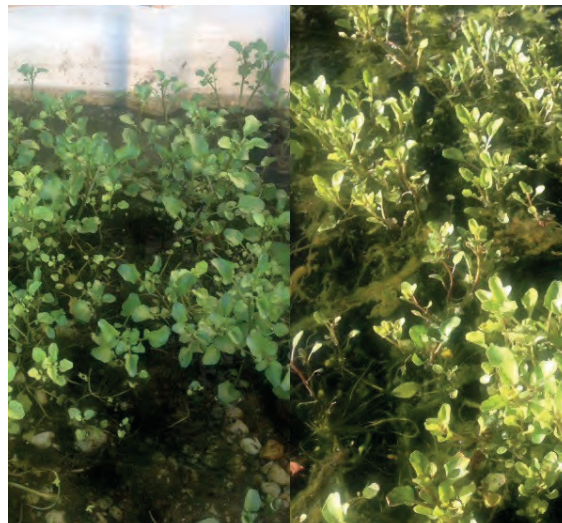


**Figure 6.** Bar chart of average number of leaves in full sunlight versus shaded conditions

From four data set collected, values from the shaded conditions were consistently higher than those from full sunlight conditions; fresh weight- 11.89 g versus 4.94 g; dry weight- 0.83 g versus 0.49 g; stem length- 17.60 cm versus 10.68 cm and number of leaves- 17 versus 15.

Water temperature may be having an effect on growth, since water temperatures between full sunlight and shaded conditions differs by 3 and 4.5 °C in morning and afternoons periods respectively.

Also the visual appearance and texture of the watercress grown in shaded conditions of the re-circulating system is better than that of the watercress grown in full sunlight and resembles the watercress produced in large scale systems more closely.



**Figure 7:** Photograph showing watercress grown under shade condition versus that grown in full sunlight

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## ZIYANM PA KA BOUT EN GWADLOUP - NEVER-ENDING YAMS IN GUADELOUPE Agrobiodiversity use for labour-intensive and sustainable production of graded yam with the “gutter-type tuber-support-container”

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**Keywords :** Yam (*Dioscorea alata*), cropping system, caliber, density

### Abstract :

Yam (*Dioscorea* spp) is an annual tuber crop which is an important food crops in intertropical diets. Its area of cultivation varies from Japan, Western Africa, to the Caribbean with a wide diversity of cropping systems and cultivars. Among them, the yam cropping system with the “gutter-type tuber-support-container” in Japan allows for a sustainable increase of the graded tuber production. The main objective of this preliminary study is to test the adaptation of this yam cropping system under our Caribbean conditions and to select cultivars adapted to this system. The experiment was set in 2015 on the INRA experimental station in Duclos where 7 cultivars of *D. alata* were planted in gutters with a high density. The use of the “gutter-type tuber-support-container” coupled to the use of compost and paper mulch can intensify in a sustainable way yam-based cropping systems while avoiding the use of chemicals (mineral fertilizers, herbicides...). First results are promising, especially for 2 cultivars from Vanuatu, called Wanorak and Nepelev, which show very good yields (50t.ha<sup>-1</sup>) and grade (1 meter length for 1.4 kg in average per tuber). This type of cropping system could represent a sustainable alternative for local communities for instance. We still need to validate these results and to realize a technical-economical analysis of the performance of such system.



**Figure 1 :** Cultivation of *Dioscorea alata* in gutters in Japan (Source : H. Shiwachi, Univ. de Tokyo)

### Materials and methods :

The experiment was set in 2015 at the INRA experimental station in Duclos (16°12'N; 61°39'O; alt. 125 m), which is characterized by rainfall of 2500 mm.yr<sup>-1</sup> and ferralsols. After plowing, yam sets of about 100 grams were planted at very high density (6 plants per m<sup>2</sup>) in gutter-type containers with a diameter of 10 centimeters. Gutters were slightly tilted (5-10°) to facilitate tuber growth. They were then covered by a mixture of compost and soil, and paper mulch for weed control (Tournebize et al. 2012, Figure 2). The experiment is a complete randomized block design with 3 repetitions of 10 plants of each cultivar. The experimental plot was irrigated and fertilized with mineral fertilization (120N, 20P, 140K par ha) applied at planting. A total of seven cultivars of *D. alata* were planted the 24<sup>th</sup> of July 2015 including 3 local cultivars, 2 cultivars from the Biological Resource Centre for Tropical Plants and 2 cultivars from Vanuatu (Lebot 2002). Table 1 shows the cultivars' origins and names.



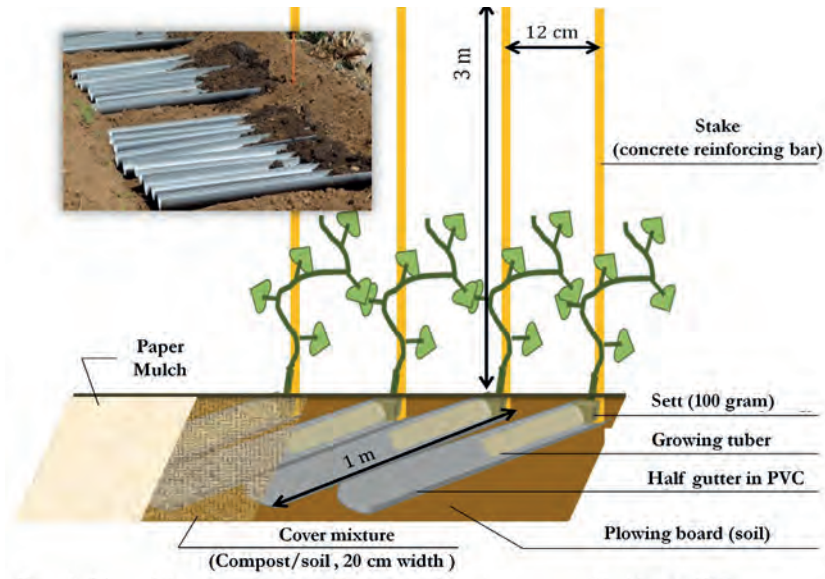


Figure 2 : Schema of the yam cropping system with “gutter-type tuber-support-containers” Guadeloupe in 2015.

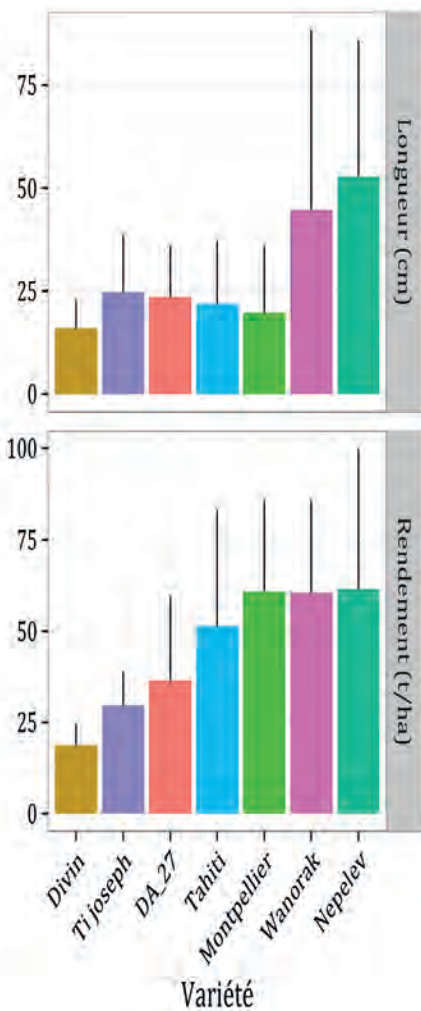


Figure 3 : Comparison of grade and yield among cultivars

N° cultivar	Origin	Cultivar name
27	CRB <sup>1</sup>	Divin
56	CRB	DA_27
63	CRB	Ti Joseph
87	CRB	Anba Bon (Tahiti)
VU750	DARD <sup>2</sup>	Wanorak
VU755	DARD	Nepelev
614	CRB	Montpellier

<sup>1</sup> CRB : Biological Resource Centre Tropical Plants (Guadeloupe)

<sup>2</sup> DARD : Department of Agriculture and Rural Development (Vanuatu)

Table 1 : Origin and name of tested cultivars

#### Main results :

First results are encouraging but show high cultivar differences in terms of yield and grade (Figure 3). Four cultivars show yields above 50 tons.ha<sup>-1</sup>. However, no local cultivars tested show a good development in gutters. Only cultivars Wanorak and Nepelev, introduced by Cirad, show tubers with uniform sizes and grades (Figure 4).



Figure 4 : Grade of the main cultivars tested in Duclos in 2015.

**Conclusion :**

To our knowledge, the yam cropping system with “gutter-type tuber-support-container” had never been tested in the Caribbean before. Lack of local adapted cultivars can explain this observation. The introduction of cultivars from Pacific allows for creating a niche production of tubers “kabannÃ©» in Guadeloupe. First results, presented here, are indeed promising. Two original cultivars from Vanuatu, Wanorak and Nepelev, show very good performance in term of grade (tuber reaching 1 meter long) and yield (above 50 tones.ha<sup>-1</sup>). This labour-intensive mode of production allows, in Guadeloupe, the harvest of graded tubers without damaging them. After all, this type of tubers, ready for processing, could be an interesting alternative for local communities for instance. But before promoting this yam-based cropping system, it is necessary to validate these first results and to complete this study by performing a complete technical-economic analysis, which is planned in 2016.

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52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

## Session 2

*Pathways to a Caribbean bioeconomy :  
Innovative technologies for agro-processing  
and green chemistry*



## INTRODUCTION AND REPORT TO SESSION 2:

### PATHWAYS TO A CARIBBEAN BIOECONOMY : INNOVATIVE TECHNOLOGIES FOR AGROPROCESSING AND GREEN CHEMISTRY

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The purpose of this session is to draw an overview relating to the technological progresses and Caribbean specificities in food and non-food processing, which allow a local socio-economic development, aid in the fight against poverty and further secure the global supply of safe foods and well-being.

The biological diversity of terrestrial and aquatic environments of the Caribbean countries, and the products of their agriculture have always been very important to feed and care for people and animals. However the lack of local adapted technologies, the high cost of processing, the narrowness of the local market hinder the development of the agroindustrial sector.

Local food agricultural production must however be developed to reduce the impact of food imports, the carbon footprint and the vulnerability of these regions (food safety, packaging waste production management, etc ...) and also to improve health and well-being.

In addition, resources from biodiversity, by their new nature, can help develop new markets, new and more environmentally friendly processing methods, respectful for the ecosystem. The proposed technological solutions must be sufficiently simple, autonomous and energy saving, in order to be efficient in a rudimentary technological context.

The Caribbean, with about 173 billion of inhabitants (about 3 % of the world population) as to take its place within the world regions which evolves toward agroecological production systems and agroalimentary sustainable systems.

Session 2 was held in room Mandarine on Monday afternoon, with an audience of about 30 people. It was based on 12 communications distributed in 3 sub sessions. 2 proposers were missing (one from Guyana and the other from Suriname). 1 submission has been presented in poster session. 9 communications were presented: five by women and four men. 4 students performed in this session, coming from the University of the West Indies, the University of Suriname, the University of Trinidad and Tobago and the Université des Antilles. 1 communication was presented by the private sector (Phytobôkaz) and 2 were from governmental consortium (PARM, Caraïbe Environnement – DEAL Guadeloupe), 6 were from Universities laboratories (4) or research institutes (2: INRA).

For the two first sub sessions the moderator was Rohanie Maharaj, and Katia Rochefort was the moderator for the last one.

#### ***The topic of the first sub session was: RESOURCES –HEALTH – FOOD RISKS.***

Phytobôkaz shows its approach from the plants from the Caribbean diversity and its traditional uses (ethnobotanic), in order to propose through the shelves of parapharmacy comfort products and phyto cosmetic products. The clinical studies are less demanding than for drugs. However, scientific studies are necessary to know and optimize functional properties of the commercial product. Caribbean plant biodiversity and ethnobotanic are treasures to explore with wisdom.

An inventory of fruit and vegetable grown in Martinique, as so much in Caribbean countries has been made by the PARM. Composition of 46 species was established in sale conditions. Data are available about the effect of various post harvest treatment (drying, frying, cooking, steaming, freezing, steaming, pasteurization, sterilization). One poster “Richés’ Péyia” is available. The data will be in the database CIQUAL. A book “Richés’ Péyia” is in preparation. Now there is an increasing promotion of fresh food eating in order to optimize functional effects of food on consumer’s health. There is an interest of proximity productions and/or short sales circuits.

Food processing can also produce fresh products based fruit and vegetable: peeled, pre cut, smoothies (mixed for immediate consumption), to promote food functional properties.

About Mango, *Mangifera indica* (1 000 varieties of which 103 in Guadeloupe) a project of pulp thermal drying in powder that shows long life properties, and could be used in culinary preparations, pastries, ice-cream, confectioneries. This project is not comparable to flour production from green banana. Lyophilisation could be an expansive processing alternative. Functional properties of the processed products have to be checked.



***The second sub session was about FOOD – ELABORATION OF FOOD.***

Processed products by fermentation are also of interest like cheese, yoghurt, and sauerkraut. Fermentation could be spontaneous or driven. To prepare products with specific properties, the fermentation parameters have to be controlled, like temperature, to optimize the properties. An example of papaya fruit and papaya leaves fermentation was presented. Organs of interest of Caribbean plant diversity have to be prospected as substrates to elaborate fermented products with checked and listed functional properties.

***The last sub session dealt: GREEN CHEMISTRY.***

We had a presentation about utilizations of waste biomass for the production of chemicals and fuels. The potential is important but precise routes have to be determined to produce targeted chemicals from renewable abundant carbon sources, like lignocellulosic biomass. Design of new catalyst systems is required for biomass conversion in an environmentally friendly and economical route. Aqueous Phase Processing (APP) are tested. Furfural conversion in furanone with a 96% yield is quite promising. Furanone has great marketability as it is used in the pharmaceutical industry as an appetite depressant and an immunosuppressive agent, and it is also utilized as a food flavoring agent.

The second speaker present results of an interdisciplinary research program in renewable energy production, which aimed at identifying the agroenvironmental, economic and industrial conditions for producing electricity from energy cane in Guadeloupe. Energy cane strains were selected. The introduction of such bioenergy systems under existing conditions and current agricultural models is still rather uncertain and requires achieving several sustainable goals. In order to build new sustainable energy systems, assessment of the conditions for a sustainable and profitable biomass supply is a critical step prior to industrial investment.

The third presentation was about pectin. Pectin is one of commercially interesting molecules frequently used as, functional agents in food, cosmetics and drugs making. Common sources of functional molecules are fractions of fruit and vegetable handled in some places of food chains like processing plants. The crop diversity is to be explored. Extraction methods operating in an environmentally friendly and economical route are researched.

The last presentation was about an inventory of bioresources products and materials for buildings available on the island wood, paper, fibers, algae, lignocellulosic materials. Potential products and building materials appropriate to be developed, indicating the necessary conditions so required. The history of some failed experiences could be visited in order progress faster.

This session, allowed addressing the key questions linked to the contribution of the innovative technologies and the green chemistry in the food and non-food valuation of the tropical bioresources met in the Caribbean. The session pointed out quite particularly, the conditions required to create *ad hoc* value chains, in the context of the small island economies. This topic constituted a major prerequisite to strengthen during the next congresses, to pursue the construction of a technological sector of the project for a Caribbean bioeconomy.

## RESOURCES - HEALTH - FOOD RISKS

### THE DETERMINATION OF AFLATOXINS IN PADDY AND MILLED FRACTIONS OF RICE IN GUYANA – PRELIMINARY RESULTS

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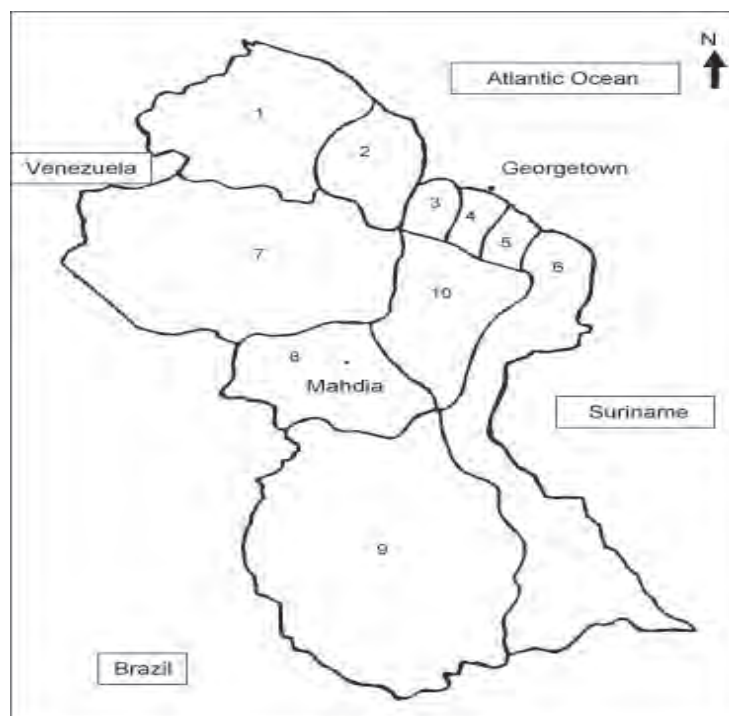
**Keywords :** Rice fractions, mycotoxins, HPLC, ELISA

#### Abstract :

A survey was conducted in the five rice-growing regions in Guyana to determine the presence of aflatoxins in multiple fractions of rice. The fractions were paddy, steamed paddy, cargo rice, white rice and parboiled rice. Samples were analyzed by High Performance Liquid Chromatography. A subset of the samples was further analyzed by enzyme-linked immunosorbent assay (ELISA) for concurrence. All analyses were conducted at the University of Missouri, USA. Of the 186 samples tested, 16 had aflatoxin concentrations greater than 20ppb the recommended limit for aflatoxins in food according to the United States Food and Drug Administration. An additional three samples had aflatoxin B<sub>1</sub> concentrations greater than the European Union Commission maximum levels for aflatoxin B<sub>1</sub> in rice at 5 µg/kg and total aflatoxins (B<sub>1</sub>, B<sub>2</sub>, G<sub>1</sub> and G<sub>2</sub>) at 10 µg/kg.

#### Materials and methods

**Sample collection and preparation.** One hundred and thirty five (135) samples of paddy, white rice, cargo rice and parboiled rice were collected from 50 rice mills along with 51 samples of paddy produced by farmers from the five main rice-growing regions in Guyana, viz. Regions 2, 3, 4, 5, and 6 (Fig. 1). The samples were collected in the June/October 2015 growing season, which corresponded to the rainy season. The samples were taken to the laboratory of the University of Guyana where the paddy and rice were ground with a Stein M-2 sample mill (15,000RPM) for one minute. All samples were sealed in appropriately sterilized containers then transferred for analysis to the Veterinary Medical Diagnostic Laboratory located at the University of Missouri, USA.



**Figure 1.** Map of Guyana showing the rice growing regions (Regions 2, 3, 4, 5, 6 and 9).

Source: [www.mapsoftheworld.com](http://www.mapsoftheworld.com) - Guyana

**High-performance liquid chromatography - Aflatoxin extraction and purification.** The aflatoxins were extracted by adding 100 mls of acetonitrile: water solution (7:3) to 25 g of the ground rice and ground paddy. This mixture was placed on a rotary shaker for 30 minutes. The supernatant was cleaned and filtered using PuriTox<sup>SR</sup> aflatoxin cleanup columns (TC-M160) purchased from Trilogy Analytical laboratory.

**High-performance liquid chromatography analysis of extracts.** The rice sample extracts were analysed for total aflatoxins consisting of AFB<sub>1</sub>, AFB<sub>2</sub>, AFG<sub>1</sub> and AFG<sub>2</sub> by HPLC. These were individually determined after derivatization with bromine using a KOBRA cell. The mobile phase was methanol:acetonitrile:water (1:1:4) with the addition of 1.2 g potassium bromide and 360 µl of nitric acid. The chromatographic parameters were: flow rate of 0.9 ml/min, injection volume of 50 µl with the column at room temperature. Aflatoxins were detected using a scanning fluorescence detector ( $\lambda_{ex} = 360\text{nm}$ ,  $\lambda_{em} = 440\text{nm}$ ). These were quantified using retention time, peak area and external calibration curves. The approximate retention times for AFB<sub>1</sub>, AFB<sub>2</sub>, AFG<sub>1</sub>, and AFG<sub>2</sub> were 7.0 minutes, 9.5 minutes, 10.4 minutes and 14.2 minutes respectively. Linearity of the HPLC method was checked from correlation coefficients of the calibration curves of the known concentration of standards.

**Analysis by Enzyme-linked immunosorbent assay (ELISA).** Samples were analyzed using the RIDA®QUICK aflatoxin method. The aflatoxins were extracted by adding 20 mls of methanol:water solution (7:3) to 10 g of the ground feed samples and mixed by vortexing for 10 seconds. This mixture was placed on a rotary shaker for 5 mins, then centrifuged for 3 minutes. Fifty (50) µl of the supernatant was placed in a microtube, 100 µl of the mobile solvent provided with the RIDA®QUICK kit was added and mixed by placing on a vortex for ten seconds. Of this solution, 100 µl was placed on the test strip insert and allowed to incubate for 5 minutes. The insert was then placed in the RIDA®QUICK measuring device and scanned.

**Statistical Analysis.** The samples were assessed based on USFDA limit of aflatoxins in food to 20 µg/kg and EUC maximum levels for aflatoxin B<sub>1</sub> in rice of 5 µg/kg and total aflatoxins, that is B<sub>1</sub>, B<sub>2</sub>, G<sub>1</sub> and G<sub>2</sub> of 10 µg/kg (USFDA, 2000; European Union Commission, 2010). For statistical analysis, the mean, minimum, and maximum values were estimated. Analysis of variance ( $p < 0.05$ ) was performed for the fractions and regions to determine if they were statistically different. Since region's 4 production and consequently sample collection was relatively small compared to the other regions, it was analysed with region 5 and represented as 4/5.

**Main results :**

Results and Discussion

From the total number of 186 samples, aflatoxin concentration above the European Union Commission standard of 10 µg/kg, was found in nineteen samples. Three of those samples were below the Food and Drug Administration regulatory limit of 20 µg/kg while two samples were considered as outliers, and were not included in the statistical analysis. Of the two, one sample was paddy collected from a farmer and the other was paddy collected from a mill with total aflatoxin concentrations of 13,984 µg/kg and 1,847µg/kg, respectively. Both samples were from region 4/5. These high aflatoxin concentrations may represent isolated incidences. However, given the critical food safety issue, and the importance of rice to Guyana's economy, the factors that might contribute to these high aflatoxin concentrations such as poor postharvest storage and handling must be investigated. Paddy, especially fresh paddy is susceptible to fungal contamination if not properly stored (Ok et al., 2014).

For each of the six fractions examined, the mean aflatoxin concentration of each of the fractions was below the European standard of 10 µg/kg total aflatoxins (Table 2). Paddy collected from farmers had the highest mean aflatoxin concentration followed by parboiled rice. The analysis of variance indicates that there are no significant differences among the different rice fractions.

Fraction	Number of samples analysed	Mean (µg/kg)	Standard deviation (µg/kg)	Minimum	Maximum
Paddy from mill	38	5.26	21.78	nd <sup>a</sup>	128
Steamed paddy	19	6.16	26.84	nd	117
Farmers' paddy	50	7.48	30.05	nd	193
White rice	35	1.11	4.78	nd	25
Cargo rice	12	0.00	0.00	nd	nd
Parboiled rice	30	6.77	17.65	nd	76

<sup>a</sup>Less than 10 µg/kg

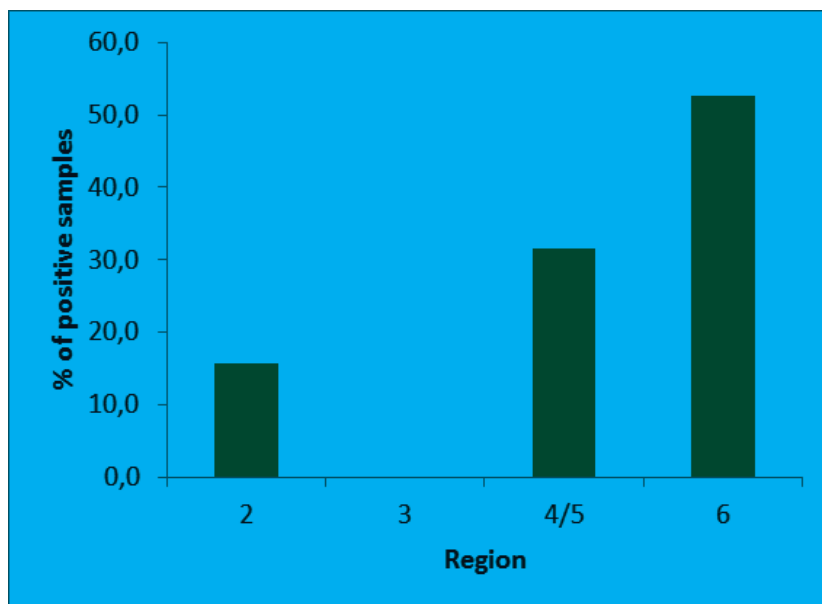
**Table 2.** Analytic results of aflatoxin concentration in six rice fractions.

The values obtained were due to detectable presence of aflatoxins in all fractions except cargo rice. The paddy collected from the farmers had the widest range of aflatoxin concentration and the highest concentration of total aflatoxin. The concentration of aflatoxin B<sub>1</sub>, which is the most toxic of the four aflatoxins, made up 17 to 90 % of all aflatoxins with an average of 48% of the total aflatoxin concentration for the entire sample set. Paddy had a higher aflatoxin concentration than white rice and parboiled rice findings consistent with observations by Iqbal et al., (2012). However, parboiled rice had the highest percentage of samples above the European standard of 10 µg/kg (Table 3). These results for parboiled rice are very similar to Dors et al., (2011) where aflatoxin concentration in the range 11 to 74 µg/kg was observed in 9% of the tested parboiled samples. The method used for the preparation of parboiled rice may allow for the growth of fungus since in some cases the paddy is soaked in tanks for between 48 to 72 hours, drained, steamed and then dried before milling. Bandara et al., (1991b) observed that there is a correlation between the soaking period and aflatoxin concentration while Dors et al., (2011) noted that the duration of soaking influences the migration of aflatoxin from the husk to the endosperm.

Sample fraction	Number of samples analysed	Number of samples with aflatoxin	% of sample fraction	Range of total aflatoxin concentration for positive samples (µg/kg)
Farmers' paddy	50	5	10	19 - 193
Paddy from mills	38	4	10.5	10 -128
Steamed paddy	19	1	5.3	152
White rice	35	2	5.7	14 and 25
Cargo rice	12	0	0.0	0
Parboiled rice	30	5	16.7	11 to 41
<b>TOTAL</b>	<b>184</b>	<b>17</b>		

**Table 3.** Occurrence of aflatoxins in six fractions of rice produced in Guyana.

Of the nineteen samples that tested positive, just over half of the samples (52.6%) were gathered from Region 6. This is a reflection of the Region's focus on producing parboiled rice which had the highest percentage of aflatoxin contamination (Figure 2). Region 3 had no positive samples. In spite of this observation, analysis of variance showed that differences in aflatoxin concentrations were not as a result of variation among the regions. Hence, geographical location did not influence the presence of mycotoxins, a finding in contrast to results obtained by Lai et al., (2015b) where geography and climate contributed to the differences observed among six provinces in China.



**Figure 2.** The percentage of positive samples in the five Regions.

The Rida®Quick aflatoxin RQS ECO method has a detection range of 4 – 75 µg/kg. Therefore, only those samples within that range from the results of the analysis by HPLC were evaluated by ELISA. The ELISA results indicated that samples that tested positive with HPLC were also positive using the ELISA. Concurrence between ELISA and HPLC was also obtained in quantifying aflatoxins in brown rice (Iqbal et. al., 2014). In outlining the advantages of both methods, Sadegh

et al., (2014) indicates that the sensitivity and specificity of HPLC are higher than the ELISA method.

The small percentage of samples with aflatoxin may be indicative of the persistent efforts by the Quality Control Department of the Guyana Rice Development Board to ensure the production of good quality rice for local consumption and international export. In Guyana, the head office of the Guyana Rice Development Board is located in the city. However, in each rice-growing Region, there is an office with qualified personnel to discharge the mandate of the Board by interfacing with farmers and millers in the Region. The Board, however, should examine areas of weakness such as the process for making parboiled rice and make recommendations for improvement. It should also focus on monitoring regions such as 4/5 for sanitary practices in the field and factory in an effort to minimize aflatoxin contamination. In addition, the rice industry may endeavor to become like Japan applying best practices in the warehouses where the humidity, temperature and moisture content are controlled, thus ensuring that the rice is free of aflatoxins (Tanaka et al., 2007).

**Conclusion :**

The survey indicates that there is no widespread aflatoxin problem in rice in Guyana. Incidence of aflatoxins appears to be localized. However, it is important to continue monitoring so that the *status quo* can remain, while endeavoring to improve by encouraging more millers to upgrade their facilities to current best practices. This will assist in expanding Guyana’s market share and ensuring the health and safety of consumers.

**Annex:**

REGION / ZONE	HECTARE				Paddy Production	Rice Equiv.
	Target	Prepared	Sown	Harvested	Bags	M/T
REGION 2	29,800	29,994.70	29,994.70	29,984.30	2,502,975	103,344
REGION 3	17,200	17,601.70	17,568.50	17,555.20	1,386,107	57,230
REGION 4	6,400	6,819.10	6,804.90	6,785.00	696,663	28,764
REGION 5	66,600	81,042.30	80,442.00	80,153.20	6,415,866	264,902
REGION 6	46,400	50,171.80	50,171.80	50,139.20	4,338,684	179,138
REGION 9	428	408	408	405	45,024	1,859
<b>Total</b>	<b>166,828</b>	<b>186,037.70</b>	<b>185,390.00</b>	<b>185,021.75</b>	<b>15,385,319</b>	<b>635,238</b>

**Table:** Guyana’s Rice Production in 2014.

(Source Guyana Rice Development Board’s Annual Report 2014, Appendix 9: Harvesting Production 2014)

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## VALORISATION COSMETIQUE ET BIEN-ETRE DE PLANTES DE GUADELOUPE

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**Mots clés:** *Justicia pectoralis*, valorisation, plantes médicinales, Phytobôkaz

### Résumé :

Le laboratoire Phytobôkaz s'est spécialisé dans la fabrication de produits de bien-être et cosmétique, issus de plantes de Guadeloupe. La gamme répond à 90% des besoins du quotidien : confort digestif, jambes légères, confort articulaire et musculaire, anti-capitons, défenses naturelles et beauté de la peau et des cheveux. Son expertise dans la connaissance des plantes des Outre-mer mais aussi en extraction et en formulation permet la création de produits innovants tout en s'appuyant sur l'usage traditionnel. La Guadeloupe est riche de 625 plantes médicinales, sources de bioactifs, valorisables. Au travers de l'exemple de *Justicia pectoralis*, une herbe riche en coumarines et flavonoïdes favorisant le drainage lymphatique nous illustrerons la valorisation des plantes médicinales en Guadeloupe.

**Matériels et méthodes :** Bibliographie ; Effet Doppler ; Etude clinique

### Principaux résultats :

*Justicia pectoralis* appelée «Herbe charpentier» est une herbacée que l'on retrouvait traditionnellement autour des ateliers des charpentiers qui l'utilisaient souvent lorsqu'ils se blessaient. Des études scientifiques ont démontrées un effet anti-inflammatoire et anti-œdémateux de l'extrait hydroalcoolique. Le gel «BIOVEN®» possède un extrait de *J. pectoralis* et permet d'augmenter de +64% la microcirculation (effet doppler).

Pays	Organes/ Préparation	Usages traditionnels	References bibliographiques
Antilles	Feuilles pilées dans du sel cataplasme	guérison des blessures et coupures	Henry JOSEPH Etude phytochimique de <i>Justicia Pectoralis</i> de l'archipel guadeloupéen Thèse, 1988
	Feuilles infusion	Maux d'estomac	
	Sirop	Affections pulmonaires (toux, bronchites, maux de poitrine, asthme)	

**Tableau 1 :** usage traditionnel

Familles	Molécules	References bibliographiques
Coumarines	Coumarine Ombelliférone Acide O-coumarique β-scopoletine	Pharmacopée végétale caribéenne TRAMIL  Henry JOSEPH Etude phytochimique de <i>Justicia pectoralis</i> de l'archipel guadeloupéen Thèse, 1988
Flavonoïdes	Swertisine Swertiajaponine O-rhamnosyl-2''-swertisine O-rhamnosyl-2''-swertiajaponine	
Lignane	Justicidine B	
Stérols/Triterpènes	β-sitosterol lupéol	

**Tableau 2 :** chimie

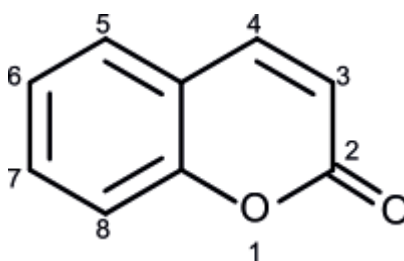


Figure 1 : coumarine

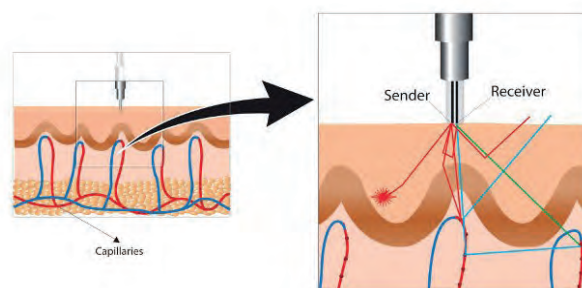


Figure 2 : Effet Doppler

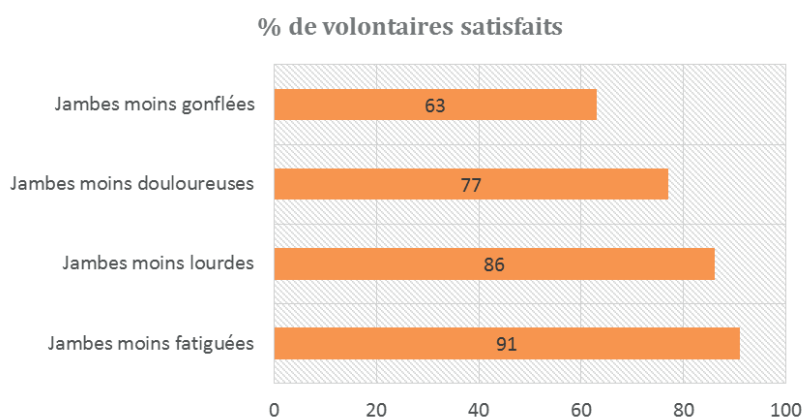


Tableau 3 : Evaluation de l'efficacité du gel BIOVEN

**Conclusion :**

Le laboratoire PHYTOBOKAZ, innove en proposant des produits aux actifs puisés au coeur de la flore caribéenne et issus des plantes de la médecine traditionnelle. Précurseur sur le marché des phytocosmétiques et produits de bien-être entièrement conçus et fabriqués en Guadeloupe, le laboratoire qui a aujourd'hui 10 ans d'existence démontre tout l'intérêt d'une réelle valorisation des filières des plantes médicinales, aromatiques et oléagineuses.

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## POLYPHENOLS, CAROTENOIDS, VITAMIN C CONTENT IN TROPICAL FRUITS AND VEGETABLES AND IMPACT OF PROCESSING METHODS

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**Keywords:** Martinique Fruits and Vegetables, Total Polyphenols, Vitamin C, Carotenoids, Technology Process, Food Composition, Food Analysis, Nutritional Quality

### Abstract

Thirty-five fruits and seventeen vegetables from Martinique were evaluated for total phenol content (TPC), Vitamin C and carotenoid content. TPC, Vitamin C and carotenoid contents ranged from 11.7 to 978.6 mg/100g, 0.1 to 2853.8 mg/100g and 9.7 to 9269.7 µg/100g respectively. Fruits and vegetables from Martinique have equivalent or higher TPC, Vitamin C and carotenoid contents than fruits and vegetables from temperate climates. Cashew apple had high values for all three parameters (55.8 mg/100g of Vitamin C, 603 mg/100g of TPC and 924 µg/100g of carotenoids). Bassignac mango and mamey apple had the highest carotenoid contents, with 3800.3 and 3199.7 µg/100g respectively. Acerola had the highest Vitamin C and polyphenol contents with 2853.8 µg/100g and 727.4 mg/100g respectively. Pigeon peas had high values for all three parameters (569.2 mg/100g of Vitamin C, 978.6 mg/100g of TPC and 364.3 µg/100g of carotenoids). Pumpkin and watercress had the highest carotenoid content, with 9269.7 and 4339 µg/100g respectively. TPC, Vitamin C and carotenoid content were significantly impacted by processing techniques. TPC, Vitamin C and carotenoid contents decreased by up to 75.78%, 100% and 70.18% respectively, depending on the processing technique used.

### Material and methods

#### 1. Sampling procedure

Varieties selected are representative of varieties cultivated in Martinique. A representative sample was obtained from local markets. Samples were collected on a selection of thirty five fruits and seventeen vegetables, taking into account the geographical and varietal diversity, the ratio of production and seasonality. A minimum of 30 pieces for each fruits and vegetables were collected for analysis.

The protocol is applied to the physicochemical characterization. Preparations were made using pilot equipment. Raw material was treated as consumed in Martinique. Fruits were peeled and seeded if necessary, the pulp recovered, crushed or pressed and then filtered according to the fruit in question. Vegetables were peeled if necessary, whether or not steamed depending on the considered vegetable. The samples obtained were frozen and stored at -18 ° C in sealed plastic bags pending analysis.

#### 2. Physicochemical and nutritional characterization of fruits and vegetables

Total polyphenols were determined using Folin and Ciocalteu's method described in Georgé and al., 2005. Total carotenoids were determined using a colorimetric method. Vitamin C was measured using the K-ASCO 11/05 Megazyme kit. For tempered fruits and vegetables, data were based on the worldwide food composition tables.

#### 3. Technological processes on fruits and vegetables

Raw material processing was performed according to the characteristics of the plant (crisps, canned in syrup, fresh-cut packaged, filtered pasteurized pure juice, flour, frozen or steamed). Treatment of plants was carried out with pilot equipments of institute technological hall. All fruits and vegetables were washed, sanitized and peeled before technological processes.

#### 4. Data statistical analysis

The physical and chemical mean values of triplicate measurements or analysis were statistically analysed. *Analysis of variance (ANOVA)* based on *Student Test*, *Principal Component Analysis (PCA)* and *Duncans multiple range test (DMRT)* were performed using the software StatGraphics CENTURION<sup>®</sup> XV 2005 and Uniwin PLUS<sup>®</sup> 2005 v6.1.

### Main results

In general, technological treatments had an effect on various nutrients contents in plants from Martinique. Heat treatment and cooking had a statistically significant effect. Boiling caused the diffusion of total polyphenols while steaming had less impact. There was a statistically significant effect of vacuum frying on total carotenoids content. This loss was due to the distribution of carotenoids, soluble compounds in cooking oil. Total carotenoids were sensitive to oxidation and, to a lesser extent, sterilization. There was a statistically significant effect (5%) of sterilization, vacuum frying, drying and steaming on vitamin C contents. This effect was even more important that technological treatment temperature and time were important. It is nutritionally more interesting to consume a portion of fresh mamey because of its vitamin C and antioxidants contents. Although chips concentrated nutrients (carotenoids and total polyphenols) compared to

raw material, its consumption provided fat and carbohydrates. Indeed, a portion of mamey chips provide twice more carotenoids, 1.5 times more total polyphenols and twice more fiber. But 5 times more carbohydrates and more than 100 times more fat than the same portion of fresh mamey. Pumpkin is interesting with its high carotenoid content. It is better to consume a steamed pumpkin portion for its carotenoid content. Fresh-cut packaged will be interesting for the total polyphenol content. As for mamey, considering the fresh material, we found that chips process focused nutrients (total polyphenols and carotenoids). However, its consumption caused the fat. Pasteurization had little impact on nutritional and functional quality of mandarins. However, filtration could retain several nutrients. Finally, sterilization resulted in a significant loss of vitamins. From a nutritional standpoint, it is better to consume mandarin pure juice for its vitamins C and polyphenols contents. Steamed or frozen Okra (and then steamed) were very rich in total carotenoids and total polyphenols. Consumption in these forms brings a nutritional quality than its consumption in canned. Martinique steamed sweet potato was rich in carotenoids and polyphenols and source of vitamin C. Consumption as steamed or frozen (and then blanched) brings a nutritional and functional quality than its consumption as flour. Similarly, consumption of christophine as steamed brings nutritional and functional quality than its frozen or canned consumption. It was rich in antioxidants and source of vitamin C.

during blanching/freezing and sterilization processes are due to diffusion of these nutrients in blanched water and in cooking juices. Anthocyanin content decreased with blanching time increase (Sian and Ishak, 1991). Boiling cooking in water caused flavonol losses of 20 % and 40 % respectively in onions and asparagus (Makris and Rossiter, 2001). Price et al. (1998) showed that canning did not cause chemical degradation of glycosides and flavonol but losses occurred by diffusion of cooking solutions, changing depending on the compound. For broccoli, there was an influence of cooking mode with a loss of 97 % of flavonoids, for microwave cooked inflorescences, whereas steaming had less significant effects (Vallejo et al., 2003). Broccoli blanching in water led to a loss of 37 % of total polyphenols (Puupponen-Pimiä et al., 2003). Similarly, Akissoe et al. (2005) reported a 40 % drop in polyphenols content in yams during blanching, regardless of temperature. Boiling caused the diffusion of total polyphenols. In the case of christophine, sweet potato and okra, loss of polyphenols was less important in the steamed raw material than in blanched frozen products. However Mallett (2006) did not observe significant loss of polyphenols in boiled, baked or microwaved sweet potatoes flesh. This is not the case of polyphenols in the skin where he showed losses of 42 %, 55 % and 37% respectively for cooking in microwave, oven and water. An increase of 40 % of the anthocyanins from 30 minutes of steaming was reported by Yang and Gadi (2008), but this increase is not significant (5 %) for longer time.

There was a statistically significant effect of vacuum frying on carotenoid content. This loss was due to the carotenoids diffusion, soluble compounds in frying oil. Total carotenoids might be susceptible to oxidation and sterilization to a lesser extent. Sahlin et al. (2004) reported that frying tomato slices led to a higher loss of lycopene than boiling or steaming (decrease of 50 % compared to the fresh slice). Similarly, frying carrots showed a more important decrease in total carotenoids content than boiled or steamed carrots (Miglio et al., 2007). The loss of carotenoids in the fresh-cut packaged products may be due to their oxidation during the manufacturing process. Degradation of carotenoids was due to light (photo-oxidation) or heat (Caris and Amiot, 1999).

We observed a decrease in vitamin C content during process. In a study on the effect of different cooking methods on vegetables, Miglio et al. (2007) showed the loss of the entire ascorbic acid between raw and fried carrot. Rickman et al. (2007) reported systematic losses of ascorbic acid during heat treatment, up to 90 % for canned carrots.

## **Conclusion**

Tropical plants studied here had a high nutritional and functional potential, especially in terms of antioxidant capacity (polyphenols, carotenoids) and vitamins (nutrition). The results showed that these features are equivalent even much higher than those of temperate plants, frequently eaten or known for their nutritional quality. Martinique fruits and vegetables had an important advantage with their antioxidant capacity.

In conclusion, in order to get the most nutritional and functional potential of tropical fruits and vegetables, it is better to consume them in fresh form for fruits, vegetables can be eaten raw or after a light cooking such as steaming. The boiling causes diffusion of minerals and total polyphenols. Vacuum frying promotes loss of total carotenoids and brings more fat. Finally, long time cooking and high temperature such as sterilization (canning) cause a high decrease in vitamin content. This study shows that fruits and vegetables grown in Martinique provide health benefits for human.

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## PROJET DE VALORISATION DE LA MANGUE (*MANGIFERA INDICA* L.) PAR LE SECHAGE THERMIQUE

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**Mots-clés :** mangue, valorisation, séchage, transformation, poudre.

### Abstract :

La mangue (*Mangifera indica* L.) est un fruit de la famille des *Anacardiaceae* appartenant à l'ordre des Sapindales. Le manguier peut se développer naturellement et il est largement cultivé à travers le Monde, particulièrement dans les zones tropicales. C'est l'un des fruits tropicaux les plus importants en terme de production et de consommation (FAO, 2005). La mangue occupe la seconde place en tant que fruit cultivé, juste après la banane (Jahurul et al. 2015). Il existe plus de 1000 variétés de mangue à travers le monde. Parmi toutes les variétés existantes seulement quelques-unes sont exploitées pour le commerce (Solís-Fuentes & María del Carmen Durán-de-Bazúa 2011). Elle est populaire pour ses saveurs exotiques, ses qualités organoleptiques mais aussi pour son intérêt nutritionnel. En effet, la présence de composés phénoliques dans l'alimentation humaine est associée à des effets protecteurs contre certaines maladies dégénératives chroniques liées au stress oxydatif (Manach, Williamson, Morand, Scalbert, & Rémésy, 2005). De ce fait, les régimes alimentaires riches en fruits et légumes ont beaucoup de succès du fait de leur rôle protecteur contre les maladies cardiovasculaires, d'autres maladies chroniques et certains types de cancer (Kris-Etherton et al. 2002). En outre, la présence de composés phénoliques au sein du régime alimentaire a des effets bénéfiques pour la santé humaine.

La mangue est une source importante de composés polyphénoliques qui lui confère de nombreuses activités antioxydantes. En outre, selon de nombreuses études la mangue est une importante source de micronutriments, de vitamines et autres molécules phytochimiques qui font d'elle une riche source d'antioxydants, de polyphénols, d'acide ascorbique, de caroténoïdes et de mangiférine (Machado Rocha Ribeiro et al. 2007). La mangiférine (C-2- $\beta$ -D-glucopyranosyl-1,3,6,7-tetrahydroxyxanthone, nommé également C-glucosyl xanthone), est un xanthonoïde naturelle avec diverses activités biologiques, bénéfiques pour la santé humaine. Toutes les parties du manguier en contiennent (feuilles de manguier, les tiges, les fleurs, les racines, l'écorce et le fruit). Une large gamme d'effets pharmacologiques est attribuée à cette molécule: antioxydant, radioprotecteur, immunomodulateur, anti-allergique, anti-inflammatoire, anti-nociceptif, anti-tumorale, anti-diabétique, activités inhibitrices du métabolisme enzymatique des glucides, activité lipolytique, anti-résorption osseuse, antiviral, antibactérien, antifongique, anti-parasitaire, activité inhibitrice de la monoamine-oxydase (Wauthoz & Balde 2007).

La mangue est un fruit saisonnier. Abondante de mai à août, il est très difficile de s'en procurer hors saison, même s'il existe des variétés plus précoces et plus tardives. De plus, ce fruit contient près de 85% d'eau, à un taux de respiration élevé et sa texture fragile supporte mal l'entassement. Les pertes liées à l'exploitation de la mangue sont donc importantes en raison du pourrissement et de l'écrasement des fruits. Le transport des mangues fraîches pose un tel problème que les pertes peuvent atteindre 60%. C'est pourquoi une filière de transformation de la mangue est indispensable pour limiter le gaspillage provoqué par la perte de ces fruits. Mais le développement d'une telle filière de production est premièrement freiné par la fragilité de la mangue quand elle arrive à maturité, et deuxièmement par sa période de production courte, qui entraîne une saturation du marché. Ces contraintes la rendent difficilement exploitable au niveau industriel. Pourtant la mangue gagnerait à être valorisée en la transformant sous formes de produits attractifs et innovants. Toutefois, il faudrait obtenir une production constante toute l'année afin d'assurer la pérennité des produits mis sur le marché local. Ainsi il serait intéressant de transformer le surplus de production afin de réduire les pertes et d'augmenter les bénéfices des entreprises qui réalisent la transformation agroalimentaire.

La déshydratation des surplus de fruits lors de la forte saison pourrait être une solution. Le séchage thermique permettrait en outre de diminuer au maximum l'activité de l'eau afin d'obtenir une poudre de mangue stable d'une durée de conservation longue. Ainsi ce mode de valorisation pourrait diminuer le phénomène de saturation du marché en limitant les pertes au moment de la récolte ou du transport tout en offrant une nouvelle alternative aux producteurs de mangues. En outre, l'objectif est d'obtenir un produit stable dans le temps, cette stabilité est vue sous deux angles : limiter voire empêcher l'évolution de la flore microbienne, et préserver les qualités gustatives et nutritionnelles de la mangue.

Une fois la poudre obtenue, du jus de mangue peut être produit à partir de la poudre de mangue et il semble que celui-ci soit plus stable que le jus de pulpe de mangues fraîches (Djantou et al. 2011). De ce fait, la transformation de la mangue en poudre déshydratée pourrait être une approche technologique pour réduire les pertes post-récolte et proposer du jus de mangue fabriqué hors saison. Pour ce faire, l'utilisation d'un séchoir à double tambour a été étudié par Gangopadhyay et al. (1976). Un tel projet s'inscrit dans une démarche de transformation des produits agricoles caribéennes dans le but de contribuer au développement du secteur agro-industriel en fournissant des produits innovants à la population locale afin qu'elle s'approprie la consommation de ses produits.

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## PERCEPTIONS ON HEALTHY EATING, NUTRITION AND OBESITY AMONG SELECT GROUPS OF THE POPULATION IN TRINIDAD

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**Keywords:** Street foods, consumer perception, consumption pattern, food safety, food borne illnesses (FBI), public health inspectors (PHIs)

### Abstract

The study investigated self-reported perceptions and awareness of females on food safety and health risks associated with certain types of street foods. Satisfaction of females with the monitoring of street food vendors by the local authorities, the food safety practices executed by vendors and factors that influenced female consumers to purchase street foods in Trinidad were reviewed. Data was collected via questionnaires and results tabulated and analysed. Reasons for purchasing street foods were different for women in different age brackets and with different educational backgrounds. Satisfaction with monitoring of street food vendors, by the relevant authorities, was only significantly different when comparing persons of different age groups. No significant differences noted between different consumer demographic groups and their perceptions of street food safety practices of vendors and their awareness of food safety and health issues associated with street foods. Vending practices of street food vendors were rated as poor to fairly safe by the different demographic groups. Consumers reported that they believed that street foods can be unsafe, some street foods are unhealthier than others, they are aware of food poisoning symptoms and some take the precaution of only buying street foods from familiar vendors.

### Introduction

Internationally, street foods have gained much attention with regards to the potential health risks associated with their consumption. Contaminated food is one of the greatest hazards of today's world (WHO, 2000). Ready to eat street foods are classed as high risk foods. These foods do not require further cooking before consumption therefore if not handled properly or kept under appropriate conditions the growth of pathogens can be sustained under normal conditions which will incur health risks (Hertzman and Barrash, 2007; Mensah et al., 2002).

### Materials and methods

A survey instrument was designed to be completed within 10 minutes and was reviewed for content and validated by three academic professionals to ensure relevant and adequate coverage of the concepts within the instrument. Survey instruments were distributed to persons in public areas from the northern, central and southern districts in Trinidad. Individuals were briefed on the survey instrument and subjects were asked to complete and sign a consent form. The instrument comprised of several closed ended questions which included questions on demographics, consumption and perceived health risk of selected street foods under investigation. With specific regard to health risk, the participants were asked to categorize the street foods on the scale 0-5 (0-no health risk; 5-greatest high risk). The scale was then subsequently re-categorized with a score of 0-1, 2-3 and 4-5 representing low, medium and high risk foods. Participants were also asked to indicate the extent of their satisfaction with the relevant authorities responsible for the monitoring street food vendors in Trinidad. Respondents could give an opinion on this as results of public health inspections are shared via media and the general population can make a request for a vendor or food service business to be investigated and monitored. Incomplete surveys (<90% was completed) were rejected, which left 156 surveys that could be analysed.

### Main results

- 1. Demographics:** One hundred and fifty seven (n=156) respondents, out of a total of two hundred (200), completed over 90% of the survey instrument. The majority of individuals in this study, were less than 50 years of age (36.9%) and attained tertiary level education (61.9%).
- 2. Experiences with Food Borne Illnesses (FBIs):** The results show that there is more variation in persons with different education backgrounds with respect to knowing someone who was affected by FBIs.
- 3. Consumption patterns:** Weekly cumulative consumption patterns reveal that doubles was consumed the most frequently (73.4%) on a weekly basis followed by pies (56.1%) and burgers (49.4%). Pholourie/Saheena, hotdogs corn soup and gyros took similar precedence for weekly consumption, 37.9%, 36.4%, 35.5% and 30.3% consecutively. Consumers less frequently purchased souse (22.8%) during the week. Black pudding and pows were amongst the least consumed street food on a weekly basis (10.1%) and (9.2%) in that order

4. **Consumer confidence on the reliability of monitoring by the relevant food safe authorities:** Monitoring of street food vendors by relevant authorities was generally seen to be judged mostly within unsatisfactory standards by consumers. The majority of female consumers were somewhat dissatisfied (36%), while only 3% were satisfied. The majority of consumers above the age of 50 communicated were very dissatisfied (31%) while consumers 50 years and under were neither satisfied or dissatisfied (32%) with the monitoring by relevant authorities.

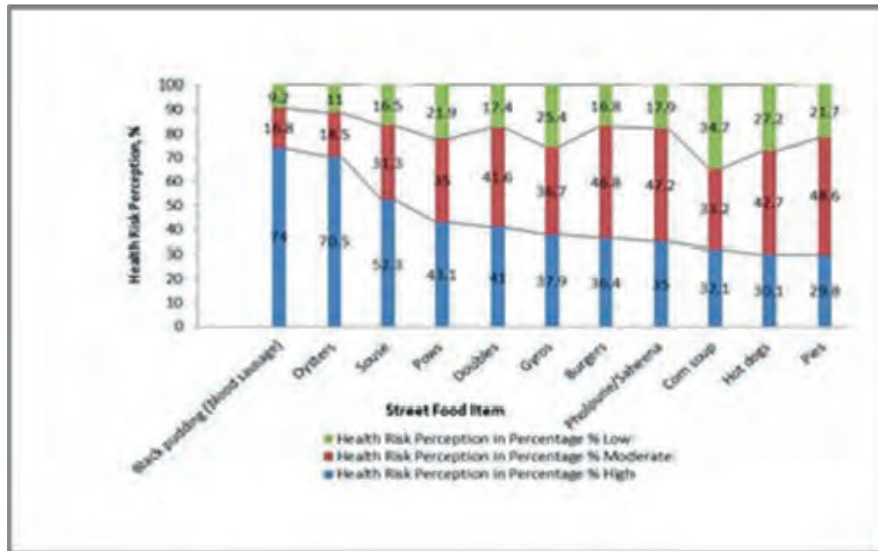


Figure 1. Consumer’s perceptions on which foods pose a higher risk as a percentage

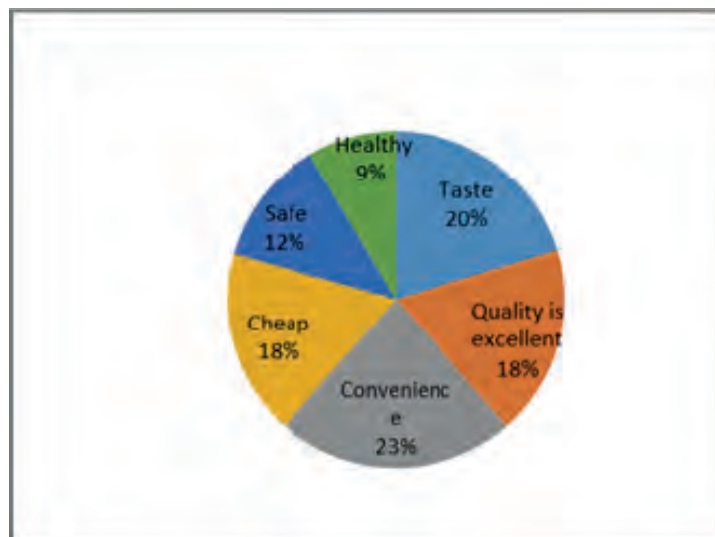


Figure 2. Self-reported reasons of the different consumer demographics for purchasing street foods

### **Conclusions**

- Since 88.67% of respondents were in the age group  $\leq 50$  years most of the inferences would be applicable to these demographics.
- Culture and the fact that women are generally more food safe conscious or interested in the practice of food safety habits explains the low number of experiences with FBI.
- Doubles, pies and burgers were found to be the most popular foods whereas, paws, black pudding, oysters and souse were found to be the least popular. The least popular foods were coincidentally associated with the highest health risk.
- The conveniences of street foods followed by the taste are the most popular reasons for the purchasing and consumption of street foods by the general population.
- Respondents surveyed indicated that they had little confidence in the regulatory mechanisms to ensure that the foods sold on the streets are indeed safe.

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## ACCELERATING THE FERMENTATION OF GREEN PAPAYA AND ITS LEAVES THROUGH MANIPULATION OF MICROBIAL CULTURE AND TEMPERATURE

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### Keywords:

#### Abstract:

The papaya fruit and the leaves are popularly used in folk medicine throughout the Caribbean and particularly in Trinidad and Tobago for its ability to treat and prevent various ailments and diseases such as strokes, heart attacks and cancer, etc. The natural bio-fermentation process triggered by adding yeast to green Papaya (*Carica papaya* L.) and their leaves preserve the antioxidant properties and enhances the immune-modulating features. The aim of the proposed experiment was to reduce the time taken for fermentation of green papaya and their leaves using a combination of yeast (*Saccharomyces cerevisiae*) and a bacterium (*Lactobacillus plantarum*). Additionally, the effect of temperature (30°C - 50°C) on the microbial fermentation of green papaya and its leaves was investigated over a 16 day period. The quantity of organic acids produced during fermentation was indicative of the reaction rate. On completion of the analysis; TSS, pH and titratable acidity were measured for each of the samples. Based on the results, all samples showed relatively similar changes in TSS and pH. Samples fermented at 41°C produced the highest volume of acid (17.99 ml) within the 16 day period.

#### Introduction

Fermented papaya (a product of yeast fermentation) has been recognized as a food supplement in many countries because it has been proven to favorably control immunological, hematological, inflammatory, vascular and oxidative stress damage to cells which can lead to a variety of ailments to the body (Cordeo, 2014). The natural bio-fermentation process that is activated by the addition of yeast serves to preserve the antioxidant composition of the papaya and the leaves and develops the immune modulating ability while also adjusting the ratio of complex carbohydrates to proteins and resulting in a fermented product containing many new classes of oligosaccharides that further add to the immune modulating ability and introduces a prebiotic function which supports the growth of beneficial bacteria in the colon (Aruoma et al, 2010 and Dolson, 2014). The process of fermenting Green papaya and their leaves were investigated to determine the most suitable conditions required to achieve the highest rate of fermentation with respect to time and temperature. The conditions investigated were effect of temperature (26°C - 45°C) for different starter cultures namely yeast (*Saccharomyces cerevisiae*) and a bacterium (*Lactobacillus plantarum*). Following 16day incubation period the following analyses were conducted: - TSS, pH and titratable acidity. The quantity of organic acids produced was used as an indicator for the reaction completed.

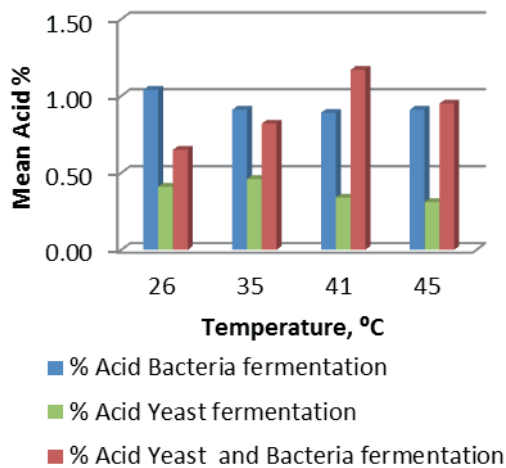
In order evaluate this, the following analyses were done on the product after a 16 day period:- TSS, pH and titratable acidity, along with the quantity of organic acids produced during fermentation will be used as an indicator of the reaction completion.

#### Materials and methods

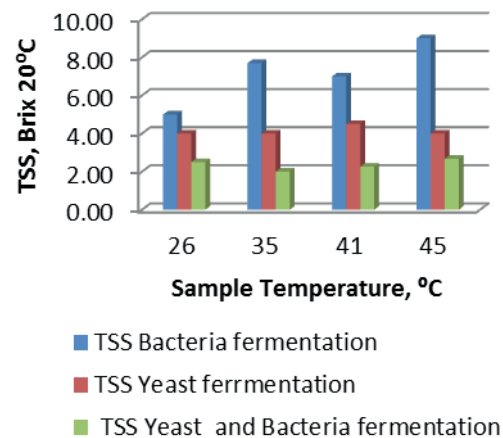
Thirty Six (36) papaya and leaf samples were prepared, to which dextrose solution was added. 12 samples were inoculated with yeast (*Saccharomyces cerevisiae*), 12 samples were inoculated with bacteria (*Lactobacillus plantarum*) and 12 samples were inoculated with both. All samples were incubated at 26°C for four (4) days. 36 samples were labeled according to the outlined temperature set points (26, 35, 41, and 45°C) with three samples in each set point, and were placed in incubators for a period of sixteen (16) days. One of each of the differently prepared samples were labeled as control and left at 26°C. After fermentation, samples were pasteurized, filtered and then analysed for TSS, pH and titratable acidity.

#### Main results

The volumes of acid produced per sample per temperature set point (Figure 1) shows fermentation was more successful at the lowest temperature (26°C) for the bacteria only and at the lower temperature ranges for yeast (optimum was 35°C). The least optimum temperatures were; 45°C for yeast and 35-45°C for bacteria. There is an increase in the volume of acid produced at the higher temperature set points for the yeast and bacteria mix. Samples fermented at 41°C were found to be the optimum temperature, and this was followed by 45°C. The least optimum temperature for the yeast and bacteria mix was 26°C.



**Figure 1:** Shows the effect of fermentation temperature on acid volumes for the different cultures



**Figure 2:** Shows the effect of fermentation temperature on TSS for the different cultures

Fermentation was more successful at the lowest temperature (26<sup>0</sup>C) for the bacteria only and at the lower temperature ranges for yeast (optimum was 35<sup>0</sup>C). The least optimum temperatures were; 45<sup>0</sup>C for yeast and 35-45<sup>0</sup>C for bacteria. There is an increase in the volume of acid produced at the higher temperature set points for the yeast and bacteria mix. Samples fermented at 41<sup>0</sup>C was the optimum temperature, followed by 45<sup>0</sup>C, the least optimum temperature for the yeast and bacteria mix was 26<sup>0</sup>C. Samples fermented at different temperatures all showed degradation of TSS more significant at the optimum temperatures identified for bacteria only and the yeast and bacteria mixture. Only the TSS degradation for the yeast only mixture did not follow the trend of being the highest at the optimum temperature for yeast. The TSS for yeast was the same for all other temperatures other than the optimum temperature which had the highest TSS.

**Conclusion**

This work reveals that temperature has a significant effect on the degree to which papaya and leaf samples are fermented to produce organic acids. Based on the data gathered as well as the referenced research, the activity of both species used, yeast (*Saccharomyces cerevisiae*) and bacteria (*Lactobacillus plantarum*), was quantified by the amount of acid produced upon the completion of the sixteen (16) day fermentation process, and optimum temperatures for fermentation for different culture mediums were identified at 41<sup>0</sup>C, 26<sup>0</sup>C and 35<sup>0</sup>C for yeast and bacteria mix, bacteria only and then yeast only respectively. The objective of the study was completed and was as expected given the understanding of temperate conditions for enzyme activity, yet it still provided new data as it relates to the function of both species within the same environment, simultaneously acting on the same carbohydrate source across different temperature set points, all within and on the border of the optimum temperature range for both the yeast and Lactobacillus species.

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## FOOD CROPS FOODSTUFF AND CARIBBEAN CULINARY IDENTITY

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**Keywords:** crops, food: dishes, culinary heritage and tradition

### Abstract

Suriname and the Caribbean English-speaking nations share typical Caribbean identities because of both their historical and geographical similarities, as the history of these countries is dominated by colonialism, slavery and immigration. By the same token, there are also differences because of that history and their geographical separation.

By means of food- and culinary concepts in the Caribbean this paper, based on the *CCD Carisur Culinair Dictionare* (Paramaribo 2013), tries to show relatedness in the national culinary cultures of the Caribbean. The *CCD*, a bilingual culinary dictionary (Surinamese Dutch-Caribbean English- Surinamese Dutch), has been compiled to further promote and strengthen the idea of the linguistic and cultural unity of the Caribbean, fully treated previously by both Richard and Jeannette Allsopp, the latter crossing linguistic boundaries in her *Caribbean Multilingual Dictionary of Flora, Fauna and Foods (CMD)*. Dutch was however not included in that publication. The *CCD* catering to Dutch-speaking users compares the culinary domain of Suriname with that of the English-speaking Caribbean, and sets out to prove the close cultural relationship between this Dutch-speaking territory and the English-speaking (is)lands of the region.

Departing from crops in their functions of staple, vegetable, condiment and edible fruit, this paper presents food in the Caribbean from a historic point of view, elements of common culinary culture, as well as distinctions throughout the Caribbean will be described and analyzed. It goes without saying that restrictions to a paper do not allow listing exhaustively food crops and products. Those dealt with in this paper are meant to illustrate, so as for example the Amerindian staple cassava and its products, such as cassavebread, farine, pepperpot, casiri, etc.

The most important results of the desk-top and field research conducted in compiling the *CCD*, included in this paper are:

- 1) Amerindian culinary heritage does not abound in current Caribbean culinary culture, although there are some food items, such as cassava-bread that surely attribute to Caribbean culinary identity. Amerindian influence is strongest in the naming of indigenous edible flora, as many fruits bear Amerindian-derived names.
- 2) Slavery has played a considerable role in culinary identity in the Caribbean. Foodstuff and reminiscing about slavery can be found throughout the Caribbean. However, in the Surinamese cuisine of today it seems as if these influences of slavery are fading and have been faded away.
- 3) Colonialism and Immigration have brought about distinctions in culinary culture in the Caribbean, such as the use or non-use, and preparation of food crops.

### Materials and Methods

#### Materials

Cookbooks of the Caribbean (is)lands, including some cookbooks of creole food in French Guiana and the French-speaking Antilles.

Dictionaries: Caribbean English (including dictionary of food, flora and fauna)

Scientific books/articles on food, flora (including history of food).

Historic newspapers from Suriname, articles on food and flora.

#### Methods

1. Observations → notes of observations  
Participation observation (eating dishes)
2. Desk-top research → study of books and articles  
Dictionaries were studied to obtain insight in names and etymology .
3. Interviews with people, including English-speaking informants:
  1. street and market vendors in Barbados, Guyana, Trinidad, Jamaica;
  2. cooks in hotels and restaurants.\*NB Interviews were not recorded (Oral interviews of which notes were taken).  
The notes acquired from interviews were compared with knowledge derived from observation and participation observation and desktop research.
4. Pictures were taken in English speaking countries in Suriname

### Conclusions

- A. Amerindian culinary heritage only reflected by:
  1. names of edible food crops e.g. Kasyuma (*Annona reticulata*)
  2. Cassava (products) as ingredients: grated cassava, cassareep, farine
- B. Throughout Caribbean slavery contributed most to culinary identity (similarities in kitchen)
  - cooking styles: one-pot-meal of ground provisions;
  - food crops (staples from Africa (yams));
  - naming of food crops – calalu, gumbo
  - Food shift reminiscing to slavery fades away in Suriname → (*Cajanus cajan*),

### C. Colonialism and Immigration

- Distinctions in culinary culture.

Suriname: Pom: creolization of Jewish dish

Green herbs substituted by Javanese/Chinese spices.

Suriname uses more greens than most other Caribbean countries → probably Javanese influences.

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## GREEN CHEMISTRY

### CREATING VALUE IN THE AGRICULTURAL SECTOR THROUGH INNOVATIVE AND SUSTAINABLE CHEMISTRY - UTILISATION OF WASTE BIOMASS FOR THE PRODUCTION OF CHEMICALS AND FUELS

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**Keywords :** Biomass, Agricultural Waste, Energy, Catalytic Conversion

#### **Abstract :**

Society's high reliance on fossil derived fuels presents several problems to global sustainability. To circumvent these problems, biomass has received given significant attention because it is the only renewable carbon source that can provide both fuels and chemicals. Specifically, agricultural wastes are inexpensive, readily available non-competitive feedstock source for biomass conversion. Due to several challenges in utilizing biomass with current technologies, since it is chemically different from petroleum<sup>1</sup>. The design of new catalyst systems is required for biomass conversion into fuels and chemicals<sup>2</sup>. Earlier research has showed that the transformation of lignocellulosic biomass in aqueous media can be an environmentally friendly and economical route to produce targeted fuels due to the lower energy requirement and compatibility of cellulose and hemicellulose monomer units with current aqueous phase separation technology<sup>3</sup>. This knowledge supported the development of new routes to chemicals and fuels, in particular Aqueous Phase Processing (APP) in 2011. However, due to the high variability of biomass sources and the vast number of potential routes to valuable products from a single lignocellulosic stream the development of selective and stable catalysts is necessary to produce economically viable and sustainable biomass conversion technologies<sup>1</sup>. This research attempts to develop novel materials that convert biomass derived compounds to targeted fuels and precursors under APP conditions.

#### **Materials and methods :**

##### Catalysts Preparation and Characterization

The 1% Cu, Fe, Co and Ru catalysts used in the reactions were prepared using the sol gel technique. The support used for the catalysts was Titanium Dioxide (TiO<sub>2</sub>) (Sigma Aldrich) and metal precursors of Cu(NO<sub>3</sub>)<sub>2</sub>·2.5H<sub>2</sub>O, Fe(NO<sub>3</sub>)<sub>3</sub>·9H<sub>2</sub>O, Co(NO<sub>3</sub>)<sub>2</sub>·6H<sub>2</sub>O and RuCl<sub>3</sub> (Sigma Aldrich). To a fixed volume of distilled water, a calculated volume of aqueous metal precursor solution was added to the beaker of distilled water. Then a known mass of polyvinyl alcohol (PVA) and sodium borohydride (NaBH<sub>4</sub>) and stirred for 30 minutes. Approximately 5 drops of H<sub>2</sub>SO<sub>4</sub> was added to the mixture followed by the desired mass of support (TiO<sub>2</sub>) and stirred for 60 minutes. The catalysts was then filtered until the filtrate was neutral. The prepared catalysts were dried in an oven for 16hrs. at 110Å°C, grinded and then placed in sample vials. Other TiO<sub>2</sub> nanotubes and zeolite (ZSM-5) catalysts were made via hydrothermal techniques.

The catalysts were characterized using Transmission Electron Microscopy (TEM) Phillips 420 at 200kV and with the Scanning Electron Microscope (SEM) Phillips 515.

##### Catalysts Studies

Preliminary studies were conducted with the substrate furfural (Sigma Aldrich) under oxidative conditions.

For the oxidation reactions 20mg of each catalyst, a substrate: oxidant of 1:5, 30mL of solvent (acetonitrile) was placed in a round bottom flask and refluxed for 3hrs at 353K. After each reaction was completed, the mixture was filtered and the filtrate analysed by Gas Chromatography-Mass Spectroscopy (Shimadzu 2014).

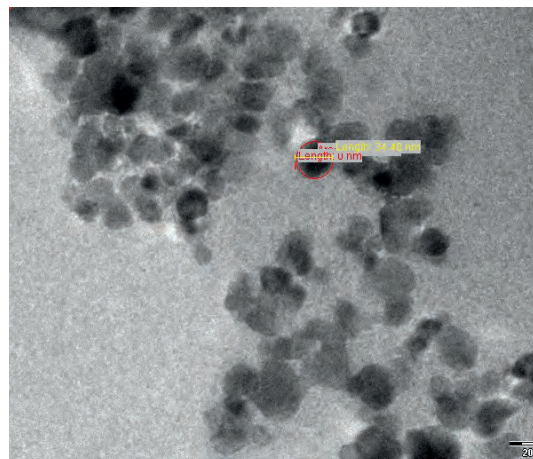
#### **Main results :**

Figures 1-3 shows some of the catalysts made and characterized by transmission electron microscopy (TEM). Under oxidative conditions furfural can be converted to acids and ketones. Table 1 shows the catalytic results of the oxidation of furfural by catalysts that were developed by the sol-gel technique. The results emphasize that the selectivity of catalysts continues to be a challenge, as all the catalysts were capable of converting the substrate (furfural). However, only the catalysts with the precursor Cu was able to convert the furfural to 2 (5H)-furanone. Its interesting and quite promising that the non-precious metal and readily available copper(Cu) converted furfural to furanone as opposed to the precious metal Ruthenium(Ru); although both catalysts had a conversion rate of 96%. This reaction when extended to 24hrs. showed a decline in the production of 2 (5H) furanone, therefore the reaction maybe economical on an industrial scale based on time and the Cu precursor. Furanone has great marketability as it is used in the pharmaceutical industry as an appetite depressant and an immunosuppressive agent, and it is also utilized as a food flavoring agent.

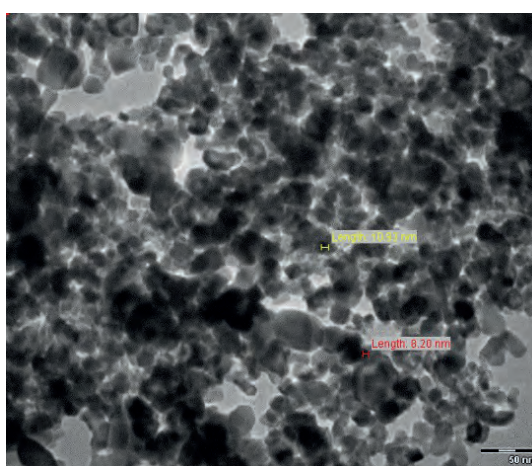




**Figure 1:** SEM image of TiO<sub>2</sub> nanotube which was synthesised by hydrothermal technique.



**Figure 2:** TEM image of ZSM-5 with particle size of 34.48nm which was synthesised by hydrothermal technique.



**Figure 3:** TEM image of Ru-Cu@TiO catalyst which was synthesised by the sol-gel technique

Catalysts	Conditions	Conversion Rate%	Product
Cu@TiO <sub>2</sub>	353K, acetonitrile, H <sub>2</sub> O <sub>2</sub> , 2hrs.	96	2(5H)-Furanone
Ru-Cu@TiO <sub>2</sub>	353K, acetonitrile, H <sub>2</sub> O <sub>2</sub> , 2hrs.	94	2(5H)-Furanone
Ru@TiO <sub>2</sub>	353K, acetonitrile, H <sub>2</sub> O <sub>2</sub> , 2hrs.	96	*
Co@TiO <sub>2</sub>	353K, acetonitrile, H <sub>2</sub> O <sub>2</sub> , 2hrs.	96	*
Fe@TiO <sub>2</sub>	353K, acetonitrile, H <sub>2</sub> O <sub>2</sub> , 2hrs.	96	*

*\*Not significant to quantify*

**Table 1:** Catalytic Results of Furfural Oxidation

**Conclusion :**

Over the years the Caribbean region have had several discussions on improving and revitalizing the agriculture sector. Creating whole value chains is a well accepted strategy for improving existing non-performing business sectors. The utilization of lignocellulosic agricultural waste can aid in this objective, via chemical and biofuel production, since the production of food can be closed looped by the use of food waste to make valuable products. Income can be generated through the agro -industrial activities which can capitalize this sector.<sup>6</sup>

There is a wide range of other chemicals that can be produced from lignocellulosic biomass. For example, aspartic acid is a key ingredient in the food and beverage industry, it is used in water treatment, agricultural products and pharmaceuticals. Levulinic acid which can be hydrogenated from cellulose is a key ingredient in pesticides, is used in the cosmetics industry, as an additive for materials such as rubber, in pharmaceuticals as a non-steroidal anti-inflammatory prescribed for fever, as a food grade preservative and is a platform chemical for fuels. Glucaric acid is another compound that can be converted from lignocellulose biomass. This compound can replace phosphates in detergents, it is used in water treatment, and has anti-corrosive properties for buildings. In addition it is found in health supplements for pharmaceuticals as well as hair conditioner in the cosmetic industry. Furthermore, the high dependency of foreign fuel for transport is becoming a burden for many countries, as a result, governments are attempting to source alternatives such as biofuels.<sup>13</sup>

Thus the application of heterogeneous catalysts and aqueous phase processing to lignocellulosic biomass conversions can produce fuels and chemicals which can prove very beneficial and cost effective to various industries.

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## PRODUCTION OF ELECTRICITY FROM ENERGY CANE IN SMALL TROPICAL ISLANDS: AN EX ANTE AGRO-ENVIRONMENTAL, ECONOMIC AND INDUSTRIAL ANALYSIS IN GUADELOUPE.

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**Keywords :** Biomass ; green energy ; sustainability ; integrated assessment ; farmer; industry ; French West Indies

### **Abstract :**

Interest in renewable energy from agricultural biomass has increased in recent years. Among renewable energy sources, biomass is considered indeed as an attractive option for sustainable energy production. This is particularly true in the case of small tropical island states, where energy demand is increasing and the energy mix currently heavily relies on fossil imported resources. Diversifying and orientating the energy mix toward locally grown energy crops could therefore be a promising sustainable option. However, the introduction of such bioenergy systems under existing conditions and current agricultural models is still rather uncertain and requires achieving several sustainable goals. In order to build new sustainable energy systems, assessing the conditions for a sustainable and profitable biomass supply is a critical step prior to industrial investment. In this paper we present the results of an interdisciplinary research program aimed at identifying the agro-environmental, economic and industrial conditions for producing electricity from energy cane in Guadeloupe.

### **Materials and methods :**

The study was made of three components: 1) an agronomic component to identify best varieties and crop management systems, 2) an economic and environmental assessment of the agricultural supply chain, 3) an industrial analysis of the power plant scenario.

The main objectives of the agricultural component were to identify: (i) most efficient sugarcane varieties under the conditions of the study for dry biomass production, (ii) sustainable farming practices, including the ability to harvest all the year, (iii) the criteria of quality for biomass transformation: humidity, low heating value (kJ/g) and chlordecone (CLD) content in the plant (Chopart et al., 2013). Seven statistical experimental trials were conducted for two to five years in the south of Guadeloupe in a farmer's field. The objective was to select best varieties, studying their performance compared to a local commercial sugarcane (CSC) variety. Several agricultural practices were also tested. We measured fresh and dry biomass of leaves and stems, as well as their calorific content.

The goals of the economic analysis was to calculate the profitability of energy cane growing and harvesting, to assess the willingness of farmers to adopt this new crop through a survey on 520 farmers, and to model the agricultural production at the scale of the island under different scenario of plant localization and market price (Chopin et al., 2015). The environmental analysis consists in the definition of sustainable ways for maintaining soil carbon content as a function of biomass removal and compost amendment (Sierra et al., 2016) 2) a life cycle assessment of electricity production.

The objective of the industrial analysis was to clearly determine the technical, economic, regulatory and social conditions that allow the realization of biomass cogeneration plants in Guadeloupe in a few years. The locks were identified and opportunities to unlock analyzed. The analysis was made of three steps: 1) chemical and physical characterization of energy cane, technical study of conversion process into heat and electricity, selection and sizing of equipment (drying and storing the biomass, possibilities of recovery of low pressure heat for cold production, operating scenarios of the power plant), 2) an economic study to define the conditions of feasibility of an industrial project and its economic impacts in the island.

### **Main results :**

Two varieties (WI81456, WI79460) imported from WICSBS (Barbados) proved to be very efficient and well-adapted. The dry entire aboveground biomass (DEAB) was 81 T/ha/year in experimental plots (Chopart and Bachelier 2012; Chopart, 2016) and the low heating value of this DEAB was 16.45 kJ/g (Chopart et al., 2013), meaning that the two best varieties produced a high energy yield: 133 MJ/m<sup>2</sup> after a 12-month cropping cycle. Dry/wet biomass ratio was 0.37 in the EA. These high-energy cane varieties were cropped using the same conventional practices as local commercial sugarcane (CSC), but yields were higher: + 33% for stalks and + 71% for dry DEAB. Mechanical harvesting was possible almost throughout the year. Cumulated DEAB after three 8-month cropping cycles or two conventional 12-month cropping cycles were close (Chopart et al. 2015). In CLD-polluted soils, CLD remains in the roots and migrates only slightly in the first centimeters of stalks.

A survey of a sample of more than 500 farms showed that the interest of farmers for growing energy cane is strong. Farmers in fact consider this opportunity as a way of securing and diversifying their income. Several conditions have to be met for this crop to be adopted by farmers: 1) a sufficient level of profitability (between 2500 and 3500 €/ha/year), 2) a support for production, particularly as regards the logistics to ensure harvest, and financial support through the pre-financing of crop costs. With an area of between 1200 and 1800 ha, the biomass required to supply a 12MWe plant can be produced for a purchase price of energy cane to be around 55 €/ton. In environmental terms, with the emission of 0.25 kg of CO<sub>2</sub> eq./kWh for the electricity produced from biomass against 0.76 and 1.07 kg CO<sub>2</sub> eq./kWh for fuel and coal, the impact on climate change are reduced by more than 70%. However, in order not to degrade the soil organic matter, it is recommended to condition the crop to regular and systematic amendment of compost for a sustainable management of biomass and organic matter in the fields (Sierra et al., 2016).

The industrial analysis allow to design a 12 MWe power plant scenario, corresponding to 40 MWth with a biomass feedstock made of 70% of energy cane and 30% of imported wood pellets. Fresh biomass will be chipped and dried before storing (in order to adapt the fuel mix to supply variation and ensure the power plant's functioning). The boiler yield could be of 89% and produced ashes could serve as agricultural amendments. The economic balance of the power plant also depends on electricity sale price, which will be negotiated with energy leadership (Energy Regulatory Commission) on the basis of a 25 years guaranteed purchase contract.

#### **Conclusion :**

Varieties WI81456, WI79460 could be considered as good feedstock for a biomass electric power plant. They can be cropped like CSC, but they need to be dried before being used as fuel. Growers are informed of the potential yield of tested varieties (although they were obtained in small plots), and purchasers are able to assess the quality of this feedstock. It is possible to maintain soil organic matter in energy cane cropping systems with compost amendment every 5 years. From an economic point of view, our study shows that it is feasible to develop a sustainable biomass energy industry in Guadeloupe. The plant activity of a 12 MWe industry could contribute to local employment and satisfy 5% of the electricity demand in Guadeloupe (85 GWh per year) with 5% of the agricultural area of the island. Strong choices must however be made to ensure the success of this bio-economic activity. These choices relate to the crop management systems, the conditions of remuneration and support for farmers, and the design and location of the power plant.

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## THE EXTRACTION OF PECTIN FROM GRAPEFRUIT *CITRUS PARASIDI* AND PASSION FRUIT *PASSIFLORA EDULIS FLAVICARPA* PEELS USING THE DIRECT BOILING EXTRACTION METHOD

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**Keywords:** grapefruit, passion fruit, peels, pectin extraction, pectin yield fresh weight base, direct boiling method

### Abstract

Pectin is a commercially interesting polysaccharide frequently used as gelling agent in food. Common sources of pectin are the peels of fruit, a waste product of for instance the juice industry. The objective of this present study was to extract pectin from grapefruit and passion fruit peels that are cultivated in Suriname under different extraction conditions with variation of two acids. The different solvents for extraction were 35% HCl and HNO<sub>3</sub> 68%. The purpose was to see which of the selected fruits had a higher yield percentage on fresh weight basis. The solvents were diluted to a pH of 2, the extraction temperature was ± 98 °C and the time periods consisted of ½h; 1h; 1½h; 2h; 2½h and 3h. The experiment was performed in duplicate. The yield of pectin on fresh weight basis extracted using diluted HCl on grapefruit was 3.17% and HCl on passion fruit was 1.22%. The extraction of pectin using diluted HNO<sub>3</sub> acid on grapefruit yielded 2.63% and for passion fruit it resulted in 1.08%. The optimum extraction times for grapefruit extracted with HCl and HNO<sub>3</sub> were both 2 hours and for passion fruit extracted with HCl was 1½ hours and the extraction with HNO<sub>3</sub> was 2 hours. The use of HCl for the pectin extraction resulted in a higher yield for both fruits. The pectin extraction for grapefruit resulted in a higher yield percentage on fresh weight basis. This study resulted in the extraction of pectin from grapefruit and passion fruit peels, providing essential information for potential industrial extraction of pectin.

### Introduction

Pectin is a commercially interesting polysaccharide frequently used as gelling agent in food. Common sources of pectin are the peels of fruit, a waste product of for instance the juice industry. Pectin is found in fruits, vegetables and nuts (Baker, 1997). Fruit pectin is primarily found in the cell wall of plant cells and it gives structure to the non-woody parts of the plant (Srivastava and Malviya, 2011.) Popular sources of commercial pectin are citrus fruit peels and seeds and apple pomace (May, 1989). Fruit pectin is an essential ingredient in the food industry but also in the pharmaceutical and cosmeceutical industry. Its main uses are as a gelling agent, thickening agent and stabilizer in foods (Srivastava and Malviya, 2011; GENU pectin book, 2004). The first commercial pectin production of liquid pectin extract took place in Germany in 1908. Soon the process expanded in the US where it was patented by Douglas (IPPA, 2001). In recent years the biggest pectin producers are in Europe and other countries are Mexico, China and Brasil (IPPA, 2001). Popular pectin brands are CPKelco, Danisco, Cargill, H&F and Yantai (Helal, 2014). From a recent trade site online the trade prices of pectin can differ from US\$1 up to US\$ 300,- per kilogram pectin (alibaba.com, 2016). Currently in Suriname there is no pectin production known to be executed. The food processing industry in Suriname mainly uses imported pectin in their processing production even though there are a lot of fruits known to be cultivated here that may potentially serve as a source of pectin. The objective of this study was to extract pectin from an exotic fruit, passion fruit, and a citrus fruit, grapefruit and to gain its pectin yield by comparing it to the literature values for the selected fruits.

### Materials and methods

The raw material was purchased in a local fruit stand for the grapefruits and market for the passion fruits nearby the university complex. The pectin extraction was performed by gathering the fruits and cleansing them with clean tap water and a brush. The pulp of the fruits are removed from the peels and the peels are collected. The peels are minimized and cut into smaller portions of approximately 2 by 2 mm. After weighing the peels, they are placed in an acid solution of either 68% HNO<sub>3</sub> or 35% HCl of pH ≈ 2 or 0.01M. The peels are heated to the boiling point, 100 °C, and left to cool down when the extraction time is reached. The alcohol precipitation is carried out using 95% ethanol. The obtained pectin is separated from the solute and dried at 50 °C for 24 h and weighed for calculating the pectin yield.

### Results and discussions

The experiment resulted in a pectin yield for grapefruit extracted with HCl of 3,17% and extracted with HNO<sub>3</sub> was 2,63% with peak extraction times of 2 hours and 2½ hours. The pectin yield of passion fruit extracted with HCl is 1,22% and extracted with HNO<sub>3</sub> was 1,08% with a peak extraction time of 2 hours and 1½ hours.



Sample extraction	Pectin yield (%)	Optimum extraction time (h)
<sup>a</sup> Grapefruit with HCl	0,44-3,17	2
<sup>a</sup> Passion fruit with HCl	0,26-1,22	2½
<sup>a</sup> Grapefruit with HNO <sub>3</sub>	1,27-2,63	2
<sup>a</sup> Passion fruit with HNO <sub>3</sub>	0,41-1,08	1½
<sup>b</sup> Grapefruit	3,30-4,50 0,65 5,0	-
<sup>c</sup> Passion fruit	1,63-1,97 1,87-2,4	-

<sup>a</sup>= experimental values of this research; <sup>b</sup>= theoretical values of pectin yield of grapefruit (Baker *et al*, 1997; Mrak *et al.*,1948); <sup>c</sup>= theoretical value of pectin yield of passion fruit (Normah *et al.*, 2000; Martosatiman, 1995); - = value is unknown or not mentioned in the reference literature.

**Table 1.** Collected values of pectin extraction on grapefruit and passion

## Conclusions

This study showed it is possible to extract pectin from grapefruit peels and passion fruit peels using the direct extraction method with the application of the strong acids HCl and HNO<sub>3</sub>. The use of HCl as solvent obtained a higher pectin yield on both fruit peels. As described in the literature this research also shows that grapefruit peels contain a higher pectin content in comparison to passion fruit peels, making it a potential interesting source of pectin. The pectin extraction using the direct boiling method yielded a lower pectin yield in comparison to the yields from previous studies on grapefruit and passion fruit peels.

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## LIVESTOCK AND ANIMAL PRODUCTS IN THE CARIBBEAN: FEED PRODUCTION PROSPECTS ON THE FARM.

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**Keywords :** Caribbean, livestock, feed, processing

### Abstract :

From the statistical basis of the FAO, animal productions in the Caribbean are evaluated in terms of self-sufficiency, taking as the percentage of self-sufficiency the percentage of Caribbean populations compared to global one. It shows that the production of chickens and eggs are self-sufficient, whereas pigs, cattle and small ruminants are far from self-sufficiency, especially in the insular Caribbean. In some sub areas, horses are particularly important, as well as beekeeping and production of skin. In the insular Caribbean, the availability of quality food to feed livestock has to be improved to meet in agroecological conditions needs in mixed crop/livestock farming systems. We are studying yeast production routes on agricultural substrates to obtain protein enriched feed in conditions that can be carried out on the farm. Sugarcane, cull banana, cassava are our raw materials on which we study baker's yeast strain development. The enrichment is better and easiest on sugarcane.

### Materials and methods :

Observation is made from data of the statistical FAO database that, insular Caribbean is less productive in animal products than the other Caribbean territories.

We study sugarcane, molasses, cull banana and cassava, that are common agricultural products and by-products in Caribbean, to be used as raw materials at the farm level, to elaborate feeds. Non-aseptically pathways could be taken to cultivate baker's yeast strains, cheap and highly available, for protein-enrichment of those raw materials to produce efficient feeds for livestock.

### Main results :

After a study of yeast development pathways in buckets shacked by hand, electric concrete mixers are tested as fermenters.

### Conclusion :

In the Caribbean area, the profile of species reared is the same than elsewhere. However, the insular Caribbean seems to be less productive than the others Caribbean areas. Co-products and by-products from major crops, common and quantitatively important, could be raw materials to process by rustic pathways to elaborate protein-enriched feeds, in order to increase local feed availability and so enhance development of rearing and animal products in an agroecological manner.

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<http://faostat.fao.org/>

Area \ Rank	Caribbean	America	Africa	Europe	Asia	Oceania	World
1	Chicken	Chicken	Cattle	Pig	Pig	Cattle	Pig
2	Pig	Cattle	Chicken	Chicken	Chicken	Chicken	Chicken
3	Cattle	Pig	S&G	Cattle	Cattle	S&G	Cattle
4	S&G	Turkey	Pig	Turkey	S&G	Pig	S&G
5	Horse	S&G	Game	S&G	Buffalo	Game	Turkey

S&G: Sheep and Goats

**Table 1:** Rank of meat produced (quantities) of different species, in 2012, for different geographical areas. (According to FAO database).

Production Species, products	Global Heads or Hives	Global pro- duction Tonnes	Caribbean islands Prod° %	Central America Prod° %	South Caribbean Prod° %	Great Ca- ribbean Prod° %
Asses*	43 731 780	211 750	0.94*	7.62*	1.26*	9.82*
Buffaloes	198 091 615	3 597 340				
Camelids, other	8 739 659	19 500				
Camels	26 76 3 215	524 390				
Cattle	1 478 720 551	63 288 605	0.37	3.63	2.14	6.14
Chickens	21 182 226 000	92 812 054	0.64	3.89	2.14	6.67
Ducks	1 326 427 000	4 340 807	0.003	0.48	0.01	0.49
Geese, guinea fowls	382 285 000	2 803 721	0.001			
Goats	992 923 577	5 300 336	0.23	0.80	0.39	1.42
Horses	58 531 753	750 747	0.77	11.86	0.9	13.53
Mules	10 317 238	53 000				
Pigs	969 885 048	109 122 261	0.31	1.30	0.38	1.99
Rabbit		1 833 843	0.001	0.23	17.12	17.35
Rodent others	18 925 000	18 600				
Sheep	1 167 086 192	8 470 307	0.15	0.71	0.13	0.99
Sheep and Goat		13 770 643	0.18	0.74	0.23	1.15
Turkeys	476 245 000	5 609 529	0.01	0.37		0.38
Game		1 992 758				
Meat total		302 390 507	0.40	2.50	1.36	4.26
Beehives		80 513 551	0.44	2.84		3.28
Honey		1 592 701	0.82	4.14	0.14	5.10
Beewax		64 688	1.98	3.68	0.26	5.92
Milk whole cow		625 754 261	0.26	2.32	1.08	3.78
Milk wholegoat		17 846 118	1.20	0.88		2.08
Milkwholesheep		10 122 522				
Milk whole buffalo		97 417 135				
Milk whole camel		2 785 382				
Milk total		753 925 417	0.25	1.95	1.18	3.38
Skins goat		1 252 174	0.13	0.58	0.20	0.91
Skin sheep		8 947 550	0.03	0.08	0.02	0.13
Eggs hen in shell		66 373 179	0.37	4.17	1.20	5.74
Hides cattle fresh		7 976 386	0.37	3.65	1.74	5.76

\*Population (heads)

**Table 2 :** Animals and animal products produced globally, and percent of global production in Caribbean islands, Central America, Caribbean South American countries, and Great Caribbean. D'après FAOstate, pour 2012.

Paper presented at the 52<sup>nd</sup> CFCS Annual Meeting, Guadeloupe, July 10-16, 2016.

%crop	%past.	*Area/ca	%Global	Populat <sup>o</sup>	Country	
4,3	90,9	0,09	1,09	48,2	Colombia	South America
				0,3	French Guiana	
1,6	73,3	0,59		0,7	Guiana	
7,3	20,7	0,12		0,6	Suriname	
3,1	84,7	0,11		30,6	Venezuela	
20,4	31,8	0,34	2,36	0,4	Belize	Central America
17,6	69,1	0,12		4,8	Costa Rica	
15,0	41,6	0,14		6,4	El Salvador	
21,5	44,4	0,17		16,2	Guatemala	
13,7	54,7	0,19		8,3	Honduras	
2,6	72,7	0,25		127,0	Mexico	
4,5	58,6	0,36		6,3	Nicaragua	
8,3	67,8	0,20		4,0	Panama	
			0,58		Anguilla	Caribbean Islands
11,3	40,1	0,06		0,09	Antigua and Barbuda	
					Aruba	
26,7	13,3	0,04		0,4	Bahamas	
6,7	13,3	0,05		0,3	Barbados	
					British Virgin Islands	
					Caymans Islands	
5,9	40,0	0,35		11,1	Cuba	
69,2	7,7	0,35		0,07	Dominica	
18,4	48,9	0,12		10,5	Dominican Republic	
63,6	9,1	0,10		0,1	Grenada	
15,8	27,7			0,4	Guadeloupe	
		0,13		10,9	Haiti	
22,3	51,0	0,08		2,7	Jamaica	
				0,4	Martinique	
					Montserrat	
					Netherlands Antilles	
				3,5	Puerto Rico	
1,7	15,0	0,10		0,05	Saint Kitts and Nevis	
63,6	9,1			0,2	Saint Lucia	
30,0	20,0			0,1	Saint Vincent & Grenadines	
40,7	13,0	0,5		1,4	Trinidad and Tobago	
					Turks and Caicos Islands	
				United States Virgin Islands		
			4,04	296,4	Great Caribbean	T

%crop: % permanent agricultural area for crop; % past: % permanent agricultural area in meadows and pastures;

\*Area/cap: Cropland per capita: ha/cap Population in million. FAO, 2011

**Table 3:** Demography, cropland per capita, and % of permanent agricultural area for crops and meadows and pastures in the great Caribbean area (2011)

Sugarcane	Banana	B Plantain	Cassava	Country	
33 363 560	1 982 702	3 326 910	2 252 315	Colombia	South America
9 722	9 000	3 500	23 920	French Guiana	
2 709 370	6 600	5 000	3 994	Guiana	
120 100	86 000	13 000	4 186	Suriname	
6 689 667	450 000	500 000	529 985	Venezuela	
1 070 000	76 000	12 000	420	Belize	Central America
4 005 752	2 136 437	80 000	147 375	Costa Rica	
6 487 423	41 500	36 385	33 019	El Salvador	
23 653 028	2 700 000	195 000	20 000	Guatemala	
5 860 502	765 000	86 000	23 109	Honduras	
50 946 483	2 203 861		18 533	Mexico	
6 718 247	42 000	66 000	78 000	Nicaragua	
2 263 890	78 500	65 000	78 500	Panama	
				Anguilla	Caribbean Islands
	250	250	115	Antigua and Barbuda	
				Aruba	
57 500	9 462	170	892	Bahamas	
278 000	950		310	Barbados	
	460			British Virgin Islands	
	225	23	15	Caymans Islands	
14 400 000	195 496	689 504	465 784	Cuba	
4 800	24 500	5 650	1 200	Dominica	
4 865 576	871 898	543 461	170 003	Dominican Republic	
7 200	3 350	300	225	Grenada	
658 560	60 000	8 000	1 650	Guadeloupe	
1 200 000	270 000	267 000	294 544	Haiti	
1 475 200	47 473	36 203	18 020	Jamaica	
175 306	260 000	14 000	290	Martinique	
	190			Montserrat	
				Netherlands Antilles	
	70 000	92 000	750	Puerto Rico	
				Saint Kitts and Nevis	
	25 000	1 700	1 300	Saint Lucia	
18 100	62 000	2 160	595	Saint Vincent & Grenadines	
	3 600	2 650	1 888	Trinidad and Tobago	
				Turks and Caicos Islands	
				United States Virgin Islands	
9,06 %	12,49 %	16,32 %	1,52 %	Great Caribbean	T

**Table 4:** Sugarcane, Banana, banana plantain productions by country and % of global production of the great Caribbean, according to data from Faostat, (2012)



## STUDY OF GUADELOUPEAN POTENTIAL IN BIORESOURCES PRODUCTS AND MATERIALS FOR BUILDINGS

### Bio economy and valuation of agricultural and forestry resources

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**Keywords :** Local and renewable resources – new agricultural and forestry valuations - bioresources products and materials-hygrothermal properties – carbon sequestration

#### **Abstract :**

Specific Guadeloupean needs in bioresources products and materials for buildings as well as the insular socio-economical context concerning work and raw material costs plead for a deeper reflexion on the use of local resources more adapted to guadeloupean concerns

Working on this hypothesis is to put into perspective the local needs of the building world (asking for new construction and renovations) and the potential for mobilization of local resources (including recycled) to produce local bio-based building materials (material deposits offers materials, local insulation... ) for the building with properties fitting the local context .

Practically, the study conducted is to identify, in a way, the “ unsustainable “ poles in the building process with regard to specific needs Guadeloupe (earthquake / thermal / para cyclonic / controlled costs) and to make up for them.

The need to identify the most relevant potential in terms of available resources on the island, potential products and building materials appropriate to be developed, indicating the necessary conditions so required.

#### **Materials and methods :**

The field of study is limited to bio-based building materials. To be know :

- The basic raw materials of vegetable origin ;
- The materials based on raw materials from waste / recycled themselves biobased.

#### **Methods:**

- Determining the potential and the minimum conditions for the creation of one or several Guadeloupe sectors of bio-based building materials from agriculture, forestry and recycled materials to specifically meet the needs of new buildings and renovate premises. And ultimately consider the development of a «Caribbean market «;
- To study the valuation of coproducts “agricultural” (banana stem, bagasse , bamboo, coconut , Sargassum etc.) , materials coming from recycling , as well as developing appropriate new crops (hemp, miscanthus ... ) .
- This work should ultimately allow to specify what specific type of product could be produced and under what conditions.

**Main results :** Ongoing study. Inventory done. Potential sectors identified.







52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

**Posters - Movie**



## **BAMBOO INNOVATION**

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*Anton de Kom University of Suriname and Leysweg 86.*

**Keywords:** Bamboo, bamboo products, innovation, tropical resources

**Abstract:** Bamboo is a tribe of ancient woody grass species native to many tropical and temperate regions of the world. It grows fast and is a major non-wood forest product and wood substitute. Bamboos also have played, historically and currently, an important economic and cultural role in many parts of the world. It is used for housing, crafts, pulp, paper, panels, boards, veneer, flooring, roofing, fabrics, oil, gas. In spite of bamboo's importance worldwide, global statistics on its resources, production and trade remain rather scarce and inconsistent. The use and marketing of bamboo products could assist in generating income within the community without having a serious environmental impact upon surrounding forests. The rapid growth in the use of bamboo is bringing concern about the sustainability of global bamboo resources. Despite the successful bamboo trade, very little is known about the actual status and dynamics of the bamboo resource base. When bamboo is grown, not only the nature is protected, it can also lead to a social and economic empowerment. Bamboo has received increasing attention over the last two decades for its economic and environmental values. The physical and environmental properties of bamboo make it an exceptional economic resource for a wide range of uses and for poverty reduction.

**Synopsis:** This video is about the quickly changing image of bamboo from the poor man tree to a high tech industrial raw material. Bamboo is an increasingly important economic asset in poverty eradication and economic and environmental development. The movie starts with a boy, stressed out from work, not able to come with any new ideas. The narrator informs him about the innovative approach of bamboo to quantify a possible range of bamboo uses, by showing him multiple examples of innovative bamboo products. The movie ends with the narrator telling about some benefits of bamboo innovation and leaving the guy behind with a new innovative idea.

## PURIFICATION OF CRUDE GLYCEROL OBTAINED FROM COCONUT OIL TRANSESTERIFICATION

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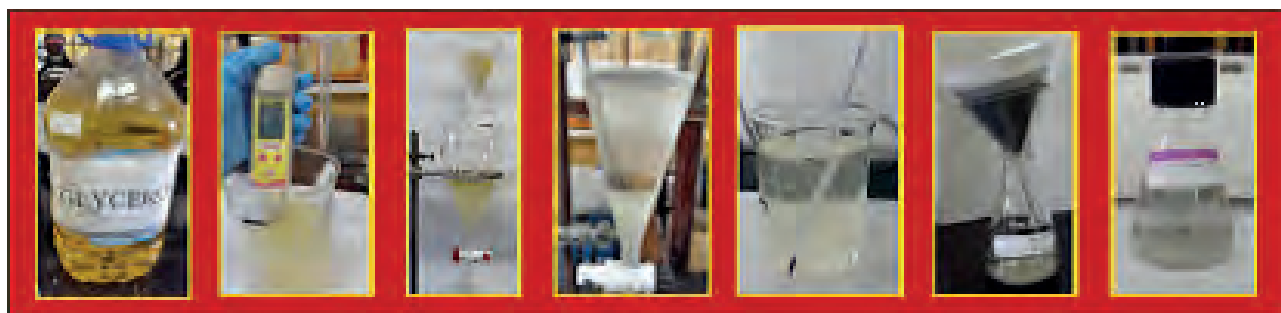
**Keywords :**Crude glycerol ; purification ; acidification; polar solvent extraction

### Abstract :

The impure condition of crude glycerol (CG) makes it virtually impossible to be used. Purification of this by-product allows it to be utilized for many value-added products. In this research CG obtained from transesterification of coconut oil was purified on a laboratory scale. A process involving acidification, polar solvent extraction and adsorption using activated carbon was utilised. Refined glycerol (RG) was compared with CG and 99.5% glycerol samples. All samples were subjected to UV-Vis spectral analysis, HPLC and a viscosity test. While the absorption spectra for RG was comparable to that of pure glycerol (PG), the viscosity of RG was extremely low. It is estimated that the RG samples contain 60-65% glycerol. Yield recovery for RG was between 20-25%.

### Materials and methods :

- Crude glycerol (CG) was obtained as a by-product from laboratory coconut oil transesterification. All other chemicals were of analytical grade.
- 300g of CG was acidified to pH 2.5 using 85% H<sub>3</sub>PO<sub>4</sub>. The solution was left overnight to allow for a 3-phase separation: a free fatty acid (FFA) top phase, a glycerol-rich middle phase and a bottom phase consisting of inorganic salts. The FFA phase was then removed and the precipitated salt filtered out.
- The glycerol-rich layer was neutralized to pH 7.0 using 40% w/w NaOH. After sitting overnight, the precipitated salt was filtered out. The purity of the glycerol-rich layer was enhanced through polar solvent extraction with 99.7% C<sub>3</sub>H<sub>7</sub>OH at 2:1 (v/v) solvent:glycerol ratio. This solution was shaken for 30 minutes and left overnight to promote a 2-phase separation: a glycerol-alcohol phase at the top, with a precipitated salt layer below. The top glycerol-alcohol phase was collected and the solvent was evaporated at 80oC in order to retrieve the refined glycerol (RG) layer.
- Finally, adsorption with activated carbon was performed to reduce colour and odour, as well as some fatty acids and metal ions. Activated carbon was added in the ratio of 1g in 50ml of refined glycerol (RG). After shaking at 200rpm for 3 hours, the suspension was filtered to eliminate the carbon.



**Figure 2 (L-R).** Crude glycerol, acidification, separation of 3 phases, polar solvent extraction, solvent evaporation, adsorption, final product.

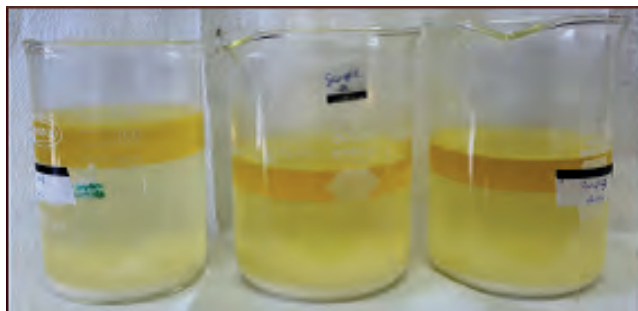
### Analysis

- Absorption of samples was measured using Analytik Jena SPEKOL 2000 UV-Vis Spectrophotometer. The wavelength of incident light was chosen between 200-800nm.
- Viscosity was measured at two temperatures (40oC and 100oC) using a Cannon-Fenske Viscometer No. 200 according to the standard method ASTM D445.
- Purity percentage was analyzed by High Performance Liquid Chromatography (HPLC) with a RID-10A refractive index detector.



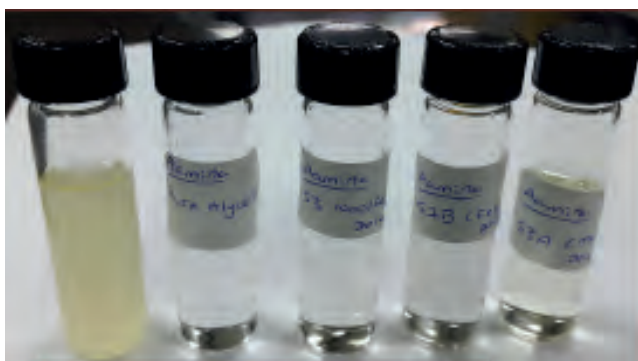
**Main results :**

CG obtained from coconut oil transesterification was an opaque, golden yellow liquid. Acidification with concentrated H<sub>3</sub>PO<sub>4</sub> resulted in a distinct 3-phase separation of the CG (Fig. 3). In this reaction, H<sup>+</sup> from the acid converted dissolved soap into insoluble protonated FFA which formed the top layer (5). Precipitation of salt in the bottom layer was due to the coupling of excess PO<sub>3</sub><sup>-</sup> with Na<sup>+</sup> from catalyst molecules to produce NaH<sub>2</sub>PO<sub>4</sub> (monosodium phosphate, MSP), which is insoluble in organic solution, including crude glycerol, and has low solubility in water (5).



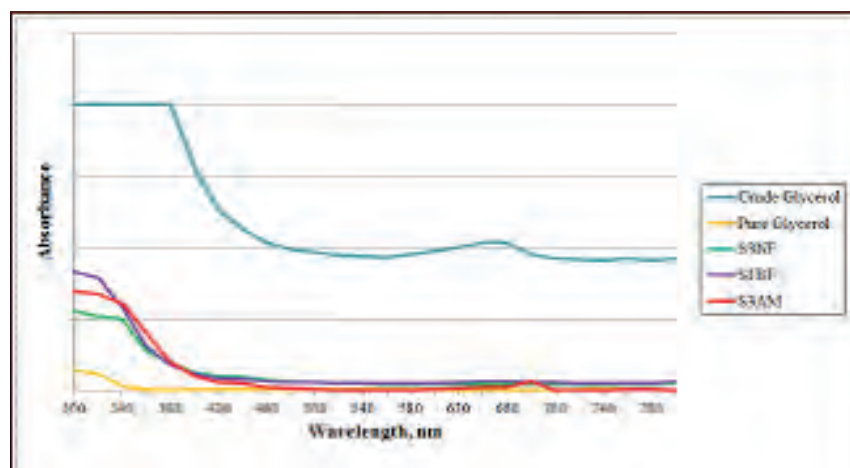
**Figure 3.** Crude glycerol samples with 3-phase separation post-acidification.

Following solvent extraction with C<sub>3</sub>H<sub>7</sub>OH, the colour of the RG samples was greatly reduced from golden yellow to light yellow. Transparency was still low, probably due to the presence of saturated fatty acids (5). Colour and odor-causing compounds, metal ions and remaining fatty acids were removed by adsorption with activated carbon. RG samples that were virtually colourless were obtained (Fig. 4) and compared to a pure sample using UV-Vis spectral analysis.



**Figure 4 (L-R).** Crude, pure and refined glycerol samples.

Figure 5 shows the spectral results of pure, crude and refined glycerol. Being colourless and transparent, pure glycerol has negligible absorbance. The refined samples showed absorption spectra quite similar to that of the pure glycerol in the visible light region (400-800nm). This is due to the removal of most of the impurities during the purification process. The crude glycerol sample was opaque and yellow due to impurities like salts, alcohol and soap, hence a very high absorbance was observed.



**Figure 5.** UV-Vis spectra of crude, pure and refined glycerol samples.

Figure 6 compares viscosity data at two temperatures for pure, crude and RG. Viscosity of RG samples were extremely low compared to that of pure glycerol, alluding to high water content. If so, the yield recovery for RG samples, which was found to be between 20-25% , may even be less. However, values for all three types of sample at both temperatures were comparable to those obtained by Segur and Oberstar (7).

Sample	Viscosity/ cSt	
	40°C	100°C
Pure glycerol	182.73	9.32
Refined Glycerol- S3NF	6.43	1.43
Refined glycerol- S1BF	4.82	1.23
Refined Glycerol- S3AM	4.70	-
Crude glycerol	4.34	1.90

**Figure 6.** Comparison of crude and refined glycerol solutions to a pure sample.

The HPLC analysis produced no tangible results regarding the purity of the RG samples, probably because the sample was unsuitably prepared. However, based on the research conducted by Segur and Oberstar (7) on varying glycerol concentrations and their viscosities at different temperatures, it is speculated that the RG samples contain 60-65% glycerol.

**Conclusion :**

Crude glycerol produced from coconut oil transesterification was refined using physical and chemical treatments. Yield recovery was 20-25%, although this value may be smaller since the low viscosity of the final product suggests a high water content. UV-Vis spectra for refined glycerol samples were comparable to that of pure glycerol. HPLC analysis failed to quantify percentage purity of the RG samples, however they are speculated to contain 60-65% glycerol based on a study conducted by Segur and Oberstar (7). Sample preparation method for HPLC will have to be revised and performed again. Other purification techniques can also be investigated, such as distillation.

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## MAKING OF BIOPLASTIC FROM AGRICULTURAL WASTE PRODUCT

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**Keywords :** Starch, yield, Bioplastics, agricultural waste

### **Abstract :**

Bioplastics are made from organic biomass sources instead of petroleum. This project aimed to produce a bioplastic material utilizing an agricultural waste product as well as to assess the starch yield of the waste peel. It is an attempt to use natural plastics to replace synthetic plastics and to reduce the negative environmental impacts and the extensive consumption of non-renewable resources. This study used the peel of *Manihot esculenta* (cassava) as the agricultural waste source. The experiment was performed in two steps; extraction of starch from raw material and the polymerization reaction. From this extraction process, the waste peel yielded 20.93% of starch., which accounted for 15.90% of the total (flesh and peel) extracted amount. The extracted starch from the waste peel was used to successfully produce a bioplastic.

### **Materials and methods :**

Starch extraction and polymerization methods, as illustrated in Figure 1, were taken from RSC Advancing the Chemical Sciences. Cassava tubers were used in this study. For the extraction process, 18 866g of sample was peeled and the weights of both flesh and peel were recorded. The flesh and peel were blended separately with water, drained and allowed to settle. It was later decanted and allowed to dry. The dried samples were then powdered using a commercial mill to achieve the desired consistency. The starch yields in weight were noted for both.

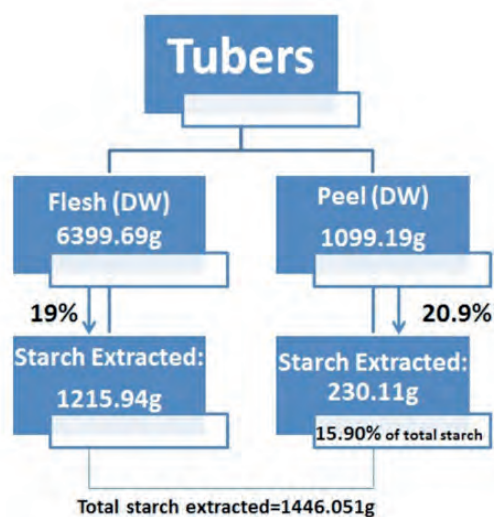


**Figure 1:** Starch extraction and polymerization  
(from RSC Advancing the Chemical Sciences)

For the polymerization process, 25cm<sup>3</sup> of water was poured into a beaker. Added to this was 2.5g of starch from the peel and 3cm<sup>3</sup> hydrochloric acid. The mixture was then brought to a gentle boil for 15 minutes and then neutralized using sodium hydroxide. The neutralized mixture was poured into a petri dish and allowed to dry. (Method adapted from “Making a Plastic from Potato Starch - Making the Plastic”, n.d.).

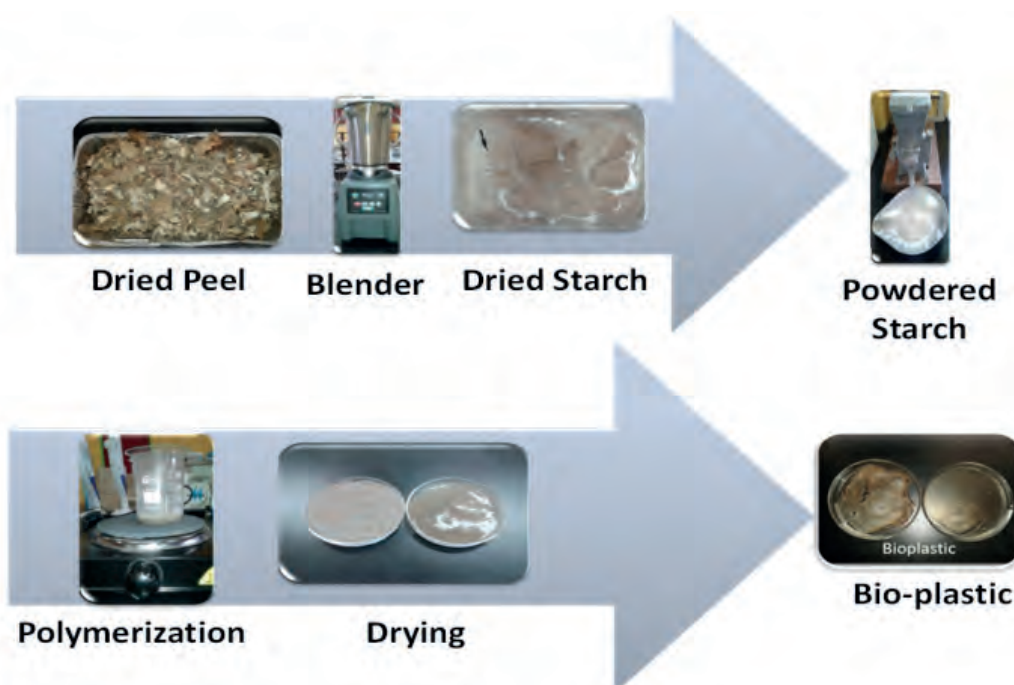
### **Main results :**

Results show that 6399.69g of dried cassava tubers produced 1446.05g of starch. Additionally, 1215.94g (19% by weight) was extracted from the flesh and 230.11g (20.9% by weight) was extracted from the waste peel. The starch from the waste product accounted for 15.9% of the total starch extracted (refer to Figure 2).



**Figure 2:** Starch Extracted from dried cassava tubers

Starch is a polysaccharide comprising glucose monomers of amylose and amylopectin joined in  $\alpha$  1,4 linkages (Starch n.d.). The amylopectin tends to prevent the starch from plasticizing and therefore needs to be broken down in order to produce the plastic. This was obtained by using  $0.1\text{mol/dm}^3$  hydrochloric acid. Figure 3 contains photos of the bioplastic produced from the cassava peel.



**Figure 3 :** production of bioplastic from the cassava peel

waste peel of *Manihot esculenta* (cassava) yielded 230.11g (20.9% by weight) of starch. The starch extracted from the waste peel was successfully used to produce a bioplastic film. This shows that a waste product can be successfully transformed into natural polymer plastic. Future work will entail mechanical testing of the bioplastic to determine its comparability with commercial petroleum-based plastics.

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## HEALTH BENEFITS OF MANGO SEED KERNEL

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**Keywords :** *Mangifera indica* by-products, seed kernel extracts, waste, therapeutic, antioxydant

### **Abstract :**

*Mangifera indica* L., also known as mango, belongs to genus *Mangifera* in the flowering plant family Anacardiaceae. Mango is one of the most popular edible tropical fruits in the world. It is appreciated for its taste, organoleptic but also health-promoting properties. Mango fruit occupies the second position of tropical crop, behind banana, in terms of production and acreage<sup>1</sup>. Many food industries with an interest in mango processing (drinks, jams, ice creams, syrups, etc) generate a lot of waste with seeds and peels. In Guadeloupe, during the period of mango fruiting, a large amount of fruits deteriorate. Scientific research and ethno medicine suggest that mango seed kernel possess a large spectrum of therapeutic and biological interest such as nutritional, anthelmintic, antimicrobial, antihyperlipidemic, anti-tyrosinase, antivenom, antiproliferative, antidiabetic, antioxidant and hepatoprotective<sup>2</sup>.

### **Conclusion :**

Those remarkable biological activities are due to the presence of phenolic compounds, phytosterols, fattyacids and many other compounds<sup>3,4</sup>. The mango seed kernel, by-product of food industry, is an easily accessible source of natural antioxidants and nutraceuticals. It can be used in pharmaceuticals, cosmetics, medicine and food industry as bio preservatives.

The purpose of this presentation is to focus upon the latest advances concerning the health interest of many cultivar of *Mangifera*. This bibliographic work is the first step of a study concerning chemical composition and biological activity, to valorize two mango varieties from Guadeloupe, The final aim is there, to develop local food industry.

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## CREATION OF A SMOOTH CARVALHO PEPPER SAUCE WITH FRUIT ADDITIVES

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**Keywords :** Condiment ; pepper sauce ; carvalho pepper

### Abstract :

The Carvalho hot pepper is an indigenous landrace in Trinidad and contains significantly higher capsaicin content compared to other local commercial peppers . It possesses many potential applications in the food industry. Sauces and condiments have numerous functions in food such as adding flavour, moisture, colour and nutrients. This study aims to explore sauces which add flavour without substantially altering the texture of food. Sauces were created using flavours extracted from the carvalho and several fruits. Pineapple, coconut, lime and carvalho were separately pulverized and macerated in different solvents – alcohol, 5% acetic acid and glycerol. Mild and very hot sauces were prepared for each of the fruit extracts creating various flavour combinations. An organoleptic test was used to evaluate the flavours of the extracts and the most liked flavour was identified.

### Materials and methods :

The carvalho hot peppers (Figure 1) were harvested from the Waterloo Research Campus greenhouse. The pepper, coconut and lime were individually pulverized using a food processor at 1500rpm and the pineapple was chopped into 1.5cm cubes (Figure 2). Three solvents were used for the extraction; 80% over proof alcohol, 5% acetic acid and 100% glycerol.



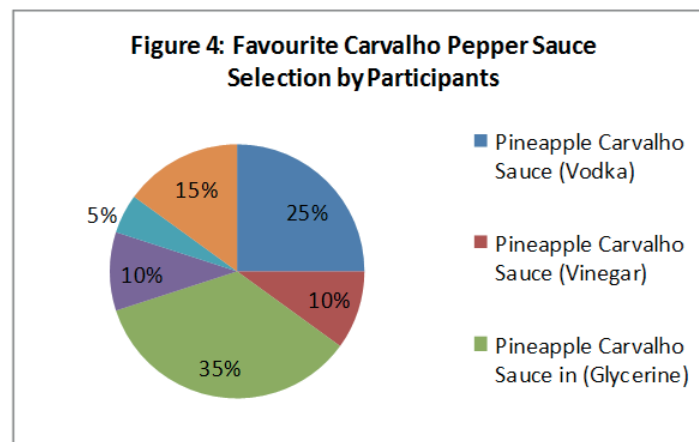
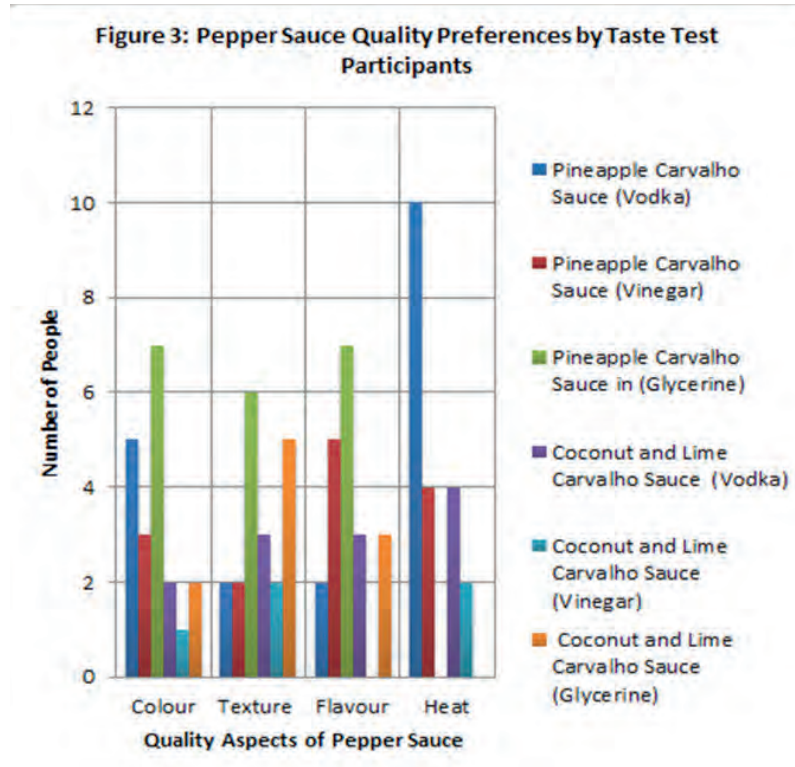
**Figure 1:** Macerated coconut (A), pineapple (B),lime (C) and carvalho (D) for pepper sauce

200mL of alcohol and acetic acid were used separately to extract the following fruits: a combination of 120g of coconut and 4g of lime, and 200g of pineapple alone. The same masses and fruit combinations were also added to 150mL of glycerol. The pepper extracts were created by adding 26g of pepper to 150mL of alcohol and acetic acid respectively. This was repeated with 50mL of glycerol.

The extracts were stored in a cool, dark place for 90 days with the bottles being occasionally shaken. The extracts were then filtered producing a smooth liquid. Various ratios of pepper to fruit sauces were created and a survey and 9-Point Hedonic Scale was used to evaluate the flavour profiles.

### Main results :

Several quality aspects of the carvalho pepper sauce such as colour, texture, flavour, level and longevity of heat were evaluated in the taste test (Figure 3). The pineapple carvalho pepper sauce steeped in glycerine was the most popular choice for colour, texture and flavour. At least 35% of the participants found this mixture more appealing when compared to the others. Generally, participants preferred the colour of the pineapple additive compared to the coconut and lime.



The colour of the pineapple mixture was amber with a syrup like texture whereas the mixture of the coconut and lime was white (Figure 5). According to the survey, the colour reminded the participants of milk, a contrast to the traditional red and yellow pepper sauces in the Caribbean, resulting in an uneasy feeling about the product. For texture, glycerine based mixtures were the most popular as 55% of participants listed this as their favourite. 35% of participants preferred the pineapple carvalho pepper sauce using glycerine followed by 25% of people who preferred the pineapple carvalho pepper sauce using vinegar.



**Figure 5: Final smooth carvalho pepper sauce with fruit additives**

Glycerine based sauces had the least lasting amount of heat due to its sweet flavour profile while 50% of participants found that the pineapple carvalho pepper sauce in vodka had the most immediate and longest duration of heat. Overall, from Figure 4, the most popular product is the pineapple carvalho pepper sauce in glycerine.

**Conclusion :**

Overall, the best product was the pineapple carvalho pepper sauce using a glycerine base followed by the pineapple carvalho pepper sauce in vodka. Future work will be performed to optimize the quality of the product (colour, texture and flavour) as well as evaluate its application in various foods. Nutritional and microbial profiles of the carvalho pepper sauce products will be done and compared to commercially available pepper sauces.

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## TESTING AN ACTION PLAN FOR THE ESTABLISHMENT OF AN ALLERGEN MANAGEMENT SYSTEM FOR THE FOOD SERVICE INDUSTRY

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**Keywords :** allergen, management, actionplan, implementation, knowledge

### **Abstract :**

The use of an allergen management system for the food service industry is regulated by law in many countries such as the USA and the EU. This is because the number of people with a food allergy has been increasing since 1997 and there is no cure for this disease (A. McKeever, 2014). Studies show that most cases of allergic reactions occur in restaurants. To ensure as much as possible the safety of people with food allergies in Suriname, it is recommended that an allergen management system is set up for the food service. At present, existing action plans are primarily for the development of an allergen management system for packaged goods and not directly applicable within the food service industry. In this study an action plan has been developed which can be used within the food service industry in Suriname.

The method consisted of 3 parts:

1. Develop an action plan for the food service based on literature study

2. Test the knowledge of the food service personnel of three restaurants on allergens by surveying:

\*kitchen staff (n=32): questions included knowledge about allergens, the handling of products containing allergens, cross-contamination and producing special allergen-free meals

\*waiters (n=31): questions included knowledge about allergens, crosscontamination and the approach & treatment of customers with food allergies

3. Testing of the established action plan in one of the restaurants through assessing the suitability of current suppliers (observation and survey), testing operations in the kitchen (observation) and testing of the operations in the service (observation)

There is not a big difference in knowledge about allergen and allergen related issues between kitchen staff and waiters. A small percentage (< 35%) of the respondents knew what allergens are. More than 50% of the respondents possessed sufficient knowledge on the handling of allergens, cross-contamination, the handling of a special order and guests with food allergies . The observation demonstrated that in the current situation in many ways cross-contamination can still occur which may cause sensitive people to suffer from a food allergy. In order to implement the established action plan for an allergen management system investment in both human personnel (training) as well as in facilities (for instance separate facilities for production of allergen free meals) is necessary.

## FOOD - ELABORATION OF FOOD NOVEL ORGANIC SUGARCANE PANCAKE SYRUP

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**Keywords :** organic sugarcane syrup, heating mantle, flavoured syrups, and brix

### **Abstract :**

Sugarcane (*Saccharum officinarum*), contains juice of high sucrose content that was conventionally used for manufacture sugar crystals in Trinidad & Tobago prior to the industry's closure in 2003. This study therefore aims to develop a novel pancake syrup of unique sweetness, natural Caribbean flavor, and of suitable viscosity, as a substitute for imported maple syrup other pancake syrups to boost employment and economic growth in the development of a new local industry. The process involved concentration of sugarcane juice in a heating mantle to 112 C and brix value of 65 to obtain the base syrup. Natural Caribbean fruit-flavoured concentrates were then added to obtain flavoured syrups from 69.8 to 80.1 Brix. Syrup selection was based on organoleptic properties of aroma, viscosity, mouth feel, colour, and flavour in a taste test conducted on ten, untrained participants. The orange flavour was the overall favourite, of the six flavours prepared (grapefruit, mango, orange, pineapple, sorrel and carambola). Future work should include the optimization of the orange flavoured syrup using additions of orange essential oil to both the orange-flavoured and base syrup formulae. The syrups produced can then be evaluated along with a popular brand of imported maple syrup using appropriate taste tests.

### **Materials and methods :**

Organic sugarcane was crushed and juiced. The juice was then clarified in a centrifuge ("International Refrigerated Centrifuge", Model: PR-2) at 4600 rpm for 30 minutes. The clarified juice was then concentrated in an Electro Heating Mantle using 5L capacity round bottom flask to 112 C and 65 oBrix and represented the base syrup. Natural flavour concentrates of grapefruit, mango, orange, pineapple, sorrel, and carambola fruits were then added. The fruit juices selected were concentrated to 1/5<sup>th</sup> its volume, except for sorrel- prepared by boiling and filtering 1:1 ratio of distilled water to sorrel fruit (minus seeds) by weight, and then concentrated to 1/10<sup>th</sup> its volume in a heating mantle and mango (100 % centrifuged juice). Sample aliquots (200mL) of sugarcane juice concentrated to 65 oBrix were then returned to the heating mantle and each flavour added separately. Each sample was allowed to boil with constant swirling to a Brix range of 69.80 to 80.10. Brix reading were obtained using a VEE GEE® refractometer, Model PDX-95. A series of preference taste tests were then conducted of the different flavoured syrups produced on a group of ten untrained participants. Questionnaires of these tests were evaluated and represented in the results.

### **Main results :**

The results were obtained from evaluation of the taste test questionnaires collected from participants. The evaluation found that participants selected the grapefruit syrup as having the best aroma (60%), followed by carambola (30%), then orange & pineapple (10%). For viscosity, orange was selected by 60% of the participants, then mango (30%) and pineapple (20%). The syrups that produced the preferred mouth feel were mango and orange (both 40% selection) and sorrel (20%). The favourite syrup colour selected was that of the orange flavoured syrup (50%) followed by grapefruit, mango and pineapple selected by 30% of participants each. The syrup with the overall best flavour was pineapple (50%) that also had the most intense fruit flavour, followed by orange (30%), mango (20%) then grapefruit (10%). The least favorite flavour was sorrel (90% of participants). Figure 1 that follows, shows the results of the preference taste tests conducted on the ten participants.

### **Conclusion :**

Overall, the best quality syrups taking all the parameters (aroma, viscosity, mouth feel, colour and flavour) into account according to Fig. 1 above are in order of preference; Orange, then mango, then pineapple followed by grapefruit, carambola then sorrel. Future work is expected to entail optimization of the flavours and other parameters particularly mouth feel and viscosity for the pineapple flavour since it is already the preferred flavour overall. A comparative taste test with a popular local brand of maple syrup is also outstanding due to time limitations

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52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

## Session 3

***Potentialities of agroecological farming systems for mitigation and sustainable adaptation of farms to global change in Caribbean small islands***



## INTRODUCTION AND REPORT OF SESSION 3:

### POTENTIALITIES OF AGROECOLOGICAL FARMING SYSTEMS FOR MITIGATION AND SUSTAINABLE ADAPTATION OF FARMS TO GLOBAL CHANGE IN CARIBBEAN SMALL ISLANDS

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This sub-session results from the tasks led within the framework of a project funded by ANR Gaia-Trop: “Viability and Adaptive Governance of Islands Agrosystems in the Tropics “ (<http://gaia-trop.fr>).

The increasingly negative effects of global change on ecosystems and biodiversity require close attention. Small Island Developing States (SIDS) are particularly vulnerable to external damage and have therefore been placed high on the international political agenda (GIEC, 2007, 2014). The damaging impacts of global change in these areas will heavily impact the agricultural sector, which is one of the most important providers of income worldwide.

This session aims to present the conditions that reinforce the viability of farming systems in small island territories or in other countries alongside stakeholders from the agricultural sector. As such a number of agrotechnical, organizational, institutional and territorial evolutions are required in order to make of agriculture a viable activity in this region, particularly at the farm level considered as socio-ecosystems (agroecological systems inextricably connected to a socioeconomic matrix).

The recent productions of the GIEC show that the capacity of natural adaptation of the ecosystems is exceeded (GIEC, 2014). In order to adapt human interventions on agrosystems are necessary as well as, on a larger scale, a profound change of agriculture. This transformation goes through a more environment-friendly agriculture (Horlings and Marsden, 2011; Duru and al., 2015). Thus the adaptive capacity of agrosystems depends on the implementation of a smart agriculture (FAO, 2010) which requires transformation of the practices, diversity of the cultures, constitution of new modes of supply, development of forms of alternative agricultures, etc. So, numbers of agrotechnical, organizational, institutional and territorial evolutions are required to make of the agriculture a viable business sector. A single political order is certainly not sufficient to implement the agroecological transition. The quality of coordination between the diverse stakeholders and their capacity to develop collective actions are central in this respect.

Inter-disciplinarity is an innovative aspect of Gaia-Trop’s approach – combining social sciences (economy, geography and management), life sciences (agronomy, ecology and zootechnics) and exact sciences (mathematics, digital analysis and computer science). The collective learning process promoted by this approach is a fundamental strength. Indeed a favorable regulatory context is not in itself sufficient to trigger ecological transition. Its modus operandi depends on a well-coordinated and diverse stakeholder group developing collective actions that lead to this transition.

This session was organised in 3 key events nurtured by the intervention of 3 keynote speakers

- i) Viability, efficiency and resilience of agrosystems – Agroecological transition – keynote address by Eduardo Chia (INRA, UMR Innovation): Territorial governance: which kind of innovations to implement agroecological transition? Case studies in Latin America and the Caribbean (Chairpersons: B. Merlot, A. Desilles, V. Angeon - Moderators : G. Alexandre , E. Chia, S. Bates)
- ii) Local experiences, network and resistance of small farming systems – keynote address by Roselyne Joachim (Chambre d’agriculture de la Martinique): Through Small and diversified agriculture, go with agriculture from Martinique toward agroecology farming. (Chairpersons: B. Merlot, A. Desilles, V. Angeon – Moderators : G. Alexandre, E. Chia, S. Bates)
- iii) The future of Agriculture – keynote address by O. Mora ( INRA, Paris): Agrimonde-Terra foresight study on Land use and food security in 2050 (Moderator: E. Chia)

A total of 26 presentations (including posters) were received, proposed by 38 authors and co-authors, coming from 13 countries, among them the most represented were Guadeloupe (8), Trinidad (4) and continental France (4).

What has been discussed?

**Topic 1 - Viability, efficiency and resilience of agrosystems - Agroecological transition**

	<p>The necessity of a common language (confidence, collective sharing, representations, projects), long run</p> <p>⇒ <b>Which organizational and institutional arrangements? Which incentives? From where to whom?</b></p> <ul style="list-style-type: none"> <li>- The strength of words and its performativity</li> <li>- The importance of stakeholders' representations and status in promoting change</li> </ul> <p>⇒ <b>Building organizational myths</b></p> <ul style="list-style-type: none"> <li>- Caribbean : great contribution to climate change (GGE)</li> <li>- Lack of farmers' awareness</li> <li>- GMO and farmers' choices</li> <li>- Integrated livestock systems increase both efficiency and resilience (Guadeloupe)</li> <li>- New methods and models</li> </ul>
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**Topic 2 : Local experiences, networks, resistance of farming systems**

	<p>Sustaining Small farming and diversified agriculture</p> <p>⇒ <b>Some insights on some concrete actions (market and non market)</b></p> <p>Promoting change through education and formation          Based-field research          Problem-based learning, participatory learning, joint learning, experience-based learning</p> <p>⇒ <b>How to be sure that farmers will benefit from these educational returns?</b></p> <p>How to measure the impacts of these new forms of apprenticeship?          And the consumers: how to educate them?</p>
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**Topic 3 : The future of agriculture**

	<p><b>Agrimonde explores 5 contrasted scenarios of land use and food security by 2050</b></p> <p>Metropolization          Regionalization          Households          Healthy          Communities</p> <p>⇒ <b>Use of scenario as intermediary tools to build the future</b></p> <p>Modelization of arable lands (Guadeloupe)          Crops production determinants</p>
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## VIABILITY, EFFICIENCY AND RESILIENCE OF AGROSYSTEMS

### **Keynote: GOUVERNANCE TERRITORIALE : QUELS TYPES D'INNOVATION POUR METTRE EN PLACE LA TRANSITION AGROÉCOLOGIQUE? CAS D'ETUDE EN AMÉRIQUE LATINE, CARAÏBES**

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Cette communication vise à introduire le concept de gouvernance territoriale pour être débattu dans le cadre des travaux qui seront conduits dans la session 3 de la CFCS 2016 « Potentialities of agroecological farming systems for mitigation and sustainable adaptation of farms to global change in Caribbean small islands ».

L'objectif de la session est d'échanger sur les modalités de transformation de l'agriculture en tenant compte des pratiques (techniques et organisationnelles) individuelles et collectives des agriculteurs. Un regard particulier sera porté aux échelles et niveaux d'organisation facilitant la mise en œuvre de la transition agroécologique dans les petites économies insulaires (principalement celles de l'espace Caraïbes) et dans les Etats d'Amérique Latine. Nous partons de l'idée que dans le travail de (re)définition technique et organisationnelle dans lequel les acteurs du développement rural sont engagés, pour faire face aux incertitudes politiques, climatiques, économiques, ils doivent mettre en place des outils, instruments et dispositifs qui leur permettent de se coordonner pour se mettre d'accord sur ce qu'il convient de faire, comment et avec qui le faire et comment l'évaluer, en mobilisant l'ensemble des acteurs publics et privés. C'est-à-dire une gouvernance territoriale.

#### **La gouvernance n'est pas le gouvernement !**

La gouvernance est devenue une des principales préoccupations des responsables politiques et un objet de recherche pour les chercheurs en sciences humaines et sociales principalement et cela dans tous les domaines de la vie économique et sociale. En effet, depuis une vingtaine d'années on a constaté un peu partout que les politiques publiques (nationales et régionales) ne répondaient pas aux besoins des populations et qu'elles font l'objet, de plus en plus, de contestations. Les populations demandent à participer à l'élaboration, la mise en place et l'évaluation de politiques publiques. La participation est née ! Les acteurs considérés, jusque là, comme des profanes sont de plus en plus organisés et informés. Ils ont développé des capacités d'expertise et d'innovation importantes pour participer à la « fabrique » des politiques publiques et actions régionales. Nous avons étudié, dans différentes situations de développement rural (France, Afrique du Nord et de l'Ouest et en Amérique Latine –Chili, Brésil, Honduras, Colombie...-) les processus de gouvernance territoriale pour analyser la construction collective d'objectifs et d'actions mettant en œuvre des dispositifs multiples qui supposent des apprentissages collectifs et des innovations institutionnelles et organisationnelles dans les territoires » (Chia et al. 2010). Dans le projet Gouv.Innov nous avons construit une définition de la gouvernance territoriale. La gouvernance territoriale est « un processus dynamique de coordination entre des acteurs publics et privés aux identités multiples et aux ressources asymétriques, réunis autour d'enjeux territorialisés » (Chia et al. 2010 ; Rey-Valette et al 2014). Cette définition rejoint celles d'autres auteurs, Stoker (1998, 2006), Le Gales (1995), Lascoumes et Le Gales (2005), Gaudin (2002, 2005) qui ont travaillé dans d'autres domaines d'intervention publique. Ainsi, Le Gales, à propos de la gouvernance des villes, définit la gouvernance comme « l'ensemble des arrangements et relations formels et informels entre intérêts publics et intérêts privés [...]. Cette définition comprend trois éléments distincts : la capacité d'agir, l'existence d'acteurs et d'intérêts organisés, les relations entre ces acteurs qui leur permettent d'agir ensemble, de former une coalition de gouvernement ».

#### **Le poids des instruments dans le travail de coordination**

Pour se coordonner (horizontalement et verticalement) les acteurs ont besoin de fabriquer un langage commun (nécessaire pour travailler ensemble, pour développer la capacité d'agir), un projet commun, des règles de fonctionnement mais aussi des instruments, outils et dispositifs qui permettent d'assurer ces actions. Cette question des outils, instruments et dispositifs dans les organisations ou l'action publique est au cœur des questions de gouvernance territoriale et de transition agroécologique.

Sans rentrer dans les détails retenons qu'un instrument constitue un système avec des éléments en interaction : un substrat technique, une philosophie gestionnaire et une vision simplifiée des relations organisationnelles. Le substrat technique est l'abstraction qui permet à un instrument de fonctionner : tableurs, ordinateurs, systèmes experts, jeux de rôle, bases de données pour des systèmes d'information géographique (SIG). La philosophie gestionnaire concerne le « système de concepts qui désigne les objets et les objectifs formant les cibles d'une rationalisation ». Enfin, la vision simplifiée des relations organisationnelles concerne « les rôles que doivent tenir un petit nombre d'acteurs sommairement, voire caricaturalement définis » (Hatchuel et Weil 1992).



Il ressort de nos observations (Chia et al. 2012 ; Merlot et al 2015 ; Angeon et al. 2015) qu'en matière de gouvernance territoriale et foncière, nous avons à faire à : i) des systèmes sociaux, non-hiérarchiques complexes ; ii) une multitude de dispositifs (CDOA, Pays, Communauté de Communes, etc.), instruments (SCOT, PLU, contentieux...) et outils (contrats, chartes, IGP...) qui vont non seulement structurer les comportements des acteurs mais vont aussi dans leur construction ou leur appropriation occuper beaucoup de temps et devenir dans certaines situations l'objet même des relations de pouvoir. iii) Enfin, pour que fonctionnent les instruments, outils, dispositifs de la gouvernance, c'est-à-dire pour qu'ils assurent la coordination, facilitent la production d'un langage commun, permettent d'explorer de « nouveaux mondes » etc. il faut que les acteurs participent à leur fabrication ou à leur contextualisation : la participation devient l'enjeu central de la gouvernance (Vitry et al. 2016).

### **Illustration à partir des trois cas**

Afin d'illustrer mes propos j'ai sélectionné trois cas ou situations permettant chacun de mettre l'accent sur des aspects (dimensions) différents de la gouvernance territoriale. En France, j'ai choisi de présenter le cas de la mise en place des CTE dans les départements d'outre-mer Guadeloupe et Réunion pour illustrer la question de l'appropriation, contextualisation d'un instrument par les acteurs locaux, son rôle dans la structuration de la gouvernance et dans les processus d'apprentissage. Pour illustrer la question de la construction de dispositifs de gouvernance territoriale je mobiliserai les recherches que nous sommes en train de conduire au Honduras. Il s'agit de mettre en place des « plateformes d'innovation territoriales » pour élaborer des stratégies innovantes quelles soient techniques, économiques, organisationnelles. Enfin, en troisième lieu, je présenterai le cas chilien, où la question de la « gouvernance territoriale », c'est-à-dire la participation des acteurs locaux à définir ce qu'il convient de faire et comment le faire, commence seulement à être posée avec la loi de décentralisation et le changement climatique. Ces situations conduisent, en particulier, les agriculteurs à repenser leurs systèmes de production ainsi que leurs relations avec le reste de la société.

### **Conclusion**

En conclusion, je voudrais seulement insister tout d'abord sur i) la complexité du développement rural et son caractère situé ou contextuel, qui rend difficile la « transposition » de recettes qui marchent ailleurs et ii) par conséquent la nécessité de développer des programmes de recherche-action ou intervention pour co-produire les innovations territoriales avec les acteurs locaux y compris en matière de (mode) gouvernance territoriale de façon à assurer la durabilité (viabilité) des systèmes de production et des territoires (Ozier et Angeon 2014). La résilience des exploitations agricoles, de l'agriculture est le produit des actions individuelles au sein d'un modèle de développement défini collectivement dans des territoires. Les territoires deviennent de plus en plus non seulement un objet de recherche ou de politique publique mais de niveaux des décisions.

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## BIOTECHNICAL PRACTICES

### MITIGATION PRIORITIES IN THE AGRICULTURE SECTOR OF SOME CARIBBEAN NATIONS

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**Keywords:** Caribbean agriculture, GHGE, mitigation, adaptation, GHG metrics

#### **Abstract**

In this study the greenhouse gas emission (GHGE) profiles in the agriculture sector of some Caribbean nations are reviewed and strategies proposed to mitigate climate change are assessed. Twenty-four (24) Caribbean nations were included in an initial assessment to determine their mean GHG emissions in CO<sub>2</sub>eq over the period 1990-2011 and then ranked according to a range of emission metrics into the highest and lowest emitters. While Caribbean nations have extremely low absolute emissions compared to most other countries/regions, relative to human population, land area and agricultural production, values in the region are comparable to the rest of the world including some of the most populated and largest countries. Eight (8) of the highest emitters were then selected and their National Communications (NC) to the United Nations Framework Convention on Climate Change (UNFCCC) were reviewed (and other sources in the case of Guadeloupe and Puerto Rico) to determine their mitigation priorities. Of the eight, only Guyana, Guadeloupe and Puerto Rico have documented any significant intent to mitigate GHG in agriculture. None however, reviewed their GHG emissions other than in absolute terms. Emissions relative to production (emission/production ratio or intensity ratio) can be particularly useful in providing a better understanding of the areas where mitigation should be prioritized. These mitigation priorities are also more likely to enhance food security goals and also contribute to climate change adaptation.

#### **Introduction**

Climate change is a global concern and Caribbean agriculture is particularly vulnerable to extreme climate events so the region must therefore address adaptation issues to protect its food security. However, all nations having ratified the Kyoto Protocol are committed to providing regular updates to the United Nations Framework Convention on Climate Change (UNFCCC) on three important issues based on a sectoral approach according the guidelines by the Intergovernmental panel on Climate Change (IPCC): greenhouse gas emissions (GHGE) inventory; GHGE mitigation strategies; and adaptations to climate change. Smaller nations (smaller emitters) feel less obligated to address mitigation issues and tend to focus on adaptations to extreme climate events; however, there may be some merit in identifying key mitigations options in the agriculture sector that may improve the region's resilience to adverse climatic changes. Given the link between GHG inventories and the prioritizing of mitigation strategies, this paper therefore reviewed the inventories of many Caribbean nations and evaluated the mitigation strategies proposed.

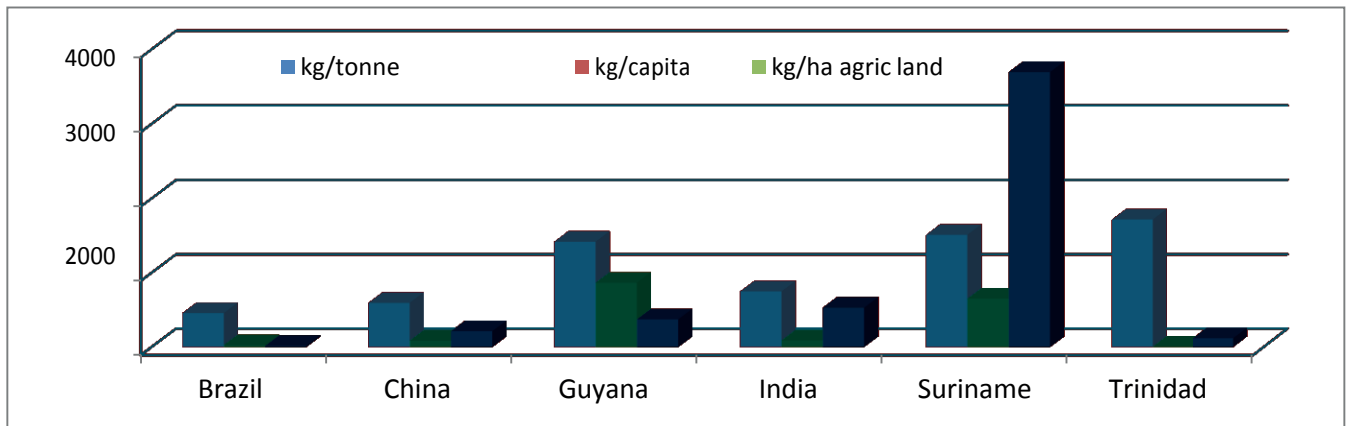
#### **Materials and Methods:**

GHGE from the agriculture sector for the period 1990-2011 were downloaded from the FAOSTAT website (<http://faostat3.fao.org/home/E>) for the Caribbean region and other major geographical regions in the world. The data was reviewed in a range of emission metrics including absolute emissions in Gg and as emissions relative to human population, agricultural and total land area, and in a separate analysis, emissions from rice cultivation were evaluated relative to paddy production (a GHG performance metric; WRI, WBCSD, 2014) for a few major rice producers in the Caribbean and the rest of the world. Twenty-four (24) countries in the Caribbean basin were selected in the first phase of the study and the six (6) largest and lowest emitters were identified in each of four (4) emission metrics: total emissions in CO<sub>2</sub>eq; kg CO<sub>2</sub>eq/capita; kg CO<sub>2</sub>eq/ha of agricultural land and; kg CO<sub>2</sub>eq/ha of total country area. The mitigation priorities by eight (8) countries that ranked as some of the highest emitters across all four emission metrics were then reviewed from their most recent National Communications ([http://unfccc.int/national\\_reports/items/1408.php](http://unfccc.int/national_reports/items/1408.php)) submitted to the United Nations Framework Convention on Climate Change (UNFCCC) and other sources in the case of Guadeloupe (Colomb et al., 2014) and Puerto Rico (Gould et al., 2015). A separate analysis of GHGE from rice cultivation among the major producers in the Caribbean and others in the rest of the world was also conducted to make comparisons of emissions relative to rice production (performance metric) with some of the other emission metrics..

#### **Main Results:**

The larger, more populated nations, expectedly, had the highest absolute emissions; however, when emissions are considered relative to human population, agricultural land area and total country area, some of the smaller nations ranked amongst the highest emitters. Montserrat ranked the highest on a per capita basis and based on total country area, with Suriname being the highest based on agricultural land area. The lowest emitter based on all four GHG metrics was the Cayman Islands. Of the eight nations ranked among the highest emitters based on the four metrics used, only Guadeloupe,

Guyana and Puerto Rico provided any substantial proposals to reduce GHGE in the agriculture sector. Emission from rice cultivation in Figure 1 shows that among some of the largest producers in the world, GHGE relative to human population, agricultural land area and production for the Caribbean nations are more comparable. Relative to production, the graph shows that all three (3) Caribbean nations had much higher emissions than Brazil, China and India, and suggest the need to improve on productivity to reduce these values.



**Figure 1.** Comparison of GHGE variables from rice production in a number of leading Caribbean and World producers.

### Conclusion

- GHGE statistics vary greatly depending on the emission metric used and while absolute emissions are extremely low in the Caribbean, values are comparable with even the largest, most populated regions/nations in the world when GHGE are considered relative to human population, agriculture land area or total country area.
- Of the eight countries selected at the second stage of analysis, only Guadeloupe, Guyana and Puerto Rico showed any evidence of seriously considering GHGE reduction in the agriculture sector.
- Mitigation in Agriculture must not lead to a decline in agricultural production so priority should be on implementing mitigation strategies that reduce GHGE relative to production (emission/production ratio) or some of the other performance-based metrics as there are limitations with the use of traditional metrics such as absolute emissions or GHGE based on population or land area.
- The emission/production ratio methodology needs to be tested in the region (and likewise some of the other performance-based metrics as well) at the local and national levels to determine its value in prioritizing mitigations in agriculture while simultaneously pursuing a path of food security and improved climate change adaptability.

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## MIXED FARMING SYSTEMS ASSESSMENT ACCORDING TO CROP LIVESTOCK INTEGRATION: CASE STUDIES IN GUADELOUPE (FWI)

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**Keywords:** Mixed crop-livestock systems; diversity; complexity; network analysis; agro-ecology; French West Indies.

### Abstract

In the new context of the agro-ecological transition, present agricultural systems will have to produce more and better in a more constraint world. Mixed crop livestock systems (MCLS) represent sound alternative ways to progressively achieve these goals through crop-livestock integration (CLI). CLI exploits the synergies between cropping and livestock systems through organic fertilization with manure or plant association, use of crop residues to feed livestock, .... It offers many opportunities to improve productivity, as well as to increase resource use efficiency and improve the resilience of the whole farming system. In the scientific literature, authors advocate the interest of MCLS and CLI, based on theoretical considerations, modelling and empirical evidence from local case studies. But these studies do not clearly identify the respective roles of diversity of activities and CLI management practices in improving performances at the level of the whole farming system. Our aim was thus to assess CLI at farm scale in a range of MCLS and to explain farm performances by analyzing the combination of activities and the level of integration. We conducted our analyses in Guadeloupe, (French West Indies), where MCLS and CLI are complex but important challenges for local agricultural. In order to analyze CLI in a holistic and systemic way, we applied a method traditionally used in ecology, ecological network analysis, to study the structure, functioning and performance of agrosystems. This method was implemented on a range of Guadeloupien MCLS where CLI practices were identified. Nitrogen was retained to conduct the analysis due to its central role for both animal and vegetal productions. The ENA method allows an estimation of productivity, resilience, efficiency, productivity and self-sufficiency of the flows network. Our results show that 1/ efficiency and resilience appear correlated to the complexity and intensity of the network of flows; 2/ efficiency and resiliency are positively correlated when we consider them in terms of N flows; 3/ in the Guadeloupien context, CLI concerns mainly specific practices, as feeding pigs with a wide range of crop residues and organic fertilization of small market gardens and plots used to grow tubers. But at whole system level, CLI remains rare and mainly depends on conventional management practices as mineral fertilization and animal complementation of some farming activities as sugar cane, cattle breeding and banana. Moreover, the combination of productions implemented determines the potential of CLI and related performances linked to relative N efficiency of each production. Consequently, performance and especially efficiency and self-sufficiency depend more on the nature of the activity than on CLI management practices. There is still a gap between theoretical studies and CLI in practice, even though CLI is more complicated than simple flows and provides other services and functions.

### Introduction

Agricultural systems will have to produce more and better in a changing world. New agricultural systems should be simultaneously efficient, productive, resilient and self-sufficient, and trade-offs have to be found between these properties. Mixed crop-livestock systems (MCLS) are sound alternative ways to progressively achieve these goals since synergies between cropping and livestock husbandry offer many opportunities to achieve sustainable agriculture. These synergies refer to the use of biomass from crops to feed animals, of manure to maintain soil fertility, of animal traction for cropping and transportation. Many analytical studies aiming to identify technical levers to improve crop livestock integration (CLI), - such as evaluation of the feed value of unconventional feed resources or ways of managing manure to enhance organic matter content of soils and increase crop yields - are reported in the literature. But none of these studies consider CLI practices at the level of the whole farming system. However, these approaches do not treat CLI in its diversity of flows configuration and intensity at farming system level. Moreover, agroecological dimension of CLI is not apprehended by current methods. The aim of the present study was rightly to apply farming system framework to ecological network analysis (ENA), in order to assess CLI at farm scale in a variety of MCLS. This framework is applied to case studies in Guadeloupe (French West Indies), to analyze CLI at the whole system level, bringing in new perspectives to agroecological features of agriculture.



### **Materials y methods**

Firstly, authors characterized the variety of CLI practices implemented in Guadeloupe, to assess the level of CLI at farm scale and to evaluate the agroecological performances (resilience, efficiency, productivity and self-sufficiency) of whole MCLS. To this end, a range of 8 MCLS were selected from a typology developed from sample of 111 MCLS farms in Guadeloupe. They were retained because 1/ they were considered to be representative of the different types overserved in the typology (productions and productions factors), and 2/ they allow to cover the diversity of agro-ecological zones observed in Guadeloupe. This sample of eight farms was interviewed in 2014 or beginning of 2015, based on the previous annual campaign (from March 2013 to February 2014). Then, the ecological network analysis method (ENA) traditionally used in ecology, (Rufino et al. 2009), was used to study the structure, functioning and performance of agrosystems. Nitrogen has been identified as the main limiting nutrient both for livestock and crop production and also as a source of pollution for agrosystems (Giller et al., 1997; Rufino et al., 2009). Data came from locally available data bases, tropical and international bibliography. Data not available was calculated assuming the conservation of mass within the system.

### **Main results**

Results show that CLI only applies to certain types of production, including feeding pigs with a wide range of crop residues (crop residues providing 16 to 45 % of the N supply to pigs) or organic fertilization of small market gardens and plots used to grow tubers (manure providing 24 to 100 % of the N supply to plots). But at whole system level, CLI remains low: in seven cases, the N circulating inside the system – ICR- represent only between 0.7 to 3.5 % of the total N circulating through the system; only one farm presents a higher intensity of CLI, with a ICR of 18.9 %. Consequently, performances and especially efficiency and productivity, depend more on the nature of the activity than on CLI management practices. However, in our systems, 1/ efficiency and resilience appear correlated to the complexity and intensity of the network of flows; 2/ efficiency and resiliency are positively correlated when we consider them in terms of N flows; 3/ in the Guadeloupian context, CLI mainly concerns specific practices, such as feeding pigs with a wide range of crop residues and organic fertilization of small market gardens and plots used to grow tubers. But at whole system level, CLI remains rare and mainly depends on conventional management practices such as mineral fertilization and animal complementation of some farming activities as sugar cane, cattle breeding and banana. Moreover, the combination of productions implemented determines the potential of CLI and related performances linked to relative N efficiency of each production.

### **Conclusions**

In the systems studied, performance and especially efficiency and self-sufficiency of MCLS depend more on the nature of the activity than on CLI management practices. There is still a gap between theoretical studies and CLI in practice, even though CLI is more complicated than simple flows and provides other services and functions. Sensibility analysis will allow to better understanding the role of diversity (number and nature of activity) and complexity (number and nature of activity) in MCLS performances.

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## THE USE OF PESTICIDES BY SMALL FARMERS IN THE RICE PRODUCTION IN DISTRICT NICKERIE

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**Keywords:** rice, pesticides, farmers, pesticide safety

### Abstract

The import data from the Ministry of Trade indicates that Suriname has increased pesticides imports over the last five years. According to research evidence, as much as 80% of potential production in various crops including rice would be lost as a result of agricultural pests without crop protection measures. Even though the benefits of chemical pesticides use are clear, negative health and environmental impacts of their use are also evident. In lieu of this information a study was conducted to determine small rice farmers' perceptions on their knowledge of pesticide use, and safety of pesticides in rice production

For this investigation a questionnaire was adapted from a pesticide use survey to generate and collect meaningful data on perceptions of small rice farmer's knowledge and practices related to pesticide use and safety aspects in rice production in Nickerie. The sample population consisted of 200 small rice farmers.

The collected data was analyzed using SPSS and Microsoft Excel. Descriptive statistics and correlation were used to describe the data. Findings reveal that the rice farmers are male, on the average older than 50 years and have more than 15 years of experience with rice production.

Results also reveal that farmers perceive the recommended dosage as too little and therefore increase the dosage. They often mix different types of pesticides and do not use all of their protective equipment while spraying. Based on the results it is recommended to develop pesticide policies to stimulate farmers to practice safe pesticide use in Suriname.

### Introduction

Exposure to pesticides can also weaken the immune system and increase the vulnerability to illness or death. Information concerning farmers' knowledge and pesticide use in rice production was a concern in Suriname.

There was also not much information available about the impact of pesticide usage in rice production by the small rice farmers. This study has focused on investigating small rice farmer's perception on their knowledge of pesticide use and the impact of pesticide use in the rice production

### Materials and methods

A combination of quantitative and qualitative research (mixed method) methodology were selected to collect data about small rice farmer's perceptions. The target population consisted of 200 small-scale farmers.

For the quantitative part, a questionnaire was adapted from the literature and validated. The questionnaire consisted of three sections. For the qualitative research part, study four focus groups were used. For the focus group, a discussion topic list was prepared to aid in the interpretation of farmers. Each focus group consisted of 10 small rice farmers.

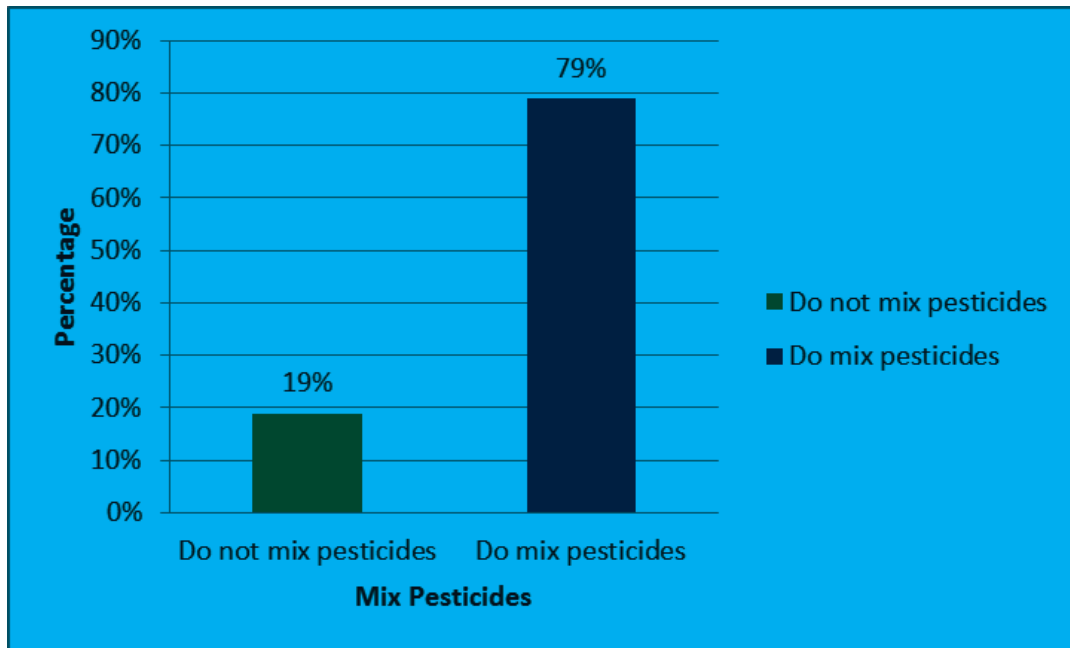
### Main results

The results revealed that the rice farmers are all male, on the average older than 50 years, who attended primary school, and have more than 15 years of agricultural experience with rice production. The majority of farmers have a profit of more than 5000 SRD. The farmer is the main person to purchase the pesticides to be used in the rice fields. Farmers perceive the recommended dosage as too little and therefore increase the dosage. They often mix different types of pesticides because they stated that it cost less, and does not require labor, and that the mixed pesticide is better and faster working. The farmers stated that they do not need to use all of the required personal protective equipment while spraying pesticides, because they feel uncomfortable wearing it. The choice for wearing personal protective equipment is based on their own judgment. Farmers have observed death fish, frogs, and birds when spraying their fields. The majority of farmers do not consider soil contamination as a hazard when applying pesticides in their fields. Results indicate that farmers do experience health effects such as breathing problems, skin rash, burning sensation, and skin problems. However, they do consider these problems a direct risk to their health.

The variable training and year of experience did not have any significant ( $P < 0, 05$ ) influence on pesticide use in contrast to the variable level of education which had a significant ( $p < 0, 05$ ) correlation with pesticide use.

**Conclusions:**

- Based on the results, with regard to the safety aspects, the surveyed farmers in Nickerie are not using pesticides safely.
- The rice farmers rely on their own experiences when it comes to pesticide use.
- Rice farmers consider pesticide use very dangerous and toxic for the environment, but not toxic for their own health.
- They find the recommended dosage insufficiently and mix different types of pesticides (cocktails) and/or increase the pesticide dosage (Figure 1).



**Figure 1.** Percentages of small rice farmers that mix pesticides

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## WILLINGNESS OF SOUTH FLORIDA FRUIT GROWERS TO ADOPT GENETICALLY MODIFIED PAPAYA (*Carica Papaya*): AN EX-ANTE EVALUATION

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**Keywords:** genetic engineering techniques, Papaya ring spot virus, PRSV, papaya line X17-2

### Abstract

Papaya ringspot virus (PRSV) has been a major factor inhibiting the expansion of papaya production in South Florida, USA. The University of Florida has developed a transgenic papaya line X17-2, which is tolerant to PRSV and is suitable for commercial production. The expected yield improvement can be as high as 380%. In spite of the yield potential, some fruit growers may be skeptical about adopting this improved GM cultivars for a variety of reasons. Consequently, a probit model with data from a survey of likely producers was used to identify those factors that may influence the adoption of the new technology. The results indicate that education level, farm size, and income derived from agriculture were among the factors likely to increase adoption of the technology. The findings suggest that a targeted education program will go a far way in increasing rate of adoption of the technology.

### Introduction

Papaya is one of world's most important tropical fruit. It is believed to have originated in Mexico/Central America but now grown throughout the tropical world. Within the continental United States, South Florida offers the best conditions for papaya cultivation, as the region's subtropical climate is suitable to grow the crop year-round. Unfortunately, as in many other papaya production areas of the world, the papaya ringspot virus (PRSV) has been a major factor inhibiting the expansion of papaya production in South Florida. PRSV is a devastating disease with negative economic consequences for growers. To overcome this constraint, the University of Florida using genetic engineering techniques has developed transgenic papaya line X17-2, which is tolerant to PRSV and is suitable for commercial production in Florida, as well as Puerto Rico and the Caribbean region. The expected yield improvement is almost 400%, as the potential yield of GM papaya is 95 tons per hectare (tons/ha) (Migliaccio *et al.*, 2010), whereas the average yield of conventional non-GM papaya production is assumed to be 25.22 tons/ha (Crane & Mossler, 2009). In spite of the yield potential, some South Florida tropical fruit growers may be skeptical about adopting this improved GM cultivars for a variety of reasons. Consequently, there is a need to identify those factors that may influence the adoption of the new GM PRSV-tolerant papaya cultivars in an ex-ante situation so that a targeted education program can be effected.

### Methodology

Since the decision to adopt a new technology can be considered a dichotomous choice problem, empirical estimation involves the use of limited dependent variable models. These types of models estimate the probability of growers' willingness to adopt the new technology based on selected characteristics. Following recent studies (Breustedt *et al.*, 2008; Keelan *et al.*, 2009) on the adoption of GM crops in an ex-ante setting, we use the probit model for the empirical estimation. The data used in the present study were obtained from an online survey conducted from November 2013 to February 2014 using Qualtrics software. The survey was distributed online to members of the South Florida tropical fruit growers' association. A total of 42 surveys were returned, but only 30 surveys contained usable information. The sample included 21 current and former papaya growers, representing 37% of the papaya growers in South Florida (USDA/NASS, 2015). To estimate the adoption of the new GM papaya cultivars the following probit model is specified and estimated:

$$Y = X\beta + \varepsilon$$

The dependent variable Y consisted of a binary variable that takes the value of one (1) if the grower is willing to grow the new GM papaya cultivars, and takes the value of zero (0) otherwise. The vector X and corresponds to a vector of independent variables that explain growers' willingness to grow the new GM papaya cultivars which include growers' demographics, farm and risks characteristics. The vector  $\beta$  represents unknown parameters to be estimated. The term  $\varepsilon$  represents the error term which is assumed to be normally distributed. Table 1 presents a description of the variables used in the present study.

### Main Results

The average marginal effects of the probit model are presented in Table 1. Model adequacy based on the likelihood ratio test indicates that the model is statistically significant at the 5% level. The marginal effects relate to a one-unit change in the variable for continuous explanatory variables, while the marginal effect for a binary explanatory variable is the discrete change in probability when the dummy variable changes from zero to one when all other explanatory variables are kept at their observed value.

## Summary and Conclusions

Variables related to grower demographics included grower's age, level of education, and previous experience growing papaya. Age was not found to be a significant factor affecting the willingness of growers to adopt GM crop. Education definitely plays a significant role as a predictor of GM crop adoption; our findings suggest that growers with advanced degrees may be able to fully understand the benefits associated with new GM papaya cultivars. Previous experience growing papaya does not impact the likelihood of adoption of new GM papaya cultivars. Farm characteristics used in the study included farm size and squared farm size. Farm size has a positive and significant effect on the likelihood of GM papaya adoption. Growers with larger farms have more resources and they are in a better position to deal with the risk associated with new technology adoption. Having the majority of income from agricultural activities was not an extremely important factor in decisions regarding the adoption of the new GM papaya cultivars despite the risk associated with growing a new GM cultivar. Increasing the knowledge about GM crops has a significant effect over the adoption of new GM papaya cultivars irrespective of educational level. While strong opposition to the adoption of new GM papaya cultivars is not anticipated, a well-targeted educational program explaining GM technology and addressing some of the misinformation is likely to further improve the rate of adoption of GM papaya cultivars.

Table 1. Results of the Probit model: Marginal Effects on the Probability of Adoption of GM Papaya

Variable	Coefficient	Standard Error	Z- statistic
Age	-0.016	0.227	-0.07
Educ	0.525***	0.153	3.42
Exp	-0.329	0.326	-1.01
Size	0.034**	0.016	2.05
Size squared	-0.0003**	0.0001	-2.45
Inc_agr	0.492*	0.297	1.66
GM_knw	0.355	0.235	1.51

\*\*\* Significant at 1% level, \*\* significant at 5% level, \* significant at 10% level

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SOCIAL SCIENCES

AGROECOLOGICAL TRANSITION AND TERRITORIAL GOVERNANCE: THE STRENGTH OF WORDS – SOME INSIGHTS FROM A GUADELOUPIAN PERSPECTIVE

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**Abstract**

Acknowledging the contribution of agriculture to global changes and its negative impacts on the environment, it is now seen as unavoidable for it to participate to the ecological transition. This research aims to understand the performativity of legal texts. This performativity does not only reveal the institutions’ approach of the model to implement. It also aims to change, in the meantime, the reality (Ambroise et al., 2015). The objective of this research is to stress the importance of concepts’ definitions in policies implementation when agricultural system reframing is at stake, and to highlight an uncertain use of words may produce. However, little attention is given to the choice of terms concerning the definition of a greener agriculture in official texts: terms are often mixed up without any clarification. Applying content analysis to official documents, we provide an analytical grid to grasp in what extent the unclear use of words and what they namely designate, lead to ambiguous policies eluding aspects of the concept of agroecology underlined by researchers or associations. We also shed light on the local appropriation process of the concept and its specification in the French Indies.

**Key words**

Agro-ecology, viability, territorial coherence, policies, governance, content analysis

**Introduction**

Given the exacerbation of global changes, the agricultural productivist system built at the end of World War II and based on the standardization of production patterns has come to an end and is now seen as obsolete (Caplat, 2014 ; Duru et al. 2014). From the 1970s, some farmers (Griffon, 2014) and then official institutions have put an emphasis on moving to a more sustainable way to grow food (Caplat, 2014). This change in the agricultural production processes is now widely called “agro-ecology”. However, this term designates either a fundamental change in the organisation of the agricultural system or only describes the steps to make the productivist system greener (M. Duru et al., 2014). We assume those confusions lead or are linked to an uncertain use of some concepts such as “viability” and that there is no consensus as to what the concept of “agro-ecology” encompasses. We postulate that confusion from the definition of this word lead to an uncertain use of this concept and some others such as “viability” or “durability”. It is now relevant to take stock of the use of words linked to ”agro-ecology” in official texts related to policies, planning policies or agricultural development. Are those terms used in a performative issue? We also specifically emphasize the use of the concept of viability in official texts concerning Guadeloupe to discover what it designates. We wonder if there is more stability concerning the use of this term. The aim of this research is to give some insights and to stress the strength of words in policies to rethink the agricultural system on a territorial scale and make it clearer to apply in terms of territorial governance.

**Method**

This research focuses on content analysis of recent official texts. Our study is based on a grounded theory approach as it is an exploratory research and follows an inductive path. From documents, we build several transitional hypotheses. We use mixed methods: mainly qualitative but also quantitative in the treatment of data. We build an analytical framework from the official texts to analyse the use of some chosen words linked to agro-ecology and agriculture in the Caribbean. The French Agricultural law of 2014 and official texts of the French Indies on different scale (national, territorial and

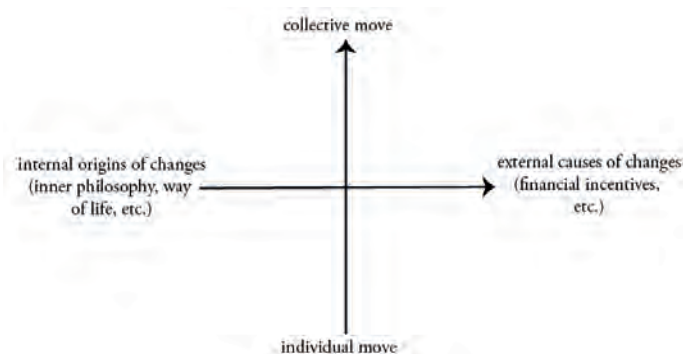


Figure 1 - Framework designed to analyse the definition of concepts. Gaïa-Trop, 2016.

local) are specifically analysed. Using the software N’vivo, we look for the occurrence of words in the texts and the nodes between those words and others. We also pay attention to the literal definition given to each concept by each text and the vocabulary used and if any specific place or example is given to illustrate the concepts. Taking account of the definition of the different forms the concept of agroecology embraces (Duru et al., 2014), we classify the definitions of agro-ecology given in the texts. We use a 2D dial to identify the meaning each text give to the words studied according to two different stresses : if the approach is either individual or global, and if changes in the agricultural system come from an external or an internal drivers (cf. figure 1).

« Strong agro-ecology » would be in the upper part of the graph whereas « weak agro-ecology » would be in the lower part. The left lower part represents the individual work of agricultures as opposed to the right upper part which represents the collective work to achieve for agroecology to become the « paradigm » off rural development.

### Results

The first results derived from basic statistics dealing with the frequency of chosen words and some of their synonyms (cf. figure 2). We identify who uses those terms and what they argue using them. We determine if those words are truly followed by means or territorial projects to be implemented or if they reveal a passing trend.

	agro-écologie	viable-viabilité	flexibilité	pérennité	vulnérabilité/vulnérable	adaptation	Résilience	durable-durabilité	territoire-territorial	gouvernance	exploitation(s) agricole(s)
Loi d'avenir pour l'agriculture, l'alimentation et la forêt (2014)	10	7	0	2	2	9	0	33	66	1	46
Vers des agricultures doublement performantes (2013)	92	6	4	0	3	36	3	57	85	8	29
Loi Grenelle II de l'environnement (2010)	0	0	0	1	7	17	1	95	125	6	2

Figure 2 - Frequency of appearance of chosen terms in three main French official texts. Gaïa-Trop, 2016.

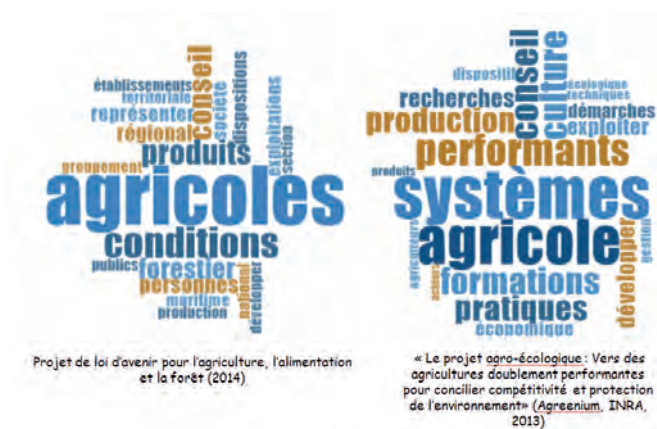


Figure 3 - The 20 most frequent words in two institutional



Figure 4 - The use of the term «viability» in two official texts (Loi d'avenir pour l'agriculture, l'alimentation et la forêt (2014) et « Le projet agro-écologique : Vers des agricultures doublement performantes pour concilier compétitivité et protection de l'environnement » (Agreenium-INRA, 2013)).

Graphically (figure 3), we can see that institutions use different concepts or terms to develop their activities or proposals. Thus, concerning development issues, the law text focuses more on production whereas the Agreenium-Inra report has a more systematic approach putting the concept of production system in the centre of the text.

Figure 4 highlights the multiple meaning of terms. In the case of “viability”, the hypothesis that this term is not part of a common paradigm is confirmed: given the increasing importance of the term, it rather emphasises the idea that we must be « politically correct ».

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## EXPLORING CONDITIONS FOR AGRICULTURAL VIABILITY IN GUADELOUPE: IDENTIFYING GATEKEEPERS. SOME INSIGHTS FROM THE FRENCH CARIBBEAN

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### Keywords

viability, gatekeepers, territorial governance, textual analysis, graph theory

### Abstract

Toward exacerbated global changes, one of the main current challenges is to implement agroecological transition. In this context, territorial scale appears as a consistent level where governance procedures are experienced. The context is the one of a multi-level and multi-actors' governance leading to change in local public policy. We questioned 21 key stakeholders from agricultural frameworks as well as actors from collective organisations. By combining textual analysis tools and graph theory, we focus on stakeholders' representations of viability as these actors produce advice regarding the settings of administrative and regulatory planning. We identify four key dimensions to viability (economical, agroecological, socio-cultural and organisational). The results show a continuum on the agroecological dimension of viability. They reveal the pivotal role of gatekeepers designed as actors able to support substantive change by transforming the agroecological dimension of viability in a 'rational myth'. By doing so, they could initiate collective actions to promote change and support agroecological transition.

### Introduction

The shift from high-yield to more viable farming systems has become one of the major issue and challenge for agriculture. The end of the productionist model is supported by the FAO that claims for 'smart agriculture' (FAO, 2010) principles which are environmentally friendly and rely on technical but also social innovations. In this context, agroecological transition may be considered as a privileged pathway. We make the hypothesis that agroecological transition comes from the ability of stakeholders to build a common paradigm on viability of farming systems and from their ability to initiate change in conceiving, managing and producing agricultural products and services. We then seek to highlight how stakeholders of the agricultural sector see viability of farming systems. Results help to set regulatory and administrative devices that could ensure viability of farming systems and more widely of agriculture in the French Caribbean. Taking the example of Guadeloupe, we more widely wonder about the adaptive capacities of small islands facing exacerbated global changes considering that a set of viable farming systems will lead to the viability of agriculture as a whole. As such agriculture will itself be a source of resilience toward global changes (Angeon, 2015).

### Method: Exploring the devices, these 'small islands of beings'

Based on a mathematical theory from the mid-seventies (Aubin & Frankowska, 1996; Aubin 2010), viability theory explores how systems that face 'viability constraints' can be regulated (Aubin 2010). Following this approach, viability of agriculture designs its potential by providing ecosystem services and by ensuring sustainable practices. It lies on the ability of farming systems to respect strong constraints mainly agronomic and ecological, economic, organisational and sociocultural. To grasp this rules, we led comprehensive interviews (Kaufman, 1996) with a sample of stakeholders selected thanks to the snow ball method (Goodman, 1961). We then got a raw material based both on discourses and formal documents mentioned by stakeholders. Using textual analysis tools, we identify the most frequent words arising from the interviews' reports and from the formal administrative and planning documents. We then used graph theory to identify gatekeepers.

### Results

Our results show that: **1/** Stakeholders do address differently the four dimensions of viability. Interviews reveal that the most common entry on viability is the economic dimension, then the agroecological one. **2/** There is a link but not a strict one between stakeholders' discourses and formal documents. 6 words mainly characterize stakeholders' representations of viability: research, territory, training, viability, property, production. From the point of view of the stakeholders and of the planning documents, Viability of agriculture on the Territory arises from Production, is constrained by Property and can be improved thanks to Research and Training. **3/** For some stakeholders, the current agricultural model framed

by dominant single crops farming systems for exportation is viable while for others the end of this era is reached. Considering that collective action ‘put together different types of force that are precisely associated because they are different’ (Latour, 2010, p107), stakeholders that wish implementation of agroecological transition will be united to work, think and propose a set of solutions and actions. Lexical analysis shows that there is a continuum of representations that describes agroecological dimension of viability. For all stakeholders, organisational dimension appears a sine qua non condition to operate actions in favour of viability. As such, it is a ‘multi-level and multi-stakeholders territorial governance process’ (Chia et al., 2010). 4/ Viability of a farming system comes from negotiations, tensions and conflicts between stakeholders on the ways and means of regional development by creating mechanisms to build new rules of actions. As such, identifying gatekeepers is needed. Graph theory allows to define clusters from a similarity matrix based on stakeholders’ representations (See Figure 1). We defined 2 groups: GROUP 1 for stakeholders who think Viability (i.e., for whom the current system is viable) and GROUP 2 for stakeholders who do not think Viability (i.e., the current system is not viable. It has to change). From our matrix, we learn that GROUP 1 considers ‘production’ as the way of action to reach viability whereas GROUP 2 rather identifies the ‘territory’ as a consistent level to implement transversal actions. Between the two groups, some stakeholders are identified as ‘gatekeepers’: actors that play a core role in linking constituted networks. In our case study, these actors are able to drive collective actions in favor of agroecological practices by supporting ecosystem services and sustainable innovations in order to promote viable farming systems. In GROUP 1, gatekeepers are number 2 and 17. In GROUP 2, the gatekeeper is number 21.

### Conclusion

A large diversity of representations explains how agriculture in Guadeloupe may be viable. In order to map this diversity, we collected and analysed stakeholders’ representations through their discourses and through institutional documents. Viability is mainly defined by economical characteristics with a major constraint expressed in terms of land property. Training and research appear to be a way of action to highlight the importance of agroecological dimension of viability. Moreover, some stakeholders are identified as gatekeepers to enable collective action as a process of territorial governance. We suggest that research has to go on with these driving actors to effectively implement devices to promote a single voice (common language and projects) for viability.

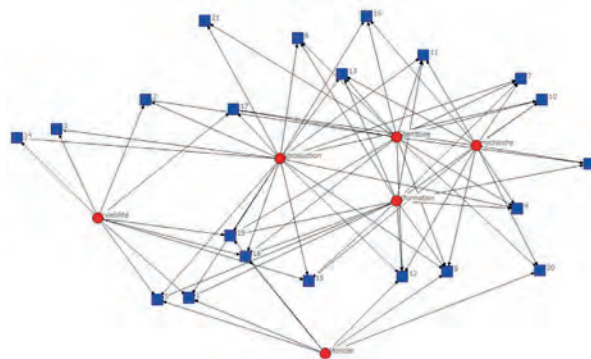


Figure 1. Matrix of viability representations. Identifying Gatekeepers

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## VOICES OF RURAL FARMERS IN SURINAME ABOUT CLIMATE CHANGE, AGRICULTURE INNOVATION AND LANDSCAPE MANAGEMENT

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**Key words:** Voices of farmers, Climate change, Innovation, landscape

### **Abstract**

Many rural areas in Suriname are lacking information on technology from extension agents from the government extension agency, and research institutes. Communication and informal voices of farmers are shared by media. As part of a baseline study conducted for the sixth operational strategic plan of the Small Grants Programme in Suriname, four communities were selected: Moengo, Pokigron, Nickerie, Sipaliwini and Para. The purpose of this study was to collect data from communities regarding problems related to climate change, agricultural innovation and landscape management. This qualitative study was done through the focus group method. Eight focus group meetings were organized and consisted of 8-15 participants each. The key questions were extracted from the SEPLS method (Socio-ecological Production Landscapes and Seascapes). The data was analyzed through the SWOT method. Based on the results, the communities have a good level of awareness about management of their landscapes. Improvement of agriculture management will be possible by access to innovative and new knowledge developed in and outside the community. Climate change is an important issue that the community already is aware of, they developed their own local strategy in resilience to this issue.

### **Introduction**

Many rural areas in Suriname are lacking information on technology from extension agents from the government extension agency, and research institutes. Before making use of new technology, farmers should acquire a broad knowledge ranging from climate conditions, cultivation techniques, pest management and price. This knowledge can be gathered through their social networks, information sharing and their own experience. The purpose of this study was to collect data from communities regarding problems related to climate change, agricultural innovation and landscape management.

### **Materials and methods**

In this research investigation, a qualitative study was conducted using the focus group method. Eight focus group meetings were organized and consisted of 8-15 participants each. The key questions were extracted from the SEPLS method (Socio-ecological Production Landscapes and Seascapes). This toolkit has provided practical guidance for making use of the “Indicators of Resilience in Socio-ecological Production Landscapes and Seascapes (SEPLS)” in the field. The respondents who participated in these workshops are members of the local community and stakeholders in the selected areas. Four communities were selected: Moengo, Pokigron, Nickerie, Sipaliwini and Para. A set of questions were designed to capture communities’ perceptions of factors affecting the resilience of their landscapes and seascape. Their participation allowed them to evaluate current conditions across the landscape and identify and reach agreement on priority actions, contributing to enhanced communication among stakeholders and empowered local communities. Data was collected and qualitative analyzed with SEPLS and SWOT indicators.

### **Results**

The results show that in the forest landscape, in contrast to the coastal zone where rice is cultivated as a monoculture, the practice ‘slash and burn’ is mainly used. Farmers reserve their lands for vegetable production. Local knowledge about ‘slash and burn’ systems is present in the focus groups. The target group is aware of new technologies and innovation. Traditional and non-traditional technology and knowledge is used by the local communities to implement in the landscapes. Women play an important role in agriculture knowledge and dissemination in their community. In the community there is a lack of experience and knowledge in climate smart agriculture practices, and in the development of improved rice varieties. Water management is a main problem for the agriculture systems in both landscapes. Seasonal changes, including rising temperature causes a lot of harm to the ‘slash and burn’ systems which are disturbed by it, and causes low production outcomes.



## **Conclusions**

From the results it can be concluded that:

- Communities have a good level of awareness about landscape management
- Access to innovative and new knowledge developed in and outside the community can improve agriculture development
- The community is aware of climate change
- Communities have developed their own local strategy in resilience to climate change

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## MATHEMATICAL PERSPECTIVES

### SIMULATION SOFTWARE FOR THE VIABILITY ANALYSIS OF AGROECOLOGICAL TRANSITION TO SOIL PRESERVATION IN THE FRENCH WEST INDIES

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**Keywords** : viability theory, optimal control, numerical simulations, agro-economic models of small farms

#### **Abstract**

The purpose of this communication is to present the simulation software for long term viability study of small farms. This software was developed within the framework of ANR TOO GAIA project. The main problem that is studied is formulated in terms of the mathematical theory of viability. The goal is to determine the ability of a farm to restore soil quality to a target level, while respecting a number of economic constraints. The software is designed to enable a comprehensive global analysis of the possibilities of soil restoration as function of the current state of the soil and of the available wealth of the farm. It allows also determining the farm management strategies that the soil restoration and the viability with respect to the economic constraints. These strategies can be found for each possible initial conditions of a parcel for a given choice of time horizon to study.

#### **Main results**

The research previously conducted by the multidisciplinary team of the project led to the development of a dynamic model describing the evolution of the quality of the soil of a parcel as function of the choices of the crop or livestock raised on the parcel and of the agricultural practices. An economic dimension has been associated with this model. The presented software is composed of a main calculation kernel and a graphical interface to set up calculations and display the results. To provide the global evaluation of the economical and agro-ecological viability of a given parcel, the main computation kernel of the software uses some numerical set-valued algorithms based on the viability theory to compute capture basins and viability kernels. In addition, the software can determine for each initial state of a parcel the optimal global economic performance by solving an optimal control problem associated with the dynamic model. One of the essential components of this simulation software is the computation of the feedback lows (viable or optimal) together with capture basins or viability kernels. The computed feedbacks determine the control strategies guaranteeing the restoration of the soil to a given target quality. When the best economic performance is computed, the corresponding feedback low gives the optimal farm management strategies.

To produce relevant results, the model implemented in software should be based on a large amount of data describing the agro-technical and economic characteristics of the different crops. In addition, it is necessary to provide for each crop the parameters of crops-soil interaction model. These parameters are crucial to define the soil quality evolution during each culture cycle. So, the data modeling for these simulations is a complex task. To facilitate the work of experts the software has a graphical user interface that allows to maintain a database of known crops and livestock. Different graphical visualization tools was designed to facilitate the calibration process of the crops parameters. The Figure 1 shows an example of the screen for editing the parameters of a crop in the database. Using this database of known crops and livestock, the user can easily create a model to evaluate the viability of a parcel and choose the computation parameters. The figure 2 shows the example of the visualization of computed optimal and viable farm conducting strategies obtained for a given parcel.

#### **Conclusion**

The simulation software developed as part of the ANR project is the first example of a complete simulation tool based on the mathematical theory of viability and dedicated to the study of agro ecological transitions for small farms. The main contribution of this tool is the possibility of global viability and capturability analysis, with respect to the starting conditions, both for soil quality for the financial health of the farm. It can be used, In particular, to the starting conditions, both for soil quality for the financial health of the farm. It can be used, In particular, to analyze the impact of financial incentives to change of the agricultural practices and transition assistance.

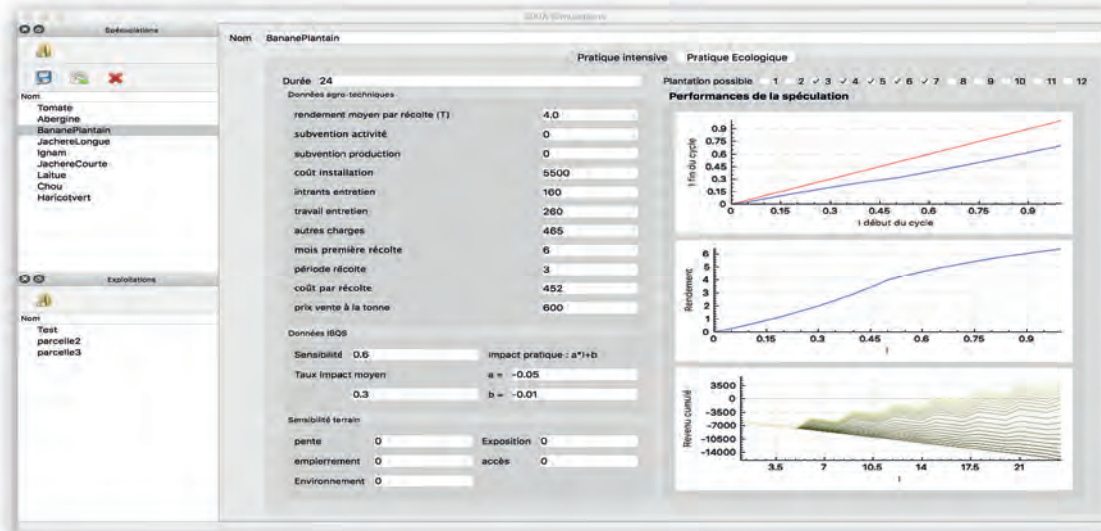


Figure 1. Crops modeling tool

Once the main computations of viability kernels finished and saved, it is possible de work with these data to compute and analyze viable and optimal farm management strategies.

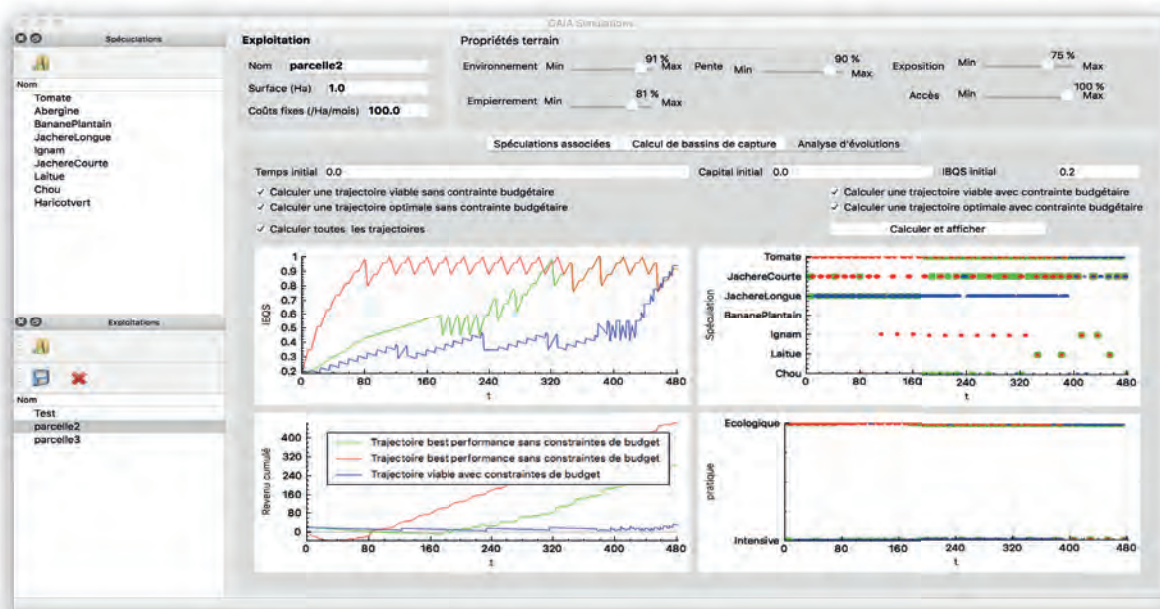


Figure 2. Visualization of optimal and viable strategies

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## HOW VIABILITY TECHNIQS ALLOW TO TACKLE EXISTING COMPLEX PROBLEMS IMPERFECTLY DESCRIBED

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**Keywords:** viability theory, numerical approximation of viability kernels, tyochastic uncertainty.

### Introduction

Applying what is so called “viability technics” to real problems arising in agronomic, economical or environmental sciences is a true challenge. The high number of variables, the lack of precised data, the necessarily stylized dynamical models mostly experimentally known, the approximate knowledge of uncertainty particularly for extreme climate disaster pose challenges to its ability to give trustful answers to live problems that concern ecology at the boundary of human activities. In the context of small islands agro-systems, studying mainly the capability of small agricultural exploitation to restore the soil quality of parcels whenever managing cropping or animal farming in a sustainable economic way leads to explore and tackle these questions in the framework of applied viability theory.

### The question of building large scale systems

We will first focus our attention on the problematic born with a previous experience dealing with the Forest Conservation and CO<sub>2</sub> emissions. For the first time, “viability technics” were applied for analyzing problems arising from reality crossing economics and sustainability. Even if this experience revealed the large field of potential applications, it was constrained by the “dimensionality curse”. The necessity to handle a large number of variable is not problematic when building large scale systems for simulation purpose designed for generating various and numerous trajectories.

### What Viability Technics bring

However a large number of variable creates difficulties when aiming at finding sustainable or viable, optimal, or that achieves specific objective in finite or prescribed time, and more particularly when searching initial conditions from which this is realizable and revealing decision strategies ensuring viability ou optimality. That is to say when one wants to answer optimal or sustainable questions. For solving such “inverse” problem one need to explore the full space using the viability algorithm principle. Since, from a numerical point of view, exploring the full space requires discretization, the computers memory limitations impose that more variables are, more rough approximations would be.

### The GAIA Model

In the framework of the GAIA project, one of the objective was to find how viability tools can be customized to solve complex “inverse” problems arising in environmental questioning and more specifically in agro-econo-ecological context. Mathematicians are keen of superb and innovative ideas or concepts like “Viability Kernels”, “Capture Basins”, “Optimal or Robust” Controllability, “Tyochastic or Stochastic” treatment of uncertainty, Resiliency or Vulnerability, just to name a few examples concerning the GAIA project and for which Jean-Pierre Aubin has made a crucial contribution. All of them are well defined in an ideal world. By facing to the reality of the field, mainly discussing with agronomists, economists and farmers, a significant amount of adjustments must be justified and implemented. Recalling the main features of the GAIA-TROP model : The viability of small islands agro-systems: the case of the French West Indies, we justify why considering a discrete model is essential.

### How this approach answers real life questions?

We will discuss about the introduction of mathematical concepts of viability, capturability and optimality, what problems one can solve et for that purpose, what new mathematical and algorithmic developments are required.

### How to handle uncertainty?

Lastly we introduce several typology of uncertainty that can perturb the management of agricultural exploitations keeping in mind the quality of soil restoration objective. We show how viability can be preserved despite uncertainty and, if not, we introduce a concept of vulnerability level regarding the aforementioned uncertainty.

### Conclusions

Even if answers must be correlated with the coarseness of the model and approximatively determined of data, the pertinence of results is surprisingly in line with what coherent guessing could be. This question should be investigated more deeply, using for instance higher computing power.

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## A VIABILITY MODEL OF FARMING SYSTEMS, THE CASE OF FRENCH WEST INDIES

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**Keywords:** viability theory, farming systems design, soil preservation, French West Indies

### Abstract

One the aims of the multidisciplinary research project Gaia-Trop on viability and adaptive management of small tropical islands agro-systems, was to devise a new model of farm system using tools of the mathematical viability theory. It has been constructed in close cooperation with French West Indies farmers to take into account their needs and expectations. The main emerging points focused on soil degradation, pest disease and climatic risks and economic constraints. A specific software is being developed for the viability calculus that will be made available for this community. We present first insights of this model and results obtained for only one parcel and without taking uncertainties at this stage. It highlights that the objective of restoring the soil quality in the long term can be unsustainable for farmers facing with financial constraints. The issue of sharing the costs of the agro-ecological transition must be asked.

### Introduction

Farm modeling has a long history from a mainly microeconomic approaches to maximize an agricultural income to bio-economic models that take into account the functioning of various biological processes or probabilistic models and simulation-based approaches to get a grasp of the market or production uncertainties. Nowadays agriculture is required to provide income and food security, to preserve environmental resources and cultural identities while being able to adapt to climatic change or to abet its mitigation. The aim of the Gaia-Trop project was to propose a new modeling approach relying on viability theory. It focused on soil preservation, a main problem in French West Indies confronted with a limited space for agricultural lands along with a growing population and soil degradation due to past practices of banana export sector. Other concerns was to take into account the agronomic constraints and traditional habits as well as economic profitability in order for the results to be appropriated by the farmers.

### Materials and methods

Viability theory is a set valued mathematical analysis designed for the control of dynamical systems with constraints and submitted to uncertainties (Aubin et al., 2011). Unlike the usual approaches based on simulations techniques, viability theory relies on an inverse approach allowing to know the set of all the current states variables for which there exist controls such that the evolution of the state variables governed by these controls always comply with a set of constraints. The main mathematical and computational challenge has been to handle the various agro-ecological, economic and cultural dimensions of farming systems with a limited number of state variables. Soil functioning and its interactions with agricultural practices are highly complex. We then used a synthetic global indicator of soil quality (GISQ, Velasquez et al., 2007) which is modified by each agricultural cycle. Impacts of various crops or cattle and agricultural practices on the value of the GISQ indicator are data provided upstream by expert knowledge. The model allows to say if it exists, or not, some sequences of crops or livestock and agricultural practices such that a low soil quality parcel can be brought to a higher wished quality in a given period of time while complying agronomic and economic constraints. Calculus have been done with a set of crops, livestock and agricultural practices: intensive agriculture with high level of inputs (fertilizers, pesticides, enclosed breeding ...) or reasoned agriculture with limited plant treatments. They are representative of main French West Indies agricultural productions, have different sowing seasons and cycle durations that span over months or years. The number of agricultural productions and practices is not limited except by the high amount of agronomic and economic data to document and a higher time of computation. The yields and therefore the economic returns, depend on soil quality while the evolution of soil quality depends in turn on crops and practices successively implemented. The farm strategies and the various decisions made successively at different times on a parcel determine the evolution of the farmer's global income and the evolution of the soil quality of the parcel. Farmers are not equal and have not the same freedom to choose their activity. Some of them rely on unpaid family workforce while other resort to salaried workers, some of them are limited by loans to repay while other, less financially restricted, can invest in more profitable productions. To take account these different situations, we introduced in the model a monthly economic constraint that can be adjusted to represent various configurations. When "viable strategies" exist, we computed the best economic performance that can be obtained on the whole period and provided the associated optimal farm management that must be followed.

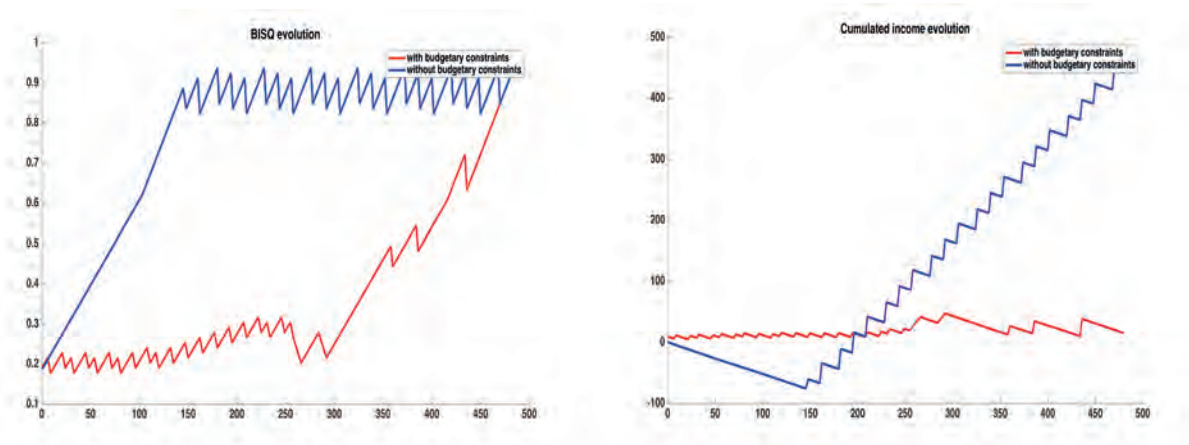
## Main results

Computations have been realized with test data obtained from surveys of farmers and expert knowledge. Due to the huge number of data to collect, only eight crops have been documented so far: plantain banana, tomato, eggplant, lettuce, cabbage, bean, capsicum, yam along with conventional and reasoned practice, as well as cow and goat breeding, long fallow for land resting and short fallow for the matching between two agricultural seasons. The spanning exercise has been set to forty years, roughly a farmer's active life, with the objective to assess the possibilities to transmit the next generation a soil with GISQ value fixed to 0.9 whatever is the initial soil quality. Computations have been made for the case of salaried workforce only and for two situations of financial capacity: with an economic constraint impeding any monthly deficit on all the period and without any economic constraint. Starting from a parcel with a low GISQ value fixed to 0.2, a comparison of the optimal farm management for these two cases shows striking differences. Without economic constraints, the optimal strategy providing the best economic performance is to restore the soil quality as quickly as possible right from the beginning of the exploitation by a 12 years period of fallow and then by a rotation of the more profitable production with short fallow. The optimal strategy of a farmer unable to sustain such preliminary investment, will be to improve the soil quality to the target level in the last few years after having cumulated some earnings through a sequence of productions and practices not degrading the soil but with a low return. The gap between the expected best economic performances is huge. The cumulated income on 40 years of a farmer willing to restore the soil quality but confronted with financial constraints, is extremely low. Sharing the cost of agro-ecological transition is then a question that must be raised.

## Conclusions

These first results, obtained with a limited set of test data, show the main principles and interest of this viability model. Ongoing development focuses on the collection of additional agricultural productions and practices with accurate economic and agronomic data, to represent the high diversity of agricultural products and practices in French West Indies, including agro-ecological practices, various forms of labor compensation, level of economic constraint and of subsidies. Multi-parcel farm management, price and yields uncertainties will be handled in a second step.

## Figures



**Figure 1.** GISQ evolution (left) and cumulated net income evolution (right) for the optimal strategy, with (red) and without (blue) economic constraints ( $I_0=0,2$ ;  $I^*=0,9$ ; calculus made for a 40 years period)

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## A SURVEY ON APPLICATIONS OF VIABILITY THEORY TO SUSTAINABLE EXPLOITATION OF RESOURCES

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**Keywords:** Viability theory, Sustainable development, renewable resources.

### Abstract

The viability theory has already started, during many years, to prove its efficiency for treating sustainable development and renewable resources problems. Given its relevance to this domain, and noticing the important and growing number of academic works applying it in this area, we took the initiative to carry out a comprehensive literature review of this field to synthesize what has already been done and have an idea about what remains or need to be done in the future. To do so, we tried to gather all papers applying viability theory to the management of any renewable resource (Fisheries, climate, forests, soil, species populations, etc). A total of 71 application papers published between 1991 and 2015 in different journals were used in this research.

### Introduction

The importance of a good and sustainable management of renewable resources is no longer in doubt. Everybody knows the dramatic consequences of over exploitation of resources (climate changes, deterioration of environment quality, diseases, famine, lose of biodiversity, etc.) and everybody agrees on the importance of having more responsible management strategies of these resources. Besides, scientists of many domains are interested in this questions and studied these problems using different methodologies. In the decision science domain, renewable resources management problems were usually studied within two frameworks: the “policy optimization approach” (based on cost analysis) and the “policy evaluation approach” (based on simulation and scenario analysis). A more recent approach, the “policy guidance approach”, is somehow intermediate between the two. The viability theory is a relatively recent area of mathematics that joins the principle of this latter approach. It was first applied in biology and economics but gradually started to be applied and proof its efficiency in managing renewable resources. Indeed, in contrast with the two first approaches, the policy guidance approach and more specifically the viability theory is not interested in finding one single optimal path. It is instead based on an inverse method starting from a set of constraints restraining the problem’s state space into a subset of states that are considered to be acceptable on the economic, environmental and social planes, and then looking backward for the conditions allowing to maintain the state of the system within this defined domain. This way of doing allows the viability theory to simultaneously deal with the dynamic, multi-criteria and generational aspects of the sustainable development and renewable resources management problems and makes it very suitable to deal with such problems.

### Materials and methods

In this work we tried to review all published papers applying the mathematical viability theory to sustainable development and renewable resources management problems. Any paper using viability theory or any of its tools to model, solve or even just discusses its applicability to sustainably manage any renewable resource was considered. Papers addressing the same problems with the same approach (Policy guidance approach) but does not explicitly use viability theory tools are excluded from this study (For example papers using tolerable window approach, population viability analysis or safe minimum standard approaches without using viability theory tools).

We were able to gather 71 application papers meeting these specifications and we read them in such a way to classify them according to the topic that they address and derive their main elements of modelling (objectives, constraints, time, uncertainty, etc.) in order to derive the main characteristics of each topic and have a global idea of what was done and what remains to be done in this domain and finally derive some future research questions and propositions.

### Main results

This review showed that the viability theory was successfully applied to different types of sustainable development and renewable resources management problems. It appears that it is very adapted to this type of problems since we found several papers addressing various topics (fisheries, climate changes, forests management, soil preservation, populations and ecosystems protection), in discrete and continuous time, in presence or not of uncertainty, etc.

The first applications of viability theory in sustainable development problems were in population biology and fisheries, they are also the most addressed topics (almost three quarters of the total number of publications with a clear dominance of publications addressing fisheries management). The next topic in the ranking of the most tackled subjects in this

literature is the climate changes. Other topics started to be addressed using this theory during the few past years like forest protection, soil preservation as well as the management of some other renewable resources, but the publications are still few in those topics.

Regarding the modelling side, we observed a good balance between the use of discrete time and continuous time models. However, even if we found some papers handling many sources of uncertainty in their models using either the stochastic or robust approach, these works are still few in number compared to the total number of publications and are mostly done in the fisheries management topic.

### **Conclusions**

The viability theory is starting to be involved at each level of the sustainable development and renewable resources management domain, however many researches could still be done to improve and complete this literature. Here are some of the most important conclusions of our work:

- Some research axes (like soil management or forest preservation) are much less addressed than the others. It will be then very interesting to focus a little bit more on these directions in future researches.
- Almost all studies are focused on one single facet of sustainable development whereas a big interaction is observed between them (we cite for example the big interaction between forest management and climate changes or between soil management and protection of some animal species). It will be then very interesting to develop this side in future researches.
- The strategic interaction between the involved agents is one of the most important characteristics of environmental problems that viability theory does not handle. So, one interesting resolution for future research could be to think about a way of integrating it to this framework. One could for example try to add some game theory flavour to the problem.
- Giving more attention to the uncertainty and risk issues in some axes of this literature could also be a good way for developing it.
- An other very interesting side of this kind of problems is their sizes and the numerical challenges that they imply. It is then very important to look further to the computing and curse of dimensionality issues.

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## LOCAL EXPERIENCES, NETWORK AND RESISTANCE OF SMALL FARMING SYSTEMS

### **Keynote: VIA LA PETITE AGRICULTURE DIVERSIFIÉE, ACCOMPAGNER L'AGRICULTURE MARTINICAISE SUR LE CHEMIN DE L'AGRO-ÉCOLOGIE**

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**Mots-clés :** viabilité, petites exploitations agricoles, diversification, gouvernance, agroécologie

#### **Résumé**

Face à la problématique des changements à l'échelle mondiale, la question de la viabilité des exploitations agricoles prend une dimension toute particulière pour les économies insulaires de la Caraïbe. Dans ce contexte, il apparaît que la capacité de résistance dont ont fait preuve jusqu'ici les petites exploitations diversifiées, ne suffira pas à assurer leur viabilité, alors qu'elles jouent un rôle central dans la dynamique économique, sociale et environnementale de ces territoires.

Notre communication relate l'expérience de la Chambre d'agriculture de la Martinique qui, s'appuyant sur un contexte social et politique opportun, a impulsé une réflexion sur la petite agriculture en cherchant avant tout à (i) à faire reconnaître et valoriser les potentialités des exploitations agricoles qui relèvent de la diversification et (ii) à proposer des dispositifs et outils économiques et non économiques permettant de les soutenir.

Nous exposons, dans une perspective critique, les retombées de ces démarches sur la période 2010 - 2015. Nous montrons que les actions mises en œuvre se sont soldées par des résultats moins probants sur la stabilisation du nombre de petites exploitations et sur les leviers financiers en leur faveur, que sur les leviers sociaux activés qui aboutissent au renforcement d'actions collectives autour des savoirs, des pratiques et des innovations agro-écologiques et créent de nouvelles solidarités territoriales.

#### **Introduction**

Au regard des événements qui l'ont impactée ces cinquante dernières années, l'agriculture martiniquaise illustre combien les changements globaux peuvent générer des situations de crise qui touchent indissociablement aux aspects sociaux, économiques et/ou environnementaux d'un territoire et sont sources de changements continus et de mutations profondes. Interrogés dès 2009 lors des Etats Généraux de l'Outre-Mer pour leur avis sur des outils de sortie de crise et dans l'objectif de définir leurs orientations actuelles et à venir, les acteurs de la Chambre d'Agriculture de la Martinique n'ont pas échappé à leur responsabilité d'intervention, pour anticiper ou réagir face à des bouleversements majeurs qui donnent au final leur cap à ceux qui s'engagent pour une agriculture durable. Sur cette base, financés par les fonds du CIOM<sup>1</sup>, trois études ont été pilotées par la Chambre d'Agriculture dans l'objectif (i) d'identifier les capacités réelles de progression des exploitations en systèmes de production diversifiés, (ii) de mieux connaître les pratiques et les productions agricoles faites selon les modes traditionnels et enfin (iii) d'appréhender la réalité des circuits courts et de proximité utilisés par les producteurs pour l'écoulement des produits locaux. La finalité de ces études était d'identifier des leviers financiers spécifiques à ces agricultures, qui ne répondent pas aux normes du modèle productiviste jusque là soutenu par les politiques publiques nationales et européennes.

#### **Méthode : une caractérisation de la petite agriculture de diversification**

Les exploitations dites de diversification<sup>2</sup> représentent environ 70 % des exploitations agricoles (Agreste 2010) et ont en moyenne une superficie de l'ordre de 5 ha. Ces exploitations de petite dimension ont aujourd'hui tendance à disparaître et sont en majeure partie écartées des dispositifs d'aides publiques (DAAF, 2014).

Notre démarche d'accompagnement de l'agriculture martiniquaise a consisté en deux temps forts. Elle s'est premièrement appuyée sur un bilan de l'existant à partir d'une enquête concernant 624 agriculteurs, ce qui représente 20% de la population d'agriculteurs et couvre entre 20 et 30 % de la production agricole martiniquaise (hors exportations) et entre 20 et 30 % de la SAU (hors grandes exploitations de banane et de canne à sucre et prairies permanentes). Ce diagnostic a été complété par une seconde étude sur les pratiques et les productions traditionnelles. Deuxièmement, une analyse critique des leviers économiques et financiers classiques (POSEI, PDRM-FEADER) a été opérée.

<sup>1</sup> Conseil Interministériel de l'Outre-Mer

<sup>2</sup> Les productions dites de « diversification » regroupent en Martinique, les spéculations hors canne ou banane d'exportation, dans des systèmes le plus souvent de polyculture élevage.



## Résultats

Quatre types de résultats sont obtenus :

(i) Mise en évidence des forces et faiblesses des exploitations selon les agriculteurs

Sont discriminés en priorité les freins tels l'accès à de la main d'œuvre, à de la trésorerie, aux crédits et aux aides publiques. Si les agriculteurs semblent sensibilisés aux problématiques liées à l'érosion de leur sol et aux risques de catastrophes naturelles, les questions relevant de la qualité de leurs sols leur apparaissent comme étant de moindre impact sur leurs potentialités. Ces appréciations nous alertent sur leur niveau d'intégration des risques environnementaux et de connaissance de leur milieu. Elles apportent des éclairages sur des axes de conseil à privilégier.

(ii) Détermination d'axes stratégiques pour l'agriculture de diversification et d'un plan d'action individualisé

Trois axes stratégiques de développement de l'agriculture de diversification ont été identifiés. Il s'agit de l'accompagnement des agriculteurs vers la professionnalisation de leurs activités, du renforcement de l'appui aux filières de diversification et de l'élaboration concertée d'un cadre territorial mieux adapté au développement des cultures de diversification.

(iii) Les petites exploitations agricoles diversifiées, socles d'innovations agroécologiques

Ces petites exploitations sont très peu spécialisées, développent plusieurs cultures de diversification en même temps et des combinaisons d'associations culturales.

(iv) Un mode de commercialisation relevant essentiellement des circuits courts

Les petites exploitations pratiquent majoritairement les circuits courts (CC) (82%). Les CC représentent une large partie de leur chiffre d'affaires : 70% des exploitations en CC faisant plus de 75% de leur CA sont des petites exploitations. Mais ce mode de vente présente des limites : une charge de travail supplémentaire (gestion des ventes et diversification), un manque de visibilité, notamment pour les marchés associatifs, un isolement relatif : non adhérentes aux OP.

Ces observations ont conduit la Chambre d'Agriculture de Martinique à faire des propositions nouvelles aussi bien dans le cadre des travaux de révision intermédiaires du POSEI que pour la définition du nouveau programme PDRM FEADER 2014 – 2020. Pour la nouvelle Collectivité Territoriale de Martinique, mise en place en novembre 2015, la Chambre propose un projet qui va au-delà d'aménagements économiques et financiers. Il s'agit, « Pour redynamiser l'agriculture vers un nouveau paradigme », de pistes d'innovations organisationnelles et institutionnelles pour soutenir l'agriculture en général et la petite agriculture diversifiée en particulier.

## Conclusion

L'expérience menée au niveau de la Chambre d'Agriculture de la Martinique ne pouvait être isolée des démarches visant la reconnaissance et la recherche de nouveaux modèles d'agriculture qui répondent, sur le plan mondial, aux enjeux connexes d'alimentation, de santé, de protection de l'environnement et de qualité de vie.

Aussi, l'intérêt manifesté au plan mondial pour la petite agriculture familiale (2014), l'élan national donné à l'agro-écologie par la Loi d'Avenir (2014), le verdissement de la PAC, apportent à ces agricultures-là, une plus grande reconnaissance et leur offrent des perspectives d'évolutions à travers des soutiens dédiés. L'ouverture de la discussion sur ce sujet avec nos homologues et partenaires de la Guadeloupe et du territoire national, ainsi qu'avec l'ensemble des DOM, constitue le prolongement d'une action qui pourra encore s'étendre.

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## STOCKTAKING OF FARMER FIELD SCHOOLS IN THE CARIBBEAN

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**Keywords:** Farmer Field School, Caribbean, Stocktaking.

### Abstract

Globally, Farmer Field Schools (FFSs) use participatory and ecological approaches for field testing and local adaptation of innovative practices and knowledge in different technical areas. FFSs were introduced in the Caribbean during 2002-2003 to address the indiscriminate use of toxic pesticides and the consequent negative impact on the environment and human health. From February to May 2016, a stocktaking of FFSs in the Caribbean was undertaken to review progress as well as to determine their impact at the national and regional levels. Towards this end, a desk research was conducted to secure the required information from the countries and collaborating regional institutions. Results indicate that the FFS approach has varied from country to country and the reach of the FFS experience was conditioned by inter alia the institutional capacity of the implementing entity, the commodity being researched, funding and the eco-region. The Paper presents the final results of the stocktaking and shares the outcomes which are anticipated to be (i) A virtual library of FFS experiences in the Caribbean as well as documents generated and related to the experiences of FFS (ii) an interactive database of related projects, organizations and institutions that focus on FFS in the Caribbean countries and (iii) systematization of relevant experiences, including list of actors, location and available thematic bibliography, and initial ideas on FFS quality.

### Introduction

Farmer Field Schools (FFSs) use participatory and ecological approaches for field testing and local adaptation of innovative practices and knowledge in various technical areas. FFSs originated in Asia during the mid- to late-1980s and subsequently spread to Africa as well as Latin America and the Caribbean. The indiscriminate use of toxic pesticides and the consequent negative impact on the environment and human health were the main triggers that led to the introduction of FFSs in the Caribbean during 2002-2003. Since then, field schools have spread within the Caribbean with varying results. In order to review progress and determine the impact of FFSs at the national and regional levels, a stocktaking exercise was undertaken by FAO via a desk study.

### Materials and methods

The FAO Sub-regional Office for the Caribbean (Barbados) sent correspondence to 14 countries and 4 regional agencies in order to obtain relevant information for the stocktaking. Responses from 11 of 14 countries and two regional agencies that have been engaged in FFS have facilitated the development of a database of FFSs in the Caribbean. Where provided, the country-specific information was used to populate the database with details on linkages to FAO programs as well as projects and institution contacts. In analyzing the information provided by the countries, due consideration was given to the issue of FFS quality and the verification of areas of strengths and weaknesses.

### Main results

In 2002, Trinidad and Tobago was the first country to be introduced to the FFS methodology, with the implementation of a Training of Master Trainers for participants from six countries (Dominica, Dominican Republic, Haiti, Jamaica, Suriname and Trinidad and Tobago) under an EU-funded Regional Pilot Project. In 2003, the six countries embarked on a Training of Trainers (ToT) under the same project. Over the next 3-4 years, field schools were organized in some of the project countries (e.g. Dominica, Suriname and Trinidad and Tobago). Guyana successfully mobilized funding from the Guyana Rice Development Board (GRDB) to launch a commodity (rice) FFS in June 2003. St. Lucia launched a FFS-TOT as part of an EU-funded project implemented by FAO. Antigua did likewise in 2013 with the launch of the Zero Hunger Challenge Initiative and St. Kitts and Nevis became engaged in May 2015, through the FAO project TCP/STK/3501. Table 1 summarizes the history of FFS implementation in the region, including the number of farmers trained in each country and by the Caribbean Agricultural Research and Development Institute (CARDI). Guyana and Haiti are the only countries with thousands of farmers trained. In all of the other countries <1000 farmers are reported to have been trained. Notably, the number of farmers trained is not reflective of the quality of the FFS experience and the degree of diffusion. FFS implementation generally targeted farmers with shared interest and willingness to take risks. The sustainability of the FFS approach is dependent on the establishment of institutional support for the efficient and effective functioning of a cadre of FFS trainers/facilitators. The TOTs undertaken have graduated a significant number of FFS trainers throughout the region.

Table 1. A summary of FFSs in the Caribbean

COUNTRY / AGENCY	Start of FFS Experience	End of most recent FFS	No. of farmers trained
Trinidad & Tobago	2002	2008	Not reported
Guyana	2003	Ongoing	> 30,000 <sup>1</sup> (attendances)
Dominica		2014	178
Haiti <sup>2</sup>		Ongoing	2,126
Jamaica <sup>3</sup>		2014	415
CARDI	2008	2016	124
Grenada	2009	2011	94
Saint Lucia	2009	2015	296
Belize	2011	ongoing	754
Antigua and Barbuda	2013	Ongoing	906
St. Vincent & the Grenadines	2013	2014	84
St. Kitts & Nevis	2015	Ongoing	22

1. Guyana reported over 30,000 attendances, some individual farmers attended more than one session

2. The report from Haiti speaks to FFS activity which commenced in November 2012 – nine (9) years after the completion of the TOT

3. The report from Jamaica speaks to FFS activity which commenced in March 2009 – approximately six (6) years after the completion of the TOT

In the Caribbean, the term ‘Farmer Field School’ has also been used for practical, hands-on farmer training conducted in the field using participatory methods. While they do not fully fit in the traditional ‘FFS mould’ these activities have been given due consideration and included in the FFS database as they contribute significantly to the overall development of small/ family farmers, backyard gardeners and rural farming communities. Furthermore, FFS curricula have covered not only crop and pest management but a myriad of other topics/thematic areas (livestock nutrition/housing, land management, backyard gardening, business skills, enterprise development) and subjects such as HIV/AIDS (Guyana). These interventions paid little attention to the women’s informal systems and survival strategies that can significantly impact FFS processes and outcomes. Participation-wise both women and men are involved, as farmer trainees and as FFS trainers/facilitators. The ratio of female to male trainers is varied: St. Vincent and the Grenadines is the only country with higher female to male (12:9) trainers. Antigua and Barbuda has the second highest ratio (0.98), followed by Haiti (0.86). All the other countries have more male FFS trainers, with Guyana having the least number of female to male FFS trainers (0.07).

### Conclusions

While the FFS methodology has been embraced by Caribbean countries, its application seems to differ widely. In some instances the duration of the interventions were insufficient to allow for experiential learning and a clear understanding of the dynamics of key agro-ecological, socio-ecological and socio-economic relationships. Some interventions bore the features of other participatory approaches that are learner-centred, field-based and designed to catalyse the transfer of technology; and many of these seemed vulnerable to loss of quality due to the short length of the interventions. In the countries reviewed, most documented evidence of the FFS approach relates to impacts at the farm(er) level. However FFS impacts transcend to the individual level. Collaboration among farmers, facilitators and experts serves to build social capital which is a prerequisite for collective action.

In most instances the FFSs included an exit strategy, but this was not sufficiently robust to facilitate next step actions among farmers, in relation to networking and knowledge management designed to reduce transaction cost along the value chain. The majority of FFS programmes did not have sustainable funding and thus suffered post-project collapse, in particular where national institutional support was limited due to fiscal challenges and deficient public-private partnerships.

In moving the process forward, in respect of FFS programming in Caribbean Agriculture, due attention must be paid to the collective level and the establishment of mechanisms that can foster equity of gender relations through genuine participation.

FAO has recently developed a Guidance Document for FFS good quality programs, which will be an essential tool to support improvement of the quality of FFS at country and field level. This Guidance Document <http://www.fao.org/3/a-i5296e.pdf> is hereby launched in the Caribbean at the 52nd Meeting of the Caribbean Food Crops Society.

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## STUDENT EVALUATIONS AS A MEASUREMENT TOOL FOR TEACHING EFFECTIVENESS & STUDENT SATISFACTION WITHIN THE FOOD SCIENCE & TECHNOLOGY UNIT AT THE UNIVERSITY OF TRINIDAD AND TOBAGO

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### **Abstract:**

Student evaluations are a useful means for gathering feedback about the overall delivery of courses and services and are used to inform staff and decision-makers about relevant issues that can impact the program and student learning. The success of the evaluations include: the validity of the evaluation instrument in capturing data on key indicators of effective teaching and service, the ability of the evaluation to be free from potential biases and to serve as a function of the instructor and unit to achieve usable data on the course delivery, unit administrative services and laboratory services to ensure the maintenance of quality standards. The ongoing and cumulative evaluations over the course of one academic year (2014-2015) provided a body of evidence to determine whether or not intended outcomes are being achieved and how the programs and services can be improved at the FS&T unit of the University of Trinidad and Tobago. Analysis of data showed that the instructors and laboratory services exceeded student expectations and that age, gender, personality/teaching style had no major effect on students' ratings. Students were satisfied with the level of knowledge and expertise shown by their instructors. However analysis of data identified courses that could be improved if some instructors changed their teaching style, incorporated more technology in teaching, added more practical and interactive sessions and improved on effectiveness in sharing information and responding to questions. In some cases, the best way for improvement would be to change the instructor or work with instructors to develop new teaching styles and methods of delivery. The average rating received by the administrative services in the unit could be improved by dissemination of information and procedures, better coordination for student IDs, improving time to release student grades and having a unit representative available for part-time students. Effectiveness of the decisions and changes made in unit improvement can be measured by analyzing results of student evaluations for 2015-2016.

### **Introduction**

The Food Science and Technology (FS&T) unit of The University of Trinidad and Tobago (UTT) developed their Course Evaluation Form to gather feedback from students each term based on their academic experiences as well as to assess the quality of the services provided by the department. The form was categorized into four main areas to capture data based on evaluation of each individual course, its respective lecturer, the delivery of labs as applicable and lastly an evaluation of the department overall, particularly with respect to the administration and the students' general perspective on the quality of the service they received.

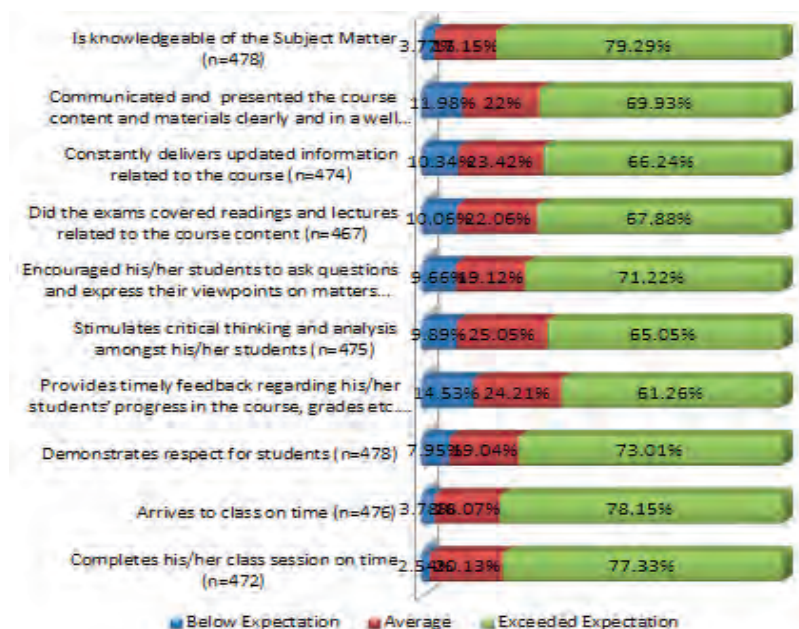
### **Materials and methods**

Evaluations were prepared and administered to students to be completed anonymously for each course per term and then returned to the programme officer of the FS&T unit.

### **Main results**

From the data captured, responses indicated that 14 courses were found to be not applicable to the student's area of study (either by scope or category e.g. science vs non-science courses or independent research etc.) and of these 14 courses, students suggested that the Instructor be changed for 7 (because of content delivery, teaching style, lack of practical sessions etc.) The quality of lab services and the lab facilities exceeded expectations in all categories according to the medians and percentages calculated from the combined students responses. Students thought that more lab equipment and a larger laboratory space were needed. The administrative services was found to be average in all categories but students indicated there were improvements between the different terms.





**Figure 1: Satisfaction with Instructional Effectiveness**

Instructors were graded out of 3 in 10 categories, with 1 being the lowest (below expectation) and 3 being the highest (exceeded expectation) and based on this rating scale, the instructors that provided service to FS&T unit exceeded expectations in all ten categories according to the medians and percentages gathered from the raw data.

Category	FS&T Staff	Other UTT Staff	PT Instructor	Mean	Std. Dev.
Is knowledgeable of the Subject Matter	2.80	2.60	2.70	2.71	0.13
Communicated and presented the course content and materials clearly and in a well-organized manner?	2.80	2.40	2.50	2.55	0.23
Constantly delivers updated information related to the course	2.80	2.30	2.40	2.53	0.28
Did the exams covered readings and lectures related to the course content	2.90	2.30	2.50	2.56	0.27
Encouraged his/her students to ask questions and express their viewpoints on matters related to the lectures	2.80	2.50	2.60	2.65	0.16
Stimulates critical thinking and analysis amongst his/her students	2.80	2.50	2.50	2.59	0.18
Provides timely feedback regarding his/her students' progress in the course, grades etc.	2.60	2.40	2.30	2.43	0.14
Demonstrates respect for students	2.80	2.40	2.60	2.61	0.21
Arrives to class on time	2.80	2.80	2.60	2.72	0.13
Completes his/her class session on time	2.80	2.60	2.70	2.68	0.14

**Table 1: Comparison between UTT FS&T Instructor Rating, UTT Non-FS&T Instructor Rating and External/Part Time (PT) Instructor Rating**

Internal FS&T instructors received higher ratings than instructors from other units and external instructors. Also when instructors were compared based on gender, female instructors received higher ratings in all 10 categories than their male counterparts.

### Conclusion

Based on the overall analysis of the data collected, the SET evaluation has provided enough information on student satisfaction and the effectiveness of instructors and services provided by the FS&T unit to at the very least identify areas for improvement within the faculty as it relates to the students' perspective and the quality of services provided to them through classes, practical sessions via the labs and the efficacy and the efficiency of student administration. However, student ratings are only one source of data and must be used in combination with multiple sources of information if a conclusion can be made about all of the components of university teaching. The SET instrument can be improved by including a section to aid in determining if the instructor makes a difference in student learning in courses that are taught by multiple persons. Analysis of the results from 2015 to 2016 evaluations can assist in determining if the departmental changes and decisions were effective in improving the unit and the services offered. This information would comment directly on the effectiveness of the instructors and their methods of disseminating the course content as well as the student satisfaction within the unit as a whole, and thus serves to be an effective instrument in assessing the quality of service output by the Food Science and Technology Unit of the University of Trinidad and Tobago.

## INTEGRATING FIELD-BASED RESEARCH INTO SUSTAINABLE AGRICULTURE EDUCATION: COMPETENCY DEVELOPMENT OF AN UNDERGRADUATE CLASS

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**Keywords:** Field-based research, competencies, self-assessment, sustainable crop production

### Abstract

Undergraduate science students experience difficulty in relating science principles to field practice. A field-based, science and practice, sustainable crop production course was developed to expose level two undergraduate students to the underlying scientific basis of principles and concepts of sustainable crop production using an agroecological approach. Students met twice per week for 12 weeks with instruction centered on the field as a classroom thus allowing students to learn through hands-on participation. The major focus of the course was providing a kinaesthetic approach where the scientific method was used to answer testable hypotheses. Students developed testable hypotheses, designed an experiment, determined sampling protocol and sample analysis, conducted statistical analysis and reported results in a peer-reviewed format. The study identified and assessed students' competency development at the beginning and end of the course. The results showed that using specific competency-based frameworks, students' competency levels were improved. Field-based courses and student-driven research projects are excellent ways to introduce research methods to undergraduate students. Student learning was enhanced during the experiential learning process by allowing the students to follow the scientific method. Horizontal and vertical synergy of such approaches into the curriculum may prove beneficial to students and University.

### Introduction

A 3-credit course titled: "Principles of Sustainable Crop Production: Science and Practice" was developed and taught during the first semester of 2015 to introduce students to field-based agroecological/sustainable crop production research methods approach. The course objective was to teach field-based methods to students that they could use for current or future research by using the methods for structured class assignments. The course was conducted every Monday morning for 4-hours on the field and on Tuesday afternoons for 2-hours for 12 weeks. Student enrolment was 58 students and majors represented Agriculture special, Agriculture Technology, Landscaping and Environmental and Natural Resources Management. Students used the demonstrated methods, which provided them real experience in the field and a better understanding of the rewards and pitfalls of field-based methodologies for sustainable crop production based research.

### Field Research Projects

The research project was designed to deepen students' understanding of crop growth, development and yield, and the influence of crop, environmental and management factors on crop performance. Crop production is a complex activity that relies on knowledge from different disciplines, therefore, the project was multi-disciplinary in content, and required that they integrate what they learnt from several courses, namely soil fertility management and research and statistical skills in agriculture. The research approach was taken to assist them to develop the habits of inquiry and information-based decision-making for crop production through training in relevant skills including proper data collection, analysis and interpretation, as well as other research skills.

### Materials and methods

For this course, competency development was assessed in two ways: (1) students were asked to complete a competency self-assessment survey at the beginning and at the end of the course. Completing the competency self-assessment survey involved students first determining the "level of development" they identified with at the time then secondly identifying the activities and assignment that helped them develop that competency and finally indicating whether their understanding of the competency itself changed over time. The survey was divided into four sections: Section 1 examined their social and personal background, section 2 detailed all course related information including their study habits, while section 3 detailed the self-competency evaluation using a Likert scale, where 1=Very incompetent/very unable; 2=Somewhat incompetent/somewhat unable; 3=Not sure; 4=Somewhat competent/somewhat able and 5=Very competent/very able. The final section was a general course evaluation using a Likert scale and was only administered at the end of the course (1=strongly disagree; 2=disagree; 3=mixed feelings; 4=agree and 5=strongly agree). For the data analysis, the level of development was quantified and the means of each were determined for each competency in the self-assessment for each period of assessment (beginning and end).

The survey instrument was presented electronically to students using Google forms and intensely followed up to retrieve the completed forms. There was a 60% and 75% response rate respectively and data were coded and analysed using SPSS and presented as descriptives.

## **Main results**

### ***Social and personal background***

A total of 24 and 32 students completed the pre-and post-survey, respectively. The majority of students were between the ages 21-25 (51.8%), followed by the 17-20 age category (25%) and 14.3 % were more matured (>30). There was an uneven distribution of males and females with the latter (66.1%) outnumbering the former (33.9%). The majority of students were full-time (82.1%) and pursued the Agriculture special degree option (64.3%) (Table 1).

### ***Course related information***

Students were asked at the beginning and end of the course how helpful the course was to the overall appreciation of their degree option and there was no significant difference as the majority found that the course was very helpful pre- and post-test (79.2 and 78.1%, respectively). There was, however, a significant difference between students indicating the number of hours they spent studying for the course at the beginning and end, with 41.7% indicating that they spent between 1 and 5 hours per week before and 25.0% at the end and 37.5% spending 5-10 hours before compared to 71.9% at the end given the increased coursework requirement. Significant differences were also seen in the methods students used to take notes in class and the use of MyElearning. Students consistently developed good study habits from early, listening and making notes of lecturers both early and later during the semester, while using the library and MyElearning more than once a week.

### ***Self-competency evaluations***

Table 2 shows that there were changes in competency self-assessment from the beginning to the end of the course using the integrated field-based approach. This was observed for all levels of competency with the Inquiry process showing the highest change of 2.1. Note that competencies such as Understanding values, Interpersonal skills and Communication skills (writing/presenting) were not assessed at the beginning of the course. There were also changes in their Ways of knowing and learning (1.5) and the Analysis/experiential learning (1.5).

The use of competency self-assessments is useful to the course in that it collects data on which assignments help develop which competencies and also informs students of their performance and notes activities in which they engage. This linking of competency self-assessment data to each course assignments allows for course instructors to observe how activities in the course can lead to enhanced student learning or development, not only individually but as a group. It can therefore serve as a course evaluation tool.

## **Conclusions**

- The data suggest that using the integrated field-based approach as a competency-based framework, students' competency levels were improved with time.
- Field-based courses and student-driven research projects are excellent ways to introduce research methods to undergraduate students, improving knowledge and self-awareness.
- Student learning was enhanced during the experiential learning process by allowing the students to follow the scientific method.
- Horizontal and vertical synergy of such approaches into the curriculum may prove beneficial to students and University.

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<b>Variable</b>	<b>Frequency</b>	<b>Percentage (%)</b>
<b>Age</b>		
17-20	14	25.0
21-25	29	51.8
26-30	5	8.9
>30	8	14.3
<b>Gender</b>		
Male	19	33.9
Female	37	66.1
<b>Status</b>		
Full-time	46	82.1
Part-time	10	17.9
<b>Degree option</b>		
Agriculture Special	36	64.3
Agriculture Technology	10	17.9
Environmental & Natural Resource Management	10	17.9

**Table 1.** Social and personal background of students

<b>Competencies</b>	<b>Pre</b>	<b>Post</b>	<b>Change Post-Pre</b>
<b>Ways of Knowing and Learning</b>	<b>1.4</b>	<b>2.9</b>	<b>1.5</b>
Know how to critically evaluate the advantages and disadvantages of various cropping systems in sustainable agriculture	1.6	3.1	1.5
Understand how the environment influences crop growth and yield	1.6	3.1	1.5
Describe specific crop growth and development patterns and how they influence management decisions such as land preparation, row width and plant population	2.2	3.6	1.4
Understand the concept of agroecosystem better	1.5	3.1	1.6
Know how to develop a farm plan for sustainable crop production that would address environmental, social and economic sustainability	1.0	2.5	1.5
Understand the importance of good agricultural practices	1.4	2.0	0.4
Collect data on crop growth and development including plant height, leaf area, dry matter etc.	2.1	3.1	1.0
Understand the principles and practices of sustainable production to commercial farm situations for soil and water management, pest and weed control, and post-harvest handling	1.2	1.9	0.7
Understand the underlying scientific basis of sustainable crop production practices	1.2	3.6	2.4
Know about the importance of seed quality as it related to crop production	1.6	2.8	1.2
Understanding values			
Examine personal values as they relate to food and the food system (local market analysis and farmer interview)	0.0	3.4	3.4
<b>The Inquiry Process</b>	<b>1.0</b>	<b>3.1</b>	<b>2.1</b>
Interpret results from various trials	1.0	3.0	2.0
Research relevant literature	1.7	3.6	2.1
Use field-based research methods (interviews and observation) involving food system actors and locations	0.0	2.6	2.6
<b>Analysis/Experiential learning</b>	<b>1.6</b>	<b>3.1</b>	<b>1.5</b>
Interpret results from various trials	1.0	3.0	2.0
Collect data on crop growth and development including plant height, leaf area, dry matter etc.	2.1	3.1	1.0
Interpersonal skills	0	2.6	2.6
Use field-based values as they relate to food and the food system (local market analysis and farmer interview)	0.0	2.6	2.6
Perform collaborative learning in teams through field research and analysis	0.0	2.8	2.8
Practice group decision-making through dialogue and consensus	0.0	2.2	2.2
Co-manage fieldwork project logistics	0.0	2.6	2.6
<b>Writing/presenting/ Communication skills</b>	<b>0</b>	<b>2.8</b>	<b>2.8</b>
Gain experience in preparing oral and written scientific communication	0.0	2.8	2.8
Average	1.0	2.9	1.9
STD	0.7	0.4	0.7

**Table 2.** Students' competency self-assessments at two points in the semester



## IMPROVING STUDENT ENROLMENT NUMBERS IN THE FOOD SCIENCE & TECHNOLOGY (FS&T) UNIT OF THE UNIVERSITY OF TRINIDAD AND TOBAGO (UTT)

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**Keywords:** Student enrolment, food science and technology programmes, university of Trinidad and Tobago, schools

### Abstract

The study examined student enrolment numbers over a five (50 year period and interventions embarked upon in the fifth year to ensure sustainability of its Food Science and Technology (FS&T) programmes at the University of Trinidad and Tobago (UTT). From the inception (2010) of the B.Sc. in FS&T full time (FT) programme with a student intake of 7; to no enrolment in 2011, and in 2012, with the launch of the part time (PT) Diploma, the enrolment numbers increased to 18. In 2013, with the launch of the FT Diploma and PT Certificate programmes, there was an overall intake of 43 students. In 2014, the unit revalidated its B.Sc. programme with new specializations increasing its intake by another 26 students to 69. In that same year, there was also a launch of the FT Certificate in Food Technology. From 2015, in addition to a PT offering of the revalidated B.Sc. programme and switching the yearly in-take of students at the start of the academic year to an in-take each term for both the FT and PT Certificate in Food Technology programmes, the numbers further increased from the prior year by 30 students to an overall total of 99 students. Concurrently, the FS&T unit explored and integrated creative ways to recruit prospective students and these exercises accounted for over 50% of the overall 99 student's enrolled in 2015. Some challenges encountered were lack of correct and updated data from the Registry unit, limited resources such as small classrooms to facilitate large audiences; lack of a recruitment budget, contact numbers provided from perspective students were invalid and many did not respond to both e-mail and phone calls. Recommendations include an improved online system, having one large event to target and accommodate an increased number of schools and industry stakeholders and targeting regional schools and workplaces.

### Introduction

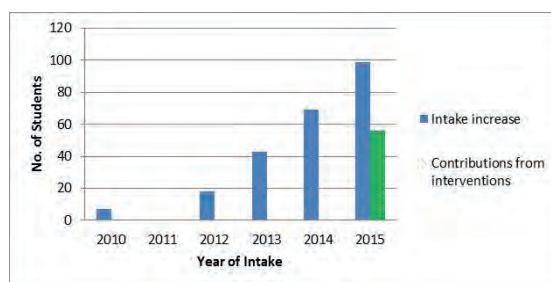
The University of Trinidad and Tobago (UTT) through its Food Science and Technology (FS&T) programmes can play a key role in transformation of this important sector through education and training of our valuable human resources and be a catalyst for diversification of the local economy. The UTT being a relatively young University of 12 years can differentiate itself from the competition by increasing branding and advertising of programmes to aid in increasing student enrolment. This aligns to the fact that institutions are dedicating far more attention to these functions than in previous years (Hanover Research, 2014).

### Materials and methods

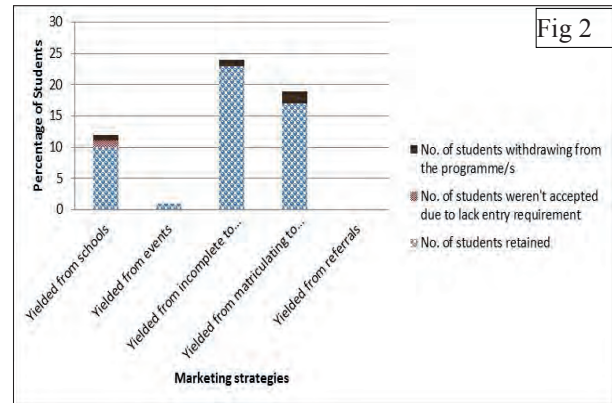
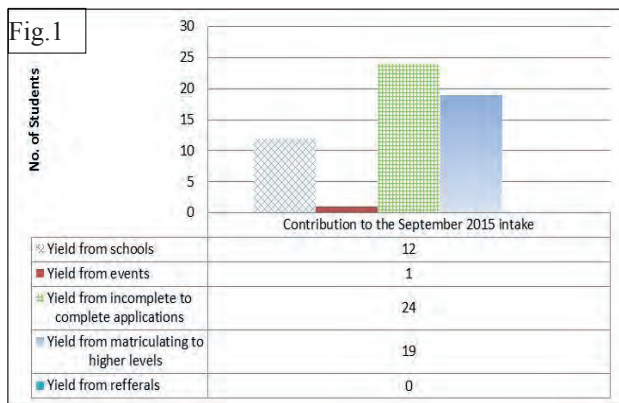
Data on student enrolment numbers were reviewed over a five year period with additions and modifications to the core Food Science and Technology programme. To improve student recruitment and enrolment numbers in 2015, a four pronged approach was used:- Phase 1: School Visits and one Mall Outreach event, Phase 2: Conversion of incomplete applications to complete, Phase 3: Recruitment of existing students in BAFT and Phase 4: Referrals.

### Main results

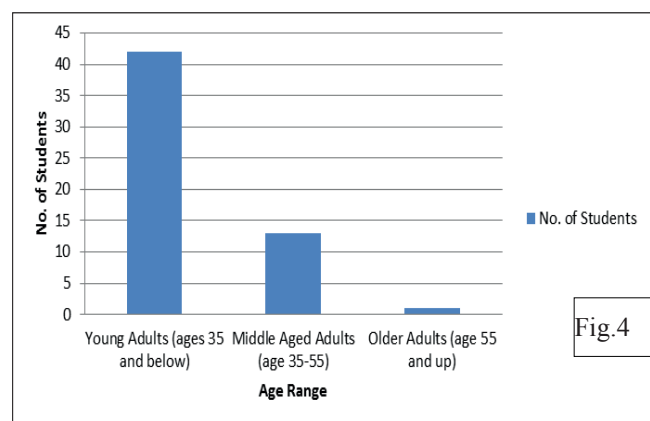
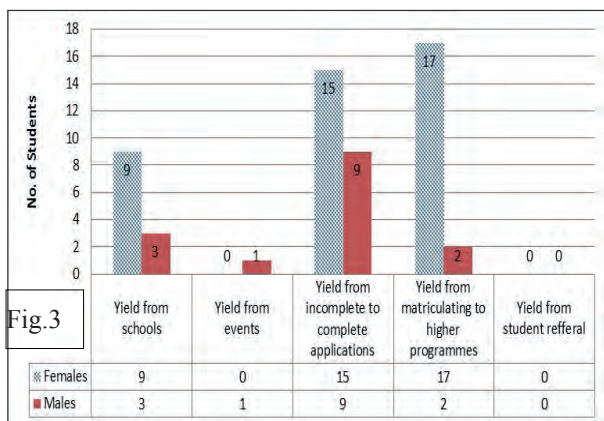
#### Recruitment during the period 2010 to 2015



**Figure 1:** Total annual intake of students into the FS&T programmes over a five year period from 2010-2015. Recruitment Strategy and Interventions for 2015



**Figure 2: Enrolment from each marketing strategy used to recruit students for the 2015 intake**  
**Figure 3: Retention rate of students enrolled from marketing interventions**



**Figure 4: Gender of students enrolled from marketing interventions**  
**Figure 5: Age groups of students enrolled from marketing interventions**

**Conclusions**

- The marketing approaches accounted for a successful contribution of over 50% of the overall 99 student’s enrolled in 2015 while all other 43 students came through the normal route of entry.
- The effort behind converting the incomplete on-line applications to completed ones yielded an improvement by as much as 43% compared to the other interventions for 2015 (schools, events, matriculating students, referrals).
- Efforts such as the Mall event and Referrals did not yield significant improvements to the enrolment numbers

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## FUTURE OF AGRICULTURE

### LAND USE AND FOOD SECURITY IN 2050 – THE AGRIMONDE-TERRA SCENARIOS

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**Keywords:** land use, food and nutrition security, diets, cropping and livestock systems, rural transformation and urbanization

#### Abstract

Land use and global food security are major issues because of uncertainties about the planet's capacity to feed a growing population (set to reach 9.7 billion in 2050) in a context of climate change and ongoing debates regarding land use change trajectories. What are the main drivers of land use changes and how do they interact and influence food and nutrition security? How will the agricultural land area change over the next 40 years, globally and regionally? What tensions will there be between food and nutrition security and climate change mitigation in 2050? After a first foresight study published in 2011 on 'World food security in 2050', CIRAD and INRA have turned their attention to a foresight exercise on 'Land use and food security in 2050' that seeks to answer these questions. Five scenarios of land use and food security in 2050 highlight levers that could modify ongoing land use patterns for improved food and nutrition security. This approach provides decision makers, stakeholders, non-governmental organizations and researchers with a tool for dialogue.

#### Materials and methods

Researchers firstly analyzed the long-term dynamics of the land use and food security system. Foresight analysis was conducted through a scenario approach based on morphological analysis. By identifying a range of variables influencing each driver and its dynamics, hypotheses on how each driver might evolve in 2050 were then produced. Secondly, five contrasted scenarios were built by combining one or several hypotheses per driver. Each scenario describes a situation of land use and food security in 2050 and has been translated into a narrative. Thirdly, the impacts of the scenarios in terms of land use, agricultural production and trade in the 14 world regions and globally have been assessed through quantitative simulations using the biomass balance model GlobAgri-AgT. The five scenarios and their outcomes were then appreciated both quantitatively and qualitatively.

#### Main results

Five scenarios have been built (Fig. 1), with an international expert group providing guidance on scenarios building. 'Metropolization' links the development of megacities with a nutrition transition led by global agri-food companies selling ultra-processed foods and an increase of animal products consumption, in a global context of development through market forces and rapid climate change. Small farmers are marginalized. 'Regionalization' relates the increase of medium-size cities and their networking with rural areas to the emergence of regional food systems based on family farming and traditional food diets, and a set of regional agreements, notably trade agreements. 'Households' links strong individual mobility between rural and urban areas and a development of non-farm employment to the emergence of hybrid diets based on both traditional and modern value chains, in a globalized world where family farms and cooperatives are major actors in land use. 'Healthy' assumes that due to the increasing cost of malnutrition, a radical move towards healthy diets occurs driven by global cooperation and public policies in a context of climate change stabilization, involving a re-configuration of agricultural systems backed by new alliances between stakeholders. 'Communities' assumes that in a context of recurrent crises, development based on small towns and rural communities occurs, focusing on managing common property in agriculture in order to ensure food security.

From those five scenarios and their simulation in term of land use, our main results are:

- Ensuring world food availability in 2050 will involve expanding the world's agricultural land area to the detriment of forests. Indeed only the 'Healthy' scenario is likely to be able to ensure sustainably world food security in 2050. 'Metropolization' and 'Communities' are not able to achieve this objective without deforestation and the two other scenarios, 'Regionalization' and 'Households', lead to ambiguous results.
- In terms of nutrition 'Healthy' contributes most to reducing overnutrition and related diseases, but also to diminishing undernutrition. 'Metropolization' contributes most to the expansion of overweight, obesity and related diseases. 'Communities' would create a reduction in food availability at the world and regional levels. 'Regionalization' works in favour of world and regional food and nutrition security, but leads to ambiguous results for world food availability. 'Households' contributes to both a decrease in undernutrition and some ambiguous effects on overnutrition.

- Whatever the scenario, international trade will play a key role in ensuring world food availability in 2050 and some regions, especially North Africa and Near & Middle-East, are likely to be highly dependent on food imports.
- Increasing food and nutritional diversity for healthier diets in 2050 while limiting the growth of agricultural land and deforestation will require greater diversification in cropping and livestock systems.

### Conclusions

- There is no given pathway to food and nutrition security. Because the challenge is complex, with many overlapping and interlinked issues that cut across sectors, territories and actors, changing the course of ongoing trends requires systemic transformation, public policies and consistent actions from a wide range of actors. Each country and region will have to find its own pathway in coherence with common responsibilities for facing global challenges. Organization of trade, access to land, farm structures, and rural transformations are major drivers for food security.
- Changes in both supply and demand are necessary for transition towards diversified and healthy diets and the reduction of waste and losses.
- Nutrition and food security are a cornerstone issue for the future of cropping and livestock systems.

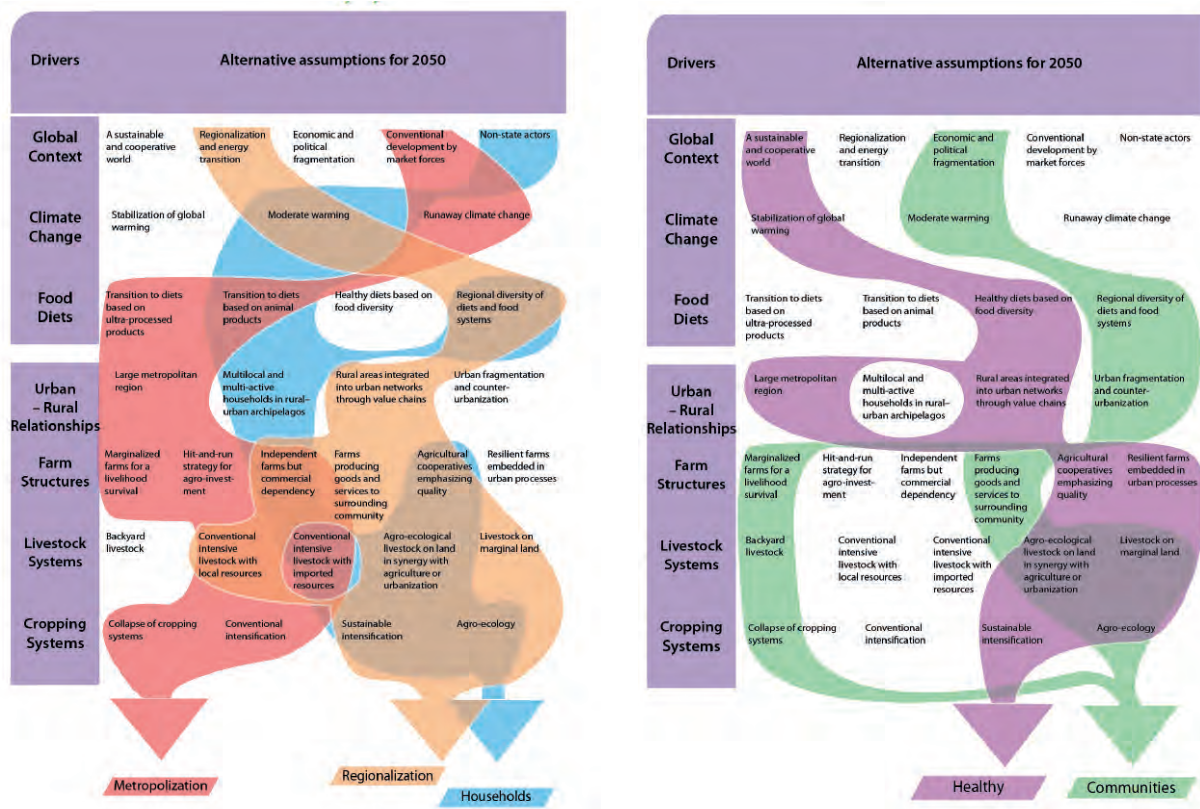


Figure 1. Alternative combinations of assumptions describing scenarios of land use and food security by 2050.

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## SOUVERAINETE ALIMENTAIRE ET STRATEGIES D'UTILISATION DES TERRES : LE CAS DE LA GUADELOUPE

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### Introduction

Autonomie alimentaire, sécurité alimentaire et souveraineté alimentaire sont des concepts qui ont fait l'objet de nombreux débats internationaux. Ils peuvent être utilisés indifféremment mais en réalité ils font état de postures et objectifs différents. L'autonomie alimentaire est une « donnée quantitative » qui mesure la capacité d'un pays à couvrir les besoins alimentaires de sa population avec les productions issues de son terroir. La FAO considère que « *la sécurité alimentaire est une situation caractérisée par le fait que toute la population a en tout temps un accès matériel et socioéconomique garanti à des aliments sans danger et nutritifs en quantité suffisante pour couvrir ses besoins alimentaires, répondant à ses préférences alimentaires, et lui permettant de mener une vie active et d'être en bonne santé* » (FAO, 1996). La souveraineté alimentaire est un concept moins neutre formulé par des mouvements paysans d'Amérique du sud en réaction à la mondialisation et au commerce international des vivres. C'est le droit des états et des populations à définir leur politique alimentaire et agricole. La souveraineté est un concept tant quantitatif et qualitatif qui intègre entre autres une dimension culturelle, éthique, sociale... Indépendamment du choix de politique agricole, l'une des conditions pour converger vers la souveraineté alimentaire est la disponibilité en terres agricoles qui doit être en adéquation avec la taille de la population. Les terres agricoles ont une limite biologique de production à raisonner dans le contexte d'une agriculture agro-écologique afin de concilier production et protection de l'environnement. A l'échelle mondiale, les surfaces agricoles régressent alors que la population augmente. En Guadeloupe le Schéma d'Aménagement Régional a figé les surfaces agricoles à 50000 hectares alors que les prédictions de population de l'INSEE pour 2040 sont de 430000 habitants. Dans cette étude avec la Guadeloupe comme exemple, l'objectif est de quantifier, suivant différents scénarii de consommation et de gestion du territoire, les besoins en surfaces agricoles dans une optique de souveraineté alimentaire.

### Matériel et Méthodes

Les habitudes alimentaires et les modèles de consommation impactent fortement le besoin en surfaces agricoles. Les besoins alimentaires ont été calculés pour un homme adulte. Le besoin énergétique retenu pour les calculs est de 3000 kcal par jour/personne dont 13% apportés par des protéines animales pour le régime omnivore (CNERNA, 2002). Les régimes végétaliens et végétariens n'incorporent pas de protéines animales mais des pois sont consommés journalièrement contre une fréquence de 3 jours par semaine pour les régimes omnivores. Deux scénarii ont été étudiés pour le régime omnivore : 0 vs. 50% des protéines sont apportées par du poisson pour les omnivore-viande vs omnivore-poisson. Pour le régime omnivore-poisson le choix a porté sur la pêche classique plutôt que l'aquaculture. Pour le régime végétarien, l'apport protéique est couvert par du lait et des œufs. L'assiette moyenne du consommateur a été composée de 5 groupes d'ingrédients issus du terroir guadeloupéen dont les valeurs énergétiques ont été estimées à : 1) 2800 kcal en moyenne par kg les tubercules racines et fruits amylicés secs; 2) 2800 kcal en moyenne pour les céréales secs ; 3) 2800 kcal en moyenne pour les protéagineux ; 4) 1800 kcal en moyenne pour les viandes fraîches (bovins, ovins, caprins, porcins et volailles) ; 5) 1500 kcal en moyenne pour le poisson. La valeur énergétique des ingrédients a été extraite de la bibliographie (FAO, 1979). La production d'énergie alimentaire par hectare a été calculée sur la base des rendements des productions agricoles observées en Guadeloupe (référence Chambre d'Agriculture). Les rendements ont été minorés de 30% pour prendre en compte les pertes de cuisine, les pertes liées à la conservation, les surfaces agricoles mobilisées, les voiries et bâtiments...

### Résultats

Les surfaces à consacrer à la production de vivres varient fortement avec les choix de consommation des populations et les stratégies agricoles. La production de protéines animales est fortement consommatrice de terres.

Les choix des régimes végétalien, végétarien, omnivore 1, omnivore 2 entraînent des besoins de surfaces agricoles respectivement de 0,07, 0,10, 0,17 et 0,24 hectare par habitant. Cela correspondrait à des besoins totaux en surface agricole d'environ 30000, 43000, 73000 et 103000 ha. Si on fait l'hypothèse du maintien des surfaces destinées aux cultures d'exportation à leur niveau actuel, soit environ 20 000 ha, seules 30000 ha sont potentiellement disponibles pour les productions vivrières. Dans un tel contexte seule l'orientation « végétalien » permettrait de converger vers une souveraineté alimentaire.

En l'état actuel des connaissances, la capacité des régimes « végétaliens » à répondre aux besoins nutritionnels de l'homme fait l'objet de controverses. L'incorporation de protéines animales et/ou de poisson serait obligatoire.

La recherche d'une meilleure efficacité dans l'utilisation des surfaces agricoles et des biomasses végétales produites est nécessaire. Plusieurs stratégies permettraient d'y converger : i) développer des systèmes de production de type polycultures-élevage incorporant des cultures alimentaires duales dont la biomasse est consommable par l'homme et l'animal ; ii) réduire les gaspillages en recyclant les biomasses non consommées (agricoles, domestiques et du commerce)



en alimentation animale ; ii) repenser une agroforesterie qui tout en préservant les fonctions environnementales de l'arbre permettrait de valoriser les sous-bois pour les productions alimentaires et industrielles et/ou de remplacer partiellement du bois d'œuvre par des arbres alimentaires.

### **Conclusion**

La production de viande est fortement consommatrice de terres. L'introduction de légumineuses et de poissons sauvages dans l'alimentation permettent de réduire le besoin de terres agricoles. L'accroissement de l'offre alimentaire par unité de surface nécessite de maximiser l'utilisation de toutes les biomasses produites (principes de l'économie circulaire) et le développement de pratiques agronomiques valorisant par exemple l'association des cultures et les sous bois en agroforesterie.

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## MODÉLISATION SPATIALE DES DYNAMIQUES D'OCCUPATION DU SOL AGRICOLE EN GUADELOUPE (ANTILLES FRANÇAISES)

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### Introduction

L'agriculture dans le monde est en pleine mutation. En Guadeloupe également, les changements sont visibles en terme de production (canne à sucre, banane, productions de fruits et légumes...), en terme d'innovations (réintroduction de haies, installation de l'irrigation...), en terme de pratiques (mécanisation, coupe à la main...). Les changements de production sur une parcelle agricole d'une année à une autre peuvent être synonymes de rotation culturale, changement de production inhérent au système mis en place par l'agriculteur, ou de changements de combinaison productive caractérisés par un arrêt du système en vigueur et le commencement d'un autre. La rotation de productions s'inscrit dans la dynamique d'une exploitation agricole alors qu'un arrêt de production sous-entend une réorientation durable quant la présence de certaines productions agricoles. Comment expliquer les changements de spéculations ? Nous faisons l'hypothèse que les agriculteurs sont influencés par les proximités qu'ils mobilisent (selon la typologie de Boschma, 2004) pour répondre aux événements survenus liés à la pollution rémanente par la chlordécone des sols de Guadeloupe (Cabidoche *et al.*, 2009).

### Données mobilisées et méthodes employées

Nous sommes partis des données de déclarations de surfaces agricoles en Guadeloupe de 2004 à 2009 à l'échelle parcellaire. Nous proposons d'analyser ces données en mobilisant plusieurs méthodes. Dans un premier temps, nous appliquerons le filtre de Kalman-Bucy (Kalman, 1960 ; Kalman *et al.*, 1961), processus markovien, méthode mathématique qui permet d'analyser les changements. Elle se décompose en deux phases distinctes : la prédiction, l'estimation de l'état futur par rapport à l'état présent et la mise à jour, correction de la prédiction par les observations réelles de l'état suivant. Le changement de spéculation d'une parcelle agricole suit une trajectoire théorique, trajectoire logique de changement dans un contexte de système de production. La trajectoire effective s'écarte plus ou moins de la trajectoire théorique pour de multiples raisons (problèmes économiques, opportunités du marché, contraintes réglementaires, catastrophes naturelles...). Dans un deuxième temps, nous proposons de mobiliser le calcul matriciel, méthode mathématique permettant de présenter les résultats d'une transition sous la forme d'un tableau. Ces matrices permettront de mettre en évidence les changements ou non d'un type d'occupation du sol. Ces changements seront présentés sous la forme de matrices de transition : elles synthétisent les différents changements possibles interannuels à l'échelle parcellaire. Ces matrices seront analysées statistiquement par des tests de comparaison des fréquences afin de comparer leurs comportements (Frontier *et al.*, 2001). A l'issue de cette première phase d'analyse statistique des matrices, dans un troisième temps, il sera possible de proposer des règles de construction d'un modèle de dynamiques d'occupation du sol sous OCELET (Degenne, 2012). Nous pouvons nous demander s'il y a des différences spatiales et temporelles dans le changement d'occupation agricole du sol et, si la pollution des sols par la chlordécone a un impact sur ces changements d'occupation du sol. Nous faisons les hypothèses suivantes : le changement de type de production est fonction de la localisation géographique des parcelles agricoles (localisation géographique des parcelles agricoles dans les communes en zone contaminée ou en zone non-contaminée, critère déterminé à partir de la carte des types de risques de contamination (Tillieut *et al.*, 2006) et des niveaux de sensibilité des productions agricoles à la chlordécone (Jannoyer *et al.*, 2007).

### Résultats

Le filtre de Kalman-Bucy propose, pour chacune des spéculations, une lecture des courbes d'évolution de 2004 à 2010. Il nous permet de déterminer les années pour lesquelles le filtre estime mal l'évolution des superficies dédiées à la production. Ces années particulières peuvent être associées aux frises chronologiques présentant les événements marquants. Les tests de comparaisons des fréquences proposent une lecture des matrices de transition et surtout une comparaison entre les transitions en zone contaminée et celles en zone non-contaminée. Nous proposons la création d'un modèle de dynamique d'occupation du sol agricole en Guadeloupe, modèle que nous implémenterons au fur et à mesure par des règles de décision. Les résultats sont visibles cartographiquement sous Google Earth©. Nous avons proposé quatre modèles :

- Modèle 1 : un modèle de présentation des dynamiques réelles d'occupation du sol à partir des données annuelles de 2004 à 2009. La cartographie dynamique est proposée à l'échelle régionale.
- Modèle 2 : un modèle de simulation à partir des données réelles des parcelles agricoles de 2004 et d'une règle de probabilités des changements. La cartographie dynamique est visible à l'échelle régionale.
- Modèle 3 : un modèle de simulation des changements parcellaires à partir des données d'occupation du sol et de règles sur le risque de contamination des zones et sur le niveau de sensibilité des spéculations à la pollution. Les cartographies dynamiques sont visibles à l'échelle de la commune administrative (3a) et de la zone agroécologique (3b).

- Modèle 4 : un modèle de simulation des changements des exploitations agricoles avec des règles sur la probabilité de mobilisation des proximités d'après des résultats d'enquêtes menées en 2008, 2013 et 2014 auprès des agriculteurs guadeloupéens.

### **Conclusion**

Au-delà du constat d'évolution de l'occupation des sols année après année, ce travail de modélisation nous permet d'apporter une dimension humaine et sociale aux décisions prises par les agriculteurs guadeloupéens en termes de choix de spéculations et ce, en fonction de chocs survenus lors de leur activité. Dans le cas présent, les modèles développés permettront d'évaluer les conséquences en terme décisionnel de la pollution par la chlordécone pour l'évolution agroproductive du foncier concerné.

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## AGRIMAPS: USING MOBILE TECHNOLOGY TO SUPPORT REGIONAL CROP PRODUCTION

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**Keywords :** Mobile Applications, Precision Agriculture, Tropical Agriculture

### **Abstract :**

Farmers often have limited contact with extension personnel in many Caribbean countries due to human resource limitations and the geographically disaggregated nature of farming communities. The Caribbean has one of the highest levels of mobile phone penetration in the world and we developed the AgriMaps mobile application to help farmers and horticulturalists make crop management decisions using an online platform. This app uses weather and soil data to assess the suitability of individual sites to a range of crops and provides recommendations to improve soil productivity. This technology can be adopted by all territories given the recent expansion of internet coverage in the region. This may help increase crop production and food security in the region by encouraging the participation of youth in agriculture as demonstrated by its acceptance by the farming community in Trinidad and Tobago. Thus, we provide the theoretical and technical underpinnings of this application to facilitate its expansion to other Caribbean territories.

### **Materials and methods :**

Secondary data was used for the development of the app. All base map data was derived from Open Street Maps while all other data (rivers, soil series, roads, contours, rainfall and land use) was collected by the Department of Geomatics and Land Management at the University of the West Indies, St. Augustine Campus. Data on dominant soils was verified using the Land Capability Survey of Trinidad and Tobago (Brown and Bally, 1970) while rainfall data was compiled by the Department of Food Production with assistance from the Trinidad and Tobago Meteorological Services. Note that recommendations provided for individual crops may also apply to the associated crop family. This list of crops is made up of those earmarked for agricultural investment and other popular crops cultivated for the local market. The list was informed by the National Food Action Plan (Ministry of Food Production, 2012). Crop profiles were developed for selected crops by identifying soil and environmental conditions considered ideal for growth. This data was sourced from long-term agronomic studies and included pH, EC, root depth, temperature, irrigation requirements and ideal soil texture (Ebusu, 2004; Brady et al., 1996; Weaver and Bruner, 1927; Lerner, 2001; Pettygrove et al., 1999). Crop profiles were compared to local soil and climatic data to determine if sites were within the defined ranges for each plant. Mitigative soil management practices were also proposed in cases where conditions fell outside the required range.

### **Main results :**

Information Communication and Technology (ICT) tools have been used in the agricultural sector of Trinidad and Tobago over the years. Radio, television, paper-based books and maps have transitioned to emails, discussion forums, virtual maps and land information online (Ganpat et al., 2009). What is presently available in Trinidad and Tobago is a range of e-extension web-based tools; virtual libraries, online learning software, electronic mailing lists (e.g. listservs), discussion forums, blogs and virtual libraries among others (Renwick, 2012). Though useful, the need for more effective technologies is important. AgriMaps is a virtual e-Extension officer which automatically personalizes details to match the needs of the user. It is an application which provides extension services to producers in an accessible way while fortifying the resource bank of those mandated to provide this service. The benefits of the AgriMaps application resides in its usefulness for farm management and agricultural planning. Direct benefits can be gained by producers, who are now empowered with the ability to make soil and crop management decisions based on analytical data, specific to their farms. The app can also provide information for agricultural planning and policy such that limited land resources can be better used. AgriMaps can be applied to any country with georeferenced edaphic and climate data. The main challenge, however, is the acquisition of relevant and correct spatial and agricultural data. To mitigate this challenge, an Open Data GeoNode platform was created - <http://maps.tt/>. Here a mechanism is provided for stakeholders to upload and display data freely. The platform is governed by a Creative Commons License.

Such a mechanism is a precursor to the National Spatial Data Infrastructure (NSDI) enabled by the National Spatial Development Strategy (NSDS) which will over time provide a readily accessible central spatial data repository, hosted and managed by the Trinidad and Tobago government (Ministry of Planning and Sustainable Development, 2013). Linking data acquisition to the NSDI will assist in the management of issues related to accuracy and availability such that any data accessed can be trusted. Another major challenge is the widespread adoption and use of The app. Many older farmers do not have smart phones and, in many cases, are not technology savvy. The AgriNeTTi team has worked with

several farmers and farmers' associations, as well as with agricultural institutions and have begun to see the fruits of these engagements. One interesting outcome is that the app provides a real opportunity to engage young people in agriculture; they see a future in agriculture that is more technology driven. This therefore can be used as a platform to involve the youth in understanding and seeing the value of agriculture, as well as create an opportunity to strengthen the sector for long-lasting business. Finally, the authors acknowledge that soil composition and surrounding geographic features are affected by temporal and spatial variability. Considering this, the features of the AgriMaps e-Extension mobile service can be maximized when used in collaboration with field and other biophysical and socio-economic metrics.

### **Conclusion :**

AgriMaps was created to provide land information and crop recommendations for stakeholders in the agricultural sector of Trinidad and Tobago. This Android app is freely available in the Google Play Store. The developers posit that despite challenges faced in developing countries, agricultural development can still be influenced by a planning methodology such as precision agriculture. Thus, this personalized e-Extension tool illustrates how land can be optimally used if soil characteristics and geographic features are carefully examined. With the correct spatial data, the application can be extended to other geographic zones

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**Posters - Movie**



## COFFEE, QUALITY AND ORIGIN WITHIN A DEVELOPING ECONOMY: RECENT FINDINGS FROM THE COFFEE PRODUCTION OF HONDURAS.

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**Keywords:** Agriculture, Coffee, Honduras, Altitude and Quality

### Abstract

Following the privatization in 2000 of the technical and economic services of the Honduran government and the following channeling of taxes from coffee production, the development of coffee policy of Honduras was at hand of the private sector influence, leaving the public sector as a secondary participant. From the launch of the policy in 2003, one special interest was given to improve the national production and to promote specialty coffees identified locally with a good potential at final markets. The Honduran Institute of the Coffee (IHCAFE), now private has turned into a key actor by having taxes managed from the public (producers, intermediaries and exporters), and due to this fact to assume the leadership in the execution of the policy, particularly in the local assistance and the international promotion of the coffee. From gathering a national coffee quality project, IHCAFE collected hundreds of samples out of the producing regions of the country (2004-08), the followed quality analysis found diverse profiles of flavors and aromas of the coffee, though the process also found important defects in the coffee, which were associated with problems of processing and quality control.

### Introduction

At the beginning of 21<sup>st</sup> century, coffee was a booming business, yet after years of commodity exports based on commercial preparations with limited quality control, many problems started to have a greater negative impact on the price paid for Honduran mainstream coffee. Internally, while the primary production kept increasing, the quality control was problematic after the harvest and particularly during the wet milling processing of fruits to parchment, leaving coffee parchment without a proper drying and with high humidity content, besides promoting the presence of fungus, provoking a rapid deterioration of coffee quality during transport, storage and trade. With a complicated scenario, different studies had found related quality problems within the Honduran coffee industry, among them: insufficient technology transference, poor processing facilities and above all complicated marketing relationships between growers and intermediaries. For instance, coffee defects affect quality, and are known to be associated to insufficient processing facilities, lack of quality control, and restricted technical assistance to the crop. In contrast, the exemplary (high quality) or specialty coffee segment was growing at final markets, and in 2003 Honduras started to discover new opportunities with the differentiated coffee niche within the local boundaries, coffees with particular characteristics, for example related to certain agronomic varieties, harvesting, crop's high altitude growth and better processing.

### Materials y methods

From the universe, the sample size of the growers was calculated by following a well-known statistical protocol for sample size estimation of 397 surveys with expected error of 0.015 and confidence of 90% (Robert, Morgan & Daryle, 1970; Hernandez et al, 2006). The statistical program INFOSTAT® was used for multivariate analysis of the data information (Di Rienzo et al, 2008; Balzarini et al, 2008, Sevilla, 2013). Following the multivariable statistical methods, commonly used to analyze quality rather than quantity type of information, the Correspondence Analysis was primarily selected to perform interdependency analysis, in which the initial contingency tables were later used to present a graphical plot visualizing the relationships between selected variables (Rencher, 2004; Di Rienzo et al, 2008). Other multivariable analysis techniques were complementary to the study: Principal Components technique to perform simultaneous analysis of quality and quantity variables, and the Canonical Correlation technique by using only quantity type of variables. In total 904 coffee bean samples were collected by IHCAFE and later analyzed in this study, during four consecutive annual coffee harvests from 2004-2008. Within the Honduran producing regions: 173 coffee samples originated from Agalta Tropical, 203 from Azul Meambar, 208 from Copan, 184 from Montecillos and 136 from Opalaca. All samples were from Arabica coffee varieties: Bourbon, Catuai, Caturra, Colombia, Geisha, IHCAFE-90, Lempira, Pacas, Typica and Villa Sarchi. Samples came from three altitude ranges: low (less than 900 meters above sea level), medium (901-1,200 masl) and high (1,201 masl and above). Samples were collected in dry parchment during the harvest season, centralized and stored in sealed plastic bags. Samples in parchment were prepared for green coffee and stored in plastic boxes within a month, before obtaining medium roast products by the Quality Control Lab (IHCAFE), after resting for a few hours the samples were ground and used in the sensory test room for cupping evaluation. Coffee bean samples were ground medium a few minutes before obtaining the infusion. The amount of ground coffee used for the infusion was set up to obtain an optimum ratio of 8.25 grams of coffee per 150 ml of water. Ground coffees were put in white ceramic cups, and hot purified water was poured over the ground coffee (93°C, reverse osmosis and carbon filtered water), some 3 to 5 minutes before cupping by panelists from IHCAFE's Quality Control Lab. 2.5. Cupping Method. The sensory test

followed the IHCAFE Criteria, based on SCAA protocol recommendations. The coffee samples were roasted a day before they were ground, allowing the coffees to rest at less 8 hours before cupping by panelists. The water used for cupping was odor free, neither distilled nor softened, within the ideal total dissolve solids; neither less than 100 ppm nor more than 250 ppm. The fresh water was brought to approximately 93°C before being poured directly onto the ground coffee up to the rim of the ceramic cups (set of five). The infusion was left undisturbed for 3 to 5 minutes before the panelists did the cupping evaluation. The perception of coffee's quality was the main reason for the sensory test done by cuppers. Once the cups were presented to the cuppers, the procedure included smelling, breaking the crust, re-smelling and testing the coffee flavors (at around 71°C). The attributes of coffee samples were: fragrance, flavor, aftertaste, acidity, body, balance, uniformity, clean cup, sweetness, defects, and overall. The attributes were rated on a numeric scale within a Cupping Form. The specific flavor attributes are positive or negative scores of quality, reflecting the judgment of cuppers.

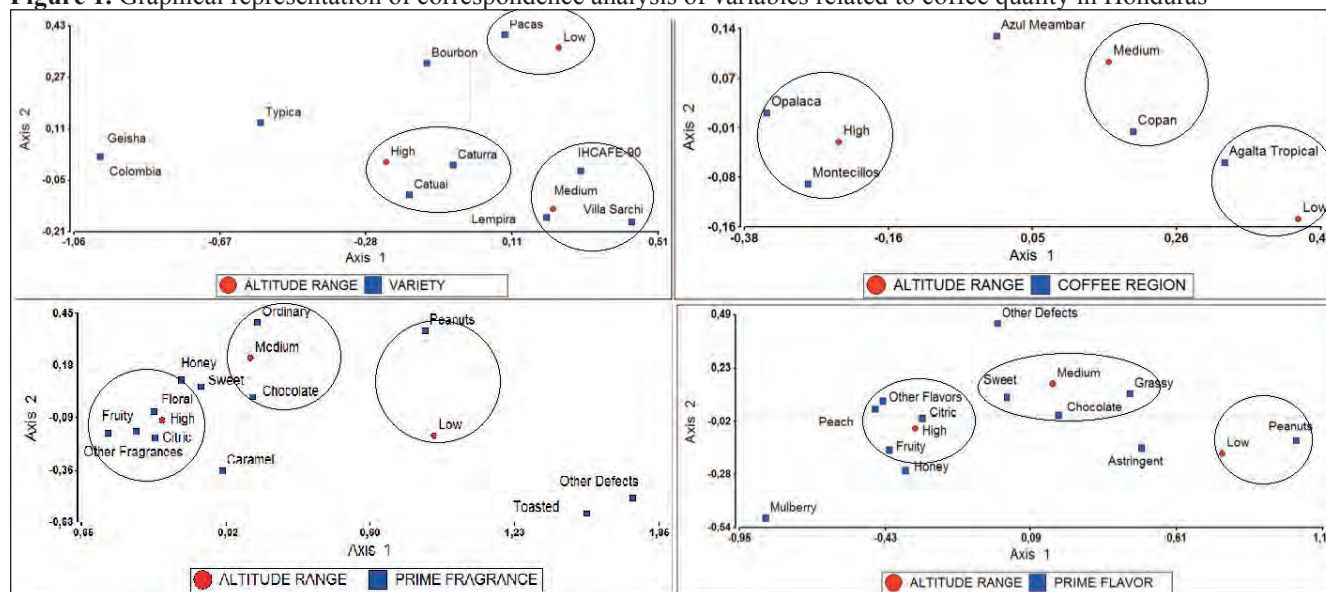
### **Main results**

Following the correspondence analysis, the study exhibited a relationship between some variables under a probability value hypothesis of  $p < 0.0001$  and using the normal approach of confidence interval with a 95% confidence coefficient (Balzarini et al, 2008; Di Rienzo et al, 2008). The analysis found statistical significance between the variables "prime flavor" and "prime fragrance", yet at the same time the analysis found neither a statistical relationship between variable "regions" and variable "prime flavor" nor between the variable "regions" and variable "prime fragrance". The correspondence analysis technique with inertia of 78.89% of chi-square distribution found a statistical relationship between variable "altitude range" and variable coffee agronomic "variety": "low altitude range" was associated to the Pacas and Bourbon varieties; "high altitude range" was associated to Caturra and Catuai varieties, less with to Typica variety; "medium altitude range" was associated to Lempira and IHCAFE-90 varieties and less to Villa Sarchi variety. Other varieties such as Geisha and Colombia were less representative to any altitude range. The correspondence analysis also found a statistic relationship between the variable "regions" and variable "altitude range": "medium" altitude range was related to coffee producing regions of Azul Meambar and Copan; the "high" altitude range was associated with the regions of Opalaca and Montecillos, both in the central part of Honduras; the "low" altitude range was associated to Agalta Tropical in the eastern part of the country. The analysis found a statistical relationship between variable "prime fragrance" and variable coffee crop "altitude range": "medium" altitude range was associated with chocolate, sweet and ordinary fragrances; "high" altitude range was associated with citric, floral, fruity and other fragrances, with more distance from caramel and sweet fragrances; "low" altitude range was distant from peanuts, toasted and other defects. The analysis found statistical significance between variable "altitude range" in files and variable "flavor" in columns: "medium" altitude range was associated with chocolate and sweet flavors, with some distance from grassy and other defects; "high" altitude range was more closely associated to citric, fruity, honey, peach and other flavors and more distant from mulberry flavor; "low" altitude range was associated with peanuts and astringent flavors.

### **Conclusions**

- This study found supporting evidence of diverse profiles of flavors and fragrances in Honduran coffee. Finding correspondences between coffee prime fragrances and flavors. In fact, the cuppers detected these prime flavors: Peanuts, Ordinary, Other Fragrances, Chocolate, Other Defects, Toasted, Sweet, Fruity, Caramel, Honey, Citric and Floral, and these prime fragrances: Peanuts, Other Defects, Astringent, Grassy, Chocolate, Other flavors, Sweet, Citric, Fruity, Mulberry, Honey and Peach. This is very important, especially for differenced coffees at final markets.
- The empirical evidence suggests the importance of crop altitude for coffee cultivation. Particularly in the specialty coffee segment, it is a well-known fact that coffees coming from higher growing altitudes have a tendency to score higher in quality appreciation carried out by coffee experts "cuppers".
- The common link "altitude range" was found amongst analyzed variables, recognizing the importance of the altitude above sea level in the flavors and fragrances coffee infusion, also in the relationship to agronomic varieties.
- Among the profiles of flavors and fragrances analyzed a disturbing fact was also found, defects on coffee were also present (Peanuts, ordinary, toasted, and others). Leaving open the window for further discussion on policy application, particularly in reference to food security and safety, rather than just classifying coffee by perception of quality.

**Figure 1.** Graphical representation of correspondence analysis of variables related to coffee quality in Honduras



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## TOWARD VIABILITY AND ADAPTIVE GOVERNANCE OF TROPICAL ISLANDS AGROSYSTEMS

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**Keywords:** viability, agrosystems, adaptive governance, research-action

### Abstract

GAIA-TROP project contributes to identify and analyze socio-technical conditions for the implementation of agroecological transition in the French Caribbean. We wonder about adaptive capacities of these areas facing exacerbated global changes. The move from a high-yield farming system to a more viable farming system based on natural resources and social interactions has become one of the major issue and challenge for agronomic research. The FAO (2010) supports the end of the productionist model and claims for “smart agriculture” principles which are environmentally friendly. In this context, agroecological transition may be considered as a privileged pathway. Our approach assumes that this transition comes from the ability of all stakeholders (farmers and institutional stakeholders) to build a common paradigm on farming systems' viability. This can be initiated through participatory approaches leading each stakeholder to transform their production systems. Our aim is to create a decision support tool dedicated to agriculture in an island context in order to better understand agrosystems. This tool will help decisions to ensure viability in the reality of global changes and other types of uncertainty.

### Introduction

Launched in 2013, GAIA-TROP is a multidisciplinary project that raises the question of agricultural viability in the French West Indies seen as a laboratory of small islands impacted by global changes. Economic and social sciences, biotechnical sciences and exact sciences are combined to produce effective knowledge on viability conditions of farms. Our objective is to model the functioning of farms from agricultural practices in order to produce knowledge, to guide farmers and to propose trajectories of agricultural evolution to institutional stakeholders. As such is viable each agrosystem that lasts in time by enabling (i) the maintenance of ecosystem services given by a high quality soil and (ii) the assurance of a satisfying income for the farmers.

### Material and methods

One aim of the project is to tackle the observed reality. Our methodology is based on a Research-Action approach (see Figure 1). From this, we developed several methods to interact with stakeholders and to better understand their representation of viability: interviews with the farmers and the institutions, focus groups and participative methods, historical analysis of agricultural sector.

A software called GAIASCOPE is created in order to simulate viability trajectories thanks to algorithms calculations. Those calculations let us know if a soil can be restored or not, on a given period of time. Calculations give the whole set of decisions to implement by taking into account farming and economic constraints. Viable trajectories show time-related evolution of soil quality and economical results regarding to agricultural choices and practices (low vs high-yield) for the soil to reach the expected quality on 40 years. Optimum trajectories give the series of practices and choices to get the best economic performance by improving quality of the soil.

### Main results

Our research show that a decision tool is needed in order to help farmers to implement agroecological transition. The discussion about results from the model let farmers and institutional stakeholders proceed to decision rules in order to guarantee viability.

From interviews with farmers, a typology is defined. 6 farming systems are described following various criteria: area, years of activity, diversity of the production, agroecological viability and socio-territorial viability. Types go from the less to the more viable. The farming system identified as the less viable is characterised by a small area (average 6 ha), exist in average for about 20 years with a weak diversity of production and with no real attention to agroecology. On the contrary farming systems seen as the most viable are biggest areas (average of 11 ha), exist for about 24 years. Agroecological and socio-cultural practices are priorities. Other types are characterised by mixed farmings except one type characterised by one dominant crop (pineapple).

At last, we learn that viability is multifaceted. A large diversity of representations from farmers and institutional stakeholders explains how agriculture in Guadeloupe may be viable. In order to map this diversity, we collected and analysed stakeholders' representations through their discourses and through the institutional documents.

### **Conclusion**

Viability of agriculture is at stake in small islands economies because of the evolution of global changes. The urgent situation to act on these territories highly impacted by global changes make of them pioneer fronts in terms of experience and knowledge of how to adapt. They also give clues on the spatial scale to define in order to impulse these technical, organisational, institutional and territorial evolutions and innovations.

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## DYNAMIQUES PRODUCTIVES ET POTENTIEL AGROECOLOGIQUE DU TERRITOIRE GUADELOUPEEN : UNE ANALYSE DE GEOGRAPHE.

### Productive dynamics and agroecological potential of the territory of Guadeloupe: a geographer analysis.

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#### Introduction

Nous avons construit un premier zonage pour la Guadeloupe, pour répondre aux lacunes des zonages existants, selon la méthode préconisée par la FAO (1997), en lui adjoignant des critères de contexte. Nous l'avons confronté à des données agricoles afin de caractériser la capacité productive des zones agroécologiques définies.

#### Matériel & méthode

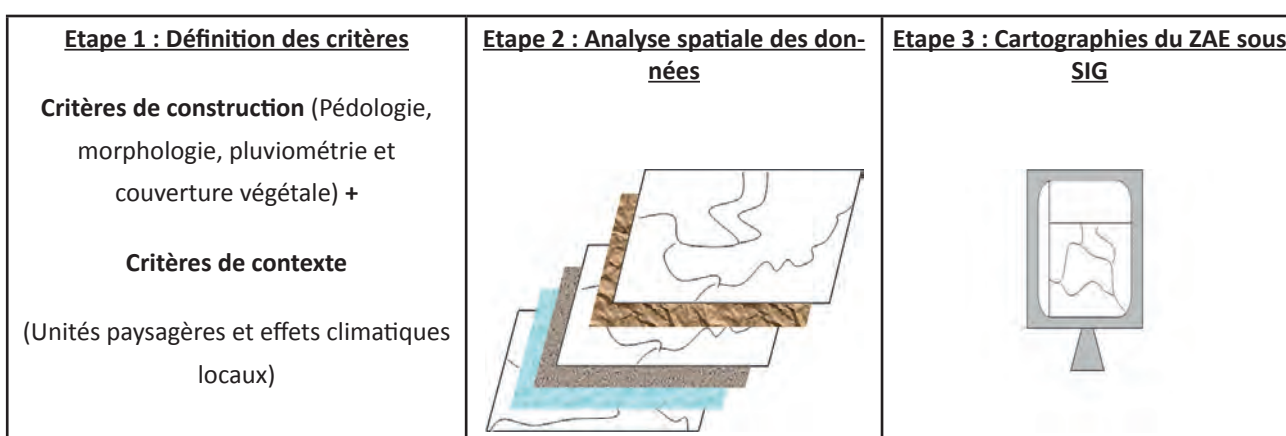
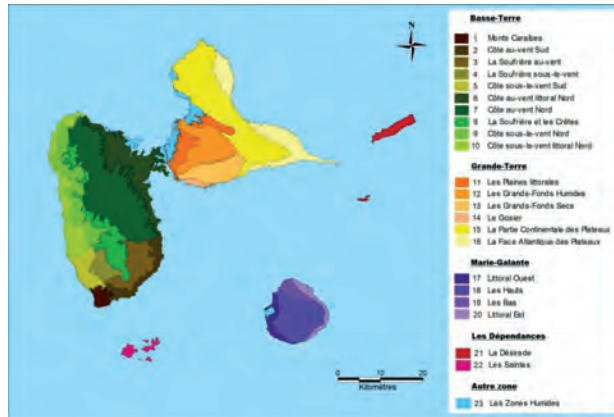


Figure 1. Déroulé méthodologique

Le ZAE se construit à partir d'un recouplement d'informations géographiques et de données : les critères de construction et les critères de contexte. Les uns correspondent aux données pédoclimatiques et aux formations végétales et constituent la base d'un ZAE, les autres sont des singularités naturelles des Antilles françaises avec la diversité paysagère (unités paysagères) ainsi que trois effets climatiques particuliers (l'effet de continentalité ; l'effet orographique ; l'effet de Foehn). Il est essentiel de les intégrer parmi les éléments constitutifs du ZAE car ils ont une influence sur les différents milieux de ces îles et participent, en grande partie, aux différentes ruptures paysagères singulières de ces territoires. Les données des critères de construction agrégées permettent d'obtenir un premier zonage. Après superposition de couches de données correspondant aux critères de contexte, on obtient le ZAE. Les frontières correspondent soit à des éléments physiques reconnaissables dans le paysage soit à des éléments cartographiques. Au regard de notre interrogation sur l'évolution de l'agriculture aux Antilles françaises, des données spatiales relatives aux spéculations produites (nature, volume, répartition) ont été introduites dans le ZAE. Ces données permettent d'évaluer la surface agricole utile (SAU) de chaque ZAE et sa diversité productive en 2009.

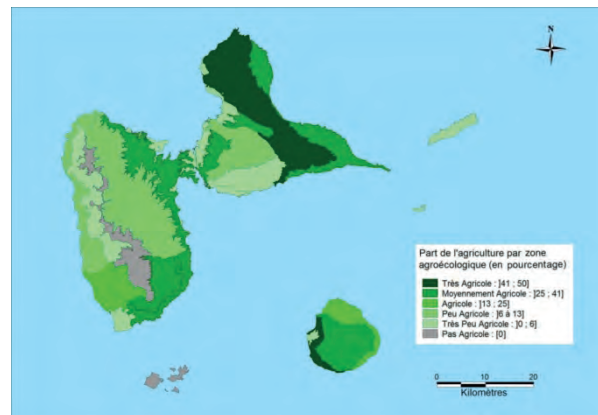
#### Résultat – Discussion :

Nous obtenons un ZAE de 23 zones (carte 1), 10 en Basse-Terre, 6 en Grande-Terre, 4 à Marie-Galante, 1 pour chacune des autres îles du Sud (La Désirade et l'archipel des Saintes) et enfin une regroupant des zones humides à mangrove du littoral du Grand Cul de Sac Marin.



Carte 1. Zonage agroécologique de la Guadeloupe

L'agriculture est partout en Guadeloupe à l'exclusion des crêtes du massif montagneux enserré au sein du Parc National (carte 2).



Carte 2. Part de l'agriculture en 2009 par zone agroécologique en Guadeloupe  
Source : d'après les données du RPG 2009.

Nous proposons une image de la répartition spatiale des types de productions en 2009 par zone agroécologique. La spécialisation historique de la canne à sucre en Grande-Terre et à Marie-Galante et de la banane destinée à l'exportation en Basse-Terre est toujours marquée en Guadeloupe. Les façades au vent sont plus propices à l'activité agricole que les façades sous-le-vent. Mais l'attractivité agricole de certaines zones dépend de facteurs naturels et de contraintes anthropiques. Les zones les plus agricoles bénéficient d'une géomorphologie favorable, d'une pluviométrie suffisante (sans déficit ni excès), de sols propices. Les zones faiblement agricoles ont généralement une accessibilité difficile, une géomorphologie défavorable (zone escarpée), une pédologie contraignante (instabilité, acidité des sols), des conditions climatiques rudes (hygrométrie élevée, vent violent, sécheresse).

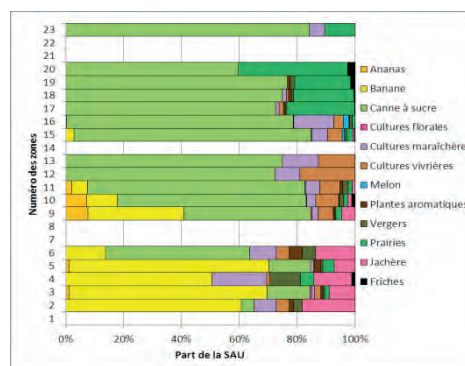


Figure 2 : Part des surfaces par production et par zone agroécologique en 2009 en Guadeloupe  
Source : d'après les données du RPG 2009.



Les contraintes anthropiques n'inhibent pas le potentiel naturel du milieu mais constituent de réels freins, plus ou moins importants, à l'activité agricole. Enfin, l'usage agricole des terres n'est pas forcément en adéquation avec le-potentiel agroécologique des zones telle que définies.

### **Conclusions et perspectives**

Le ZAE de la Guadeloupe a été réalisé en respectant la méthodologie de la *FAO* et a été adapté au contexte naturel du territoire. Il présente un certain nombre de plus-values par rapport aux découpages classiques du territoire. Il est un outil de définition du potentiel agricole et d'aide à la décision dans l'orientation productive. L'analyse de la répartition surfacique des cultures nous permet de voir que si la Guadeloupe demeure un territoire à fort potentiel agricole, la transition écologique n'est pas encore manifeste dans les orientations productives qui prédominent dans les zones distinguées.

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## GADELOUPEAN AGRICULTURE IN 2040: BUILDING UP SCENARIOS TO FOSTER INNOVATION

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**Key words:** foresight study, innovation, scenario planning, global change, agriculture, Guadeloupe

### Abstract

In a context of global change and increasing uncertainties, foresight studies have proven to be a useful methodology to help stakeholders anticipate the future (De Jouvenel, 2000; Godet, 2000). At the global scale, Institutions have undertaken foresight studies to examine the challenges addressed to an agriculture meant to meet the needs of a growing population in a context of increased anthropogenic pressure on natural resources and global change (see Dorin et al., 2011 for the Agrimonde foresight study for food and agriculture in 2050 and the follow up Agrimonde-Terra foresight study on land use and food (in) security, actually in progress). In the different scenarios, innovation has a central role to play to enable agriculture to tackle those challenges. In a proactive attitude and in order to get ready to tackle those challenges the Chamber of Agriculture of Guadeloupe designated a consortium (Inra, HPC Conseil and Ambre Développement) to conduct a foresight study on Guadeloupean agriculture up to the horizon 2040. The objective was to provide an overview of the alternative futures of guadeloupean agriculture so as to help in the future definition of a shared agricultural project for Guadeloupe. The method employed was the scenario methodology (Godet, 2007). Five scenarios were built up that give contrasted representations of the possible futures of Guadeloupean agriculture. Those can be hybridized so as to reflect the views of the different stakeholders. Once those visions have been shared and debated, they will have to be translated into an effective action plan in order to build up a proper agricultural project for Guadeloupe.

### Material and methods

We adopted the scenario methodology, a participatory methodology that implies the consultation of a wide range of experts on the past tendencies and future evolution of the system at stake. Eight foresight workshops were conducted during ten months with a working group that comprised a panel of experts and a project team. The system: Guadeloupean agriculture in 2040, was defined as a set of 9 components and more than 40 variables. Each variable was analyzed in order to understand its past and present tendencies and hypotheses were elaborated on its possible future evolution. These hypotheses were combined to produce scenarios that complied with a set of principles that include: relevance, likeliness, coherence, importance and shared representation (Godet, 2007).

### Main results

#### *Main tendencies of evolution of the system*

Guadeloupean agriculture is characterized by a general decline (fewer arable land, fewer farmers and farms, lower accessibility to loans and credits) and high dependency from external inputs (imports, subsidies) in a context where the availability of productive resources (land and water) is relatively low.

There is an historical coexistence of on one side, a sectorial organization of the agricultural sector based on public help and export oriented productions, and on the other side an informal sector characterized by self-organized micro-networks targeting local markets.

Technical advice and support exist but there is heterogeneity in their accessibility to farmers and a certain amount of demands are not met.

In a Creole society that has been formatted by the colonial system, the social group of Guadeloupean farmers has emerged relatively recently and has only been institutionally recognized for the last 40 years with the progressive decrease of the importance of the sugarcane sector in the economy. Therefore self definition and projection is a real stake for this group today.

Food habits are standardized. This can be explained by a heavy reliance on imports for food supplies that diffuses an exogenous model of food consumption. As for local production consumers consider that it is expensive, lacks visibility and of uneven quality.

There is a shift towards a global governance of agriculture. At the European level, a common agricultural policy has been defined which is enforced by regions under state control. Important subsidies have been provided to Guadeloupe whose impacts on agriculture are somehow mixed.

Global trade has been liberalized and there is a regional economic convergence within which new actors - emerging countries – appear with potential high consequences on regional trade. At the same time, the import substitution strategy of Guadeloupe has failed; its export apparatus remains structurally weak and mostly targets mainland France. The focus has been on export crops which are subject to quotas and guaranteed prices but not competitive at the global scale. Negative impacts of climate change have been perceived and include at the regional level: regional droughts, light increase in waterfalls, increase in the frequency of climatic events, continuous degradation of arable land, increase of the sea level and soil erosion.

#### *The five scenarios*

Five contrasted scenarios were built up that represented the diverse possible futures of the guadeloupean agriculture up to 2040. Those were entitled: 1) The status quo: a declining agriculture and an increased dependence; 2) The end of peasants, long live agribusiness; 3) Go for cane! Versatility and quality as the basis for rural development; 4) Biodiversity and ecosystem services managers; 5) The agroecological turn for food supplies of proximity and quality. While the scenario 1 represents the pursuit of the actual trends of guadeloupean agriculture, the scenario 2 testifies of the replacement of the actual group of farmers by businessmen in a context of high private financial inputs in agriculture. Scenarios 3, 4 and 5 imply a paradigm shift in the way agriculture is conducted and perceived within the territory. They represent different pathways for innovation within the agricultural sector. The scenario 3 is the one of the appropriateness by farmers of a specialized form of agriculture around one specific production that is valorized in several possible ways. It is the scenario of a specialized bioeconomic development of agriculture. The scenario 4 establishes farmers as real ecosystem services providers and biodiversity managers for the whole society while scenario 5 proposes that farmers contribute to a qualitative break in household purchasing practices, like a kind of response to a serious awareness of public health problems and bad consumption habits within the guadeloupean population. It has to be noted that the different scenarios are non exclusive and that hybridation can occur between them according to the different stakeholders' vision. Whatever the scenario, policy makers are involved with the agricultural sector, often with direct financial contributions. It must however be noted that the scales of governance in Guadeloupe are diverse and not all meet the same objectives. Social peace and territorial development objectives for local authorities, protection objectives of the national food industry for the state, trade liberalization objectives for the European Union... The relative weight of these three levels of decision for the agricultural policy guidelines of Guadeloupe is decisive to build the future of agriculture within this territory... It is clear that stakeholders do not always see the farmer from the same angle, so that their look undoubtedly influences the relative empathy they will feel towards those professionals and their socio-economic and environmental contribution to the identity and sustainable development of the territory.

#### **Conclusion**

Those five scenarios give different representations of the possible future of Guadeloupean agriculture. S1 and S2 could be considered as business-as-usual scenarios albeit under different funding schemes. S3, S4 and S4 are breakup scenarios based on different public policies. Those scenarios answer different challenges that Guadeloupean agriculture will have to tackle in the future and raise new questions about the adequate levers to implement those alternatives visions. Results of the study now need to be shared and debated with a broader range of actors within the territory. Consequences of implementing the different scenarios must be assessed at different levels before they can be translated into strategic and operational planning.

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## DESIGNING GUADELOUPEAN AGRICULTURE IN 2040: IMPLICATIONS AND CONDITIONS OF FIVE FORESIGHT SCENARIOS ON THE FUTURE OF GUADELOUPEAN AGRICULTURE IN ORDER TO TACKLE FUTURE CHALLENGES

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**Key words:** scenario planning, evaluation, global challenges, sustainable agriculture, territorial development, governance, identity

### Abstract

Agriculture constantly has to adapt to new challenges. Among the tools actors on the ground, can mobilize in order to prepare themselves and to anticipate those challenges is scenario planning (De Jouvenel, H., 2000; Godet, M., 2000). Five scenarios were elaborated after a foresight study on Guadeloupean agriculture in 2040 at the request of the Chamber of Agriculture of Guadeloupe and in order to pave the way for a shared agricultural project for Guadeloupe (see Barlagne et al., 2016 a). We examined the extent to which those scenarios could help local stakeholders tackle head-on, some of the challenges for Guadeloupean agriculture. This is the first step towards the definition of an action plan leading to the desired outcomes for Guadeloupean agriculture in the future.

### Material and Methods

Issues considered (by the working group involved in the scenarios definition) as important for Guadeloupean agriculture in the future were among others: i) to design a sustainable agriculture that improves food security and generates employment through a well balanced territorial development; ii) to define governance mechanisms giving venues to endogenous policies answering local expectations and; iii) to ensure that the social group of the Guadeloupean farmers is maintained in its ability to remain the custodian and guarantor of a shared identity basis. The five scenarios were examined in their capacity to tackle those challenges. First, their implications in terms of local employment and territorial development were evaluated. So was the agriculture they describe, in its ability to meet the food needs of the population both quantitatively and qualitatively. Then, the dynamics they trigger within the territory was explored while the options they offer in response to climate change were discussed. Next the conditions of their realization were assessed in terms of the possible sources of funding for agricultural activities as well as adequate research, training and development system (RTD) and governance mechanisms. To finish with, the joint evolution of the social group of farmers and of the society was extrapolated.

### Main results

The five scenarios provided a differentiated answer to the different challenges.

As far as employment and territorial development are concerned, scenario 1 and 2 reflect a general decrease in the number of farms and farmers and indirect employment on the opposite to scenarios 3, 4 and 5. When it comes to hired labor, S2 and S3 are the ones that contribute more importantly to an increase of direct employment.

Contribution to food security, food sovereignty and public health indicators were evaluated as follow: in terms of food security, S4 and S5 are more likely to contribute to food security than S1, S2 and S3; food sovereignty is more warranted in S4 and S5; public health indicators are also the best in S4 and S5.

The triggered dynamics at the territorial scale results either in the containment of agriculture to specific areas or in a well balanced and coherent spread of it throughout the territory. In S1 and S2, the focus on economic performances of agriculture leads to the use of the least expensive to develop area (ei.: mountain ridges). In S3, the specialization on one crop entails its generalization to the more difficult areas even. In S4 and S5, agriculture takes advantage of the agroecological potentialities of the territory and is designed in those lines.

The scenarios offer different responses to climate change. S2 and S3 provide two options to cope with global warming. While S2 foresees the development of an industrial agriculture that can be regulated to cope with a wide range of conditions and constraints, S3 bets on a safe speculation – cane – that can adapt to an increase in temperatures and unpredictable events. In S4 and S5, global warming is handled thanks to the alternatives offered by biodiversity and by adapted varieties and farming practices.

In terms of financial support to agriculture, S1, S4 and S5 establish the retention of public funds while private and foreign capitals take over in S2. In S3, the competitiveness of agriculture increases and lays the ground for a self-financed

agricultural development. Civil society also represents a stakeholders' group of growing importance in the orientation of agriculture and territorial development. It gets involved in S4 and fully supports farmers in S5.

As for the Research, Training and Development System (RTDS), it evolves from a sector oriented form in S1 (in continuity with what has traditionally been the rule so far in Guadeloupe), to complete outsourcing of the agricultural expertise and support in S2. It embraces diversification through the widening of the spectrum of agricultural activities in S3. S4 and S5 testify of a complete evolution of the RTDS towards more comprehensive visions. The focus is on ecosystem services, their recognition and remuneration in S4 and on food production thanks to agroecological farming in S5. In both cases, references on such topics have been elaborated so as to design efficient farming systems and provide farmers with adequate support.

In terms of governance, different levels were identified that need to converge in order for the different scenarios to become effective. In particular, the conditions of convergence of the regional and civilian governance need to be newly defined and improved for a shared and adequate development scheme to be adopted at the local scale.

Finally, the evolution of the social group of farmers as a reference group for culture and identity was extrapolated as follow: from a complete disappearance in S1 and S2 with the recognition of external values as the norm in S2, the group gets a better recognition in S3, S4 and S5. Its status evolves towards the one of identity custodian (albeit under contrasted schemes) in S3 and S4 while there is a complete osmosis between the identity basis and projection of the social group in modernity in S5.

### **Conclusion**

The five scenarios addressed different challenges and reflected contrasted public policies. Their evaluation enabled to realize that heading towards a desired future is not a single issue and that conditions, implications and consequences need to be thoroughly assessed before moving forward.

This work is the first step towards the definition of an action plan leading to the desired outcomes for Guadeloupean agriculture in the future. Results of the study now need to be shared and debated with a broader range of actors within the territory in order to be translated into strategic and operational planning.

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## WATER AMBASSADOR PROGRAM

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**Keywords:** Water conservation, water resources, Water Supply Problem, Education, Hydrology, <sup>1</sup>

### Abstract

The United States Virgin Islands is a small territory in the Caribbean Sea just to the east of Puerto Rico that consists of four main islands, Saint Thomas, Saint Croix, Saint John Water Island, and a few smaller, mostly unpopulated islands. The majority of the people in the territory live on Saint Croix and Saint Thomas. Saint John and Water Island contain smaller populations. A significant proportion of the population of all of these islands draws their water from cisterns that collect rooftop water. The others are dependent upon groundwater sources. In addition to its permanent residents, Saint Thomas has one of the busiest tourism industries in the Caribbean (Allen 1992) with more than 2 million visitors annually in recent years (USVI BER 2012). Children were given six lessons in hydrology, took part in a pre and post test and also wrote an essay about the water cycle. They also tested water from their schools, home and around the community. They charted the outcome of the testing results and presented them to professors from UVI. These activities increased their awareness of the need for clean water in our community.

### Introduction

This project set up a Water Ambassadors Program which trained Cooperative Extension Service personnel at the University of the Virgin Islands to deliver lessons to youth in grades six on hydrologic processes and watershed protection, extend the existing network of climate recording stations on Saint Thomas and create an interface for collecting map data on hydrologic condition from the public. The project advanced the literacy about hydrology and was aimed at youth in public education, specifically, about water resources and their management on Saint Thomas. There has been and continues to be a need for data collection on the status of streams and watersheds and increased understanding of climate patterns on the island. The goal was to prevent or reduce nonpoint source pollution (NPS) of underground and surface water as well as bring to attention the importance of water quality and the need for the testing of water in schools, homes and the community overall while also encouraging and promoting development of the understanding of watersheds so that youth can reduce their impact and conserve water and other natural resources. This proposal began a model educational program to teach students the stewardship of good water and landscape conservation practices, create a system for collecting crowd source data (data collected by the public through a web mapping interface) on the status of hydrologic systems in the Territory using these students to report on their own watersheds, and increase the spread of weather station system currently operated by the University of the Virgin Islands on Saint Thomas by bringing a station to each participating school.

### Methods

Researchers Dr Morris and Dr Primack at UVI also increased the overall territory weather station network which allow for greater resolution in constructing climate models for Saint Thomas. The collaboration between the VI WRRRI grants allowed for more than six stations to be added to a network of more than 16 weather stations across the territory (Figure 1). This project greatly contributed to the overall reach and success of that network and what UVI researchers are hoping to accomplish as far as the data collection from those systems.

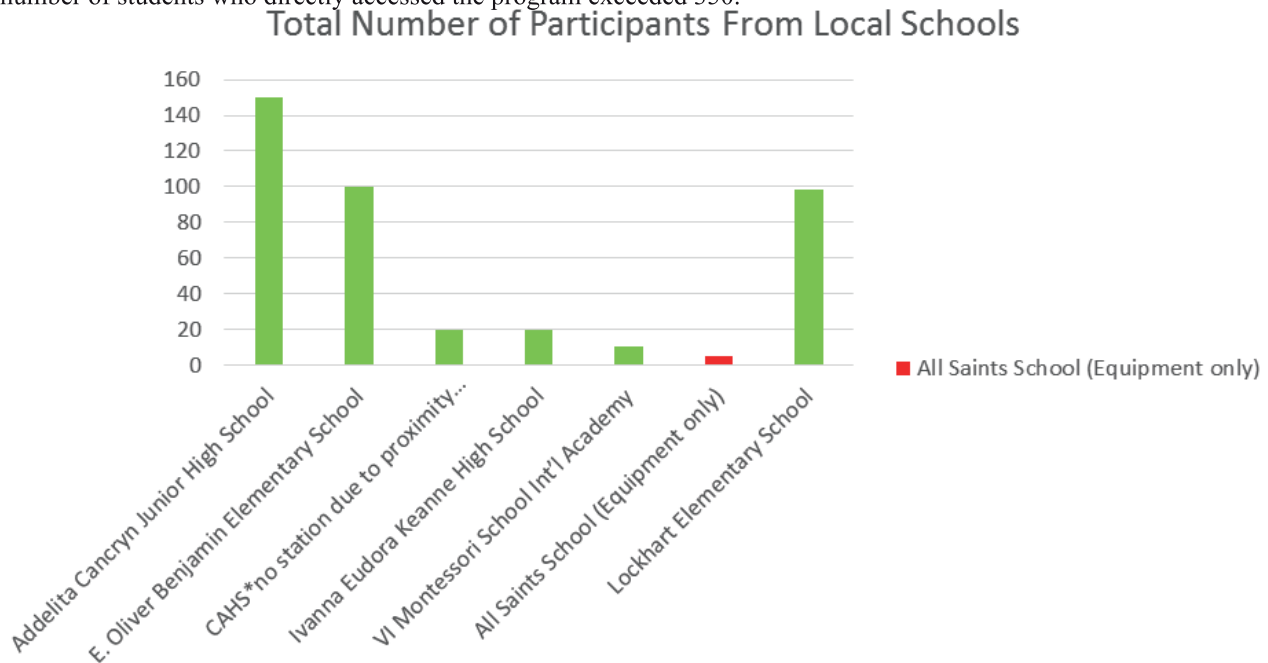
### Research

#### Weather Stations Added to Network

School	Grade
Addelita Cancryn Junior High School	7-8 <sup>th</sup>
E. Oliver Benjamin Elementary School	K-5 <sup>th</sup> (4-5)
Ivanna Eudora KeanHigh School	9-12 <sup>th</sup>
VI Montessori School Int'l Academy	K-12 (private)
All Saints School	K-12 (private)
Lockhart Elementary School	K-6 (4-6) (ESL)

(Figure 1) More than 6 stations were added to the network in St Thomas

Furthermore, it was estimated that 100 youth from five schools in St. Thomas would take part in the program but the actual number of students who directly accessed the program exceeded 350.



(Figure 2) More than 350 youth accessed the Water Ambassador Pilot Program

### Conclusion

The Water Ambassador Program advanced the literacy of hydrology in youth in the public education school system specifically in the areas of water conservation, water resources and their management on the island of Saint Thomas. Youth took part in data collection on the status of watersheds and increased understanding of climate change and climate patterns on the island. More than 16 teacher and 350 youth participated in the program. The project needs a more specific evaluation process to ensure that both ESL and non ESL youth accessing the program can be equally served. Having a Big Production is vital as it gave youth a chance to present their findings in a formal college level setting and afforded them the chance to interact directly with a variety of researchers. In the future, administrators and teachers alike should be trained as the needs for STEM based learning is helpful in meeting their goals as they relate to science and the Next Generation of STEM Standards (NGSS) which are being used by DOE. Overall, the program was highly successful, had an impact in raising awareness and gave youth a chance to learn about and create messages on clean water initiatives. Youth also took part in writing essays about the water cycle. Youth, teachers and administrators took part in testing water from their home and schools. Broadening the program to reach more youth is beneficial as it increases the data collection being done by Dr Morris and Dr Primack for the purposes of weather climate modeling. It also contributes to the research being completed by VI Department of Ag to monitor drought conditions territory wide.

### References

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### List of Presentations

CJ Fahie; Kamal Walters; (youth presenters); August 2015; 31<sup>st</sup> Annual Agro Economics Conference; St Croix, USVI  
 Christina Chanes, Dr Avram Primack, March 2016, Water Ambassadors Program; eXtension Conference; San Antonio, TX

### Student Participation

Calywn Morton (Undergraduate), University of the Virgin Islands, Biology





52<sup>nd</sup> CFCS Annual Meeting,  
Guadeloupe, July 10-16, 2016

**Farmer's Forum**  
**Policy Marker Forum**



## SYNTHESIS OF THE FARMER'S FORUM

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### agro

The Farmer's Forum is usually conducted in the form of a mini-show, opened to agricultural and agroprocessing professionals and agri-suppliers. Since the 51st congress of the CFCS in Surinam in 2015, a new dynamic has been initiated, giving priority to workshops bringing together agricultural professionals (farmers, breeders, agroprocessors, advisors, technicians, researchers, engineers) and participants of the CFCS meeting, around issues and strategic issues for agricultural development. In line with the challenge of ecological modernization of Caribbean agriculture, the Steering Committee of the CFCS 2016 prioritized a workshop focused on innovation and the evolution of structuring mechanisms and networks to boost the impact and progress in Caribbean agriculture.

The Farmer's Forum aimed, on the one hand, at a collective appropriation of different concepts and devices for innovation and transfer in the context of the agroecological and energy transition, and on the other hand, to facilitate the sharing of experiences on existing structuring mechanisms aiming at elaborating a first specification for a networked Caribbean living labs device.

The forum was held on a single day (Wednesday, July 13, 2016), with three highlights, articulating in:

- i) a crossed fertilization around the concepts and definitions about "innovation",
- ii) testimonies on dedicated structuring devices for innovation in agriculture;
- iii) the organization of a workshop on the living labs project.

The Farmer's Forum attracted a good mobilization of local professionals (82), associated with the participants of the 52nd congress of the CFCS (147 participants in total). It was organized around 4 presentations that allowed defining, in a generic way, the definitions and concepts useful to apprehend the innovation processes in agriculture:

- i) Innovation (V. Weck, Regional Council of Guadeloupe & N. Chevon, Synergile);
- ii) Transfer in innovation processes (P. Rebuffel, Cirad);
- iii) The agro-ecological transition (V. Angeon, INRA);
- iv) The specificities and possibilities of living laboratories in the light of experiments (D. Lafontaine, University of Quebec).

These conceptual presentations were enriched with testimonies on concrete examples of innovation and transfer processes:

- i) in the West Indies, with:
  - the experience of RITA (M. Gérard, RITA-Guadeloupe),
  - the experience of the DEPHY farms in Guadeloupe (Y. Boc, Chamber of Agriculture);
- ii) in the Caribbean with the examples of :
  - Caribbean Agriculture Providers' Network (CAEPNet) (N. Samuel, University of Florida),
  - the PIAL experience in Cuba (E. Calves-Somoza, National Institute of Agricultural Sciences in Cuba)

The main deliverable of this forum is the collection of the main concepts that revolve around the theme of innovation and especially the emerging concept of living labs.

Four round-tables were led in parallel with dedicated moderator and reporters (P. Obertan, T. Noglotte, P. Rebuffel and S. Gabon), including between about 20 professionals. They tried to answer mainly two expectations:

- i) Positioning and needs of the farmers (techniques, organization, outlets, etc.) with regard to the priority given to agroresources and particularly protein resources ?
- ii) What governance for the structuring devices for innovation (living labs)?

The main priorities targeted by these discussions are:

1. Has the question relative to the positioning towards the protein resources, echoed the following proposals:
  - Do not limit to the only protein resources, as announced in the pre-project OCABA, and work on the diversity of the local vegetable and animal resources, with a focus on the local peas for the protein sector.
  - Facilitate the access to seeds, in particular to traditional seeds.
  - Requirement to draw up a current situation of the resources and the traditional practices of production and processing.

- Work according to the principles of the agroecology, including the mixed farming and breeding systems, the associations of cultures and the cultural rotations.
  - Develop the demand and the sensibility of the consumers: question of outlets for the agricultural and food-processing production sector, in connection with the change of food practices and the health of the populations.
  - Recognition of the real potential of the practices and the traditional know-how, and difficulties for the ad hoc development of production sectors (in particular for the protein resources), in sync with the constraints inherent to the small territories
2. Concerning the question of the governance of the devices of innovation:
- How to develop the notion of networks on small territories and more particularly places dedicated in exchanges between actors? build a common link of meeting and writing between the actors.
  - Necessity of a multi-actors partnerships between the production and the processing sector (participative governance: professionals, representatives of the companies, Farmers' association, technical institutes, RITA, Research institutes, investors, political decision-makers) in connection with experimental farmers.
  - Required to impulse mixed public and private financing
  - Need to improve the advisory process: scientific, technical, and financial support for the technological and organizational innovation at the scale of the farm.
  - Better communicate by the mean of all the media / press, and the organization of pragmatic debates, according to three topics: i) agronomy, soil, plant and animal productions, ii) health and human food supply, iii) health and animal feed.

The Farmers Forum allowed identifying several points of vigilance

- - The difference which still remains between the perception of the needs of the farmers by the research vs. the expectation which have the farmers towards research institutions, and which are not registered as priorities with regard to the local context, for example fights against the cassava ant (*Acromyrmex octospinosus*), supply of local seeds of traditional or orphan products. Tracks are proposed to the RITA for a more regular updating of the expectations of the producers.
- The presentation on the agroecological transition and living labs aroused some remarks of the professionals on their academic side, insufficiently documented by concrete examples, what not sufficiently deprives their intrinsic interest. It hindered a little the capacity of the producers to fall on precluded living labs during the workshop of the afternoon, in particular on the notion of collaborative space on the open innovation.
- The focus on the protein resources, initially prioritized in the OCABA project, made debate, and the producers pronounced unanimously for a wider consideration of the biodiversity of the tropical agroresources.
- The initial schedule was considered slightly too ambitious,
- No concrete proposal in favour of the agrotransformation, while it is about a major stake for the development of our local sectors, in particular for the protein resources.

The key point of the workshop was to put in situation the professionals and the participants of CFCS on the major theme of the innovation. It is the first local initiative on the development of the concept of living lab in agriculture. Globally this forum opens several interesting working tracks:

- The sector testimony allowed reminding that there are several examples of structuring devices for the innovation which work and which could gain to be better valued in living labs to come.
- In the light of the various presented initiatives, RITA or quite different structuring device for innovation could open gradually to establish a real Caribbean network of innovation.
- The workshop was an opportunity for the workgroup to appropriate of the concept of living laboratory, in connection with challenges regarding transfer and innovation; it was also one constructive stage around the consolidation of the reliable plan of the continuum research-innovation-impact in agriculture, in particular for the innovation pole Synergile in its approach of opening to the agricultural world. It constitutes besides an excellent prerequisite in the projections to come within the framework of the project OCABA.

The perspectives converge on the preservation of a local animation on the approached subjects, aiming in particular to fill the unsatisfied expectations during the forum, namely:

- Those concerning living labs: plan a meeting in situation around the living lab of Gourbeyre followed by a debate to concretize better the concept;
- The prioritization of agroresources for the strengthening of the food safety;
- A debate on the food stakes and the development of the bioeconomy in the Caribbean

So, we plan a workshop on the return of CFCS at the beginning of 2017, and more particularly of the farmers forum to the agricultural sector, enriched by the evolutions concerning the OCABA project.



## VOICES OF RURAL FARMERS IN SURINAME ABOUT CLIMATE CHANGE, AGRICULTURE INNOVATION AND LANDSCAPE MANAGEMENT

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**Key words:** Voices of farmers, Climate change, Innovation, landscape

### Abstract

Many rural areas in Suriname are lacking information on technology from extension agents from the government extension agency, and research institutes. Communication and informal voices of farmers are shared by media. As part of a baseline study conducted for the sixth operational strategic plan of the Small Grants Programme in Suriname, four communities were selected: Moengo, Pokigron, Nickerie, Sipaliwini and Para. The purpose of this study was to collect data from communities regarding problems related to climate change, agricultural innovation and landscape management. This qualitative study was done through the focus group method. Eight focus group meetings were organized and consisted of 8-15 participants each. The key questions were extracted from the SEPLS method (Socio-ecological Production Landscapes and Seascapes). The data was analyzed through the SWOT method. Based on the results, the communities have a good level of awareness about management of their landscapes. Improvement of agriculture management will be possible by access to innovative and new knowledge developed in and outside the community. Climate change is an important issue that the community already is aware of, they developed their own local strategy in resilience to this issue.

### Introduction

Many rural areas in Suriname are lacking information on technology from extension agents from the government extension agency, and research institutes. Before making use of new technology, farmers should acquire a broad knowledge ranging from climate conditions, cultivation techniques, pest management and price. This knowledge can be gathered through their social networks, information sharing and their own experience. The purpose of this study was to collect data from communities regarding problems related to climate change, agricultural innovation and landscape management.

### Materials and methods

In this research investigation, a qualitative study was conducted using the focus group method. Eight focus group meetings were organized and consisted of 8-15 participants each. The key questions were extracted from the SEPLS method (Socio-ecological Production Landscapes and Seascapes). This toolkit has provided practical guidance for making use of the "Indicators of Resilience in Socio-ecological Production Landscapes and Seascapes (SEPLS)" in the field. The respondents who participated in these workshops are members of the local community and stakeholders in the selected areas. Four communities were selected: Moengo, Pokigron, Nickerie, Sipaliwini and Para. A set of questions were designed to capture communities' perceptions of factors affecting the resilience of their landscapes and seascape. Their participation allowed them to evaluate current conditions across the landscape and identify and reach agreement on priority actions, contributing to enhanced communication among stakeholders and empowered local communities. Data was collected and qualitative analyzed with SEPLS and SWOT indicators.

### Results

The results show that in the forest landscape, in contrast to the coastal zone where rice is cultivated as a monoculture, the practice 'slash and burn' is mainly used. Farmers reserve their lands for vegetable production. Local knowledge about 'slash and burn' systems is present in the focus groups. The target group is aware of new technologies and innovation. Traditional and non-traditional technology and knowledge is used by the local communities to implement in the landscapes. Women play an important role in agriculture knowledge and dissemination in their community. In the community there is a lack of experience and knowledge in climate smart agriculture practices, and in the development of improved rice varieties. Water management is a main problem for the agriculture systems in both landscapes. Seasonal changes, including rising temperature causes a lot of harm to the 'slash and burn' systems which are disturbed by it, and causes low production outcomes.

## **Conclusions**

From the results it can be concluded that:

- Communities have a good level of awareness about landscape management
- Access to innovative and new knowledge developed in and outside the community can improve agriculture development
- The community is aware of climate change
- Communities have developed their own local strategy in resilience to climate change

## **References**

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## POLICY MAKER'S FORUM

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The Policy Maker's Forum is an original initiative within CFCS. It proceeds of the conclusion that the projections regarding research and development in our Caribbean region cannot exclude the dimension concerning the public policies. So, in addition to the scientific and technical sessions and to the Farmers' forum, classically handled during the congresses of CFCS, it seemed to us important to include this strategic dimension associating the policy-makers around whom and for whom this forum was held. It meets also the initiative of the "Road map for Guadeloupe", led by the Regional council of Guadeloupe in 2014, and answers more particularly the challenges associated to the implementation of a blue and green economy in our Caribbean region. The central hypothesis relies on the idea that a bioeconomic development cannot be made in an isolated way, but requires an integrated and strategic approach, mobilizing a set of country of the Caribbean. The objective consisted in deepening the question of bioeconomy as a possible answer for problems shared in the Caribbean. This forum was planned in connection with a strategic meeting scheduled on September 16th after the CFCS, around a preparation of an INTERREG project entitled OCABA "Observatoire Caraïben et Amazonien de la Biodiversité et des Pratiques Agricoles" with a set of Caribbean partners.

This workshop attracted a strong mobilization, bringing together representatives of the Greater Caribbean, representatives of territorial communities (Guadeloupe, Martinique, Saint Martin) and many participants at the 52nd congress of the CFCS (112 participants in total). The workshop was introduced by a brief presentation of the OCABA project (H. Ozier-Lafontaine), allowing to put into perspective the debates to come. It was complemented by a presentation of the challenges facing the Caribbean bioeconomy (T. Noglotte), highlighting the challenge of food security: the vast majority of Caribbean economies depend on between 70 and 80% of food imports. Dr. Adrian Rodriguez's (ECLAC) master presentation laid the foundations of the bioeconomy and facilitated a shared understanding of the inherent concepts through a rich mix of definitions and meanings about this emerging movement, including the relationship between the various components that revolve around the bioeconomy. This dimension was enriched by an analysis of the stakes surrounding the valorization of local agrosources and adaptation to climate change (H. Ozier-Lafontaine).

The second highlight, dedicated to the testimonies, made it possible to bring out two complementary visions: i) that of the KBBE (C. Hodson), which emphasizes a scientific popularization of the bioeconomy in a dynamic application; ii) that of the Barbadian Government (D. Bynoe), which develops a vision for the implementation of a green economy based on coordination between government and civil society.

The third highlight was the restitution of two surveys: i) an exploratory survey, on the positioning of the Caribbean countries on the agroecological transition and the bioeconomy, ii) an analysis of the bioeconomic potential of the Caribbean countries vs. the associated risks and threats.

Finally, we can conclude that there is a real blend of vision among stakeholders from different countries on the issues, concepts, risks and shared interest in promoting the bioeconomy in the Caribbean region. We were besides able to measure convergent interests, being translated around the initiative OCABA, in particular during the meeting of July 16th, 2016 with the partners. We were so able to establish and validate the constitution of a consortium for the implementation of the project.

It is thus the very positive balance sheet which we pull of this original initiative of the Policy Makers Forum, which opens a concrete way of Caribbean co-construction around the concept of bioeconomy.



