Application of DEXiPM® to assess the sustainability of an innovative apple production system : the exclusion netting

Aude Alaphilippe, Frédérique Angevin, J. Buurma, T. Caffi, Yvan Capowiez, Gabriele Fortino, B. Heijne, H. Helsen, I. Holb, M. Mayus, et al.

Future IPM in Europe

19-21 March 2013 | PalaCongressi - Riva del Garda, Italy

BOOK OF ABSTRACTS

About the Conference | Organizers

Fondazione Edmund Mach

Centro di sperimentazione agraria e forestale di Laimburg

European project “Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management” – PURE

in collaboration with:

Provincia Autonoma di Trento

Provincia Autonoma di Trento

Regione Trentino Alto-Adige

Ministero delle politiche agricole alimentari e forestali

European network ENDURE

International Organisation for Biological Control of noxious animals and plants (IOBC-WPRS)

International Biocontrol Manifacturers’ Association (IBMA)

Mediterranean Phytopathological Union (MPU)

Giornate Fitopatologiche

Società Entomologica Italiana

Società Italiana di Nematologia

Società Italiana di Patologia vegetale

Associazione Italiana per la Protezione delle Piante

CIHEAM/Mediterranean Agronomic Institute

European project “Strategies to replace copper-based products as plant protection products in low input and organic farming systems” – CO-FREE

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Program | Plenary session - March 19

Plenary sessions – Sala 1000*	
9.00 9.15	**Welcome and opening -** Ilaria Pertot, Claudio Ioriatti and Manfred Wolf
9.15 9.30	**Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management; an EU project -** Françoise Lescourret
9.30 10.15	**The EU strategy for sustainable use of pesticides and the promotion of integrated pest management (IPM) -** Patrizia Pitton
10.15 11.00	**IPM - an old concept full of innovation -**Franz Bigler
11.00 11.30	**Coffee break**
11.30 12.15	**Optimization of spraying techniques to reduce impact of pesticides-** Jan van de Zande
12.15 13.00	**Design cropping systems with high productive performance and low use of pesticides -**Jacques Wery
13.00 14.00	**Lunch break**
14.00 14.40	**Developing alternative, non-pesticidal pest management methods: case studies from fruit crops -** Jerry Cross
14.40 15.20	**The EU directive 2009/128 may upgrade pathogen biocontrol agents from niche to full scale applications: are we technologically ready? -** Matteo Lorito
15.20 16.00	**The biopesticide innovation chain: how can researchers and industry collaborate to commercialize biopesticide products -** Susan Boyetchko
16.00 16.30	**Coffee break**
16.30 17.10	**IPM strategies and non-traditional biological and chemical alternatives for the management of plant-parasitic nematodes -** McGawley Edward
17.10 17.50	**Cis-genic plants as alternative to fungicide for the benefit of the environment and consumers -** Cesare Gessler
17.50 18.30	**Double role of Biochar: climate change mitigation and a tool for integrated management in agricultural systems -** Yigal Elad
18.30 19.00	**Research on sustainable management of crop health at INRA -** Le Gall O. and Reboud X.

*** Streaming on www.futureIPM.eu**

Program | Parallel Sessions - March 20

Parallel sessions FUTURE IPM - Sala 1000			
Session - IPM: STATE OF THE ART, CASE STUDIES PROSPECTIVE IN EUROPE AND FUTURE CHALLENGES - chairpersons Ricci P., Galassi T.			
09:00	**09:30**	Ricci P.	The promotion of IPM and pesticide-related research in the frame of the French Ecophyto plan (keynote speaker)
09:30	**09:55**	Ciampitti M.	Evolution of IPM in Italy (keynote speaker)
09:55	**10:15**	Tommasini M.G., De Natale R.	Application of IPM in Italy: the point of view of producers and large scale retailing (keynote speakers)
10:15	**10:45**	Jiménez Diaz R.M.	Verticillium wilt in olive: a paradigm for IPM of a complex soilborne disease (keynote speaker)
10:45	**11:00**	Fracasso F.	IPM against soil pests: the basic strategy and some successful case studies
11:00	**11:30**	**Coffee break**	
11.30	**12.00**	Logrieco A.	MycoRed contribution in Fusarium head blight integrate management (keynote speaker)
12:00	**12:15**	Vos J.	Plantwise: global alliance for plant health in support of integrated pest management
12:15	**12:30**	Reau R.	Innovative IPM for winter wheat based rotation: first results of ex post assessment from France
12:30	**12:45**	Melander B.	Non-chemical weed control methods as components in IPM solutions for reduced tillage systems
12:45	**13:00**	Samietz J.	Combination of alternative strategies for low-residue fruit production in Switzerland
13:00	**14:00**	**Lunch break**	
14:00	**14:15**	Wijnands F.	Farming with future - stakeholder involvement in development and implementation of IPM in he Netherlands
14:15	**14:30**	Jansen J.P.	Pest Select Database: a new tool to use selective pesticide for IPM
Session - CURRENT REGULATION AND NATIONAL ACTION PLANS - chairpersons Dachbrodt-Saaydeh S., Barzman M.			
14:30	**15:00**	Dachbrodt-Saaydeh S.	Goals in national action plans and IPM implementation - core elements of the sustainable use directive (keynote speaker)
15:00	**15:15**	Barzman M.	What's happening with IPM implementation in Europe?
15:15	**15:30**	Veres A.	IPM activities of the food and agricultural organization of the United Nations in regional office for Europe and Central Asia
15:30	**15:45**	Laitinen P.	National action plans in Nordic-Baltic countries
15:45	**16:00**	Galassi T.	Implementation of directive 128/09/EC in Italy
16:00	**16:30**	**Coffee break**	
Session - STAKEHOLDERS - chairpersons De Wolf P., Jensen J.E.			
16:30	**16:45**	Lefebvre	Adoption of Integrated Pest Management: what role for

		M.	economics?
16:45	**17:00**	Buurma J.S.	Shaping IPM with NGOS and retailers
17:00	**17:15**	Furlan L.	Directive 2009/128/CE and arable crops: how can we get ready for the 1st of January 2014?
17:15	**17:30**	Peters M.	Use of checklists and a scoring system for evaluation of IPM implementation on demonstration farms
17:30	**17:45**	Benjamin E.	A socio-economic analysis of integrated pest management: a review of the effects of irreversibility
17:45	**18:00**	Hillocks R.	IPM - can it deliver? Balancing environmental and economic sustainability
18:00	**18:15**	Wijnands F.	IOBC: from guidelines to action on farm level - lessons learnt from case studies
18:15	**18:30**	Chiarini F.	IPM against ECB (*Ostrinia nubilalis*) in maize: is it possible?
Parallel sessions DESIGN - Sala Belvedere			
Session - MODELLING, DESIGN APPROACHES AND INDICATORS - chairpersons Alaphilippe A., Lescourret F.			
09:00	**09:15**	Alaphilippe A.	Using Life Cycle Analysis to optimize IPM implementation (keynote speaker)
09:15	**09:30**	Fortino G.	DEXiPM, a tool for supporting the design of innovative IPM strategies
09:30	**09:45**	Aubertot J.N.	X-PEST, an online generic modelling platform to design models that simulate crop losses as a function of injury profiles and production situations
09:45	**10:00**	Wustenberghs H.	The indicator set discuss as a tool to help farmers achieve future IPM
10:00	**10:15**	Garcea G.	The sustainability certification in support of Integrated Pest Management
10:15	**10:30**	Settimi L.	Surveillance of acute poisoning incidents related to plant protection agents in Italy
10:30	**10:45**	Vasileiadis V.P.	Field-scale evaluation of IPM tools in maize: what is their agronomic and economic impact?
10:45	**11:00**	Heijne B.	Economic analyses of apple scab management
11:00	**11:30**	**Coffee break**	
Session - ECOLOGICAL ENGINEERING AND ENVIROMENTAL ASPECTS - chairpersons Begg G., Ratnadass A.			
11:30	**11:45**	Ratnadass A.	Optimizing ecological mechanisms of pest and disease control for sustainable improvement of agroecosystem productivity: major lessons drawn from CIRAD's Omega3 project
11:45	**12:00**	Jonsson M.	Landscape structure and the efficacy of conservation biological control of arthropod pests
12:00	**12:15**	Fitzgerald J.	Effects of ground cover management on carabid ground beetle populations in organic apple orchards in the UK
12:15	**12:30**	McFadden C.	The problem with conservation biological control
12:30	**12:45**	Kovacs G.	The impact of companion planting on the abundance of Lepidopteran pests on white cabbage
12:45	**13:00**	Kaasik R.	Effects of nitrogen fertilization on insect pests, their parasitoids, plant diseases and volatile organic compounds in

			Brassica napus
13:00	**14:00**	**Lunch break**	
Session - PEST AND DISEASE FORECASTING MODELS - chairperson Rossi V., Samietz J.			
14:00	**14:25**	Samietz J.	Use of pest forecasting models and according decision support systems in IPM - Basics and application by example of the Swiss System SOPRA (keynote speaker)
14:25	**14:45**	Rossi V.	Plant disease models: from field observations to biological mechanisms (keynote speaker)
14:45	**15:00**	Desanlis M.	Analysis of the influence of sunflower canopy on *Phomopsis helianthi* epidemics as a function of cropping practices
15:00	**15:15**	Dik A.J.	Botrytis alert system in rose: a disease warning model
15:15	**15:30**	Stöckli S.	Modelling the impact of climate change on sustainable management of the codling moth (*Cydia pomonella* L.) as key pest in apple
15:30	**15:45**	Lux S.A.	Stochastic model of on-farm behaviour of the cherry fruit fly, *R. cerasi*, under the challenge of IPM
15:45	**16:00**	Dubuis P.H.	Using Vitimeteo-Plasmopara to better control downy mildew in grape
16:00	**16:30**	**Coffee break**	
Session - DECISION SUPPORT SYSTEMS - Chairperson Kuflik T., Caffi T.			
16:30	**17:00**	Kuflik T.	Web-based Decision support systems in agriculture (keynote speaker)
17:00	**17:15**	Caffi T.	A web-based decision support system for the management of integrated vineyards
17:15	**17:30**	De Filippi R.	ENVIRO an innovative web mapping tool to monitor and forecast plant and pests dynamics based on climate data
17:30	**17:45**	Mendelsohn O.	IDeMCroP: development of an integrated fine scale system for informed decision making in sustainable crop protection
17:45	**18:00**	Prevostini M.	Calibration and in-field validation tests of a web-based adaptive management system for monitoring - *Scaphoideus titanus*
18:00	**18:15**	Steinger T.	A decision-support system for managing aphid-borne virus diseases in seed potato
18:15	**18:30**	Trematerra P.	Spatial distribution and precision targeting against some fruit and grape pests
Parallel sessions TOOLS - Sala 300			
Session - EQUIPMENT AND TECHNOLOGY INTEGRATION - chairpersons Triloff P., van de Zande J.			
09:00	**09:15**	Triloff P.	Low Loss-Spray Application - A Concept for more Efficiency and Safety in Top Fruit Crop Protection (keynote speaker)
09:15	**09:30**	Yaseen T.	Enhancement of fruit quality during post-harvest: the ozone option
09:30	**09:45**	Norman S.	User-engagement is key to implementing low-drift nozzles in orchards & vines: lessons from year-1 of UK Chlorpyrifos say-no-to-drift campaign & strategy for drift-reduction program in Italy
09:45	**10:00**	Gilbert M.	Semiosbio precision pest management system: real-time mating disruption
10:00	**10:15**	West J.	Development of the miniature virtual impactor - MVI - for long-term and automated air sampling to detect plant pathogen spores

10:15	**10:30**	Mazzoni V.	Mating disruption with vibrational signals: results of 2012
10:30	**10:45**	Hàri K.	Webcam-based pest monitoring
10:45	**11:00**	West J.	DNA analysis for plant pathogen detection in air samples
11:00	**11:30**	**Coffee break**	
Session - BIOPESTICIDES AND BOTANICALS - chairpersons Schmitt A., Pertot I.			
11:30	**11:45**	Bruce T.	Developing novel approaches to manage pest populations (keynote speaker)
11:45	**12:00**	Angeli D.	Increasing efficacy of Ampelomyces quisqualis by the use of an activator
12:00	**12:15**	Caffi T.	New strategy fot the use of *Ampelomyces* spp. against grapevine powdery mildew: sanitation and disease modelling
12:15	**12:30**	Razinger J.	Integrated Pest Management of cabbage root fly (*Delia radicum* L.) with timed insecticide applications and entomopathogenic fungi
12:30	**12:45**	Parisi O.	Microscale ELISA plate screening of essential oils against European damageable plant pathogens
12:45	**13:00**	Riccioni L.	Seed treatment with essential oils
13:00	**14:00**	**Lunch break**	
Session - SEMIOCHEMICALS AND PHEROMONES - chairpersons Ioriatti C., Tasin M.			
14:00	14:30	Tasin M.	Semiochemicals in European IPM: time to move beyond a regulatory bottleneck? Populations (keynote speaker)
14:30	**15:00**	Daane K.M.	Mating disruption for the vine mealybug (*Planococcus ficus*) in California populations (keynote speaker)
15:00	**15:15**	Lucchi A.	Pheromone techniques in the EGVM (*Lobesia botrana*) eradication program in California
15:15	**15:30**	Cortesero A.M.	Selecting volatiles in the field to protect brassicaceous crops against the cabbage root fly, *Delia radicum*
15:30	**15:45**	Martí S.	PUFFER® and MAGNET™: understanding stepped-up technology for pest control
15:45	**16:00**	Deasy W.	Laboratory- and field-collection of root volatiles from *Brassica* plants infested with *Delia radicum* larvae using a new solid phase microextraction-based methodology
16:00	**16:30**	**Coffe break**	
16:30	**16:45**	Escudero-Colomar L. A.	Ten years of mass trapping for control *Ceratitis capitata* Wied. in fruit Orchards in the Northeast of Spain
16:45	**17:00**	Ton J.	Priming of defence: a future cornerstone of IPM?
17:15	**17:30**	Trematerra P.	Advances in the use of pheromones for stored-product protection
17:15	**17:30**	Martini K.	The Puffer Project in the South Tyrolean Vinschgau valley: field report and first results.
Session - BREEDING FOR RESISTANCE - chairpersons Gessler C., Velasco R.			
17:30	**17:45**	Velasco R.	New insights in sustainable viticulture breeding for resistance (keynote speaker)
17:45	**18:00**	Lucatti A.	Different mechanisms of whitefly resistance in tomato
18:00	**18:15**	Lof M.	Durable plant disease resistance by evolution management
18:15	**18:30**	Djian-	New resistance-genes deployment strategies as non chemical

		Caporalino C.	alternatives for the durable management of root-knot nematodes in vegetable crops rotation
Parallel sessions and workshops INDUSTRY AND NEW PRODUCTS - Sala 120			
Session - NEW PRODUCTS AND STRATEGIES - Elad Y., Marin F.			
09:00	**09:15**	Iodice A.	Isomate CM Mist: A New Aerosol Mating Disruption Formulation for Codling Moth
09:15	**09:30**	Korman I.	TIMOREX GOLD - A potent Bio-fungicide for the control of plant diseases and Black Sigatoka in banana
09:30	**09:45**	Zanon M.J.	CLEANSTART: the program for sustanable soil pest management from CERTIS Europe
09:45	**10:00**	Santori A.	Dimethyl disulfide: a new solution for controlling root-knot nematodes in protected crops in Europe
10:00	**10:50**	Hendryckx H.	Workshop: Bi-PA and Belchim Crop Protection: the bridge between green research and sustainable farming
11:00	**11:30**	**Coffee break**	
11:30	**13:00**	ValentBioscience	Workshop: The value of quality BT in an Integrated Pest Management program
13:00	**14:00**	**Lunch break**	
14:00	**15:00**	Beverley C.	Workshop: Plantwise Knowledge Bank - a tool to support plant health
15:00	**15:15**	Ehlers R.U.	Priority to non-chemical pest management? The case of diabrotica *V. virgifera* in european maize production
15:15	**15:30**	Avé D.	Quality differences among BT bio-insecticides, detrimental to the biocontrol industry
15:30	**15:45**	Achleitner D.	Biotechnological protection against Botrytis bunch rot on grapes
15:45	**16:00**	Peters A.	Influence of culture conditions on the production of surfactants and antibiotics in *Aneurinibacillus migulanus*
16:00	**16:30**	**Coffee break**	
16:30	**16:45**	Łabanowska B.H.	Efficacy of spirotetramat (Movento 100 SC) in the control of strawberry mite (*Phytonemus pallidus*) on strawberry plantations in Poland
16:45	**17:00**	Rizzotti G.	TERGEO – A project for a sustainable viticulture and enology
17:00	**17:50**	Perez-Fernandez P.	Workshop: Homologa™, the Global Crop Protection Database of MRLs and current product registrations

Program | Plenary session - March 21

Plenary sessions – Sala 1000	
9.00 9.40	**IPM: Fifty years to prove itself? -** Steve Wratten
9.40 10.20	**Plant protection strategies in organic farming: Is there potential spillover to IPM? -** Lucius Tamm
10.20 11.00	**Opportunities and constrains for biocontrol manufacturers to contribute to IPM implementation -** Ralf-Udo Ehlers
11.00 11.30	**Coffee break**
11.30 12.10	**Directive 2009/128/EC-NAP - Changes for the Fruit- and Winegrowers and the role of the Extension services -** Walther Waldner
12.10 12.50	**2009/128/EC: The point of view of the growers and the implementation in Trentino and South Tyrol -** Alessandro Dalpiaz
12.50 13.00	**Discussion**
13.00 14.00	**Lunch break**

Program | Poster session - March 19, 20, 21

N.	Presenting author	Title
1	Antonelli M.	BACTERIA ISOLATED FROM COMPOST AS POTENTIAL BIOLOGICAL CONTROL AGENTS OF *PSEUDOMONAS VIRIDIFLAVA* ON MELON
2	Dassonville, N	THE USE OF A MIX OF PARASITOIDS TO CONTROLL ALL APHID SPECIES IN PROTECTED VEGETABLE CROPS
3	Hokeberg M.	THE SLU CENTRE FOR BIOLOGICAL CONTROL: GENERATING NEW KNOWLEDGE ON SUSTAINABLE APPLICATION OF BIOLOGICAL CONTROL
4	Hokkanen H.	BICOPOLL: TARGETED PRECISION BIOCONTROL AND ENHANCED POLLINATION
5	D'Addabbo T.	CROSSTALK BETWEEN NEMATODE BIOTIC STRESS AND EPIGENOME
6	Nannini M.	ALTERNATIVE METHODS FOR THE RELEASE OF PREDATORY MIRIDS INTO GREENHOUSE TOMATO CROPS
7	Rossi Stacconi M.V.	A SURVEY OF PARASITOIDSOF *DROSOPHILA SUZUKII* IN ITALY FOR THE DEVELOPMENT OF BIOLOGICAL CONTROL STRATEGIES
8	Yaseen T.	PRODUCTION OF CERTIFIED CITRUS ROOTSTOCKS USING ORGANIC GROWING MEDIA AND BIO-CONTROL AGENTS
9	Angeli D.	REDUCING PRIMARY INOCULUM SOURCES OF GRAPEVINE POWDERY MILDEW BY THE HYPERPARASITE *AMPELOMYCES QUISQUALIS*
10	Perazzolli M.	RELEVANCE OF THE PLANT GENOTYPE FOR BIOCONTROL TOOLS BASED ON RESISTANCE INDUCTION
11	Campisano A.	VINEYARD MANAGEMENT AND MICROBIAL ENDOPHYTES: THE IMPACT OF IPM ON PLANT-ASSOCIATED MICROBIAL COMMUNITIES
12	Clematis F.	POST HARVEST CONTROL OF GREY MOULD ON CUT ROSES
13	Corsi B.	CHITOSAN, A POSSIBLE BIOCONTROL AGENT OF *A. DELICIOSA* (A. CHEV) DISEASES
14	D'Addabbo T.	PLANT-DERIVED FORMULATIONS FOR THE CONTROL OF THE CARROT CYST NEMATODE HETERODERA CAROTAE IN FIELD
15	D'Addabbo T.	BIOACTIVE PLANT METABOLITES FOR THE CONTROL OF ROOT-KNOT NEMATODES
16	Donnarumma L.	POWDERY MILDEW INTEGRATED CONTROL ON ZUCCHINI WITH ESSENTIAL OILS AND QUINOXYFEN
17	Giovannini O.	USE OF *SALVIA OFFICINALIS* EXTRACT TO CONTROL GRAPEVINE DOWNY MILDEW: TESTS IN GREENHOUSE AND FIELD
18	Giovannini O.	A PROTEIN EXTRACT IN THE PLANT PROTECTION: NOVEL ALTERNATIVE TO CHEMICALS AGAINST POWDERY MILDEW
19	Innerebner G.	LABORATORY AND FIELD TRIALS WITH COMMERCIALLY AVAILABLE BIOCONTROL AGENTS AGAINST FIRE BLIGHT AND BOTRYTIS BUNCH ROT
20	Hoffmann C.	NEW INTEGRATED STRATEGIES FOR THE CONTROL OF GREY MOLD *BOTRYTIS CINEREA* IN GRAPEVINE
21	Jaskulska M.	RESEARCH ON POSSIBILITY OF CONTROL OF *ARION LUSITANICUS* MABILLE, 1868 BY NEMATODES *PHASMARHABDITIS HERMAPHRODITA* AND IRON PHOSPHATE
22	Kaddes A.	INHIBITION OF *FUSARIUM CULMORUM* AND *COCHLIOBOLUS SATIVUS* GROWTH BY SIX VOLATILES ORGANIC COMPOUNDS
23	Hinze M.	FIRE BLIGHT CONTROL WITH BLOSSOM PROTECT
24	Lenzi L.	CHARACTERIZATION OF EFFICIENT RESISTANCE INDUCERS FOR CONTROL OF CROP DISEASE
25	Lenzi L.	IDENTIFICATION OF SPECIFIC GRAPEVINE BIOMARKERS TO SELECT EFFICIENT RESISTANCE INDUCERS
26	Sassanelli N.	NEMATICIDAL EFFECT OF CHESTNUT TANNIN SOLUTIONS ON THE CARROT CYST NEMATODE *HETERODERA CAROTAE* JONES
27	Mugnai L.	PROTECTION OF GRAPEVINE WOUNDS FROM FUNGAL TRUNK PATHOGENS: INFLUENCE OF THE APPLICATION PROTOCOL IN THE EFFICACY OF TRICHODERMA TREATMENT
28	Muljar R.	THE EFFECT OF BIOFUNGICIDE PRESTOP MIX ON RESPIRATION, WATER LOSS AND LONGEVITY OF BUMBLEBEEBOMBUS TERRESTRIS L.
29	Orzali L.	AN ECOLOGICAL ALTERNATIVE TO THE USE OF CHEMICALS: CHITOSAN AS ELICITOR OF RESISTANCE TO DISEASES IN WHEAT
30	Osti F.	PRODUCTION OF METHYL-JASMONATE IN POTTED VINES TREATED WITH TRICHODERMA AND SILICON AND EFFECTS ON DOWNY MILDEW INFECTIONS
31	Palmieri M. C.	*TRICHODERMA HARZIANUM* T39 BIOCONTROL ACTIVITY AGAINST *PLASMOPARA VITICOLA*: ROLE OF PROTEIN PHOSPHORYLATION IN INITIATING GRAPEVINE RESISTANCE
32	Pane C.	*BRASSICA CARINATA* TISSUES CONTAINING GLUCOSINOLATES AND ESSENTIAL OILS ENHANCE BACILLUS-BASED ANTAGONISTIC ACTIVITY AGAINST SOIL-BORNE PLANT DISEASES
33	Pane C.	COMPOST-TEAS: NEW BIOPESTICIDES AND BIOSTIMULANTS FOR A SUSTAINABLE HORTICOLTURE
34	Pellegrini A.	STUDY BIOLOGICAL CONTROL ACTIVITY OF *TRICHODERMA HARZIANUM* BY ISOTOPE RATIO MASS SPECTROMETRY (IRMS)
35	Pellegrini A.	SURVIVAL OF *TRICHODERMA ATROVIRIDE* ON GRAPEVINE PRUNING WOUNDS AND LEAVES
36	Prodorutti D.	POSSIBLE AND POTENTIAL USE OF *TRICHODERMA ATROVIRIDE* SC1 AS BIOFUNGICIDE
37	Puopolo G.	THE EFFECT OF TEMPERATURE ON *BACILLUS AMYLOLIQUEFACIENS* STRAIN S499 AND ON ITS INTERACTION WITH CROP PLANTS
38	Ratajkiewicz H.	CREEPING THISTLE [CIR*SIUM ARVENSE* (L.) SCOP.] HEALTHINESS AND PATHOGENS - PERSPECTIVES OF BIOLOGICAL WEED CONTROL
39	Roatti B.	CHARACTERIZATION OF *TRICHODERMA HARZIANUM* T39 INDUCED RESISTANCE AGAINST *PLASMOPARA VITICOLA* DURING ABIOTIC STRESSES
40	Sasanelli N.	THE IN VITRO EFFECT OF *APHANOCLADIUM ALBUM* ISOLATE MX-95, A NEW PROMISING BIOCONTROL AGENT, ON THE ROOT-KNOT NEMATODE MELOIDOGYNE INCOGNITA
41	Schmitt A.	GLYCYRRHIZA GLABRA LEAF EXTRACT FOR CONTROL OF DOWNY MILDEW (*PSEUDOPERONOSPORA CUBENSIS*) OF GREENHOUSE GROWN CUCUMBERS AND OTHER PLANT PATHOGENS

N.	Presenting author	Title
42	Siegwart M.	LOW FITNESS COST OF THE RESISTANCE OF WILD INDIVIDUALS OF CODLING MOTH TO *CYDIA POMONELLA* GRANULOVIRUS (CPGV)
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The adoption challenge for IPM - 20 March, 9.00-11.00 - Sala Presidenza

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Vine mealybug: what we should know - 20 March, 18.00-19.30 - Sala 120

IPM & pollinators: ecological services and risk analysis - 21 March, 14.00-16.00 - Sala Belvedere

Abstracts | Oral presentations

PESTICIDE USE-AND-RISK REDUCTION IN EUROPEAN FARMING SYSTEMS WITH INTEGRATED PEST MANAGEMENT: AN EU PROJECT

Françoise Lescourret

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To meet food demands and preserve environmental resources, agriculture needs to increase the quantity and quality of harvests while reducing its ecological footprint. This is the context in which the European, four-year project "PURE" (standing for Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management) has been launched in 2011. This project, coordinated by INRA, involves fourteen European research institutions or universities, two agricultural development organisations, five industrial partners and one project management and consulting company. PURE focuses on supplying integrated crop protection solutions and a toolbox for their implementation in six European farming systems (wheat-based crop rotations, maize-based crop rotations, field vegetables, pomefruit, grapevine, protected tomato crops) where a reduction in pesticide use and improved pest control will have a notable impact. For each of the six farming systems, and taking account of the diversity of biological, agronomic and economic conditions prevailing in Europe, PURE combines existing methods with new tools in the context of novel integrated protection solutions. These solutions range from simple combinations of tactical control methods to more ambitious techniques involving strategic changes. With its industrial partners, PURE benefits from recent advances in several disciplines in order to enhance integrated crop protection solutions with innovative systems for diagnosis, decision-making or control using bio-products and strategies focused on ecological regulation and the sustainability of control methods. PURE tests the efficacy, practicality and pertinence of these solutions under the conditions that prevail in the main European production regions through on-station and on-farm experiments, and ensure a comparative assessment of their environmental, economic and social sustainability. By associating both researchers and stakeholders in crop protection, PURE intends to facilitate the adoption of these innovative solutions. In this way, PURE intends to contribute to reducing the risks to human and environmental health caused by the use of, and dependency on, pesticides, and enable the initiation of regulations on pesticides.

THE EU STRATEGY FOR SUSTAINABLE USE OF PESTICIDES AND THE PROMOTION OF INTEGRATED PEST MANAGEMENT (IPM)

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The Regulation (EC) No 1107/2009 concerning the placing on the market of plant protection products (PPP) and the Directive 2009/128/EC on sustainable use of pesticides (SUD) provide for the implementation of general principles of Integrated Pest Management (IPM). In addition, the finalization of the review of active substances used in PPP, the introduction of new criteria for approval and for comparative assessment of PPP, and the obligation for all professional users to apply the general principles of IPM, are expected to further promote integrated production.
Ongoing work and progress at EU level will be presented, in particular the follow-up on the transposition and implementation of the Directive 2009/128/EC. The update will also consider the National Action Plans and other provisions in the SUD with relation to IPM.

IPM – AN OLD CONCEPT FULL OF INNOVATION

Bigler F.

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The concept of Integrated Pest Management (IPM) has a long history and was by far not born out of the blue as it is often assumed and misinterpreted. The starting point dates back to the early 1950s when the first failures of synthetic pesticides (insecticides) became obvious after only a few years of use. A closer examination reveals, however, that the concept of IPM was not always straightforward, and the considerable array of interpretations is manifested by over hundred definitions of IPM. As early as some 40 years ago, scientists distinguished already between the main steps in the development of IPM still valid nowadays. A number of examples of IPM systems as used today will be presented in the talk. In the late 1980s, the modern concept of Integrated Production (IP) was developed by the International Organization for Biological and Integrated Control (IOBC) in which IPM is for the first time considered as one element in a sustainable systems approach. In the concept of IP it is obvious that crop protection cannot repair damage caused by inadequate farming practices and thus, planning of appropriate farm operations is the very first step. Highest priority is given to all preventive measures on the farm, including the optimal use of natural resources, elimination of farm operations with negative impact on the agro-ecosystem (e.g. excessive fertilizer use) and the protection and augmentation of natural antagonists of pest organisms. Monitoring and forecasting systems as important second elements provide the necessary instruments for the decision if and when direct plant protection has to be applied. However, the use of non-chemical control options has priority and pesticides are used only as the last resort if other methods do not produce acceptable results. Why are important IPM elements such as preventive measures and monitoring of pest organisms less often applied today than in former times? Economic pressure on farmers is most often the main driver for simplifications of farm operations leading to simplified production systems with one or very few crops only. Innovative ideas of farmers to cooperate across farms with each farmer specializing in one crop and jointly planning and managing land interchangeably may open new avenues for improved crop rotation and other "good farmer practices". It is often easier and cheaper to apply a pesticide treatment (particularly in combination treatments) instead of counting pest organisms and forecasting an economic threshold. This is not to blame farmers. In most countries, policy and markets have not seriously considered the concept of IPM and IP so far, and they have missed the chance to take advantage of sustainable agricultural systems that are adding great values to our environment and human health. Policy, market chains, distributors and consumers should after all recognize the increased value of such products and give the IPM/IP farmers a fair share for their products.

OPTIMIZATION OF SPRAYING TECHNIQUES TO REDUCE IMPACT OF PESTICIDES

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When applying pesticides the plant protection product (PPP) is distributed over the target and some losses do occur towards the soil surface underneath the crop and to the environment because of spray drift. An example is given for the infield spray distribution of arable crop and fruit crop spraying. An overview is given of spray drift research in the Netherlands for the past 25 years. For the Netherlands the state-of-the-art of the spray drift data is described and standard drift curves are presented for boom spraying in field crops and cross-flow fan spraying in fruit crops. Based on the crop growth situations spray drift deposition curves are discriminated in early and late spray applications (bare soil/dormant tree, full developed leaf canopy) to determine the exposure to surface water. The potential of Drift Reducing Technology (DRT) is presented. A matrix approach was developed to assess spray drift exposure combining classes of Drift Reducing Technology (for drift reduction classes 50, 75, 90 and 95) and stepwise widths of crop-free buffer zones. The methodology of using the matrix structure is discussed for the assessment of drift deposition on surface water and non-target areas for downward sprayed field crops (arable) and sideward and upward sprayed fruit crops. Also attention is paid to airborne spray drift giving potential risk to bystanders and residents. Similar approaches as for surface water can be setup to reduce the risk for bystanders and residents close to sprayed fields. The use of the classification of DRT for bystanders is highlighted.

New spray techniques more and more make use of sensors to detect and quantify e.g. the place and amount of crop canopy. Accordingly variable rate application techniques (VRA) are developed taking into account the change in crop canopy volume during the growing season. This influences spray distribution over crop canopy and biological efficacy and therefore dose adaptations are needed. Most of these Canopy Density Spraying (CDS) techniques reduce spray volume during the crop growing season and therefore applied dose to the field. This influences therefore also the emission of PPP to the environment as spray drift is from smaller applied areas in the field or originating from lower spray volumes as intended. As spray volumes in the field are lower and applied more on the target, the crop canopy; as a result less spray deposits on the soil surface underneath crop canopy. These VRA or CDS spray techniques therefore also reduce the potential drainage to the soil water and through the drainage system to the surface water. CDS techniques lead to higher levels of emission reduction through an adding up the classified spray drift reduction of the application technique itself and the spray volume or use reduction through the applications in practice. The potential of using this methodology; emission reduction = spray drift reduction + use reduction, in the authorisation procedure of PPP is highlighted.

DESIGNING CROPPING SYSTEMS WITH HIGH PRODUCTIVE PERFORMANCE AND LOW USE OF PESTICIDES: CONCEPTS, METHODS AND KNOWLEDGE, WITH ILLUSTRATION ON VINEYARDS

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Sustainable development of agriculture in Europe relies on the design of innovative cropping systems able to achieve high productive performance (quantity and quality) with low use of pesticides, while remaining compatible with socio-economic (e.g. labour use) and other environmental objectives (e.g. energy use). Over the last decade, this has led to the emergence of inter-disciplinary research activities driven by system's analysis and design methodologies. Designing such multifunctional cropping systems requires to develop new knowledge on the relationships between the structure of agroecosystems, the processes involved in plants and pest/disease interactions and how they influence the productive performances of the system and the trade-offs with the other agroecosystem's services. Designing a "pest suppressive or less susceptible" agroecosystem with less chemical inputs generally leads to complexity its structure (e.g. more plants species in rotation and or association) and put emphasis on poorly known processes such as the interaction between plant vigour and the trade-off between pest/diseases susceptibility on one side and yield formation on the other side. Conceptual models have been developed to integrate existing knowledge from various disciplines, as well as expert knowledge, in order to analyse how the various cropping techniques, including pesticides and genotypes, can be combined in an operational Technical System (TS), in order to manipulate the process involved in plant productivity and pest/disease control to reach the set of objectives fixed for a given context (a farm in a soil/climate and a supply chain). Analysis and management indicators are essential tools to provide information, under field conditions, on the agroecosystem processes and properties in order to guide the design process and support decisions for the management of the TS. Prototyping methodologies have been developed to conceptualize these innovative TS, test them in system's experiments, evaluate them with a set of assessment indicators and adjust them to reach a targeted compromise among agroecosystem's services in a progress loop. In return this design oriented approach yields new knowledge on the emerging properties of the agroecosystem and new questions on poorly understood processes or components, which can be further used to prioritize research objectives and conduct analytical experiments. Simulation models can contribute to the approach at various steps and their role and nature will be discussed on the basis of processes to be simulated, affordable uncertainty and available data for their parameterization/evaluation. Specific questions arise from this field-based approach on how to integrate it at farm and landscape scales and how to ensure farmer's and stakeholder's involvement in the design/assessment process in order to increase the probability of adoption of these TS by farmers. We will illustrate these concepts, methods and new knowledge on the example of vineyards with results and research questions emerging from the EcoViti network in France.

INTEGRATED PEST AND DISEASE MANAGEMENT PROGRAMMES TO REDUCE PESTICIDE USE AND RESIDUES IN BERRY CROPS

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Consumers want perfect fruit without pesticide residues. Berry crops are intensively treated with programmes of pesticide sprays to control large complexes of pests and diseases which otherwise cause severe damage to the crop and render production uneconomic. Many sprays are applied to developing fruit, often close to harvest. As a result there is a high incidence of pesticide residues on harvested fruit. Leading multiple retailers are seeking to greatly reduce the incidence of detectable residues on the fruit they sell but recent reductions in reporting limits has made eliminating residues much more challenging.

Three five year research projects, one on raspberry which has recently been completed, and ones on strawberry and stone fruits (cherry and plum) that are in progress have developed new alternative management methods for the main pests and diseases of each crop and combined them with existing methods into Integrated Pest and Disease Management (IPDM) programmes which have then been evaluated in commercial crops.

A wide range of new management methods have been developed for the different pest and disease targets including computerised models for predicting the risk of disease infections, microbial biocontrol agents, non-synthetic crop protection products, semiochemical based monitoring and control methods, biocontrol with predators and parasitoids, disrupting ant-aphid mutualism and autumn treatment to control aphids, and cultural and physical control methods.

The IPDM programmes devised have had mixed but generally good success and have led to significant reductions in pesticide dependency and in the incidence of pesticide residues. The arrival of the Spotted Wing Drosophila, which will necessitate the application of broad-spectrum insecticides to protect ripening fruit, threatens to seriously disrupt the progress made. Highlights of the methods developed and the results of the projects will be overviewed.

THE EU DIRECTIVE 2009/128 MAY UPGRADE PATHOGEN BIOCONTROL AGENTS FROM NICHE TO FULL SCALE APPLICATIONS: ARE WE TECHNOLOGICALLY READY?

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The commercial use of biological control agents as active ingredients of biopesticide or biofertilizer formulations, either as living microbes, extracts or bioactive molecules, has generally been expanding relatively slow in Europe in comparison to other geographical zones. For instance, a much wider application is reported in Central and South America, as well as in India and China, where hundreds of products are available on the market. The delayed development has occurred in spite of the numerous and well known success stories of quality products available with good track records, such as the case of effective strains of *Bacillus*, *Trichoderma*, *Coniothyrium*, *Pseudomonas*, *Streptomyces*, etc. used for more than a decade in a variety of conditions. Finally, the new EU directive 2009/128 is going to change this situation, making it possible to place the really useful products on a fast track to gain a much larger market share. In fact, the required move from chemical to IPM-based disease management will correspond to the loss of an estimated 50% of the synthetic active principles available today, and has to be to be fully implemented within the next 24 months. Obviously, the big question is: are we ready to catch this opportunity both technically and scientifically? The answer is complex and still being debated. There is no doubt that the scientific know-how, technical development and application experience gathered for several biocontrol products has never been so significant, with a big leap forward observed in the last half decade. But are these products ready to leave their niche and play a much larger role in the European farming system? How far are they from the high effectiveness levels, also seen on a wide spectrum of patho-systems, that are typically reached by conventional pesticides? Interestingly enough, though, large multinational pesticide-producing enterprises have shown a world-wide interest in incorporating SME that have their core business in the biocontrol sector.

THE BIOPESTICIDE INNOVATION CHAIN: HOW CAN RESEARCHERS AND INDUSTRY COLLABORATE TO COMMERCIALIZE BIOPESTICIDE PRODUCTS

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Investment in biopesticide research globally has progressed during the last 35 years, with a significant number of products registered since 2000. Greater awareness and demand by the general public for safer foods and the environment and recent government legislation have spurred the development of reduced risk pest control products and renewed further interest in biopesticides. While the synthetic pesticide market has decreased by 12% over the last 5 years, demand for biopesticides is expected to exceed $1 Billion in sales. In Canada, banning of chemicals in urban municipalities, development of pesticide resistance in crop pests, demand for new products by organic farmers, and the recognition of hidden costs to human health and the environment are further fueling the need for biological alternatives. The discovery of new and promising microbial candidates for development as active ingredients in biopesticides has far out-paced the knowledge and related technology required to bring these to commercialization. Although there are numerous biopesticides registered for use globally, the public wonders why there are “so few” biopesticides available in the marketplace. The fact remains that the field of biological control combines various scientific disciplines including biology, microbiology, entomology, plant pathology, weed science, and agronomy. It is further complicated by superimposing subject matters related to economics, sociology, law, international trade, business, and many other fields not traditionally considered in a scientific research endeavor. It has become apparent that there is a need to demonstrate that biopesticide research has evolved beyond the lab bench and that there is a clear process for implementation and commercialization. For this reason, a strategy for developing biopesticides was designed with the creation of the “biopesticide innovation chain”. The Innovation Chain depicts nine critical stages for developing a biopesticide product using a series of “Go vs No-Go” criteria which are used by industry to make economic decisions. The early stages link discovery to proof-of-concept to the development of platform technology (fermentation, formulation, application technology, and molecular biology). Basic assessments of biology, environment, biochemistry, and small-scale fermentation and formulation are conducted under laboratory, greenhouse and field conditions, with emphasis placed on characterization, safety, and practicality of the biopesticide organism. The importance of regulatory and market considerations cannot be underestimated since they will dictate the success or failure for commercialization. Another key feature of the innovation chain is that it encourages development of novel technology platforms that can be expanded to other potential applications and crop pests, thereby broadening onto other target hosts, pathogens & biopesticides, new production systems, or be integrated into various crop production systems. This R&D model is unique and an excellent strategy because it illustrates the delivery of new biopesticide products, from discovery to industry development for commercialization and adoption.

IPM STRATEGIES AND NON-TRADITIONAL BIOLOGICAL AND CHEMICAL ALTERNATIVES FOR THE MANAGEMENT OF PLANT-PARASITIC NEMATODES.

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Integrated Pest Management IPM) practitioners avoid “silver bullet” solutions to pest infestations and instead use a combination of prophylactic measures that may include biological, cultural, chemical and precision agriculture components. The publication of Silent Spring by Rachel Carson cemented the IPM concept into the foundation and language of modern plant protection agriculture. Traditionally, IPM tactics include those that involve the use of quarantine, post-plant sanitation, tolerant/resistant cultivars, biologically-clean planting material, crop rotation, inter and intra-cropping, fallowing, tillage, trap/cover crops, soil amendments, planting/harvest time manipulation, solarization, flooding, fumigant and non-fumigant chemicals and biological agents. A review of publication titles from the six major nematology journals in the world from their beginning to the present was conducted to determine the research focus of articles dealing with IPM tactics for the mana gement of nematodes. Results of this literature survey showed that research, in order from most to least common, has focused on: nematicides, host resistance, rotation, biocontrol, amendments, tillage and precision agriculture. However, from 2005 to the present, the trend is almost exactly the opposite of this with a marked surge in the last six years in nematode management research in the areas of precision agriculture and biocontrol. Additionally, in last two years, most agricultural chemical producers are exploring and evaluating reduced-rate colloid formulations, prescription application methodology, and seed-treatment biocontrol agent combinations to provide economical nematode management with reduced, legislatively demanded, negative environmental impact. The nematology project in the Louisiana State University Agricultural Center has ongoing research projects in the areas of colloid-based nematicide formulation, seed-treatment nematicides, biocontrol agents, esp ecially Paecilomyces and *Pasteuria* spp., and site-specific nematology. Field trials evaluating classical IPM management tactics for nematode management such as crop rotation and soil amendments are also currently in progress. Data from each of these project areas will be reviewed and discussed as part of the presentation to be made at the 2013 “Future IPM in Europe” conference in Riva del Garda, Italy.

CIS-GENIC PLANTS AS ALTERNATIVE TO FUNGICIDES FOR THE BENEFIT OF THE ENVIRONMENT AND CONSUMERS

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The EU directives are currently oriented toward the concept of Sustainable Agriculture, requesting to consider all possible means to reduce the impact of pesticides on human health and on the environment and to consider. Several agricultural production systems advertise with labels their concepts and products, often with a strong "less pesticides" aspect. Most known examples are "Integrated production" IP and "biological (organic) production". Consumers associate these labels with a more ecological production than label less products, with the bio label having the highest appreciation. Consumers (wherever affordable) can contribute therefor to a system of perceived ecological positive impact. The concept "S.A." is centered on maintaining the production factors, environment and human/social system functioning. So the impact of any factor leading to degradation or depletion of resources or social strain has to be mitigated or substituted. The current increase of knowledge and technologies offers new possibilities and can be oriented to substitute factors little compatible with a S.A. The pesticide based disease and pest management are currently the most questioned production factors, having a high return rate if considered on the plot level, however not on a global level. The use of resistant cultivars has a high return rate on the ecological and economical side. However as the input costs for developing such cultivars can only be amortized through sale of seed or planting material and possibly an associated production factor (herbicide), only few species and traits are of interest to developers. So mostly it is left to the public hand to develop through breeding or/and genetic engineering disease/pest resistant plants. The beneficiaries (environment - consumers) are mostly unaware of the potential benefits and will therefore not actively contribute to the development and use of such products. Products obtained through genetic engineering have a great potential to contribute to sustainability as highly targeted amelioration are possible and can be done in a relative short time and low costs. But only under a holistic evaluation and holistic benefit/cost analysis, the public research sector will be charged to develop such plants. Ten years ago the first scab resistance (the same as used in classical apple breeding) gene originated from the wild *Malus floribunda* 821was cloned and demonstrated to incite full scab resistance inserted into a Gala apple under the control of a 35S promoter. Since technology developed so that cisgenic (only genes & regulatory sequences from a crossable donor) scab resistant Gala trees were developed and are tested in field trials. Additional scab resistance and Fire blight resistance genes are described and functionality tested. The employment of such scab and Fire blight resistant cisgenic Gala (or any other cultivar) would be of relevant benefit to the environment, consumer and producers.

DOUBLE ROLE OF BIOCHAR: CLIMATE CHANGE MITIGATION AND A TOOL FOR INTEGRATED MANAGEMENT IN AGRICULTURAL SYSTEMS

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Biochar is a product of pyrolysis (thermochemical decomposition of organic material at elevated temperatures without oxygen). Organic wastes can be converted into energy sources by pyrolysis and it can be used as a soil conditioner. The half-life of biochar is hundreds of years and longer, resulting in carbon storage in soil and CO2 removal from the atmosphere, and reduction of N2O and methane emissions. Positive effect of biochar soil amendment on field crops and trees grown under greenhouse and commercial conditions were reported. Biochar can improve soil tilth, productivity, nutrient retention and availability to plants via slow-release fertilizing properties and improved water and nutrient holding ability. Biochar was applied in pots and in field for intensively grown plants and we tested whether it could impact plant growth when nutritional and soil physical aspects were eliminated. Tomato, cucumber, sweet pepper and wheat plants grown under an optimal fertilization and irrigation regime proved that biochar-induced plant growth stimulation goes beyond obvious contributions to plant nutrition and improved soil physical and chemical properties. This effect was termed 'The Biochar Effect'. Biochar addition caused significant changes in microbial community composition and enzyme activities in both bulk soil and the rhizosphere towards beneficial plant growth promoting rhizobacteria and fungi. The plant growth stimulation occurred as a result of either chemical or physical attributes of the biochar; or low doses of biochar-borne chemicals ("hormesis"), many of which are phytotoxic or biocidal at high concentrations. Biochar amendment was generally characterized by an increase in the relative abundance of members of the Actinobacteria and Bacteriodetes phyla. The Bacteroidetes-affiliated *Flavobacterium* was the genus most strongly induced by the biochar. It, moreover, resulted in suppression of the foliar pathogens *Podospaera aphanis* (powdery mildew=PM), *Botrytis cinerea* (gray mold) and *Colletotrichum acutatum* (anthracnose) of strawberry plants and of *B*. *cinerea* and *Leveillula taurica* PM in pepper and tomato plants. Research on the effect of biochar on soilborne diseases is ongoing. The fact that the biochar location was spatially separate from the site of infection indicates an induced systemic response of the plant against the pathogens. Molecular evidence for both systemic acquired resistance (SAR) and induced systemic resistance (ISR) pathways by biochar was recently presented. All in all, biochar can be integrated as a general tool in agricultural systems for combating several biotic problems in roots and foliage of plants.

RESEARCH ON SUSTAINABLE MANAGEMENT OF CROP HEALTH AT INRA

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The current challenge of a sustainable management of plant health calls for extensive efforts and a cross-disciplinary approach which addresses all aspects of this complex issue. Combining the three pillars of sustainability – economic, social and environmental performances – requires integrating approaches from multiple scientific disciplines such as biology, ecology, social sciences, and economics. More generally, this strategy contributes to the emergence of agro-ecology as a full-fledged discipline. Integrating spatial, temporal and organizational scales is another related challenge. Four operational objectives can be identified around the general concept of sustainable management of plant health, which should enable to put together research teams:

- Developing shared reference frameworks,
- Designing novel levers for plant health,
- Designing and evaluating alternative cropping systems,
- Instigating, stimulating, guiding and accompanying change.

These principles are implemented at INRA under the form of a metaprogramme on Sustainable Management of Crop Health (SMaCH) where researches are organized by means of key actions. Each key action is a coordinated and consistent "bunch" of research projects and involves the cooperation of several disciplines. "Plant resistance sustainable management", "Technological lock-in and transition processes", "Design of cropping systems and agricultural landscapes for a low pesticide use", "Evaluation of the damage caused by pests" are examples of key actions. This metaprogramme is intended to function as an incubator of innovative ideas enabling moving towards the re-design of management systems of crop health.

THE PROMOTION OF IPM AND PESTICIDE-RELATED RESEARCH IN THE FRAME OF THE FRENCH ECOPHYTO PLAN

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The Ecophyto plan adopted in 2008 was not designed simply to fulfill the requirements of the “Sustainable Use” Directive. It resulted from a dialogue between multiple stakeholders, with the aim to reconcile economic and environmental goals in agriculture, the challenge being to significantly reduce the use of plant protection products while maintaining a high quantitative and qualitative level of production. The plan was recently embedded into the larger goal of “changing the way of cropping” by relying increasingly on the principles of agroecology.

The underlying assumption of the plan is that changes at the farming system level are needed to reach the pesticide reduction goal. This assumption was substantiated by a large scale survey performed at the government’s demand at the onset of the plan: a prominent conclusion was that a reduction by 50 per cent at the national level would result in a decrease of production if the farming systems remained unchanged. Multidisciplinary analyses on case studies also indicated that the transition from chemical control to IPM could hardly be limited to a few changes of practices, and rather implied a whole reconsideration of crop protection at the system level. The needs for change are not restricted to the farming community; they also address the whole sociotechnical system that surrounds it. This encompasses new expectations from research and innovation.

While implementing the many actions included in the nine axes of the plan, the managers of Ecophyto are confronted with gaps of knowledge and lacks in methodologies. An *ad hoc* expert group has been established to analyze these needs, identify relevant research items and set up an appropriate roadmap. These priorities are posted *via* a diversity of calls for short/medium term research projects. The presentation will illustrate some of the topics selected in the roadmap.

For instance, Ecophyto has established a pest monitoring network based on observations in 12,000 fields which delivers weekly information bulletins at the regional level. Research is questioned on how this information can be combined with local variables and epidemiological models to assess pest risks at the farm level, and on the conditions and reference marks that would optimize farmers ‘use of this assessment in making their decisions. Ecophyto has also selected nearly 2,000 demonstration farms where cropping systems with strategies for pesticide use reduction will be tested over years in real farming conditions. Methodologies are needed to properly assess their technical and economic performances and to analyze their variability in time and space in order to build up more general and robust references. Other items will be further illustrated.

The Ecophyto research roadmap is attracting scientists on topics linked to the practical implementation of the plan and where their contribution can have a rapid impact. While these topics are framed to fit the specific Ecophyto needs, most of them have a broader significance and could be relevant for NAP implementation in other countries. Shared interests in research and extension relevant to IPM within the EU have recently been surveyed by a collaborative working group of the Standing Committee for Agricultural Research.

INTEGRATED PEST MANAGEMENT IN ITALY

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Integrated Pest Management (IPM) was first launched in Italy in the mid-70s with the help of the academic science community but it was only in 1987 with the nationwide “integrated pest and disease control strategies” and the related first IPM funding of regional action plans that the program began to take off.
The evolution of IPM has been influenced by the adoption of community standards such as Council Regulation (EEC) No 2078/92 and EEC Decision "- N. C (96) 3864/96 Principles & criteria of IPM and integrated weed control”.
In 1996 a National Committee was established in Rome by the Ministry of Agriculture to review the compliance of IPM technical standards in each region with those outlined in the EEC Decision (96) 38464/96.
Since 2007 the IPM National Committee has been publishing on an annual basis "National guidelines for Integrated Pest Management", covering 119 of the most important crops grown in Italy. The guidelines contain control strategies for each crop to guard against major diseases, pests and weeds, rather than just black or green lists.
Over the years the impact of the IPM in Italy has grown to cover an area that is currently estimated to be at least one and a half million hectares, equal to approximately 10 % of cultivated land. The crops involved have mostly been fruits and grapes, where the use of plant protection products is highest.
The application of IPM has yielded very positive effects, such as the early exclusion of the most dangerous plant protection products, which were later withdrawn by the EU.
This policy reduced the use of plant protection products with chronic effects and residual herbicides and diminished dosages of herbicides.
Today, most producers apply the IPM guidelines because national supermarket chains demand that their suppliers do so.
Italy will satisfy the “low pesticide-input pest management” requirements set out in Directive 2009/128/EC establishing a framework for community action to achieve the sustainable use of pesticides” by applying three distinct approaches: compulsory IPM, voluntary IPM and organic farming.
The experience accumulated in Italy over the past 20 years provides a valuable background for the application of the three approaches.

APPLICATION OF IPM - THE POINT OF VIEW OF PRODUCERS

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In Italy the production based on IPM principles corresponds to Integrated Crop Production (ICP) based on the application of the National /Regional IPM Guidelines which are not only related to pest management but also to other aspects of cultivation (e.g., nutrition, irrigation, soil management). In Italy the ICP of pome fruits, stone fruit, vegetables and arable crops correspond to about 50% of the total production.

Based on the experience of producers the application of IPM has presented advantages but also some criticalities. Among the advantages the first one has been represented by a qualification of the products and the possibility to certify a process of production, in order to guarantee consumers and trade through a traceability system. Beside this it has been necessary to qualify the extension service and so to enhance the capability and skills of advisors within each Producer Organization and/or Association. This allowed to reach a support by the CMO (Common Market Organization) funds and improve the cooperation with public bodies (e.g., Regional governments) and to develop together experimentations addressed to the application of IPM and Integrated Crop Production. Furthermore ICP has simplified to reach the expectation of the market and in particular that of Large Organized Distribution (LOD) (e.g., ipermarket, supermarket and discount) that requires Integrated Products as basic product. IPM guidelines applied in Italy represent in fact the basis of most of the ‘supply protocols’ required by LOD.

On the other hand the main critical point declared by producers is that in general the ICM has not been recognizable by consumers who are not aware of what it is compared to conventional production. ICP and so IPM has become a prerequisite from the LOD without to recognize an added value to these products. Furthermore there is a lack of an European Guideline that harmonize the IPM guidelines at regional/ territorial and National level corresponding to a confusing market and an unbalanced competition among the EU countries’ suppliers. On the other hand there have been a low tendency to find common objectives also within the Italian agricultural system, with the result to be forced to accept the different mandatory protocols of the LOD. Nowadays IPM has become a common practice for most of the production coming from the organized agriculture system in Italy although it requires important efforts by producers.

The future perspectives of the Italian producers is linked to the National Quality System of Integrated Production (NQSIP). This Italian voluntary system of certification will represent the next challenge for Producers Organizations (PO) in Italy. Producers stress the importance that the market system should recognize these producers as accredited suppliers for both IPM application, origin of the product and traceability.

VERTICILLIUM WILT IN OLIVE: A PARADIGM FOR IPM OF A COMPLEX SOILBORNE DISEASE

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Verticillium wilts are amongst the most devastating diseases in agricultural production worldwide. Collectively, these diseases cannot be effectively controlled by applying a single control measure, but rather are best managed by an integrated disease management (IDM) strategy. IDM is an ecology-based approach aimed to minimize damage caused by diseases through the combined use of all available disease control measures, either simultaneously or in a sequence, which are applied prior and after establishing the crop. The integrated management of Verticillium wilt diseases is difficult because complexities of the management strategy itself are overlaid on the inherent complexities of target pathosystems. Verticillium wilt of olive caused by *Verticillium dahliae*, the most important soilborne disease of olive worldwide, is an example of such complexities. Control of this disease is made difficult by: (i) the long survival of the pathogen in soil; (ii) the ability to infect hundreds of plants confined within the xylem during its parasitic phase; (iii) the genetic and virulence diversity of *V. dahliae* populations; and (iv) the easy spread of the pathogen within and among orchards by means of: (a) infected planting material; (b) infested soil; (c) infected debris from cultivated and alternative hosts; (d) irrigation water; and (e) leaves fallen from trees infected with the defoliating (D) pathotype. An IDM strategy for the management of Verticillium wilt in olive that combines the use of pre-planting and post-planting control measures includes: (i) site selection and risk assessment; (ii) use of *V. dahliae*-free planting material; (iii) reduction or elimination of *V. dahliae* inoculum in soil; (iv) protection of healthy planting material from infection by residual inoculum in soil; (v) use of resistant cultivars and rootstocks; (vi) cultural practices; (vii) soil solarization; and (viii) organic or biological amendments. The efficiency of those control measures may be compromised in olive-growing areas where the (D) pathotype prevails (such as at southern Spain and the Aegean coastal region in Turkey) because: (i) the lowered threshold inoculum density for disease by (D)-isolates compared with that by nondefoliating ones; (ii) the role of leaves fallen from infected trees as a source of inoculum for secondary infections; and (iii) the increased susceptibility of olive cultivars to infections by (D) *V. dahliae* and the decreased ability to recover from them. The recovery phenomenon is an intriguing feature of olive wilt whereby the plant is able to recover from disease over time, thus determining that new infections through the root system are needed for disease to develop in a tree on successive years. The recovery phenomenon should facilitate an integrated management of the disease, aimed at reducing the potential for severe disease in young trees and protecting the root system of recovered trees from new infections. The practice of IDM of Verticillium wilt in olive, as is the case for other plant diseases, requires involvement of well-trained professional plant pathologists able to implement the tenets of that concept at the local level, as well as to incorporate into decision-making frameworks new knowledge and technologies that may be developed from scientific research. This requirement might be at risk as institutional support has been reduced through declining or even despairing University education in Plant Pathology.

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IPM AGAINST SOIL PESTS: THE BASIC STRATEGY AND SOME SUCCESSFUL CASE STUDIES

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The widespread use of soil insecticides (this category often represents the highest quantity of insecticides applied in Europe) has been considered unavoidable in many European countries for long time despite its non target effects and environmental impacts. This situation has been caused by a) the paucity of information about the actual impact of the target pests on crops and b) the lack of feasible and inexpensive methods for identifying infested fields. Over the past several years, this gap has been greatly reduced and necessary IPM strategies have been made available. A comprehensive approach suitable for the European countries and applied to the PURE maize experiments will be described; according to provisions of the Directive 2009/128/CE, it includes: a) Evaluation of the agronomic factors that increase the risk of soil pest damage such as continuous soil cover with vegetation in previous year, organic matter content; the absence of risk factors greatly decreases the risk of economic damage and make useless the application of soil insecticides; b) Suitable tools for estimating pest population levels (beetles, larvae) such as pheromone traps (YATLORf) or bait traps and the first relative economic thresholds for maize; the establishing of reliable correlations between adult trap catches and subsequent larval populations for all the species/crops in different climatic and agronomic (mainly rotation) conditions should be promoted in order to have a complete set of thresholds; c) Short and long term agronomic solutions to avoid crop damage such as: timing of grass plowing, hybrid choice and modification of sowing date (short term solutions); alteration of rotation, interference on newly established populations with tillage options or modifications to irrigation timing or method (long term solutions); with respect to rotation management, this would mean that at least in the two years before a sensitive crop (e.g. potato) no crops that are favourable for oviposition and larval survival of *Agriotes* species overwintering as adults should be grown. From a theoretical point of view a crop rotation suitable for avoiding wireworm damages should not include crops that keep the soil continuously covered with alive plants like grasses, alfa alfa, winter cereals plus a second crop in the summer) in the two preceding years; d) Biological solutions to reduce pest populations under the economic threshold including biocidal plants and seed meals suitable for soil bio-fumigation. The implementation of the IPM procedure allowed to reduce the soil insecticides by 99% in 1-3 years in thousands of hectares. When risk factors presence is low, the practice of avoiding any soil insecticide use in arable crops can be kept for dozens of years without any increase of pest populations.

MYCORED CONTRIBUTION IN FUSARIUM HEAD BLIGHT INTEGRATE MANAGEMENT

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Fusarium Head blight (FHB) is a worldwide disease associated with mycotoxin contamination, principally deoxynivalenol (DON), a member of the trichothecene family, that are potent inhibitors of proteic synthesis. The need to reduce mycotoxin contamination in cereals, is a target identified by various international organizations (e.g. FAO, CIMMYT, EFSA, IITA, SAFE consortium, Bill Gate foundation), EU experts and relevant food industry representatives, as one of the most important challenge with a great economical and social impact at global level. According to the FAO, it has been estimated that 25% of the world's crops are contaminated by mycotoxins. Several projects and researches have been conducted in the past years to address the problem, contributing to create a complete approach to handle the effects of the contamination. In this framework, the international project MycoRed funded by EU in 7th FP, for the first time, tries to link the mycotoxin concerns from different point of views, aging at different levels through incisive actions to combat this menace from "the farm to the fork", following all the processes along the entire chain, and supporting this complex strategy by pushing international attention on the problem as well as enforcing training and awareness among main players and users.
Integrated strategies for FHB control in the field include the use of good agronomic practices (such as crop rotation, tillage, correct fertilization and seed treatment), the adoption of resistant varieties, treatments with effective fungicides and/or Biological Control Agents (BCA), but also the development of predictive models and Decision Support System. In MycoRed, a set of strategies to be fit in an integrate plant magement approach has been developed. The plant resistance to FHB has been carried out by identifying some wheat genotypes with low FHB incidence and DON content. Moreover, genetic traits (QTLs) responsible for FHB and DON resistance in wheat have been validated. The QTLs tested gave significant resistance to both initial infection (type 1 resistance) and to fungal spread (type 2 resistance). Regarding the optimization of fungicide distribution, a better nozzle composition was developed causing 50 % additional reduction compared to the best technology found until now. On the other hand, BCA used in wheat at flowering gave promising results in reducing the level of inoculum of FHB casual agents. Moreover, a predictive model for DON contamination in small grains has been validated and reliable predictions were confirmed; fields with DON contamination over the legal limit were correctly predicted in around 80% of cases. Finally, as further tool for the control of DON contamination in post-harvest, MycoRed has also provided the developing of innovative and novel practical strategies for post-harvest handling, minimising DON exposure in wheat chain. An ambient intelligence system for predicting and controlling *Fusarium* species contamination in stored wheat has been developed. These results provide novel integrated strategies for wheat protection programs against FHB and consequent DON accumulation.

PLANTWISE: GLOBAL ALLIANCE FOR PLANT HEALTH IN SUPPORT OF INTEGRATED PEST MANAGEMENT

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on behalf of CABI's Plantwise team -CABI (first author based in the Netherlands, second author based in Switzerland)

Plantwise is a global initiative to collect and share knowledge and information about plant health problems. Crop losses are reduced by timely identification of plant health problems and the implementation of appropriate management practices. Plantwise is an alliance of global partners looking to reduce crop losses by getting the right information to the right people as a solid foundation for local plant health services, including Integrated Pest Management (IPM) programmes. It was initiated by CABI in 2010. The Plantwise approach is based on three inter-linked components: 1. Networks of independent plant clinics in developing countries that diagnose plant health problems brought to them by smallholder farmers and deliver practical IPM advice to address these problems. 2. National plant health systems, within which plant clinics are linked to other relevant stakeholders (e.g. extension, research, input suppliers and regulators), to provide an integrated system of support for addressing the crop problems that affect smallholder farmers. 3. A global knowledge bank, through which plant health information is collected and disseminated, including distribution maps, diagnostic tools and pest management information. Results: to date, (pilot) plant clinics have been established in 24 countries. Plant clinics show benefits to smallholder farmers who follow the advice of plant doctors. In Uganda, four clinics received more than 2000 queries from around 1100 farmers on 62 crops in five years, representing an estimated 150 different types of plant health problems. IPM recommendations provided by plant doctors will result in more judicious use of pesticides, which will lead to reduced environmental impact and biodiversity loss. Plant clinics have an important role to play in pest vigilance and have already been instrumental in the detection of new plant pests, alerting local authorities so that appropriate actions can be taken. The knowledge bank contains a range of features, all of which can be filtered by country, including:

- Interactive pest and disease distribution maps
- Over 1,000 fact sheets and data sheets on plants and their pests
- Diagnostic tools
- New pest alert service
- The latest news on plant health from around the world

Distribution data are a major component of the knowledge bank, but it also contains pest descriptions, extension materials, and images, for use by all IPM stakeholders, including public and private sectors. Green and yellow lists of sound crop health management practices are being formulated for important cropping systems in plant clinic countries. Conclusion: plant clinics, working within broader plant health systems, will help farmers to overcome plant health problems and reduce crop losses using more appropriate management measures. Plantwise will harness plant health observations recorded at the plant clinics and through other mechanisms, thereby improving the geographic mapping of pest occurrence. These data will help developing countries to better manage pests and offer a level of detail that was previously not available. Combined with text-mining and crowd sourcing™, this will create a powerful resource for global biosecurity vigilance, policy planning, research and implementation of plant health services. For more information, please visit: www.plantwise.org.

INNOVATIVE IPM FOR WINTER WHEAT BASED ROTATION: FIRST RESULTS OF EX POST ASSESSMENT FROM FRANCE

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Given the constant increase in the amount of pesticides found in groundwater and rivers in EU countries, innovative cropping systems that account for actual on-farm constraints (i.e., a reduction in nitrogen leaching, energy consumption and greenhouse gas emissions, as well as an increase in economic gains) need to be proposed.
Within the context of the PURE project (WP2), innovative IPM solutions were designed for winter wheat based rotations in different countries of the EU (Denmark, Poland, Scotland, Germany, and France). Firstly, crop successions and agricultural practices were defined in order to reduce pesticide use. In each location, three cropping systems were designed and represent (i) current agricultural practices in terms of pesticide use, (ii) an intermediate level of an IPM solution with a reduction in pesticide use and (iii) an advanced level of IPM, for example in France, where no pesticides are allowed. Secondly, these cropping systems were ex ante assessed for sustainability with the DEXIPM tool. Thirdly, the most promising systems started to undergo testing ex post in field trials in 2012. In the case of France, these ex post assessments have undergone testing since 2009. Experimental results are analysed according to (i) pesticide use (frequency treatment indicator, F.T.I.) and environmental pesticide impacts [four indicators from the INDIGO tool (v.1.9)]; (ii) different environmental components (e.g., nitrogen leaching or the level of organic matter in the soils with the INDIGO tool; energy consumption or greenhouse gas emissions with the GES'TIM database (2010); (iii) yield; and (iv) economic margins.
First results show that cropping systems perform very differently when sustainability is accounted for. These results are discussed from both agronomic and methodological points of view: (i) Is it possible to reach the objectives set for pesticide reduction and economic gains? (ii) Are all the given agricultural practices innovative? (iii) Because the available tools only partially take into account the different mechanisms involved in these systems, what sort of tool do we need to assess these systems? Later, our analytical approach could be used to assess other UE WP2 trials once data have been recorded for several years.

NON-CHEMICAL WEED CONTROL METHODS AS COMPONENTS IN IPM SOLUTIONS FOR REDUCED TILLAGE SYSTEMS

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Tillage systems with tine or disc based cultivations and no inversion of the soil prior to crop establishment is the most common way of reducing tillage for arable cropping systems with small grain cereals, oilseed rape and maize in Europe. However, new regulations on pesticide use may hinder further expansion of non-inversion tillage systems. European agriculture is asked to become less dependent on pesticides and promote crop protection programmes based on integrated pest management (IPM) principles. Conventional non-inversion tillage systems rely entirely on the availability of glyphosate products, and herbicide consumption is mostly higher as compared to plough-based cropping systems. Annual grass weeds and cleavers often constitute the principal weed problems in non-inversion tillage systems in which crop rotations concurrently have very high proportions of winter cereals. There is a need to redesign cropping systems to allow for more diversification of the crop rotations to combat these weed problems with less herbicide input. Especially the inclusion of spring sown crops is an important component in this context but needs economic justification as the yield potential is usually lower than for winter cereals. Cover crops, stubble management strategies and tactics that strengthen crop growth relative to weed growth are also seen as important components in future IPM systems but their impact in non-inversion tillage systems needs validation. Direct mechanical weed control methods based on rotating weeding devices such as rotary hoes may become useful in reduced tillage systems where more crop residues and less workable soils are more prevalent but further development is needed for effective application. A new seeding technology based on GPS-technology that enables cross hoeing of row crops could mean a major step forward in omitting herbicide use in maize, sugar beets and many vegetables. Owing to the frequent use of glyphosate in reduce d tillage systems, perennial weeds are not particularly problematic. However, results from organic cropping systems clearly reveal that desisting from glyphosate use inevitably leads to more problems with perennials, which need to be addressed in future research.

COMBINATION OF ALTERNATIVE STRATEGIES FOR LOW-RESIDUE FRUIT PRODUCTION IN SWITZERLAND

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In several European countries, consumers and retailers are demanding a large reduction or elimination of pesticide residues on fruits. Producers need information and advice on how to meet these demands. In a strategy trial with Golden Delicious and the scab resistant varieties Topaz, Otava and Ariane, common crop protection strategies (integrated and organic apple production) were compared to a low-residue strategy (reduced use of synthetic fungicides). Pest and weed control was identical to the integrated strategy. In all strategies, alternative measures applied were insect exclusion netting, mating disruption against codling moth (*Cydia pomonella*) and mulching of leaves to reduce scab (*Venturia inaequalis*) inoculum. Insecticides were used only if damage thresholds were exceeded. Further trials with exclusion netting were carried out on apple and also on sweet cherry. The first year of the apple strategy trial has shown that a reduced fungicide use in summer results in an unacceptable increase of fruit scab incidence on Golden Delicious and bull's eye rot (*Gloeosporium album* and *G. malicorticis*) incidence on Golden Delicious and Topaz. For the next four years, synthetic fungicides were used only until end of bloom. After bloom, control of diseases was done with potassium bicarbonate and sulphur. Using this strategy, no pesticide residues could be detected and control of scab and powdery mildew was comparable to the integrated strategy and superior to the organic strategy. At storage, Ariane appeared to be the most robust variety in all strategies. Losses due to bull's eye rot remained a weakness of the organic and the low-residue strategy for Golden Delicious and Topaz. However, hot water treatments after harvest reduced the incidence of this disease. The key pest codling moth was successfully controlled by the combination of exclusion netting and mating disruption. No other pest caused relevant losses during the five years. Further trials with netting on apple have shown that a hail net improves the efficacy of mating disruption of the codling moth. The effect is even stronger with additional vertical nets at the edges of the orchard. In these trials, no effect of netting could be observed for the smaller fruit tortrix (*Grapholita lobarzewskii*) though. In a cherry trial with exclusion netting from change of colour to harvest a 98% reduction of cherry fruit fly (*Rhagoletis cerasi*) infestation has been observed. Our field trials with organic fungicides after bloom, hot water treatment after harvest, exclusion netting and mating disruption showed that a combination of these alternative measures can be used to reduce the use of synthetic pesticides and the detectable residues in fruits.

FARMING WITH FUTURE - STAKEHOLDER INVOLVEMENT IN DEVELOPMENT AND IMPLEMENTATION OF IPM IN THE NETHERLANDS

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EU policy identified the need to reduce the use and impact of pesticide use. The Sustainable Use Directive (SUD) asks for National Action Plans to address these issues. Integrated Pest Management is considered to be the key to a sustainable use of pesticides. In the past 20 years many resources were already allocated to the development and promotion of IPM methods. In general the adoption of these methods remains however too low, in spite of occasional successes. The Dutch crop protection policy focusses since 1990 on the implementation of IPM. In the period 2008-2010 the Farming with Future project constituted the national effort to develop and promote IPM in practice. The project is a network project in which researchers, advisors, farmers and stakeholders work closely together. The approaches methodologically developed, evolved over time, taking aboard new insights in participatory approaches and stakeholder management. For the design of the project in the last phase 2008-2010, two factors were addressed as key issues for success (the degree of adoption of IPM methods in practice). These factors were: 1) the focus, context and approach of knowledge development and 2) the Involvement of all relevant stakeholders in the knowledge chain. The first issue was addressed by getting stakeholders involved in prioritization of methods, letting the determine which promising new techniques need to be the first to be further developed. And by subsequently testing and developing the new methods in practice together with farmers, advisers and stakeholders, the so called road test. The second issue was addressed by intensifying the dialogue with all relevant stakeholders in practice eventually leading to hundreds of contacts, aimed at involving them in road testing and communication. Here stakeholder management techniques were used to get stakeholders involved, to connect their interests to the interest of the reduction of impact of pesticide use, to address their responsibility to get involved.

The approaches were successful. The network was the focal point and transfer point of new knowledge on IPM, in the period 2008-2010 100 new methods were tested, 80 developed into useful effective and feasible strategies. They were documented, described, demonstrated etc. in hundreds of activities, reaching thousands of farmers. All activities were organized together with stakeholders. Of the more than 200 stakeholders we initially invested in, more than 100 became regular partners in activities (regional, national). In general we noticed a more open dialogue on the challenge, more coalitions between different partners, and more concerted actions. It also became clear that stakeholder enrolment takes time. The final impact was that the adoption of new tested methods increased clearly and that in water protection area’s were coalitions of stakeholders were active the water quality problems reduced.

PEST SELECT DATABASE: A NEW TOOL TO USE SELECTIVE PESTICIDE FOR IPM

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The selectivity of plant protection products for natural enemies of crop pest is a key factor in the success of IPM strategies. An abundant scientific literature concerning this subject exists, but for the final pesticide users, the information is not always easily accessible or understood to be used in the IPM context. The IOBC working group “Pesticides and Beneficial Organisms” (PBO) has developed a new database to compile all data concerning pesticide selectivity on beneficial arthropods obtained with methods that followed the IOBC test standard characteristics, developed since the 70’s by the Working group Pesticide and Beneficial Organisms. This database include a first set of data previously published, coming from the different Joint Pesticide Testing Programs, with the addition of all pertinent papers published in the IOBC Bulletin. The second set of data has been extracted of the Public verse of the Draft Assessment Report (DAR) established by the different EU members states in the context of the registration process at the European Level. As nearly all active ingredients have to be tested on at least 2 to 4 selected beneficial arthropod species with methods that followed the IOBC standard characteristics, the DAR represent an important source of information for pesticide users dealing with beneficial arthropods and selectivity, with about 50% of the actual records. This source was previously only exploited for registration purposes, but a lot of results, mainly from the first tier testing, have been compiled and interpreted to be used for IPM. The new database is available online on the IOBC website (h ttp://www.iobc-wprs.org/restricted_member/toolbox.cfm) on the area restricted to the IOBC-members. This database will be updated regularly on basis of the new IOBC publications, EFSA Draft Assessment Report and scientific publication results that followed IOBC standard characteristics.

GOALS IN NATIONAL ACTION PLANS AND IPM IMPLEMENTATION – CORE ELEMENTS OF THE SUSTAINABLE USE DIRECTIVE

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The Directive 2009/128/EC to achieve the sustainable use of pesticides was adopted in 2009. The core element for the implementation of the Directive are National Action Plans associated with different goals in terms of volume, frequency of use or risk and impact and the mandatory implementation of IPM by all professional users by January 2014. By November 2012, Member States were required to develop National Action Plans and to report them to the Commission and to other Member States. The plans provide the framework for the implementation of the Directive 2009/128/EC; contain goals, time tables and detailed measures to achieve the overall objective to reduce the risks and impacts of pesticide use. A number of countries have a history of national plans and programmes to reduce pesticide use and risks. The comparison of such plans reveals the national characteristics which greatly influence the definition of goals and the goal setting process. In general, it can be observed that in history reduction goals evolved from volume reduction to reduction goals measured by treatment frequency index to risk and impact reduction in recent plans. In the presented overview the national characteristics and the different approaches of the goal setting process are compared. A novel element in the Directive is the encouragement of integrated pest management and alternative approaches. The mandatory implementation of IPM by January 2014 and the adoption of the General Principles of IPM are challenges for most Member States. The approaches of IPM implementation vary between countries regarding the main players and stakeholders and range from the general adoption of the IPM principles, government driven programs for demonstration farms and national IPM projects, to development of crop specific guidelines and scoring systems to evaluate the national IPM performance.

WHAT'S HAPPENING WITH IPM IMPLEMENTATION IN EUROPE?

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Societal demands and expectations led to national and European legislation creating a policy landscape conducive to the design and implementation of new IPM schemes that contribute to sustainable development while preserving the competitiveness of European agriculture. The legislation marks a significant boost for IPM. Concerted efforts in research and extension are putting IPM firmly back on the map. Europe is set to become a source of renewed inspiration for IPM applied to conventional agriculture in industrialized countries and broadened to encompass all pest categories—animal pests, weeds and diseases. IPM is a continuum and approaches on how to implement it sometimes overlap and sometimes differ across Europe. Some countries emphasise reduction of overall use or dependency while others focus on risk reduction covering impact on the environment, on water quality, or on human health. The focus of research efforts ranges from increasing the efficiency of pesticide use and reducing its impact, to substitution strategies or revisiting the entire cropping systems and, in some case the food system. The factors expected to drive change also differ widely. Depending on the country and on point of view, the drivers of change include direct subsidies to farmers, broad mobilisation of the entire agricultural knowledge chain, pesticide taxes, communication initiatives, pressure from NGOs, supermarket procurement policies, etc. This diversity of approaches and experiences across Europe is an asset that can be taken advantage of to share lessons learned or even to coordinate research and extension efforts to create synergies. The European network ENDURE and the EC's Directorate General Health and Consumers facilitate such exchange at the European level and some regional groupings such as the Nordic Association of Agricultural Scientists or the CEUREG Forum address IPM at the regional level. The future development of an ERA-Net on IPM will offer an interesting opportunity for more substantial exchange and collaborations across Europe.

IPM ACTIVITIES OF THE FOOD AND AGRICULTURAL ORGANIZATION OF THE UNITED NATIONS IN REGIONAL OFFICE FOR EUROPE AND CENTRAL ASIA

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FAO's Plant Production and Protection Division (AGP) promotes Sustainable Intensification of Crop Production. This approach requires the integration and harmonization of all appropriate crop production policies and practices aimed at increasing crop productivity in a sustainable manner, thereby meeting key millennium development goals aimed at reducing hunger and preserving the natural resources and environment for future use. The focus of our activities are to develop and strengthen (1) effective and strategic decisions that increase crop production using an ecosystem approach, (2) national capacities to monitor and to respond effectively to transboundary and other important outbreak pests, (3) policies and technologies appropriate to needs of a country and/or region to reduce negative impact of pesticides, (4) conservation and sustainable use of plant genetic resources with strong linkages between conservation, plant breeding and seed sector development. Regional Office for Europe and Central Asia (REU) and the Sub-regional Office for Central Asia (SEC) are supporting member countries with few following ongoing projects related to IPM of pest species. In Georgia, IPM program was developed to control fall-webworm (*Hyphantria cunea*). Exceptionally in Georgia, outbreaks of this pest occur every year, that can be explained by the interaction of the recently evolved agronomic, institutional, social and economic factors. In Armenia, the control of potato tuber moth (*Phthorimaea operculella*) and of mole species such as blind mole rat (*Nannospalax nehringi*) is supported. Technical support provided in monitoring and surveillance of wheat rusts and implementation of "Five-year program to improve national and regional locust management (Acrididae) in Caucasus and Central Asia (CCA)". IPM was promoted in vegetable, fruit orchard and grape production in Turkey. Farmer Field Schools (FFS) for promotion of conservation agriculture and IPM in Kyrgyzstan were organized. The status of plant protection in Central-Asian countries was analyzed. IPM approach is necessary to be supported in the region. The current activities of the offices are related rather to the implementation of international agreement on phytosanitary measures (IPPC), such as quarantine issues, and on pesticide management (Rotterdam Convention) such as pesticide quality control, residue monitoring, management of obsolete pesticides. The Regional Consultation to Promote Ratification of the Rotterdam Convention on the Prior Informed Consent Procedure for Certain Hazardous Chemicals and Pesticides in International Trade conducted with participation of four REU countries. In addition to that, the plant genetic resources management, the seed breeding and production systems are important focal areas. Due to the specific agro-environmental conditions, conservation agriculture has special relevance.

NATIONAL ACTION PLANS IN NORDIC-BALTIC COUNTRIES

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The use of plant protection products (PPP) in Nordic-Baltic countries accounts for about 4% of the PPPs sold in the EU. The utilised agricultural area (UAA) is about 11% of the EU's UAA, meaning less PPP use than the EU average. Nevertheless, due to the cold climate and slow PPP degradation, there are a few findings of pesticide residues from surface water and groundwater drills. At the EU level, there is a common concern of risks linked to the use of PPPs. Therefore, the directive on the sustainable use of pesticides 2009/128/EC commits EU Member States to adopt the National Action Plan (NAP) on the sustainable use of PPPs. The NAP shall include quantitative objectives, targets, measures and timetables to reduce risks and impacts on human health and the environment, and to encourage the adoption of integrated pest management (IPM). The SUD articles related to NAP follow the life cycle of PPPs from sales to safe use, environmental fate, awareness raising, disposal and follow-up. The objective of the study is to describe and compare the national action plans in the Nordic-Baltic countries, including Norway. The study has been conducted by sending a questionnaire to the national ministries or authorities responsible for NAP. Each respondent answered in November 2012. Some countries will publish the NAP at the end of 2012, and in that case, the situation will be updated during February 2013. This study reviews the actions that impact on the everyday life of professional users, namely training, inspection of sprayers, sales of PPPs, protection of the aquatic environment and drinking water, IPM, indicators, handling and storage. The results indicate that some Nordic-Baltic countries have had national plans concerning use of PPPs since the 1980s. The objectives of the new NAPs are a) general risk reduction; b) direct quantitative risk reduction targets; and/or c) indirect risk reduction targets, such as the amount of professionals holding a certificate. The training will be mandatory for all professional users throughout the region except in Denmark and Finland, where users are allowed to gather the information from other sources and take an exam without training. In some cases, the length of the training is up to 72 hours. Major changes will occur in Finland and Estonia, where the present training is mandatory only to farmers committed to EU agri-environmental measures (AEM) and to users of certain products, respectively. The sprayers have been inspected in Finland, where it has been linked to the AEM, whereas in Estonia, Lithuania, Sweden and Norway, it has been mandatory in professional use or for users of classified substances. In Denmark and Latvia, the large-scale inspections will start after the implementation of SUD. The implementation of the NAPs is truly national and is related to the history of the country.

IMPLEMENTATION OF DIRECTIVE 128/09/EC IN ITALY

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The new Directive n. 128/09/UE is an important opportunity to complete and bring to a regime many initiatives that our country has long since started to improve and optimize the use of plant protection products. For example:

- Since 1968, who sell and buy on PPPs with the classification T, T + and Xn must have a specific license;
- For nearly 20 years have been launched to disseminate experiences on a voluntary basis experiences for the control and regulation of sprayers in facilities specifically prepared and approved by the regional authorities;
- On IPM there are several important practical experiences from 30-40 years, with a widespread application.

For this reason, various initiatives have been taken in the preparation of an optimal application of the Directive for some time:

- Setting up First Technical Table for NAP - July, 2008;
- Stakeholder consultation on the first draft NAP - September, 2009;
- Setting up Technical Table for NAP - January, 2011;
- Implementation of the Directive - Law decree n. 150 - August 14, 2012 (OJ 202 of August 30, 2012 - Suppl. Ordinary n. 177);
- New draft of the Italian NAP: November 8, 2012;
- Stakeholder consultation on the new draft NAP - November 8, 2012 - January 15, 2013.

The draft of the Italian NAP has been drawn up in agreement between the three ministries (Agriculture, Environment and Health) and hence have used the support of a technical committee composed of experts from various ministries and regional administrations.
In this moment the situation is not easy, there are some critical position by Regional Administration, Professional Organizations and Agrofarma, which represents all pesticide manufactures. The economic situation is critical and there is not any certainty about the new CAP.
However, the Involved Ministries think that a constructive discussion will take place soon in such a way that a complete NAP will be ready in few months.
The NAP has been structured for each of the actions introduced by the Directive and the national intervention Decree defining the resulting application constraints for farms and at the same time, assuming appropriate media applications.
The definition of the objectives and the same way in which support and guide companies in the application of the elements of the plan are still subject introduced by the instruments in this sense can be made available by the new European budget, the CAP and Rural Development future plan.
The new NAP will be a good opportunity only if: it is integrated with a good policy of support; it is able to integrate each other the experiences of all MSs of the EC.

ADOPTION OF INTEGRATED PEST MANAGEMENT: WHAT ROLE FOR ECONOMICS?

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Integrated pest management (IPM) provides both a conceptual approach and an implementation paradigm for sustainable agriculture. It has been retained as one of the possible approaches to promote low pesticide-input pest management in the EU “pesticides package” and Sustainable Use Directive (article 14 of 2009/128/EC). However, despite strong political support towards pesticide-use reduction, and considerable scientific progress in terms of tactical approaches to control pests (biological control, plant resistance, etc.), farming practices, and thus pesticide usage, have not changed substantially (EUROSTAT 2007). Limited effort has been made to exploit interactions between individual methods and integrate them into global solutions taking into consideration the whole cropping and farming system in a wider perspective, including the socio-economic dimension (PURE 2011). Therefore, despite the availability of crop-specific guidelines for IPM practice implementation, it is unclear how readily, or within which practical timeframe, such guidelines can be effectively adopted by European producers. Why would EU farmers adopt IPM practices? To what extent should public money be used to promote IPM adoption? Would retailers be willing to create specific market segments for IPM products? Will insurers be willing to cover the potential risks linked to IPM adoption? Will consumers be willing to pay higher prices for goods produced with IPM practices? Answers to these questions are beyond the scope of agro-ecology research in pest management, but are nevertheless central to the success of evolution of farming towards more sustainable use of pesticides. The economics tool box can provide some answers to these questions. This paper attempts to raise the important economic issues for the development and adoption of IPM, with a view to addressing them on the basis of available empirical evidence. First, we consider the broad picture and present the economic tools available to evaluate the welfare impacts of IPM adoption at the societal level and to design the public policy instruments likely to promote adoption. The adoption of the "pesticide package" results from various analyses conducted within that framework, in order to provide policy makers with the evidence of the benefits from large scale IPM adoption in the EU. Since the adoption of the "pesticide package" in 2009, the question is now how to achieve adoption at the farm-level, effectively reducing pesticide use in the fields. In order to do so, it is necessary to identify what drives the modification of farmers' practices and how they react to policy incentives. Therefore, in a second part, we present the tools available in microeconomics and agricultural economics that are useful towards understanding farmers' adoption decisions.

SHAPING IPM WITH NGOS AND RETAILERS

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In many European countries the general public fears the risks of pesticides, especially on fruit and vegetables. Members of national Parliaments and NGOs urge governments, primary producers and food chain partners to reduce the risks of pesticides. Long-lasting and fierce public debates have resulted in retailers imposing ambitious residue restrictions on their suppliers. The objectives of this paper are 1) to improve the understanding of the dynamics behind transitions in food chains, and 2) to show IPM researchers how they can help farmers and growers in meeting the residue requirements of retailers and their customers (i.e. the general public). The first objective has been addressed in ENDURE by analysing the public debates on pesticides and crop protection in the Netherlands and France, using newspaper articles and questions in Parliament over the period 1995-2008. In the Netherlands the dynamics of the public debate has been charted through a dramaturgical analysis of the newspaper articles and questions in Parliament. The second objective has been addressed in PURE by collecting the residue requirements of German retail companies for fruit and vegetables. Furthermore, the price premiums for exported tomatoes from Spain, Italy, France, Belgium and the Netherlands to Germany have been calculated on the basis of Eurostat data. The dramaturgical analysis of the Dutch public debate on pesticides resulted in a flow chart of the dynamics behind transitions in food chains. The flow chart shows pressure coming from citizens, NGOs and the Dutch Ministry of Agriculture. These parties first commission knowledge partners to clarify the problem, and then challenge primary producers and food chain partners to improve 1) production practices, and 2) product qualifications. This twin innovation is crucial. Otherwise the efforts of the primary producer in improving product quality and meeting residue requirements vanish in the bulk of conventional products on the consumer market. Hence, a willingness-to-pay of consumers cannot be cashed. Consumer willingness-to-pay for high quality and low pesticide residue levels is clearly expressed in the price premiums of tomatoes exported to Germany from Spain, Italy, France, Belgium and the Netherlands. German retail companies impose high quality standards on their suppliers but in return they also pay higher prices. This price premium of high quality tomatoes is €0.10-0.40 per kg. NGOs and Members of Parliaments challenge retailers to reduce pesticide residues on fruit and vegetables. Low pesticide residue levels provide producers access to the top segment of the consumer market. This market segment is willing to pay price premiums. IPM researchers should help primary producers to meet the residue requirements of this market segment by e.g. market intelligence, biological control and decision support.

DIRECTIVE 2009/128/CE AND ARABLE CROPS: HOW CAN WE GET READY FOR THE 1ST OF JANUARY 2014?

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Despite most of the worldwide used pesticides are applied to control pest and weeds in arable crops, IPM strategies have not played a significant role in these crops yet, while they have been widely implemented in crops like orchards. Then, arable crops represent a more difficult case for the implementation of the Directive 2009/128/CE. A particular effort is needed for making successful the directive considering the arable crop framework: low income crops, low manpower availability and low technical knowledge. This means that for the implementation of IPM in arable crops, there is a need for: a) low cost strategies; b) not time consuming tools; c) "sustainable pesticides" (from the economic and environmental points of view). To reach this goal an innovative and cheap advisory system is necessary that can give an on-line information about the needed treatments and at the same time supplying all the useful criteria for creating a new technical background. This has been achieved by the "Bulletin for arable crops" issued by the Agencies for Agriculture development and for Prevention and Environmental protection (ARPAV) and the Plant Health Service of Veneto Region with The University of Padova (DAFNAE). The bulletin is based on an "area-wide" monitoring system for pests, diseases and weeds and indicates where and how a "complementary field monitoring" is needed. The "area-wide" monitoring is low cost since it is based on: a) semiochemicals (traps) that are a powerful tools provided they are developed to make their use easy and inexpensive for users b) crop-pest models based on meteorological information (black cutworm alert program, Davis model for WCR egg hatching, etc.); c) statistical evaluation methods (e.g. geostatistics); d) agronomic information about the cultivated areas. By putting together all the information it is also possible to identify the proper timing of treatments where needed. While doing this, the professionalism of farmers can progressively improve. The main characteristics of the Bulletin are: flexibility, on average it is issued weekly, but it can vary according to the needs since it is closely related to the evolution of crops and pests; the information is forwarded by e-mail and always available on the web-site (http://www.venetoagricoltura.org); in case of immediate risk, the alert is given also via SMS; preparation: it gives a continuous information on how to react promptly and properly in case of alert message; vocational training: bulletins are designed in a way to provide in-depth information (e.g recognition of symptoms, pests); participation: the farmers can be part of the monitoring network; interaction: possibility of asking questions and proposing changes.

USE OF CHECKLISTS AND A SCORING SYSTEM FOR EVALUATION OF IPM IMPLEMENTATION ON DEMONSTRATION FARMS

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The German National Action Plan on Sustainable Use of Plant Protection Products (NAP) calls for the establishment and maintenance of demonstration farms for integrated pest management (IPM). This project was launched in 2011 to demonstrate IPM on apple, viticulture and arable cropping farms in representative regions of Germany. The farmers receive intensive support from state advisory services and special project-financed scouts. Here, IPM is implemented based on the drafted IPM guidelines for apple, viticulture and arable cropping, which follow the structure of the general principles of IPM published in Annex III of Directive 2009/128/EC. Checklists and a scoring system were developed to evaluate the implementation of IPM on the demonstration farms. This presentation reports on the approach in arable cropping. Firstly, IPM guidelines containing 20 requirements were developed for arable cropping. The checklist is based on these requirements. Each requirement is described in detail to ensure an evaluation in terms of the degree of implementation of a given requirement. The requirements include the use of professional information on IPM, crop rotation, sowing dates, use of resistant varieties, measures for enhancement of natural control, pest monitoring and use of decision-making aids, use of non-chemical measures, and compliance with necessary minimum of pesticide use by including data on reference farms, etc. In each case, there is a table for comments and the degree of implementation is assessed on a scale of 0 to 3, 5 or 6, depending on the importance of the requirement within the IPM concept. The assessment is done by experts from the state plant protection services in collaboration with the scouts. If they determine that implementation does not meet the requirements of the IPM guidelines, the farm receives a score of 0 or, at most, 1. If implementation performance exhibits room for improvement, the score can be 2, 3 or 4, and if performance fully meets the requirements of the IPM guideline, the maximum score (3, 5 or 6) is possible. This approach allows identification of shortcomings in IPM implantation in arable cropping, e. g., insufficient use of fungus-resistant cereal varieties or of non-chemical crop protection measures. The current discussion relates to what percentage of the maximum achievable score must be obtained to fulfil an adequate level of IPM. Further development of the IPM scoring system to include bonus points for certain cultural and non-chemical control measures within the context of special environmental protection programs is being considered.

A SOCIO-ECONOMIC ANALYSIS OF INTEGRATED PEST MANAGEMENT: A REVIEW OF THE EFFECTS OF IRREVERSIBILITY

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The Economic evaluation of integrated pest management strategy (IPM) is predominantly done through cost-benefit analysis. From a social welfare perspective uncertainty over benefits and costs, irreversibility effects and external benefits and costs need to be considered as well. We introduce the maximum incremental social tolerable irreversible costs (MISTICs), I*, as a tool for such consideration. Only when the incremental benefits of an IPM strategy outweigh possible irreversible costs should the IPM strategy be introduced. The approach allows to differentiate between an assessment of an IPM strategy from a private sectors point of view (excluding external effects) as well as from a societal point of view (including external effects). The differentiation between reversible and irreversible benefits and costs provides information about impacts of the new strategy that might warrant special attention from a regulators perspective (in the positive as well as negative sense). The model can be extended to include other factors which may delay introduction of an IPM strategy from a private sectors point of view including regulatory hurdles, where technologies that can be applied for effective IPM systems are delayed due to strict regulatory frameworks or unclear paths for registration.

IPM – CAN IT DELIVER? BALANCING ENVIRONMENTAL AND ECONOMIC SUSTAINABILITY

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There is a renewed interest in IPM in Europe because of the importance given to it in EU policy on pesticide reduction in agriculture. The Sustainable Use Directive (SUD) requires that by 2014 all farms in Member States, implement their crop protection activity under some form of IPM. Governments are expected to produce National Action Plans [NAPs] as road maps to pesticide reduction and IPM adoption. IPM has therefore become a central pillar of the EU Pesticide reduction strategy. Food security in Europe is now on the EU policy agenda, as rising population and climate change put pressure on global food supplies, reflected in volatile food prices. Within the SUD, it is stated that the implementation of IPM should not lead to significant decreases in European food production, nor should any additional cost be borne by the European farmers. However, it is doubtful if this is possible to achieve at the current level of IPM technology development. Adoption of IPM remains low in arable agriculture which is the main user of pesticides. There appears to be a contradiction between EU policy on pesticide reduction and on food security, as most informed opinion predicts that rapid removal of conventional pesticides will result in substantial decreases in food production. The SUD was developed and is implemented within the EC by DG Environment and DG SANCO and therefore, the objectives and indicators relate to environmental protection and food safety. Little consideration is given to agricultural productivity, nor to the impact of pesticide withdrawals on farming livelihoods. If IPM is to play a central role in mitigating the effects of pesticide reduction on European food production, pesticide use must be addressed within the context of European food security and the enhancement of farming livelihoods. This paper presents the case for more adaptive research on IPM component technologies and systems, with closer engagement with producers and other stakeholders and for a closer partnership between research, farming organizations and biopesticide SMEs.

IOBC: FROM GUIDELINES TO ACTION ON FARM LEVEL - LESSONS LEARNT FROM CASE STUDIES

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According to IOBC, Integrated Production (IP) is a concept of sustainable agriculture that is based on the use of natural resources and regulating mechanisms to replace potentially polluting inputs. In IP, including IPM as the part of IP focusing on pest and disease management, emphasis is placed on a holistic system approach involving the entire farm as a basic unit, on the central role of agro-ecosystems, on balanced nutrient cycles, and on the preference of preventive measures and non-chemical interventions over direct chemical control. IOBC has established a framework of general and crop-specific guidelines describing in detail how IP, and in particular IPM, should be implemented in practise. These guidelines are regularly updated, incorporating new knowledge, and therefore represent a state-of-the-art compilation of farm and crop management practices for an optimal IP/IPM implementation. Based on the guidelines, IOBC offers endorsement to farmer's organisations looking for a robust, transparent and feasible application of IP/IPM. The endorsement includes benchmarking the organisation's own production guidelines with IOBC standards, eventually followed by adaptations to the guidelines based on the dialogue with IOBC. When endorsed, annual controls of compliance follow. A key element of these inspections is SESAME, a checklist containing a catalogue of control points which covers the major requirements in the IOBC guidelines. This checklist both serves as self-control tool and as tool for the inspectors, as part of the certifying schedules. Three organisations have a long-standing history of IOBC endorsement: LIVE (low input viticulture and oenology) in Oregon (USA), TYFLO (viticulture) in the Alsace (France) and TREECOOP (pome fruit) in Spain. These excellent examples demonstrate how IP programmes are implemented and continuously improved. Using these examples, it will be shown, how requirements in the guidelines can be translated into practical actions on a farm level. For example, how, in the case of LIVE, the topic „protection and enhancement of beneficial organisms“ was translated into several measures, starting with the requirement that farmers know their key beneficials, that inter-vine strip management promoting beneficial insects is implemented, and that other preventive measures are applied. The insecticide use is limited to a specified list and must be documented as to reason of use. The organisation- and region-specific translation/adaptation of the general IOBC guidelines and the subsequent systematic assessment of its feasibility, including as well the self-control schemes and inspection controls from certifying bodies, offers excellent material for a feedback and improvement cycle for more effective and at the same time feasible IPM approaches. This type of interaction has been a driving force in developing IPM further, as well for the endorsed organisation as for IOBC. The LIVE case demonstrates this very clearly.

IPM AGAINST ECB (*OSTRINIA NUBILALIS*) IN MAIZE: IS IT POSSIBLE?

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IPM implementation requires reliable economic thresholds that can be easily evaluated by the users in different locations and conditions. Unfortunately no practical thresholds are currently available to implement IPM of ECB (*Ostrinia nubilalis* Hübner), despite ECB represents the major insect pest of maize in Europe. In order to fill this gap, the swarming period of ECB has been studied by using blacklight traps equipped with a 15-watt bulb over a thirty years period at different sites in Veneto, Italy. Traps were inspected at least twice per week, when not daily. At the same sites the numbers of moths caught have been compared with the density of egg clusters that was estimated by observing hundreds of plants at least once per week. At harvest time plant damage (broken stems, damaged ears) and yield of treated and untreated strips were recorded. The insecticides used were mainly Pyrethroids; they were applied with a high clearance sprayer at the beginning of a significant larval presence on plants. The agronomic characteristic of the fields with treated and untreated strips were the same. As to the main results obtained, population levels greatly varied among sites and over the years at the same sites. A clear correlation between ECB pressure and yield reduction was found. Low moth captures and egg cluster densities resulted in no or negligible yield reduction. Mycotoxin contents of the grain were evaluated too. Since, in order to implement IPM, it is needed to forecast the population level and the subsequent plant damage early enough for deciding on the possible rescue treatment, the correlation between early light trap captures and plant-yield damage at harvest was studied along with a development model describing the populations patterns from climatic conditions. Based on these results a practical approach for IPM against ECB in maize will be described. This is mainly based on two parameters: a) the absolute value of light trap captures in the first days of the swarming of the second ECB generation; b) the egg density in the same period. An area-wide monitoring based on early light trap captures and scouting of egg clusters in some representative fields, allows an effective advise to farmers and contractors for: i) assessment of the areas where maize treatment against ECB is needed or not; ii) assessment of the time interval suitable for getting the highest ECB control when it is convenient; iii) assessment of the periods when a treatment against ECB may give a significant reduction of other pests (e.g. *Diabrotica virigifera virgifera*). This makes feasible the implementation of IPM against ECB according the provisions of Directive 2009/128/CE. This IPM approach should be evaluated in different European countries.

USING LIFE CYCLE ANALYSIS TO IMPLEMENT INTEGRATED PEST MANAGEMENT

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Integrated Pest Management (IPM) will become the European standard in crop protection policy by 2014. IPM is a strategic approach to optimize the tradeoff between agronomical and environmental performances. It promotes the use of natural resources and regulating mechanisms to avoid potentially polluting inputs such as pesticides. An emphasis is given to preventive measures such as sanitation practices. Different pest control tools can be integrated to design advanced IPM production systems. To help the selection of the best combination, a global evaluation of its environmental performances is needed. Beside ecotoxicity and human toxicity, other impact categories such as global warming potential should be considered to evaluate the overall environmental performance of production systems. The life cycle analysis (LCA) also named cradle-to-grave analysis permits such quantitative and global evaluation of the production systems, considering numerous impact categories and avoiding burden shift when re-designing farming systems. Based on case studies on apple, we will demonstrate how LCA could be used to identify best options/scenarios and to improve the environmental performances of apple production systems. The LCA methodology and its application to apple will first be detailed. Then examples will be given to illustrate the interest of LCA to define pest control strategies towards more environmentally friendly production systems.

DEXIPM, A TOOL FOR SUPPORTING THE DESIGN OF INNOVATIVE IPM STRATEGIES

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Agricultural sustainability encompasses economic, environmental and social dimensions. In the design of innovative cropping systems (CS), several alternatives can be proposed to achieve a specific goal like pesticide use reduction. The DEXiPM model (Pelzer et al., 2012) was developed for the multi-criteria assessment of the sustainability of arable CS and it is used as a support for designing innovative cropping systems. Indeed, the ex ante assessment of the sustainability performances estimated by the model allows researchers identifying strong and weak points and possible improvements of the cropping systems to be tested in field.
DEXiPM has been chosen as a key tool within the PURE project (http://www.pure-ipm.eu), supporting a multi-year loop which consists in the design, testing and adjustment of different typologies of CS with reduced pesticide inputs: arable, field vegetables, protected vegetables, grapevine and pomefruit. In this process, ex ante assessment of the proposed prototype systems and ex post assessment of their performances in the field are essential. Therefore DEXiPM has been adapted to: (i) the specificities of the each typology of CS and (ii) the frame of ex post assessment, in order to allow every year the identification of practices that should be modified and to provide a global evaluation of a system implemented in a given context.
DEXiPM evaluates the overall sustainability of a cropping system decomposing it into more and more specific attributes starting with environmental, social and economic sustainability. The model's attributes are characterized by qualitative classes of values and their aggregation into more complex attributes is defined by utility functions (if-then rules). These functions are synthesized by relative weights which are affected to the involved attributes, reflecting their influence on the value of the upper one. The basic attributes of the tree represent the model's inputs and they are related to the cropping system as well as the context of the assessment.
The purpose of DEXiPM goes beyond scoring alternative systems: it is also important to analyze their performances taking into account their complexity. The strength of the model is the comprehensive "dashboard" of sustainability indicators that is elaborated. It represents the value of all the assessed attributes enabling discussions on the alternatives compared. In this contribution we will give some examples of possible use of the model, showing the flexibility of the approach in a diversity of assessment objects and goals.

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X-PEST, AN ONLINE GENERIC MODELLING PLATFORM TO DESIGN MODELS THAT SIMULATE CROP LOSSES AS A FUNCTION OF INJURY PROFILES AND PRODUCTION SITUATIONS

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Limitation of crop losses (quantitative and qualitative losses) is the main objective of crop protection. However, there is a need to better quantify and analyse crop losses as a function of dynamics of injuries and production situations. Several models have been developed to represent damage mechanisms for a wide range of harmful organisms (weeds, plant pathogens, animal pests) on several crops. However, these models are crop specific, even if their conceptual basis is generic. In order to promote this modelling approach, an online interactive generic modelling platform is being developed. The platform is composed of 3 sections. The first section provides general information about yield losses, the overall purpose of the platform and references. The second section is an interactive forge allowing the user to design a specific version of X-PEST adapted to a given crop, using a common generic framework. This section allows the user to define the structure of the model that he is currently developing according to three steps. First, the user provides the number of organs considered, along with the dynamic of assimilate partitioning coefficients, as well as whether senescence and remobilisation will be represented in the model or not. The biomass production through photosynthesis is simply represented by the Monteith's equation. Second, the user has to provide a description of the dynamic variables that describes pest dynamics. For each considered pest, the user indicates which damage mechanism(s) is (are) associated with the considered pest. The damage mechanisms represented in X-PEST are fivefold. Pests can affect the Leaf Area Index (for light stealers), the Radiation Use Efficiency (for assimilate rate reducers), or reduce the pool of biomass (assimilate sappers), directly decrease organ biomass, or induce a loss in quality. Third, for each damage mechanism, the user has to describe the relationship between the injury and the variable(s) affected by this injury. Once the model fully defined, it can be run online through the last section of the platform (simulation center) or through a downloadable R package. The third section of X-PEST is the simulation center. Authorised users can use models embedded within X-PEST to launch simulations. Graphics and numerical results are available in a downloadable zip file, along with online visualisation. Simulations (input variables, parameter values, and model structure) are saved in a database in order to limit the time consuming operation of entering parameters and input variables. Models developed under X-PEST will help to perform diagnoses at the field scale, design durable cropping systems less vulnerable to damage caused by pests (if coupled with epidemiological models that take into account cropping practices) and rank pests according to the damages they cause at regional, national or continental scales.

THE INDICATOR SET DISCUSS AS A TOOL TO HELP FARMERS ACHIEVE FUTURE IPM

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DISCUSS, the Dual Indicator Set for Sustainable Crop protection Sustainability Surveys, was designed to help farmers achieve more sustainable crop protection, i.e. to achieve sustainability beyond IPM. The indicator set pairs a risk indicator with a response indicator. POCER, the Pesticide OCcupational and Environmental Risk indicator, assesses risk for human health and the environment exerted by chemical crop protection. An inquiry reveals farmers' response to this risk, both in terms of their management actions and their knowledge, awareness and attitude. DISCUSS was designed for implementation in a social learning setting, i.e. in small discussion groups, coached by an advisor. Before taking DISCUSS off the design table into practice, we need to gain insight into its operational limits and conditions. We thus perform sensitivity analyses on both parts of the dual indicator set. Flemish fruit farms serve as a first case of implementation. First, the conditions for calculating POCER in the context of farm level sustainability assessment are examined. Questions are raised about comparing farms with different fruit crop mixtures. As each fruit species requires specific protection, one can discuss whether it is the farm's sustainability or its crop mixture that is measured? What is the correct way of expressing the environmental pressure exerted by the pesticides used on a fruit farm if comparison to peers is the goal? Second, conditions for implementing the inquiry are considered. Is the inquiry specific enough to detect differences in crop protection management between fruit farms, who have already been using IPM for a decade? Analogously, can differences in knowledge, awareness and attitude between fruit growers be detected sufficiently? Can results from fruit farms be extrapolated to other farm types? Results from the first test implementation will be presented.

THE SUSTAINABILITY CERTIFICATION IN SUPPORT OF INTEGRATED PEST MANAGEMENT

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The development of Integrated Pest Management has led to a progressive rationalization in the use of chemicals in agriculture and greater knowledge of production processes themselves. Also considering the route taken in recent decades on regulation revision (e.g. the latter EU Directive 128/2009) also setting the mandatory application from 01.01.2014 regarding the IPM principles and criteria, and the development of national rules, IPM wants to answer more and more to a general need of sustainability, and not only reducing the use of chemicals (fertilizers and pest control), but also looking at a more general environmental friendly sustainability in the agriculture. Tools developed by the research community can support this IPM's role. This is the case of the Life Cycle Assessment (LCA) approach, which represents a valuable tool to define most sustainable choices also within the IPM. Through evaluation of all inputs and emission involved in a production chain, this standard procedure gives the possibility to quantify the environmental impact acting on soils, resources, human and ecosystem health, atmosphere, etc., thus representing an holistic approach to sustainability. Recently LCA studies are also involving IPM agro-production schemes, which, among main aims there is the definition of impact factors for active principles, understand the chemical's fate in soil, water and air, the definition of most important kind of impacts (e.g. freshwater or human toxicity) and environmental compartment (e.g freshwater ecosystem or human health) related to IPM, the most impacting chemical typology (acaricide, fungicide, herbicide, insecticide), the comparison of toxicological impacts of several production systems. Quite common is the use of LCA in IPM to compare between pesticides to study potential substitutions and optimal doses. LCA can thus give the possibility to evaluate pest management alternatives and sustainable management choices, as well as, t he rules contained in IPM specifications. More importantly for IPM, his sustainable approach should be converted in "environmental value". This philosophy is behind the CCPB's initiative, who strong experienced in the field of organic and sustainable products, and that for over four years, with the support of organizations, scientific institutions and companies, designed a model for certification of impacts in agri-food sectors based on the calculation of LCA in accordance with the international volunt ary standards (ISO 14040, 14044). The main task is to achieve the certification of impacts per functional unit of product. The measurement process through the analysis of specific environmental impact factors can provide information in a transparent way to the market or to the supply chain "downstream" and to set improvement targets to be achieved over time and in the same time, the information gathered can be used for marketing strategies and strea mline processes to reduce some production costs.

SURVEILLANCE OF ACUTE POISONING INCIDENTS RELATED TO PLANT PROTECTION AGENTS IN ITALY

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Introduction: Directive 2009/128/EC requires that Member States (MSs) shall adopt National Action Plans (NAPs) aimed at reducing risks and impact of pesticides on human health and the environment and at developing alternative approaches and techniques to reduce their use. Among the objectives and measures to carry out, NAPs shall include the implementation of systems for gathering comparable information on pesticide acute poisoning incidents (Art. 7). Italy has the National Program for Surveillance of Toxic Exposures to Pesticides (NP-STEP) to meet this specific requirement. The present contribution is aimed at describing the main characteristics of human unintentional exposures to PPAs identified by NP-STEP in 2005-2009. Methods: The Italian Program requires that the collaborating centres collect the following main categories of data: patient information; exposure information; clinical effects; therapy; outcomes. Human exposures are reviewed and classified as pesticide-related poisonings according to the standard definition provided by CDC (http://www.cdc.gov/niosh/docs). Severity of poisoning is assessed according to the Poisoning Severity Score (J Toxicol Clin Toxicol, 1998). Exposures to PPAs are classified according to Regulation 2009/1185/EC. Results: In the period under study, NP-STEP identified 2,580 cases of PPP-related poisonings. About 95% of them were notified by Poison Control Centers (PCCs) and the remaining 5% by Local Health Units. Some 75% of cases were men and about 63% of exposures occurred at work, especially in agricultural settings (76% of all occupational exposures). The mean age was 45 years. Individuals aged less than 5 years were 5%. Some 70% of all the reported incidents occurred between May and September. Most of the illnesses were of low severity (94%). Severity was moderate in 5% of the cases, high in 1%. No fatalities were identified. Insecticides were responsible for 45% of all illnesses. The active ingredients responsible for the largest number of cases were: glyphosate, copper sulphate, methomyl, and metam-sodium. Conclusion: The primary objective of surveillance of acute poisoning incidents, as required by Directive 2009/128/EC, is to alert the health authorities about the risk that pesticides my pose to human health under certain conditions and to provide information to the regulatory authorities about the need for risk mitigation measures. PCCs represent a critical source of data for implementing this type of activity at national and international level (http://www.fao.org/docrep/005/y4544e/y4544e00.htm).

SUSTAINABILITY OF EUROPEAN MAIZE-BASED CROPPING SYSTEMS WITH DIFFERENT LEVELS OF IPM AS EVALUATED WITH THE DEXIPM® MODEL

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There is strong social and political pressure to reduce pesticide use in European crop production systems. Evaluating the overall sustainability of cropping systems is a complex task due to the conflicting objectives underlying the economic, social and environmental dimensions of sustainability. The development and use of models that assess different Integrated Pest Management (IPM) scenarios and evaluate the most sustainable practical options at regional, national and European level is essential. Within the EU Project PURE, a working group was formed aiming to design, assess and compare ex-ante (before testing them in field experiments) the sustainability of advanced (AS) and innovative (IS) maize-based cropping systems (MBCSs), using different IPM levels, for three European regions (northern Italy, southern France, eastern Hungary), against the conventional approach (CS). The systems' design derived from expert-based surveys that were performed during the EU project ENDUR E and from further discussion with different stakeholders in each region. The DEXiPM® model for arable crops, a qualitative and multi-attribute model developed within ENDURE and based on DEXi software, was used to evaluate and compare ex-ante the sustainability of these systems. In France, the AS and IS consisted of a maize/soybean rotation with different levels of IPM against the continuous maize that is the dominant system in southern France. In Italy and Hungary, the AS consisted of maize/winter wheat/soybean rotation and the IS of maize/winter wheat/ (cover crop) soybean (cover crop) rotation, both against the conventional maize/winter wheat rotation. IPM-based strategies used in all AS and IS aimed at the reduction in or sustainable use of pesticides (i.e. band application of herbicides, mechanical weeding, insecticides selective towards beneficial organisms or bioinsecticides to control *Ostrinia nubilalis* Hübner). Results of the ex-ante assessment using DEXiPM showed that in France, the AS maintained the same high economic sustainability as the CS, whereas the IS had a lower score, mainly due to an increase in the production risk (lower potential yield). However, both AS and IS increased the social sustainability with a better landscape social value and higher contribution to employment, while the IS even improved the environmental sustainability compared to the other systems. In Italy, the AS was the most sustainable system compared to the CS and IS, improving the environmental and social sustainability. However, the IS had the same overall sustainability as the CS because, although the economic sustainability decreased the environmental sustainability increased. In Hungary, AS and IS had an overall sustainability similar to that of CS, since although the economic sustainability was reduced the social sustainability was greatly improved. In conclusion, the overall sustainability of all AS and IS designed by the partners and assessed with DEXiPM maintained or even had higher sustainability than the CS, indicating that these MBCSs are acceptable for further consideration and testing in field experiments.

ECONOMIC ANALYSES OF APPLE SCAB MANAGEMENT

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Recent surveys in the ENDURE-project (EU project no. 031499) showed that some of IPM tools to control pests and diseases in pome fruit are used to a small extent in practice in the major pome fruit production areas in Europe. In the ENDURE survey several bottlenecks were identified hindering IPM tools implementation in practice and one of them was costs, mainly of labour. Moreover, research on the dynamics behind transitions in food chains in the Netherlands revealed that the introduction of sustainable production systems like IPM should result in distinguishable products in the market. Otherwise the consumer cannot exhibit his willingness to pay for sustainable products. These were the reasons for the development of PREMISE, a simulation model for economic assessment. PREMISE is developed within the EU-project PURE. PREMISE was developed first for apple scab, caused by *Venturia inaequalis*, because it is one of the most economic important diseases worldwide. Adequate management of the disease is essential and consumes considerable amounts of fungicides especially in wet climates. However, management incurs substantial costs of equipment, labour and materials. For a fruit grower it is essential to know if money is well spend on apple scab management. Therefore, the goal of PREMISE is to provide ex-ante economic assessments of apple scab management. PREMISE assessment model couples the scab epidemic to the economic effects. Management of the apple scab epidemic is input for the model. And the resulting apple scab epidemic is described as a chain model with three stages of the scab epidemic differentiated. These are (1) the quiescence stage, (2) the primary season with mainly ascospores and (3) the secondary season with conidia. The outcome of one stage influences the start situation of the next stage. Specific conditions and measures taken by the fruit grower results in qualitative and semi-quantitative indicators of the economic effects of the apple scab management for this farm. The specific farm conditions are considered as fixed variables in the model. For an assessment, these conditions should be filled up into the model. The conditions included in the model are: climate conditions, mainly restricted to number of infection periods, susceptibility of cultivars for apple scab, planting density which is related to drying up period of leaves, growers skills including the use of decision support systems, soil activity related to leaf degradation and inoculum conditions such as potential ascospore dose (PAD) and leaf infestations. Measures taken by the fruit grower to control apple scab are so-called control measures in the model. All control measures are available in the model such as fungicide use, leaf shredding, urea treatments, use of an antagonist, etc. The user of the assessment model can immediately see the economic effect if he would apply for example leaf shredding during late autumn. Or another example, if the fruit grower uses fungicides with the aid of a decision support system it can be compared to weekly spraying and the assessment model shows the economic consequences of that. In this way PREMISE can be used as a learning tool for the farmer. In the chapter results, we describe an example for economic analysis when a fruit farm choses to implement more advanced IPM systems for the control of apple scab.

In the example it is shown that management of apple scab in an orchard can be done more environmentally friendly and in an economic sustainable way. One of the achievable measures is to reduce the inoculum potential during winter. This would result in more effective fungicide schedules in spring and a reduced application of fungicides in summer time. This might also have the economic side effect that less residues on the fruits are present, which might result in a

premium marketing effect. These effects are described. It is concluded that PREMISE will be a valuable assessment tool for growers in their decisions to manage more environmentally friendly and in an economic sustainable way.
Next step is to validate the PREMISE prototype economic assessment tool with data from different practical situations in different European countries. And additional within the EU-funded PURE-project (project no. 265865), we intend to link this assessment model to the Synops model (Strassemeyer et al., 2012) in order to improve the assessment of the environmental impact of the scab management of the farm. The authors hope that this assessment tool will help fruit growers in their decisions to more readily implement IPM tools in the apple scab management, and to learn the mechanisms of IPM related to the farm specific situation. The development of PREMISE is supported by the European Community Framework Programme 7, “Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management (PURE)”, grant agreement no.: 265865.

OPTIMIZING ECOLOGICAL MECHANISMS OF PEST AND DISEASE CONTROL FOR SUSTAINABLE IMPROVEMENT OF AGROECOSYSTEM PRODUCTIVITY: MAJOR LESSONS DRAWN FROM CIRAD'S OMEGA3 PROJECT

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CIRAD's Omega3 project, which operated from 2008-2012, aimed at (i) gaining knowledge on ecological pest and disease regulation processes that can be mobilized via plant species diversity (PSD) deployment in agroecosystems, as an alternative to conventional practices based on pesticide use, and (ii) generating tools and methods to design and evaluate innovative pest and disease-resilient cropping systems based on PSD. Some biological models (="pathosystems") representing a range of spatial scales of PSD deployment, across the pest/pathogen life history traits the most amenable to manipulation via by PSD (namely dispersal ability and host specificity), were selected, with a view to robustness and generality of expected results. At a metric scale, we studied the effects of sanitizing plants on soil borne white grubs and parasitic weed *Striga* affecting upland rice in Madagascar, and on tomato bacterial wilt (TBW) in Martinique. At the field level, we studied the luring effects of trap plants, combined (i) with barrier effects and conservation biological control on tomato fruitworms (TFW) and sap-feeding pests on vegetable crops in Martinique and Niger and, (ii) with a food attractant mixed with a biological insecticide on cucurbit fruit flies in Reunion. We also studied the effect on cocoa plant bugs and black pod rot (BPR) of intercropping cocoa trees with other perennial plants using different spatial designs in Cameroon. At the landscape scale, we studied the effects of the arrangement of various land uses on the incidence of coffee leaf rust (CLR) and the abundance of coffee berry borer (CBB) in Costa Rica. Our examples stressed the need for trade-offs to manage conflicts or exploit synergies in underlying PSD-based processes. For instance, against TBW or upland rice white grubs, the trade-off between high biomass production for indirect regulation via alteration of microbial communities vs low biomass production but direct regulation via biocidal/allelopathic effect. Or the trade-off between the prevention or encouragement of infestation of the main vegetable crop by early occurring/little damaging sap-feeding pests, in perspective with a positive or adverse effect on regulation of later occurring/highly damaging fruit pests (e.g. TFW), via top-down pathways. Or the trade-off to account for conflicting interactions between cocoa and plant bugs and BPR in relation with shade and natural enemies (entomopathogenic fungi and ants) on the one hand, and between CBB and CLR (and their natural enemies) on coffee in relation with landscape fragmentation/connectivity, on the other hand. Specifically, a spatially-explicit individual-based model including three interacting modules was developed, to be used as a

generic tool to improve our understanding of system functioning in our field-level case studies, by assessing relative attractiveness of the commercial vs trap crops, the spatiotemporal planting design of the crops, and the insect behavioural traits.

LANDSCAPE STRUCTURE AND THE EFFICACY OF CONSERVATION BIOLOGICAL CONTROL OF ARTHROPOD PESTS

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Considering how landscape structure impacts pest control has large relevance for development of effective IPM-programs. It has repeatedly been shown that complex landscapes host a higher abundance and diversity of natural enemies compared to simplified landscapes dominated by intensive agriculture. However, few studies have assessed how this affects the level and stability of biological control across landscapes, and ecological models, that can predict such relationships, are lacking. Aphids are major pests on cereal crops such as wheat and barley in Europe, and both generalist predators such as spiders and ground beetles and specialist enemies like parasitoids, hoverflies and ladybeetles are known to be important biological control agents in this system. First of all I will present an experiment in which we estimated how the level and spatial stability of biological control of cereal aphids varied with landscape complexity and crop rotation intensity using predator exclusion cages. We found that the average level of biological control increased with landscape complexity, but surprisingly, the spatial stability of biological control increased with increasing crop rotation intensity in the landscape. To provide a more mechanistic understanding of how different natural enemy taxa contribute to biological control of cereal aphids in different landscapes, we have constructed a semi-mechanistic model based on aphid population dynamics, predation rates and abundances of different natural enemy taxa in different landscapes. To parameterize the model we used literature reviews and analyses of our own data. This model maps biological control services across cereal fields in a Swedish agricultural region varying in landscape complexity. The model predicted that biological control would reduce crop damage by 45 – 70% and that the biological control effect would be higher in complex landscapes. The relative contribution of different predator taxa to biological control varied with landscape composition, but generalist predators collectively contributed with about 50% of the biological control effect in most landscapes. The model was able to predict a significant proportion of the biological control effect in the dataset available for validation. If this kind of ecological model is combined with similar models for other ecosystem services they may become powerful tools for designing multifunctional landscapes. Finally, landscape structure may have a large impact on the efficacy of local measures taken to enhance pest control. It has been hypothesized that such measures should have the largest effect in fields located in relatively simple landscapes, but be less effective in cleared landscapes lacking non-crop vegetation and in complex landscapes dominated by non-crop vegetation. In this presentation I will review the evidence for this hypothesis and exemplify with a study testing the impact of flower strips on biological control in different landscapes.

EFFECTS OF GROUND COVER MANAGEMENT ON CARABID GROUND BEETLE POPULATIONS IN ORGANIC APPLE ORCHARDS IN THE UK

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To produce fruit more sustainably, integrated pest management (IPM) strategies can reduce pesticide use and thus pesticide residues in fruit. Using IPM in crop production often requires the use of predators and parasitoids to control pests. This can be achieved by enhancing the environment to attract and retain naturally occurring beneficial arthropod species, or in high value crops, such as soft fruit production, by releasing commercially produced predators and parasitoids when required. Much research has been done to develop strategies that enhance naturally occurring flying predators and parasitoids in orchards, for example the sowing of nectar and pollen producing plants or the use of attractive semiochemicals. However, the ground dwelling fauna in orchards has not been so extensively investigated. Carabids are the most abundant taxon caught in pitfall traps in apple orchards and many carabid species are generalist predators with the potential to contribute to biocont rol of pests that have a ground dwelling life stage such as codling moth (*Cydia pomonella*) and apple leaf midge (*Dasineura mali*). Earlier work at East Malling Research found that carabids were found more frequently in traps in particular types of vegetation, indicating that it may be possible to enhance numbers of these predators by manipulating vegetation in orchards. A replicated experiment was run over three years in an organic apple orchard at EMR to assess the effects of different ground cover management on carabids caught in pitfall traps within and outside the treated areas. Treatments were applied in the tree rows. Two plant species with different growth habits were sown; knapweed (*Centaurea nigra*) with an upright growth habit and clover (*Trifolium pratense*) with a spreading growth habit. These were compared with an organic mulch and bare soil. The type of ground cover used affected the total numbers of carabid beetles recorded. In general more carabids were caught i n the tree rows in plant treatments than in the mulch or bare soil treatments. In general there was no overall effect of treatment on numbers of ground beetles caught in the grass alleys between the treated tree rows; effects of vegetation type were only detectable within the treatment plots.

THE PROBLEM WITH CONSERVATION BIOLOGICAL CONTROL

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As an IPM tool, conservation biological control (CBC) seeks to suppress arthropod pests and the damage they cause by supporting endemic populations of their natural enemies. As with all attempts to manage natural populations, CBC suffers from an inherent lack of precision. This is accentuated because the majority of arthropods are unable to maintain viable populations within a cropped field so that the maintenance of diverse and abundant populations must be achieved beyond the field boundary. At these scales in particular, CBC strategies such as habitat manipulation tend to be non-specific approaches affecting extended communities of natural enemies, pests and other taxa. It follows from this that, to be effective, CBC should seek to combine a diverse regional 'pool' of abundant natural enemies combined with mechanisms to ensure the effective interactions (links) between these regional pools and pest regulation at the field scale. If true, this should be evident in the outcomes of previous CBC experiments. Therefore to test our proposition we first outline a consistent framework that places interventions, mechanisms, and outcomes within a multi-scalar view that captures the spatio-temporal and trophic complexity of CBC. Using the framework we have identified expectations of CBC strategies consistent with our proposition which, when framed as hypotheses, were tested using a meta-analysis of published studies. The results of this analysis were in part consistent with CBC framework set out. However, a particular feature of the analysis was the lack of studies in certain key areas against which our framework could be tested. For example tests of the population dynamic response to CBC are almost entirely absent from the existing literature; we are addressing this particular gap through the development of spatially explicit models capable of simulating the dynamics of pest populations across farmed landscapes but here we point towards the need for complimentary empirical studies. Other knowledge gaps are also discussed and the consequence of our findings for future CBC and IPM strategies considered.

THE IMPACT OF COMPANION PLANTING ON THE ABUNDANCE OF LEPIDOPTERAN PESTS ON WHITE CABBAGE

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Cruciferous plants are grown around the world while white cabbage (*Brassica oleracea* L. var. capitata) is one of the most cultivated cruciferous vegetable plants in temperate regions due to its high nutritional value. Insect pests of cabbage can cause severe economic damage; the most important ones belong to the order Lepidoptera, such as *Pieris brassicae* L., *P. rapae* L. (Pieridae), *Mamestra brassicae* L. (Noctuidae) and *Plutella xylostella* L. (Plutellidae). The aim of the study was to find out whether companion planting with *Anethum graveolens* L. will effectively decrease the abundance of lepidopteran pests on white cabbage and therefore prevent the damage. Studies were carried out in an experimental field of the Estonian University of Life Sciences from 2010 to 2012. The experimental layout was a randomised block design with four replicates of two treatments: cabbage plants intercropped with companion plant and control plots. Each plot measured 2x5 m, and was planted with ten cabbage plants in two rows. On intercropped plots *A. graveolens* was sown between the cabbage rows, control plots were non-intercropped. The buffer zone between plots was one meter of bare soil around each plot. To determine the abundance of lepidopteran pests, all pests from all cabbage plants were inspected weekly and all specimens were counted. The years significantly influenced the mean number of larvae of cabbage pests per cabbage plant. The infestation level was high in 2010, up to five specimens per plant, the threshold level in Estonia is five caterpillars per plant on at least 25% of the plants; low in 2011, only one specimen per plant and medium in 2012, when the mean number of larvae per plant was three. When the abundance of larvae was pooled over three years, companion planting effectively reduced the number of pests' larvae on cabbage plants. However, no evidence was found that companion planting lowered the abundance of pests neither in 2010 when high pest abundance was recorded, nor in 2011 when only few larvae were found. At the same time, in 2012 intercropping with *A. graveolens* had a significant effect on the abundance of pests, less lepidopteran larvae were found from plots planted with *A. graveolens*. The effect of companion planting was affected by the abundance of pests; in the year of high pest numbers all plants, even the less suitable ones, were infested whereas in the year with low number of pests, the abundance stayed low on both variants. As the mean number of larvae per plant was significantly diminished by intercropping over three years, it can be assumed that companion planting can only be effective if the population size of pests stays at a medium level.

EFFECTS OF NITROGEN FERTILIZATION ON INSECT PESTS, THEIR PARASITOIDS, PLANT DISEASES AND VOLATILE ORGANIC COMPOUNDS IN *BRASSICA NAPUS*

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Nitrogen (N) availability is a key factor influencing the yield of *Brassica napus* L. Thus, mineral fertilization is widely used to improve the quality and quantity of seeds. In this study, we conducted field experiments to determine the impact of nitrogen fertilization on *B. napus* pests, their parasitoids and plant diseases. The field studies were conducted with seven different N-fertilizer levels: 0, 60, 80, 100, 120, 140 and 160 kg of N per hectare in 10 m2 randomized replicate plots of winter oilseed rape. Abundance of *Meligethes aeneus* Fab. (Coleoptera: Nititulidae) larvae and its' parasitoids were determined by dissecting flowers and second instar larvae, respectively. The occurrence of *Ceutorchynchus obstrictus* Marsh. (Coleoptera: Curculionidae) and its parasitism rate were determined by counting damaged pods and emerged parasitoids or their remains from pods. Plant disease assessments were carried out visually at the mature pod stage (BBCH 80–85), the abundance of *Alternaria brassicae* (Berk.) Sacc. lesions was rated on a qualitative scale from 0 to 6 (no disease; 5%; 10%; 20%; 30%; 50%; over 50%). The volatile organic compounds measurements were carried out using multichamber cuvette system for collecting and Shimadzu TD20 automated cartridge desorber combined with Shimadzu 2010 plus GC MS instrument for analysing. The compounds were identified by comparing their mass spectra with a NIST library (National Institute of Standards and Technology) and with authentic standards. The results showed that N treatment had an impact on the abundance of *M. aeneus* and *C. obstrictus* as well as *A. brassicae*. Since pest abundance was not correlated with the flower and silique numbers, the feeding and oviposition sites, plant smell bouquets were analysed to determine potentially attractive or repellent volatile organic compounds. We detected 19 different compounds among which acetic acid and several lipoxygenase pathway products were emitted at higher levels from N-treated plants. Emission of a few other terpenoid compounds was correlated with the pest abundance in field conditions. Abundance of parasitoids of both pests was related to the host availability rather than to the fertilization treatment. Therefore, we suggest that plant chemical cues play a minor role in localization of hosts in close proximity to parasitoid. The levels of *A. brassicae* decreased with increasing N availability, possibly reflecting enhanced emissions of acetic acid, a known antifungal volatile. This study demonstrates the effects of N fertilization on bud and flower volatile bouquets, which might play a role in *B. napus* insect pest host selection and in resistance to fungal plant diseases. Further studies are necessary to investigate the behavioural responses of insects to the changed volatile bouquets.

USE OF PEST FORECASTING MODELS AND ACCORDING DECISION SUPPORT SYSTEMS IN IPM – BASICS AND APPLICATION BY EXAMPLE OF THE SWISS SYSTEM SOPRA

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The decision finding process in advanced pest management relies on precise timing of surveillance and control of pest populations. Thereby timing of monitoring measures assures reliability of results and saves time during decision finding. Precise timing of plant protection measures increases their efficacy, reduces side effects and may substantially reduce the number of treatments and thereby resources and money spent during pest management. The aim of according decision support tools should be to establish reliable and readily available information to be used by growers and consultants. Consequently they have to consist of a technical part to establish phenologies or population dynamics and of an end-user part to communicate the according decision support. As for the technical part, hitherto, temperature sums and more recently simulation models have been used to predict the phenology of pests. However, the technical tools are often not designed to be used by growers, consultants or extension services, they are often based on very different approaches and programming languages or require special driving variables, which makes them difficult to be used in practice. How these obstacles for application can be successfully circumvented is exemplified here by the forecasting tool SOPRA which has been developed to optimize timing of monitoring, management and control measures of major pests in Swiss fruit orchards. The system consists of a locally based user interface with the different species models (technical part) and a web-interface to provide simulation results and decision support to consultants and growers (end-user part). Applying time-varying distributed delay approaches, phenology-models were developed driven by solar radiation, air temperature and soil temperature on hourly basis for major pests of apple, pear, cherry and plum. In order to achieve most precise forecasts, insect body temperatures in those mechanistic models have to be based on studies of habitat selection of relevant developmental stages and according simulations using driving variables and structural orchard features. For validation, model predictions have to be compared with independent field observations from several years. On base of local weather data, age structure of the pest populations is simulated and crucial events for management activities are predicted by the SOPRA system. Through a web-interface, the simulation results are made available to consultants and growers (www.sopra.info). Phenology is directly linked to a detailed decision support and to extended information about pest insects as well as to control strategies and plant protection products. SOPRA is applied as decision support system for major pests of fruit orchards on local and regional scale and has a wide range of possible applications across Europe. The development, improvement add wide application of the system successfully show how forecasting tools may become essential parts of innovative IPM.

PLANT DISEASE MODELS: FROM FIELD OBSERVATIONS TO BIOLOGICAL MECHANISMS

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A plant disease model is a simplification of a real pathosystem (i.e., the relationships between a pathogen, a host plant, and the environment) that determine whether and how an epidemic develops over time and/or space. Different approaches have been used for the development of plant disease models, with relevant improvements in recent years.

Empirical models have been elaborated using data collected under variable field conditions since the second half of the last century. The so called 3-10 rule for predicting first seasonal infection of grape downy mildew is a precursor of this empirical approach for understanding relationships between pathogens, plants and the environment. By using this approach, the model is developed by searching mathematical or statistical relationships between field collected data and these relationships do not necessarily have cause-effect meaning. Lack of knowledge, accuracy and, especially, robustness are the main weaknesses of these models, which impose accurate validation and, usually, proper calibration when these models are used in different environments or under changing climate. Recent methods of data analysis, like for instance neural networks, improve the capability of searching the mathematical structure of the model but they do not overcome the above mentioned weaknesses.

Mechanistic models are a new class of models based on knowledge of biological and epidemiological behaviour of the system under study. These models (also referred to as explanatory, theoretical, or fundamental) explain the pathosystem on the basis of what is known about how the system works in relation to the influencing variables. Mechanistic models are dynamic, because they analyse the changes over time of the components of an epidemic due to the external, influencing variables. Dynamic modelling is based on the assumption that the state of the pathosystem in every moment can be quantitatively characterised and that changes in the system can be described by mathematical equations. These models overcome the weakness of the empirical models. Compared to the 3-10 rule, a mechanistic model for grape downy mildew increased the overall accuracy of the predictions from ~60% to ~90%.

Complexity of mechanistic models has been regarded as a problem for the implementation of models in practical disease control, compared to the simplicity of the empirical models. This is a false problem, because confusing complexity of the mathematical framework of the model with complexity of model output is misleading. Indeed, it is possible to use complex models, able to depict the complexity of the biological systems, to produce simple, easy-to-use output for growers. Implementation of the above mentioned mechanistic model for grape downy mildew in a Decision Support System used by viticulturists clearly demonstrates the inconsistency of the "complexity paradigm".

ANALYSIS OF THE INFLUENCE OF SUNFLOWER CANOPY ON *PHOMOPSIS HELIANTHI* EPIDEMICS AS A FUNCTION OF CROPPING PRACTICES

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Phomopsis stem canker (*Diaporthe helianthi* Munt.-Cvet.) can cause drastic reductions in sunflower (*Helianthus annuus* L.) yield and oil content in the main areas of production. The influence of crop management on the incidence and severity of phomopsis stem canker have already been studied in field experiments. However, a more thorough study was required to analyse the effects of soil, crop status (including canopy development) and microclimate on the epidemics of this airborne pathogen, under the influence of cropping practices throughout a growing season. In a 2-year study (2010-2011), carried out in Toulouse (France), the effects of cropping practices (plant density, N fertilisation, and irrigation) and genotypic tolerance (susceptible to tolerant cultivars) on the epidemics of *Diaporthe helianthi* were monitored under conditions of reinforced inoculum. Data on inoculum, plant injury, microclimate, crop N status and canopy development were collected. Data on atmospheric ascospore concentration were used to assess the predictive quality of the Asphodel model regarding spore ejection. No statistically significant difference was found between observed and simulated values for both years over a three-day time range. In 2010, despite irrigation, the dry weather strongly limited the incidence of phomopsis on leaves. In 2011, two main waves of infection were observed: from mid-June to the beginning of July, and from the end of July to the beginning of August. For both years, the Nitrogen Nutrition Indices (NNI) were significantly different between N fertilisation treatments. Differences in NNI at anthesis due to plant density or water regime were not significant. For both years, the number of hours of high Relative Humidity (higher than 85%) within the canopy during vegetative growth, which are supposed to promote spore release and leaf infection, was positively related to maximum Leaf Area Index at anthesis. The development of disease injury was broken down into three stages: leaf infection, leaf-to-stem passage and girdling spots on stem. This enabled to analyse the effects of cropping practices on each of these stages in order to acquire knowledge for the prediction of Phomopsis stem canker severity on sunflower. The interpretation of results showed that: (i) the number of leaf symptoms was determined by the canopy microclimate, especially during vegetative stages, but that after flowering, green leaf tissues potentially available for leaf infection could be an additional limiting variable; (ii) the leaf-to-stem passage was determined by leaf length and senescence rate, either natural or induced by phoma black stem; (iii) the proportion of girdling symptoms on stems was related to stem diameter. This knowledge will help the design of crop management systems, reducing the risk of crop losses caused by phomopsis stem canker on sunflower.

BOTRYTIS ALERT SYSTEM IN ROSE: A DISEASE WARNING MODEL

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Botrytis cinerea is a major problem in greenhouse floriculture. In roses, the spores are deposited on the flowers during cropping but don't germinate due to too low RH. After harvest, the spores germinate and cause spots and lesions on the flower petals. The disease needs to be tackled during the cropping period, but growers cannot base their decision to spray with fungicides on infection levels because disease only occurs after harvest. To help the growers, a disease warning system was developed to identify periods of good survival of the spores with subsequent risk of disease development in the post-harvest phase. First, experiments were conducted in experimental glasshouses of Botany B.V. (Horst, The Netherlands) in which untreated control plots were compared to plots sprayed according to a tentative model by Kerssies (1994) and plots sprayed according to a system based on combined literature data. The flowers were harvested regularly and treated the same as common post-harvest practice. Then the flowers were put on vases to simulate the situation in consumer's houses and disease was rated several times. The experiment was conducted twice for 2-3 months with four replicates per treatment. The results were used to develop a new model based on temperature and RH which was validated with historical data from commercial growers and then tested in seven commercial production glasshouses in The Netherlands for a 4-6 month period. Post-harvest infection levels were compared for standard treatment and treatment according to the model. After adjusting the model with the results, it was tested again in the third year in four commercial glasshouses. In two glasshouses, a grid of 9 data loggers was installed in 10 by 10 m plots in which flowers were harvested separately, to establish in more detail the relationship between temperature, RH and post-harvest disease incidence. These data were used to fine-tune the model which was subsequently released with the acronym BAS (Botrytis Alert System). It is sold as a module in the climate computer and predicts the daily expected percentage diseased flowers. Installing extra data loggers will improve the reliability in glasshouses with large horizontal fluctuations in climate. BAS helps growers in timing of fungicide applications but also in preventively adjusting their climate settings.

This model was developed in collaboration with Verdict Systems B.V., Aalten, The Netherlands

MODELLING THE IMPACT OF CLIMATE CHANGE ON SUSTAINABLE MANAGEMENT OF THE CODLING MOTH (*CYDIA POMONELLA* L.) AS KEY PEST IN APPLE

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Global warming will lead to prolongation of growing seasons in temperate regions and will have pronounced effects on phenology and life-history adaptation in many species. These changes were not easy to simulate for actual phenologies because of the coarse temporal and spatial resolution of the climate predictions. Seasonal and regional climate change signals were downscaled to the hourly temporal scale of a pest life-cycle and the spatial scale of pest habitats using a stochastic weather generator in combination with a re- sampling approach. The simulated synthetic hourly weather data for 10 meteorological sites in Switzerland consistent with a future climate scenario (2045-2074) was then analysed by a seasonal phenology model implemented in the forecasting system SOPRA (www.sopra.info). Codling moth (*Cydia pomonella* L.) serves as a relevant model species for a key pest with multiple generations per year that already under present climate requires intensive control efforts. Under future conditions of increased temperatures the present risk of below 20% for a pronounced second generation (peak larval emergence) in Switzerland will increase to 70–100%. The risk of an additional third generation will increase from presently 0-2% to 100%. We identified a significant two-week shift to earlier dates in phenological stages, such as overwintering adult flight. The magnitude of first generation pupae and all later stages will significantly increase. The presence of first generation pupae and later stages will be prolonged. A significant decrease in the length of overlap of first and second generation larval emergence was identified. Such shifts in phenology may induce adaptation in life-history traits such as photoperiodic diapause induction to shorter day-lengths . The projected shifts in phenology and voltinism will extend the control season over an at least one month and will have relevant consequences for codling moth management. The most suggested management strategy is based on pheromone mating disruption. With increasing temperature the present amounts of pheromone will most likely not cover the entire season anymore and the dispenser load has to be increased. The sole application of mating disruption and granulosis viruses alone may also no longer be sufficient to control codling moth because during multiple generations higher population densities may build up and because of the increased risk of resistances to granulosis viruses. Similarly, resistances to insecticides are expected because of the repeated treatment with the same group of ingredients. A future control strategy with insect growth regulators considers innovative products with new modes of actions, consequent anti-resistance management and precisely timed app lication as ensured by decision support systems.

STOCHASTIC MODEL OF ON-FARM BEHAVIOUR OF THE CHERRY FRUIT FLY, *R. CERASI*, UNDER THE CHALLENGE OF IPM

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Implementation of the 'IPM' Directive 2009/128/EC will boost demand for site-specific IPM solutions, decision-making and training, while at the same time, on-farm evaluation of local IPM scenarios is becoming increasingly expensive and, often, impracticable. However, modern IPM largely relies on manipulation of insect behaviour, hence in principle, customisable models simulating 'on-farm' pest behaviour could be used for 'virtual' pre-assessment of various localised IPM options, and thus serve as tools for training and decision-making. The proprietary PESTonFARM model is presented as an example of such approach. The model - agent-based, pattern-oriented with elements of cellular automata - was developed to simulate individual insect behaviour within seasonally changing mosaic of faming landscape, under the challenge of IPM actions. The model is based on a software construct ("virtual insect"), dynamically emulating daily behaviours, events and risks faced by individual insects, generating for each of them stochastically equivalent, but individually unique 'virtual life-history'. The model operates according to an in-built set of explicit biological and behavioural rules describing the key aspects of pest biology, and is based on user-defined-and-managed spatiotemporal parameters reflecting local on-farm conditions and assumed/tested IPM regimes. Incompatibility among IPM treatments, e.g. pesticide vs biological control, also could be taken into account. Unit costs of IPM interventions and infestation-dependant reduction of crop values can be specified to obtain cost/benefit assessment for each IPM scenario. The model simulates only daily behaviours and events of individual insects, while the 'higher-level on-farm phenomena' with intricate spatiotemporal patterns, such as seasonal pest translocations with locally fluctuating population densities or evolving patterns of crop infestation, are neither program med nor determined. They emerge as a consequence of the actions undertaken by individual 'virtual insects'. The model emulates behaviour of pest population during a 'virtual IPM experiment', and, upon each run, generates stochastically equivalent, but unique set of results, presented in a format usually collected during real on-farm experiments. Currently, the model can handle 'farm-area' with at least 5 different multi-plot host zones, over 2,000 sectors, over 1,000,000 insects and 10 (or more) independent IPM treatments. In the presented example, the model was adjusted to represent behaviour of a univoltine pest, the cherry fruit fly, *Rhagoletis cherasi*, on a cherry farm, under the pressure of IPM treatments. The model was designed to assist IPM assessment and implementation, and to support localised decision-making and training. It can also be customised to test various farm configurations for optimisation of crop arrangement and landscape planning, assessment of effects of environmental barriers or wild hosts as pest reservoirs etc.

USING VITIMETEO-PLASMOPARA TO BETTER CONTROL DOWNY MILDEW IN GRAPE

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Downy mildew caused by the oomycete *Plasmopara viticola* is one of the most important diseases of grapevine. Regular spraying with fungicides over the entire growing season is needed in order to protect the grapes. Even so, in years with difficult weather conditions like 2012 or 2008, downy mildew is causing yield losses. The implementation of disease forecasting models to control the main fungal diseases of grapevine according to their epidemiology is a central element of integrated pest management. The use of decision support systems (DSS) is increasing in importance among advisers and growers. The VitiMeteo-Plasmopara model is an expert system developed by the Grapevine Research Institute of Freiburg (WBI, Germany) and Agroscope Changins-Wädenswil (Switzerland), and programmed by the company GEOsens (Germany). Using relevant weather data VM-Plasmopara simulates the main development steps of the epidemiology of *Plasmopara viticola*. The software generates graphics and tables freely available for the growers on the Internet. The model also incorporates weather forecasts data to simulate the development of the pathogen during the next 5 days. VM-Plasmopara is currently used over all vineyards of Switzerland, Germany and parts of Austria and northern Italy. Model validation during nine years in Changins (CH) has shown its high reliability. Outputs of the model were compared to observations made in the lab and in a small untreated experimental plot. Predicted downy mildew development was in accordance with disease appearance and progression in the experimental plot. However, improvement is still needed to better understand conditions required to have oospores maturation and germination in spring. Different protection strategies based on the model were tested in the field and allow to better control downy mildew and to decrease the number of fungicide applications. Growers using VM-Plasmopara are spraying more in accordance with the disease epidemic. They can objectively decide to delay the first spray or to enlarge spray intervals, thus reducing the number of sprays. The model allows them to evaluate the disease risk and decide of fungicide treatments opportunity on an objective basis.

WEB-BASED DECISION SUPPORT SYSTEMS IN AGRICULTURE

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New developments in Information and Communication Technology (ICT) that coincide with globalization are influencing several aspects of agriculture: market globalization has increased exports from producing to consuming countries where different food safety or pesticide residue regulations apply, and has raised awareness of global problems linked to agriculture production (i.e., chemical pesticide pollution). At the same time ICT development, in the form of the web and mobile technology makes knowledge dissemination easier than ever. Pests, diseases and weeds may cause significant damage to growers while the cost of pesticide increases. Environmental pollution and risk of unwanted residues on food has forced researchers to find ways to optimize pesticide applications. However, extension services and research in pest management is often fragmented and efforts to develop support tools for pest management are often duplicated. Furthermore, sometimes the knowledge does not spread from research centers to growers due to difficulties in knowledge transfer.

Decision support systems (DSS) are widely used in agriculture for assisting with integrated pest management (IPM), crop nutrition, and other aspects of information transfer. Developing highly portable and, especially, web-based DSSs that can be easily adapted to new environments is therefore desirable in view of the globalization of agriculture. Web-based models and DSSs have the major advantage of reducing software development, maintenance, and distribution costs, while making the relevant knowledge easily accessible to growers world-wide.

The talk will discuss the potential of harnessing recent ICT development to agricultural knowledge dissemination to farmers wherever they are.

ENVIRO AN INNOVATIVE WEB MAPPING TOOL TO MONITOR AND FORECAST PLANT AND PESTS DYNAMICS BASED ON CLIMATE DATA

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Scientists and policy makers from the agricultural, environmental and socio economical sector need new Information and Communication Technologies (ICT) tools to study and understand the influences of climate and meteorology on the dynamics of agriculture systems. With this goal, we developed ENVIRO, an innovative WebGIS platform which integrates weather-driven, Ecosystem Modeling (EM) to monitor the effects of climate and study the impacts of climate change on Trentino's major agricultural systems. Researchers and stakeholders can apply ENVIRO to map and overlay environmental, agricultural and socio-economic data. The platform is modular and it is designed to support the entire pipeline of implementation, validation of experimental models, based on high resolution climate data.

The backbone of ENVIRO system is *enviDB*, a spatial temporal database for vector and raster data which addresses the main objective of the system: i.e, to harmonize and to provide access to regional time series of weather-climate data, climate change scenarios, land use geodata and general administrative statistical data. The core of the system is a web geoprocessing engine where a library of models (*Vitis Vinifera, Botrytis Cinerea, Lobesia Botrana, Erwinia Amylovora, Malus Domestica, Blumeria Graminis, Peronospora Farinose*) is accessible to simulate and map the influences of weather and climate and to forecast the impact of future climate change scenarios on plant-pathology systems. *EnviGrid* is the a spatial temporal user panel to access the climate databases at different aggregation scales in time and space. Two web mapping interfaces complete the system: *enviMapper*, the interface for decision makers, a web client to monitor the influences of climate and the vulnerability to climate change on agricultural systems, and *enviModel*, the interface for researchers that provides tools for real time processing and models sharing.

All modules and technical components are Open Source and they build on software endorsed by the Open Source Geospatial Foundation (OSGeo). The implementation follows the international Open Geospatial Consortium (OGC) standards for geodata transmission and geoprocesses to ensure a complete interoperability with existing spatial data infrastructures (SDIs). Researchers can add the implementation of new models, as well as simulate in quasi real time life cycles of plants and pathogens and their interaction using the implemented models via web geoprocessing technologies. The platform includes also a rich metadata catalog to provide clear indications on quality and provenance of data. To sustain the requests for on line geoprocessing of large environmental models on climatic data, the ENVIRO scientific computing environment is based on high performance computing methods (GPGPU and Cloud Computing). In summary, ENVIRO is a state of the art ICT platforms for applied climate and climate change studies with a focus on modeling effects on agriculture at high resolution, in space and time. The system was developed within the ENVIROCHANGE project funded by the Autonomus Province of Trento.

A WEB-BASED DECISION SUPPORT SYSTEM FOR THE MANAGEMENT OF INTEGRATED VINEYARDS

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The transition from conventional to integrated pest management and, more in general, to integrated production requires an increase of knowledge about the vineyard system and includes also an increase of limits and fulfilments. The vineyard manager needs to be more and more informed and has to take several decisions for the proper management of the vineyard. Therefore, a web-based Decision Support System (DSS) was developed for guiding decision about tactical management of the integrated vineyard. The DSS is provided by Horta srl, a spin-off company of the University of Piacenza (www.horta-srl.com), and is available for registered users via the internet in an interactive way. It is composed by: (i) a network of weather stations that send real time data, (ii) a server repository that stores the weather data; (iii) an user interface that makes it possible to readily input vineyard-specific information and obtain supports for informed decision-making; (iv) a set of mathematical models that use weather data and vineyard-specific information to predict the epidemiology of the main grapevine fungal diseases and the plant development. Output provides information on: (i) current weather conditions and 3-day forecasts; (ii) the growth stage of the plants; (iii) information and decision supports for primary and secondary infections of *Plasmopara viticola* and *Erysiphe necator*, causal agent of grapevine downy and powdery mildew, respectively. In particular, two weather-driven, mechanistic, dynamic models are used to provide the following information for *P. viticola*: dynamic of the oospore population; occurrence of the main events for primary infections (oospores germination, zoospores release and dispersal, infection establishment and appearance of downy mildew lesions); infection severity and epidemic pressure of primary infections; fitness of the sporulating lesions and availability of the secondary inoculum; relative severity and epidemic pressure of secondary infections. Similar models provides information for primary and secondary infection of *E. necator*: the dynamic of chasmothecia population, the release and dispersal of ascospores, the infection establishment and the symptoms onset, as well as the production of secondary inoculum and its efficacy in causing new infections.

Within the FP7-KBBE project "Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management" (PURE) 16 commercial vineyards across Italy were managed so as to compare the management according to the DSS, the usual grower’s practice and an untreated control. Results collected during the first season confirmed the advantages due to the use of the DSS, in terms of rationalisation of fungicide schedule with a reduction of the number of treatments till to 36%. Other commercial vineyards will be managed according to the DSS in the following grapevine-growing seasons to further validate the DSS and demonstrate t he benefits rising from its use.

IDeMCroP: DEVELOPMENT OF AN INTEGRATED FINE SCALE SYSTEM FOR INFORMED DECISION MAKING IN SUSTAINABLE CROP PROTECTION

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Wide scale monitoring, real time data analysis for decision support and use of prediction models are major tools in implementing IPM. Growers, who need to make proper decisions according to IPM principles and, at the same time, safeguard their income, require relevant information constantly and timely in order to make effective informed decisions. Current crop protection warning systems are mostly using regional scale weather and environmental data, but can only partially relate to local variability which is affected by microclimate, actual field level of pest infestation and disease severity, crop varieties, pesticide and agronomic treatments, etc. On the other hand, Decision Support Systems (DSSs) which consider more detailed local data are usually operated on a single grower level, and their local data is not or poorly used on a regional/multi-growers level. A substantial aspect in promoting current IPM practice should be combining and securely sharing both local and regional data in a simple and flexible manner, in order to improve analysis and informed decision making. The required tool is an accessible web based and real time combined system, which should allow holistic decision making with data and analytics up to a plot level, serving growers, agronomists, extension, academy and authorities for IPM practice and overall supervision. The IDeMCroP project is developing such a breakthrough combined platform, based on two innovative systems: Italian Vite.netTM for providing decision support through modelling and Israeli AgriTask for monitoring/scouting and data sharing. These field proven systems present complementary approaches in providing comprehensive real time information and prediction for decision making. Vite.netTM is a web-based DSS for crop protection in vineyards which analyses real time meteorological data from real and virtual weather stations, uses advanced modelling techniques and formulates decision support for controlling fungal diseases, such as downy and powdery mildew, and insect pests, such as the grape berry moth and Mediterranean vine mealybug, according to IPM principles. AgriTask SaaS cloud platform and field scouting cellular application enable real time informed decisions, based on analysis and presentation of geo-referenced pest infestation field reports, crops and treatments history and infestation spatial and temporal trends. The system is already used for area wide multi-grower IPM projects of Mediterranean fruit fly, late blight and other pests in thousands of plots and various crops. The project will connect/integrate the two systems in order to provide a complete set of information and improve the performances of its single components. It will be designed to optimize scouting activities and crop protection treatments, and allow secure data sharing for improving both routine operations by growers and agronomists, and authorities supervision of IPM implementation according to the new directive.

CALIBRATION AND IN-FIELD VALIDATION TESTS OF A WEB-BASED ADAPTIVE MANAGEMENT SYSTEM FOR MONITORING - SCAPHOIDEUS TITANUS

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We developed a Web-based Adaptive Management System (WAMS) within a research project, called "SMART VINEYARD", which was funded by the Swiss Federal Commission for Technology and Innovation (Project 11307.1 PFES-ES). Goal of the project was to address the challenge of proposing a decision support system to provide real-time forecast of the life stages of *Scaphoideus titanus*, vector of flavescence dorée. The benefit of using the WAMS is to decide the timing of insecticide application and the planning of in-field monitoring tasks. After some laboratory tests done in 2010 and based on historical data, we performed some preliminary in-field tests of the system in the Canton of Ticino, Switzerland, between April-July 2011. The obtained results allowed us to developed a calibration algorithm aiming at setting up the initialization of *S. titanus* monitoring in new vineyards of regions with different micro-climate conditions. A first in-field validation of this calibration techniques was performed in Romandie, the french speaking part of Switzerland, in particular in two vineyards, in Changins and Satigny, in the Canton Vaud respectively Geneva. The obtained results were very promising. Even if the region was not "known", our system was able to generate prediction windows about three weeks in advance and with an error rate of +/- 2 days. We strongly believe that end-users of our WAMS (i.e. wine growers, phytosanitary services, scouts) can benefit by operating in a cycle of system monitoring, data processing and adapting their activities to the current situation in their vineyards. End-users are given the possibility to interact with the monitoring system by means of a customizable web-based application able to provide real-time prediction windows, visualization of real-time temperature, as well as aggregated data like minimum, maximum and average temperature. Moreover, an alert feature regularly notifies the end-user about prediction windows via email or sms. The monitoring system can be easily interfaced with both weather station and wireless sensor networks. The engine of the monitoring system is a set of proprietary software implementing: (i) phenology models for predicting the life cycles of the vector and (ii) the auto-adaptiveness of the system based on machine-learning techniques.

A DECISION-SUPPORT SYSTEM FOR MANAGING APHID-BORNE VIRUS DISEASES IN SEED POTATO

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Vector-borne virus diseases represent a major economic threat to the production of seed potatoes. Of the vast number of viruses causing infectious disease in potato plants, the aphid-transmitted Potato Virus Y (PVY) is of particular concern in many potato-growing regions worldwide. Controlling PVY indirectly through the application of insecticides targeting the aphid vectors has proven to be inefficient. Therefore, other virus control strategies must be explored and optimised, particularly in regions where vector pressure is high. We have developed a disease forecasting model for PVY adapted to the epidemiological situation in Switzerland. Predictions on the risk of virus transmission are based on vector pressure during the first 5-6 weeks following potato emergence, with vector pressure being estimated from daily captures of winged aphids in a suction trap. The statistical model was parameterised with high-quality data of PVY incidence in tubers, collected over two decades within the Swiss seed certification program. Cross-validation procedures showed that the model can predict virus risk with high accuracy. A parallel statistical analysis of the data on the spatio-temporal distribution of virus disease allowed to identify additional risk factors for dissemination of virus. This information can be used to adjust forecasts to particular epidemiological situations in a given year and region. Predictions of the forecast model are disseminated to growers on a weekly basis through the web-based national pest information platform “Agrometeo”. Such information on virus risk is invaluable for optimising virus control interventions, such as oil sprays. It also assists in making decisions concerning the optimal scheduling of haulm destruction, which aims to minimise virus risk while also maximising tuber yield.

SPATIAL DISTRIBUTION AND PRECISION TARGETING AGAINST SOME FRUIT AND GRAPE PESTS

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According to the precision IPM approach, studies on spatial distribution and spatio-temporal dynamic provide crucial information for improving the pest monitoring and precision targeting control. Specifically, the precision targeting uses spatially explicit statistical methods to define pest distribution with a minimal priori knowledge of the pest behaviour and to provide with simple, documentable procedures for minimize direct control tactics. Geostatistic methods are among the most utilized statistical tools. Cases showing the importance of this approach, especially in heterogeneous and fragmented agro-ecosystems, were reported in the present paper. Studies interested some pests of fruit orchards and vineyards, such as the Lepidoptera *Grapholitha funebrana* Treitschke, *Cydia pomonella* (L.), *Lobesia botrana* (Denis & Schiffermüller) and the Diptera *Ceratitis capitata* (Wiedemann), monitored using traps or direct sampling. For each example, results relevant for the precision targeting application and the design of a pest management strategy were reported and discussed.

LOW LOSS-SPRAY APPLICATION - A CONCEPT FOR MORE EFFICIENCY AND SAFETY IN TOP FRUIT CROP PROTECTION

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Limited time frames caused by infection threat and weather conditions demand for efficient pesticide application techniques in modern integrated and organic fruit farming. This demand is best complied by low volume spraying minimizing traveling time and number of fillings per treatment and the chances of contamination of the operator with concentrated pesticides. For a good spray cover small droplets are most suitable, hence support low volume spray application and offer numerous benefits, but also carry a high drift potential.
Adapting the air support through the use of cross flow fans with a uniform horizontal reach of the air stream over working height, an adaptation of fan speed to canopy width at any forward speed and the use of a mixed nozzle set of the Venturi nozzles at the two top most positions of the spray boom and a hollow cone nozzle at the remaining ones, spray drift is reduced by approx. 84% below the German reference values. With this drift reduction growers may officially use reduced buffer zones close to surface waters. Adapting fan speed to the canopy reduces fuel consumption up to 80% and noise perception up to 50%.
The adaptation of fan speed also increases the efficacy of spray cover formation in a wide range of canopy structure calculated as relative change of spray cover parameters per litre of spray liquid delivered in relation to a standard application. Concerning spray deposit on the entire leaf, this increase ranges from 14 - 35%, while specific relative coverage and droplet deposit density both on the upper leaf surface varied between 29 and 67%, and increased by 5 - 55%, respectively.
Unfortunately vertical air distribution of most orchard sprayers with cross flow characteristics has been very poor, resulting in an uneven reach of the air stream over working height. Since a poor air distribution may result in continuous failures of pest and disease control because of an incomplete spray cover at reduced fan speed, vertical air distribution urgently needed to be improved. Therefore the “South Tyrolean Advisory Service for Fruit and Wine Growing” at Lana, South Tyrol, Italy, the “Styrean Fruit Growers Association” at Graz, Austria and the fruit cooperative “Marktgemeinschaft Bodenseeobst eG” at Friedrichshafen, Germany, in 2010 started a joint project for testing and adjusting the air distribution of new orchard sprayers. Based on guidelines and a positive list of fans meeting its requirements published in the internet and an addition in the contract of purchase that the customer will purchase a sprayer only after it successfully passed the test, interested manufacturers are on the way of improving the air distribution of their orchard sprayers. Completed by a test and adjustment of the vertical spray liquid distribution on a patternator and other mandatory tests, the grower is guaranteed to purchase a fully functioning orchard sprayer and allows him to benefit from all the advantages of low loss spray application.

ENHANCEMENT OF FRUIT QUALITY DURING POST-HARVEST: THE OZONE OPTION

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Fruit and vegetables represent an important sector in the world agricultural industry. These commodities are subject to high qualitative and quantitative losses, from the field to the post-harvest period. Fungi are a particularly insidious group among contaminating agents since they can induce a significant product loss and also, many of them can synthesize different toxic secondary metabolites known as mycotoxins. This impairs the product quality and health characteristics. Post-harvest is a critical stage in the production of horticultural foodstuffs, in particular where storage facilities are limited and/or when long-term storage is applied. Until now the most common approach to extend the shelf life of these products has been the use of fungicides, but the growing concern about environmental protection and sustainable agriculture has led to take into consideration environment friendly crop protection strategies. Recent research shows interesting results related to the application of physical means like ozone (O3) to prevent the growth of fungal contaminants and the production of mycotoxins on different types of fruit (apples, cherries, oranges). Moreover, O3 treatment allows the degradation of some widely used pesticides like methylparathion, parathion and cypermethrin. In this study some apple varieties (Gala, Golden, Fuji) were challenged with a *Penicillium expansum* patulin producing isolate after being harvested and stored in cold rooms under O3 (0.5 ppm) at 1°C±1. Every 15 days samples were collected to analyze the amount of Colony Forming Units (CFUs) and to check for the presence of the mycotoxin patulin; the activity of some Pathogenesis Related proteins (PRPs) was also evaluated. The results suggest that O3 at the tested concentration significantly reduces the number of CFUs and patulin biosynthesis linked with *P. expansum* contamination during the post-harvest period. PRPs activity was not significantly altered by O3; just some peroxidase or phenylalanine ammonia-lyase induction was reported in the first or in the last incubation period, respectively. The lack of PRPs involvement was very likely due to the length of the trial period, or we can alternatively assume that the enzymes studied are not involved in the apple response to ozone exposure. The results highlighted that ozone treatment can be useful to extend apple fruit shelf life and decay control with a view to applying environment friendly storage strategies.

USER-ENGAGEMENT IS KEY TO IMPLEMENTING LOW-DRIFT NOZZLES IN ORCHARDS & VINES: LESSONS FROM YEAR-1 OF UK CHLORPYRIFOS SAY-NO-TO-DRIFT CAMPAIGN & STRATEGY FOR DRIFT-REDUCTION PROGRAM IN ITALY.

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The insecticide chlorpyrifos is very toxic to aquatic invertebrates. Hence, it is very important to prevent spray drift onto ponds and streams. To protect aquatic ecosystems while maintaining availability of this substance to UK farmers, the "Say No to Drift" campaign was launched in Oct '11 by Dow AgroSciences, Makhteshim Agan & Headland Agrochemicals (Cheminova). Experiences are relevant for implementing low-drift nozzles (LDN) for pesticides in general, chlorpyrifos being used in all major sectors in UK (arable, grassland, vegetables, soft fruit & orchards). Drift-reduction is also fundamental to EU Directive on Sustainable Use of Pesticides & the National Action Plans which will enact it. Aim is to have LDN used for all chlorpyrifos sprays in UK plus extended buffer zones. LDN can reduce fine droplets (smaller than 0.1 mm) by 95% consequently reducing spray-drift by 90-95%. Over the last 10 years, use of LDN has increased in UK arable sector no w accounting for ca. 80% of applications. However, in orchards (the use which creates most drift), uptake of LDN in UK has been minimal. A possible reason is that no orchard LDN is officially rated in UK, as opposed to DE & NL where they are classified e.g. Albuz TVI Anti-Drift nozzle. Also the challenge of implementing LDN in orchards & vines is that a major change in attitude is needed due to historical emphasis on fine droplets being linked with biological efficacy. New field trials spraying chlorpyrifos through Albuz TVI Anti-Drift nozzles have shown no loss of effectiveness in apples & vines compared with conventional nozzles. The "Say No to Drift" philosophy is clear-communication, direct-engagement, active-listening and team-working. The campaign was realised via events and articles - widely reported by press and online; a website www.saynotodrift.co.uk; listening and talking to growers, agronomists, spray-technicians and associations; and on-farm orchard training sessions. 200 sets of TVI nozzles were also given to growers free-of-charge. In terms of the impact of Say-No-to Drift in 2012, an independent survey of growers by a UK official government group obtained scores of 9 out of 10 for agronomic-importance of chlorpyrifos, with high awareness of the campaign (arable: 97%, orchards: 99%). For orchards, use of LDN increased from 6% in 2011 to 88% in 2012, a major shift to LDN. Plans for 2013 are ongoing to consolidate this excellent progress. These results are from a postal survey, and face-to-face interviews are ongoing. Experiences in UK are valuable for planning of a new drift-reduction program in Italy, called "MIRALBERSAGLIO" (aim at the target), which will be a communication, promotion and dissemination program, tailor-made for the agronomic challenges in Italy and for Italian farmers. The aim is to maintain access to chlorpyrifos for Italian farmers, while meeting strict regulatory requirements to protect aquatic ecosystems.

SEMIOSBIO PRECISION PEST MANAGEMENT SYSTEM: REAL-TIME MATING DISRUPTION

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With tighter regulations on pesticides and increased awareness of IPM techniques, use of pheromones to tackle insect infestations has come to the forefront as a viable component of pest management. Currently, mating disruption (MD) works passively using either solid matrix or preset time-released puffs. SemiosBIO has developed an active system to account for real-time conditions and deliver targeted pheromone release. The system consists of a gateway connected to cellular networks and a wireless mesh network of weather stations, camera-enabled pest traps and automated aerosol pheromone dispensers capable of deploying multiple pheromones. All components are managed on a cloud database and remotely controlled using SemiosBIO's platform software. Pilot studies of SemiosBIO's system were conducted in British Columbia (BC), Canada during the summer of 2012. In this study we used SemiosBIO's system to test low-load and targeted custom spray schedules in real-time a ccording to local weather conditions and under high pest pressure. A 14 hectare commercial apple orchard in Cawson BC, Canada had an internal grid of remotely-controlled dispensers deployed at a rate of 2.5 per hectare. Two thousand sterile codling moths (*Cydia pomonella*) (50:50 sex ratio) per hectare were released weekly. The study was broken down into weekly trial and control periods. The trials involved varying the number and location of units dispensing pheromone as well as the dispensing schedules. Efficacy of MD was assessed using pheromone-baited delta traps placed every 60m. The percent reduction of moth catches during the treatment trials was calculated against control periods. Moth capture was reduced in all trials and was as high as 98%. Leading edge pheromone application, dispensed only at the upwind end of the orchard, achieved 70% reduction in trap captures across the site using only 0.37g/ha of pheromone. MD was most effective (>95%) at the two highest doses applied (1.28 and 2.57g/ha). High reductions (98%) in trap capture occurred with two different schedules, both dispensing 1.28g/ha. Using SemiosBIO's system, high levels of MD were achieved and the value of precision pheromone delivery based on live conditions, including wind and topography patterns, was demonstrated. SemiosBIO was able to achieve effective control using half the amount of pheromone as passive aerosol dispensers. When an active MD system is used, high effectiveness, lower active use, and reduced installation and maintenance costs can be realized by tailoring the release system to real-time orchard conditions; these advantages will prove particularly powerful in large area-wide pest management programs. Further trials of automated camera traps as well as automated record keeping to enable complete traceability are currently underway. In 2013, large area-wide trials of SemiosBIO's technologies will be conducted in North America, South America and the EU.

DEVELOPMENT OF THE MINIATURE VIRTUAL IMPACTOR - MVI - FOR LONG-TERM AND AUTOMATED AIR SAMPLING TO DETECT PLANT PATHOGEN SPORES

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In support of the 'Emerging Technologies' workpackage of the PURE project, a new air sampler has been developed based on the principal of virtual impaction. The sampler operates at an air-flow rate of 20 L/minute and provides an efficient way to sample air for biological particles such as spores of plant pathogens. Air is directed into a chamber where it changes direction towards a suction pump, causing airborne particles to separate from the airflow due to their momentum and fall under gravity to settle passively into a collection vial. Spores, pollen and other airborne particles are deposited either as a dry deposit, or into a liquid. Most other devices that sample into liquids suffer from high evaporation rate which means that the collection liquid has to be replenished or the sampling period restricted to relatively short periods. In contrast, the MVI can sample for 24 hours with minimal evaporation, which means spores can be deposited into culture medium to test for viable organisms, or directly into DNA extraction buffer. Viability of collected spores is also unaffected by impaction, which is thought to damage or kill a proportion of spores collected using other methods. The MVI was designed to be compatible with a wide range of downstream diagnostic methods such as microscopy, DNA-based detection, immunological or chemical detection by biosensors, lateral flow devices, dip-sticks or by optical characteristics. As part of other related IPM and precision farming-related projects, the device has already been tested for efficiency of collection of spores of *Sclerotinia sclerotiorum*, which is an important but sporadic pathogen of crops such as oilseed rape, sunflower, soya, peas, carrots and lettuce. Results compared very well with detection of Sclerotinia spores sampled simultaneously at the same field-site using traditional Hirst-type air samplers, from which DNA was extracted and spores quantified by qPCR.

MATING DISRUPTION WITH VIBRATIONAL SIGNALS: RESULTS OF 2012

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Numerous insect species communicate with vibrations transmitted in substrates. For example, the Nearctic leafhopper *Scaphoideus titanus*, the vector of flavescence doreé grapevine disease, uses substrate-borne vibrations for mating and rivalry. In the present study, a pre-recorded disturbance noise from *S. titanus* was played back to field-growing grapevine plants, in order to mask the mating communication between males and females that had been released into netting sleeves on the plants for 24 hours. The aim was to study the effect of mating disruption by distance from the signal source and if different durations of the system have an effect on the number of mated females. A high percentage of virgin females were found in plants with disturbance transmission on for 24 h, 21 h and 19 h, however only at a distance of 5 m. When the system was on for less than 19 h and at distances until 45 m, the mating frequency increased to approximately 50-60 % mated females. Although the result shows that there is a good potential for mating disruption with vibrations, major technological improvements are necessary for decreasing both the energy consumption and the economic expenses before any application is possible. Also, more knowledge is needed about transmission of vibrational signals in plants. For this, a laboratorial experiment was made, where the role of intensity, directionality and sensitivity of mating signals in *S. titanus* was studied with laser vibrometry. Males and females were placed on different leaves of the same plant and the male behaviour when searching for a female was recorded. The results showed that males use specific signals to identify and locate a female before courtship and that such searching process depends on the arrival of directional cues in combination with a level of received signal intensity. For increasing the efficiency of a vibrational mating disruption strategy this knowledge is important since it shows that there are behavioural phases which should be more susceptible to disruption and that the masking of mating signals requires a higher intensity than those emitted by natural insects in order to prevent mating.

WEBCAM-BASED PEST MONITORING

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The efficiency of pest control in any IPM strategies largely depends on the accuracy of the pest monitoring method applied. Without collecting information on the population dynamics of the key pests and recording relevant meteorological data in a given plantation, it is almost impossible to control pests sufficiently. In modern IPM technologies, sex pheromone traps are used for pest monitoring extensively. However, the regular checking of sex pheromone traps is a time- and labour-consuming task for the grower. That is why the aim of our work was to develop a pest monitoring system which can take the advantages of the wireless communication technology. By applying this method, it is not necessary to check all the traps on the spot each day. Besides a commercially available sex pheromone trap, the automated system consists of a built-in webcam and the necessary technical equipment for recording and forwarding the required data to a remote server. Preliminary check of the electronic monitoring system was started in 2008 in apricot orchard. Based on successful preliminary checks the testing of the automated trap was carried out in different orchards (apricot, apple and grapevine) in Hungary between April and September, 2012. The suitability of the system to monitor different pests was tested for three moth species (*Anarsia lineatella*, *Cydia pomonella* and *Lobesia botrana*). The automated trap took a photo each day during the trial, and the picture was immediately forwarded to a remote server for visual evaluation of the captured moths. As a control, visual inspections of traditional (non-automated) traps were carried out twice a week. Sticky inserts of the traps were regularly replaced depending on their contamination with insects. Pheromone lures were replaced every fifth week. Due to the use of the webcam-based sex pheromone trap, a valuable series of data on the flight dynamics of different moth species could be collected. During the field tests, malfunction was not registered. The exposure of the camera was not modified by any environmental factors (eg. high wind or sprayings). The use of the automated trap, if set to take and send a photo each day, gives a chance for a more accurate timing of pesticide application, and can help the regional plant protection directorates and other organizations improve pest forecast models. According to our results, the described monitoring method might be a promising solution in IPM systems.
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DNA ANALYSIS FOR PLANT PATHOGEN DETECTION IN AIR SAMPLES

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Many plant pathogens are dispersed by air. Spores of different pathogens are released either actively or passively, under specific weather conditions and in particular seasons. New DNA-based diagnostic methods, applied to air samples, allow us to assess the presence or the quantity of particular species to inform on the disease pressure for a certain crop. The technology can also be used to monitor genetic changes in pathogen populations, such as those conferring virulence to crop varieties or resistance to a class of fungicide. Methods to produce rapid results either in a research laboratory or farm-site are under development to inform a new level of precision on crop protection decisions. The optimal deployment of air samplers is thought to be affected by how common the pathogen is, and the volume of air sampled by the device used. For common plant pathogens it is possible to detect airborne inoculum from an air sampler located at rooftop height. Further research is require d to understand how the deployment of samplers in fields or rooftop sites affects our interpretation of disease risk over local and regional scales. Rapid and automated methods to quantify airborne spores are also under development. Within the PURE project, emerging technologies work-package 11, the use of air sampling for both direct inoculum-based disease forecasts and as a survey tool is currently being investigated. Burkard seven-day spore traps, based on the Hirst spore trap design, were operated at ground and rooftop level at Rothamsted Research (UK), rooftop level at Wageningen (NL) and at Slagelse (DK). The Burkard spore traps each sampled air at 10 L/minute (i.e. 14.4 m3 per day) continuously for periods of 3-4 weeks in the autumn 2011 and spring 2012. Samples were sent to RRes, where each daily section (48mm x 20mm of sticky film onto which spores and other airborne particles are impacted) was divided into two sub-samples, each placed into a 2ml screw-top tube. DNA was extracted from each sub-sample by shaking in a Fastprep machine with microscopic glass beads in an extraction buffer, followed by DNA purification. DNA pellets were resuspended in 30µl of sterile deionised water for use in furth er DNA analysis using two platforms:

- Real-time PCR’s for pathogens relevant for the project. A selection of 20 PCRs have been devised to target key pathogens of arable crops.
- 454 amplicon sequence analysis of fungal spore composition.
- The first results are presented and discussed.

DEVELOPING NOVEL APPROACHES TO MANAGE PEST POPULATIONS

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As the EU is trying to reduce pesticide use in crops there is a need to develop alternative ways of controlling pests and diseases to safeguard harvests against the losses that these attacking organisms cause. This is important for food security especially in the context of global pressures to produce more food with fewer resources. There are drivers from government and demand from consumers to replace pesticides but our crops would be very vulnerable to damage and loss if left unprotected. In my talk I describe some alternative approaches and their prospects. Plants activators, biocontrol agents for plant pathogens and insect pests and biopesticides are being developed as part of the EU-PURE project. Biocontrol agents for insect pests can be delivered in large numbers in greenhouses and in many such situations have replaced insecticides. However, their use in tomato greenhouses is threatened by an emerging pest, the tomato leafminer, *Tuta absoluta* which requires new biocontrol agents to avoid the need for insecticide treatment. A parasitoid wasp, *Trichogramma achaeae*, and a predator, *Necremnus artynes*, are being developed for this purpose. Quality control is important and correct characterization is essential before using *T. achaeae* parasitoids in biocontrol programmes. Furthermore, parasitoid rearing conditions influence their performance. Natural products can provide novel sources of bioactive material of value for crop protection. Known and novel compounds are being tested for their biological activity against pest targets and in terms of reducing fungal mycotoxins. For example, clerodane antifeedants, extracted from the Ajuga plant, had strong antifeedant activity against larvae of the insect pest, *Plutella xylostella* and 3-5 Dicaffeoylquinic, Caffeic and chlorogenic acids performed well in reducing mycotoxin production by *Fusarium* species. Resistant crops have considerable potential for reducing pesticide use. An example is given of orange wheat blossom midge management in the UK. Collaborative LINK projects with wheat breeders enabled development of resistant cultivars which now comprise at least 40% of the UK wheat. Higher quality wheat is still susceptible but insecticide use on these crops has been reduced through use of pheromone traps to rationalise spray applications. Traps, baited with the sex pheromone, 2,7-nonadiyl dibutyrate, allow very sensitive monitoring of the pest and give farmers the confidence not to spray when the pest is not present. Successful promotion, establishment and support for IPM under Directive 2009/128/EC, requires research and development of alternative approaches to crop protection together with effective knowledge exchange and transfer to growers and agronomists. Common agricultural policy (CAP) reform could support IPM development. There is also an opportunity for private investment. The EU could help by simplifying the registration of alternative crop protection products and crops.

INCREASING EFFICACY OF *AMPELOMYCES QUISQUALIS* BY THE USE OF AN ACTIVATOR

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Powdery mildew is one of the most important diseases worldwide. High disease pressure is linked to successful overwintering of pathogen inoculum and suitable environmental conditions for its development. Pycnidial fungi belonging to the genus *Ampelomyces* are the most widespread natural antagonists of powdery mildew and they are unique in their ability to actively infect and kill the causal agents of this disease (*Erysiphales*). The efficacyof *A. quisqualis* in the biological control of its fungal hosts is often inconsistent under field conditions whereas the most successful biocontrol experiments using *A. quisqualis* were carried out in greenhouses where temperature and relative humidity (RH) are suitable to the mycoparasite. Clearly, the high RH requirement of *A. quisqualis* represents one of the major obstacles in its use as a reliable biocontrol agent. In this study, novel tools for exploring future application of *A. quisqualis* in biological control of powdery mildew fungi were investigated. For this purpose, selection of new highly effective mycoparasitic strains and identification of specific mechanisms to increase the biocontrol efficiency are considered to be the most appropriate methods. Thus, some attempts were made to enhance the efficacy of different strains of *A. quisqualis*. A procedure to increase the performance of *A. quisqualis* in the biological control of powdery mildews was developed by increasing and speading the conidial germination rate of the fungus before leaf application. The method may be useful to improved the efficacy of biological control agents under limiting temperature and RH conditions.

NEW STRATEGY FOR THE USE OF *AMPELOMYCES* SPP. AGAINST GRAPEVINE POWDERY MILDEW: SANITATION AND DISEASE MODELLING

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Powdery mildew, caused by *Erysiphe necator* (Schw.) Burr., is one of the most widespread and economically important diseases of grapevine. It is a policyclic disease, with primary, sexual infection cycles followed by several secondary, asexual cycles. The primary inoculum consists of ascospores produced in chasmothecia overwintered on the bark of vines, or of conidia produced by the mycelium present in dormant buds. Nonetheless, in many grape-growing areas, flag shoots (i.e. shoots generated by the infected, dormant buds) are usually absent in commercial vineyards. Chasmothecia form in late summer on the affected host tissue and, once mature, are dispersed by rain splashes to the bark of vines. In the following spring they repeatedly release ascospores that trigger new infection. The usual approach to powdery mildew control consists of repeated applications of fungicides from budburst to berries pea-size, and more; sanitation, i.e. the process that reduces or eliminates the initial inoculum from which the disease epidemic starts, would be highly effective in early-season control of powdery mildew. Efficacy of sanitation has been already evaluated in Northern Italy; interestingly, the application of a BioControl Agent based on *Ampelomyces quisqualis* Ces. (the biofungicide AQ10® WG) gave good results, comparable with those obtained with fungicides. This biofungicide applied twice, before and after harvest (i.e., during the formation and maturation of the chasmothecia) halved disease severity on bunches until the pea-sized berries stage in the following season. When sanitation with *A. quisqualis* was coupled with early-season (i.e., between bud break and fruit set) sulphur applications scheduled according to a weather-driven disease prediction model, disease severity on bunches was reduced by 98% (vs. an 80% reduction with sulphur sprays alone). Since this new strategy provided very promising results under experimental field conditions, it is being adopted under commercial vineyard conditions in different grapevine-growing areas around Europe within the FP7-KBBE project "Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management" (PURE). The use of the biofungicide was tested in 10 vineyards in Italy (2 in the Po Valley, 3 in Tuscany and 5 in Trentino), 2 vineyards in Germany and 3 vineyards in France, for two seasons. The first results confirmed the efficacy of *A. quisqualis* in reducing the overwintering inoculum and delaying the disease onset the following spring. Low efficacy of the biofungicide was observed in few vineyards, which confirmed the need to detect the optimal timing of the application, i.e. when most of the chasmothecia are immature (i.e., in the “yellow stage ” of development). This new strategy may have a relevant impact on powdery mildew control in organic viticulture, but may be useful also in the integrated disease management in those vineyards where the chasmothecia population is expected to be high.

INTEGRATED PEST MANAGEMENT OF CABBAGE ROOT FLY (*DELIA RADICUM* L.) WITH TIMED INSECTICIDE APPLICATIONS AND ENTOMOPATHOGENIC FUNGI

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Brassicaceous plants are attacked by a wide range of pest insects. Specifically the cabbage root fly (CRF) species *Delia radicum* and *Delia floralis* present major threats for many brassica crops in Europe. The aim of this research was to assess several insecticides and entomopathogenic or potentially plant growth promoting fungal species against cabbage root fly (CRF) in a field experiment. Insecticides based on spinosad, lambda-cyhalothrin, and thiametoxam were used. Fungal species tested were: *Trichoderma atroviride* (1 strain), *T. koningiopsis* (1), *T. gamsii* (1), *Beauveria bassiana* (1), *Metarhizium anisopliae* (2) and *Clonostachys solani* (1). The fungi were isolated from various substrata in Slovenia. Spinosad and lambda-cyhalothrin increased the average plant weight. Spinosad significantly decreased the number of *D. radicum* pupae and larvae in the cauliflower root system. It offered considerable protection to the roots against herbivory as assessed by an improvement of the average root quality class. Significantly more pupae or larvae were found in the root systems of plants treated with lambda-cyhalothrin compared to control. Lambda-cyhalothrin and thiametoxam did not have a significant effect on the root quality class of the cauliflower plants. The preliminary results showed that all fungal isolates tested were infective to one or more of life stages of CRF (eggs, larvae, imago or pupae). However, rhizosphere competence varied considerably, possibly due to the ecological preferences of the different fungal species. The use of pest flight monitoring and timed insecticide or entomopathogenic fungi application in integrated pest management programs is discussed.

MICROSCALE ELISA PLATE SCREENING OF ESSENTIAL OILS AGAINST EUROPEAN DAMAGEABLE PLANT PATHOGENS

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Plant extracts, such as essential oils, are known since a long time to have potentialities to prevent and/or to cure human diseases by their bactericidal and fungicidal effects. As consumers desire pesticides-free commodities and the European legislation suppresses a lot of former active ingredients and greatly limits the registration of new pesticides, it is important to dispose of new molecules for the control of plantpathogens. It was already reported that essential oils could be used as postharvest biofungicides (Antunes & Cavaco 2010). In that context, the main objective of the present study was the identification of effective essential oils against the most important plant pathogens in Europe (in term of loss, treatment necessity and/or cost). The study began with the selection of 89 essential oils based on their cost and availability but also on the knowledge available in the literature. Then, 20 plant-pathogen pairs were selected from the most important Europ ean crops (i.e. Sugar beet-Rhizoctonia solani, soil-*Pythium ultimum*, Potato-*Phytopthora infestans*, Bean-*Colletotrichum lindemuthianum*, Wheat-*Septoria tritici*). This was followed by the optimization of a protocol based on a microscale bioassay ELISA plate using optical density for a rapid quantitative evaluation of biofungicidal activity of essential oils (in liquid culture medium) previously developed in the Plant Pathology Unit (Kouassi et al., 2012) . Kinetics of growth of the 14 pathogens cultivable in liquid medium were determined before testing the impact of the essential oils. Finally, pathogens which did not grow on liquid medium were tested in Petri dishes. The efficacy of the 89 essential oils will be presented against *Rhizoctonia solani*, *Pythium ultimum*, *Phytopthora infestans*, *Colletotrichum lindemuthianum* and *Septoria tritici*. Some tested essential oils have presented a high percentage (more than 70%) of growth inhibition at 1000ppm and 500ppm against these fungal pathogens. These results showed that EOs have some potentialities as biocontrol compounds of postharvest pathogens has previously described (Antunes & Cavaco 2010; Lopez-Reyes et al. 2010), but also for the crop protection in field. To our knowledge, this is the first study proceeding to a wide screening of essential oils against European important plant, and especially row crops, pathogens.

SEED TREATMENT WITH ESSENTIAL OILS

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In the organic farming the prevention is one of the action to be performed to reduce the risks of pathogen attacks. The use of healthy seeds is the first option available to prevent diseases, in particular seed-borne and soil-borne diseases. We conducted during the last years studies about the use of essential oils like *Melaleuca alternifolia* (tea tree), *Thymus vulgaris* (thyme), *Laurus nobilis* (laurel), *Mentha* x *piperita* (peppermint), *Origanum vulgare* (oregano), *Syzygium aromaticum* (clove) and *Rosmarinus officianalis* (rosemary) oils for seed treatment against the main fungal pathogens transmitted by legumes (lentil, pea, chickpea, bean), rice and wheat seeds. In vitro and in vivo assays were carried out to test the activity of the oils against fungi. Trials in greenhouse and in the field were performed to verify the activity of the essential oils, using healthy and inoculated seeds. To set up the proper concentration also the phytotoxicity was evaluated. Results showed a significant activity of the oils on reducing fungal growth. It was calculated the percentage of Mycelial Growth Inhibition (%MGI) and the Minimum Inhibitory Concentration (MIC) for each oil, that was dose-dependent and it differed depending on the fungal species. Thyme, clove, peppermint and oregano oils were the most effective against fungal isolates tested but also tea tree, laurel and rosemary oils showed a good effectiveness. The firsts were also the most phytotoxic as they reduced the percentage of seed germination at the higher concentrations. The use of the right amount of the oil in the treatment solution, especially if seeds were treated by immersion, allowed to obtain positive results in reducing disease incidence in vivo, as well as in greenhouse and field experiments. Therefore the essential oils tested can be considered very interesting for developing alternative natural fungicides to the synthetic chemicals that are currently used to prevent and control seed-borne diseases. The best application (immersion or spray) should be evaluated to achieve the best performance in terms of germinability and reduction of disease incidence, as well as the best concentration for each type of seed and pathogen. We conclude that essential oils can be potentially used in organic agriculture for safe and low environmental impact seed-treatments.

SEMIOCHEMICALS IN EUROPEAN IPM: TIME TO MOVE BEYOND A REGULATORY BOTTLENECK?

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Increasing public concern over undesirable effects of pesticides has resulted in a European-wide shift towards the adoption of Integrated Pest Management (IPM). This policy shift has been embraced by the European Union (EU) in the Directive 128/2009 on sustainable use of pesticides. This directive makes the adoption of IPM mandatory from 2014, and has encouraged research and implementation of efficient pesticide alternatives. Semiochemicals are promising candidates to replace conventional pesticides in IPM programs. In certain instances, such as top fruit and vine growing, their use as a viable alternative has been established for over a decade. To date, in pest management, pheromone-mating disruption, monitoring, and trap-outs remain the most successful and broadly adopted uses of semiochemicals. As a result of these established methods, semiochemical adoption rates are increasing worldwide. In addition to pheromone development, chemical ecology research is increasingly exploring the potential of host-derived volatiles to monitor insect species, to manipulate pest host-location and to recruit natural enemies into the agro-ecosystem. IPM relies on multiple strategies to keep pest populations below an economic threshold. The combination of semiochemicals with a diverse range of plant protection products, including biocontrol agents and botanical insecticides, is proposed as an appropriate strategy to support the adoption of IPM. At present, some semiochemicals, such as certain straight chain lepidopteran pheromones, are listed as single compounds in the European database of authorised active substances, although in nature they only exist as species-specific blends. Although these compounds are well-recognised as behaviour modifying chemicals with no toxicity to humans or the environment, EU Regulation 1107 on plant protection products requires that they be subjected to the same regulatory requirements as chemical insecticides. Such restrictions constitute a major regulatory barrier for products containing semiochemicals and as a consequence, their use in IPM programs. This barrier is more severe inside the EU compared with other countries, and impedes new semiochemical adoption. Decision makers at the national as well as the European level should thus urgently co-operate with researchers and practitioners to create new regulatory opportunities that foster quicker implementation of semiochemicals within European IPM crops. Replacing pesticides with non-toxic and target-specific semiochemicals will provide substantial beneficial impact on human health, for both applicators and consumers and the wider environment. Broader goals such as preservation of biodiversity, ecosystem services and food safety need to be considered alongside emerging IPM regulations.

MATING DISRUPTION FOR THE VINE MEALYBUG (*PLANOCOCCUS FICUS*) IN CALIFORNIA

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The mealybug, *Planococcus ficus* (Signoret), has spread from its likely origins in the Mediterranean basin to become a primary pest in California vineyards. *Pl*. *ficus* infests grape clusters and is a vector of several viral diseases and, therefore, is considered an economic pest even at low densities. In California, multiple insecticide applications can reduce *Pl*. *ficus* damage; however, this does not eliminate the pest and requires annual applications. Herein, we review the development and use of the *Pl*. *ficus* sex pheromone in California vineyards as an additional control tool. The sex pheromone was identified as a single component, lavandulyl senecioate. In field trials, with adult male trap captures, male rubber septum lures loaded with 10-1000 µg doses of the pheromone were equally attractive, suggesting a low dose response, and lures loaded with 25 µg of pheromone remained attractive for at least 12 weeks, suggesting pheromone stability in the field. This early success led to trials with *Pl*. *ficus* mating disruption using a sprayable, microencapsulated formulation in 2003 and 2004. Compared with a no-pheromone control, there were significantly lower male trap catches and crop damage in mating disruption plots. After this initial success, product development was aimed at producing a delivery system that would be commercially adopted. From 2004-2006, large (5–10 ha) commercial vineyards were used and, typically, Suterra LLC 'Checkmate' dispensers were loaded with 100–150 mg a.i. and deployed at 101 dispensers per ha. Results showed lower male mealybug flight activity, as monitored by pheromone-baited traps, although this was not always associated with lowered *Pl*. *ficus* crop damage. Development of a commercial program was studied from 2007 to 2011. Again, we showed a consistent reduction in male trap captures. However, we also showed that while mating disruption could affect pest damage in vineyards with initial low mealybug densities, it did not lower high density populations, suggesting that it cannot be used similar to an insecticide. Additionally, studies with dispenser density (20, 50, 76 and 101 dispensers per ha) and meta-dispensers (8 per ha) showed a successful program required >50 dispensers per ha (100–150 mg a.i.) with multiple point sources throughout the vineyard. The cumulative work led to our recent studies that incorporated mating disruption with areawide control efforts. In 2010-2012, demonstration plots in Napa wine grapes showed that *Pl*. *ficus* control should be considered as a regional issue rather than by individual vineyards. Pheromone trap catches were used to identify 'problem' vineyards where insecticides applications were needed. Mating disruption applied throughout the region lowered re-infestation. For growers concerned with Grape Leafroll Associated Virus (GLRaV) management, attaining a 'zero' mealybug population density may only be achieved by this combination of control tools.

PHEROMONE-BASED STRATEGIES IN THE MANAGEMENT OF THE RECENT INTRODUCTION OF LOBESIA BOTRANA IN CALIFORNIA

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Following the first detection of *Lobesia botrana*, European grapevine moth (EGVM), in North America (October 2009 – Napa County, California), sex pheromone-baited traps were deployed to determine the extent of the infestation. In 2010, traps were deployed at densities of 6 to 10 traps per km^2 in commercial vineyards throughout California and at 2 traps per km^2 in select urban areas. From 2011 onward, detection trapping inside the quarantine area was 10 traps per km^2 in both commercial vineyards and urban areas. In March 2010, a state interior quarantine was established encompassing areas within an 8 km radius in which EGVM had been detected to date. The original quarantine area was 420 km^2 increasing to 5,416 km^2 by the end of 2010 and 6,045 km^2 by 2011. These quarantine areas included 9,281, 52,600 and 58,664 vineyard ha, respectively. In 2011, portions of 10 counties were under quarantine. At the end of 2011, 4 counties met deregulation requirements and the regulated areas in the remaining 6 counties were reduced from 8 to 5 km buffer around sites of any EGVM finds, reducing the total area under regulation to 3,372 km^2, which included 38,377 vineyard ha. By the end of 2012, 5 more counties met deregulation requirements further decreasing the regulated area to 1,779 km^2, which includes approximately 21,452 vineyard ha. In 2010, 100,831 moths were caught in Napa County and 128 moths in 9 other counties. In 2011, 113 moths were caught in Napa County and 33 moths in 4 other counties. In 2012, 77 moths were caught only in Napa County. Mating disruption was an integral part of the management and eradication strategy in conjunction with insecticides (cultivated areas) and flower/fruit removal (non-cultivated areas).

SELECTING VOLATILES IN THE FIELD TO PROTECT BRASSICACEOUS CROPS AGAINST THE CABBAGE ROOT FLY, *DELIA RADICUM*

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Volatiles resulting from plant herbivore interactions play an important role in the behavioral decisions of phytophagous, predatory and parasitoid insects and could be used for managing pest insects. However, to date and after about 40 years of research, documented studies on applications in the field remain extremely scarce. *Delia radicum*, the cabbage root fly, is a major pest of brassicaceous crops for which classical control strategies are currently lacking. We have shown that dimethyl disulfide, a compound emitted by roots heavily infested by *D. radicum* larvae, was attractive for its main natural enemies and could lower the number of eggs laid on treated plants in the field by 60%. As a follow up of this work, we conducted another field study to select additional volatiles that could be used in a push-pull approach. Several synthetic HIPVs, selected on the basis of their potential action on the behavior of both the fly and its natural enemies, were placed in odor dispensers in experimental broccoli plots. Our results confirmed the role of dimethyl disulfide in reducing *D. radicum* egg numbers on broccoli plants and revealed other compounds that both influenced plant infestation by the fly and regulation by its main natural enemies. This study is a first step in designing a push-pull method to control the cabbage root fly.

PUFFER® AND MAGNET™: UNDERSTANDING STEPPED-UP TECHNOLOGY FOR PEST CONTROL

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The increasing public concerns about residues on commodities and the new legislation restricting the range of insecticide options and establishing a framework for achieving a sustainable use of pesticides lead to an increasing need for effective alternatives. The development of semiochemical-based products during the last decades has brought solutions for monitoring and control of some pests. Suterra® LLC is a leading company in the research, development, formulation and commercialization of semiochemical-based products, which have brought complementary solutions for monitoring and pest control during the last decades. The mating disruption and mass trapping techniques are now widely used methods of pest management in a wide number of crops. Many different technologies have been developed which are adapted to both the crop and the requirements of the pheromone or the food attractants to be formulated. Suterra® LLC commercializes dispenser and microencapsulated sprayable formulations both for Lepidopteran and Homopteran pests mating disruption, as well as vapour pressure membrane-based dispenser technology for fruitfly mass trapping. In a continuous effort on investment and technology evolution, Suttera® has developed advanced, friendly, and effective solutions for the application of mating disruption (Puffer®) and for the control of fruitflies with the attract and kill approach (Magnet™). Puffer® is a timer-activaded mechanical active aerosol dispenser, which provides a very high emission of pheromone from a low number of point sources at pre-programmed intervals. The Puffer® technology solves the main problems associated to the use of hand-applied dispensers, such as the stability of the sexual pheromone, the seasonal variability in emission rates mainly due to weather conditions and, therefore, seasonal persistence, and the labor cost. Puffer® is used at a very low density (1,25-5 units/ha), protects sex pheromones from UV degradation and oxidation, allows a constant pheromone release rate throughout the season, and can be used to control daily periodicity of the sex pheromone release. Magnet™ is an attract-and-kill technology, which relies on the use of hand-applied devices of low rates together with powerful attractants that bring in the insect to a purpose built device with a killing agent at low dose with seasonal residual effect and no direct contact of the insecticide with the crop. Magnet® MED has been developed for Medfly control, with the use of potent patented food attractants and an effective and persistent deltamethrin formulation, giving a control of at least 6 months with a single application. This paper describes the field work conducted to understand the functioning of Puffer® under actual field conditions and the Magnet™ MED technology for fruitflies attract and kill.

LABORATORY- AND FIELD-COLLECTION OF ROOT VOLATILES FROM *BRASSICA* PLANTS INFESTED WITH *DELIA RADICUM* LARVAE USING A NEW SOLID PHASE MICROEXTRACTION-BASED METHODOLOGY

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Manipulation of volatile organic compounds (VOCs) released by plants, particularly herbivore-induced plant volatiles (HIPVs), offers promising prospects for their use in novel crop protection strategies. VOCs are known to affect the behaviour of herbivores as well as their predators and parasitoids. Previous studies found that dimethyl disulfide (DMDS), a compound emitted by Brassica plants when attacked by cabbage root fly (*Delia radicum* L.) larvae, both reduced oviposition and attracted natural enemies. It remains unclear however, whether constitutive and/or induced Brassica root VOCs play a role in the below-ground behavioural responses of the larvae of this specialist insect. Here we present a novel method for non-invasive collection of glasshouse- and field-grown broccoli (*Brassica oleracea* L. Convar. botrytis (L.) Alef. Var. cymosa Duchesne) root volatiles, pre- and post-infestation with larvae of *D. radicum*, using solid phase microextraction (SPME) and in situ perf orated polytetrafluoroethylene (PTFE) tubes. The aim of this study, part of an ongoing PhD research project, was to identify potential bioactive compounds, hypothesised to influence orientation behaviour of neonate larvae, which are being tested in investigations combining choice-test bioassays and EthoVision® video tracking software. Perforated PTFE tubing positioned next to roots of a commercially important broccoli variety was used for collection of volatiles. SPME fibers were inserted into the tubes and exposed for various sampling periods. Entrainments were carried out on undamaged control, and *D. radicum* larval damaged plants using several different fiber chemistries. Volatiles were analysed by gas chromatography-mass spectrometry (GC-MS). Infested roots emitted a consistent enhancement of VOCs in comparison to undamaged roots. Several sulfur-containing compounds including DMDS showed elevated detection levels. We have shown that the method described here for the collection and identification of key volatiles associated with below-ground herbivory provides a simple, non-invasive technique that is readily adaptable to glasshouse and field environments. A good understanding of the key compounds involved in plant-insect interactions is a crucial step towards the development of more sustainable pest management strategies incorporating host plant volatile signals to alter pest behaviour.

TEN YEARS OF MASS TRAPPING FOR CONTROL *CERATITIS CAPITATA* WIED. IN FRUIT ORCHARDS IN THE NORTHEAST OF SPAIN

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Medfly, *Ceratitis capitata* Wied., is a worldwide pest that affects more than 350 plant species. In the northeast of Spain it is especially important the cultivation of pome and stone fruit-trees which are susceptible to this pest. In this area, all orchards are under Integrated Production rules, and within this framework, the mass trapping system, has been applied from the beginning of this century as a control method for Medfly. Many studies were carried out for assessing the best methodology of mass trapping at commercial level, based on the knowledge of the behaviour of this pest. Amongst these, the biology and ecology of the pest in the area were studied, as well as its spatial distribution at orchard and regional levels. With that purpose, traps were placed and identified in the space and adult captures were weekly reviewed, quantified and sexed. Mass trapping system was evaluated studying different distribution of traps in the field, homogeneous layout and perimeter trapping. The number of traps to be reviewed for properly knowing the level of the population in an orchard with mass trapping was calculated using a macro written in IML (SAS matrix language). Finally, a complete program to control medfly with mass trapping in a wide-area approach was applied for 6 years. The results on population dynamics showed a seasonal variation of the medfly with one population peak in September–October, and with adult activity ending in December or January, independently of the kind of host studied. Mass trapping as a control method showed different efficacy in the fruit species. In apples it can properly protects the harvest by itself, but peaches, a highly sensitive fruit to medfly, need reinforcement of mass trapping with chemicals to avoid damage higher than 1%. Results on the distribution studies showed that the field colonization by the pest, usually starts by one, or more, plot edges, and from there, it spreads over the orchard. The main factors for the estimation of pest population through the trap captures are the plot size and the population level. The wide-area program was highly successful and besides the good results in controlling medfly with mass trapping (1% damage as a maximum), a high confidence in the methodology was achieved by all the people involved: technicians, growers, government officers and researchers. The consequences of the achieved knowledge in the medfly control and in the IPM in fruit orchards in NE of Spain will be discussed.

PRIMING OF DEFENCE: A FUTURE CORNERSTONE OF IPM?

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The use of induced resistance as an alternative method to control pests and diseases in crops requires further study, since previous attempts to exploit this concept resulted in variable levels of effectiveness or undesirable side effects on plant growth, and did not address durability of the induced protection. This project aims to re-evaluate the use of induced resistance in integrated pest and disease management (IPM). Long-lasting induced resistance phenomena are typically based on priming of defence, which is not associated with a direct up-regulation of costly defence mechanisms in the plant. Instead, defence priming sensitizes plants for a faster and stronger activation of inducible defence mechanisms after subsequent pathogen or insect attack. The efficiency and durability of different chemical priming agents were studied in tomato against Botrytis blight. Extended seed treatment with jasmonic acid (JA) resulted in mild disease protection in 4-week-old plants without growth reduction. Treatments of 1-week-old seedlings with JA and beta-aminobutyriuc acid (BABA) provided better disease protection, but were associated with minor reductions in plant growth. Current work focuses on the effectiveness of combinations of JA and BABA with other chemical defence activators and its dependency on tomato genotype. Preliminary results indicate strong interactions between effectiveness of priming agents and tomato genotype. Secondly, the discovery of a putative BABA receptor in Arabidopsis opens possibilities to optimise the cost-benefit balance of BABA-induced priming in tomato and potentially other crops. Selected rhizobacteria can induce growth promotion and aboveground defence priming simultaneously. To identify plant semiochemicals that are important for the establishment of this plant-microbe interaction, we profiled maize root exudates for their ability to attract priming-inducing *Pseudomonas putida* bacteria from non-sterile soil. The benzoxazinoid 2,4-dihydroxy-7-methoxy-2H-1,4-benzoxazin-3(4H)-one (DIMBOA) was identified as a key factor in recruitment of *P. putida* from non-sterile soil. Moreover, mutant lines impaired in DIMBOA exudation failed to develop systemic defence priming in *P. putida*-containing soil. Hence, DIMBOA serves as an important semiochemical for recruitment of priming-inducing rhizobacteria during the young and vulnerable growth stages of maize. Our work supports integration of chemically and biologically induced defence priming in crop breeding programmes. This goal can be achieved through selection for genetic traits that optimise durability and effectiveness of chemically induced priming, but can also focus on genetic traits that improve recruitment of natural, priming-inducing soil bacteria.

ADVANCES IN THE USE OF PHEROMONES FOR STORED-PRODUCT PROTECTION

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Pheromones are promising tools for monitoring and control of stored-product insect pests. In recent years, considerable progress has been made using pheromones for mass-trapping, mating-disruption and attracticide methods for beetle and moth pests associated with stored products. In integrated pest management (IPM) programs for stored products the use of pheromones can lead to a drastic reduction of chemical treatments, with economic advantages and improvement of food quality. Crucial factors for IPM in stored-products include understanding factors that regulate ecosystems, monitoring insect populations, maintaining good records and using this information to make sound management decisions. Successful IPM programs should complement other preventive pest management techniques such as sanitation, stock rotation, pest exclusion practices, and inspection of inbound and outbound materials. In this review, I report on some promising results that offer efficient detection and control of stored-product pests with pheromones and highlight a number of questions to be answered in order to improve the reliability and competitiveness of the methods used.

THE PUFFER PROJECT IN THE SOUTH TYROLEAN VINSCHGAU VALLEY: FIELD REPORT AND FIRST RESULTS

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Mating disruption has been used in South Tyrol (Italy) successfully since 1993. Currently on approximately 90% of the South Tyrolean apple production area pheromone technology is used as part of an apple IPM program. The introduction of this biotechnological method for codling moth control has reduced the use of broad spectrum insecticides substantially. Now a new mating disruption method is finding its way into the codling moth control strategy: the puffer technology. The main objective of the utilization of this new dispenser type is cost reduction. In 2011 the chairman of the fruit cooperative OG Juval in the Vinschgau Valley, the South Tyrolean Extension Service for Fruit- and Winegrowing and the Research Center Laimburg initiated a project to test the new technology under South Tyrolean production conditions. The company SUTERRA distributes the so-called CM Puffer consisting of a plastic case, an interval timer and an aerosol can for the pheromone. During the night, when the codling moth flight usually occurs, the puffer emits pheromones. Per hectare only two puffers are necessary, which is definitively an advantage compared to conventional dispensers of which up to 1,000 pieces have to be applied per hectare. For the implementation of the project 100 hectares on a south-facing hill, the so-called Tscharser Hügel in the Vinschgau Valley at between 570 and 800 m sea-level, were selected. On the 100 hectares 240 puffers were distributed. The specific spots were identified by a professional planning agency and localized by GPS devices. Several infestation checks have been made during the growing seasons 2011 and 2012. In both years growers applied fewer additional sprays than in the years before, when conventional dispenser types like Isomate C were used. The fruit infestation level in 2010, the year before the project started, was between 0.5 and 8%. In 2011 it was between 0 and 1.7%. It could be observed, however, that the pheromone released by aerosol dispensers causes injuries on fruit and foliage around the dispensing unit. Up to now the 2 project years have shown that it is possible to reduce codling moth infestation by using the puffer technology. As with conventional pheromone dispensers, additional sprays in the vicinity of buildings and peripheral orchard zones are necessary. The reduced number of dispensers per hectare is definitively an advantage since it leads to labor savings. On the downside, the elaboration of the distribution plan has to be made in the first year, taking substantial time. Another disadvantage consists in the fruit and foliage injuries around the puffers caused by the pheromone released. In 2013 the project is going to be extended to three more test sites in other South Tyrolean valleys to examine if the puffer technology is really an effective alternative to conventional dispenser types.

NEW INSIGHTS IN SUSTAINABLE VITICULTURE: BREEDING FOR RESISTANCE

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Since the second half of the 19th century, Europe has to deal with a number of devastating diseases which almost caused disappearing of cultivated grapevine from the old Continent. Agricultural management (pest and fungal pathogens) and grafting on wild resistant rootstocks (Phylloxera) were adopted to control major diseases, and since the advent of more and more sophisticated chemicals, pests and pathogens have been successfully controlled, but with high environmental costs. Actually, European breeders tried for many decades to develop new varieties using the sexual compatibility between *Vitis* spp., both from American as well as Asiatic origin, carrying genetic resistances to the major diseases. In spite of their enormous efforts, those wild accessions were carrying also many low quality traits and undesirable aromas which caused their debacle. In the middle of the last century, hybrids were prohibited for cultivation and wine production in the major wine producing countries and only few middle European breeding institutes like Germans, Austrian, Hungarian and some Eastern countries continued on these attempts with low success rate. After a hundred years experiences, several backcrosses into *V. vinifera* background and improved knowledge, like the sequencing of the grapevine genome, grapevine breeding is facing a new deal of opportunities. Several new varieties, with no longer much traces of non-vinifera chromosomal DNA but with an interesting resistance level, mainly to powdery and downy mildews, reached the market in the North of the Alps and two of them have been registered to the National catalogues also in Italy, with a few more coming also in France. Tools for increasing success rate, based on the over hundred years of experience and molecular markers for resistance as well as quality traits, will guarantee future grape varieties (wine and table grape) with improved quality married with several natural resistances which will impact on a new grape orchard management, environmentally and economically more sustainable.

DIFFERENT MECHANISMS OF WHITEFLY RESISTANCE IN TOMATO

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Whiteflies (*Bemisia tabaci* and *Trialeurodes vaporariorum*) are a major problem in tomato growing. They feed directly from phloem sap causing both direct (yield reduction) and indirect damage (virus transmission). Whiteflies are difficult to control with insecticides. Also, they develop resistance to the insecticides very quickly. To overcome these problems, the use of resistant varieties has been proposed as an effective alternative. Plant resistance can act at different stages of the insect's life cycle, which may be based on different resistance mechanisms. We have carried out a broad screening for whitefly resistance in tomato wild relatives. All plants were phenotyped by non-choice insect assays, resulting in the identification of several interesting accessions. In the next phase we focused our efforts on mapping whitefly adult survival in a population derived from *S. galapagense*, and fine mapping of a QTL affecting oviposition rate which was derived from *S. habrochaites*. The analysis performed on the *S. galapagense* mapping population resulted in the identification of two QTLs affecting whitefly adult survival, a major QTL that confers full resistance when present in homozygote state and a minor QTL, which is effective when the first QTL is present in heterozygote state. Acyl sugars are the most likely compounds affecting the reduction in adult survival. The fine mapping of a QTL affecting oviposition rate, but not adult survival in *S. habrochaites* resulted in the identification of one introgression. By combining resistances based on different mechanisms it may be possible to develop tomato varieties with a durable resistance against whiteflies and possibly other insects as well.

DURABLE PLANT DISEASE RESISTANCE BY EVOLUTION MANAGEMENT

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Durable resistance to plant pathogens is highly desired but hard to achieve. In a modelling study, we explore the factors that promote or jeopardize durability of resistance. The purpose of the project is to derive strategies of host plant breeding and spatio-temporal plant genotype deployment that reduce as much as possible the rate of resistance breaking. In other words: the purpose is to manage evolution. We use a spatial implicit model to calculate the development of resistance breaking phenotype in the pathogen population to assess under which conditions pyramiding is the most durable solution. The host and pathogen interaction is modelled with gene for gene relationships governing compatibility. We assess the pros and cons of pyramiding and sequential use of resistance genes and how life history traits of the pathogen affect the most durable solution. The model will be applied to pathosystems of global importance, particularly yellow rust of wheat (*Triticum aestivum*), caused by the fungal pathogen *Puccinia striiformis* f. sp. tritici and Septoria leaf blotch, caused by *Mycosphaerella graminicola*. For both diseases, the development of durable resistance is of great importance. Model parameterization will be achieved by a combination of analysis of process-based information on pathogen life tables and analysis of historical patterns of pathotype dynamics (inverse modelling). The modelling results will be linked to field work in the PURE project that aims at the development of European farming systems that reduce the use of pesticides (http://www.pure-ipm.eu/project).

THE GEDUNEM PROJECT : VARIETAL AND TECHNICAL INNOVATIONS FOR THE SUSTAINABLE AND INTEGRATED MANAGEMENT OF ROOT-KNOT NEMATODES IN PROTECTED VEGETABLE CROPPING SYSTEMS

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The recent banning of the most active chemical nematicides raised root-knot nematodes (RKN) as the major problem of vegetable growing in the south-east of France, with over 40% of horticultural farms affected. Resistant (R) cultivars successfully limit nematode attacks of the crop itself and reduce nematode abundance in soil in the short term. But their use in commercial fields faces two major constraints: (1) the limited number of cultivated species with RKN R-genes available (tomato, pepper), which would lead to major changes in crop rotations with socio-economic constraints; (2) the emergence of virulent root-knot nematode populations, able to overcome the resistance conferred by some of the R-genes. Recent research showed that the durability of the resistance per se was possibly increased with an optimal choice of the R-gene or allele combination, and of the genetic background in which the major R-genes where introgressed. However, the requirement for agronomic performance, does not always allow the breeder to fully use the genetic diversity available in R-genes and genetic backgrounds. In such cases, spatio-temporal deployment strategies of resistant cultivars in the rotation were proposed and provided some success. But combination of genetic resistance with cultivation practices including multicrop rotations, intercultural management and/or prophylactic treatments was poorly tested for its ability to provide complementary selection pressures on the pathogen populations and to increase the durability of the protection. The project aims at identifying innovative strategies across the agrosystem, combining varietal resistance in crop rotations with agronomic practices, for a sustainable control of RKN that infect vegetable crops in protected crop systems. This pilot and demonstrative project involves analytical and systemic aspects: i/ the validation of previous results on the durability of RKN genetic resistance in tomato and pepper by long- term experiments in research stations and in farms, ii/ the impact of agronomic practices on the parasitic pressure in the soil and its contribution in the increase of resistance durability, and iii/ the impact of such innovations on the yield and the economic viability for protected crop systems in a Mediterranean climate. The added value here is to combine together currently dispersed approaches based on synergistic and long-term effects, towards a satisfying level of nematode control over pluri-annual crop sequences. The diversity of partners (research, experimental stations, technical institutes) and associated forces (growers' development structures, 'chambres d'agriculture') brings all the complementary expertise needed for answering specific short-term questions as well as generic mid-long term expectations. 'GEDUNEM' has been launched in the framework of the INRA metaprogramme SMaCH (Sustainable Management of Crop Health), action PRESUME (Plant REsistance SUstainable ManagEment).

ISOMATE CM MIST: A NEW AEROSOL MATING DISRUPTION FORMULATION FOR CODLING MOTH

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Hand-applied formulations of mating disruption products are the most widely used throughout the world as they have been demonstrated to be technically superior and cost effective. An estimated 770,000 hectares were treated in 2012 (SEC 2011) for various crops and pests. While successful, hand-applied formulations have limitations. Hand-labor is increasingly expensive and hard to obtain. Furthermore, some crops such as walnuts with their tall and spreading canopies are difficult to treat with hand-applied products. Sprayable products have been tried but their efficacy is limited and the products expensive relative to the cost of insecticides.

Thomas et al. (1975) successfully formulated the first pheromone aerosol delivery system. The device was used to release the pheromone (frontalin) of the southern pine beetle. The emitting devices were battery powered and designed to release a 5-sec burst of pheromone twice per day. Frontalin was sprayed onto a cheese-cloth target located in front of the nozzle from where it dissipated into the forest environment. The main issue reported by Thomas et al. 1975 was the reliability of the emitter. Development of aerosol type formulations for mating disruption began in earnest in the mid-1990's with the efforts of well known pheromone research scientists Dr. Harry Shorey and Dr. Tom Baker. Aerosol emitters have been tested against more than a dozen different insects including navel orangeworm, *Amyelois transitella,* cabbage looper*, Trichoplusia ni,* almond moth, *Cadra cautella*, beet armyworm, *Spodoptera exigua,* blackheaded fireworm*, Rhopobota naevana,* blueberry leafroller*, Sparganothis sulfureana,* European corn borer, *Ostrinia nubilalis,* pink bollworm, *Pectinophora gossypiella,* oriental fruit moth, *Grapholita molesta,* codling moth, *Cydia pomonella,* omnivorous leafroller, *Platynota stultana,* artichoke plume moth, *Platyptilia carduidactyla* and European grapevine moth, *Lobesia botrana.*

In 2010, Pacific Biocontrol Corporation (PBC), Vancouver, Washington, USA began development of an aerosol emitter formulation. PBC tested over 150 aerosol emitters in 2011. Based on very positive results in both quality control (QC) and field experiments, PBC registered Isomate CM Mist in early 2012. PBC field tested over 800 Isomate CM Mist units in the United States, Italy and Spain in 2012. Based on positive results, PBC introduced Isomate CM Mist to the market place in 2013. PBC will sell over 10,000 units in the United States.

TIMOREX GOLD – A POTENT BIO-FUNGICIDE FOR THE CONTROL OF PLANT DISEASES AND BLACK SIGATOKA IN BANANA

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The natural extract of the tea tree plant (*Melaleuca alternifolia*) has been proven to be an effective antiseptic, fungicide and bactericide. The tea tree plant extract, because of its unique mode of action was added to FRAC list of ingredients for anti resistance management programs. A Bio-fungicide formulated product has been developed from this extract under the brand "Timorex Gold". This product was found to be effective against a broad spectrum of plant pathogenic fungi in various crops. These include members of Oomycetes, Ascomycetes, Basidomycetes and Fungi imperfecti. Trials exhibited that it inhibited spore germination, mycelial growth, lesion development and expansion and suppression mildewed tissues of various fungal pathogens. Timorex Gold has been found to act as a prophylactic and curative product. Black Sigatoka, caused by *Mycosphaerella fijiensis* Morelet, is a major concern for the banana production. The disease spreads rapidly globally and causes vast economic damage. The intensive use of fungicides, of up to 70 sprays/year, due to resistance development, is a major concern for the environment and human health. Timorex Gold has demonstrated both in trials and commercial use high efficacy against Black Sigatoka in both organic and conventional production plantations. It effectively inhibits lesion development, limited the expansion of lesions and demonstrates high curative activity. Unlike other fungicides, which can inhibit Black sigatoka only at stages 1 and 2, Timorex Gold controls Black sigatoka in stages 1, 2, 3, and 4 of disease development. Transmission electron microscopy study of leaf sections infected with Black Sigatoka and treated with Timorex Gold results in lower level of fungal hyphae within the intracellular spaces of the mesophyll tissue. Timorex Gold, unlike systemic fungicides, caused a disruption of the cell membrane and destruction of the cell wall of the fungal cells on stages 4 and 5 of disease development. The exceptional curative activity of Timorex Gold makes it a unique bio-fungicide and enables growers to use it even when the disease is already visible on the banana leaves. Field trials revealed that Timorex Gold at 0.4 l/ha was as effective as spiroxamine, difenoconazole and azoxystrobin as standards. Consequtive foliar applications in large plots in Central and South America showed that Timorex Gold at 0.4-0.5 l/ha provided the best protection and was compareble or superior to commercial standards. Alternating treatments of Timorex Gold with conventional fungicides in commercial large plots were as or more effective than commercial fungicides alone. Timorex Gold treated plants also had a greater number of healthy leaves per plant than standard treatments. This paper provides substantial evidence on the unique mode of action of Timorex Gold which explains the activity against broad spectrum of plant pathogens and the high curative activity in controlling Black Sigatoka fungus in banana.

CLEANSTART: THE PROGRAM FOR SUSTAINABLE SOIL PEST MANAGEMENT FROM CERTIS EUROPE

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Soil hygiene is a key pillar for successful and sustainable crop production, particularly in high-value and intensive crops. Actually EU farmers have limited options for pre-plant soil treatments and are looking for new solutions, especially against nematodes. Following the restrictions and phase out of some key soil fumigants over the past years, there is a clear need for new and sustainable solutions for soil pest management. Certis Europe, from its establishment in 2001, has been focused on IPM solutions and started the CleanStartTM program fully dedicated to soil pest management. CleanStart is the integrated portfolio of tools and solutions that Certis provides to high-value crop growers aiming to optimise their soil environment and ensure the cultivation of healthy crops. In line with IPM principles, CleanStartTM offers a combination of chemical, biological, physical and agronomic tools for soil disinfestation resulting in a reduced need for other post-planting treatments. Certis's portfolio of soil treatment products includes Basamid (dazomet), Monam (metam sodium), Mocap (ethoprophos), Jet 5 (peracetic acid), as well as biological solutions such as Tusal (*Trichoderma* spp.), and other biopesticides under development, which are distributed under CleanStartTM brand. Dimethyl Disulfide (DMDS) is a naturally occurring organic chemical compound that is currently used in industrial processes as well as being registered as a food additive in the EU. In December 2012, Arkema has applied for the registration of DMDS as soil fumigant at EU level. This application opens the way to the registration of a new fumigant in Europe after decades without new fumigant pre-planting solutions. The product has broad-spectrum activity, with particular nematicidal efficacy. Arkema and Certis have entered into an exclusive joint agreement for DMDS (Paladin® trademark) in Europe. Under this agreement, Certis is Arkema's partner for the development, registration and distribution of any DMDS-derived formulation across the EU 27. DMDS will be part of Certis's future CleanStartTM portfolio in two formulations: Paladin® EC (94.1%) for drip irrigation in protected crops and open field, and Paladin® (99.1%) for shank application in field crops. Alongside CleanStartTM, a pan-European fumigation stewardship program has been developed to support sustainable soil fumigation practice followed by appropriate measures to ensure safe use by minimizing the product's impact on the environment and human health. Main activities within the program are: preparation and distribution of (Best Practice) technical documents on fumigants and fumigation practices; instruction for equipment optimization; training of applicators, customers, farmers; carrying out of national and/or international demonstration field-days on fumigant applications, etc.. In 2012, within the framework of the CleanStartTM program, Certis has started a regional research and exchange program on sustainable fumigation strategies involving key experts from Southern countries. The program has started with protected crops and carrots, and will include other field crops and food value chains in the future. The first experiences have been very positive and will be followed by other similar activities in 2013.

DIMETHYL DISULFIDE: A NEW SOLUTION FOR CONTROLLING ROOT-KNOT NEMATODES IN PROTECTED CROPS IN EUROPE

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The use of Dimethyl Disulfide (DMDS) as a soil fumigant has been patented by Arkema. In December 2012, it was notified as a soil fumigant at EU level. This opens the way to the registration of a new fumigant in Europe, after decades without a new product for pre-planting treatments. DMDS is a broad-spectrum fumigant, particularly effective against plant-parasitic nematodes of several crops, both under protected and field conditions. Certis Europe is Arkema's exclusive partner for the development, registration and distribution of DMDS formulations across the EU 27. DMDS will be registered in EU countries in two formulations: Paladin EC (94.1%) for drip application in protected and field crops and Paladin (99.1%) for shank application in field crops. Six GEP efficacy trials, were conducted during 2012 in Italy and Spain in protected crops (tomato, pepper and cucurbits), that focused on root-knot nematodes *Meloidogyne* spp. Here we present a summary of the results obtained with Paladin EC (94.1% DMDS), carried out with tomato (2) and melon (2) in Italy by ARA (Catania), CRSFA (Locorotondo), and CNR-IPP (Bari), and with cucumber (1) and pepper (1), in Spain carried out by Eurofins. The tested rates of DMDS were 300 and 400 kg a.i./ha and were compared with the market standard 1.3-D at 140 l/ha (for melon) and 180 l/ha of commercial product (for tomato) in Italy; and 150 l/ha for both cucumber and pepper in Spain. All applications were via drip irrigation systems under VIF plastic sheet. The plastic film was removed 14 days after application, whereas transplanting was done one week later. Nematode and yield variables recorded were: (i) presence of galls on the roots during and at the end of the crop cycle and ii) total produc tion during the crop cycle. The average results of the 3 trials with cucurbits, expressed as GSI (Gall Severity Index according to the 0-5 scale), showed a medium-high root damage 70-100 days after transplant (DAT), with an index of 3.03 in the untreated control. DMDS showed very good control of *Meloidogyne* spp. at both rates of application: GSI of 0.47 with 400 kg/ha and 0.67 with the 300 kg/ha rate. The standard treatment 1.3D (at 140-150 l/ha) was less effective (GSI of 1.35). The 3 trials with solanaceous crop plants showed an average GSI in the untreated control of 2.94 after 72-80 DAT. DMDS again proved very effective with GSI of 0.09 for DMDS at 400 kg/ha and GSI 0.13 for DMDS at 300 kg/ha, slightly superior to the standard 1.3-D (GSI 0.20). Details of the results, including yield data, will be given in the presentation. As reported in several previous articles, our results confirmed the excellent efficacy of DMDS against *Meloidogyne* spp. Under protected crops, the highest efficacy in the presence of medium-high infestation level of the nematode was given even by the lowest rate of 300 kg/ha when the crop cycle was not longer than 100 days.

BI-PA AND BELCHIM CROP PROTECTION, THE BRIDGE BETWEEN GREEN RESEARCH AND SUSTAINABLE FARMING

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In light of the paradigm shift towards 'Sustainable Agriculture', recent developments in legislation at European level have set the framework to achieve the sustainable use of pesticides. Belchim Crop Protection N.V. and Bi-PA N.V. (Biological Products for Agriculture) recognize the need for an integrated use of conventional and biological plant protection strategies and are taking the lead in the search for new and innovative tools to achieve sustainable crop protection. Today, the use of biological plant protection products is limited due to the lack of implementation within conventional agricultural practices and because of the poor understanding of the product characteristics and technical requirements. Still, the opportunities for the use of biological products cannot be ignored, whether it be in light of limiting residue, of resistance management, as a complement or alternative to a conventional treatment or because of the selective properties.

The translation of new ideas to industrial applications is only possible through a collaboration on different levels. On one hand there is a key role for basic and applied research, but on the other, there is the need for product development and product commercialization. Bi-PA (Biological Products for Agriculture) specializes in development, registration and implementation of biological plant protection products. Belchim Crop Protection, a major European distribution company, is known for its promotion of good plant protection practices through its focus on positive advances in chemical and biological control technology. Together, they form the bridge between green research and sustainable farming. Through a series of practical case studies, the unique approach of Bi-PA and Belchim Crop Protection in the development and implementation of biological plant protection products will be highlighted. Starting from the widely known success story of CONTANS, several other examples of new products will be addressed to demonstrate how innovative solutions that meet the needs of the market can be created from sound scientific principles and rational engineering in a solution driven approach.

PLANTWISE KNOWLEDGE BANK - A TOOL TO SUPPORT PLANT HEALTH

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Plantwise is a global initiative to collect and share knowledge and information about plant health problems. The Knowledge Bank (KB) is one component of the Plantwise approach and contains a range of features, which can be filtered by country, including a diagnostic tool, pest alert service and pest distribution data.
This workshop introduces participants to the KB and compliments Janny Vos' presentation 'Plantwise: global alliance for plant health in support of integrated pest management'. The workshop proceeds with a live demonstration of the KB, followed by an interactive session where participants will be encouraged to find their way around the site, test the tools and search the content. Ensuring development of the KB continues to meet user requirements, feedback is welcomed and delegates are provided with a unique opportunity to suggest input into the future development of a tool to assist global pest management. Delegates are asked to bring their mobile PCs.

INFLUENCE OF CULTURE CONDITIONS ON THE PRODUCTION OF SURFACTANTS AND ANTIBIOTICS IN *ANEURINIBACILLUS MIGULANUS*

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The bacterium *Aneurinibacillus migulanus* produces antimicrobial peptides and surfactants and was shown to have an effect against downy mildew in vine and cucumber. It is therefore a potential candidate to replace copper in the treatment of these plant diseases. Early work has shown that the production of antibiotics decreased sharply when scaled up from shaken flasks to bioreactors. By culturing the bacteria in 200 ml shaken flasks with different media volumes (25,50,75, 100 and 150 ml), the impact of aeration on the production of antimicrobial activity was assessed. Well aerated bacterial cultures produced significantly less antimicrobial activity than cultures with less gas-exchange. The highest concentrations (Gramicidin S equivalents) were observed in flasks filled with 150ml (420mg/l). The results were corroborated in a 2 l bioreactor, it was shown, that onset of low aeration must occur at the beginning of the exponential growth phase to achieve highest antimicrobial activity. The production of surfactants was assessed by measuring the spreading of droplets on plastic Petri-dishes. Like the antimicrobial activity, surfactant activity increased with decreasing aeration in shaken flasks. The results indicate that an upscaling of *A. migulanus* production requires specific growth conditions characterised by low oxygen concentrations and, possibly, high carbon-dioxide concentrations.

PRIORITY TO NON-CHEMICAL PEST MANAGEMENT? THE CASE OF *DIABROTICA V. VIRGIFERA* IN EUROPEAN MAIZE PRODUCTION

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The European SUD Directive 2009/128/EC on Sustainable Use of Pesticides aims to implement Integrated Pest Management (IPM) across European Union member states. This is in accordance with consumer demands for healthier food and less impact of agricultural practice on the environment. The implementation of the SUD is challenged by decisions on how to control the invasive maize pest Western Corn Rootworm (WCR) Diabrotica v. virgifera. This chrysomelid coleopteran insect overwinters in the egg stage in the soil. After maize has germinated, the L1 hatch in June and develop through three larval instars feeding on maize roots. This often causes plant lodging and yield losses. Adults occur in July/August and can occasionally reduce yields through intensive silk feeding, which interferes with maize pollination. Over the last 25 years, the pest has moved into Europe causing major problems in maize. In North America, control is by seed treatment with neonicotinoides, one of the larg est pesticide markets. To an increasing extent these and other insecticides are also used in Europe although the compounds have no official Annex 1 authorisation (Regulation 1107/2009) against WCR (neonicotinoides) or have been excluded (tefluthrin). Attempts to eradicate WCR (EC Decision 2003/766/EC) forces farmers to rotate their fields, thereby interrupting the life cycle of Diabrotica and to use insecticides The EU recommendation for containment of WCR (Recommendation 2006/565/EC) equally led to a more intense use of soil pesticides. However, this practice is problematic due to the related non-target effects. Increasing evidence indicates that neonicotinoides may promote colony collapse of honeybees. Some EU member states have therefore banned the use of neonicotinoides. In an attempt to reduce such insecticides, a biological control product was developed based on the entomopathogenic nematode Heterorhabditis bacteriophora (Dianem®). Results from numerous field trails p erformed during 2004 until 2012 in Hungary, Austria and Italy have documented that the nematode product provides comparable control like seed treatments with neonicotinoides or tefluthrine granules. Application techniques have been developed allowing application of the nematodes during sowing. Although EU member states should give priority of non-chemical management of Diabrotica in accordance with the SU Directive, all states provided emergency authorisations (Article 53, Regulation 1107/2009/EC) for chemical insecticides to control the WCR. This article allows use only “where such a measure appears necessary because of a danger which cannot be contained by any other reasonable means”. In conclusion, we suggest implementing and executing of EU regulations/directives in accordance with consumer demands. Consistent enforcement of European legislation would lead to preference for non-chemical control, prevent the use of problematic pesticides and promote low pesticide-inpu t management thus contributing to implementation of IPM in maize production.

QUALITY DIFFERENCES AMONG BT BIO-INSECTICIDES, DETRIMENTAL TO THE BIOCONTROL INDUSTRY

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Microbial biopesticides are dominated worldwide by products based on *Bacillus thuringiensis* (Bt). Although the Bt-based products are commercially more than 40 years old they remain a strong insect control category in current and future IPM crop protection and public health programs. Current regulatory dossiers are extensive, but are lacking in depth on the subject of comparative quality of Bt-based products. Each Bt active is considered a separate regulatory entity allowing each Bt manufacturer to develop their own version of a quality control method. Non-standardized bioassay methods using a variety of insect species have resulted in a measure of "potency" more of use for internal monitoring of quality then of use to growers, consultants and biocontrol officials.

Low field efficacy resulting from the use of low-quality Bt products has the potential to reinforce a grower's perception that microbial biopesticides cannot be trusted. Therefore for our biopesticide industry it is especially important to work towards a common understanding of comparative quality. USA EPA demands labelled potency to be expressed as a unit of mortality on a specific insect species. In the EU, attempts for standardization were made in one of the COST Action 862 Work Groups. Discussed will be various quality control techniques as well as the outcome of comparative Bt product analysis and field tests.

Valent BioSciences Corporation evaluates competitive Bt products for quality on a regular bases. Large differences in potency have been found among Bt products in the market place, resulting in significant differences in field efficacy at equal product use rates. Quality standards for any industry are important, and for the biopesticide industry it is especially important to work towards a common understanding of comparative quality. Comparing Bt subspecies *kurstaki* products having a labelled 32000 International Unit potency per milligram of product from different manufacturers can have surprising results, with some products found to have one 3rd of the labelled potency and significantly lower field efficacy. Other Bt products had substantially lower potencies in bioassays as compared to their label statement. The delta-endotoxin content of these low quality Bt products as measured with SDS-PAGE method was also substantially lower. In addition to these examples, the presentation explores various QC methods for Bt-based products. The entire biocontrol market is poised to take an increasingly important role in pest control due to risk reduction of chemical insecticide use on food crops. Bt products make up a large portion of the biocontrol market and extra vigilance to quality control should be the paramount concern for our industry.

BIOTECHNOLOGICAL PROTECTION AGAINST *BOTRYTIS* BUNCH ROT ON GRAPES

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In 1989, two strains of the yeast like fungus *Aureobasidium pullulans* with antagonistic activity against *Botrytis cinerea* were isolated from untreated apple trees in Germany. The microorganism colonizes micro-scratches of grapes, which arise during fruit growth, ripening and because of friction, and compete on the fruit successfully with pathogens for nutrients and space. For both strains inclusion to Annex I (according to Directive 91/414 EEC) is expected in 2013. Meanwhile the plant protection product Botector received a provisional 3 years registration (according article 8(1)) in Austria in 2010, in France and Italy in 2012. Since 2012 a registration in USA (according to EPA) has been achieved. From 2007 to 2012, several field trials in middle and southern Europe were performed with the biotechnological botryticide, containing the active substance *Aureobasidium pullulans*. Reference substances used were standard chemical treatments (Fenhexamid, Cyprodinil, Fludioxonil). It could be demonstrated that the new product had an efficacy comparable with a twofold application of chemical botryticides. No delay of ripening and no phytotoxic reaction were detected in any trials. Spontaneous fermentation trials were performed at the University of Natural Resources and Life Sciences in Vienna, Department of Plant Protection, Prof. Dr. DI. H. Redl. Treatments with *A. pullulans* did not influence must and wine quality. Must density, sugars, acids and nitrogen in the must did not show significant differences. Furthermore, there was no influence of treatments with *A. pullulans* on the vinification: during spontaneous fermentation no difference in starting point, shape of the fermentation curve and final attenuation was ob-served. Compared with the untreated control there was no difference in *A. pullulans*-treated samples concerning alcohol, sugars, acids and nutrients. During professional wine tastings performed by different groups of wine producers and officials there were no negative comments on taste, smell or colour of the wines. Further a taint test with treated table grapes was performed, proving that those treatments did not influence taste of fresh table grapes. The new botryticide is suitable for integrated and organic production and can be integrated into IP-spray schedules. Botector is harmless for humans, animals and beneficials and has no harmful impact on the ecosystem, soil and groundwater. *A. pullulans* does not produce any chemical-synthetic residues and based on the antagonistic effect there is no risk for the development of resistant strains in *Botrytis cinerea*.

EFFICACY OF SPIROTETRAMAT (MOVENTO 100 SC) IN THE CONTROL OF STRAWBERRY MITE (*PHYTONEMUS PALLIDUS*) ON STRAWBERRY PLANTATIONS IN POLAND

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The strawberry mite (*Phytonemus pallidus*) is a very important pest of strawberry in Poland.
The main acaricides used for many years to control the pest as endosulfan and amitraz were withdrawn few years ago. Additionally, last year also propargite as Omite 570 EW was lost from the list of acaricides for strawberry protection. New product spirodiclofen and bifenazate gave promising results in the control of this mite few years ago, but they are not registered for the protection of strawberry plants in Poland. For the past two years newest active substance spirotetramat as product Movento 100 SC was tested to control the strawberry mite on strawberry. Movento 100 SC at the rate 0.75 and 1.0 l/ha was used as foliar application once or twice with one week interval just after harvest of fruit gave good efficacy in the control of the strawberry mite (82.3-100 % 5 weeks after treatment, depending on the experiment). Movento 100 SC applied at the rate 0.75 and 1.0 l/ha once about two weeks before expecting of flowering of strawberry, gave about 90 % efficacy 4 weeks after treatment and 82-84 % 6 weeks after treatment. Movento 100 SC used at the lower rate – 0.45 l/ha gave poorer control of the strawberry mite to compare with higher rates.

TERGEO – A PROJECT FOR A SUSTAINABLE VITICULTURE AND ENOLOGY

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Tergeo (www.tergeo.it) is the project for a sustainable viticulture and enology promoted and coordinated by the Italian Wine Union (hereafter quoted with its actual Italian name: "Unione Italiana Vini"), the main Italian trade union for wine and spirits producers, representing about 500 companies that sum up nearly the 70% of the export value of Italian wine. The main aim of the project is to provide a model of environmental, social and economic sustainability through the involvement of all stakeholders in the sector. Sustainability is a concept that still needs to be deeply "thought" to provide innovation and improvement on the field, and objective criteria to guide (and to measure) sustainable development of enterprises have also to be established. Tergeo promotes the sharing of theoretical and applied research provided by actors at all levels of the supply chain, such as wine companies, suppliers of products and services, scientific community with the result of its research and experimentation. A Technical- Scientific Committee, composed by business leaders of enterprises associated with Unione Italiana Vini and by researchers working in the field of viticulture, wine-making, environment and representatives of institutions, guarantees the validity of the content offered by Tergeo. The Committee shall decide the strategies and the guidance for developing the project, and evaluate the contents proposed by the members.

At the Conference FutureIPM in Riva del Garda, the following matters will be presented: i) A guide of good practices for sustainable viticulture; ii) A self-assessment tool to measure the sustainability performance of the enterprises.

The Guide of Good Practice.

It contains information that represents opportunities for sustainability improvement. It focuses in particular on: i) A set of information about the main hazards and risks that the management of the vineyard presents towards the health and quality of the grapes, the vineyard workers safety, the environment in terms of pollution; ii)- A set of suggestions, called "best practices", to minimize the risks, to fully comply with the requirements of the law, and to facilitate the whole activity of the winery.

The self- assessment tool.

It is an evaluation tool to measure the sustainability of the vineyard management, and has the following goals: i) Self-assessment of participating farms; ii) Improvement of the average level of sustainability; ii) Promotion and dissemination of sustainability practices; iv) Construction of a certifiable system.

The grid in is divided into the following chapters:

1. Planting and Establishment of vineyard; 2. Soil management; 3. Fertilization management; 4. Irrigation management; 5. Vine management; 6. Pest management; 7. Harvesting management 8. Environment and Biodiversity management;

Each chapter comprises a variety of topics (120 requirements in whole); for each requirement, practices with different degrees of sustainability (3 or 4 levels) are listed. Some practices are considered "core" to reach a minimum degree of sustainability.

Through the tool, the winegrower gains a tool to take its strategic decisions, to measure the sustainability of its actions and to identify topics that need to be improved.

HOMOLOGA™, THE GLOBAL CROP PROTECTION DATABASE OF MRLS AND CURRENT PRODUCT REGISTRATIONS

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Spotting risks in the food chain is a daily challenge faced by growers, importers, producers, retailers, laboratories and regulators. It is a task made more difficult by having to wade through endless reports, other information sources (often in foreign languages) and trying to compare the results of this search cross-country just to find the bits that might apply to you.
The regulatory framework concerning the occurrence of pesticide residues (MRLs) is changing. The standardization of the MRLs for EU members helps but there is still the problem with registered versus expired (last use/expire date) agrochemicals. Sometimes no MRL exists but there are still agrochemicals in use with this active substance in the country.
Homologa™ is set to change all that. Available for use in primary production by product and regulatory managers, researchers, laboratories and agricultural consultants, and in the food industry by retailers, food processors and food chain managers, Homologa™ provides agronomic information including the current pesticide product approval status (expired agrochemicals are also included) of over five dozen countries together with the MRLs, to support strategic business decisions and ensure compliance within the prevailing regulatory frameworks.
Homologa™ facilitates the access to regulatory data and hence saves important resources to its subscribers. There are numerous examples in which Homologa™ has been used to resolve critical problems. Subscribers can search online for expired and registered crop protection products as well as their associated MRLs in several countries in a single report. There is also the posbility to receive alert e-mails when registrations or MRLs change. In addition, the new version of Homologa™ provides access to product label information for many countries and companies. The database can also communicate using a WebService to other user platforms.
The Homologa™ Team and it's global collaborators update constantly the database. Today the mark of 7 000 000 lines of registration data is passed and will continue to increase further.

PRELIMINARY EXPERIENCES OF *DROSOPHILA SUZUKII* CONTROL ON SMALL FRUITS IN TRENTINO (ITALY) WITH A MASS TRAPPING METHOD

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In Trentino Province, north-eastern Italy, the control of Spotted Wing Drosophila, SWD (*Drosophila suzukii* Matsumura) on sweet cherry and small fruits still relies mainly on pesticide applications. Particularly on small fruits, the contribution of the insecticides in reducing the fruit damage is often insignificant and many factors can affect their efficacy. Moreover, their repeated application on small fruits is very complicated and unsustainable over a long time, since these crops require multiple harvests during the ripening.

Preliminary trials were carried out in 2011 in order to develop a trap effective for the mass trapping method and, as a consequence, to set up sustainable management strategies. Results indicated that red colour increased the attractiveness of standard traps baited with apple cider vinegar. High captures of adults and a limited damage on fruits were obtained in a mass trapping trial on highbush blueberry using a mixture of apple cider vinegar and red wine (nicknamed "Droskidrink") as a bait in standard traps.

Based on these results, in 2012 we suggested to our local growers a large-scale application of mass trapping as a basic control method. About 45,000 red plastic jars baited with Droskidrink were distributed by Sant'Orsola Soft Fruit Grower Association to its members. The traps were exposed in small fruits and strawberry fields from April till November. A trial was carried out on highbush blueberry in one of the most infested areas of the region, with the aim to evaluate the effectiveness of the mass trapping method, comparing different layouts of the traps.

Results confirmed the high attractiveness of the "Droskidrink" bait. Between the factors that contributed to limit the SWD damage and population development on our territory in 2012, it is likely that a role has been played also by the wide area application of mass trapping method. Particularly low damages were recorded in those farms where an optimal integration of sanitation practices, harvest procedures, mass trapping and insecticide application was applied.

However, results of our trial indicate that where the pest pressure was very high, traps were not sufficient to significantly reduce the damage on the fruits to a tolerable level for the grower. The most effective arrangement was that with traps both on border and inside the field.

Intensive trapping can be considered as a control method that can contribute to the reduction of SWD damage on small fruits, particularly if combined in an integrated management system.

IPM: FIFTY YEARS TO PROVE ITSELF?

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The well-known Californian pioneers of IPM, including van den Bosch, Stern and Hagen as well as van Emden in the UK changed the paradigm of pest management globally, reducing the over-use of insecticides through an advocacy for crop scouting, economic thresholds, host-plant resistance, biological control and a consequent reduction in prophylactic insecticide use. A plethora of books and reviews followed the lead of these researchers and IPM became a part of the vocabulary of pest managers and of many arthropod ecologists. However, it is often considered that biological control of insect pests was a minor component of IPM as it was formulated by those researchers and it was classical biological control that dominated the early thinking. Today, biological control seems to have a greater emphasis but with habitat manipulation/conservation biocontrol being at the forefront. Now, in the 21st century, we need to consider whether IPM has left a lasting practical legacy and whether prophylaxis really has been sustainably reduced. It is true that organophosphorous and other broad-spectrum insecticides have been replaced to some extent in some “developed” countries but even a passing knowledge of agricultural practices in many parts of the world reveals a continuing, heavy reliance on these environmental toxins. Also, it is probably rare for commercial growers to have available or to use crop scouting followed by economic thresholds in their daily practices. This may be considered to be a failure of attempts at “outreach”. The work of Warner in California emphasises the vital role that “social learning” among farmer stakeholders must play in achieving such outcomes. Classical biological control as an IPM component has recently been through a phase of severe criticism, based on non-target effects. This “campaign” was led by Howarth of Hawaii, among others but now, there seems to be a general acceptance that this practice is “risky but necessary”. However, it is expensive and research is usually conducted for the benefits of nations or states. The individual farmer has little role to play. In contrast, habitat manipulation/conservation biocontrol require farmers to change practices, ideally informed by researchers’ outreach/technology transfer of how to manipulate the ecosystem service (ES) called biological control. A very helpful concept in this context was the development of Service Providing Units (SPUs) by Luck, Erlich & Daily. An SPU is effectively a “recipe” giving the details of where, when, how and why habitat manipulation protocols are carried out. Also in the ES context and in contrast to early IPM days, habitat manipulation is much more ecologically based and is likely to lead to an enhancement of a suite of ES, including pollination, in parallel with the targeted ES of biological control. Currently, Europe and the USA are emphasizing “no residues” on fresh food but achieving this can still invoke the use of broad-spectrum pesticides, which may give “clean” fruit but which have killed beneficial arthropods in the process. “Biologicals” are coming to the fore more than in the past but problems of formulation, efficacy, price and persistence remain. A wider global context to the above discussion is provided by the challenges brought about by a world population reaching nine billion in a few decades, very high rates of food wastage, including world supermarkets’ insistence on uniform, unblemished fresh produce. The human “right to food” is not succeeding globally. All these problems are being compounded and the prospects are not good In conclusion, the problems which led to the IPM concept certainly remain but the ecosystem services concept in which it exists is now globally recognised, as are global threats. IPM in all its forms and definitions must continue to play a pivotal role in meeting these global challenges.

PLANT PROTECTION STRATEGIES IN ORGANIC FARMING: IS THERE POTENTIAL SPILLOVER TO IPM?

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Organic growers face the same pest and disease problems as their colleagues in conventional or IPM production. However, organic farmers have only a limited range of approved plant protection products at hand. Pest and disease control in therefore relies to a large extent on consequent use of preventive measures, supplemented by direct or reactive control. The first tier of the plant protection strategy consists in the implementation of preventive strategies such as a diverse crop rotation, enhancement of soil quality by incorporation of specific cover crops and/or the addition of soil amendments, or choice of resistant varieties that help to prevent pest outbreaks. In a second tier, habitat management (e.g. consequent use of cover crops, incorporation of hedgerows and wild flower strips) is implemented to facilitate the survival of significant populations of pest antagonists. The third and fourth tiers include deployment of direct measures such as bio control agents and approved fungicides and insecticides.

However, high expectations of yield and farm profitability in conventional and IPM farming systems trigger the necessity to use simple crop rotations, high inputs of fertilizers and pesticides, and often the use of susceptible but productive varieties. For example, if wheat is driven to extreme performance, it tends to be highly susceptible to diseases due to altered crop canopy structure and crop physiology. In organic farming, yield expectations are in general lower than in IPM farming systems. Thus, there is more room for adoption of techniques that are efficient only in low input production systems: Crop rotation is used in arable crops and adequately controls a majority of soil-borne diseases and pests. Highly susceptible cultivars are avoided whenever possible and thus the necessity for direct crop protection is in general reduced. However, the availability of resistant/robust cultivars that fulfil most market requirements is limited.

Tools for direct control of pests and pathogens are rapidly adopted in organic farming, once they are included in the legal framework. Biocontrol and semiochemicals are preferred options and are widely used even if more expensive and/or less efficacious than pesticides available to IPM.

The combined use of elements that support biodiversity as well as direct control of important pests and diseases has a huge potential in organic and IPM farming systems. We are convinced that functional biodiversity supplemented by direct pest/disease control will be a key strategy to reach the objectives of the ‘Technology Platform (TP) for organic food and farming research’ (www.tporganics.eu), i.e. the increase of productivity while reducing environmental impacts. The implementation of biocontrol agents and functional biodiversity in real-life farming systems is a challenge and we still stand at the beginning of this development. We have learned that the composition of the elements needs to be adapted to the crop, pest complex, pedo-climatic conditions, as well as to the farm structure and the farmer. From the point of view of the IPM sector, organic farming is an ideal laboratory to develop and implement novel plant protection strategies. Successful strategies can be picked up at a later stage by IPM farmers, once efficacy and economic feasibility is demonstrated.

OPPORTUNITIES AND CONSTRAINS FOR BIOCONTROL MANUFACTURERS TO CONTRIBUTE TO IPM IMPLEMENTATION

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Biodiversity provides a huge potential for the development of biological control agents (BCAs). The biocontrol industry, represented by the International Biocontrol Manufacturers Association (IBMA), has commercialised many of these BCAs. Products are almost exclusively used in inundative control and to improve plant health and yields. Driving forces for biological control have been the development of fungicide and insecticide resistance, problems with chemical residues in food, the consumer-orientated policy of retailers in Europe and more stringent EU pesticide legislation, which now prioritises non-chemical control measures. Whereas in Europe biocontrol is the dominant approach in glasshouse IPM, the use in outdoor agriculture is still limited, but steadily increasing. The structure of biocontrol industry is consolidating. Growing profits capitalised small and medium sized enterprises (SMEs), which permitted major investments into production facilities, registration of new products and improved marketing. Recent mergers of SMEs provided the opportunity to form larger product portfolios. Whether recent acquisitions of biocontrol companies by transnational chemical companies will enhance the role of biocontrol in IPM practice, will be noticeable within the next few years. Major constrains for biocontrol are lacking acceptance of growers, long-lasting and expensive authorisation of BCA products and authorisation of chemical products for minor use or emergency situation (Article 53 EC regulation 1107/2009). Policy makers want to promote reduction of chemical pesticides as documented in the Sustainable Use Directive (2009/128/EC), but still underestimate the potential contribution biocontrol products can provide to improve IPM.

DIRECTIVE 2009/128/EC-NAP – CHANGES FOR THE FRUIT- AND WINEGROWERS AND THE ROLE OF THE EXTENSION SERVICES

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Directive 2009/128/EC of the European Parliament and the Council establishes a framework for the sustainable use of pesticides, which aims to reduce the risks and impacts of pesticide use on human health and the environment and promotes the use of IPM as well as of alternative approaches or techniques such as non-chemical alternatives. The Member States were called upon to draw up National Action Plans within 26 November 2012 laying down the measures intended to achieve these objectives. A preliminary draft of the Italian NAP was presented to the general public on 8 November 2012, the open consultation phase closed on 15 January 2013. The definitive version of the Italian NAP is not available yet. An analysis of the draft shows that the fruit-and winegrowers will be faced with changes in seven areas:
1. A standardised basic training of presumably 25 hours will be required to obtain the certificate for buying and applying pesticides. For the renewal of this certificate at least 12 hours of additional training within a period of five years will be mandatory.
2. The provisions for informing all parties concerned before applying pesticides will be improved. Neighbours have to be informed about the pesticides used on request.
3. Regular technical inspection and calibration of the spraying equipment will be mandatory; fine-tuning will be an optional measure.
4. The protection of the aquatic environment will be further improved. Three state departments are charged with working out provisions for safeguarding water bodies within the following 18 months.
5. If pesticides are applied on agriculturally used areas, they must not be entered without protective gear for at least 24 hours.
6. The rules for handling pesticides will be more precisely defined. In future, in- and output records of the pesticides acquired and used by the professional end-users will have to be integrated into the field-books.
7. Italy has opted for a 3-phase system aimed at reducing the use of synthetic pesticides and substituting those of major concern by pesticides of low toxicity. The first step is the so-called “obligatory” IPM, followed by the “voluntary” IPM and finally the organic production. The extension services also have to adapt to the modifications regarding their certification, training, the subject areas covered and the information transfer. The challenges arising from the Italian NAP for the fruit- and winegrowers as well as for the advisors will be dealt with in this talk.

DIRECTIVE 2009/128/EC: THE POINT OF VIEW OF THE GROWERS AND THE IMPLEMENTATION IN TRENTINO AND SOUTH TYROL

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For the last 25 years, growers from the Region of Trentino and South Tyrol have focused their attention on food safety and the environment. Over the course of this period, fruit growers in cooperation with extension services and research centers have progressively improved their way of working due to a strong systemic approach driven by the two autonomous Provinces of Trento and Bolzano. The use of phytosanitary products is substantially different from before. 'Self-control guidelines' favored the substitution of hazardous active substances, reducing the level of use of some products. Today, the choice of authorized active principles has improved as a consequence of Reg. EC 1107/2009/EC that regulates the way new phytosanitary products are placed on the market. Out of almost 1.200 authorized active substances previously admitted, 800 have been eliminated with the implementation of the new evaluation criteria. The reduction process will be continued with the new evaluation of all the active substances still authorized. The inspections of the admitted Maximum Residue Level (MRL) gave very positive results both in Italy and Europe. In the Region of Trentino and South Tyrol, results are also very encouraging. As far as consumers are concerned, the safety of our fruit is at the highest level. With the introduction of guidelines and rules regulating the use of other production factors such as fertilizers, herbicides, plant growth regulators and water, growers have become progressively more careful. Today all these production factors are regulated by the requirements of the plants and the quality of the product. Through the constant improvement of their own activity, fruit growers decided to check the quality of the equipments used to spray phytosanitary products. By the end of the 1990s, four 'control stations' allowed them to test and regulate their machines, improving the efficiency of the treatment and mitigating the side effects, particularly the 'drift' effect. Today, the process already meets the requirements of Directive 128/2009/EC that establishes a framework to achieve the sustainable use of pesticides. In Italy, as far as Integrated Production is concerned, Regions refer to the National System for Quality and Pest Risk Management that provides guidelines regional legislation must respect. This process allowed for the improvement of the quality of the environment in production areas. The positive trends of the population density of some species (e.g. birds) show the high quality of the orchards in Trentino and in South Tyrol. More environmental indicators can be investigated, in the same systematic way, in order to give transparent and positive information to the citizens. Apple growers in Trentino and South Tyrol have also recently focused their attention on the environmental impact of production, considering the input/output carbon balance in the different phases of the production cycle. The results are gratifying: in November 2012, the 'Environmental Product Declaration' certified that the 'apple' has a low impact on the environment in terms of the '*carbon footprint*' of its production. These studies are now being further investigated in cooperation with the Free University of Bolzano. The organization in Cooperatives and "Producer Organizations" (POs) of the fruits growers in Trentino and South Tyrol played a fundamental role showing both the economic relevance of such realities and the 'environmental' role of such Organizations (POs). The requirements of the Directive 128/2009/EC, which is now being implement in Italy through the National Action Plan, did not change the way of working of fruit growers in Trentino and South Tyrol, where farmers were already acting according to the newly introduced norms. Some of the proposals need to be fine-tuned in order to make them compatible with the structure of the fruit and vegetable sector of the

Region Trentino and South Tyrol. It is urgent that public administration adopts an open and convincing position towards the public opinion, promoting the positive results achieved in terms of food safety and environmental quality. This approach would provide a legitimate response to the ‘safety’ demand coming from those residing in rural areas. Together with the constant commitment of fruit growers, this activity will prevent or mitigate certain aspects of the possible conflicting relationship between agriculture and society in some producing areas. These situations are common today and producers should view them as a ‘*cultural challenge”* that can favor improvements in competitiveness and foster economic gains for fruit growers.

Abstracts | Poster presentations

BACTERIA ISOLATED FROM COMPOST AS POTENTIAL BIOLOGICAL CONTROL AGENTS OF *PSEUDOMONAS VIRIDIFLAVA* ON MELON

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Pseudomonas viridiflava (Burkholder) Dowson (Pv) is a Gram negative, aerobic, rod-shaped, fluorescent and pectinolytic bacterium. A wide host range makes this pathogen one of the most economically important and for this reason it is of growing concern by growers, breeders and researchers. On the other hand, Pv can cause soft rot on diverse vegetables (asparagus, belpepper, Chinese cabbage, cauliflower, carrot, celery, chicory, eggplant, lettuce, potato, spinach, tomato and zucchini squash) during the refrigerated storage by further increasing the economic losses. Hence, effective control of Pv both in the field and during the storage became a serious challenge to reduce the losses caused by the pathogen. On melon, the disease symptoms caused by Pv consist of water-soaked lesions on the cotyledons; small, dark-brown and angular leaf spots on the true leaves, and necrosis on the stem. The damage caused by the bacterium was recently reported on melon in central Italy, especially in Latium region. Since the pathogen has an epiphytic phase on melon plants, periodic monitoring is requested to avoid the infection. Once the disease is present in an area only the preventive measures, based on the use of copper compounds, can reduce the dose of inoculum of the pathogen. However, the use of copper compounds, the only chemicals allowed in Europe, has been restricted by the recent regulation of the European community. Therefore, researchers are focused to find alternative control methods which on the one hand could be environmentally friendly and on the other be effective. In this study, we investigated the potentiality of bacterial species present in compost, as alternatives to the use of copper-based compounds, in the control of Pv. To this aim, eighty one strains belonging to *Bacillus* spp. and *Pseudomonas* spp. were isolated from compost and tested for their antagonistic as well as Plant Growth Promoting (PGP) activity. Approximately 35% of the tested bacteria showed in vitro antimicrobial activity towards Pv and in particular 4 strains belonging to *Pseudomonas fluorescens* were promising also for their PGP traits (phosphate solubilisation, IAA production, HCN production, motility, biofilm formation and enzymes production). In vivo experiments performed in greenhouse and growth chamber confirmed the PGP potentiality (reduction of the mean of germination time, increase of melon plant biomass) of these strains when tested alone or in pair combination. Similarly, the strains demonstrated a good antagonist activity through the reduction of disease severity, when sprayed on leaves or applied into root surfaces. The results demonstrated the potentiality of some bacteria isolated from compost as melon plant growth promoters, both by indirect (antagonism) and direct mechanism, confirming compost as a potential source of beneficial microorganisms.

THE USE OF A MIX OF PARASITOIDS TO CONTROLL ALL APHID SPECIES IN PROTECTED VEGETABLE CROPS.

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Aphid control in protected vegetable crops is increasingly facing different challenges. Due to multiple insecticide resistance and to the pressure of the market to reduce the level of residues in the final products, chemical products are progressively abandoned and biological and integrated methods meet a growing success. Viridaxis developed an innovative concept to fight against all different species of aphid attacking protected vegetable crops such as sweet peppers, eggplants, cucumbers. It is a cocktail of six different species of parasitoids (Order: Hymenoptera, Family: Braconidae (subfamily: Aphidiinae) and Aphelinidae) called VerdaProtect. When used preventively, it is able to control all commonly appearing aphids attacking vegetable crops. One advantage of working with a mix is that the aphids do not have to be identified to choose the right parasitoid. Furthermore, one aphid species can be attacked by several species of parasitoid increasing the efficiency of the biocontrol. The VerdaProtect tubes are ready to use and their application is faster and easier than even any chemical treatment. They are installed in the crop at the very beginning of the crop season. Then releases in intervals of two weeks guarantee the permanent presence of fresh adult parasitoids in the crop. The preventive strategy allows keeping the aphid population below the economic damage threshold during all the season. In 2012, trials have been conducted with VerdaProtect in France, in The Netherlands and in Germany in vegetable production under unheated tunnels as well as in big heated glasshouses. In all these different situations and on all crops (peppers, cucumbers, zucchini, eggplants), VerdaProtect kept the different appearing aphid species (*Aphis gossypii*, *A. nasturtii*, *Macrosiphum euphorbiae*, *Aulacorthum solani*…) under the economic damage threshold. Furthermore, the application of the product is quick and easy and this was much appreciated by the growers involved in the trials.

THE SLU CENTRE FOR BIOLOGICAL CONTROL: GENERATING NEW KNOWLEDGE ON SUSTAINABLE APPLICATION OF BIOLOGICAL CONTROL

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Biological control has a great potential to restrict the damages caused by pests and diseases within agriculture and horticulture. It is expected to gain in importance as a part of Integrated Pest Management (IPM). However, there is still a lack of biological control products and methods against important pests and diseases. The Swedish University of Agricultural Sciences, SLU, has started a Centre for Biological Control (CBC), on a mandate and funding from the Swedish Ministry for Rural Affairs. At CBC, we conduct fundamental and applied research on biological control (i.e. the use of living organisms to control populations of harmful organisms), which aims to strengthen the knowledge base and facilitate the development and implementation of new biocontrol products and approaches. The centre works with augmentation, conservation and classical approaches, with utilization of both microorganisms and invertebrate animals. Close cooperation with stakeholders, such as g rowers, industry, authorities and organisations is an integral part of CBC activities. The research at the centre is lead by five scientists: Margareta Hokeberg's research area concerns bacteria for biological control, where she earlier has worked with biological seed treatment with bacteria. Her current interest is how to use combinations of different biocontrol agents and combining biocontrol with other control measures for sustainable disease control. She is also the CBC director. Hanna Friberg works on fungi in biocontrol. She has focused on plant pathogenic fungi causing disease in agricultural crops - how they can be managed without chemical control and how different cultural practices influence their abundance and activity. Sebastian Hakansson's areas of interest are that of long-term stabilization of microorganisms and life in the dry state, anhydrobiosis. Mattias Jonsson is specialised in insects and arachnids for biocontrol. His research is mainly focuse d on conservation biological control of invertebrate pests in agroecosystems. Ingvar Sundh, CBC deputy director, works with issues related to safety and regulatory measures. He focuses on strategies to determine that a biocontrol agent has no unacceptable adverse effects in humans, non-target organisms in agriculture and forestry, and the general environment. Experiences from the development and use of biological seed treatment products in Sweden will also be presented. Biological seed treatment, based on the bacterial isolate *Pseudomonas chlororaphis* MA 342, has been used in Sweden in cereals since 1997 (Cedomon, Cerall). These products are now being used for seeds sown on a quarter of the Swedish cereal acreage. Through the newly registered product Cedress, biological seed treatment is also available for control of pre- and post-harvest diseases in peas and carrots. The main targets are pea leaf blight, caused by *Ascochyta* spp. in peas and the storage Rhexo rot, caused by *Rhexocercosporidium carotae*, in carrots.

BICOPOLL: TARGETED PRECISION BIOCONTROL AND ENHANCED POLLINATION

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BICOPOLL and BICOPOLL-NET bring together 12 research units from 10 different European countries and autonomous regions into a concerted effort to develop, and to bring into practice, improved methods of biological control and pollination services, using strawberry as the case study. Berry and fruit production in general suffers heavily from the lack of effective disease and pest management tools, particularly in organic production, and from inadequate insect pollination at times. BICOPOLL partners will use bees to (i) precision deliver biological control agents to the flowers of the target crops to provide control of problem diseases (or pests), and to (ii) improve the pollination of horticultural crops. BICOPOLL will provide a pan-European case study on protecting strawberry from its most important disease, the grey mould. In addition we will improve the efficiency of the entomovector technology via innovative research on bee management, manipulation of bee behavior, com ponents of the cropping system, and on the plant-pathogen-vector-antagonist –system, and will investigate possibilities of expanding the use of the concept into other berry and fruit growing systems. This is a highly innovative approach to solving some of the most difficult disease and pest problems in berry and fruit production, offering solutions in areas where no solutions as yet exist. The entomovector approach represents the only significant breakthrough in sight for improving plant protection in organic cropping systems, particularly in high-value crops. It also will bring significant benefits to conventional growers. BICOPOLL brings together for the first time the fragmented research in the area, where small groups have previously worked on their own. We investigate, exploit, and support the natural ecological functions of biocontrol and pollination, and enhance these via innovative management. The entomovector technology contributes to improved resource use and efficiency in production, and enhances local biodiversity unlike most other plant protection systems. The main target groups of the BICOPOLL project are organic and conventional strawberry growers, other berry and fruit growers, as well as beekeepers and their organizations, to whom technology and knowledge transfer will be implemented during the project via direct contacts and by demonstration trials. The projects will cover three growing seasons, from 2012 till 2014.

CROSSTALK BETWEEN NEMATODE BIOTIC STRESS AND EPIGENOME

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Plants must continuously defend themselves against attack from bacteria, viruses, fungi, invertebrates and nematodes. More than 20 genera of nematodes cause plant disease: infections by this tiny, round worms are nearly confined to the plant root system. The root infection can, however, dramatically alter the entire metabolism of the plant and often produce substantial modification of the root architecture. By far the most damaging nematodes in the world are the root-knot nematodes of genus *Meloidogyne*. Epigenetic modification, such as cytosine methylation, are inherited in plant species and may occur in response to biotic or abiotic stress, effecting gene expression without changing genome sequence. The presence of epigenetic modification will be investigated in the interaction of the root gall nematode *Meloidogyne* incognita and *Solanuum lycopersicum* to understand if the methylation state of plant genome is modified by nematode infection. The study of the interaction plant - nematode interactions may provide sustainable practical solutions for the control of nematode pests in agricultural crops. In addition, such studies could help to elucidate the signalling mechanisms by which plant cells cope with a stress situation and could also lead to discover how organisms from different kingdoms communicate with one another. Potential changes in plant DNA methylome as a defence mechanism nematode attack from will be briefly considered.

ALTERNATIVE METHODS FOR THE RELEASE OF PREDATORY MIRIDS INTO GREENHOUSE TOMATO CROPS

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Over the last twenty years the introduction of new invasive pests has fostered insecticide use in tomato crops, with adverse effects on economic, environmental and technical sustainability of the chemical control approach. Among the IPM techniques that have demonstrated a potential for the control of noxious arthropods, the augmentative releases of macrobial biocontrol agents has found commercial application in Europe. With regard to the use of predatory mirids, commercially available for the management of whiteflies and other pests since the beginning of the 1990s, their inoculative releases into the unheated greenhouses typical of the Mediterranean region frequently result in poor establishment of the beneficials in the crops, delayed population growth and unsatisfactory control of target pests. Several release methods alternative to the traditional one (weekly introductions of up to 2 individuals per m^2, starting 3-4 weeks after planting) have been proposed to enhance biological control. The present work reports the results of preliminary tests performed to compare the effects of two innovative release methods on the establishment and population build-up of the predators *Macrolophus pygmaeus* and *Nesidiocoris tenuis* (Heteroptera: Miridae), introduced respectively into spring and autumn greenhouse tomato crops. One of the two techniques considered for the introduction of the mirids was pre-plant release, i.e. the introduction of biocontrol agents before transplanting, which has found recent commercial application in the south of Spain for the release of *N. tenuis*. The other method consisted of the introduction of groups of 50 adults into release points covered by a non-woven film, where the beneficial insects were provided with an alternative food source (*Ephestia kuehniella* eggs) and plants were not deleafed for a period of 3-6 weeks. The experiments were carried out during 2012 in two glasshouses where tomato crops were grown for about 4 months. In both cases approximately 0.8 adult mirids per plant were released. On spring crops *M. pygmaeus* population has shown a more rapid growth when the mirid was introduced into the confined release points, achieving a 6-fold higher density with regard to pre-plant released predators. Contrastingly, on autumn crops both the introduction methods allowed *N. tenuis* to reach high density levels, although population build-up was initially more rapid when the mirid was released in the nursery. The results of these preliminary tests appear to indicate the pre-plant release method as very effective for *N. tenuis*, but not appropriate for the introduction of *M. pygmaeus* on spring tomato crops, whereas the release into confined areas has been demonstrated to be suitable for both species and cultivation periods.

A SURVEY OF PARASITOIDS OF *DROSOPHILA SUZUKII* FOR BIOLOGICAL CONTROL IN ITALY

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Drosophila suzukii (Matsumura) (Diptera: Drosophilidae), is an invasive species native of Eastern and Southeastern Asia. Since its introduction in USA and Europe in 2008, this pest caused hundred thousand dollars worth of damage to small and stone fruits business. These severe damages were mainly due to the absence of specialized natural enemies, able to control the population outbreaks of the introduced species in the invaded regions. In order to evaluate the presence and the effectiveness of native generalist enemies, a survey for parasitoids of *D. suzukii* was set up. Petri dishes containing either standard medium diet for drosophilids, or banana slices or blueberries were previously exposed to mated *D. suzukii* and *Drosophila melanogaster* females in order to be infested with eggs and used as attractant for parasitoids in traps. Traps baited with both *D. suzukii*- and *D. melanogaster*–infested substrates were deployed in three locations in Trento province: a forest environment (600 m a.s.l.), an organic blueberry orchard (900 m a.s.l.) and a vineyard (200 m a.s.l.). The experiment started at the end of July 2012 and traps were controlled and changed weekly until the end of October 2012. A generalist pupal parasitoid, *Pachycrepoideus vindemmiae* (Rondani) (Hymenoptera: Pteromalidae), was found to be able to attack both the fly species. After rearing it under controlled conditions, it was able to develop a second generation on *D. suzukii*. A more extensive sampling is planned for 2013. Long-range attraction of Drosophila parasitoids is commonly mediated by the same olfactory cues to which their hosts are attracted. Therefore, an additional faunistic survey was carried out using *D. suzukii* monitoring traps baited with apple vinegar. The traps were located both in Trento and Bari provinces to provide a comparison of the presence of potential natural *D. suzukii* enemies between North and South Italy, with Alpine and Mediterranean climates respectively. The species were identified and a check-lists is presented, by locations and by crops.

PRODUCTION OF CERTIFIED *CITRUS* ROOTSTOCKS USING ORGANIC GROWING MEDIA AND BIO-CONTROL AGENTS

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The European legislation on organic production (EC No 889/2008) regulates citrus nursery production under organic management for the establishment of organic citrus groves. Due to the lack of technical protocols to comply with these requirements, a study was funded by the Italian Ministry of Agriculture (MiPAAF) on the production of organic substrates suitable for citrus nursery plants and the evaluation of the bio-product 'Clonotri' (*Trichoderma harzianum* and *Clonostachys rosea*) for the control of soil-borne pathogens. Organic substrates were prepared using compost, commercial (ECOS) and experimental (COMPAS), and coconut fiber in order to partially (35%) or fully replace the peat moss, which is a non-renewable natural resource. The growing medium developed by IAM-Bari (IAMB mix) for citrus indicator plants was used as control. One per cent of guano-based fertilizer was added and elemental sulfur was used for pH adjustment. Trials were carried out in the Premultiplication facility set up within the Apulian programme for citrus plant certification. About 3-4 months-old Volkameriana lemon, Troyer citrange and Sour orange seedlings were transplanted into the produced growing media and into the IAMB mix. During the 8 months of the trial, all growing media were evaluated individually and in combination with Clonotri, using 20 replicates per treatment per rootstock. Plant growth, diameter and dry weight were evaluated at the end of the experiment. The partial replacement of 35% of peat moss gave the best results. All citrus rootstocks grown in the Compas-based medium showed significant increase in vegetative parameters. However, no significant results in enhancing plant growth were achieved by the combination of all tested media with the bio-product Clonotri.

REDUCING PRIMARY INOCULUM SOURCES OF GRAPEVINE POWDERY MILDEW BY THE HYPERPARASITE *AMPELOMYCES QUISQUALIS*

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Grapevine powdery mildew, caused by the obligate biotrophic fungus *Erysiphe necator* (Schw.) Burr., is one of the most important grapevine diseases in Italy, because of the presence of pathogen inoculum and favorable environmental conditions for its development. In northern Italy, *Erysiphe necator* overwinters almost exclusively as chasmothecia which represents the main source of primary inoculum. In the spring, ascosporic infections originating from chasmothecia commonly appear randomly in the vineyard. Fungi of the genus *Ampelomyces* are the major antagonist of powdery mildew. The mycoparasite attack various developmental stages of powdery mildews. The present study addresses the occurrence of artificial parasitism of grapevine powdery mildew chasmothecia by *A. quisqualis.* Two-years field experiments performed in five different vineyards focused on the ability of *A. quisqualis* in reducing the powdery mildew primary infections by the reduction of chasmothecia. Spores of the hyperparasite were rarely detected in mature chasmothecia with fully developed appendages. In contrast, the large number of fully developed chasmothecia without asci and ascopores were considered to be parasitized by the mycoparasite. However, in our study a low effectiveness of this hyperparasite in terms of reduction of overwintering chasmothecia in its natural environment was found. *A. quisqualis* may only colonize young, immature chasmothecia of powdery mildew, transforming them into its own reproductive structures. Infested chasmothecia do not reach the stage of maturity, do not form appendages nor ascospores, which is linked with the reduction of the source of primary infections. We think the low survivability of *A. quisqualis* could be due to the immature wall of chasmothecia which at this developmental stage are not capable of surviving low temperatures. Therefore, the stage of colonizing mature chasmothecia by the hyperparasite seems to be understandable. Probably, it provides suitable conditions for the hyperparasite for a better overwintering and trasmission in its environment.

RELEVANCE OF THE PLANT GENOTYPE FOR BIOCONTROL TOOLS BASED ON RESISTANCE INDUCTION

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Downy mildew caused by *Plasmopara viticola* is a serious disease of grapevine, and its control is based on the intense application of chemical fungicide. We previously showed that *Trichoderma harzianum* T39 (T39) and benzothiadiazole-7-carbothioic acid S-methyl ester (BTH) reduce downy mildew severity in the Pinot Noir grapevine variety by enhancing plant resistance. However, the effect of the plant genotype on the resistance induction mechanisms was not yet analyzed in grapevine. The aim of this study was to characterize the physiological and molecular properties of the T39-induced resistance in different grapevine varieties used for table and wine grape production, in order to further optimize the use of this agent for downy mildew control. Rooted cutting from 14 grapevine varieties were grown under greenhouse conditions. T39 conidia, BTH and water (control) were applied to grapevine leaves and *Plasmopara viticola* sporangia were then inoculated. Here we show that T39 treatment significantly reduces downy mildew symptoms in the different grapevine varieties. However, different levels of T39 efficacy were observed: T39 efficacy was particularly high in Negroamaro plants, but it was lower in Primitivo than in Pinot Noir plants, indicating that the plant genotype is a key determinant of T39-induced resistance. Moreover, the efficacy of resistance activated by BTH was higher than T39 and was not affected by the grapevine genotype. Gene expression analysis of four defence marker genes confirms the complex effect of the plant genotype on the molecular mechanism activated by pathogen inoculation and by T39 treatment in different varieties. In Pinot Noir and Primitivo varieties, T39-induced resistance is based on a dual effect: direct induction of *PR-2* and *PR-4* genes and enhanced expression of these genes after pathogen inoculation. Correlation between gene expression and T39 efficacy was observed in Primitivo and Pinot Noir plants, but more complex regulation or additional defence genes are implicated in the T39-induced resistance in the variety Sugraone and Negroamaro. Grapevine varieties have different reaction to the same stimuli, indicating that specific receptors are probably involved in the regulation of the plant response. The evidence reported here suggests that a good resistance inducer should be applied on a highly responsive cultivar in order to maximize the effect of the biocontrol agent.

VINEYARD MANAGEMENT AND MICROBIAL ENDOPHYTES. THE IMPACT OF IPM ON PLANT-ASSOCIATED MICROBIAL COMMUNITIES

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Endophytic microorganisms dwell in plants both intra- and extra-cellularly without causing disease symptoms. The mechanisms that govern the presence of endophytic bacterial and fungal taxa inside plants are not yet known, and the exploration of community fluctuations when the plant's environment is altered, is still in its infancy. Previously we have demonstrated that grapevines organic and IPM farming harbour distinct fungal endophytes. Here we show that, similarly to what previously was observed with fungal communities, bacterial endophytes also vary with farming style. We also show the fluctuations observed in communities of endophytes from organic and I.P.M. treated grapevines using Roche 454 pyrosequencing. A mixed greenhouse and field setup is adopted to dissect the mechanisms underlying community shifts.

POST HARVEST CONTROL OF GREY MOULD ON CUT ROSES

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Botrytis cinerea (Grey mould) is a widespread disease of rose crops and many other cut flowers. Flower petals infected with Grey mould significantly reduce the ornamental value of cut roses and determine postharvest losses in rose flowers and in other cut flower crops. The control of Grey mould has been accomplished almost exclusively by chemical fungicides, which have been often ineffective and potentially harmful to the environment. New strategies of crop protection are urgently needed in the objective to minimize the chemical quantities of pesticides in the soil and their residues. Among the new biological approaches, the stimulation of natural plants defences is considered as one of the most promising alternative strategy for crop protection. Studies over subsequent decades were focused on the plant metabolite salicylic acid (SA). This hormone is a major component in the signal transduction pathways of plants playing an important role in Systemic Acquired Resistance (SAR). Several candidate signalling molecules have emerged in the past two years. In this work ellagic acid (E.A.) (2,3,7,8-Tetrahydroxy-chromeno [5, 4, 3 – cde] chromene - 5, 10 - dione) was tested for its potential SAR - inducing activity for postharvest control of Grey mould on various cut rose cultivars. E. A. is a component of *Eucalyptus* sp. phenolic pool, and the chemical structure of its monomer shares some features with that of salicylic acid. For the experiments an alcoholic mother solution of E. A. was prepared. Cut roses were kept in water added with different doses of E. A. mother solution. Grey mould was inoculated by spraying conidial suspension on flowers. Disease incidence was scored 5-7 days after inoculation by evaluation of the percentage of flower area covered with lesions according to a disease index. E. A. applied at 85 mg/l showed a disease control (disease index ranging between 14 and 52 %) comparable to that obtained when ciprodinil plus fludioxonil fungicide (Switch) was applied (d. i. ranging between 2,6 and 53%). Grey mould grown in liquid medium containing E.A. (0,1 mg/ml) proved able to degrade this phenolic, as demonstrated by HPLC analysis of the spent growth medium; on the other hand, an inhibitory effect of 50 % toward Grey mould was recorded only at high E.A. concentration (4,2 g/l) confirming no direct antifungal action but a potential SAR - inducing activity. E. A. could therefore find some interesting application for the post harvest control of Grey mould on cut rose flowers. Further studies will be carried out to assay a possible effect of E. A. in controlling Grey mould on rose plants under greenhouse conditions.

CHITOSAN, A POSSIBLE BIOCONTROL AGENT OF *A. DELICIOSA* (A. CHEV) DISEASES

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Kiwifruit (*A. deliciosa* A. Chev.) is a crop with a production of more than 500,000 tons per year and a steady growth in exports. Such profitable product must be certainly preserved from the most common diseases in the Italian area: kiwifruits bacterial cancer caused by *Pseudomonas syringae* pv. actinidiae (PSA) a well-known epidemic booming and wood decay caused by a complex of fungi which one of the most important is *Phaeoacremonium aleophilum*. All pesticides to control kiwifruits bacterial cancer and other wood-decay fungi currently used are toxic, used extensively and often uncontrolled. Their high doses per unit area custom increases the risk of harmful effects on plants, soil fauna and human health. Recently a new legislative framework on pesticides, adopted by the European Union, states strict criteria for the use of substances in agriculture and establishes a mechanism for the substitution of more toxic pesticides by safer (including non-chemical) alternatives, as biocontrol agents. The thematic of this work fits in with this European trend, starting from the prevention of disease outbreaks fielding plants able to better resist to the pathogen infections with the use of chitosan, an “environment friendly” compound. Completely biodegradable, chitosan is a well known elicitor of Systemic Acquired Resistance (SAR) and has been tested in micropropagated kiwi plants, one of the crucial nursery chain steps. In both phases of growth (multiplication and rooting), micropropagated of the cultivar Hayward were treated by adding chitosan (15 and 50 mg/L) to the medium. Twenty-one days after treatment, on both multiplication and rooting phase, the plant material was sampled for the assessment of several parameters and for enzyme assays, looking for possible SAR markers. Following the elicitor application there was an increase of dry biomass, total soluble proteins and phenols amounts, as it has been reported in literature for others species. Chitosan was also able to enhance the activity of several enzymes, that play a role in SAR: guaiacol peroxidase (G-POD) and ascorbate peroxidase (APX), involved in detoxification process; phenylalanine ammonia lyase (PAL), key enzyme of phenylpropanoid pathway and polyphenol oxidase (PPO), implicated in polyphenols oxidation. These first results suggest that chitosan is an elicitor for Actinidia defense response and it has a role in the activation of the systemic plant protection against pathogens. This study has allowed a better understanding of the elicitor-plant interaction in a model system like in vitro cultures. Basing on the idea of fielding plants able to resist to most likely diseases, the plants will be inoculated with two harmful kiwifruit pathogens: the fungus *P. aleophilum* and the PSA bacterium. The inocula will allow us to verify the elicitation induced by the chitosan in the presence of the pathogen in natural conditions.

PLANT-DERIVED FORMULATIONS FOR THE CONTROL OF THE CARROT CYST NEMATODE *HETERODERA CAROTAE* IN FIELD

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The carrot cyst nematode *Heterodera carotae* Jones can cause remarkable yield losses in the intensive carrot crop systems of Southern Italy. Chemical treatments controlled satisfactorily the infestations of this nematode throughout the past decades, but concerns raised by their massive use led to the dismission of most available nematicides and to the consequent search for alternative IPM strategies. Liquid formulations based on plant extracts of neem and quillay and soil amendments with granular or pelleted biomasses of *Brassica juncea* or *Medicago sativa* have been largely demonstrated to be suppressive on root-knot nematodes (*Meloidogyne* spp.), but few information is available on the effects of these plant formulations on cyst nematodes. Therefore, two field experiments were undertaken to assess the effect of two commercial liquid formulations of neem or quillay and of granular or pelleted biomasses of *B. juncea* and M. sativa against the carrot cyst nematode *H. carotae*. In th e first experiment, quillay and neem formulations were applied at 30 and 4 L ha^{-1}, respectively either as a single application at plant emergence or splitted into two or three applications at 15 day interval starting on plant emergence. In the second experiment, application of the pelleted dry biomass of *M. sativa* at 20 and 40 t ha^{-1} and of a commercial granular formulation of *B. juncea* biomass at 3 t ha^{-1} was compared with 30 L ha^{-1} quillay formulation. In both experiments, soil nontreated or treated with 30 L ha^{-1} liquid fenamiphos were used as controls. At the harvest, marketable and total yield were recorded and *H. carotae* population density was counted after the extraction from a 100 g soil sample. In the first experiment, quillay and neem treatments significantly increased the marketable fraction of carrot yield compared to the untreated control. The largest yield increase was provided by phenamiphos, though the neem formulation was similarly effective. Soil population of *H. carotae* was significantly lower in all the treated plots than in the nontreated soil. Final nematode population in the soil treated with the neem formulate was significantly lower than in soil treated with the quillay-derived not significantly different from fenamiphos. Dry biomasses of *M. sativa* and *B. juncea* strongly suppressed soil population density of H. carotae compared to nontreated soil, with no significant difference from phenamiphos. *M. sativa* biomass resulted significantly more suppressive than *B. juncea* formulate, without significant differences between the two amendment rates. The highest increase of total and marketable carrot yield was provided by the fenamiphos treatment and *B. juncea* formulate. However, also both dosages of alfalfa pellets remarkably increased carrot yield and improved tap root quality compared to nontreated soil and quillay extract treatment, though significantly less than phenamiphos. In conclusion, liquid formulates of neem and quillay, as well as soil amendments with dry biomasses of *B. juncea* or *M. sativa* may be a valuable control option whenever the use of conventional nematicides is not allowed, such as in organic cropping systems.

BIOACTIVE PLANT METABOLITES FOR THE CONTROL OF ROOT-KNOT NEMATODES

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The withdrawal of most chemical nematicides has been rising a strong need for environmentally safer control strategies. Plant bioactive secondary metabolites have a huge potential for the production of low risk nematocidal formulates, as largely present in many common plant families and mostly still unexploited. The effect of a number of plant compounds, previously reported for their biocidal properties, was tested either in vitro and in vivo against the root-knot nematode *Meloidogyne incognita*. Glucosinolates from seven brassicaceous plants, saponins from the leguminous plant *Medicago sativa* and essential oils from two lamiaceous species were tested in vitro on the juveniles of *M. incognita* at different concentrations (125, 250, 500 and 1,000 g ml^{-1} saponin solution. In the experiments in potting mixes, almost all brassicaceous amendments significantly suppressed nematode multiplication on the roots and in the soil compared to the untreated control, with no difference s from the chemical-treated pots. Almost all brassicaceous treatments positively affected also the tomato fruit weight. All amendments with *M. sativa* plant material suppressed root and soil nematode population density compared to either nontreated and chemical controls, though suppressiveness differed between top and root material and among the rates. Dry biomass of lamiaceous plants were less suppressive and caused some phytotoxicity to tomato plants. Results from the experiments evidenced the biocidal effect of glucosinolates, saponins and essential oils on root-knot nematodes, as well as the high suppressive potential of soil amendments with plant material from crucifers, leguminous and lamiaceous species. Application of these amendments may be particularly suitable for vegetable cropping systems in organic agriculture, where the range of available control tools is particularly restricted.µl ml-1) and exposure times (2, 4, 8 and 24 hours). The suppressiveness of soil treatments with the dry biomasses from the same plants was also tested against M. incognita on tomato in potting mixes at rates ranging from 2.5 to 40 g kg-1 soil. In the in vitro tests, pure glucosinolates were active on root-knot nematode juveniles also at low concentrations and short exposure times, though only in the occurrence of their myrosinase enzyme-catalized hydrolysis. M. incognita juveniles were also highly sensitive to the essential oils from lamiaceous plants after few hours of exposure to very low concentrations. Saponin fractions from *M. sativa* top and roots were found to be less active than the other compounds, as causing high nematode mortality rates only after a 24 hour exposure to at least 500 µRoot-knot nematodes (Meloidogyne species) are responsible for heavy yield losses in numerous vegetable crops and, as poliphagous and widely spread, are also very difficult to control.

POWDERY MILDEW INTEGRATED CONTROL ON ZUCCHINI WITH ESSENTIAL OILS AND QUINOXYFEN

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Integrated Pest Management (IPM) has been an important issue for a long time but the new EU directive (2009/128/EC) pushed the IPM development radically. Powdery mildew, *Podosphaera fusca* (Fr.) U. Braun & Shishkoff [synonym *Podosphaera xanthii* (Castagne) U. Braun & Shishkoff], is an obligate biotroph parasite that colonizes rapidly green tissues of zucchini, negatively affect host physiology and can lead to heavily harvest loss. The aim of our research was to evaluate the efficacy of some essential oils (EOs) used alternating with quinoxyfen in order to suggest an integrated control management able to reduce the use of synthetic fungicides. Experimental trials were carried out in greenhouse and in plastic tunnel in field on zucchini crop ('Romanesco' cultivar), in different seasons and years, to evaluate the effect of NB strengthener (based on alimentary oils) Tea tree oil (TTO), Clove oil (C), Rosemary oil (R) and Oregano oil (O), weekly sprayed and alternate d with quinoxyfen. The composition in main compounds of EOs object of study was quantified by gas chromatography analysis with mass detector. Plants were infected naturally and the first treatment was performed with oils after the first signs of powdery mildew disease were observed. Thereafter, treatments were repeated in seven day intervals for five weeks according to protection program; plants were sprayed from a hand sprayer until run-off. During the assay daily temperature and humidity were monitored. Oils were emulsified with 0.05% Tween 20 before their distribution. In all experimentations different application programs were carried out and different associations of essential oils were assessed: oils applied once a week, alternated weekly with the fungicide quinoxyfen (2 applications of synthetic fungicide in the treatment program), and finally quinoxyfen distributed one time during the treatment program. Control plots were also performed distributing weekly water and Tween 20 and synthetic fungicide alone. Disease incidence (percentage of infected leaves in each treated plant) and disease severity were assessed after 6 weeks through observations on each plant. All leaves in plant grown in pots in greenhouse and 5 previously marked leaves in each plant grown under plastic tunnel in field were analysed. Disease severity was assessed visually on individual leaf as percentage of infected area (EPPO guideline PP1/57). Obtained values were evaluated by McKinney index. The effect of each the treatments was estimated by analysis of variance (ANOVA) by LSD test for $p \leq 0.05$ and $p \leq 0.01$. Preliminary results seem to confirm that the alternation of EOs with effective synthetic fungicide can maintain a good disease control and may also assist with resistance management. Phytotoxicity was not observed on treated plant at used concentrations. The association of C+R and C+R+O was promising to reduce the input of synthetic chemicals in the environment.

USE OF *SALVIA OFFICINALIS* EXTRACT TO CONTROL GRAPEVINE DOWNY MILDEW: TESTS IN GREENHOUSE AND FIELD

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Herbs and aromatic plants could be potential sources of natural compounds usable in agriculture against the main diseases. The antimicrobial activity of essential oils of these plants has been studied extensively for medical use while there are still few studies on the control of plant pathogens. The vast family of Lamiaceae includes several interesting plants for the high level of secondary metabolites. One of these is *Salvia officinalis* L., whose essential oil has antifungal, antibacterial and antioxidant features. In this work the effectiveness of sage extract was tested against grapevine downy mildew (*Plasmopara viticola*) under greenhouse and field conditions. Moreover, the persistence and rain fastness of sage extract were also investigated on treated grapevines in relation to its effectiveness against downy mildew. This extract was obtained from dried leaves of *S. officinalis* which were extracted with 99.8% ethanol in a Soxhlet extractor. The sage extract at 5%-dosage has showed high levels of effectiveness in greenhouse condition, reducing the disease severity (96.1%), similar to a formulation of copper hydroxide (93.4%). Furthermore the activity is prolonged over time and the efficacy of sage is very similar to copper sprayed on leaves 6 days before the inoculation of downy mildew. Unfortunately the rain fastness is rather low showing a significant reduction of activity (25%) with only 10mm-artificial rain. The sage extract was tested in two different vineyards of Trentino (Rovereto and S. Michele a/A) and in two different years (2006 and 2012) in order to evaluate the real potential of the product. In 2006, the weather conditions were highly conducive for infection in the final part of the season. Sage extract effectively controlled downy mildew, reducing the AUDPC of disease severity on leaves by 63% and reducing the incidence of disease on bunches of grape berries by 94%. The results obtained for sage extract were not significantly different from those obtained for copper hydroxide. In 2012 the first primary infections of downy mildew were been early and very strong (especially on grapes and shoots) that were evolved in a high level of disease at the end of June (96% of incidence on untreated leaves). The numerous and intense spring rains have severely tested the efficacy of crude vegetable extract provided only 20% reduction in disease incidence and 35% reduction in AUDPC of disease severity, on berries and leaves respectively, reaching a level of disease control significantly different from that provided by copper hydroxide and untreated control. Overall, in a not very rainy season, the crude *S. officinalis* extract controls effectively grapevine downy mildew and could be a promising alternative to the copper fungicides used in organic viticulture. A formulation of sage extract with a high level of rainfastness should be developed for improving retention, enhancing spray adhesion, avoiding run-off, and encouraging an even spreading of active ingredients on the leaf tissue. Moreover, to obtain a commercial product, it will be necessary to improve the current extraction process, which is too expensive and time consuming.

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A PROTEIN EXTRACT IN THE PLANT PROTECTION: NOVEL ALTERNATIVE TO CHEMICALS AGAINST POWDERY MILDEW

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Powdery mildew is a disease caused by obligately parasitic fungi which attacks about 10.000 angiosperm species. These fungi belong to the family *Erysiphaceae* that includes ca. 650 species. Powdery mildew attacks a lot of coltivated plants including grapevine (*Erysiphae necator* and *Oidium tuckeri*) and cucumber (*Golovinomyces cichoracearum* and *Podosphaera xanthii*).

Since 1850 sulphur is been amply used to control this disease and still it represents the main product in organic agriculture for its good efficacy and low cost. However it has a toxic effect versus humans and beneficial arthropods, causes a cytotoxicity on leaves and shoots in presence of high temperature, dirties the fruits reducing its commercial value and interferes in the fermentation process of white wine at early harvest.

Many studies have tested antimicrobial and antifungal activity of proteins and peptides. This class of molecules can control the pathogen directly, by antibiosis, or indirectly, inducing the resistance system of the host plant.

SCNB2 is a patented product for the use in plant protection and is a preparation based on hydrolyzed natural proteins that possesses a good activity against powdery mildew of the most important fruit and vegetable crops. It acts principally as a resistance inductor (local and systemic) and, since it is based on compounds of natural origin (vegetal and animal proteins), the product can be considered safe for human health and for the consumer.

SCNB2 was tested against powdery mildew on Zucchini plants in greenhouse and on grapevine in field in two different season.

The Zucchini plants were inoculated with *Podosphaera xanthii* and treated weekly with the proteins hydrolyzed in comparison with an untreated control. The disease severity on leaves was evaluated weekly and elaborated to obtain the AUDPC values (Area Under the Disease Pressure Curve).

In the all trials SCNB2 showed an high efficacy (75.9-79.4%), statistically different to the control.

In the seasons 2010 and 2011, the effectiveness of product was evaluated the control of grapevine powdery mildew in a susceptible vineyard of Trentino with weekly applications. The weather conditions, in both years, were very favorable to the development of pathogen, but the proteins hydrolyzed showed an high antifungal activity. The disease was reduced of the 94.6-96.8% of AUDPC for disease severity on leaves and 76.7-65% of incidence on bunches, statistically comparable at the sulphur control, with values respectively 99.0-99.24% and 60.0-80.0%.

Unfortunately SCNB2 showed a slight phytotoxicity on young leaves, probably due to the salt content, but this problem is easily resolvable. A cheaper production process of protein hydrolyzed should be found to allow a commercial use of this promising product.

LABORATORY AND FIELD TRIALS WITH COMMERCIALLY AVAILABLE BIOCONTROL AGENTS AGAINST FIRE BLIGHT AND BOTRYTIS BUNCH ROT

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The application of biological control agents (BCA) is receiving increasingly attention as an important part of integrated pest management strategies. Here we present the results of experiments conducted at laboratory and field scale using a set of commercially available products containing microbial antagonists. Serenade® MAX (*Bacillus subtilis* strain QST 713), Amylo-X® (*Bacillus amyloliquefaciens* ssp. plantarum strain D747), and Blossom Protect/Botector® (Aureobasidium pullulans) were chosen for tests to control fire blight disease on apple trees and botrytis bunch rot on wine grapes. *Erwinia amylovora* and *Botrytis cinerea*, the causal agents of fire blight and botrytis, respectively, differ in both infection pattern and their prerequisites for disease containment: whereas in Italy no antibiotic is available for fire blight control, many active ingredients are registered to control botrytis bunch rot. Experiments against *E. amylovora* included efficacy assays on apple blossoms at laboratory scale and field trials in apple orchards to evaluate phytotoxic effects (fruit russeting, leaf necrosis) of the products. In the laboratory, antagonists were applied to apple blooms 2 h after artificial infection with *E. amylovora*. After a wetting event (36 h post inoculation) and 10 d incubation, the percentage of infected blossoms was determined. All three BCAs showed some control of fire blight, with *A. pullulans* being the most effective one. However, in field trials *A. pullulans* created problems with rusting on some apple varieties. A first in-vitro compatibility test of Serenade® with copper hydroxide was performed to see whether the simultaneous use of both fungicides could alter the efficacy of the antagonist. Our results showed that at concentrations ranging from field dosage to 100-fold dilutions copper negatively affects the growth of *B. subtilis* resulting in loss of its capacity to inhibit the pathogen. In a botrytis field trial conducted in 2012 on Pinot grigio, beside efficacy, the total number of colony forming units (CFU) on the berry surface was surveyed over time after BCA application. Disease pressure was too low to get reliable efficacy data, however, we observed that CFU counts on grapes treated with either one of the two *Bacillus* products were higher than on grapes treated with *A. pullulans* or the untreated control. For a successful application of biocontrol agents in the field, a good timing of treatments is essential. Decision support models, such as Maryblight, are useful tools; however, the mode of action of an antagonist has to be considered for the implementation of a successful management strategy, in particular to increase and to stabilize efficacy.

NEW INTEGRATED STRATEGIES FOR THE CONTROL OF GREY MOLD *BOTRYTIS CINEREA* IN GRAPEVINE

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Grey mould caused by the fungus *Botrytis cinerea* is a common disease on several kinds of ripening fruits, including grape. In addition to quantitative losses, if strongly affected grapes are processed into wine the enzymatic activity of the fungus can have a negative effect on the wine quality. Epidemics are usually initiated in Spring from inoculum produced on different overwintering structures. Leaf infections and, with higher impact, floral infections can generate fruit infections through different infection pathways, some of which include a degree of symptomless latency. Not only environmental conditions but also bunch architecture and berry structure can influence disease severity and incidence: grape varieties with compact clusters are more susceptible to the disease. Traditionally, the control of *B. cinerea* in the vineyard is performed using synthetic fungicides: up to three applications per season, depending on the production line, the weather conditions and the risk a grower wants to take. Within the FP7-KBBE project "Pesticide Use-and-risk Reduction in European farming systems with Integrated Pest Management" (PURE) two different strategies were tested to reduce the use of synthetic fungicides against *B. cinerea* in viticulture: i) create a microclimate less favourable to the pathogen, and ii) use of Biological Control Agents (BCAs). The first strategy was tested at the Julius Kühn-Institute in Siebeldingen (Germany) in the grape growing seasons 2011 and 2012. Manual defoliation of the berry zone was performed before and after flowering to modify the bunch structure of compact varieties and at veraison to enhance ventilation of the berry zone during ripening. Defoliation was compared with one, two and three synthetic fungicides applications. In 2011, with high disease pressure, the defoliation at flowering was as effective as three botryticide treatments, while in 2012 disease pressure was too low to check differences between defoliation and fungicides. In the second strategy, three different BCAs were applied alone or in combination in 3 vineyards located in different geographical areas of Italy. *Bacillus subtilis, Aureobasidium pullulans* and *Trichoderma atroviride* were applied at four critical stages for infection: i) before bunch closure, ii) at veraison, iii) 20 days before harvest, and iv) 3-7 days before harvest. In the trials carried out in central Italy, both disease incidence and severity were low (disease severity from 8.9 to 14.6) and all treatments gave a good control of the disease in both years, even when applied alone. In the Po Valley vineyard (northern Italy) disease pressure was low in 2011 and nil in 2012; nonetheless, in 2011 bunches treated with the different BCAs were less affected than the untreated ones. The tested BCAs appeared very promising, especially when applied at the right phenological stages of the vines and under a moderate disease pressure. Further data are necessary to confirm these results with higher disease pressure. Combing the use of defoliation and BCAs with models able to predict both the phenological stage of the plants and the risk of infection would lead to optimize the control of bunch rot in grape.

RESEARCH ON POSSIBILITY OF CONTROL OF *ARION LUSITANICUS* MABILLE, 1868 BY NEMATODES *PHASMARHABDITIS HERMAPHRODITA* AND IRON PHOSPHATE.

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Arion lusitanicus Mabille, 1868 (*A. vulgaris* Moquin-Tandon) is a member of the family Arionidae. It is an invasive species in Poland, coming from the south-western part of Europe. Slugs of this species cause serious damage to agricultural crops, fruits, ornamentals and vegetables, especially Chinese cabbage or head cabbage (Port and Ester 2002). Application of recommended molluscicides is unsatisfactory and harmful to the natural environment. Therefore, research on new safe and effective methods and substances to control slugs in crops were carried out. For many years, the parasitic nematode Phasmarhabditis hermaphrodita was used to protect plants against slugs in Europe. It is present in the commercial product called Nemaslug® (Becker Underwood Ltd, UK) and is used in organic and integrated crop production. The research will help determine the optimal dose of Nemaslug to control slugs in crops. Recently, an enviromentally safe product against slugs became available on the market: iron phosphate. This compound is used in food and artificial fertilizers. In Poland, it has been available since 2011 in the form of granules called Ferramol GR. This research verified the suitability of this active substance to protect brassica crops against slugs. The aim of the study was to determine the feeding rate and condition of *A. lusitanicus* and damage to cabbage plants. Replicate tests were performed under laboratory conditions. Every two days, damage to the plants was determined by using a five-point scale (0, 25, 50, 75 and 100% of the damaged surface of the plant). Obtained data was statistically analysed (covariance test with weight of slugs as the disturbance variable, and Fisher's test at α = 0.05). The results showed that *P. hermaphrodita* reduced damage to cabbage plants in 7 days of observations. Ferramol significantly decreased the damage to plants from the 1st day. Research has indicated that both products are a valuable alternative to currently used molluscicides.

INHIBITION OF *FUSARIUM CULMORUM* AND *COCHLIOBOLUS SATIVUS* GROWTH BY SIX VOLATILES ORGANIC COMPOUNDS

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Cereals barley are constantly threatened by various edaphic fungal diseases.Common root rot, caused by *Fusarium culmorum* and *Cochliobolus sativus*, is one of the major fungal diseases of barley, causing between 9 and 23 % of yield losses. Since most of chemicals used for crop protection are being forbidden, new ways of protection are needed. It has been shown that plant secondary metabolites like volatile organic compounds (VOCs) are emitted after an attack and can repel aggressors like pests and pathogens. In a previous study, we showed that barley roots infected by common root rot emit 23 VOCs that were not emitted by healthy barley roots. This objective of this study was to test, the efficiency of the six main VOCs on fungal growth inhibition. Three organic esters (MG001, MG002, MG003), one ketone (MG004), one terpene (MG005) and one alkene (MG006) were tested. *F. culmorum* and *C. sativus* were grown during 240 hrs on agar media containing various concentrations of molecule (i.e. 0, 25, 50 and 100 µM). The diameter of each fungus was measured daily. All molecules inhibit the growth of the two fungi between 14% and 72%. The ester MG001 showed the best inhibition capacity by decreasing *F. culmorum* growth by 72% and *C. sativus* growth by 64%.The alkene MG006 was also able to significantly decrease the *F. culmorum* growth by 50% and *C. sativus* growth by 34%. Those interesting results suggest that MG001 and MG006 could be used to control common root rot on barley. Further studies are needed to assess the effect of those six molecules on germination capacity of the fungi and to better understand cellular and molecular mechanisms underlying the production of new VOCs and their effect on pathogenic fungi.

FIRE BLIGHT CONTROL WITH BLOSSOM PROTECT™

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Fire blight caused by *Erwinia amylovora* is the most serious bacterial disease in apple and pear. During the last four decades it has spread throughout Europe. Sanitation methods like pruning of infected shoots and uprooting of infected trees are necessary to reduce infection pressure in the orchards. However, it is not possible to eliminate all fire blight bacteria due to their epiphytic and endophytic abundance on and in trees free of symptoms. Under favourable weather conditions *E. amylovora* multiplies on blossom surfaces (e.g. stigma) and invades the plant tissue by the nectarthodes in the hypanthium routed by chemotaxis. Each blossom is a potential infection site and therefore efficient control agents are needed to prevent blossom infections. Streptomycin was used in many countries but was banned in the EU. In USA and in Israel *E. amylovora* developed resistance against this antibiotic. Blossom Protect composed of two strains of *Aureobasidium pullulans* and an acidic buffer component was developed in Germany. It decreases ph in the nectar of the blossom below five and by this disturbs the chemotaxis of the pathogen. Blossom Protect was tested in field trials since 2003 and reduced blossom infections by 78% in average in a eight years study in Germany and showed the highest efficacy of all biological products tested. Its efficacy was comparable to that of streptomycin in trials in Germany as well as in the USA. Meanwhile Blossom Protect is registered in many European countries, Morocco, the USA and Canada for use in organic orchards as well as in orchards managed according to Integrated Pest Management (IPM). The biotechnological product has to be integrated into spray schedules of pome fruit producers, who want also to control apple or pear scab. Tank mixtures of Blossom Protect with some fungicides (wettable sulphur, fluquinconazole, penconazole, a nilinopyrimidines) can be applied. Other scab fungicides like dithianon, captan or dodine have to be applied in spray strategies the day before or two days after the application of Blossom Protect. After all the implementation of Blossom Protect into spray strategies allows the control of both fire blight and apple scab during bloom in organic as well as in IPM orchards.

CHARACTERIZATION OF EFFICIENT RESISTANCE INDUCERS FOR CONTROL OF CROP DISEASE

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Downy mildew, caused by the obligate biotrophic oomycete *Plasmopara viticola*, is one of the most destructive grapevine diseases. *P. viticola* infects especially leaves and berries reducing photosynthetic activity, quality and quantity of grapevine production. Its control is based on the intense application of chemical fungicides, but concerns about the environmental impact of pesticide overuse have sparked an interest in efficient biocontrol alternatives. Enhancement of plant resistance by natural resistance inducers seems to be a promising strategy for controlling crop diseases. Several *Trichoderma* strains are active against numerous plant pathogens and they are frequently used as biocontrol agents. We previously demonstrated that treatments with *Trichoderma harzianum* T39 (T39) significantly reduced downy mildew symptoms by activating grapevine resistance both locally and systemically. Our aims were to test the efficacy of other *Trichoderma* strains against grapevine downy mildew and to characterize their mechanism of action in comparison to T39 and to the resistance inducer benzothiadiazole (BTH). The strain *T. atroviride* SC1 (SC1) was isolated from decayed hazelnut wood and it was patent as biocontrol agent against soil borne pathogens. Repeated foliar application of SC1 strongly reduced downy mildew symptoms on grapevine leaves, with efficacy of 80% and persistence of 7 days after three treatments at one-day interval before pathogen inoculation. The analysis of the mechanism of action revealed that SC1 induced systemic resistance in grapevine and it showed also direct activity against *P. viticola* sporangia. SC1 application did not affect grapevine growth, leaf dimension and chlorophyll content, indicating absence of apparent energy cost for resistance activation. On the other hand, BTH applications significantly reduced downy mildew symptoms but it negatively affected the grapevine growth. The evidence reported here suggests that SC1 could be a value biocontrol agent against downy mildew. However, future molecular characterization of grapevine genes involved in the resistance against downy mildew and the study of their spatio-temporal modulation by laser-capture microdissection will be necessary to better understand the key processes for grapevine self-protection and to develop robust plant protection products.

IDENTIFICATION OF SPECIFIC GRAPEVINE BIOMARKERS TO SELECT EFFICIENT RESISTANCE INDUCERS

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Downy mildew, caused by *Plasmopara viticola*, is one of the most severe diseases of grapevine and is commonly controlled by fungicide treatments. The beneficial microorganism *Trichoderma harzianum* T39 (T39) has previously been shown to induce plant-mediated resistance and to reduce downy mildew symptoms in susceptible grapevines. Transcriptomic and proteomic analyses were used to study the global molecular changes associated with T39-induced resistance in grapevine leaves. By next generation RNA sequencing (RNA-Seq) approach, more than 14.8 million paired-end reads were obtained for each treatment and 7024 grapevine genes resulted as differentially expressed during resistance activation. Moreover, 800 unique proteins were identified and quantified by high-throughput eight-plex iTRAQ protocol and 218 proteins resulted as significantly changed in abundance during T39-induced resistance. The complex transcriptional and proteomic reprogramming of T39-induced resistance included the direct activation of the microbial recognition machinery after T39 treatment and the enhanced expression of defence-related processes after pathogen inoculation. We showed that T39-induced resistance partially inhibited some disease-related processes and specifically activated defence responses after pathogen inoculation. In particular, some defence processes known to be implicated in the reaction of resistant grapevines to downy mildew were partially activated by T39-induced resistance in the susceptible grapevine. Genes and proteins identified in this work are an important source of specific biomarkers to select novel resistance inducers and to better characterize the environmental conditions that might affect induced resistance mechanisms under field conditions. The final aim is the use of specific ISR biomarker to optimize the use of this biocontrol method for downy mildew control.

NEMATICIDAL EFFECT OF CHESTNUT TANNIN SOLUTIONS ON THE CARROT CYST NEMATODE *HETERODERA CAROTAE* JONES

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The effectiveness of chestnut tannin aqueous solutions was tested against the carrot cyst nematode *Heterodera carotae* in a field experiment at Zapponeta (province of Foggia) in Apulia region (Italy). A sandy soil infested by the cyst nematode was deeply ploughed, rotavated and subdivided in 2 m x 3 m plots distributed in a randomized block design with five replications per each treatment. Chestnut aquoeus solution treatments were: a) 25 g/m ^{2} in 4 l water/m^2 applied in pre-emergence, b) 25 g/m^2 in 4 l water/m^2 applied in pre-emergence and 30 days after carrot emergence, c) 45 g/ m^2 in 4 l water/ m^2 applied in pre-emergence, d) 45 g/m^2 in 4 l water/m^2 applied in pre-emergence and 30 days after carrot emergence. Untreated soil and and the nematicide fenamiphos (60 l c.p./ha) were used as controls. At harvest, number and weight of marketable tap-roots from the central square metre of each plot were recorded. Soil samples, each a composite of 20 cores, were collected in the same central area of each plot. Cysts from a 100 g dried sub sample were extracted with a Fenwich can and crushed to count eggs and juveniles. All data were statistically analysed and means compared by LSD's test. Treatments with tannin solutions at 45 g/m^2 applied in pre or in pre and post carrot emergence significantly increased carrot marketable yield in comparison to untreated control. All treatments significantly increased the average weight of carrots, with the exception of the lowest dose of tannin applied before emergence, in comparison to untreated control. No significant differences were observed in the number of cysts/100 g soil among the different treatments including the fenamiphos and the untreated controls. The final nematode population density observed in the untreated control was significantly higher than those observed in all other treatments in which no differences were observed. On the base of results, the use of tannin should be favourably considered for plant protection against phytoparasitic nematodes although some aspects remain to be investigated.

PROTECTION OF GRAPEVINE WOUNDS FROM FUNGAL TRUNK PATHOGENS: INFLUENCE OF THE APPLICATION PROTOCOL IN THE EFFICACY OF *TRICHODERMA* TREATMENT

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Pruning wounds are the main infection courts for fungal pathogens associated to trunk diseases of grapevine. This is true also for the vascular disease called Leaf stripe disease (within the Esca complex), which is mainly caused by *Phaeomoniella chlamydospora* and species of *Phaeoacremonium* (mainly *Phaeoacremonium aleophilum*). Several studies showed, as confirmed in the present trials, that pruning wounds remain susceptible to infection for an unusually long time, also linked to the nature of grapevine, a climbing vine, with large vessels. Wounds could be succesfully infected by artificial inoculation also after 4 months or more since pruning. Wound dressing products usually applied offer only a temporary protecion and therefore can not be considered efficient as expected against such spread and damaging pathogens. Formulates based on selected *Trichoderma* strains offer a persistance of several months, even after the harvest, potentially protecting the wounds for a much longer period than the usual dressings.

For a succesful protection, anyway, the time of application is of essential importance. Trials carried out in Emilia Romagna and in Tuscany were based on applications by a commercial formulate containing *Trichoderma asperellum* and *Trichoderma gamsii* (Remedier®), followed at different distance by inoculation with *P. chlamydospora*, chosen as the most relevant pathogen involved in the whole esca complex. Reisolation after 7 months showed a good, even if variable efficacy (up to 100%) with applications from March to sap flow, when it get a higher efficacy. In all trials the solely preventive action of the product is confirmed. Furthermore is underlined as the *Trichoderma* product needs a few days in order to colonize efficiently the wound and therefore the efficacy grows with time in the first week of application. *Trichoderma* was shown to grow well on fresh wounds but also on older wounds, after one or two months from wounding: this allows to apply the product also on full winter pruning, in March, when the pathogen inoculum preassure increases. In general applications are more succesful if applied when average temperature is 10°C or more. The protection with *Trichoderma* against this vascular pathogen allows to gain a reduction of new infections in the field becoming an potential strong contribution to a succesfull integrated management of wood diseases.

THE EFFECT OF BIOFUNGICIDE PRESTOP MIX ON RESPIRATION, WATER LOSS AND LONGEVITY OF BUMBLEBEE *BOMBUS TERRESTRIS* L.

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Prestop Mix is based on a natural soil fungus *Gliocladium catenulatum* J1446, which is applied to control fungal plant diseases. Bees can be used as vectors in carrying the biofungicide powder onto crop flowers; this has two benefits: pollination and protection from fungal pathogens. An important precondition is for the biopreparation to be safe for bees, therefore lethal and sublethal effects have to be tested. The safety of a pesticide cannot be tested solely through the direct impact on longevity, it is essential to assess also the sublethal effects, which in many cases can be even more detrimental, causing the whole bee colony to weaken or even die. One way to assess sublethal effects of pesticides is to measure the metabolic rate (MR), respiratory patterns and water loss of an insect (Kestler, 1991; Zaferidou, Theophilidis, 2006). So far no detrimental effects of Prestop Mix on bumblebee reproduction, foraging behaviour or survival have been found (Mommaerts et al 2009, 2011, 2012). However, the effects on respiration have not been tested. Aim of the study was to determine the effect of Prestop Mix to MR, respiratory patterns, water loss and longevity of bumblebee *Bombus terrestris* L.. Experiments were conducted with bumblebee foragers from commercially reared hives. The MR, respiratory patterns and water loss were measured 3h before and 3h after treatments. Longevity of treated and untreated bees was followed daily after treatments. Treatments (pouring the powder on a bee) used were Prestop Mix, wheat flour and untreated blank as negative and the entomopathogenic fungus Beauveria bassiana GHA as positive control. For respiratory measurements LI-7000 differential CO_2/H_2O Analyzer was used. Prestop Mix had no significant effect on the mean MR of bumblebees, nor did it change the respiratory patterns. However, after treatment there was a significant increase in total water loss. Nor Prestop Mix neither wheat flour did change the median lifespan of foragers significantly, still the number of long-living foragers decreased in both cases, whereas wheat flour decreased maximum life span more than Prestop Mix. B. bassiana decreased the longevity of bumblebees significantly. In conclusion Prestop Mix cannot be considered completely safe for bumblebees; dermal contact with the biofungicide may significantly increase water loss and shorten the lifespan of foragers. The detrimental effect of Prestop Mix may not result from the fungus itself; it could rather be the effect of carrier substances in the biopreparation powder, which could absorb the lipid layer of the insect cuticle, leading to increased water loss. Excessive water loss can be very hazardous on hot summer days, if foragers are not able to regulate water loss and may die because of desiccation.

AN ECOLOGICAL ALTERNATIVE TO THE USE OF CHEMICALS: CHITOSAN AS ELICITOR OF RESISTANCE TO DISEASES IN WHEAT

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The new European trend about the agricultural policy has the objective of achieving the reduction of the environmental negative impacts of chemicals in crop protection. The goal of our study consisted in reducing dangerous active compounds replacing them with an eco-friendly alternative. Increasing knowledge of the mechanisms underlying the plant response to pathogen attacks has strengthened the idea that inducing artificially a defensive response in plants, this might confer increased protection against virulent pathogens. In this view, chitosan has prospect as a biocontrol agent, since it is easily extracted from the chitin of crustacean shell wastes, it is biodegradable and non toxic and it is well-known as resistance inducer. The potential ability of chitosan to induce the systemic acquired resistance (SAR) in plants of durum wheat (*Triticum durum* Desf.) was studied and, in particular, the seed treatment efficacy of a commercial chitosan in strengthen plant defences against the seed borne fungal pathogen *Fusarium graminearum* (Schwabe), one of the main causal agents of root and foot rot in wheat, was evaluated. For this purpose, two durum wheat cultivars Simeto and Creso were studied and the chitosan seed treatment efficacy was evaluated by biochemicals analyses in addition to greenhouse and field trials. The experiment consisted in the following treatments: 1) seeds treated with chitosan which seedlings were infected with the pathogen at the first leaf stage; 2) treated seeds not followed by inoculation; 3) untreated seeds followed by seedling inoculation; 4) untreated seeds and not uninfected seedlings. Sampling of seedlings was performed at the 2nd, 4th and 10th days post inoculum. Activities of some important enzymes involved in defence mechanisms were analyzed: guaiacol peroxidase (G-POD), ascorbate peroxidase (APX), polyphenol oxidase (PPO), phenylalanine ammonia lyase (PAL); phenols content was also evaluated.. Results showed that seed treatment with chitosan increased some enzymatic activities and the phenols content that was the highest in the samples of seeds treated and inoculated seedlings. In order to verify the effectiveness of seed treatment in greenhouse condition, trials were performed with inoculated soil and the disease incidence of the fungus on plants was estimated by Mc Kinney index. Finally, field trials were conducted with inoculated seeds comparing chitosan seed treatment with copper treatment as chemical control. Data about the number of emerging plants, the crop yield and the disease incidence were collected. The chitosan treatment reduced disease severity both in greenhouse and field conditions, supporting the idea of a possible use of this molecule in crop protection in order to improve the plant defence response against seed and soil borne pathogens.

PRODUCTION OF METHYL-JASMONATE IN POTTED VINES TREATED WITH TRICHODERMA AND SILICON AND EFFECTS ON DOWNY MILDEW INFECTIONS

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The modern approach to plant disease control involves the adoption of tools that are compatible with the environment, that are based on the integration of varietal selection, best agronomic practices, periodical inspections and control of sprayer equipment, as well as the adoption of a diverse range of products including new classes of fungicides with novel modes of action as stimulating plant defense. The understanding and exploitation of complex mechanisms of action that characterize biological control agents as Trichoderma, or natural products Silicon, appear to have evolved to allow more efficient plant response to stress, with an improvement of the effectiveness of disease control strategies. Effects of Trichoderma and Silicon have recently been verified on downy mildews. The present work was carried out in order to investigate the occurrence of metabolic pathways related to the production of methyl-jasmonic acid, a signal molecule involved in the elicitation of plant defen se response processes. The concentration of methyl-jasmonic acid was investigated on leaves of grapevine potted plants treated at roots by Trichoderma and/or sprayed with Silicon and then inoculated with *Plasmopara viticola*. From each of the six plants each consisting of a replicate, one leaf was taken for 4 consecutive days after the inoculation. Leaves were analyzed for the concentration of methyl-jasmonic acid. The appearance of oil spot lesions and sporulation were visually assessed and evaluated by video-image analysis. The results showed an increase of methyl-jasmonic acid in plants treated with Trichoderma and with Silicon. Moreover, although a reduction in the number of leaves attacked by the disease there was not observed, a reduction of the extension of symptoms (oil spots and sporulation) in the leaf surface was noticed. Results seem to support the hypothesis that these treatments can help make the plant less susceptible to the attacks of downy mildew, although our data did not show a real activity of Trichoderma and Silicon against downy mildew. Basically, it seems important to emphasize that an approach based on the creation of favorable conditions in the plant aimed at making the plant less susceptible to the disease, can help and improve the effectiveness of control strategies.

TRICHODERMA HARZIANUM T39 BIOCONTROL ACTIVITY AGAINST *PLASMOPARA VITICOLA*: ROLE OF PROTEIN PHOSPHORYLATION IN INITIATING GRAPEVINE RESISTANCE

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Several *Trichoderma* spp. are effective biocontrol agents against numerous pathogens. In grapevine, preventive applications of a commercial formulation of *Trichoderma harzianum* T39 has been shown to reduce downy mildew symptoms both locally and systemically, without negative effects on plant growth. We previously demonstrated that T39 induce plant resistance with a direct activation of the microbial recognition machinery after T39 treatment and the enhanced expression of defence-related processes after pathogen inoculation. In order to better characterize cellular processes associated to the early stages of T39-induced resistance, changes in protein phosphorylation activated by T39 have been analysed before and at 1 day post inoculation of *Plasmopara viticola* inoculation. Increasing evidence indicates that plant protein phosphorylation plays a pivotal role at different stages of plant response to pathogens activating a state of alert with low metabolic cost in plant. By combining a multi-dimensional strategy for phosphopeptides enrichment with the high-throughput eight-plex iTRAQ protocol, 161 proteins with at least one phosphorylation event were identified and quantified. Among them, different plasma membrane associated receptor kinases and proteins involved in signal cascade were differentially phosphorylated during T39-induced resistance, proving the importance of phosphorylation in resistance signal transduction. Moreover, the categories of secondary metabolic process (i.e. cell wall strengthening) and nucleic acid metabolic processes (chromatin and histone modification) were significantly overrepresented in T39-treated samples upon *P. viticola* infection.
All together, our results offer a better understanding of the mechanisms underlying the grapevine induced resistance and furnish knowledge to improve its efficacy. Indeed, new candidate proteins able to strengthening the plant's state of alert with low metabolic cost for the plant were identified and will be used for developing strategies for controlling downy mildew diseases.

BRASSICA CARINATA TISSUES CONTAINING GLUCOSINOLATES AND ESSENTIAL OILS ENHANCE BACILLUS-BASED ANTAGONISTIC ACTIVITY AGAINST SOIL-BORNE PLANT DISEASES

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Bacillus species have received greater attention as effective biological control agents to suppress soil-borne pathogens causing severe damping-off outbreaks and root diseases. To enhance their spectrum of activity, these sporulating Gram-positive bacteria can be co-formulated with other natural substances with biocide properties. Here, we propose *Brassica carinata* seed meals and essential oils. *B. carinata* seed meals are biodiesel chain by-products, derived from seed oil extraction. They have an higher potential as biofumigant, because contain glucosinolates that can be transformed, by myrosinase-mediated hydrolysis, in isothiocyanates, very fungitoxic volatile molecules. Instead, essential oils are stem distilled of medicinal plants, belonging to the family Lamiaceae, in which terpenes and phenoles are the major responsible for biocide activity. Actually, activity and toxicity of these bioactive substances against several plant pathogens have been well demonstrated. In the current research, an in-vitro strategy was developed to evaluate the use of *B. carinata* meals as biofungicide, used in combination with plant essential oils exhibiting antimicrobial activity and with antagonistic strains belonging to Bacillus genera. The study was focussed on three soil-borne pathogens: *Rhizoctonia solani*, *Sclerotinia minor* and *Fusarium oxysporum* f. sp. *lycopersici*. *B. carinata* seed meals showed a significant antifungal effect, at a dose-dependent manner, towards all the three filamentous fungi. The work was carried out both in vitro and in vivo assays, in which each single component and all their combination were tested both against the sole fungi, and, subsequently, in plant-pathogen interaction. *B. carinata* seed meal showed a significant antifungal effect, at dose-dependent manner, towards all three filamentous fungi. S. minor resulted the more sensitive to isothiocyanates, followed by *R. solani* and *F. oxysporum*. Glucosinolates-containing tissues, moreover, enhance pathogen inhibition, due to essential oils of thyme and oregano, suggesting a synergistic effect between combined molecules. To insert also some antagonist in the biocidal formulate, useful bacteria belonging to the genera Bacillus were selected as tolerant to biocidal compounds released by *B. carinata* sees meals and to antimicrobial action of essential oils extracted from several officinal plants. Results of combined use of three components indicated that *B. carinata* seed meal fortified formulate improving, together with essential oil, the ability to control by selected antagonists. Results suggested that *B. carinata* seed meal can be used in formulation of low-impact multi-component fungicides, considerable to replace banned or unsustainable chemical molecules.

COMPOST-TEAS: NEW BIOPESTICIDES AND BIOSTIMULANTS FOR A SUSTAINABLE HORTICOLTURE

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Composting is a biological process where biodegradable organic compounds are transformed in compost. In the last years in agriculture, the use of new products derived from compost, such as compost-tea (CT) is increasing, due to their positive effects on the crops. In particular, they show positive effects both on disease control and on stimulation of plant growth, with subsequent interesting improvement of quantity and quality of crop productions. Compost-tea is a compost-derived liquid formulate produced by extraction and/or fermentation process, conducted in liquid phase, for a period of time from few hours to two weeks, with or without active aeration and with or without the addition of nutrients (molasses, casein, etc.). The presence in the CT of soluble organic molecules, such as humic substances, and useful microorganisms, such as bacteria, fungi, protozoa and nematodes, have positive effects on suppression of diseases and on plant growth promotion. In this work, we firstly have reviewed and illustrated principal literature results about the use of CT in growth promotion and plant protection in horticulture. These include example of biostimulating effects, as well as direct and/or indirect plant nutrition implications, hormone-like activities, photosynthesis effectiveness improvement, useful microorganisms providing and enhancement of general plant status, that reflect on several morphological, physiological and productive characters of the crops. Similarly, we have presented a number of examples of CTs protecting plants against several diseases. This action is explicated through both biotic (microorganism) and abiotic mechanisms. These latter include the effective humus-like and phenolic fractions of CTs. Finally, we have presented a case-study in which five agricultural residues-based compost-teas were assayed for their suppressive ability against a wide range of plant pathogens, chosen among the most feared in horticulture. Teas were produced by a water-phase fermentation of three-mouth on-farm composted agricultural residues including artichoke, fennel, cauliflower, sweet corn, lettuce, tomato and fresh cut salads. In addition, an animal waste anaerobic digestate and a commercial municipal waste compost were used. All compost-teas inhibited in vitro growth of *Verticillium dahliae*, *F. oxysporum* f. sp. *lycopersici*, *Rhizoctonia solani*, *Sclerotinia minor*, *Sclerotium rolfsii* and *Botrytis cinerea*. While, filter and thermal sterilization of teas have completely eliminated their suppressive ability. The block of mycelial growth without physical interaction between pathogen and microbiota, reveal an antibiotic-like antagonism effect due to active microbes. Future prospective consist in testing the best ACTs as potential alternatives to the use of synthetic chemical fungicides for disease control in open field.

STUDY BIOLOGICAL CONTROL ACTIVITY OF *TRICHODERMA HARZIANUM* BY ISOTOPE RATIO MASS SPECTROMETRY (IRMS)

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The study of the interactions among the microorganisms, especially between pathogen and other microorganisms, is very useful to identify possible biocontrol agents. The use of microorganisms labeled with stable isotopes could represent an efficient approach to study the direct parasitization or metabolites assimilation by microorganisms. A microorganism labeled with stable isotope can be monitored in the environment and, if it is directly parasitized or its metabolites are used by other microorganisms, the label can be detected using isotope ratio mass spectrometry (IRMS). In this study we isolated and identified 159 different species of fungi and bacteria naturally present in the soil and their ability in the control of a plant pathogen (*Armillaria mellea*) activity was investigated. The screening was carried out basing on the antagonistic and mycoparasitic activity of the isolates against the pathogen. The selection was carried out in vitro by dual-culture test, carried out in Petri plates containing labelled pathogen on the opposite side of *Trichoderma* and by IRMS analysis using ^{13}C isotope, to detect the active degradation and metabolic assimilation of the labeled *A. mellea* by the microorganisms. *Trichoderma harzianum* in contact with labeled *A. mellea* had higher $\delta^{13}C$ values (244.03 ± 36.70‰) and was able to inhibit the pathogen development for 80 ± 0.19%. This variation is able to explain an active degradation of the pathogen by *Trichoderma.* The microorganism is able to suppress *A. mellea* after 29 days in direct contact in a broth of malt extract. Studying the parasitism activity of the fungus in microcosm soil condition, *Trichoderma* present a mycoparasitism activity and its $\delta^{13}C$ values increase (1.97 ± 2.24‰) after one month in direct contact with labeled pathogen. The microcosms were composed by 20 g of natural autoclaved soil, inoculated with pathogen-microorganism and stored under six different conditions, at 5 or 20% soil humidity and at 2, 10 or 20°C.

SURVIVAL OF *TRICHODERMA ATROVIRIDE* ON GRAPEVINE PRUNING WOUNDS AND LEAVES

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Esca disease causing damage in vineyard in almost parts of the world. The disease is caused by three different fungi (*Phaeomoniella chlamydospora, Phaeoacremonium aleophilum* and *Fomitiporia mediterranea)*, on the whole these pathogen affects the shoot of the trunk and the branches with chronic or acute evolution. At the moment the prevention of pruning wounds infection by following correct cultural practices remain the main way to manage the disease but the possibility of introducing microorganisms such as biological control seems to represent an alternative or a complementary strategy. We have examined the survival of *Trichoderma atroviride* SC1, as biological control agent on grapevine pruning wounds in vineyard. The results obtained is very interesting; *T. atroviride* survived for a long time (90 days after inoculums) into the shoot, assuring by this way a potential protection of pruning wounds versus Esca fungi infection. For this trial during the winter season we have pruned the plants, and a suspension of *T. atroviride* SC1 (1×10^8 conidia/ml) was spread on fresh pruning wounds. After the inoculation the wood (7 cm long) was collected, disinfected (90% ethanol for 30 s, 2% sodium hypochlorite for 3 min and then 90% ethanol for 30 s) and five sections (1 mm thick) were cut at homogeneously distances from the inoculated point along the shoot (0, 5, 10, 15 and 20 mm) and plated onto 2% malt extract agar amended with 0.2 g/l chloramphenicol. The cultured plates were incubated at 25°C, in the dark and daily evaluated to verify the presence of the colonies of *Trichoderma*. The percentage of infected wounds (incidence of infection) was calculated, and the extent of SC1 penetration inside the wood was measured at 15, 30 and 90 days after suspension treatment. In the second trial the survival of *Trichiderma* on grapevine leaves was evaluated after treatment with two commercial pesticide, fosetil-aluminium and copper, employed in viticulture against downy mildew. The leaves of potted plants were inoculated with *T. atroviride* SC1 as previously descript and after one day treated with the two different pesticides. After 2 and 8 days grapevine leaves were collected, washed in sterile water amended with NaCl (0.8 %) and the suspension was serially diluted and placed onto MEA + chloramphenicol. The plates were incubated at 25°C, and the colonies of *Trichoderma* were evaluated after three days. The survival of *T. atroviride* SC1 on grapevine leaves after fosetil-aluminium and copper treatment was confirmed.

POSSIBLE AND POTENTIAL USE OF *TRICHODERMA ATROVIRIDE* SC1 AS BIOFUNGICIDE

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Several strains of *Trichoderma* species are registered and used as active ingredients in biofungicides. The activity of *Trichoderma* strains is based on different mechanisms (i.e. competition for space and nutrients, antibiosis, parasitism, induction of resistance). *Trichoderma atroviride* SC1 is characterized by a fast and persistent colonization of soil, plant residues, bark and pruning wounds, and antagonism against pathogen is mainly based on niche exclusion and direct antibiosis by production of cell wall degrading enzymes. Efficacy and persistence of *T. atroviride* SC1 against root rots and wood diseases were evaluated in several trials. On strawberry, blueberry and grapevine potted plants, artificially inoculated with *Armillaria* spp., *T. atroviride* SC1 significantly reduced the infections, with efficacy ranging from 67 to 100%. Protection of wounds in nurseries and vineyards is a key point in preventing infections by trunk pathogens. After winter applications *T. atroviride* SC1 can colonize wounds, persisting for several months and protecting plants during the growing season. In trials in nurseries *T. atroviride* SC1 colonization was high and stable (approximately 100% at the end of the season). Other potential targets of this biofungicide are root rots and canker diseases of apple tree. Preliminary trials under controlled conditions show that *T. atroviride* SC1 could limit *Rosellinia necatrix* infections on roots and protect wounds from pathogens as *Phomopsis* spp., *Diplodia* spp., *Neonectria galligena*, etc. Optimal formulation is crucial in a biofungicide especially to protect conidia, promote germination and increase rain fastness. Different carriers and activating substances are being evaluated to improve enzyme production and increase efficacy and persistence of *T. atroviride* SC1. Based on its mechanism of action *T. atroviride* SC1 represents an interesting strain for further developments in the protection of wounds and roots from other microorganism and in the reduction of fruit rot infections.

THE EFFECT OF TEMPERATURE ON *BACILLUS AMYLOLIQUEFACIENS* STRAIN S499 AND ON ITS INTERACTION WITH CROP PLANTS

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Although the world is facing climate changes, little is known about the effect of temperature on several biocontrol mechanisms shared by plant beneficial bacterial strains. *Bacillus amyloliquefaciens* strain S499 protects plants against several phytopathogenic fungi by producing surfactins. These amphiphilic cyclic peptides are involved in bacterial motility, biofilm formation and root colonization and directly interact with plant cells triggering Induced Systemic Resistance (ISR). The effect of low and high temperatures either combined with or without water stress on S499 and on its interaction with plants has been evaluated in this work.

In vitro tests showed that S499 growth at 15 and 20°C was characterized by a much longer lag-phase compared to 35°C. As consequence, swimming and swarming motility of strain S499 was drastically impaired when it was incubated at 15°C. Additionally, exposure at 15°C also incited a reduction in biofilm formation in comparison with 25 and 30°C. Intriguingly, temperature influenced the structure of biofilm and pellicles at air-liquid interface developed when the bacterium was incubated at 35°C only.

ISR experiments were carried out in greenhouse to assess the effects of temperature (15, 25 and 35°C) and water stress on the ability of S499 to trigger ISR in bean, tomato and zucchini plants. Root treatment with S499 significantly reduced disease severity in all tested conditions. The highest protection levels (up to 65%) were observed on S499-treated bean and tomato plants grown at 15 and 35°C. Interestingly, no differences in the efficacy of plant protection were observed between plants normally watered and those submitted to drought at any of the tested temperatures. This suggests that the decrease in ISR efficiency due to water stress can be relieved by application of S499.

Since no differences in S499 plant root colonization was observed within plants exposed at different temperatures, the effect of temperature on *in planta* production of surfactins by S499 was investigated in order to explain the different protection levels reached at the temperature values used ISR experiments. Interestingly, the quantities of surfactin produced at 15 and 35°C on the roots of tomato and bean plants were higher than at 20 and 28°C. This fits well with the higher ISR-mediated protection level observed at these temperatures and clearly supports the involvement of surfactins in ISR triggered by S499 in these two host plants. Results achieved in this work represents a first step in understanding how different temperatures may affect the interaction between plants and a beneficial bacterium. In the case of S499 it seems that both high and low temperatures do not negatively affect colonization of plant roots and, more importantly, the ability to trigger ISR in plants.

CREEPING THISTLE (*CIRSIUM ARVENSE* (L.) Scop.) HEALTHINESS AND PATHOGENS - PERSPECTIVES OF BIOLOGICAL WEED CONTROL

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Pathogenic fungi that occur naturally in biocenosis play important role in regulation of *Cirsium arvense*. Creeping thistle is a burdensome weed of crop plants especially in ecological farms. Creeping thistle pathogens potential to regulation of this weed is still not enough recognized and could be explored. The aim of the study was to evaluate the healthiness of *C. arvense* at natural habitats, to identify its pathogenic fungi and the assessment of their pathogenicity to this weed in laboratory experiments. Observations of diseases on *C. arvense* and plant material collection were made on vast meadows of the Warta River valley from 2008 to 2012. It was found that disease symptoms occurred on *C. arvense* of a different nature in all plant organs: leaves, shoots and roots. It was also observed dying of inflorescences and infructescences, sometimes the whole plant, as well as damages caused by pests. The most isolates from spots, shoots and infructescences were *Alternaria* sp., *Epicoccum* sp. and *Fusarium* sp. Also from leaves often were isolated fungi - *Coniothyrium* and *Epicoccum*, from the basis of shoots and roots - *Acremonium*, *Coniothyrium* and *Phoma*. It was found that plants of *C. arvense* suffered at all observed locations, however the intensity of infection, depended on location and age of the plants. In July and August, when in plan population young plants were predominant, lower infections of *C. arvense* by pathogens were recorded. The powdery mildew (*Oidium* sp.) and rust (*Puccinia punctiformis*) were dominating, while in the older populations leaf spot diseases and dying of inflorescences and infructescences were observed. In the greenhouse experiments tested fungal isolates originated from *C. arvense* differed in their pathogenicity. The results of performed research indicated that some of these fungi (genera *Coniothyrium*, *Fusarium*, *Alternaria* and *Sclerotinia*) might be considered as potential agents for biological control of *C. arvense*. Application of bioherbicides on pastures and meadows is ultimately one of the most suitable method of direct control of creeping thistle and other weeds. A use of *P. punctiformis* cannot raise epidemiological doubts, however, due to necessity of manual application this method, should be the best in ecological farms. It was considered the most appropriate techniques of *P. punctiformis* application.

CHARACTERIZATION OF TRICHODERMA HARZIANUM T39 INDUCED RESISTANCE AGAINST PLASMOPARA VITICOLA DURING ABIOTIC STRESSES

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Climate change will increase the temperature and decrease precipitations in several areas of the world, increasing heat and drought stress for plants. Abiotic stress response in plants is largely controlled by the hormone ABA while the defence against biotic stresses is controlled by salicylic acid (SA) and jasmonic acid (JA)/ethylene signalling pathways. ABA signalling plays a crucial role in the modulation of defence reactions under multiple stress exposure. Thus, environmental stress is an additional factor to consider when studying the plant defence responses. Downy mildew of grapevine (*Plasmopara viticola*) is one of the most destructive diseases and plants are treated with chemical fungicides to avoid substantial yield losses. To reduce the use of chemicals, a strong interest was recently focused on enhancement of plant defence. After treatment with a resistance inducer, plants react with a faster and/or stronger defence against pathogens. This defence mechanism is called induced systemic resistance (ISR). ISR protects from a broad spectrum of pathogens but is often inconsistent and likely to be influenced by the environment. Since abiotic stresses may strongly influence the induced resistance, the aim of this project was to study the effect of a heat and/or drought exposure of grapevine plants on the resistance induced by *Trichoderma harzianum* (T39) against downy mildew. Grapevine plants were maintained at different temperatures and irrigation regimes to simulate heat and drought stress for 14 days. Soil moisture was daily measured in each pot with a soil moisture probe and leaf water potential was measured using the Sholander pressure bomb. Treatments with T39 and water (control) were applied on days 12, 13 and 14. Plants were inoculated with a *P. viticola* suspension (1×10^5 sporangia/mL) and disease severity was evaluated one week after inoculation. Leaves were sampled before and after pathogen inoculation and ISR marker genes were analysed in real time RT-PCR. The exposure of plants to heat and drought stress given singularly did not affect the efficacy of the T39 treatment, while efficacy was negatively affected when the stresses were combined. The induction of grapevine ISR marker genes were attenuated in heat and drought stressed plants. The weaker efficacy of the T39-induced resistance in heat + drought stressed plants could be related to the attenuated induction of the defence-related genes. Our results indicate that ISR could be less effective in areas where climate change will take place and when plants are exposed to heat and drought stresses. Future climate change should, therefore, be taken into account in disease management and in evaluating the efficacy of resistance inducers.

THE IN VITRO EFFECT OF *APHANOCLADIUM ALBUM* ISOLATE MX-95, A NEW PROMISING BIOCONTROL AGENT, ON THE ROOT-KNOT NEMATODE *MELOIDOGYNE INCOGNITA*

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The effect of the chitinolytic fungus *Aphanocladium album* isolate MX-95 was tested against the root-knot nematode *Meloidogyne incognita* in an in vitro experiment. *M. incognita* egg masses from infested tomato roots were sterilised and then immersed in flasks containing APS substrate (as m aperture) and each sieve was put in a 3.5 cm diameter Petri dish. Three ml of distilled water, were then added to batches as natural hatching agent. Four replications per each treatment were considered and egg masses were incubated in a growth cabinet at 20+2 °C. Emerged juveniles were removed and counted at weekly intervals, renewing the hatching agent at the same time, over a six weeks period. At the end of the in vitro experiment egg masses were immersed in a 1% sodium hypochlorite aqueous solution and the unhatched eggs were counted. Numbers of second stage juveniles emerging weekly were expressed as cumulative percentages of the total egg content of the egg masses.µculture media. Half of the total number of flasks were then inoculated with 2 ml of a conidial suspension (6.8×10^6 CFU/ml) while the remaining flasks were untreated. Egg masses and the substrate, with the presence or the absence of the fungus, were then transferred into 5.5 cm diameter Petri dishes (10 ml/dish) and incubated in a dark growth cabinet at 24+2 °C to allow the growth of fungus and the development of its enzymatic activity. After exposure of 0, 4, 8, 12, 16, 20, 24 and 28 days to *A. album*, egg masses were subjected to a hatching test, in distilled water. Untreated egg masses, with the same exposure time, were used as control. Batches from treated and untreated *M. incognita* egg masses were prepared and placed on 2 cm diameter sieves. Data from in vitro experiment showed that the treatments with *A. album* isolate MX-95 significantly affected the final percentage hatch of *M. incognita* egg masses in comparison to the untreated egg masses. No statistical differences were found between the two treatments until 8 days exposure time. Statistical differences were more evident after 12 days exposure time, without significant variation until the last exposure time (28 days). The final hatch percentage recorded in *A. album* isolate MX-95 treated egg-masses was lower than that recorded in untreated egg-masses and the final hatch percentage decreased with the increase of the exposure time. Main effects of treatments, exposure times and their interaction were highly significant. The suppressive effect of *A. album* isolate MX-95 on the final percentage hatch of *M. incognita* eggs could be attributed to different mechanisms: direct and indirect. The direct mechanism is the lytic action of chitinase to give a series of monomer and dimer useful to *A. album* as nutritive substrate. The indirect mechanism could be the ammonia production that occurs during chitin decomposition process with consequent nematocidal action.

GLYCYRRHIZA GLABRA LEAF EXTRACT FOR CONTROL OF DOWNY MILDEW (*PSEUDOPERONOSPORA CUBENSIS*) OF GREENHOUSE GROWN CUCUMBERS AND OTHER PLANT PATHOGENS

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Infection of plants with downy mildew or related diseases like late blight in potato and tomato are one of the major problems in agriculture, especially in organic production. There are years, dependent on temperature and weather, in which infections with these pathogens lead to major harvest loss. For control of downy mildews and of several other fungi in organic production copper preparations are the only available products. However, copper is a heavy metal, which accumulates in soil and can cause negative effects on soil or aquatic organisms, birds or mammals. In order to reduce dependency on copper in crop protection, effective alternative plant protection preparations are highly required. *Glycyrrhiza glabra* extract was tested under semi-commercial conditions in organic greenhouse grown cucumber. Since in Germany, copper preparations are not registered for use in greenhouses, control of this pathogen is a major problem when climate conditioning is impossible. Plants were treated in 4 trials in 7 to 12 day intervals with *G. glabra* raw extract (ranging from 2 to 3% w/v). Plants were either inoculated artificially or disease occurred naturally. Disease rating was done in weekly intervals. Besides *G. glabra* extract, the German plant strengthener ElotVis (5%) and water were used as control. In control plots, disease severity at the end of the trials reached between ca. 30 and 50%. *G. glabra* raw extract showed dose-efficacy dependency. At 3% concentration, efficacy (based on AUDPC) was best and reached around 70 to 80%, independent on the application interval of 7 or 10 days. The extract controlled the disease in all trials as good as or better than ElotVis. In previous investigations an ethanolic plant extract from *G. glabra* leaves (2.5% w/v) showed 100% efficacy against late blight (*Phytophthora infestans*) on detached tomato leaves. The extract was tested against *P. infestans* and other important plant pathogenic fungi on potted plants. Treatments were carried out prophylactically. Against *P. infestans*, efficacies of 75% and 58% were achieved on tomato and potato plants with 5% extract concentration, respectively. In a trial on beans against bean rust (*Uromyces appendiculatus*), *G. glabra* extract (5%w/v) showed 92% efficacy. These results together with the outcome of preliminary trials with *G. glabra* raw extract (5% w/v) against *P. infestans* in field-grown tomato underlined the high potential of this plant extract to control important plant pathogens.

LOW FITNESS COST OF THE RESISTANCE OF WILD INDIVIDUALS OF CODLING MOTH TO *CYDIA POMONELLA* GRANULOVIRUS (CPGV)

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This study was done in the PURE program WP8.3 task. The codling moth *Cydia pomonella* is the major insect pests of apple, pear orchards and walnut orchards worldwide. Its intensive control using chemical insecticides lead to the selection of high levels of resistance to currently available chemical insecticides (Boivin et al., 2005). *C. pomonella* thus appears to have a high adaptative capacity to environmental constraints. The use of the *C. pomonella* Granulovirus (CpGv) provides a potent an environmental friendly way of control of this pest, and is also expected to bring down the selection of resistance to chemical insecticides. It was first registered in Europe in 1988. Since 2003, some organic growers indicated a possible loss of efficacy of CpGv. This loss of efficacy resulted in an increasing number of treatments, in fruit damage and in the number of adults caught in sexual traps. The susceptibility of these codling moth populations to commercial CpGv was assessed in 2004 and 2005, in Germany (Fristsch et al., 2005) and France (Sauphanor et al., 2006), respectively. In both studies, the failure of control with CpGv was associated with a reduced susceptibility of *C. pomonella* population to the first virus formulation. From the first analysis, the resistance character seems to be the controlled by a single locus in a dominant manner (Berling et al. 2007). But deepened studies show that it doesn't explain all resistance cases (Berling et al. 2013). Insecticide rotation tactics and temporal or spatial relaxation of chemical selection may contribute to the reduction of the selection pressure. Their implementation relies on the assumption that no cross-resistance between different insecticides occurs (Roush 1989), which is the case between chemical insecticides and CpGv. These strategies also involve potential selective disadvantages associated with pleiotropic costs of resistance in the absence of insecticide (Rouch and McKenzie 1987). Thatis why we have tested the existence of this fitness cost in this study. During 4 years, wehave measured wild insects' fecundity, fertility, weight, emergence timing and susceptibility to the virus in function of their genotypes. All these data seems to show that no fitness cost is clearly identifiable. Moreover we found that 10 generations after the first apparition of this resistance in a commercial orchard without any selection pressure after this detection we still found 44% of resistant insects. This result shows the high time stability of this resistance in a completely open space. In the same hand, we show that this resistance has recently spread in distant location from the initial outbreak. This resistance had a slow spreading not because of a high fitness cost but because of a perturbed gene flow into the treated area with a different way of protection (not using CpGv). These results are crucial to set management plans to prevent the spread of resistance to CpGv.

ROOT EXUDATES AS COMMUNICATION MEDIUM BETWEEN ARBUSCULAR MYCORRHIZAL FUNGI AND THE SOIL-BORNE TOMATO PATHOGEN *FUSARIUM OXYSPORUM F.*SP. *LYCOPERSICI*

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The interactions between soil-borne plant pathogenic fungi and their host plants are mediated via root exudates to a substantial extent. Although the knowledge on signaling in plant–microbe interactions has increased in the recent years the signal communication between roots and microbes is still not satisfactorily understood. The need for alternatives to chemicals in disease management due to legislation and the growing concern of consumers about pesticides pave the way for biological oriented alternatives. Besides improved plant nutrition arbuscular mycorrhizal fungi are known to have beneficial effects on plant health. These plant symbionts can be combined with the benefits of intercropping against soil-borne diseases. The aim of our work was to elucidate the plant root exudate response in a biological system consisting of the crop plant tomato, the arbuscular mycorrhizal fungus *Glomus mosseae* and the soil-borne tomato pathogen *Fusarium oxysporum* f.sp. *lycopersici* (Fol) in an intercropping setting. Root exudates of 6-week-old plants were collected and tested for their effects on Fol. After chemical analyses of root exudates chemical components were identified and tested in different concentrations on Fol as well. Both, positive as well as negative effects of root exudate compounds on Fol were found and thus, give more insights into plant–pathogen–symbiont interactions.

BIOFUNGICIDES AS ALTERNATIVE TOOLS IN DISEASES PROTECTION

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The Directive 2009/128/EU "establishing a framework for Community action to achieve the sustainable use of pesticides" proposes to reduce the risks and impact on human health and on the environment by the development of an integrated pest management and of alternative agriculture techniques. Alternative or complementary phytoiatric practice are necessary to reduce the use of pesticides in order to obtain healthy crop and more environmentally production, as well as to improve farmworkers healthiness. In recent years there has been a growing interest in the application of allelopathic substances in agriculture. Allelopathy is a biological phenomenon by which an organism produces one or more secondary metabolites (allelochemicals) that influence the growth, survival, and reproduction of other organisms having beneficial or detrimental effects on the target organisms. In this study the allelopathic properties of essential oils as natural fungicides was tested as well as the evaluation of their residual toxicity in soil, in order to promote their use in alternative agriculture. The experiment was set up in a greenhouse using zucchini crop ('Romanesco' cultivar) treated with two mix of essential oils (first: Tween 20-emulsion of *Maleleuca alternifolia australiana*; second: Tween 20-emulsion of *Euglenia cariofillata* and *Rosmarinus officinalis* L. essential oils at different concentrations), exclusively or alternated with a synthetic fungicide (quinoxyfen). The treatments were applicated when natural fungi infection of *Podosphaera fusca* appeared on zucchini plants and, thereafter, treatments were repeated in seven day intervals for five weeks; plants have been sprayed until runoff. Phytotoxicity and genotoxicity tests (comet assay and micronuclei analysis) were performed using root meristems of *Vicia faba minor* (a bioindicator plant) grown in vitro on the soils sampled from zucchini plants treated in order to evaluate the potential damage to DNA caused by residual effect of essential oils in soils. Preliminary results seem to point out that the alternation of natural compounds materials with effective synthetic fungicide can maintain a good disease control and may also assist with resistance management. The eco-toxicity data show no phytotoxic effect but an increase of the primary root length, supported also by the high mitotic index value calculated. However, the comet assay shows an increase of the DNA damage in all the samples treated with all essential oils, as confirmed also by recent literature. The micronuclei test highlights a genotoxic effect only in weekly *M. alternifolia australiana* oil treatment. These data demonstrate that essential oils may be used as potential fungicide although additional work is required to determine appropriate application doses and formulations that could be used under field conditions.

SOIL MICROORGANISMS VS. PESTICIDES. POTENTIAL BIOEFFECTOR MOLECULES FOR AN ENVIRONMENTAL-FRIENDLY VITICULTURE

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The advent of crop protection technology during the 60's has greately helped the world agriculture to meet the even growing demand of food, fiber and food by-products. It is estimated that at least 50% of the six most important agricultural crops would be lost without the use of chemicals. Thousands of weeds, insects and plant disease affecting crops are controlled or eradicated, with an overall positive impact on the global economy. Despite these benefits, the large use of pesticides, which includes herbicides, insecticides and fungicides, has a negative impact on environment and human health mainly due to their large application and long-time persistence in soils. A sustainable and environmental-friendly agriculture is hence the goal of the next-generation crop and fiber productions by the use of low-impact pesticides and of bioeffector molecules.

Soil is the largest container of biological diversity ("the black box") and it represents a source of biomolecules with high application potential. To elucidate how soil microorganisms might contribute for a sustainable agriculture, a study has been carried out to evaluate the persistence of fungi and bacteria *versus* six different pesticides and their relative active ingredients. Increasing concentrations of two fungicides R6 Albis (fluopicolide) and Scala (pyrimethanil), insecticides such as Pirimor (pirimicarb) and Actara 25WG (thiamethoxan), Chikara (flazasulfuron) and Goal 480SC (oxyfluorfen) as herbicides, have been *in vitro* tested over time in soils collected from conventional and biodinamic grapevines located in Trentino.

Differences found among the two management systems indicate that microorganisms from conventional soil are more "resistant" to pesticides, as consequence of their large use and persistence in soil, in contrast to the biodinamic managment.

The overal ability of the selected strains to survive and growth in poor nutrient solution amended with pesticides assumes that these microorganisms use the above tested chemicals as nutritive substrate for their growth with an active involvment in their degradation pathways.

INTEGRATION OF AUREOBASIDIUM PULLULANS IN GREY MOULD CONTROL IN SOFT FRUIT

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Fruit decay is one of the most serious diseases in plants and causes especially in commercial soft fruit production enormous economic losses. *Botrytis cinerea* causing grey mould is the main pathogen in strawberries and starts infections already at the beginning of the blooming period. The occurrence of infections on ripe fruit depends very much on weather conditions during harvest. Because the pathogen can only be combated protectively, up to five fungicide treatments have to be done during bloom to protect all open blossoms. Distinctive for the chemical active ingredients nowadays used in Botrytis control is the specific mode of action (single site inhibitors). The repeated use of these substances led to a selection of resistant strains in the pathogen population. One opportunity to reduce the risk for resistance is the reduced use of specific fungicides and the application of products with a different mode of action like antagonistic yeasts. Boni Protect forte based on the yeast like fungus *Aureobasidium pullulans*, has antagonistic potential against several pathogens in fruit-growing. In numerous trials *A. pullulans* showed its high efficacy. Therefore the strategic use of Boni Protect forte could be a helpful manner to prevent resistances in *B. cinerea* against chemical fungicides. Field trials were done in strawberries at two locations in Germany in 2011 and 2012, and in a raspberry field 2011 in Poland. In 2011 Botrytis incidence was low in Buchholz at BBCH 85 evaluation. All treatments showed significant disease reduction with efficiencies of more than 59%. At a higher infection pressure resulting in an incidence of 180 infection sites per 28 plants in 2012, again all three treatments reduced the disease incidence significantly. The stand-alone treatment with Boni Protect forte as well as the spray strategy using chemical fungicides in alternation with Boni Protect forte was comparable to the chemical standard in both years. In Oberkirch Botrytis incidences in the control were comparable in both years. In 2011 the chemical standard as well as Boni Protect forte reduced Botrytis incidence by 73%. In 2012 efficiency of 57% and 63% was reached with the chemical standard and Boni Protect forte, respectively. Botrytis incidence in the raspberry trial was 29% in untreated control. All three treatments showed significant reduction of *B. cinerea* incidence. The spray strategy (eff. 86%) and the chemical standard (eff. 89%) were significantly better than the stand alone treatment with Boni Protect forte (eff. 69%). In all five trials Boni Protect forte reduced the *B. cinerea* incidence significantly compared to untreated control. Spray strategies of Boni Protect forte and chemical fungicides showed also significant effects and tended to be better than the stand-alone treatment with Boni Protect forte.

APPLICATION OF BONI PROTECT® AGAINST POSTHARVEST DISEASES IN INTEGRATED APPLE PRODUCTION

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Postharvest diseases are caused by a wide range of different fungi and cause major losses in pome fruit production. In Integrated Production (IP) one to three preharvest applications with chemical fungicides are conducted to prevent postharvest rots during storage. Preharvest intervals and the risk of resistance development by pathogens complicate their use. Especially the detection of a range of different chemical residues impair the image of fruit as healthy food and trade chains already demand fruit containing less than five detectable residues. In a screening of more than 300 different bacterial and fungal strains done at the University of Konstanz in the beginning of the 1990ies, two strains of the yeastlike fungus *Aureobasidium pullulans* were able to prevent symptoms of decay fungi (e.g. *Botrytis cinerea*, *Monilinia fructigena*, *Penicillium expansum*, *Pezicula alba*) after artificial inoculation of wounds and prevented storage rots after preharvest applications in field trials . Therefore production procedures were developed for the two strains and laboratory and field trials showed that different formulations of the two strains have to be used for different indications. Boni Protect is one of those formulations and is used for preharvest applications against storage diseases in pome fruit. The product has no preharvest interval and can therefore be applied until harvest and between different pickings. Since 2002 preharvest use of Boni Protect in field trials showed results comparable to efficiencies of chemical fungicides. From 2007 to 2011 Boni Protect showed its potential to replace chemical fungicide applications in several European countries, achieving a maximum efficiency of 89%. In addition Boni Protect increased the efficiency of chemical treatments when applied during their preharvest interval. In four field trials adding up to two Boni Protect treatments to standard fungicide treatments an additional reduction of infected fruits of 4% was obtained, which leads to an additional yield of 1200 kg/ha. Therefore Boni Protect offers new strategies for fruit growers in reducing postharvest rots. Furthermore it minimizes residues and the risk of resistance development by fungal plant pathogens.

INTERESTS OF A BOTANICAL EXTRACT AS AN ESSENTIAL OIL IN THE CONTROL OF SEPTORIA LEAF BLOTCH OF WHEAT

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The aim of the study is to investigate an alternative to synthetic fungicides currently used in the control of devastating fungal pathogen *Septoria tritici*, the causal agent of Septoria leaf blotch of wheat (up to 40% yield loss). The pathogen can respond to the use of fungicides by evolving resistance. Here, two different strains in relation to their sensitivity to triazols are used in order to estimate the natural antifungal activities of thyme EO (S6, sensitive strain ; R1187, resistant strain). In vitro, a range of EO concentrations was tested in microplates, crude, with Tween®80 (5% v/v) or with DMSO (1% v/v) compared to a fungicide (metconazole). The comparison of the calculated IC50 shows that thyme EO is effective on both strains, the sensitive strain as well as the strain wich is resistant to triazols, whatever the formulation tested. In vivo, a range of EO concentrations was tested crude or with TAPG (50% v/v) in comparison with a fungicide (Caramba star/metcon azole). Preventive and curative treatments were applied on wheat (var. Bermude) with the strain wich is the resistant to triazols. Preventive treatments are more effective than curative ones and show efficiencies comparable to commercial fungicide.

IN VITRO EVALUATION OF FUNGICIDAL PROPERTIES OF THE THYME ESSENTIAL OIL (EO) ON *FUSARIUM GRAMINEARUM* AND *FUSARIUM OXYSPORUM*

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In order to decrease the use of chemical pesticides, the use of thyme EO as a biopesticide may be considered in the context of sustainable agriculture, whatever the crop protection methods (integrated or organic). Thyme EO (*Thymus zygis*) and its major compound, thymol, were tested in vitro on agar medium (PDA) and in liquid medium (microplate) according to a range of concentrations on two species of Fusarium (*F. graminearum* and *F. oxysporum*). *F. graminearum* is particularly known for producing mycotoxins (DON, deoxynivalenol) as part of wheat Fusarium Head Blight. The IC50 values calculation in liquid medium and agar medium are used for comparing the efficiencies of thyme EO and thymol with reference fungicides such as metconazole and boscalid. If both Fusarium species are resistant to boscalid, they are both sensitive to metconazole, with a higher sensitivity of *F. graminearum* in liquid medium. Concerning thyme EO and thymol, the effectiveness is better on agar medium tha n in liquid medium. In addition, it has been shown on agar medium for thyme EO and thymol that the effect of vapor was largely responsible for the observed efficiencies. In conclusion, thyme EO and thymol have a fungicidal effectiveness naturally interesting, much more than boscalid (ineffective) but much less than metconazole (very efficient) which in our case is the most efficient molecule to control the growth of Fusarium.

PRODUCTION OF CERTIFIED *CITRUS* ROOTSTOCKS USING ORGANIC GROWING MEDIA AND BIO-CONTROL AGENTS

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The European legislation on organic production (EC No 889/2008) regulates citrus nursery production under organic management for the establishment of organic citrus groves. Due to the lack of technical protocols to comply with these requirements, a study was funded by the Italian Ministry of Agriculture (MiPAAF) on the production of organic substrates suitable for citrus nursery plants and the evaluation of the bio-product 'Clonotri' (*Trichoderma harzianum* and *Clonostachys rosea*) for the control of soil-borne pathogens. Organic substrates were prepared using compost, commercial (ECOS) and experimental (COMPAS), and coconut fiber in order to partially (35%) or fully replace the peat moss, which is a non-renewable natural resource. The growing medium developed by IAM-Bari (IAMB mix) for citrus indicator plants was used as control. One per cent of guano-based fertilizer was added and elemental sulfur was used for pH adjustment. Trials were carried out in the Premultiplication facility set up within the Apulian programme for citrus plant certification. About 3-4 months-old Volkameriana lemon, Troyer citrange and Sour orange seedlings were transplanted into the produced growing media and into the IAMB mix. During the 8 months of the trial, all growing media were evaluated individually and in combination with Clonotri, using 20 replicates per treatment per rootstock. Plant growth, diameter and dry weight were evaluated at the end of the experiment. The partial replacement of 35% of peat moss gave the best results. All citrus rootstocks grown in the Compas-based medium showed significant increase in vegetative parameters. However, no significant results in enhancing plant growth were achieved by the combination of all tested media with the bio-product Clonotri.

BACILLUS STRAINS ISOLATED FROM SOLANACEOUS PHYLLOPLANE EXHIBITING BIOCONTROL ABILITY OF *ALTERNARIA* SP.

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Biological control is one of the most viable environmental and health-friendly approaches for suppressing plant diseases caused by fungal pathogens. The introduction and establishment of living natural enemies of pathogens is viewed as a powerful alternative to chemical fungicides conventionally used in agriculture, satisfying the preference of consumers for sustainable products with few or no chemical residues. The biological control of aerial diseases have stimulated a smaller number of studies than soil-borne one. In this work, some strains of spore-forming bacteria, isolated from tomato, eggplant and pepper phylloplane, were proposed as biological control agents of early blight disease caused by *Alternaria* spp. A stepwise screening strategy was performed and five new *Bacillus* spp. strains were chosen as result of both in vitro and in vivo control assays. In vitro and in vivo activity and M13-PCR DNA-fingerprinting led to the selection of these valuable biological control agents from a wide collection of 93 candidates, isolated by thermal treatment from leaf samples. All isolates were gram positive and physiologically characterized for production of endospore, fungistatic volatile compounds and siderophore-like substances. At the end of this selection, the highest potential antagonists were identified by 16S-rRNA gene sequence analysis, and results assigned them to *Bacillus thuringiensis* group-related strains. By in vivo tests, spore-forming bacteria provided substantial biocontrol of *Alternaria* disease on tomato. In particular, five strains proven to be very effective. The evident inhibition zone seen in dual culture plates suggested antibiosis-like antagonisms as the main mechanisms used by these bacterial isolates in interaction with the pathogens. *Bacillus* strains isolated from solanaceous phylloplane are promising biocontrol agents that have potential for practical application as biofungicides.

SEED TREATMENT WITH ESSENTIAL OILS

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In the organic farming the prevention is one of the action to be performed to reduce the risks of pathogen attacks. The use of healthy seeds is the first option available to prevent diseases, in particular seed-borne and soil-borne diseases. We conducted during the last years studies about the use of essential oils like *Melaleuca alternifolia* (tea tree), *Thymus vulgaris* (thyme), *Laurus nobilis* (laurel), *Mentha* x *piperita* (peppermint), *Origanum vulgare* (oregano), *Syzygium aromaticum* (clove) and *Rosmarinus officianalis* (rosemary) oils for seed treatment against the main fungal pathogens transmitted by legumes (lentil, pea, chickpea, bean), rice and wheat seeds. In vitro and in vivo assays were carried out to test the activity of the oils against fungi. Trials in greenhouse and in the field were performed to verify the activity of the essential oils, using healthy and inoculated seeds. To set up the proper concentration also the phytotoxicity was evaluated. Results showed a significant activity of the oils on reducing fungal growth. It was calculated the percentage of Mycelial Growth Inhibition (%MGI) and the Minimum Inhibitory Concentration (MIC) for each oil, that was dose-dependent and it differed depending on the fungal species. Thyme, clove, peppermint and oregano oils were the most effective against fungal isolates tested but also tea tree, laurel and rosemary oils showed a good effectiveness. The firsts were also the most phytotoxic as they reduced the percentage of seed germination at the higher concentrations. The use of the right amount of the oil in the treatment solution, especially if seeds were treated by immersion, allowed to obtain positive results in reducing disease incidence in vivo, as well as in greenhouse and field experiments. Therefore the essential oils tested can be considered very interesting for developing alternative natural fungicides to the synthetic chemicals that are currently used to prevent and control seed-borne diseases. The best application (immersion or spray) should be evaluated to achieve the best performance in terms of germinability and reduction of disease incidence, as well as the best concentration for each type of seed and pathogen. We conclude that essential oils can be potentially used in organic agriculture for safe and low environmental impact seed-treatments.

EVALUATION OF PLUM POX VIRUS SENSIBILITY ON DIFFERENT STONE - FRUIT VARIETIES IN EMILIA ROMAGNA REGION (ITALY)

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Sharka, caused by Plum pox virus (PPV), is a serious stone fruit disease easily transmitted by aphids and by vegetative multiplication. In Emilia Romagna some PPV foci are present yet, despite of compulsory controls and eradication of infected plants. The introduction and cultivation of less-sensitive varieties represent the only chance to maintain stone fruit industry in these places. For 8 years an experimental activity was addressed to evaluate long-established and new varieties from breeding activity, in order to individuate someone less susceptible, tolerant or partially resistant to PPV. During the years 2003 – 2012, 79 peach, 50 nectarine, 48 apricot and 28 plum varieties, grown in screen house, after chip budding inoculation with PPV M strain, were inspected to evaluate symptom expression on leaves, flowers and fruits. Few varieties, remained symptomless, were re-inoculated with the same PPV isolate and submitted to further observations and analysis for at least 3 years. Every year, in spring, leaves samples were collected from inoculated plants and appropriate analysis, based on serological (ELISA) and molecular (Real time PCR) tests were performed, in order to confirm the virus infection in symptomatic and non–symptomatic samples.
A large number of inoculated plants of the tested varieties showed on leaves light chlorotic rings, and blotches, vein clearing and distortion in spring; almost all peach varieties with rosaceous flowers displayed colour breaking on petals.
Some peach and apricot and few plum varieties respectively, showed evident fruit deformations with typical rings and mottling. Other peaches and nectarines have not shown fruit symptoms to date. In 2012, only 10 apricot, 1 peach and 1 plum varieties still showed no symptoms on both leaves and fruits and resulted negative at ELISA and Real time PCR assays. These experimental data evidenced high sensibility of stone fruit germplasm to PPV-M, and in particular of all traditional varieties, as well as new developed cultivars obtained in Italy or imported from other European countries. The few varieties that appear promising for PPV tolerance or resistance are mainly of apricot. These results have to be confirmed by field evaluation even if the information gathered in the Emilia-Romagna region by inspectors of the local Plant Protection Service, confirmed, for some varieties, the behaviour showed in screen-house.

IMPLEMENTATION OF IPM TO REDUCE PESTICIDE RESIDUE ON FRUITS: A CASE STUDY IN TRENTINO REGION

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The reduction of the residue of pesticides on fruits both in terms of the number of active ingredients and quantity of individual pesticides, is now not only a request from the consumer or the retailer, but a specific objective of the growers. The Integrated Apple Production System operating in Trentino (Italy) has been engaged on this front for years. According to the chemical analyses performed on the 575 samples collected in 2011 there are in average 3.24 p.a. per sample. Moreover, in 98% of the samples with detectable residues, the level did not exceed 30% of the official MRL. This result is achieved thanks to the implementation of the guidelines for integrated production by the 8000 fruit growers, to an extension service which justifies the need of the treatment and gives advice on which pesticide fit better for the time-pest combination, to the systematic check up of the sprayers, to the correct sizing of mix volumes to spray according to the size of the canopy, to the selection of active ingredients based on their residual activity in field tests, and to the systematic monitoring of the level of residues found on representative samples of the product at harvest . With these assumptions, the next goal is to eliminate all traces of insecticides and acaricides now present only in 30% of the samples. This aim could be achieved by extending the use of pheromone mating disruption to control fruit feeding Lepidoptera, as well as by promoting the use of short persistent residue products during the final part of the season. Results of some of the experimental field trials are presented and commented.

HAS WHEAT GENETIC IMPROVEMENT DELIVERED REAL BENEFITS TO IPM IN EUROPE?

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Today wheat is the UK's largest crop and constitutes almost half of the EU cereal production at 131.7 million tonnes. Domestication of wheat increased yields, but in the last 15 years those increases have slowed and we now face yield stagnation across the EU and in many parts of the world. This is partly because domestication has eroded wheat diversity. Research at NIAB is focusing on extending the bread wheat gene pool by understanding, exploiting and incorporating novel genetic diversity from wild and cultivated relatives of bread wheat.
UK Perspective on wheat performance. The period from the 1940s to the 1990s saw exceptional growth in wheat yields in the UK. National average yields rose from 2.7 t/ha to 7.6 t/ha (1 t/ha per decade). From 1980 to 1996, wheat yields in the UK improved rapidly, by an average of 0.10 t/ha per year. Since then, yields have stagnated. This situation is reflected across the whole of Europe. In the UK efforts of the plant breeders have delivered yield increases of 0.05 t/ha per year through new varieties. This yield increase has not been transferred to on-farm yields. Fungicide-untreated yields remain stubbornly low. Average responses to fungicides in UK Recommended list trials are about 17% (1.5 t/ha). The UK Recommended List trialing system has attempted to improve disease resistance in UK varieties by introducing minimum standards for some diseases. This has prevented very susceptible varieties from being recommended and thus generally improved disease standards in the UK. However, the UK Recommended List of varieties is still dominated by very high yielding varieties which demand high fungicide inputs. Disease resistance is a major target for wheat breeders but so too are many other attributes including height, flowering time, straw stiffness, yield, maturity, specific weight, HFN, bread-making quality etc. These combined targets make wheat breeding very difficult indeed. It is likely that in the medium term, highly resistant varieties are likely to suffer a significant yield penalty.
Pesticide use. In the UK over the last 10 years there has been no reduction in the area of wheat treated with fungicides or the amount of fungicide applied. The UK Government have published their "UK Pesticides Strategy: A strategy for the sustainable use of plant protection products". The policy encourages the introduction of cost-effective alternative approaches and greater use of integrated crop and pest management, which includes the use of disease-resistant varieties. However, it is clear that plant breeders are struggling to achieve the many demands on their breeding programmes and in the short to medium term, improvements in disease resistance are unlikely to have a significant impact on fungicide use. In the medium term, disease resistance is likely to continue to increase but yields may be penalised as a result.

CHARACTERIZATION OF RESISTANCE IN PEAR GENOTYPES TO PEAR PSYLLA *CACOPSYLLA PYRI*

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Most of the present *P. communis* breeding programmes in the world are aimed not only to upgrade fruit quality but to introduce resistance to the main diseases and pests, such as pear psylla. The resistant selections obtained from *P. communis* x *P. ussuriensis* crosses readily exhibited egg-laying non-preference, and high mortality to nimphs. The aim of the present study was to develop molecular and chemical markers linked to psylla resistance other than the tissue localization of mechanisms of resistance in pear resistant selection. Construction of a linkage map and molecular marker development: seedlings derived from the cross NY10353 x Doyenne du Comice have been replicated by grafting each seedling on quince and trials for phenotyping have been conducted in a tunnel. The following parameters have been evaluated as soon as the plants were available: number of adults and eggs per seedlings (antixenosis), number of nymphs and the honeydew production (antibiosis). By using the above described progeny the construction of a map frame based on microsatellites was started to identify the genomic locations of markers associated with psylla resistance. During the first year the DNA from each seedling and the parental lines have been extracted and a "Genome Scanning Approach" was used to identify genomic regions putatively involved in psylla resistance by using apple SSRs which are easily transferable from apple to pear. The analysis of the SSRs marker is still in progress on the resulting parental maps, and by merging molecular and phenotypic data already available it was possible to identify a major QTL for psylla resistance in linkage group 17 of the resistant parent. The molecular markers linked to psylla resistance developed in this project will be tested in the future for their application for MAS (marker assisted selection). A Candidate Gene Approach will be also started for identification and mapping of putative genes involved in psylla-pear interaction. Indications about putative genes involved in pear-psylla interaction in the resistant genotype NY10353 will be used to develop sequence-specific molecular markers. The mapping activity will be further implemented and all the polymorphic markers available will be mapped. Chemical analysis of compounds will be linked to psylla resistance. The activity to identify chemical compounds putatively involved in pear resistance will be investigated by HPLC in the resistant genotype NY10353 and susceptible cv. Doyenne du Comice and Bartlett. The plant penetration and feeding behavior of *C. pyri* on resistant genotype NY10353 will be determined by EPG system. These data will be employed for tissue localization of mechanisms of resistance in pear.

DO WE NEED TO WORRY ABOUT ASYMPTOMATIC INFECTION OF PATHOGENS?

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Scald, *Rhynchosporium*, or leaf blotch of barley, caused by the fungus *Rhynchosporium commune*, can be of considerable importance to barley growers worldwide. It is the most serious disease on winter and spring barley in the UK, causing substantial losses nationally, despite expenditure of £50M per year on fungicides. The disease is difficult to control with fungicides and severe epidemics may appear suddenly. The sources of infection responsible for such epidemics are not well understood as in general we only have data on disease rather than the presence of the pathogen. However, the ready availability of molecular probes and quantitative PCR enable detection and quantification of pathogen DNA in barley plants in both pre-symptomatic phases of infection and where they remain asymptomatic throughout their life cycle. Seed-borne inoculum was identified as a significant source for early infection of barley crops, with substantial amounts of *R. commune* DNA found in seedlings of crops grown from infected seed. However, there was little evidence that severity of seed infection influenced amounts of pathogen DNA (leaves) or disease severity (leaves) or yield loss later in the cropping season. The discovery that *R. commune* can colonise barley crops extensively throughout the cropping season (from seed to seed) in the absence of visual symptoms has completely changed the understanding of the disease by industry with implications for the use of fungicides, breeding programmes and national variety recommended lists. Even when substantial early symptomless infection was identified in winter barley crops, epidemic severity late in the season was largely dependent on amount of spring rainfall that encouraged secondary disease spread by splash dispersal of pathogen spores. Therefore the PCR quantification of early *R. commune* infection could not be used to accurately predict epidemic severity late in the season. Similarly, early season PCR assessments of cultivar resistance could not be used to accurately predict resistance ratings based on late season disease assessments. Clearly whether fungal infections caused by species such as *R. commune* are symptomatic or not is determined by many complex factors and is dynamic. However, by using internal comparisons in mapping populations and disease nurseries, new sources of resistance to *R. commune* have been identified, molecular markers have been developed, and methods to screen material for resistance have been improved, all of which could considerably improve resistance sustainability in practice. In conjunction with a breeding company, KWS-UK, the genetic basis of several different components of resistance to R. commune in barley was investigated in a mapping population derived from a cross between winter and spring barley types. Both the severity of visual disease symptoms and amount of R. commune DNA in leaf tissues were assessed in field trials in Scotland in the 2007/2008 and 2008/2009 growing seasons. Relative expression of symptoms was defined as the residual values from a linear regression of amount of R. commune DNA against visual plot disease score at GS 50. Amount of R. commune DNA and visual disease score were highly correlated traits and identified nearly identical QTL. The genetic control of relative expression of symptoms was less clear. However, a QTL on chromosome 7H was identified as having a significant effect on the expression of visual disease symptoms relative to overall amount of R. commune colonisation. Clearly understanding the genetic basis of pathogen infection of plants is critical to decisions about control; for example whether it is likely to remain restricted, become symptomatic as adult plants, remain benign, be extensive but not damaging to yield, or be a reservoir of variability. Furthermore, these options do not consider interactions of other organisms that frequently form part of the disease complex in the field in practice.

SUSCEPTIBILITY OF HIGHBUSH BLUEBERRY CULTIVAR BRIGITTA BLUE AT FIVE DIFFERENT ARMILLARIA SPECIES IN TRENTINO REGION (NORTHERN ITALY)

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In 2005 carpophores and rizhomorfhs were collected in 40 forestall sites in Trentino region, they were isolated and identified by *mating tests* method. The results have demonstrated the presences of 5 different species of *Armillaria* (*A. cepistipe, A. ostoyae, A. gallica, A. mellea and A. borealis*) in the monitored area. One year later, Prodorutti et al. have identified in highbush blueberry (*Vaccinium corymbosum*) orchards only two species of this pathogen (*A. gallica* and *A. mellea*). Those works in forest and in field have confirmed that in Trentino region exist 5 species of *Armillaria*. The aim of these trials is to establish the potential aggressiveness of the five pathogens toward highbush blueberry plants (*A. cepistipe, A. ostoyae, and A. borealis* never observed on highbush blueberry). Two experiments were carried out, the first in vitro and the second in greenhouse. In laboratory the 5 species of *Armillaria* were plates in the centre of Petri dishes (90 mm of diameter) containing malt extract agar (MEA). Five repetitions for every different species of pathogen were made. The plates were incubated at 25°C and the growth of *Armillaria* was evaluated at 5, 10, 15 and 20 days. For the greenhouse trial, the 5 species of *Armillaria* were grown in Petri dishes containing MEA and sterilized apple tree shoots (7 mm diameter, 5 mm length). The plates were incubated at 25°C. After 21 days, 2-year-old highbush blueberry potted plants, variety Elliot, were infected by the apple tree shoots put into the grass, near the roots. Teen replications for every different species of pathogen were made. The pots were stored in the greenhouse and regularly irrigated. The manifestation of symptoms on plants was weekly observed during the entire season. The results obtained in vitro after 20 days of growth observation have evidenced an high aggressiveness of *A. mellea*, *A. borealis* and *A. cepistipes*. The development of the three pathogen were about 90 mm, but among all the theses we cannot observe significant differences ($P<0.05$). In the treatments with *A. ostoyae* and *A. gallica* the growth of pathogen was low, about 50 mm, without significant differences ($P<0.05$). In greenhouse the major number of symptomatic plants was monitored in the treatments inoculated with *A. gallica* (60%) and *A. mellea* (50%). The disease incidence of *A. borealis* was 20% and no plants inoculated with *A. cepistipes* and *A. ostoyae* were infected. This work demonstrates that among the 5 different species of *Armillaria* identified in Trentino, only *A. gallica* e *A. mellea* are potential pathogens in highbush blueberry orchards. *A. ostoyae*, *A. cepistipes* and *A. borealis* are three typical species of the forest and even if they are noticeable in the entire Trentino region, they do not attack highbush blueberry, though *A. borealis* has some potentiality.

BREEDING FOR CABBAGE WHITEFLY RESISTANCE IN *BRASSICA OLERACEA*

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The cabbage whitefly (*Aleyrodes proletella*) is a phloem-feeding insect that is becoming more and more of a problem in Western Europe. Especially Brussels sprouts, kale and Savoy cabbage can be heavily infested. Besides causing cosmetic damage, whiteflies excrete a sugary substance (honeydew) that allows the growth of sooty mould. Both types of damage reduce the marketability of the crop. The use of pesticides is hazardous to the environment and usually not very effective as whiteflies feed on the underside of leaves. Breeding for resistance would be a sustainable alternative. We have carried out a large resistance screening in the field. The screening included 434 accessions of crop wild relatives (CWR) and *Brassica* landraces (Pelgrom et al 2012). Several accessions of *B. oleracea* subsp. *capitata* were found to be resistant as well as some CWR, including *B. incana* and *B. villosa*. Previous studies have shown differences in the natural occurrence of adults, eggs, and nymphs on the closely related *B. oleracea* cultivars Christmas Drumhead and Rivera grown in the field (Broekgaarden et al 2010) also indicating that resistance is present in these heading cabbages. We aimed to identify the nature of these differences and to gain insight into the resistance mechanisms against *A. proletella*. We used no-choice experiments on field- and greenhouse-grown plants to show that the differences between the two cultivars are mainly based on antibiosis (traits that reduce herbivore performance) and not on antixenosis (traits that deter herbivory). This was further supported by laboratory choice experiments that indicated little or no discrimination between the two cultivars based on plant volatiles. We showed that resistance is dependent on plant age, that is, resistance increased during plant development, and is mainly independent of environmental factors. Analysis of probing behaviour revealed that the resistance trait affects *A. proletella* at the phloem level and that morphological differences between the two cultivars are most likely not involved. We hypothesize that compounds present in the phloem reduce sap ingestion by the whitefly and that this explains the observed resistance (Broekgaarden et al 2012).

FUNGICIDE FUNGICIDE REDUCTION BY USING MILDEW RESISTANT GRAPE VARIETIES

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Downy mildew (Oomycota: *Plasmopara viticola*) and powdery mildew (Ascomycota: *Erysiphe necator*) are the pathogens in charge of most of the pesticide applications in viticulture. In Europe quality wine is made from European or “noble” varieties that are generally susceptible to these two diseases. Only since a few years new resistant varieties are available especially in Germany, Switzerland, Austria, and the Netherlands. Their potential for quality wine production can be high. As wine economy is one of the most conservative businesses, a lot of attention is on varieties, tradition and terroir. In some countries the new resistant varieties are still regarded as “hybrids”, a word which in a viticultural context is often associated with bad quality. With regard to the wine potential and by applying the O.I.V. criteria for *Vitis vinifera* - varieties they can be classified as “European varieties” or “noble varieties” in other countries. Here the authors present two projects about the possible reduction potential of plant protection products (here copper) in mildew resistent grape varieties, financed by the PURE-Project and the German BÖLN-Programm (German federal research programm for organic farming and other forms of sustainable agriculture), respectively. Reducing fungicides in resistant varieties can be equivalent with a shortening of the spraying season or with the extension of spraying intervalls. Within the BÖLN project we followed the first and within PURE the second strategy. The trials were done in four adjacent organically managed vineyards, two of which with classical varieties and two with resitant varienties. As sulphur treatments in organic vineyards are considered as not problematic for the environment we focused on the reduction of copper. Copper is a heavy metall widely used in organic viticulture; as a drawback it shows a high aquatic toxicity that accumulates in the soil and can be toxic both for plants and grazing animals. Using a plot sprayer we sprayed up to nine different strategies in fourfold repetition each. Copper amounts were reduced in several degrees; in this way we wanted to learn about the number of essential applications per season. During the seasons 2011 and 2012 field observations were performed every week to observe the epidemiology of downy mildew. In late season one exact monitoring was carried out according to the EPPO standard PP 1/31(3). Both disease incidence and disease severitiy of leaves and clusters were calculated in each variant. For the estimation of severity we used ≤ 10%-intervals. Both years were characterized by a low disease pressure so that we could not find any berry attack by *Plasmopara*. In the two years disease severity on leaves in the untreated control plots ranged between 22 % and 25 % in the suceptible variety Pinot Noir and between 1% and 5 % in the resitant variety Calandro. Pinot Blanc and the resistant variety Regent were intermediate. That is the difference between Calandro and the “resistant” Regent was nearly as big as between Calandro and the succeptible Pinot Blanc. In effect, the resistant variety Calandro wouldn’t have needed any copper sprayings in both years under the local trial conditions. Regent on the other side needed a certain number of copper sprayings in 2012 to stay under a level of 5 % disease severity. Extending the application intervalls by only spraying every second time was an acceptable strategy for both resistant varieties and Pinot Blanc but not for Pinot Noir in 2012. The relative resistance of the varieties decreased as follows: Calandro > Regent > Pinot Blanc > Pinot Noir. For the reduction potential of fungicides other than copper against *Plasmopara viticola* probably the same alignment of the varieties is to be expected. The results are promising with regard to the reduction potential of resistant varieties for fungicides, but it should be kept in mind that this potential is as well correlated with the local and annual disease pressure. Both in 2011 and 2012 powdery mildew could be controlled sufficiently by sulphur applications.

EVALUATION OF RESISTANCE AGAINST FUSARIUM HEAD BLIGHT IN WHEAT VARIETIES

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Fusarium head blight (FHB) is caused by different fungi part of the genus *Fusarium* and *Micodochium nivale*. The disease can entail sever yield losses and the accumulation of different types of mycotoxins in the grains. Spores of the pathogens can infect the flowers under wet, especially rainy, conditions. Once established in the flower, the progression of the infection depends mainly on suitable climatic conditions and the resistance reaction of the plant. Wet and warm conditions promote the infection, while dryness or temperatures below 18°C slows it down. Wheat disposes of different types of resistance mechanisms able to impede primary infection of the spikelet (type 1) or the resistance against progression of the disease throughout the spike (type 2). Other resistance types influence the infection of the developing grains or the accumulation of mycotoxins therein. In the last years, several FHB epidemics have caused damage to wheat production in Europe and raised concerns about safety of food. Use of chemical fungicides having only a limited efficacy, control of the disease relays greatly on appropriate cultivation techniques to avoid infections and the use of resistant wheat varieties. The present work addresses the evaluation of the resistance against FHB in wheat varieties in the interplay between visible symptoms and accumulation of the mycotoxin deoxynivalenol (DON) in the kernels, climatic conditions and plant resistances. Several recent wheat varieties have been tested in two trial sites Nyon (canton Vaud, Western Switzerland) and Cadenazzo (canton Ticino, Southern Switzerland, South of the Alps) with artificial inoculation with high pathogenic strains of F*usarium culmorum* during 4 years. Disease severity has been scored as symptoms on spike but also on grain as Fusarium damaged kernels (FDK), modification of kernel size and accumulation of DON. Correlations of symptom scorings with climatic parameters allow to better understand resistance reactions of plants and hence improve selection methods for breeding of resistant wheat varieties.

INNOVATIVE STRATEGIES FOR COPPER-FREE LOW INPUT AND ORGANIC FARMING SYSTEMS (EU-PROJECT CO-FREE)

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In January 2012 the EU-project CO-FREE (theme KBBE.2011.1.2-06, grant agreement number 289497) with duration of 54 months, was launched. The project is coordinated by Dr. Annegret Schmitt with support of Dr. Sara Mazzotta (Julius Kühn-Institut). Deputy coordinator is Dr. Lucius Tamm (Forschungsinstitut für Biologischen Landbau). The CO-FREE project aims to develop innovative methods, tools and concepts for the replacement of copper in European organic and low input fruit, grapevine, potato, and tomato production systems. Copper-free production systems will be achieved by (i) providing alternative compounds and biocontrol agents, (ii) smart application tools and (iii) by integrating these tools into traditional and novel copper-free crop production systems, including agroforestry. The copper-free apple, grapevine, potato and tomato production systems will be (iv) evaluated in a multi-criteria assessment with respect to agronomic, ecologic and economic performance. CO-FREE will also develop strategies to develop (v) smart breeding goals by development of crop ideotypes and (vi) foster consumer acceptance of novel disease-resistant cultivars by consumers and retailers. The project follows a construction kit system, in which the different tools are integrated in to effective strategies and combined with horizontal activities regarding determination of socio-economic and ecological impacts. By involving farmers, advisors, plant protection industry, policy makers and researchers as well as the stakeholders of the European organic and low input sector (food supply chain, retailers, producers associations), CO-FREE will ensure a rapid development, dissemination and adoption of the copper replacement strategies. The multidisciplinary consortium proposed for the project includes 11 academic and 9 industry (all small and medium enterprises) partners from 10 European countries. All partner institutions are leaders in their respective fields and/or are leading providers of advisory services to farmers, retailers, policy makers and other stakeholders in the organic and low input sector. More information and the possibility to register for the CO-FREE newsletter is available under www.co-free.eu.

THE AGROENVIRONMENTAL POLICIES AND ITS IMPROVEMENT ON ENVIRONMENTAL QUALITY IN PORTUGAL

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During the last 20 years, common agricultural policies have been implemented addressing the environmental concerns of agricultural production. Key targets of those policies are the reduction of agricultural practices` impacts on the natural resources, water, soil and biodiversity. Organic farming (OF) and integrated production (IP) are sustainable production systems that are, theoretically, based on principles, tasks and technologies that expectably reduce negative impacts on the environment. Biodiversity and agricultural production are interlinked and their ability to be reciprocally supportive is recognized. The issue biodiversity involves diversity of species and habitats either depending on agricultural practices or negatively affected by farming (e.g. fertilizer and pesticides use). In Portugal, to evaluate how OF and IP are effective in ecological benefits on farmland, a survey was performed with 141 vineyard farmers in the main important regions: Verdes, Douro, Dão and Alentejo in 2005 and 2006, supported by the national project AGRO 545 "The environmental indicators to assess the IPM, the integration production, the organic farming and the sustainable use of pesticides", with the major goal of assessing the impact(s) of farming practices on pest importance and functional biodiversity. A total of 1215 arthropods were captured, belonging to the groups Araneae, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera, Orthoptera, Psocoptera and Thysanoptera. A total of 15388 specimens of weeds were identified, belonging to 63 species or genus, distributed in 26 families Amaranthaceae, Boraginaceae, Cyperaceae, Clusiaceae, Compositae, Convolvulaceae, Cruciferae, Dennstaedtiaceae, Equisetaceae, Scrophulariaceae, Fumariaceae, Geraniaceae, Gramineae, Labiatae, Leguminosae, Malvaceae, Onagraceae, Plantaginaceae, Polygonaceae, Portulacaceae, Primulaceae, Pteridaceae, Chenopodiaceae, Rosaceae, Solanaceae, Umbelliferae. Differences among regions were found due to territorial structure and farm dimension. OF and IP impacts on biodiversity revealed to be low, with small differences to conventional farming. Agricultural impacts on ecosystems seemed to be better evaluated with indicators related to cultural practices, farm characteristics and farmers attitudes. "Total amount of pesticides", "Number of pesticide applications", "Use of herbicides" and "Different species surrounding" performed good results to assess biodiversity and sustainability. Therefore the results revealed that ecosystem assessment should not be based only on production systems as a variable. In fact, sustainable production systems have not been sufficient to ensure environmental quality. Results are important to improve the effectiveness of current and future policy programs and, as expected, OF and IP impacts on the environment have a tendency to be low, but conventional systems revealed a similar tendency, induced by the need of reducing production costs.

WATER QUALITY AND IPM – CORE TASKS OF THE CZECH NATIONAL ACTION PLAN

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The Czech National Action Plan sets quantitatively measurable tasks, milestones and final objectives, measures and timetables to reduce the risks and limit the impact of using the products on human health and the environment, with the aim to support the development and implementation of integrated pest management (IPM) and alternative approaches or procedures in order to reduce dependency on the use of the plant protection products (PPP´s).
The quantification of the objectives and milestones of the NAP for the Czech Republic respects the basic role of plant health care, i.e. to ensure plant health and plant products with regard to food safety and consumer protection, and is based on identifying the risks associated with using the PPP´s. The main general principles of IPM already work in practice in the CR, thus it does not concern completely new procedures. The implementation of a large number of individual NAP measures puts high demands on institutional cover. The Ministry of Agriculture (MoA) will therefore strengthen its specialist division, in the framework of its organizational structure, to ensure strategic management during the implementation of the NAP. An analysis of the financial demands of all 69 proposed measures to implement the NAP shows that 40 NAP measures can be carried out within the existing working capacities and duties of state administration in the respective branches of agriculture, health and the environment, without additional demands on the state budget. A number of the NAP measures are aimed at increasing the effectiveness of the existing control activities, e.g. the mutual exchange of monitoring results, therefore, extra costs are not assumed in this area. A total of 18 measures are aimed at transforming existing data collection systems and at obtaining, transmitting and evaluating information. The extra costs incurred for implementing these measures are estimated at around CZK 25 million/year and financial means will be requisitioned in the context of the MoA, Ministry of Environment (MoE) and Ministry of Health (MoH) budgets. The NAP also sets out quantitative performance indicators for the NAP such as reduction of residues in food and water by 2020, by about 10 or 15% compared with the average of all measurements taken during the reference period 2008–2010. Another quantitative indicator is the reduction in the area of groundwater or surface water bodies that exceed environmental quality standards due to the presence of residues. The NAP will be implemented from 2013. The NAP update will be prepared on the basis of a draft submitted by the ministers of agriculture, health and the environment to the Government for approval by resolution every 5 years at the latest.

SCOUT&CLOUD: A GIS-EVOLUTED DATABASE TO MONITOR GRAPEVINE PESTS AND DISEASES PROCESSING DATA REAL-TIME INTO CLOUDS.

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Environmental concern and awareness are nowadays particularly considered by the society, thus also the new EU Directive 2009/128/EC moved towards this direction. One of the aspects discerned in the directive is related with the pest/diseases monitoring. Usually technicians visit vineyards in order to evaluate the occurrence of diseases or pests, but a fast and precise numerical evaluation is sometimes difficult to make. Moreover, this information is never available real-time for other technicians/winegrowers and regional phytosanitary services, since data are often registered on notes with different collection methods. Thus a real-time availability of information is not accessible, and data are often analysed only at the end of the season when they are useless for pest management. Since 2004, a phytopathological database was set up and uploaded in a portable GPS with the aim to create a georeferenced archive of the occurrence of pests/diseases together with other vineyard information (phenology, mineral/water deficiency, etc.). In the different fields of the database there is the possibility to enter monitoring data (raw indices of severity and incidence) but also precise evaluation based on EPPO guidelines. Control plots (untreated with fungicides) must be separated on the database thus with post-processing they can be analysed alone. In any case these plots should not be averaged together with the data collected for monitoring purposes. For field purposes, GPS device needs to be rugged and possibly GPRS-connectable. The information can be sent to a cloud computing service where the data are processed real-time; at this stage a checking system evaluates data accuracy indicating possible mistakes, leaving to the operators to correct the problem. Once error-checking is ended, post-processing throughout maps or pivot table could be easily produced in clouds in real-time. The data presented on cloud could be confirmed or denied by advisors since there is nowadays availability of free mobile apps that can be used for this purposes. The ping-pong system becomes a valid tool for the interaction between technicians and winegrowers, profitable also for monitoring purposes since more vineyards can be surveyed. One important task to solve is the preparation of advisors and technicians, since a comparable monitoring method for disease/pest assessment is required. Together with phytopathological models, the knowledge of the occurrence and development of pest/disease is an important tool nowadays in order to support decisions. For each pest/disease, thresholds can be identified and used for fungicide/insecticide applications. After several years of field experience, the collection method is now well established and uploaded on the GPS devices. The interaction between field scouting and data “clouding” could be in the near future a low cost and a highly reliable solution for pest/disease monitoring, thus allowing information to be real-time available for winegrowers.

APPLICATION OF DEXiPM® TO ASSESS THE SUSTAINABILITY OF AN INNOVATIVE APPLE PRODUCTION SYSTEM: THE EXCLUSION NETTING

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Tree crops production are highly dependent on external inputs, namely pesticides. Redesign tree crop production on other bases becomes a necessity. Before being tested in an experimental station or in real farm conditions, the global sustainability of these newly designed orchards needs to be evaluated. Adapted on the DEXiPM® model, the DEXiPM-pomefruit tool has been designed to make an ex ante assessment of the sustainability of innovative orchard systems. This model is based on a decision tree breaking the decisional problems of sustainability assessment into simpler units, referring to the economic, social and environmental dimensions of sustainability. In the frame of the PURE European project, we tested DEXIPM-pomefruit relevancy to assess the sustainability of innovative orchards. Two apple production systems were compared: one with exclusion netting against codling moth and one without. Exclusion netting is an innovative control method, which decreases the number of treatments by 30 % since all treatments against codling moth are suppressed. Moreover nets represent a good protection against yield loss risk due to climatic conditions (i.e. hail). However, its cost requires an important investment capacity. Assessed by DEXiPM-Pomefruit, the exclusion netting system globally ranked better than the uncovered system. Concerning the social aspect, the result was similar for both production systems. In contrast, economical performances were improved in orchards covered with nets, which are therefore protected against the climatic risk of yield loss. Moreover, the important decrease in pesticide use under nets contributed to improve all environmental impact indicators.

DEXiPM-pomefruit helped selecting the most promising innovations in a given context. It was also used as a dashboard to determine strengths and weaknesses of the tested production systems and therefore to identify potential improvements.

METHODS FOR IPM: ADVANCES IN THE METHODOLOGICAL WORKPACKAGE OF PURE

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The overall objective of PURE is to provide practical IPM solutions to reduce dependence on pesticides in selected major farming systems in Europe. This paper summarises methodological advances with regards to the design and assessment of IPM solutions. The presented case studies include major crops (cropping systems based on wheat or maize), field vegetables, orchards, vineyard and Controlled Environment Agriculture systems.
- Ecological modelling. A software package (Universal Simulator) for collaborative ecological modelling is now available:http://www.ecolmod.org/.
- Modelling for ex-ante and ex post assessment of IPM solutions. A multi-criteria model (DEXIPM) for sustainability assessment of innovative crop protection strategies has been developed along with SYNOPS, a web-based model for scaling up ex-post pesticide risk assessments at the individual crop level to the farm and regional levels. In addition, a model for ex-ante evaluation of IPM solutions is currently under development specifically for orchards (PREMISE).
- Multiple pest modelling. An interactive generic modelling platform to help design models that simulate yield losses caused by an injury profile in a given production situation (X-PEST) is currently under development. Moreover, theoretical mathematical modelling approaches are conducted to represent the interactions between generalist biological control agents and multiple pests.
- Optimisation techniques. Reinforcement learning methods have been adapted and applied to IPM. Multiobjective optimisation algorithms for model-based design of IPM solutions are being developed. The Graph based Markov Decision Process framework is being used for the optimisation of sequential decisions under uncertainty in a spatial context.
- Cost-benefit analysis and consumers' willingness to pay. Cost-benefit analyses are conducted for IPM solutions tested in the PURE project. An experimental approach is planned to characterise consumers' willingness to pay for agricultural goods produced under IPM solutions as a function of their level of information on the mode of production.
It is important to state that the methodological breakthroughs produced in this work package will not only benefit to the PURE project, but also aim at contributing to the design of practical IPM solutions to reduce dependence on pesticides for a wider range of farming systems. This is made possible by ensuring as much as possible genericity in the developed approaches.

PESTICIDE RESIDUES IN ARTICHOKES, TOMATOES AND PEACHES: FIRST RESULTS OF A SURVEY IN SARDINIA

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Pesticide residues in food represent one of the most important causes of concern in the field of food safety. Although most farmers use pesticides properly, following the instructions on the ministerial label and minimizing the number of treatments, there is always the possibility that a pesticide residue might be found on food. Reliable residue analysis data resulting from monitoring programs in foods may be of great value in showing the possible risks connected with dietary exposure to pesticide residues. The objective of this work is to increase our knowledge on diffusion, frequency and causes of pesticide residues on various agricultural products in Sardinia. Starting from May 2011 up to June 2012, 289 samples of artichokes, salad tomatoes and peaches were collected and analyzed as part of the Sardinian Regional Monitoring Programme. The samples were collected at the moment of harvesting directly in the field, during the entire period and throughout all areas of production for each species. Each sample was accompanied by a document on which was recorded each chemical treatment applied during the cycle of cultivation and other identifying details (variety, geographic coordinates, date of samplings, date of treatments, commercial formulations, dosages, etc.). The analytical methods allowed a good extraction and separation of more than 330 pesticides (using LC/MS/MS and GC/MS/MS devices). The method limits of quantification (LOQs) and determination (LODs) were calculated as 10-fold, and 3-fold the signal-to-noise ratio. All pesticides showed LODs and LOQs far below their maximum residue level (MRLs) set by the European Community. Artichokes. 102 samples were collected and analysed; 94.1% were found to be free of pesticide residues, while 5.9% showed residues lower than 50% of their MRLs peaches. Results relate to 86 samples; 66.2% revealed residues lower than 50% of their MRLs, while 4.7% between 50% and MRL. Most of the residues found were due to Tebuconazole (33 samples) and Propargite (18); 29.1% were void of pesticide residues. Tomatoes. 58.4% of the 101 samples analyzed were found to be void of pesticide residues, while 40.6% revealed residues below 50% of their MRL. Only one sample showed a residue close to its legal limit. The agricultural products most contaminated were found to be peaches, while artichokes and tomatoes showed a very low level of pollution. However, no residues were found above the EU legal limits. The results obtained by the survey show no cause for concern related to the pest management strategies applied to the species investigated and based on the use of chemical products.

ALTERNATIVES TO CONVENTIONAL PESTICIDES IN CONTROLLING GRAPE BERRY MOTHS

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A number of microbial and botanical pesticides have been selected (i.e. *Bacillus thuringiensis*, azadirachtin, *Beauveria bassiana*, pyrethrins and spinosad) to test their effectiveness against berry moths and leafhoppers. Their side-effects on beneficials were also evaluated. Trials were conducted in two experimental vineyards located in Tuscany and Veneto regions in 2011 and 2012, following a randomized block design. Regarding the efficacy of microbial and botanical pesticides on *L. botrana*, results of trials carried out in 2011 stressed the high performance of spinosad. Azadirachtin and *B. thuringiensis* gave satisfactory results in Veneto but not in Tuscany. In 2012, berry moth populations in Tuscany reached lower levels compared to the previous season. Trials carried out in Veneto confirmed the efficacy of spinosad, *B. thuringiensis* and azadirachtin towards *L. botrana*. In this farm leafhoppers were more abundant in spinosad and pyrethrins treated plots. The side-effects of pesticides were evaluated on predatory mites (*Typhlodromus pyri* and *Amblyseius andersoni*). Spinosad and pyrethrins reduced significantly predatory mite populations compared to other treatments.

MODELLING IPM STRATEGIES AT THE LANDSCAPE SCALE

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There is plentiful evidence that pest regulation should be considered at spatial scales beyond that of the cultivated field; weeds (Roschewitz et al., 2005), arthropods (natural enemy and pest species) (Tscharntke et al., 2008) and microbial pathogens (Plantegenest et al., 2007) all respond to broad landscape characteristics such as fragmentation and complexity. These results suggest that pest-suppressive landscapes could be designed in a way which is consistent with the pattern-process-design paradigm of landscape ecology (Nassauer and Opdam, 2008). However, such studies have yet to provide sufficient knowledge of either the pattern or processes in order to direct the design phase. Because of the limited capacity to manipulate and observe pest systems at a sufficiently large spatio-temporal scale, we must rely heavily on modeling approaches to tackle both the process and design steps required (Begg et al., 2010). To address this we have been developing software for the implementation of a class of spatially explicit models, capable of simulating the dynamics of pest populations across farmed landscapes. Our objective is to be able to simulate the response of a broad range of pest systems to spatio-temporal patterns in the deployment of IPM control strategies across farmed landscapes, including the dynamics of secondary pests and natural enemies as necessary. To achieve this, a spatially explicit population model (SEPM) framework has been adopted, which couples matrix population models with an explicit representation of the farmed landscape. In this presentation we introduce our approach; describing the class of models, outlining their implementation, and listing some potential applications. A model of the Western corn rootworm (*Diabrotica virginifera virginifera*) has been developed for illustration; here we present some simulations to show the response of this major pest to the deployment of IPM-related control measures at the landscape scale.

PEST ADVISE STATION IN NAVARRA, SPAIN

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The Advise Station is a network of monitoring and follow-up of plagues and diseases for the different cultures of Navarre (Spain). The principal aim is to provide to the agricultural sector of a precise information that helps him to give response to his demand in protection of cultures. The second aim is to assure to the public organisms, the Department of Rural Development, Environment and Local Administration, offer a technical necessary support in official actions of follow-up, evaluation and analysis of the sanitary condition of the cultures of Navarre, included the pathogenic ones of quarantine. The third aim is to provide as detailed as possible information for the agricultural technical personnel who are supporting the actions of the farmer All the information gathered by the Station of Notices is transmitted to the sector for Web route, presses and messages to mobiles.

MODEL OF ECONOMIC THRESHOLD AND ECONOMIC INJURY LEVEL – CASE STUDY FOR CEREAL BEETLES AND EUROPEAN CORN BORER

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Economic threshold (ET) is important part of integrated pest management. ET differs according to pest and crop. ET varies with economical parameters as cost or price. Model of ET enabling to take into consideration agronomical and economical parameters was established. Model of ET or economic injury level (EIL) were established as: ET (EIL) = 100 × C × e × i/ D(Pd) × Y × P, where damage curve was D = A0 + A1 . Pd, D = damage (decrease of yield in %), Pd = population density of pest, C = cost of pest control, e = efficacy index (e = 100/efficacy in %), i = impact on the environment (from 1 to 3), Y = yield, P = price of product. Damage curves were established for cereal beetles and European corn borer based on field experiments. According to damage curves it is possible to predict yield losses according to population density of pest. According to model of ET and damage curve it is possible to determine population density of pest as a criterion for pest control. Model of ET takes into consideration efficacy of pesticide and economically evaluate negative impact of used pesticide on the environment. Model of EIL enables to evaluate economical efficacy of pest control. For European corn borer, model of EIL enables also evaluate economical efficacy of Bt-maize growing. The work was supported by the project of the Technology Agency of the Czech Republic, no. TD010056.

EVALUATION OF CHRONIC TOXICITY OF EIGHT PESTICIDES TO *ADALIA BIPUNCTATA* L. (COLEOPTERA COCCINELLIDAE) USING A DEMOGRAPHIC APPROACH

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Abstract: Acute mortality estimates are the most widely used measures of toxicity and often they are used as endpoint in ecological risk assessment. Such methods do not provide enough information about the actual effects that may occur in pesticide-exposed populations over longer time periods than a few days. In this study we utilize demographic and population modelling for estimation of pesticide effects on a beneficial species. Bioassays were carried out in the laboratory to assess the demographic responses of the coccinellid *Adalia bipunctata*, exposed to four neonicotinoids, including imidacloprid, thiacloprid, thiamethoxam, and acetamiprid at sublethal dose and to rynaxypyr, emamectin benzoate, spinosad, and spirotetramat at maximum recommended field rate, as indicated on the label for stone fruit. Demographic parameters were calculated by means of life tables. Life table data were also used to generate an age-classified projection model (Leslie matrices). Demography has been used to evaluate the total effects, lethal and sublethal, of pesticides on population by means of a Life Table Response Experiments (LTREs). Finally the Delay in Population Growth Index, a measure of population recovery, was calculated to compare the time required to a control population and pesticide-exposed populations to reach a predetermined number of individuals. Exposure of adult stage to imidacloprid, thiamethoxam, rynaxypyr and spirotetramat significantly reduced all the demographic parameters in comparison with control, with the sole exception of mean generation time, and results in a pronounced slower increase in the coccinellid population. LTRE analyses showed very different effects on the vital rates among insecticides. Respect to control, adult exposed to imidacloprid suffered higher acute mortality and reduced adult fecundity, instead for thiamethoxam survival of young adults, and not reproduction, had the major effect on population growth. Reduction in egg fertility had the higher effect on population growth when coccinellids were exposed to rynaxypyr and spirotetramat. For the former also acute exposure contributed to reduction of population growth. Rynaxypyr and spirotetramat caused a faint population delays, instead the exposure of adult to the two neonicotinoids imidacloprid, thiamethoxam resulted in a very pronounced effect. Demographic approach showed to be effective to evaluate lethal and sub-lethal effect of the different insecticides. Moreover, LTRE analyses pointed out significant differences among insecticides belonging to the same family, resulting a very sensitive method.

ANALYSIS OF SOIL NEMATOPHAUNA DIVERSITY AS INDICATOR OF PESTICIDES RISK

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The wide range of feeding types and the ability to adapt to seasonal succession make nematodes significant indicators of ecological conditions of the soil in which they occur. Soil nematophauna is highly sensitive to any environmental damage and, therefore, the analysis of soil nematode community can be a useful diagnostic tool of soil health changes caused by polluting agents, among which also pesticides. Traditional morpho-taxonomic techniques for analysis of soil nematophauna have been flanked or substituted by more innovative and quicker molecular tools. Effectiveness of morpho-taxonomic and molecular techniques was comparatively evaluated through the analysis of soil nematode community from three selected relatively undisturbed and disturbed sites in Apulia region (Italy). Nematodes for both analyses were extracted from 100 g sub-samples of composite soil samples collected at each site. Specimens for morphological analysis were fixed in a 2.5% formaldehyde solution a nd then identified at family and genus level under an optical microscope. The maturity and trophic diversity indices were determined. Total DNA was extracted from the nematode community of each soil subsample and PCR amplification was performed by using the small subunit (18S) of the ribosomal DNA gene, as diagnostic marker. The 18S rDNA was selected because of the large number of 18S sequences in GenBank, the existence of an 18S-based phylogenetic tree and the conserved nature of this gene to ensure complete phylogenetic coverage of the phylum. Sequence analysis through BLAST allowed to classify most of them at genus level and some of them at species level. Few sequences showed no similarity with those present in the database suggesting that they are new for the scientific community. The maturity and trophic diversity indices were also calculated for genera identified at molecular level. Results confirmed that nematodes are good indicators of soil health, as showing a different level of disturbance for each of the three sampled sites. Both morpho-taxonomic and molecular tecniques showed to be effective, though morpho-taxonomic is more time-consuming and skilfulness-requiring whereas a molecular analysis is largely more expensive.

SYNOPS-WEB, AN EASY-TO-USE ONLINE TOOL TO ASSESS THE POTENTIAL AQUATIC AND TERRESTRIAL RISK OF PESTICIDES ON FIELD LEVEL

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The use of pesticides in agriculture causes environmental risks that must be carefully managed. One overall goal of the current German National Action Plan (NAP) on the Sustainable Use of Plant Protection Products is to reduce the environmental risk by 25%. Within the NAP the risk indicator model SYNOPS is used to assess the terrestrial and aquatic risk of pesticide use in agriculture. The current indicator model is applied for different modes of action. SYNOPS-TREND is used to assure the tracking of the risk trends on national level on yearly basis with annual sales data. SYNOPS-GIS is applied for regional risk analysis and the detection of hot spots with field based surveys on pesticide use and extended GIS based datasets on land use, slope, soil types and climate. In this study a third application level, SYNOPS-WEB was developed in order to make this indicator available as an easy-to-use online tool, which can be used by farmers, advisors and stakeholders for risk analysis and comparison of single pesticides application strategies on field level. Within the EU project PURE, SYNOPS-WEB is applied for ex-ante assessment of newly designed IPM strategies for the different crops. The user can select a certain field by using a map-service, choose a crop to be treated and enter the pesticide applications to be tested. With the field selection SYNOPS-WEB will automatically extract the field and environmental parameters which are necessary to assess the aquatic and terrestrial risk from the soil geographical database of Eurasia at a scale of 1:1000000, a database on the soil erodibility and a generalised land-use map, which lists the most important land-use types (annual corps, grass, permanent crops and rice). In addition interpolated datasets for mean monthly temperature and precipitation are linked for meteorological input parameters. Furthermore a database of about 500 active ingredients and a dataset of all registered pesticides in Germany are linked to the tool. Using these datasets the user can easily choose an active ingredient or products (only for Germany) to be applied and enter the application date, rate, area and the type of equipment used. SYNOPS-WEB then calculates and displays the risk indices in the form of tables or charts per active ingredient or for the complete pesticide use strategies. These results can be downloaded as excel- tables, XML-files or as report files.

SUSTAINABILITY OF THREE WINTER CEREALS BASED CROPPING SYSTEMS – PRESENTATION OF THE EX-POST ASSESSMENT OF A FRENCH TRIAL

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We have been testing 3 cereals based cropping systems since 2008 in the experimental station of Boigneville (FR-Essonne). In the advanced system (AS) crop protection practices follow the organic production rules. The intermediate system (IS) follows integrated pest management principles. The current system (CS) represents the current conventional practices of the region which aims to optimise crop production. The objective of the trial is to compare the overall sustainability of the three winter cereals based systems on economic, social and environmental points of view. Economic sustainability implies that the AS and IS are as profitable as the CS in terms of yield and quality of the harvested products despite a lower input of both pesticides and fertilizers. Conducting the experiment over a number of years under contrasting climatic conditions allow us to assess the robustness of the 3 cropping systems. The three cropping systems are compared in large plots of 1 to 3 hectares (in total 14 plots). The AS is a 6 years rotation while the IS and CS are 4 years rotations. Each crop of the rotation is grown every year to allow us to examine the climate impact on crop performance. For each of the 3 cropping systems we follow a set of decision rules. All operations, inputs and results are registered in SYSTERRE®, a software that calculates about 20 different indicators at the plot or the system levels. Since 2008 we have been successful in implementing the three cropping systems according to their decision rules. But we have also found that the IS system is not successful every year and is more variable and more influenced by climatic conditions than the CS. In the IS and CS the use of pesticides is crucial to ensure maximum yields and high quality of the harvested crops. In recent years all the cropping systems have been profitable, and each system has fulfilled its objectives. But in some years quality of the harvested crops is an issue in the AS and IS and we also have bigger problems controlling the weed flora in some crops in all three cropping systems. For the 3 years between 2008 and 2010 the three different cropping systems showed good sustainability performances according to the DEXiPM model. They achieved a score going from high (4/5) to very-high. Despite the same final score (high), CS and the IS showed different performances on the three categories. AS obtained a very-high overall sustainability score, characterized by high socio-economic and very-high environmental performances. We foresee to complete the assessment of the three systems by following the long term results over 2010. Lastly, some methodological elements need to be discussed to conclude on the innovative IPM, including: how to assess the link between pesticide use and risk of transfer in the groundwater, what is the long term effects of the systems on the environment (flora, biodiversity, soil quality,...), what is the representativeness and extrapolation of the results observed.

SUSTAINABILITY OF EUROPEAN MAIZE-BASED CROPPING SYSTEMS WITH DIFFERENT LEVELS OF IPM AS EVALUATED WITH THE DEXIPM® MODEL

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There is strong social and political pressure to reduce pesticide use in European crop production systems. Evaluating the overall sustainability of cropping systems is a complex task due to the conflicting objectives underlying the economic, social and environmental dimensions of sustainability. The development and use of models that assess different Integrated Pest Management (IPM) scenarios and evaluate the most sustainable practical options at regional, national and European level is essential. Within the EU Project PURE, a working group was formed aiming to design, assess and compare ex-ante (before testing them in field experiments) the sustainability of advanced (AS) and innovative (IS) maize-based cropping systems (MBCSs), using different IPM levels, for three European regions (northern Italy, southern France, eastern Hungary), against the conventional approach (CS). The systems' design derived from expert-based surveys that were performed during the EU project ENDUR E and from further discussion with different stakeholders in each region. The DEXiPM® model for arable crops, a qualitative and multi-attribute model developed within ENDURE and based on DEXi software, was used to evaluate and compare ex-ante the sustainability of these systems. In France, the AS and IS consisted of a maize/soybean rotation with different levels of IPM against the continuous maize that is the dominant system in southern France. In Italy and Hungary, the AS consisted of maize/winter wheat/soybean rotation and the IS of maize/winter wheat/ (cover crop) soybean (cover crop) rotation, both against the conventional maize/winter wheat rotation. IPM-based strategies used in all AS and IS aimed at the reduction in or sustainable use of pesticides (i.e. band application of herbicides, mechanical weeding, insecticides selective towards beneficial organisms or bioinsecticides to control *Ostrinia nubilalis* Hübner). Results of the ex-ante assessment using DEXiPM showed that in France, the AS maintained the same high economic sustainability as the CS, whereas the IS had a lower score, mainly due to an increase in the production risk (lower potential yield). However, both AS and IS increased the social sustainability with a better landscape social value and higher contribution to employment, while the IS even improved the environmental sustainability compared to the other systems. In Italy, the AS was the most sustainable system compared to the CS and IS, improving the environmental and social sustainability. However, the IS had the same overall sustainability as the CS because, although the economic sustainability decreased the environmental sustainability increased. In Hungary, AS and IS had an overall sustainability similar to that of CS, since although the economic sustainability was reduced the social sustainability was greatly improved. In conclusion, the overall sustainability of all AS and IS designed by the partners and assessed with DEXiPM maintained or even had higher sustainability than the CS, indicating that these MBCSs are acceptable for further consideration and testing in field experiments.

SUSTAINABILITY OF THREE WINTER CEREALS BASED CROPPING SYSTEMS – PRESENTATION OF THE EX-POST ASSESSMENT OF A FRENCH TRIAL

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We have been testing 3 cereals based cropping systems since 2008 in the experimental station of Boigneville (FR-Essonne). In the advanced system (AS) crop protection practices follow the organic production rules. The intermediate system (IS) follows integrated pest management principles. The current system (CS) represents the current conventional practices of the region which aims to optimise crop production. The objective of the trial is to compare the overall sustainability of the three winter cereal based systems. Sustainability is assessed on economic, social and environmental points of view. Economic sustainability implies that the AS and IS are as profitable as the CS in terms of yield and quality of the harvested products despite a lower input of both pesticides and fertilizers. Conducting the experiment over a number of years under contrasting climatic conditions allow us to assess the robustness of the 3 cropping systems. The three cropping systems are compared in large plots of 1 to 3 hectares (in total 14 plots). The AS is a 6 years rotation while the IS and CS are 4 years rotations. Each crop of the rotation is grown every year to allow us to examine the climate impact on crop performance. For each of the 3 cropping systems we follow a set of decision rules. All operations, inputs and results are registered in SYSTERRE®, a software that calculates about 20 different indicators at the plot or the system levels. Since 2008 we have been successful in implementing the three cropping systems according to their decision rules. But we have also found that the IS system is not successful every year and is more variable and more influenced by climatic conditions than the CS. In the IS and CS the use of pesticides is crucial to ensure maximum yields and high quality of the harvested crops. In recent years all the cropping systems have been profitable, and each system has fulfilled its objectives. But in some years quality of the harvested crops is an issue in the AS and IS and we also have bigger problems controlling the weed flora in some crops in all three cropping systems. For the 3 years between 2008 and 2010 the three different cropping systems showed good sustainability performances according to the DEXiPM model. They achieved a score going from high (4/5) to very-high. Despite the same final score (high), CS and the IS showed different performances on the three categories. AS obtained a very-high overall sustainability score, characterized by high socio-economic and very-high environmental performances. We foresee to complete the assessment of the three systems by following the long term results over 2010. Lastly, some methodological elements need to be discussed to conclude on the innovative IPM, including: how to assess the link between the pesticide use and the risk of transfer in the ground water, what is the long term effects of the systems on the environment (flora, biodiversity, soil quality, etc.), what is the representativeness and extrapolation of the results observed.

THE NL CERTIFY WATER QUALITY PROJECT - ENSURING IMPLEMENTATION OF EFFECTIVE EMISSION PREVENTION

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The evaluation in 2011 of the results of the Dutch Crop Protection Policy over the period 1998-2010 showed that in spite of the progress in reducing impact of pesticides that was achieved, the ecological surface water quality still remained problematic. Frequently too high concentrations of pesticides were found in the measurements. In 2009 more than 50% of all measurements showed one or more pesticides exceeding the water quality norms. Explanations can be found in the behaviour of farmers, not always sticking to the rules, and maybe even more important in differences in criteria for allowance of pesticides and criteria for water quality (more severe). Whatever might be the cause, fact is that all involved stakeholders, working together during the last part of this policy period in the national agreement on sustainable crop protection (the so called covenant), agreed in 2011 on the necessity to reduce the incidence of exceedances of water quality norms. Their interest are different, but all of them want a more lasting solution for water quality problems via the pathway of ensuring that effective methods to reduce emission of pesticides are taken up in different certification or regulation schemes, varying from private efforts in the supply chain to government regulations of environmental legislation. Therefore they together financed the socalled Certify Water Quality project, that started in early 2012. The project brings together the group involved in the Farming with future project (Wageningen UR and DLV Plant) and CLM, a private research/consultancy. The premise of the project is that there is sufficient knowledge of the problem itself, the emission pathways leading to the problem and the technical possibilities to reduce the emission losses in these pathways. This knowledge was gained over the last 10 years in a rather large portfolio of different projects. To reach the objectives the project takes the following steps: 1) establishing working groups of stakeholders in different sectors and regions in the Netherlands, 2) identifying the key problems (joint fact finding), 3) determining the major emission pathways, 4) drafting a list of possible measures to reduce the emission risks, 5) establishing which methods have broad support from the stakeholders, 6) exploring the possibilities to integrate these methods into existing regulations or private certifying schemes, 7) eventually preparing the technical paragraphs for the diverse instruments. The work has progressed through step 6. It is basically a selection process, selecting relevant measures, then selecting those with broad support and then selecting instruments that are suitable to host these measures. However, without the support and determination of the stakeholders and their subsequent acting in the agricultural network, solutions cannot be implemented. Stakeholder involvement and -management therefore is a crucial part of the project.

LOCAL AND LANDSCAPE EFFECTS ON THE FUNCTIONAL BIODIVERSITY IN MANGO ORCHARDS ON REUNION ISLAND

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Mango production, which is an important part of tropical areas' economy, is at a phytosanitary and technical dead-end on Reunion Island. The use of chemical insecticides doesn't limit the losses in economy, caused by harmful insects (Diptera, Heteroptera, Homoptera and Thysanoptera). The inefficiency of these energizing and chemical inputs, dictate plant protection evolution towards agro-ecological practices. One of them is to create habitats in crops, in order to promote diversity and abundance of pests' natural enemies. Management of functional biodiversity requires the understanding of the ecological processes involved and the capacity to identify the factors governing predatory arthropod communities in agro-ecosystems. The integrative approach of this study is to characterize the richness and diversity of arthropod predators in mango orchards, depending on various factors: plant species richness in the crop, farming practices and landscape context. The study focuses on epigeal arthropod predators, which are involved in the cycle of several pest species, such as Cecidomyiidae and Tephritidae whose last instar is characterized by a fall to the ground, so as to achieve their pupal stage in the soil. Twenty-four plots were considered, divided into the mango production basins of Reunion Island. Characterization of the composition and properties (richness and diversity) of predatory arthropod communities was conducted by sampling, using pitfall traps. Vegetation adventitious inventory within the orchards permitted to quantify plant species richness. Plots were pooled (fuzzy partitioning) according to their agricultural practices and landscape context. The measures of 17 parameters, corresponding to the nature and frequency of the plant treatment, as well as the weed vegetation management, have identified four practices intensity regimes. The landscape has been mapped to a circle of 400 m radius around each plot; the 11 measured parameters, characterizing the landscape structure and heterogeneity, have distinguished three types of landscape contexts. Richness and evenness of predatory arthropod communities were correlated and compared to these three scales of factors. Trappings revealed that predator communities consisted mainly of ants (Hymenoptera: Formicinae) and of 11 spider families (Araneae). Analysis highlighted the fact that these communities had: (1) a diversity positively correlated with the richness of the vegetation, (2) a greater richness in more moderate cultural practices, (3) a species richness higher when landscape context is heterogeneous, with fragmented mango orchards. To our knowledge, this is the first simultaneous detection of local and landscape factors effects on terrestrial arthropod predators' diversity in a tropical agro-ecosystem.

EFFECT OF CULTIVATION AND CHEMICAL TREATMENT ON DIFFERENT GUILD OF ARTHROPODS IN GRASSLAND OF INNER MONGOLIA

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In grassland of Inner Mongolia, China, outbreak of pests is getting serious probably due to intensification of agricultural activities. The area of cropland has increased from 43,300 km^2 in 1949 to 76,300 km^2 in 2005. Pesticide application is a main method for pest management in grassland of Inner Mongolia. To clarify the influence of agricultural activities on characteristic of arthropod distribution under field condition using a combination of several covariates: pesticide application, landscape, climatic factors and plant type, which are commonly known as determinants of arthropod population. Sweep net samplings were conducted at 41 sites in natural grassland. Consequently, 1287 individuals belonging to 23 families and 9 orders of arthropods were collected. We grouped samples into 2 guild types, predators and herbivore. We analyzed six groups (grasshopper, hervivory Coleoptera, herbivory Hemiptera, Cicadidae, Araneae, predatory Coleoptera) of them. We analyzed the relationship between sampled population size of each group and environmental factors by negative binomial regression analysis. The best model of each group was determined by Akaike's Information Criteria. The result of negative binomial regression revealed that pesticide application, vegetation coverage, agricultural site and dominant plants were selected as parameters of the best model of grasshoppers showing positive relationship. In other words, more grasshoppers were sampled at sites where pesticide was applied, vegetation coverage was relatively high, agricultural site and dominant species was Cyperaceae or Asterales. Pesticide application and dominant plants were also selected as parameters for best model of Araneae, but these parameter values were negative. Additionally, the parameter of mean temperature is negative and the parameter of agricultural site is positive. It was implying that Araneae has a trend of occurrence at sites with low temperature, no pesticide applied, near to cropland site and dominant by neither Cyperaceae nor Asterales. Herbivory Coleoptera likely occurred at areas with lower temperature and near to cropland area. Predatory Coleoptera likely occurred at areas with taller vegetation. Herbivory Hemiptera except Cicadelidae usually occurred at sites with a taller and higher density of plants and far from cropland areas. Because the utilization of grassland of Inner Mongolia tends to be intensified, according to the result of this study, it will cause the increasing of population of grasshopper and decreasing of population of spider. Pesticide application as a traditional pest management strategy can lead to extinct of spider. Our results suggest that the current use of pesticides may not be effective for pest control and that alternative options should be considered in the grasslands of Inner Mongolia.

FATAL ATTRACTIVENESS – HOST PLANT MAY KILL ITS ENEMY'S OFFSPRING

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Manipulation with the different attractiveness of host plants to insect pests is a useful tool in ecologically sustainable and economically viable integrated pest management. There is growing interest in the value of enhanced agro-ecosystem diversity and "push-pull" strategies for suppression of insect pests. Crucifer-specialist insects are attracted and stimulated to oviposit on the plants that contain secondary metabolites – glucosinolates or their degradation products. But not all plants that are suitable for feeding and oviposition, do not offer safe environment for the development of larvae. These plants are called dead-end trap crops. In our study, we compared the oviposition activity and larval survival of *Meligethes aeneus* on the buds of *Brassica napus*, *B. rapa*, *B. nigra*, *B. juncea*, *Eruca sativa*, *Raphanus sativus* and *Sinapis alba* to assess their potential as trap-crop for oilseed rape. The studies were carried out in an experimental field of the Estonian University of Life Sciences in 2011 and 2012, Tartu County, Estonia. The plants were grown in a randomized complete block design with three replicates of each plant species. To determine the oviposition activity of *M. aeneus*, green (BBCH 51–53) and yellow buds (BBCH 59) were collected from randomly chosen plants and dissected under a microscope. All eggs, larvae, infested and non-infested buds were counted. Overall infestation rate of green and yellow buds of different plant species varied from 0 to 71%. The least attractive plants were *S. alba* and *E. sativa* in both growth stages and years as their infestation rate reached only up to 30.7% in green buds and 44% in yellow buds. Other plant species were similarly attractive to *M. aeneus* as oviposition sites. The mean number of *M. aeneus* eggs in the green buds was extremely low on *S. alba* and *E. sativa*, which indicates that the architecture of plants and/or chemical composition of buds were unattractive to beetles. In 2011, the most preferable plant to *M. aeneus* was *B. nigra* at green as well as yellow bud stage of plants. The number of larvae in yellow buds on *B. napus*, *B. rapa*, *B. juncea* and *B. nigra* was greater than on *R. sativus*, *E. sativa* and *S. alba*. Dead larvae were found only in the buds of *E. sativa* and *R. sativus*. All dead larvae were in first instar or were perished during moulting to the second instar stage. In 2011, the ratio of dead and alive larvae on *R. sativus* was almost equal; the average mortality was 46%, but in 2012 it was only 27%. The average mortality of larvae on *E. sativa* was much lower and stayed around 20%. Therefore, we can conclude that *R. sativus* is equal in value as oviposition site for *M. aeneus* in attractiveness with oilseed rape, but can perform as dead-end trap-crop because almost a third of the larvae cannot survive.

THE IMPACT OF COMPANION PLANTING ON THE ABUNDANCE OF LEPIDOPTERAN PESTS ON WHITE CABBAGE

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Cruciferous plants are grown around the world while white cabbage (*Brassica oleracea* L. var. capitata) is one of the most cultivated cruciferous vegetable plants in temperate regions due to its high nutritional value. Insect pests of cabbage can cause severe economic damage; the most important ones belong to the order Lepidoptera, such as *Pieris brassicae* L., *P. rapae* L. (Pieridae), *Mamestra brassicae* L. (Noctuidae) and *Plutella xylostella* L. (Plutellidae). The aim of the study was to find out whether companion planting with *Anethum graveolens* L. will effectively decrease the abundance of lepidopteran pests on white cabbage and therefore prevent the damage. Studies were carried out in an experimental field of the Estonian University of Life Sciences from 2010 to 2012. The experimental layout was a randomised block design with four replicates of two treatments: cabbage plants intercropped with companion plant and control plots. Each plot measured 2x5 m, and was planted with ten cabbage plants in two rows. On intercropped plots *A. graveolens* was sown between the cabbage rows, control plots were non-intercropped. The buffer zone between plots was one meter of bare soil around each plot. To determine the abundance of lepidopteran pests, all pests from all cabbage plants were inspected weekly and all specimens were counted. The years significantly influenced the mean number of larvae of cabbage pests per cabbage plant. The infestation level was high in 2010, up to five specimens per plant, the threshold level in Estonia is five caterpillars per plant on at least 25% of the plants; low in 2011, only one specimen per plant and medium in 2012, when the mean number of larvae per plant was three. When the abundance of larvae was pooled over three years, companion planting effectively reduced the number of pests' larvae on cabbage plants. However, no evidence was found that companion planting lowered the abundance of pests neither in 2010 when high pest abundance was recorded, nor in 2011 when only few larvae were found. At the same time, in 2012 intercropping with *A. graveolens* had a significant effect on the abundance of pests, less lepidopteran larvae were found from plots planted with *A. graveolens*. The effect of companion planting was affected by the abundance of pests; in the year of high pest numbers all plants, even the less suitable ones, were infested whereas in the year with low number of pests, the abundance stayed low on both variants. As the mean number of larvae per plant was significantly diminished by intercropping over three years, it can be assumed that companion planting can only be effective if the population size of pests stays at a medium level.

WEEDS AS SOURCES OF PESTS AND NATURAL ENEMIES: CONSEQUENCES FOR AGRO-ECOSYSTEM MANAGEMENT

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Identifying management options that enhance ecosystem services has become a critical issue. As an important service that could reduce pesticide use, pest control resulting from the activity of naturally present predators and parasitoids is frequently cited. However, the link between management options, pest control and crop yield is still poorly understood. In particular, the role of plant diversity in and around cultivated fields requires more scientific support to identify the plant species that indeed favour pest population regulation. Movements of predators and parasitoids between crops and non-cultivated plants imply that insects can colonize and develop on hosts with potentially contrasting characteristics. For example, Brassicaceae crops have many wild relatives growing in non-cultivated areas or as weeds in cultivated fields. These species differ in a number of traits associated with plant defences that may have an impact on the natural enemies of their herbivores . To determine to what extent wild plants (including weeds present in the fields) may serve as refuges for aphid parasitoids, we investigated the suitability (in terms of colonization and population growth) of two cultivated species (*Brassica oleracea* and *B. napus*) and two non-cultivated species (*B. nigra* and *Sinapis arvensis*) for two common pest aphid species, the cabbage aphid (*Brevicoryne brassicae*) and the green peach aphid (*Myzus persica*) and for their main parasitoid (*Diaeretiella rapae*). We recorded colonization of *B. oleracea* by aphids under field conditions. *B. oleracea* was surrounded by *B. oleracea* (control), *B. napus*, *B. nigra* (weed), or *Solanum lycopersicum*. The focal plant *B. oleracea* was more colonized by the specialist aphid Brevicoryne brassicae when it was surrounded by *B. nigra* or *B. napus*. In contrast, *B. oleracea* was less colonized by the generalist aphid when it was surrounded by *S. lycopersicum*, *B. nigra*, or *B. napus*. Population growth rates of the two aphids were smaller on the two cultivated plant species *B. oleracea* and *B. napus*. Similarly, the performance of the parasitoid was affected by the host plant on which the aphid was feeding. Unexpectedly, parasitism rate was lower on *B. oleracea*. Thus, variation in host plant characteristics had an impact on the fitness of the parasitoid through its aphid host. Thus, in temporally changing landscapes, pests and natural enemies may utilize crops and wild related host species with contrasting impacts on their fitness. Furthermore, attraction or repulsion of the specialist aphid *B. brassicae* and the generalist aphid *M. persicae* resulted in decreased or increased colonization of the crop *B. oleracea*. Careful spatial and temporal management of weed populations could thus favour pest control in Brassicaceae crops.

EFFECT OF MANAGEMENT STRATEGIES AND ROTATION ON PLANT-PATHOGEN SUPPRESSION BY SOIL MICROBIAL COMMUNITIES

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Enhancement of disease suppressive properties of soils limits disease development and is, as a result, essential for sustainable agriculture. Moreover, it can be a profitable strategy for farmers to manage diseases with lowered levels or without pesticides. Agricultural soils differ in their suppressiveness towards soil-borne plant pathogens, which can be attributed to soil type, organic matter content, as well as by management practices such as crop rotation, tillage and fertilization. The objective of the current research is to devise management strategies supporting disease suppression based on the response of pathogen-suppressing soil microbial communities. A field trial is being conducted to test experimentally the effect of crop rotation and management treatments on crop health and yield, as well as the suppressive response of the soil and its physical, chemical and biological properties. An experimental site with an on-station field trial with a winter-wheat rotation in the North of France has been selected. Soil samples are taken twice in the cropping seasons of winter wheat in 2012 and 2013. Soil suppressiveness is tested in bioassays with three different soil-borne pathogens in winter wheat under controlled environmental conditions. Biological targets which are assumed to provide complementary information on soil quality and diseases suppressive capacity of soil have been selected: 1) fungal and bacterial diversity and community structure, being important quality parameters of soil life; 2) arbuscular mycorrhizal fungi (AMF), obligatory mutualistic symbionts that supply plants with inorganic nutrients and protect them against diverse abiotic and biotic stresses; 3) *Lysobacter* spp., a recently described antagonist that correlates with soil suppressiveness in Dutch soils; 4) community structure of nematodes, expressed as maturity index, proposed as indicator for soil quality. A preliminary consideration of the results so far shows a variable response to crop sequence and management for bacterial and fungal, AMF, and nematode communities. Some limited changes in disease suppression were detected. *Lysobacter* spp. is present in the selected field, but is not influenced by the soil treatments. Correlation between the treatments and the different measurements will be performed when all samples have been analysed (i.e. mid 2013).

SPINOSAD-BASED ADULTICIDE BAIT (SPINTOR-FLY®): AN ALTERNATIVE METHOD AGAINST THE CHERRY FRUIT FLY

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In the last years in the Emilia-Romagna Region (Norther-Italy) the control of cherry fruit fly (*Rhagoletis cerasi* L.) has become more complex due to the increase of infestations and low availability of pesticides. Nowadays neonicotinoids are the most applied insecticides against *R. cerasi*, but only some of them are authorized for the control of this pest in cherry orchards in Italy. Furthermore they have a short persistence and repeated sprays can lead to resistance onset. A further pesticide available is phosmet, but it has some limitations due to phytotoxicity on some cherry cultivars. Among alternative techniques evaluated in the last years to control *R. cerasi*, also in organic production, the proteic adulticide bait with Spinosad (Spintor-fly®) showed to be very promising. In particular in 2010-2011 the application of Spintor-fly has been evaluated by experimental trials in the Emilia-Romagna Region with very good results. Thanks to the support of the local public administration (Vignola, Modena), in 2012 this experience has continued developing a large scale experiment on commercial cherry orchard of 7 hectares in which a mechanical system of distribution of Spintor-fly has been applied. A specific mechanical sprayer of 28 litres capacity, applied to a tractor and managed by an electronic handle, was used to spray the product. In total 6 sprays were carried out, on a weekly base, since the first cherry fruit fly detection. About 40 minutes were spent for each spray per hectare. At harvest the check on fruits confirmed the efficacy of this technique (0.4% of fruit damaged in the treated orchard in respect to 29.2% on the control). These results show the high potential of Spintor-fly. Furthermore the low dose of application of this product (5 L of bait solution/Ha) is coherent with the new EU directive (128/09) on the sustainable use of pesticides. This is an important aspect to consider particularly in the Emilia-Romagna Region which is characterized by a high density of population together with many small farms growing different fruit crops together (cherry, apricot, plum, peach, apple, etc.). Furthermore in cherry orchards several cultivars with different harvesting periods are grown together. In these conditions the risk of contamination by pesticides for both inhabitants and other crops is very high. The application of Spintor-Fly by mechanical distribution represents an additional positive aspect. In fact it can be promptly applied also on large orchards or on consortia of small farmers/orchards. This can be a strategic approach to optimize the control of cherry fruit fly with a low impact effect. Finally the fast diffusion in the modern cherry orchards of the covering against rain could create a synergic approach to diffuse the application of this technique because the cover can also protect the baits from rain. This activity will go over the following years by enlarging the extension of the areas treated with Spintor-fly.

HOW VIBRATIONAL SIGNALS CAN GUIDE MATING BEHAVIOUR IN *SCAPHOIDEUS TITANUS*

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The development of sustainable control methods of insects requires detailed knowledge about the biology of the pest and how it communicates with conspecifics. For example when creating a mating disruption strategy to control vibrational communicating species, it is important to understand the mechanisms of the mating behaviour in such pests. We have studied the leafhopper *Scaphoideus titanus*, which is a serious pest of grapevine where it is a vector of the phytoplasma grapevine disease flavescense doreé. In laboratory experiments, males and females were positioned on different plant parts of the same grapevine cutting and the searching behaviour of the male was recorded with laser vibrometry. The communication started with an identification phase in which there was an increased male pulse period and random walking after female reply. Thereafter followed a location phase, in which male calls became shorter, with more regular pulse period and correct directional decisions were recorded towards the female leaf. When a searching male reached the leaf with the female the perceived intensity of female reply increased significantly and a courtship phase was shown until copulation. With these experiments we have shown for the first time that intensity is an important parameter in vibrational communication of plant-dwelling insects. Different phases of mating behaviour are associated with different levels of perceived signal intensity and accordingly, males adjust the emission of vibrational signals and searching behaviour. Consequently, may external interferences result in loss of information necessary either for identification or location and thus preventing mating. It is possible that mating disruption with vibrations has a successful target in the more susceptible behavioural phases of *S. titanus*.

DROSOPHILA SUZUKII MATING BEHAVIOUR: SOUNDS AND VIBRATIONS BESIDES VISUAL SIGNALS

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Drosophila suzukii (Matsumura) (Diptera Drosophilidae), the spotted wing drosophila (SWD), is a major pest in many Holartic areas, which is spreading as an invasive species across Europe and North America. Females are able to lay eggs in ripening fruits and seem to prefer these over overripe ones, seriously affecting the production. Long-term and sustainable solutions are required to control the pest spread and damages. In several species of the genus Drosophila a species-specific courtship song has been described. Instead, to date, the mating behaviour of SWD was believed to focus only on visual signals. The aim of this study was to investigate the use of acoustic, in particular substrate-borne, signals by the SWD during the courtship. In laboratory, pairs of flies (one male and one female) were placed into a recording arena, a laser vibrometer recorded the substrate-borne vibrations and simultaneously the behaviour was recorded with camcorder for all the mating process. During courtship the male can produce three specie-specific signals: broadband pulses, associated with dorso-ventral abdominal oscillations, emitted in trains of variable length and irregular repetition rate ("quivering"), a brief sound with harmonic structure ("toot"), often associated to a "pulse" song, which consist of short trains of pulses with specie-specific pulse repetition time. The analysis of the videos showed a tight combination between visual and acoustic/vibrational cues to increase females acceptance. Further studies on the relevance of vibrational signals over the visual ones can enable the development of a specie-specific mating disruption approach, as it has already been done for other insect pests.

RADIO FREQUENCY TREATMENT WITH FRUIT IMMERSED IN WATER TO CONTROL POSTHARVEST BROWN ROT IN PEACHES

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Brown rot caused by *Monilinia* spp. is the most important postharvest disease of stone fruit. Currently, chemical fungicides are not allowed in the European Union to be applied to postharvest of stone fruit, which has increased the need to develop new alternatives controls. Radio frequency (RF) treatment at 27.12 MHz was study to control brown rot in peaches and nectarines. From preliminary studies, a RF treatment with 17 mm distance between fruit and upper electrode and 18 min exposure time was selected as effective treatment to control brown rot without affecting fruit quality. Then, these conditions were used to evaluate the effectiveness of RF treatment to control *M. fructicola* inoculated 0, 24 and 48 h before treatment, at different inoculum concentrations (103, 104 and 105 conidia mL^{-1}) and in different fruit size. Brown rot reduction ranged from 44 to 82 % and 63 to 100 % in 'Summer Rich' and 'Placido peaches, respectively. RF efficacy generally was not affected by infection time. Brown rot incidence was significantly reduced in 'Summer Rich' peaches at all inoculum concentrations evaluated, whereas in 'Placido' peaches, RF treatment was only effective when fruit were inoculated at 103 conidia mL^{-1}. The RF treatment was also studied in naturally infected fruit where *Monilinia* spp. development was completely inhibited in both, 'Summer Rich' and 'Placido' peaches. Although high disease control was achieved, RF effectiveness was affected by fruit size and no brown rot control was observed in nectarine. In order to address these problems, RF treatment with fruit immersed in water was studied. The application of RF treatment in fruit immersed in water at 20 ºC for 9 min significantly reduced brown rot incidence in both, peaches and nectarines and no significant differences in RF efficacy were observed depending fruit size. Moreover, the decrease in treatment time with increasing water temperature was also evaluated. Reduction of treatment time to 6 and 4.5 min was achieved increasing water temperature at 35 and 40 ºC, respectively, to control brown rot without impair fruit quality in both, peaches and nectarines. In conclusion, these results indicated that RF heating with fruit immersed in water may provide a potential postharvest alternative treatment for brown rot control in peaches and nectarines.

USE OF ELECTROLYZED WATER TO IMPROVE FRUIT QUALITY OF SOME *CITRUS* SPECIES

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To reduce *Citrus* fruit losses and enhance fruit quality is important to implement strategies for preventing microbial contamination both during the pre-harvest and post-harvest phases. Few chemicals are left available in post-harvest application and can only be used in small amounts or under restrictive conditions; moreover the current production trend is aimed at intensifying the use of integrated strategies to protect the environment and to minimize potential damages resulting from the use of pesticides. A very promising alternative to chemicals application in post-harvest is the use of Electrolyzed water (EW). EW is obtained either by adding KCl to tap water or by reverse osmosis in a container with a separating polyester membrane. It has good antioxidant and antimicrobial effects, therefore it can represent an alternative technology for the preservation of agro-food quality and an effective surface sanitizer of post-harvest pathogens. In this work *Citrus* fruits of sweet oranges (cvs. Valencia late and Navelina) and 'Common' clementine were treated with EW produced on site by equipment Eva System® of Industrie De Nora S.p.A. Italy, in the field or immediately after harvest. In both cases fruits were stored at 4°C±1 for 20 days. At the end of the conservation stage, the shelf life was evaluated by storing the fruits at 23°C for 7 days. During the conservation Colony Forming Units (CFUs), constituted by fungal contaminants (yeasts and filamentous fungi) present on fruit surface were evaluated every 7 days. The results revealed that the EW treatment significantly reduces microbial CFUs both when applied in the field and when used after harvest, congruently with the induction of fruit shelf life. The use of EW provides a very interesting means for improving the quality of fruit production by limiting the use of pesticides due to its effectiveness, low costs and ease of use.

THE INSPECTION OF SPRAYERS IN TRENTINO

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Since 1997, the Association of Fruit and Vegetable Producers in Trentino (APOT) in accordance with the local Government with the support of the Extension Service of the Centre for Technology Transfer of the Fondazione E. Mach, to achieve a better efficacy of treatments and rationalize use of chemicals, have putted in place the mandatory inspection activity for all the associate growes. Until now nearly 10,000 checks have been carried out using mobile test stations. In addition in Trentino a calibration of the sprayer is mandatory on the basis of the Resolution of the Government of the Province of Trento 2012/2009 for the main crops on the farm. The Fondazione E. Mach is the responsible body for the accreditation of inspection centers and monitoring of their activity. Until today the wine industry, has worked on a more bland inspection activity. In the wine sector a part of sprayers, in recent years, have been checked with the mobile centers operating in the fruit industry and a regularly accredited private workshop is currently operating. To meet all the requirements of the Directive 2009/128/CE it will be necessary also to quantify the amount of sprayers in use in fields other than the fruit/vine growing (e.g. herbicide application, treatment to urban green spaces, etc.) in order to organize inspections with an adequate number of centers and qualified personnel. Certainly the experience gained to date will help this task.

MANAGEMENT OF PESTICIDE DRIFT IN ORCHARDS OF TRENTINO

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Drift of pesticides is a critical element in achieving the plant protection management. Since the fruit season 2009 comparative tests have been carried out during different wind conditions (almost total absence and presence of wind) to verify the mitigation ability of anti-drift nozzles, used with different sprayer adjustments and coupled with the other devices. Actually in Province of Trento the most of growers who sprays next to drift sensitive areas (houses, roads, bicycle patches, etc.) uses spray lances. Several technologies are available to mitigate drift along with many techniques. On the other hand the differences between training and pruning systems, planting distances, cultivation environments, etc., must be taken into consideration to achieve the highest level of reduction. The main characteristics of the orchard landscape of Trentino are: strict connection with inhabited areas, medium or steep slope of most apple plots and intensive orchard growing with height of trees up to four meters. At first the most appropriate machinery to adopt in that growing contest appeared on-target sprayers with anti-drift air injector nozzles. Other devices and application strategies such as the exclusion of airflow and spray when treating the border rows of the orchard or the presence of an hedgerow should help to reduce the risk of pesticide drift. To ensure the maximum level of drift reduction, further experiments are needed to find other technical approaches which may be combined with the spray equipment already tested.

DIMETHYL DISULFIDE: A NEW SOLUTION FOR CONTROLLING ROOT-KNOT NEMATODES IN PROTECTED CROPS IN EUROPE

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The use of Dimethyl Disulfide (DMDS) as a soil fumigant has been patented by Arkema. In December 2012, it was notified as a soil fumigant at EU level. This opens the way to the registration of a new fumigant in Europe, after decades without a new product for pre-planting treatments. DMDS is a broad-spectrum fumigant, particularly effective against plant-parasitic nematodes of several crops, both under protected and field conditions. Certis Europe is Arkema's exclusive partner for the development, registration and distribution of DMDS formulations across the EU 27. DMDS will be registered in EU countries in two formulations: Paladin EC (94.1%) for drip application in protected and field crops and Paladin (99.1%) for shank application in field crops. Six GEP efficacy trials, were conducted during 2012 in Italy and Spain in protected crops (tomato, pepper and cucurbits), that focused on root-knot nematodes *Meloidogyne* spp. Here we present a summary of the results obtained with Paladin EC (94.1% DMDS), carried out with tomato (2) and melon (2) in Italy by ARA (Catania), CRSFA (Locorotondo), and CNR-IPP (Bari), and with cucumber (1) and pepper (1), in Spain carried out by Eurofins. The tested rates of DMDS were 300 and 400 kg a.i./ha and were compared with the market standard 1.3-D at 140 l/ha (for melon) and 180 l/ha of commercial product (for tomato) in Italy; and 150 l/ha for both cucumber and pepper in Spain. All applications were via drip irrigation systems under VIF plastic sheet. The plastic film was removed 14 days after application, whereas transplanting was done one week later. Nematode and yield variables recorded were: (i) presence of galls on the roots during and at the end of the crop cycle and ii) total produc tion during the crop cycle. The average results of the 3 trials with cucurbits, expressed as GSI (Gall Severity Index according to the 0-5 scale), showed a medium-high root damage 70-100 days after transplant (DAT), with an index of 3.03 in the untreated control. DMDS showed very good control of *Meloidogyne* spp. at both rates of application: GSI of 0.47 with 400 kg/ha and 0.67 with the 300 kg/ha rate. The standard treatment 1.3D (at 140-150 l/ha) was less effective (GSI of 1.35). The 3 trials with solanaceous crop plants showed an average GSI in the untreated control of 2.94 after 72-80 DAT. DMDS again proved very effective with GSI of 0.09 for DMDS at 400 kg/ha and GSI 0.13 for DMDS at 300 kg/ha, slightly superior to the standard 1.3-D (GSI 0.20). Details of the results, including yield data, will be given in the presentation. As reported in several previous articles, our results confirmed the excellent efficacy of DMDS against *Meloidogyne* spp. Under protected crops, the highest efficacy in the presence of medium-high infestation level of the nematode was given even by the lowest rate of 300 kg/ha when the crop cycle was not longer than 100 days.

TOOLS AND CHECKLISTS FOR THE IMPLEMENTATION OF IOBC IP GUIDELINES ON INTEGRATED PRODUCTION ON FARM LEVEL (WITH EMPHASIS ON IPM)

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IOBC has established a framework of general and crop-specific guidelines describing in detail how IP, and in particular IPM, should be implemented in practise. These crops-specific guidelines are organised in chapters covering all major IP issues, including appropriate field site selection and management, promotion and conservation of biodiversity and ecological infrastructure, choice of appropriate cultivars, Integrated plant protection (IPM), conservation of soil health and fertility, irrigation and plant nutrition. The IPM chapter includes pest and disease monitoring, preventive measures and non-chemical control, as well as a reasonable use of pesticides. A compilation of successful IPM strategies for pome, stone and soft fruits, grape vines, citrus, olives, arable cops and field-grown vegetables was published 2012 by IOBC/wprs in "INTEGRATED PEST MANAGEMENT - Design and application of feasible and effective strategies" (eds: F.G Wijnands, R. Baur, C. Malavolta, & B. Gerowitt, see http://www.iobc-wprs.org for download). Comprehensive guidelines, including all aspects of IP for these crops are also available for download on this website.
For the implementation of IPM, IOBCs "Green/Yellow chart" of plant protection measures proved to be an essential and successful tool, since this flow chart translates the more general directives in the guidelines into specific and detailed requirements on the level of individual regions, grower's organisations, or even farms. An introductory document (the "Identity card") identifies the local climate and geographic (landscape, soil, topography) conditions, the key pests and diseases as well as the key antagonists. This ID-card is a prerequisite for the preparation of the green part of the Green/Yellow chart which contains all possible indirect measures against the key pests and diseases as well as the unavoidable direct measures. Finally, the yellow part indicates further chemical control measures, that can be applied if green list measures do not provide adequate control. To foster their commitment, growers organisations must be involved into the compilation of such lists. SESAME is a multi-level checklist system covering the requirements specified in IOBC guidelines, following the concept of mandatory items (must items) and a set of bonus options for which a minimum target number for compliance can be defined. The different levels comprise one for a self-evaluation at farm-level, one for external inspections, one with detailed explanations for all items and a visual display ("radar") showing the performance of farms or farmers organisations. SESAME has been tested in practise and proved to be applicable and inspiring for farmers organisations. Details of the structure and contents of SESAME will be shown at the OECD conference.

SPATIAL AND TEMPORAL DYNAMICS OF *FRANKLINIELLA OCCIDENTALIS* AND ITS NATURAL ENEMIES IN ORNAMENTAL CROP SYSTEMS

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Frankliniella occidentalis Pergande (Thysanoptera: Thripidae) is a major problem of various ornamental and vegetable crops. Failures in insecticide applications to control this pest is frequently reported because of resistance. Alternative control strategies are based on augmentative biological control. Conservation biological control through the empowerment of natural occurring biocontrol agents is often overlooked in ornamental crop systems. We explored the potential for conservation biological control of *F. occidentalis* on ornamentals grown in open field and under greenhouse. We investigated the spatial structures of the pest and its natural enemies and their evolution over time. Spatial patterns in *F. occidentalis* and its natural enemies distributions on ornamental crops are reported. An association was found between the distributions of the pest and its natural enemies, in particular in open field. The study provided interesting information on the role of surrounding environment on interactions between the pest and its natural enemies populations on ornamentals.

NEW STRATEGIES OF IPM TO CONTROL CODLING MOTH IN PEAR ORCHARDS

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In the last 3 years (2010-2012) in the Emilia Romagna region (Northern Italy) experimental trials have been carried out to assess and define new low impact strategies to control codling moth (*Cydia pomonella* L.) in pear orchards. The aim has been to integrate and combine organic techniques and biotechnologies together with the use of the most efficient, newly introduced insecticides. The base of the strategy developed has been the Integrated Production guidelines available at the regional level in Emilia Romagna with the exclusion of the use of phosphorganic products. This would aim to reach a satisfying control of *C. pomonella* reducing the number of sprays in respect to the common practices that in the region vary from 10 to 12 sprays (including the microbiological products). Another objective was to reduce the residue level (no. of active ingredients and quantity) in the fruit at harvest. It is in fact crucial nowadays to combine efficacy of the control with the requirements of the market. For these reasons the trials have been carried out in 3 pear orchards, on a surface of about 3 hectares each, located in the provinces of Bologna, Modena and Ferrara respectively. The strategy applied had seen the use of entomophatogenic nematods (*Steinernema feltiae*) in October, the application of mating disruption at the beginning of the flight of adults in spring and the spraying of insecticides based on the forecasting model (MRV) commonly used in the region. The main active ingredients applied during the 3 years have been Chlorantraniliprole, Emamectin benzoate, Spinosad, *Cydia pomonella* Granulovirus (CpGV). The last one was chosen because of both its high efficacy to control codling moth in the 1st generation and its very low environmental impact and selectivity toward natural enemies (i.e., *Anthocoris nemoralis*). The protocol of sprays has respected as much as possible the anti-resistance rules, using the same group of active ingredients in only one generation of pest. Specific checks have been carried out at the end of each generation of the pest to assess the presence of codling moth damage on fruit (%). The final results have been very satisfying with a decrease in the number of sprays in respect to common strategies of previous years (from 12 sprays on average in 2009 to 6 on average in 2012). Together with a reduction in sprays there has also been a significant decrease in the damage on fruit in all 3 orchards, arriving at zero damage in the final year (2012). Concerning residues, the result has been very satisfying too. On average no insecticides were detected apart from 1 case in 2010 where the residue value was about 0.01 ppm.

ESTABLISHMENT OF AN INTEGRATED PEST MANAGEMENT SYSTEM FOR INTEGRATED PRODUCTION OF DRY-BEANS (*PHASEOLUS VULGARIS*)

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The pest control on dry beans (*Phaseolus vulgaris* L.) in many cases is performed based on calendar (usually weekly sprays) or by the presence of the insect, even when the population is well below the control action level. There is also a tendency to overestimate the damage of the insect. To help producers and technicians in pest decision control, an integrated pest management of dry beans (Bean-IPM) was established in Brazil since 2000. This system was incorporated into the integrated production of dry-bean initiated in 2007 by Brazilian Agricultural Research Corporation (Embrapa) and the Ministry of Agriculture, Livestock and food supply (MAPA). Methodology for monitoring pests and their natural enemies in the crop and control action levels for each pest were validated in five dry beans farmers. The bean-IPM consisted of the following steps: 1) identification of the bean pests and their natural enemies, 2) sampling of pests and the natural enemies; 3) recording the results of the samples, 4) decision making accordingly the control action levels for each pest. In the region of Santa Helena de Goiás-GO, with the use of this technology, the application of insecticides was reduced by 64%, with a saving of 78% on cost control. In the region of Cristalina and Anápolis (GO), beans were harvested without any spraying, and others, with just one spray. Normally these areas are between 5-7 sprays with insecticides per crop. The monitoring of the ecosystem elements, such as pests, their natural enemies and other factors that limit pest population is a determining factor for the success of integrated pest management. Farm managers have been professionally trained in all aspects of integrated dry-bean production by attending locally organised training courses. The technology of Bean-IPM fits into the society's demand for an agriculture where there is greater respect for the environment. This technology gives priority to ecologically safer methods, by minimising the undesirable side effects and use of agrochemicals and by enhancing the safeguards to the environment and human health.

SOCIOECONOMIC CHARACTERIZATION OF AGRICULTURAL SYSTEMS TOWARDS IPM IN THE BRAZILIAN SAVANNA

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The socio economic data collected from farmers assisted by the IPM project are part of the effort to improve adoption levels and reinforce sustainability. This study is a follow up of such data on the farm level for monitoring a variety of agricultural systems as soybean, rice, beans, corn, inter related production systems. Food crises worldwide have boosted grain prices and profits have potentialized the high risks involved in agricultural activities, mainly IPM adoption. Building agricultural soils and crop systems intensification resulted in higher crop yields and the development of a portfolio of technologies targeted to the natural systems management for increased food production in the tropics. Agricultural systems technologies permitted yield increase for rice, from 1,650 to 3,100, beans, from 500 to 2,000, corn yields varied from 2.5 to 6 tons and soybeans from 2.2 to 4 tons/ha on the farm level. Production systems based on crop rotation, no tillage, and precision agriculture, lead to crop intensification with adverse effects for sustainability. Interviewing farmers for low IPM adoption levels are explained by two main reasons: the need for human capital specialization (28% of all responses) and uncertainty forcing prevention (25.5%) resulting in high levels of insecticides use, with increased demand for chemicals. Number of applications, 3.5 in average with maximum 7 in a first assessment and maximum 5 applications in the last, when about 70 farmers were interviewed. Economic and social dimensions of the integrated pest management and intensive crop systems are evident. Production costs for pest control are around 11% in corn, 23% for irrigated beans and 16% in soybeans. For the IPM monitoring, there is urgent need for training field assistants and for the precision agriculture, the demand for specialized personnel related to the new machinery arsenal. The dynamics of integrated crop systems result in high profits from crop int ensification but must be revised for sustainability.

A STRATEGY TO PREVENT CROP PEST RESISTANCE LEADING TO A REDUCTION OF PESTICIDES IN PLANT PROTECTION, USING POLLEN BEETLE AS AN EXAMPLE

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Monitoring of crop pests' susceptibility levels to active substances of plant protection products is now one of more important elements of IPM. The presence of resistance in some species necessitated the increase of treatments in the practice of plant protection and forced the scientific world to identify protocols to prevent this phenomenon. On the basis of intensive scientific research into pesticide mode of action, mechanisms of pest resistance and agronomic conditions favouring resistance, the strategies of plant protection to reduce the negative effects of resistance whilst decreasing the number of chemical treatments and the selective pressure on pests, are being elaborated and introduced into practice. An example is the strategy worked out in Poland for preventing resistance of pollen beetle (*Meligethes aeneus* F.), the most important oilseed rape pest in the country. The strategy relies on controlling chemical protection of oilseed rape, aiming to achieve the highest level of effective pollen beetle control and, at the same time, decreasing the selective pressure of insecticides and other undesirable effects, especially on beneficial insects. The work presents main elements of the strategy of oilseed rape protection in Poland, taking into consideration the conditions of oilseed rape protection in this country.

EFFECTS OF NITROGEN FERTILIZATION ON INSECT PESTS, THEIR PARASITOIDS, PLANT DISEASES AND VOLATILE ORGANIC COMPOUNDS IN *BRASSICA NAPUS*

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Nitrogen (N) availability is a key factor influencing the yield of *Brassica napus* L. Thus, mineral fertilization is widely used to improve the quality and quantity of seeds. In this study, we conducted field experiments to determine the impact of nitrogen fertilization on *B. napus* pests, their parasitoids and plant diseases. The field studies were conducted with seven different N-fertilizer levels: 0, 60, 80, 100, 120, 140 and 160 kg of N per hectare in 10 m2 randomized replicate plots of winter oilseed rape. Abundance of *Meligethes aeneus* Fab. (Coleoptera: Nititulidae) larvae and its' parasitoids were determined by dissecting flowers and second instar larvae, respectively. The occurrence of *Ceutorchynchus obstrictus* Marsh. (Coleoptera: Curculionidae) and its parasitism rate were determined by counting damaged pods and emerged parasitoids or their remains from pods. Plant disease assessments were carried out visually at the mature pod stage (BBCH 80–85), the abundance of *Alternaria brassicae* (Berk.) Sacc. lesions was rated on a qualitative scale from 0 to 6 (no disease; 5%; 10%; 20%; 30%; 50%; over 50%). The volatile organic compounds measurements were carried out using multichamber cuvette system for collecting and Shimadzu TD20 automated cartridge desorber combined with Shimadzu 2010 plus GC MS instrument for analysing. The compounds were identified by comparing their mass spectra with a NIST library (National Institute of Standards and Technology) and with authentic standards. The results showed that N treatment had an impact on the abundance of *M. aeneus* and *C. obstrictus* as well as *A. brassicae*. Since pest abundance was not correlated with the flower and silique numbers, the feeding and oviposition sites, plant smell bouquets were analysed to determine potentially attractive or repellent volatile organic compounds. We detected 19 different compounds among which acetic acid and several lipoxygenase pathway products were emitted at higher levels from N-treated plants. Emission of a few other terpenoid compounds was correlated with the pest abundance in field conditions. Abundance of parasitoids of both pests was related to the host availability rather than to the fertilization treatment. Therefore, we suggest that plant chemical cues play a minor role in localization of hosts in close proximity to parasitoid. The levels of *A. brassicae* decreased with increasing N availability, possibly reflecting enhanced emissions of acetic acid, a known antifungal volatile. This study demonstrates the effects of N fertilization on bud and flower volatile bouquets, which might play a role in *B. napus* insect pest host selection and in resistance to fungal plant diseases. Further studies are necessary to investigate the behavioural responses of insects to the changed volatile bouquets.

COMPARATIVE MORPHOLOGY AND EVOLUTIONARY GENOMICS PROVIDE USEFUL CLUES FOR MANAGEMENT OF AN EMERGING DROSOPHILA PEST

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Drosophila suzukii is one of the few fruit flies to lay eggs and feed on fresh fruit. Its recent outbreak in western countries, and its peculiar ecological behaviour makes it an emerging model for pest management and biology. A recent genomic survey suggested that *D. suzukii* unusual behaviour is intimately linked with an ecological pre-adaptions to temperate climates and the ability of overwinter in sexual diapause state. Here we provide comparative morphological and behavioural evidences supporting that diapause occurs preferentially in females, is temperature dependent, and is likely mediated by an enlargeable highly pigmented spermatecha. Comparative genomics reveal a cytochrome associated with spermatecha as the gene under stronger positive selection in *D. suzukii* genome. Evolutionary genomics further identify two genes under positive or abnormal evolution involved in insecticide resistance and immune response to parasitoids. Based on our results, we advocate that early spring trapping is key for *D. suzukii* population control as it may target the few overwintering females exiting diapause. Our results show that evolutionary genomics and comparative morphology are useful tools to guide application in the field of pest management.

THE CURRENT STATUS OF MANGO MALFORMATION IN EGYPT

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Malformation is one of the most threatening diseases which causes significant economic losses and limits mango production in many countries. Mango malformation was first reported from Egypt in 1955, but the disease aetiology has been controversial for a long time. The aim of this study was to assess the current status of the disease and its associated *Fusarium* species in Egypt. A survey was carried out during spring and summer 2011 in the main mango growing areas. A total of 75 samples were collected from different orchards located in Ismailia, Sharqia, Nobaria, Monofya, Suez, Giza, Fayoum, Helwan and Behyira governorates. Typical symptoms of vegetative and floral malformations were observed. The pathogen was isolated from the collected samples using a selective substrate. Monoconidial *Fusarium* isolates were morphologically identified. Eighty-three *Fusarium* isolates were grouped according to their morphological characteristics and then molecularly identified by DNA Sequence-Based method using the sequence of ß-tubulin and translation elongation factors genes. Results showed a low disease incidence in the desert land, probably due to the modern farming system. Molecular results demonstrated that most *Fusarium* spp. obtained in this study showed a high homology with *Fusarium mangiferae*. Also *F. solani* and *F. equiseti* were isolated from infected samples with a low incidence. Four new sequences of *F. mangiferae* were submitted to GenBank accession number. These results indicated that malformation disease is the main constraint on mango production and is widespread in all mango growing areas in Egypt. *F. mangiferae* proved to be the most frequent species associated to the disease.

IMPLICATIONS OF SOIL TEMPERATURE FOR THE POPULATION DYNAMICS AND MANAGEMENT OF POTATO CYST NEMATODES

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The potato cyst nematodes (PCN) *Globodera rostochiensis* (Stone) and *Globodera pallida* (Woll) are major parasites of potatoes and other members of the Solanaceae family. They are listed in the EU Plant Health Directive 2000/29/EC and are regulated by the European PCN Directive (2007/33/EC). In the UK, management of PCN relies on long rotations, nematicides and resistant cultivars, though for *G. pallida* there are few cultivars available with high levels of resistance. Conditions differ in potato growing regions but there is a trend towards increasing temperatures and changes in rain fall associated with climate change.
The relationships between soil temperature and PCN development and the subsequent effects on nematode multiplication and plant damage have not been thoroughly investigated or developed into practical management tools. Many nematodes are adapted to particular temperature ranges and temperature is often a key environmental factor affecting their biology. We have been examining the effects of temperature on the life cycle of PCN in vitro, in controlled environment cabinets and in the field to understand the risk to potato crops and to support the development of the Potato Council`s PCN management model. Two generations of both *G. rostochiensis* and *G. pallida* on cv. Desirée were observed with the numbers of cysts increasing with temperature. This confirms that for PCN diapause is not obligatory in appropriate conditions. A second generation of juveniles was observed by 10 weeks at 20º with the susceptible cv. Desirée with both species. We are also monitoring the crop development on a monthly basis and looking at the nematodes in the roots and soil. A site in Shropshire has been compared with a site in Scotland, to see if there is a correlation between temperature and nematode development in field conditions. Preliminary data suggest significant differences between harvests and with and without nematicide application in the numbers of eggs/g of soil as well as delayed invasion and development of PCN. The data presented above are being used to develop a dynamic temperature based model for the life cycle of PCN and to understand the risk from a second generation of PCN.

A NEW INTEGRATED PEST MANAGEMENT (IPM) MODEL FOR CERCOSPORA LEAF SPOT OF SUGAR BEETS IN THE PO VALLEY

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Cercospora leaf spot (CLS), caused by the fungus *Cercospora beticola*, is the most economically important foliar disease of sugar beets (*Beta vulgaris*) in Italy. It can be controlled with the integrated use of resistant varieties, crop practices and foliar fungicides. Environmental conditions strongly influence the activity of *C. beticola* in the field; they can be used to guide fungicide applications once the relationships are understood. To assist growers in making profitable decisions regarding the application of foliar fungicides for CLS control, a predictive model, developed and improved by researchers at the University of Minnesota and North Dakota State Universities, was adjusted to Italian conditions and evaluated. The model was designed to predict the time when the infection by *C. beticola* was likely to occur based on hourly temperature and relative humidity data. CLS control is currently based on treatments scheduled using a “calendar” programme. This system recommends to start fungicide applications on a fixed date and continue regularly every 18-20 days. Three years of field trial evaluation of the CLS prediction model at several experimental sites, compared with the calendar programme, has resulted in a savings of 1.5 fungicide treatments (corresponding to 130 €/ha) without a significant loss of yield. To control CLS, multiple applications of the same fungicide during a growing season are unfortunately common. This practice provides the target fungus with the conditions to evolve resistance. Sensitivity assays of *C. beticola* to DMI and QoI fungicides were carried out on isolates collected in 2009 and 2010 in Northern Italy by the University of Bologna and North Dakota State University, respectively. Isolates principally came from trial plots but also from commercial sugar beet fields and were tested for sensitivity to tetraconazole, difenoconazole, pyraclostrobin and trifloxystrobin using radial growth and spore germination assays. All samples collected in 2009 showed EC50 values for QoI ranging from 0.0008 to 0.2195 µg/ml. The percentage of isolates collected in 2010 with EC50 values >1 for tetraconazole was 44%, for difenoconazole 84%, for pyraclostrobin 27% and for trifloxystrobin 34%. For isolates with EC50 values >1 µg/ml, the range of EC50 values (µg/ml) for tetraconazole was 3.4-70.0, for difenoconazole 2.0-69.5, for pyraclostrobin 1.5-43.6, and for trifloxystrobin 3.8-77.1.

IPM IN OPEN FIELD VEGETABLES IN FLANDERS (BELGIUM)

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Flanders is one the main vegetable growing regions in Europe. A lot of vegetable freezing companies are situated in Flanders. More than 1 million tonnes of fresh frozen vegetables, representing one fourth of the total European production, is produced in Flanders. The most important crops are cauliflower, Brussels sprouts, beans and carrots. Several vegetable research stations developed methods to monitor and predict pests and diseases in these vegetable crops. Cabbage fly (*Delia radicum*) and diamondback moth (*Plutella xylostella*), sometimes called cabbage moth, are among the major pests of cauliflower and Brussels sprouts in Belgium and Europe. Diamondback moth is monitored with delta traps with a sex pheromone. Once the threshold is exceeded, the cabbage growers are advised to spray. Cabbage fly is attracted with a pheromone, ethyl-isothiocynate, which resembles the odor of cabbages. Based on these weekly catchments the grower is informed about the situation of the cabbage fly. Carrot is also one of the major crops for the frozen vegetable industry. The major pest of carrot is the carrot fly (*Psila rosae*). These bugs are caught with yellow traps in the field. The appearance of carrot fly is specific for one region or even field-specific. Therefore it is needed to put several traps in each carrot field. When an average of more than 3 flies are caught, it is necessary to spray. Belgian leek (*Allium porrum*) is threatened by two major pests, thrips and leek moth (*Acrolepiopsis assectella*). The appearance of thrips is predicted on the basis of a temperature model. The actual intensity of the pest appearance in the field is weekly monitored with blue glue traps. Growers are informed if they need to spray based on this model and the catches in the traps. Leek moth is weekly monitored with delta traps with a sex pheromone. The growers are advised to spray when the threshold is exceeded. For *Phytophthora porri*, a major disease in leek, a model has been developed. Based on field specific input (crop history, cultivar, crop rotation,…) by the growers and the metereological data of a nearby weather station, the webmodel advices whether or not to spray. On average the same level of disease control was reached with this webmodel compared to a 3-weekly spraying scheme (with up to 3 fungicide applications less).

Research stations in Flanders places the traps in the fields and weekly count the number of insects. A weekly report is send to the growers whether are not they have to spray. All these trapping systems contribute to a sustainable cropping system for vegetables. Calendar spraying could be omitted and growers only spray when the pest is present.

CFD MODELING OF MICROCLIMATE IN THE BOUNDARY LAYER OF LEAVES: THE ECOLOGICAL NICHE OF PESTS

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Knowledge of the biophysical mechanisms underlying the development of the greenhouse climate, particularly climate prevailing at the ecological niche of beneficial insects and pests, is of particular interest if you want to implement alternative methods to chemical control. With this in mind, the work developed in this paper aims to use Computational Fluid Dynamic software CFD to model the climatic parameters inside greenhouses and especially in the boundary layer of leaf-level, natural habitat of pests who inhabit plants. This approach allows providing information about the climatic conditions prevailing at the ecological niches of biological agents. This is a prerequisite to an action that targets the control of the local climate in order to fight against plant pests. The tools used in this study combine fine measurements of microclimate and distributed climate modelling in the leaf boundary-layer by means of analytical and numerical approaches. Experiments were conducted in a 922m² multi-span greenhouse covered with a 200 µm thick thermal polyethylene plastic. The greenhouse was located in the INRA experimental Unit of Sophia Antipolis in South France. The cultivated crop was a rose watered by a drip irrigation system. The climatic conditions prevailing near the under leaf surface were determined by means of a set of small thermo-hygrometers (model EE06, Intertechnique) whose protection caps were removed to determine more precisely the temperature and humidity conditions at distances of 5 and 15mm from the leaf surface. The temperature and humidity patterns inside greenhouse were simulated using the commercial software solver: Fluent with the choice of a classical k-e turbulence model to model the turbulent constraints. In addition, this CFD code was customized for simulating, the sensible and latent heat exchanges between the air and the crop (assimilated to the solid matrix of the porous medium) within each mesh of the crop canopy following the procedure described by Fatnassi et al. (2006). The temperature and air humidity distributions in the boundary layer of the leaves were deduced from velocity profiles depending on the Prandtl and Schmidt numbers (Schlichting, 1974). The results showed that the microclimate (air temperature and humidity) close to the lower leaf surface is different from the climate inside the greenhouse, particularly during daytime when crop transpiration is maximum.

SURVEY ON PEST MONITORING SYSTEMS ACROSS EUROPE WITHIN THE REALM OF INTEGRATED PEST MANAGEMENT

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Within the “Collaborative Working Group on integrated pest management for the reduction of pesticide risks and use” under the Standing Committee on Agricultural Research (SCAR) a Europe-wide survey on pest monitoring systems (PMS) was conducted in 2012. The goal of this survey was to draw a picture at European level of the various national PMS for integrated pest management including the variety of approaches and technologies. The SCAR-CWG was established in May 2011 to provide recommendations on research needs to the EC’s DG Research and Innovation and to Member and Associated States. It takes stock of those aspects of plant protection that could benefit from European-level information sharing and coordination. PMS integrate a wide range of domains, from forecast and monitoring of pests and diseases, warning and alert systems to scouting thresholds and advisory services on integrated pest management. It also covers a wide range of actors including farmers, advisors, scouts, people from government, industry, researcher etc. In this respect pest monitoring systems are not limited to computer-based systems but comprise initiatives, networks, activities, tools etc. that assist farmers in taking the right decision in integrated pest control. The following three major components of PMS and their interlink were in the focus of the survey: In-field monitoring/surveillance/scouting: Up-to-date and periodic in-field monitoring/ surveillance/scouting of weeds, pests and diseases; Decision support systems: Alert systems, simulation and forecasting systems which help famers to identify monitor and control weeds, pests and diseases; Pest warning services by extension services/advisors: Specific advice from independent extension services/advisors. The advice is generally based on individual professional working experience and the interpretation of up-to-date DSS outcomes and monitoring/surveillance/ scouting results. The poster presents outcomes of the survey. The results will serve to identify what research and development is needed to support PMS, assess the added value and opportunity of jointly addressing needs and finally, make recommendations on cross-national initiatives.

SAMPLING METHODS FOR *CITRUS TRISTEZA* VIRUS (CTV) MONITORING IN APULIA REGION, ITALY

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Citrus tristeza virus (CTV), the most destructive virus of citrus, is present in almost all citrus growing countries worldwide, reaching different infection levels. It induces the typical quick decline when the trees are grafted onto the susceptible sour orange rootstock. In the Mediterranean basin, CTV is efficiently transmitted mainly by *Aphis gossypii*, whereas *Toxoptera citricidus*, the most efficient virus vector, has been reported to date only from Portugal and Spain. CTV monitoring and eradication programmes in Apulia region, South of Italy, totally rely upon virus incidence in citrus groves, whose evaluation is based on the sampling method applied. In compliance with the regional phytosanitary regulation, the sampling procedure adopted in the last 10 years for CTV field monitoring has been based on the scheme developed by Gottwald and Hughes (2000). This scheme, which is usually based on a hierarchical method (HS), was applied by adopting a systematic method, introducing individual testing by DTBIA instead of grouped testing by DAS-ELISA. A detailed comparison between Gottwald's HS method and the systematic approach applied in Apulia region (called MAIB-S) was investigated in this study. The evaluation was conducted in 15 citrus commercial groves, which were previously tested and whose infection rates were known. Advanced spatial and statistical analyses were used: automatic tree extraction, Moran's I, Ripley's K-function, Rcitrus and a MATLAB-based simulation (CTVSimula). In the surveyed groves, CTV incidence ranged from 0.46% to 16.21%, when testing 100% of the trees by DTBIA. By simulating the different sampling methods, the infection rate proved to be underestimated by HS and more accurate when MAIB-S was performed. Noticeable reduction in the accuracy of CTV incidence estimation was observed with HS (0.1% to 65%) whereas estimation increased for infection levels exceeding 50%.

DEVELOPMENT OF A RISK FORECAST MODEL FOR THE BARLEY DISEASE *RAMULARIA* LEAF SPOT

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Ramularia collo-cygni is now one of the most economically important fungal pathogens which attack barley (*Hordeum vulgare*) crops in temperate countries around the world. The epidemiology of this disease is only slowly being elucidated. Seed borne infection has been revealed to be the primary source of early *R. collo-cygni* infection in crops. The effectiveness of seed treatments is currently under evaluation. Later *R. collo-cygni* spore release events were found to be related to periods of maximum leaf surface wetness. The effect of *R. collo-cygni* on yield has also been studied by analysing Area Under Disease Progress Curves (AUDPC) and yield figures from untreated crops over a number of years and sites. A relationship between yield and AUDPC was established for winter and spring barley crops. A risk forecast scheme for *R. collo-cygni* severity in a cropping season based on surface wetness at GS 31 has been devised. The risk forecast is compiled for Scottish growers and disseminated early in order to allow control programmes to be tailored accordingly.

STUDYING THE BIOLOGY OF *RAMULARIA COLLO-CYGNI* AND THE DEVELOPMENT OF AN INTEGRATED PEST MANAGEMENT SYSTEM TO MATCH NEW CHALLENGES FROM A CHANGING CLIMATE

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Long term surveys show a shift in pathogen population in Bavaria. As a consequence efficiency of established control strategies has been reduced. Unsatisfying barley yields have been attributed to the occurrence of heavy leaf spotting caused by environmental factors and Ramularia leaf spotting (RLS). A joint project between the Technische Universität München and the Bavarian State Research Center (LfL) investigated the biology of *Ramularia collo-cygni* as the biotic cause of leaf spotting for the development of an Integrated Pest Management System. Different sites in Bavaria were monitored and specific fungicide trials conducted in spring barley and winter barley. The field trials were accompanied by intense studies of the pathogen-biology. The objective of the project was to integrate the results into an established Integrated Pest Management tool (Gerstenmodell Bayern) for improved control. With the focus on the detection of *Ramularia collo-cygni* in the field and interaction of the epidemics with climatic factors, the project had the advantage of intense observations in a region with high incidence and high agricultural and climatic variability. The monitoring showed a broad and regular occurrence of the leaf spotting complex on all tested sites. Based on the results from specific fungicide trials an improved management strategy was developed. Compared to the traditional "Gerstenmodell Bayern" the new strategy proved to give generally better disease control and superior yield benefit under different environmental and epidemiological conditions in the past three years. Still to further optimize the tool a better understanding of the pathogen biology will be necessary. Sporadic sporulation on senescent leaves and molecular detection from asymptomatic leaves early in the season give evidence of endophytic stages and a hemibiotrophic life style. Additionally, *Ramularia collo-cygni* can be detected on seed and seedlings proposing the opportunity of seed transfer. While new seed treatments achieve good disease control the role of seed transfer for the late epidemics, population dynamics and the development of fungicide resistance is the subject of current projects. So far no resistant variety was identified, but differences in tolerance and a strong influence of plant senescence were observed. As a consequence our investigations propose a complex interaction between the latency of *Ramularia collo-cygni*, plant development and environmental factors.

MULTIFACTORIAL ANALYSIS OF THE *FUSARIUM* COMPLEX ON BARLEY

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Fusarium head blight is caused by a complex of *Fusarium* species and known as a destructive disease in all cereal growing areas of the world. As in other small grain cereals, the infection of barley implies yield loss, quality reduction and mycotoxin contamination of grain. A multifactorial analysis of the *Fusarium* complex on barley was performed to determine influencing factors on the *Fusarium* epidemiology and to evaluate their importance. Plants of different varieties were sampled throughout the growing season in a weekly frequency. Sampled plants were divided into their organs (spike and single leaf levels) and analyzed for the presence and development of *Fusarium* species by polymerase chain reaction (PCR). Moreover, inoculum distribution by wind and its contribution to infection were evaluated. This was performed by sampling of airborne *Fusarium* inoculum with a Burkard spore sampler and a subsequent quantitative PCR analysis. PCR analysis of harvested grain s indicated a predominance of *F. langsethiae*, *F. poae*, *F. avenaceum* and *F. tricinctum*. The species *F. graminearum*, *F. culmorum* and *F. sporotrichioides* were less prominent. Quantitative PCR analysis of plants prior and at the beginning of anthesis respectively, indicated that distribution patterns of *F. avenaceum* and *F. culmorum* on leaf levels followed gradients. Higher leaf levels contained more fungal DNA than lower levels. Furthermore, *F. langsethiae* was dominant in spikes and occurred rarely on leaves, whereas *F. avenaceum* and *F. culmorum* were predominantly found on leaves. Observations of the disease development throughout the season indicated variable DNA contents of *F. avenaceum* in various plant organs, but an increase by trend towards harvesting. Analysis of airborne inoculum identified *F. avenaceum*, *F. culmorum*, *F. langsethiae* and *F. graminearum* to be distributed by wind. In this context, *F. avenaceum* was dominant, followed by *F. graminearum*, *F. culmorum* and *F. langsethiae*, showing specific peaks of increased inoculum densities. Peaks of *F. culmorum* were detected early in the growing season. *F. langsethiae* was rarely observed. Airborne inoculum of *F. avenaceum* and *F. graminearum* increased throughout the season. A correlation and regression tree analysis with prevalent weather conditions identified rain as most influencing factor for the presence of airborne inoculum. Moreover, the termination of rain events considered rain-splash dispersal of *F. avenaceum*, *F. poae* and *F. langsethiae*. Those observations suggested that different distribution pathways are of different importance for various *Fusarium* species. The present study detected differences in the epidemiology of single *Fusarium* species. First and foremost, the generated information could simplify the choice of single factors for further investigations on the *Fusarium* epidemiology. Over and above, results could be conductive for a future, more effective decision support with regard to choice of variety and application of fungicides.

USE OF FIELD TRIAL NETWORK FOR DEVELOPMENT OF VARIETY SPECIFIC FUNGICIDE REGIMES IN WINTER AND SPRING CEREALS

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The incidence and severity of plant diseases depend from combination of host plant and pest genotypes, climatic conditions and management practises. Environmentally sound and economically efficient disease control needs considering all these factors. Use of less susceptible varieties is considered to be one of most effective measures in disease control enabling reduction of fungicide application. A series of field trials was carried on in 2010-2012 for development of variety specific guidelines for efficient fungicide use in winter and spring cereals. A field trial network of varieties of spring and winter cereals consisting of more widespread varieties of spring and winter wheat, winter rye, winter triticale, spring barley and oat were established in farmer's fields in four locations of Estonia for this purpose. The number of assessed varieties in a single year varied from forty six to fifty two. Three fungicide treatment regimes with half fungicide dose were applied in all crops - early treatment (BBCH 32-37), late treatment (BBCH 55-65) and both treatments. Disease incidence in untreated and fungicide treated variants were recorded in the trials throughout the growing season. Yield increase from fungicide application and economic return were used for assessment of need of fungicide use. The routine, two time fungicide application was reasonable only in limited number of varieties. A single application of half fungicide dose was adequate in majority of varieties in most locations. In less favourable conditions of disease incidence - drier years and/or less susceptible varieties the fungicide use did not result in net yield increase. The data of current study are used in development of simple decision support system for the control of cereal diseases. The study is carried on in frames of the project No 171011780017, financed from the measure 1.7.1 of Estonian Rural Development programme.

SLOVENIAN AGROMETEOROLOGICAL INFORMATION SYSTEM – SUPPORT IN THE FORECASTING OF APPLE SCAB

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Apple scab (*Venturia inaequalis*) is a disease which is economically still the most important and difficult to control in the apple production (*Malus domestica*) in Slovenia. Thus, in the climate with an average annual rainfall of 1100 mm, the main challenge for protective measures is an apple crop that would be free from apple scab symptoms in either integrated or organic production. In Slovenia, the prognosis of preventive fungicide application against apple scab is focused mainly on the management of primary infections and prevention of the development of secondary infections. The Ministry of Agriculture and the Environment, together with the forecasting services at five regional centres, is responsible for the operation of the Slovenian Arometeorological Information System, which supports also forecasting models for apple scab. The system dates back to 1994, when the first automatic weather stations (Adcon Telemetry) were installed in the Slovenian territory and it belongs now to the wider Phytosanitary information system. Over the years, the system passed through a number of infrastructural and technical changes and today it uses all the available information technology (software, automatic measurements, models, telecommunications, Internet, GIS). More than 90 automatic weather stations are used in the network with radio or GPRS transmission. Most of them are placed in the agricultural area, where also the phenology of agricultural plants and pest phenology are monitored and used in the prognostic models. The system enables real-time data and prognostic information dissemination to the interested parties via website, e-mail or SMS. Forecasts and advices are issued during the season to provide for plant protection against major economic harmful organisms in orchards, vineyards, hop gardens, olive growing, arable crop production and horticulture. Since prognostic centres operate as public services, information in electronic form is given to professional growers and other users free of charge with the aim that they provide for a targeted, timely and rational use of plant protection products in their agricultural production. Prediction of the risk of apple scab infections is based on the evaluation of data from weather stations, which are located on representative fruit growing localities, and on the monitoring of biological data: phenological stage of apple trees, development of the fungus and its infectious potential (maturity of peritecia at detached leaves of apple trees in the field and air-capturing of ascospores). The complexity of agrometeorological system and efforts to optimize the usefulness of data made so far, together with its role in the prediction of apple scab, are discussed.

PERFORMANCE AND SIDE EFFECTS OF IPM SOLUTIONS USING MODEL-BASED TOOLS TESTED BY GREENHOUSE TRIALS

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Up to now, alternatives to chemical pesticides using biological control strategies have been implemented empirically at the cost of huge experimental efforts in order to provide wide-test ranges of biological control agents (BCAs). Satisfactory answers to pest problems require a shift in understanding, such as promoting biological agents as well as more widely ecologically-sound practices. Despite being poorly biodiversified, many complex interactions can occur among biotic components and between biotic and abiotic components in agro-ecosystems such as protected cultivation systems. Understanding these interactions is a major hurdle to overcome for the development of future IPM strategies. Within this framework, we have, first, investigated aerial plant systems via spatio-temporal modelling of the abiotic environment. Distributed climate modeling specially at leaf level provide crucial information on pests and BCAs ecological niches. Similarly, abiotic transfers are considered to be likely pest vectors. By applying the expertise gained in the study of energy and mass transfers between the greenhouse and its environment, the threefold objective was to provide satisfactory habitat for plant growth; to restrain pest encroachment through use of prophylactic techniques such as insect-proof nets; and to promote environmental acceptability of the plant growth system by controlling power consumption. From the biotic point of view, a panel of diversified pests is also currently present at the same time to which all the biocontrol agent species released by the grower have been added. Therefore studies have focused on the mechanisms underlying the outbreak and the dynamics of pests and diseases in the canopy. In this case, the ecological approach, based on both theoretical and applied studies, is of major interest to describe the biotic interactions taking place between the crop, pests and BCAs, as well as to refine pest control methods, specially through the use of multiple natural enemies. Research is not only carried out on the creation of new technical routes for crop protection (IPM) but also, by means of models, noticeably, on better understanding the greenhouse ecosystem and the corresponding communities, i.e. cultivated plants, pests and biological control agents. The objective is both to assess and promote the ecological services among a complex network of manifold biotic interactions. More generally, the integration of the huge amount of interacting entities and control tools of the greenhouse agro-ecosystem requires multicriteria model based assessment in order to set up the most appropriate crop protection strategies. Therefore, this study presents very diversified modeling approaches, each of them playing an important role in the implementation of robust IPM strategies under greenhouses.

CONTROL OF THE DAMSON-HOP APHID (*PHORODON HUMULI* SCHRANK) ON HOP (*HUMULUS LUPULUS* L.) WITH INTEGRATED PEST MANAGEMENT STRATEGIES

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Damson-hop aphid (*Phorodon humuli* Schrank) is an important hop pest (*Humulus lupulus* L.) occurring yearly on hop plants and causing economic losses in Slovenia. The prognosis and signalling of damson-hop aphids are based on the monitoring of the migration from the primary to the secondary host, as well as its monitoring on both host plants. In Slovenia, the first species of the damson-hop aphid in nature can be found when the temperature sum reaches 217ºC above the temperature threshold of 5.6°C, which is usually at the beginning of May. The duration of the flight of damson-hop aphids from the primary hosts – *Prunus* – to the secondary host – hops – on average lasts for 46 days, which mainly depends on the air temperature. The control of the damson-hop aphid with an insecticide begins when on average 50 aphids are found per leaf, or more than 200 aphids are found on individual leaves. When the aphids are present in high populations in the upper part of hop plants , insecticide must be used immediately because aphids significantly reduce the growing and development of hop plants. The use of systemic insecticides is deemed efficient when the aphid population reaches the threshold of economic loss and before the hop plants to flower. In Slovenia, systemic insecticides are currently only used once per growing season for management of damson-hop aphids.

PESTICIDE NON POINT SOURCE POLLUTION RISKS: AQUAVALLEE®: A GIS BASED DIAGNOSIS TOOL

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This poster introduces a unique method to pinpoint Non Point Source (NPS) pollution risks at field level. Based on the rigorous CORPEN methodology, ARVALIS developed a user-friendly GIS based tool. The resulting decision-making tool efficiently locates zones where risks of NPs are present, even within rather large watersheds. The methodology encompasses saturated and unsaturated behaviour of both superficial and groundwater aquifer system analyzing transfer types, and makes wide use of the following key parameters:

- Field location and land-cover
- Soil composition
- Slope and orientation
- Hydrographic network
- Location and nature of phreatic aquifers
- Pervious and impervious zones

Aquavallée® allows suitable solutions for each type of pesticide transfer to be found: buffer zones, changes to agricultural practices, reduction in pesticide doses, spray period and modification of pesticide type. This tool has been applied on more than 1 000 000 ha in France and in some European countries. Aquavallée® has allowed for the diagnosis of diffuse pesticide transfers on 41 areas of water supplies. As part of the European TOPPS Prowadis project, the use of Aquavallée® has been extended to Germany, Denmark, Poland, Belgium, Italy and Spain. The system has proved to be efficient in reducing workload by targeting only fields where NPS is real. In addition, it allows an homogenization of risk ranking when several surveyors are used within a single watershed. The Aquavallée® map, with the localization of the plots, is a good educational tool to help farmers to appropriate the results of risk diagnosis and mitigation measures.

A WEB-GIS DECISION SUPPORT SYSTEM FOR PARASITE CONTROL IN ALPINE REGIONS: APPLICATIONS TO GRAPEVINE PHENOLOGY AND MODELLING OF EUROPEAN GRAPEVINE MOTH

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The environmental variability in the mountains regions like Trentino made needed a WEB GIS tool to the decision support system (DSS). High variability of temperature along of each valley made necessary one real time system to help in the monitoring activities and management of the sanity controls. Furthermore, collecting biological samples is always time consuming and expensive. Phenological model of each growth stage of grapevine cv. *Chardonnay* was overlapped with the time of flight of each generation of the European grapevine moth to adjust more the time of controls. *Lobesia botrana* is the one of the most important pest in Italian vineyards. Larvae feed on flowers during the first generation, and then on grape berries during the second and third generations. From 1998 the common control is mating disruption and the viticultural area is treated with pheromones. Modelling the time of flight at daily scale and overlap both models is one advantage to know the data when and where start to make the controls. The aim of this work was to modelling host pest phenologies in maps at 200 hundred meters of resolution at daily scale in Trento province to management of the time of pest controls. The output of the models were running into a friendly modular WEB GIS called ENVIRO and the impacts of the climate change scenario downscaling at regional level was evaluated.

IPSIM, INJURY PROFILE SIMULATOR, A HIERARCHICAL MODELLING FRAMEWORK TO PREDICT AN INJURY PROFILE AS A FUNCTION OF CROPPING PRACTICES, SOIL, CLIMATE AND FIELD ENVIRONMENT.

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The limitation of damages caused by pests (weeds, plant pathogens and animal pests) in any agricultural production requires integrated management strategies. Even if significant efforts have been made to develop the combination of genetic, biological, cultural, physical or chemical controls in Integrated Pest Management (IPM) strategies (vertical integration), there is a need for tools to help manage injury profiles (horizontal integration). Farmers design cropping systems according to their goals, their cognition and their perception of socio-economic and technological drivers as well as their physical, biological, and chemical environment. In return, a given cropping system, in a given production context will lead to a unique injury profile, defined as a dynamic vector of the severities of all injuries occurring on a crop. This simple description of agroecosystems has been used to develop IPSIM (Injury Profile SIMulator), a modelling framework to predict injury profiles on arable or perennial crops as a function of cropping practices, soil, climate and field environment. Due to the tremendous complexity of agroecosystems, a simple aggregative framework was chosen to develop this model. In order to provide a proof of concept, a model, named IPSIM-Wheat-Eyespot, has been developed according to the conceptual framework of IPSIM to represent final incidence of eyespot on wheat. IPSIM-Wheat-Eyespot's modelling approach consists of designing a model with an aggregative hierarchical and qualitative tree of attributes. The predictive quality of the model was assessed using a dataset embedding a wide range of climates, soils and cropping practices (526 observed sites-years). IPSIM-Wheat-Eyespot proved to successfully represent the annual variability of the disease, as well as the effects of cropping practices (Efficiency = 0.64, Root Mean Square Error of Prediction = 25%; bias = 6.2 %). IPSIM-Wheat-Eyespot does not aim at predicting precisely the incidence of eyespot on wheat. It focuses on the ex ante evaluation of the risk of eyespot on wheat for a cropping system in a given production situation or on the diagnosis of commercial wheat fields. Its structure is simple and permits to combine available knowledge in the scientific literature (data, models) and expertise. IPSIM-Wheat-Eyespot is now available to help design cropping systems with low risk of eyespot on wheat in a wide r ange of production situations, and can help perform diagnoses of commercial wheat fields. IPSIM-Wheat-Eyespot will be one of the sub-models of IPSIM-Wheat, a model that will predict injury profile (main diseases, weeds and animal pests) on wheat as a function of cropping practices and the production situation.

VARIABILITY IN RESISTANCE OF POLLEN BEETLE POPULATIONS TO PYRETHROIDS

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In 2009 - 2012, resistance of pollen beetle from different parts of the Czech Republic to six pyrethroids (deltamethrin, lambda-cyhalothrin, cypermethrin, bifenthrin, etofenprox and tau-fluvalinate) was evaluated in bioassay by topical application method. LC50 and resistance ratios were calculated for all the tested pyrethroids. Resistance of pollen beetles to pyrethroids was proved in most of the samples, but the level of resistance largely varied between localities. The highest resistance was detected to deltamethrin and lambda-cyhalothrin. On the other hand, the lowest resistance was detected to tau-fluvalinate. High risk of cross-resistance was found between deltamethrin, lambda-cyhalothrin and cypermethrin. Contrary, low risk of cross-resistance was proved between etofenprox, bifenthrin and tau-fluvalinate. Antiresistant strategy was proposed based on the results. The work was supported by the project of the Ministry of Agriculture Czech Republic, no. QJ1230167.

EPI MODEL FOR MANAGEMENT OF GRAPEVINE DOWNY MILDEW IN LOMBARDIA

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Grapevine downy mildew, caused by *Plasmopara viticola*, often requires numerous chemical treatments in order to reduce serious damages on leaves and clusters. The management strategy suggested by the Italian extension services is based on the occurrence of meteorological conditions suitable for *P. viticola* infections and the calculation of the incubation period. However various treatments executed following this strategy could be avoided in presence of low infection risk. EPI (Etat Potentiel d'Infection), an heuristic model designed for the assessment of infection likelihood of *P. viticola*, can be used to define a rational treatment strategy against the pathogen. The aim of this work is to compare the treatment schedule based on the EPI simulations with the extension service strategy in vineyards located in Lombardia, by assessing the corresponding infection indexes and the number of treatments applied in the different plots. Twenty experimental assays were carried out from 2008 till 2012 in Oltrepo Pavese, Valtellina, Sirmione (BS) and in the Mantova province, at Monzambano (MN) and Mantova (MN). In each experimental vineyard, the treatments corresponding to the two strategies were carried out in two plots, consisting of three rows, 80 m long. An analogous plot was not treated against *P. viticola*. The downy mildew epidemic development was assessed weakly in the untreated plots on 100 leaves and 100 clusters located in four subplots and at the end of the season on the treated plots. Each grapevine organ was classified in one of the following classes: 0- healthy; 1: 0.1-2.5 % symptomatic surface; 2: 2.5-5 % symptomatic surface; 3: 5-10 % symptomatic surface; 4: 10-25 % symptomatic surface; 5: 25-50 % symptomatic surface; 6: 50-75 % symptomatic surface; 7: 75-100 % symptomatic surface. The percentage infection indexes (I%I) per treatment and grapevine organs were calculated and compared using one-way ANOVA. The I%I assessed on the plots treat ed according to the different strategies were analogous, but the EPI strategies required a lower number of treatments. Overall, the treatment number was reduced by 57 % by EPI and in three vineyards no treatments were applied against *P. viticola*. Therefore the simulations obtained by using the EPI model represent a valuable indication for defining a sustainable and rational treatment schedule against *P. viticola*.

DISTRIBUTION AND SEASONAL POPULATION DYNAMICS OF *FUSARIUM* SPP. IN *CITRUS* NURSERIES OF SOUTHERN ITALY

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Fusarium spp. are generally classified as soil-borne fungi causing various vascular wilts, root and stem rots of cultivated plants. *F. solani* (Mart.) Appel. & Wremend. Snyd. & Hans. is the main species isolated from citrus, associated with dry root rot and symptomless infection on rootlets. This fungus is ubiquitous in citrus groves and nurseries, attacking feeder roots under stress conditions. In this work, the distribution and seasonal population dynamics of *Fusarium* spp. in four citrus nurseries located in Basilicata, Calabria, and Sicily (Southern Italy) was evaluated in order to define the suitable period for applying efficient control measures. Soil and root samples were collected from the rhizosphere of six rootstocks from September 2006 to December 2007. The number of *Fusarium* spp. propagules was assessed using soil dilution plate method with a *Fusarium* selective medium. Isolates were grouped according to their morphological characteristics and classified using the DNA Sequence-Based method by amplifying and sequencing two genomic regions: betatubulin (benA) and translation elongation factor 1-alpha (tef) genes. In all nurseries *F. solani* was the predominant species followed by *F. oxysporum* and, at a very low frequency, by *F. proliferatum*. *Fusarium* spp. propagules showed the lowest values in December, then they increased in March and reached a peak in June. *Fusarium* spp. population in the soil collected from four citrus nurseries showed different average values, very high in Nursery 2 and 4, and low in the two other nurseries. *Fusarium* spp. population fluctuated according to the rootstocks, being generally high in Troyer citrange, Carrizo citrange and Volkameriana lemon seedlings.

USING VITIMETEO-PLASMOPARA TO BETTER CONTROL DOWNY MILDEW IN GRAPE

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Downy mildew caused by the oomycete *Plasmopara viticola* is one of the most important diseases of grapevine. Regular spraying with fungicides over the entire growing season is needed in order to protect the grapes. Even so, in years with difficult weather conditions like 2012 or 2008, downy mildew is causing yield losses. The implementation of disease forecasting models to control the main fungal diseases of grapevine according to their epidemiology is a central element of integrated pest management. The use of decision support systems (DSS) is increasing in importance among advisers and growers. The VitiMeteo-Plasmopara model is an expert system developed by the Grapevine Research Institute of Freiburg (WBI, Germany) and Agroscope Changins-Wädenswil (Switzerland), and programmed by the company GEOsens (Germany). Using relevant weather data VM-Plasmopara simulates the main development steps of the epidemiology of *Plasmopara viticola*. The software generates graphics and tables freely available for the growers on the Internet. The model also incorporates weather forecasts data to simulate the development of the pathogen during the next 5 days. VM-Plasmopara is currently used over all vineyards of Switzerland, Germany and parts of Austria and northern Italy. Model validation during nine years in Changins (CH) has shown its high reliability. Outputs of the model were compared to observations made in the lab and in a small untreated experimental plot. Predicted downy mildew development was in accordance with disease appearance and progression in the experimental plot. However, improvement is still needed to better understand conditions required to have oospores maturation and germination in spring. Different protection strategies based on the model were tested in the field and allow to better control downy mildew and to decrease the number of fungicide applications. Growers using VM-Plasmopara are spraying more in accordance with the disease epidemic. They can objectively decide to delay the first spray or to enlarge spray intervals, thus reducing the number of sprays. The model allows them to evaluate the disease risk and decide of fungicide treatments opportunity on an objective basis.

INSIGHTS INTO *DROSOPHILA-WOLBACHIA* INTERACTIONS: INNOVATIVE STRATEGIES FOR INSECT PEST MANAGEMENT

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Drosophilidae is a well-studied host family of *Wolbachia*, an obligatory intracellular and maternally inherited symbiont. *Wolbachia* infects many insect species and is capable of manipulating the reproductive properties of their insect hosts by inducing Parthenogenesis, Male-killing, Feminization and most commonly, Cytoplasmic Incompatibility (CI). We propose that the release of *Wolbachia*-infected males to promote incompatibility with female natural populations can enhance the efficacy of pest management of *Drosophila suzukii*, an emerging new pest of European and American fruit production. Here, we present the draft genome of a novel *Wolbachia* strain named "wSuzi" that was retrieved from the genome sequencing of its host *Drosophila suzukii*. The final assembly yielded approximately 1.35 Mbp in 110 contigs, with an average depth of coverage 60X. We found wSuzi in close relation with wRi strain infecting *D. simulans*. The two genomes displayed extensive similarity, however, several structural variations (InDels and genomic rearrangements) are able to discriminate between two strains. These findings may facilitate exploitation of *Wolbachia* mediated CI in *Drosophila*-*Wolbachia* associations. This, together with fitness measurements, and comparative genomic studies shall provide new insights on *Drosophila-Wolbachia* biology and practical outcomes for the management of this insect pest

IMPACT ON THE SIZE OF PEST POPULATION IN STRAWBERRY PLANTATIONS IN LATVIA

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Using the single-cropping cultivars the strawberry production season in Latvia traditionally lasts from the middle of June until the second ten day period, while growing strawberries in different polythelene tunnels shifts the season from the end April until the third ten day period of June. Being interested in selling strawberries for a higher market price, growers are striving to extend the strawberry production season and obtain yield in untraditional. One of the options for achievement of later yield is growing of ever bearing cultivars. Over the vegetation seasons of 2011 and 2012, trials were carried out in LSIFG (Latvian State Institute of Fruit-Growing) to observe pests and their populations in strawberry plantations in high FGV type tunnels with and without manure. The cultivars investigated two breeds: 'Polka' and 'Sonata'. In high FGV type tunnels with and without manure four commercially significant pests were detected: strawberry blossom weevil *Anthonomus rubi* Hbst., thrips *Thripidae* gen. sp., two species of mites: *Tetranychus urticae* Koch. and *Phytonemus pallidus* Banks as well as three species of snails. After assessing strawberry plantations in LSIFG, it was established that the highest levels of damage inflicted on buds by *Anthonomus rubi* were seen in high type tunnels without manure, where *A. rubi* had damaged 4.64% of the buds in breed 'Sonata'. The highest levels of *Tetranychus urticae* (on average 1.46 individuals per leaf) and *Phytonemus pallidus* (on average 19 individuals per leaf) invasion were seen in high FGV type tunnels with manure in breed 'Sonata'. Cultivar 'Polka' had the best results among the cultivars tested in high type tunnels with and without manure. Another line of investigation was influenced by plastic cover used in high FGV type tunnels on strawberry yield quality in early season. There were no significant differences as to impact of insects on fruit yield quality in high FGV type tunnels with and without manure.
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THE SPREADING OF *FRANKLINIELLA OCCIDENTALIS* (PERGANDE) OVER CITRUS ORCHARDS: THE IMPACT ON PEST THRIPS FAUNA AND THE EVALUATION OF ECONOMIC THRESHOLDS

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Since its introduction into Europe, at the end of 1980s through the horticultural trade in living plants, *Frankliniella occidentalis* (Perg.) (Thysanoptera, Thripidae) has become one of the most harmful pest to economic importance crops, in greenhouses and in open field. The species is highly polyphagous and this characteristic is responsible of its impact, as new introduced pest, on the native thrips fauna in the Mediterranean Basin crops, and its influence on the agricultural systems of southern European regions. Relatively to citrus crops, *F. occidentalis* has not been reported in the past literature, as the main pest thrips, comparing to other indigenous thrips species, as *Pezothrips kellyanus* (Bagnall), *Thrips flavus* Schrank, *T. major* Uzel and *T. tabaci* Lindeman. Only recently, results of surveys carried on in some specialized citrus areas in Spain, Turkey and Cyprus have shown the spreading and colonization of citrus crops by WFT and the reducing of infestations by the native thrips species. The aim of the present contribution is to demonstrate the spreading on citrus crops by WFT in some intensive growing areas of Calabria region, the impact on infesting activity by indigenous pest thrips and to provide data for economic thresholds, in order to produce IPM protocols suitable for the investigated area. Surveys have been carried on, in 2010 and 2011 years, from March to November, on bergamot, lemon and orange crops in Reggio Calabria growing area (South Italy). From each crop, a plot of 200 plants homogeneous in variety and age, was selected and a sample was constituted by 50 shoots (as one shoot was done by 1 flower or fruit with 1/2 leaves). Each sampling was taken every 15 days. The mean values of adults of each thrips species have been performed with statistical analysis. Results have shown the most abundance of WFT on bergamot and lemon, during end of spring/summer and autumn. The relationships between abundance of thrips and damage symptoms on flowers/fruits show that 1 adult specimen/shoot of WFT can be considered as threshold value on bergamot and lemon. This value derives from a few considerations which limit the acceptable percentage of damage: the biological characteristic of the species (i.e. preference for the flower parts) and the destination of products (market or industry).

USING SPECTRAL DATA FOR IDENTIFYING CITRUS PLANTS INFECTED WITH *CITRUS TRISTEZA VIRUS* (CTV)

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Citrus tristeza closterovirus (CTV) is one of the main causes of loss and destruction in citrus groves across the world. Detecting promptly the virus presence and determining how the infection develops in time and space is necessary to support an efficient large-scale monitoring programme. High resolution satellite imagery, successfully applied in the identification of pests/diseases in wheat and vegetable crops, was used in this study to assess CTV infection. Trials were conducted under a temperature-controlled greenhouse and in some CTV infected citrus groves in Apulia region (Southern Italy). In the greenhouse, 28 Mexican lime plants (the universal CTV indicator) were grown in optimum nutrition and temperature conditions for disease expression. Half of the plants were inoculated with a local CTV-quick decline isolate (IAMB-Q 109) and half were un-inoculated. In the field, six infected commercial groves of 'Navelina' orange, located in the CTV outbreak area, were selected and 28 trees/grove were chosen based on sanitary results. Greenhouse plants and field trees were tested by serological (DTBIA and ELISA) and molecular (PCR) assays to assess the virus presence. In order to identify the vegetation indices, the HandHeld Post Dispersive Spectroradiometer (325-1075nm), connected to a plant probe-leaf clip, was used for spectral measurements on citrus plants. In the greenhouse, the spectral reflectance was acquired from the leaves under artificial light, approximately 20 days after inoculation. In the field, spectral signatures were provided by leaf and canopy measurements at nadir position. In both trials, results highlighted spectral differences of infected plants in the visible (500-740nm) and near infrared (750-950nm) ranges. In the greenhouse the spectral discrimination was more evident than in the field. Specific indices (NDVI, mYI, PSRI, NCI, MCARI) were selected for the implementation of a detection algorithm, which was developed for processing a 2m multispectral GeoEye-1satellite image with a spatial resolution of 0.5 m in panchromatic band. The spatial resolution of the four-band multispectral image have been improved through techniques of pan-sharpening (ERDAS IMAGINE software). The output image with all combined indices was effective in discriminating the CTV-infected and -uninfected trees in the studied groves. The elaborated image allowed the assessment of CTV infection correlated to different canopy stresses. Such correlation was almost 100% in the severe declining trees, while it reached 75% in highly chlorotic trees. However, 52% of correlation was also reported in mild chlorotic or apparently asymptomatic trees.

SEX-SPECIFIC RESPONSE OF THE TORTRICID PEST *LOBESIA BOTRANA* TO VOLATILES EMITTED BY THE ASIAN FOOD-PLANT *PERILLA FRUTESCENS*

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Grapevine Moth *Lobesia botrana* (Denis & Schiffermüller, 1775) is a major pest of grape worldwide. By multiple generations per year in its native range and its generalist feeding, *L. botrana* also affects the production of other fruit crops at different ripening stages. Control of this pest still largely relies on insecticide applications and on the combination of chemical, biological and integrated pest-managements. *L. botrana* kairomones have been extensively studied but their effectiveness for control purposes is limited by overlap with background odors in the vineyard. Behaviorally active compounds from non-host plants may represent an interesting alternative. Volatiles of food plants origin, i.e. from capsicum, garlic, pepper and mint, are known to activate specific receptors across species and phyla, giving the so called somatosensory sensation. These plants have also been used in agriculture for their known ability to interfere with insects and nematodes. Among those plants, *Perilla frutescens* (L), native of Asia, was shown to produce compounds strongly activating sensory rat Transient Receptor Potential (TRP) channels, also involved in the perception of the above mentioned volatiles, which were found expressed in the antennae of tortricid pests. We screened the biological activity of essential oil metabolites isolated from *P. frutescens* on the olfactory system of *L. botrana*. Then, we investigated the expression of candidate TRP-genes comparing full length cDNAs samples synthesized from several tissues of another tortricid model (*Cydia pomonella*). Electrophysiologically active compounds released from two different *P. frutescens* varieties having specific chemical makeup (chemotypes) were identified by gas chromatography-coupled with electroantennography (GC-EAD). In a dual choice oviposition test based exclusively on olfactory cues, females showed a preference for the odors released by a Perilla variety which profile is dominated by S-(-)-Perillaldehyde (PA), even in presence of the odor bouquet of grape bunches. In a Y-olfactometer test compared with an odorant-free control experiment, males showed a significant behavioral enhancement in the presence of odors released by a Perilla variety which profile is dominated by ketones Perillaketone (PK) and Isoegomeketone (IK). Comparing cDNA samples, we identified a singular pattern of expression in tortricid antennae for specific TRP candidates and sex-specific relevance of different level of expression of other candidates. Future molecular, physiological and behavioral studies will focus on the mechanisms of action of Perilla compounds on insect senses, with the aim to validate the motivation of different sex responses to Perilla compounds.

OLIVE OIL MASSIVE CAPTURES

Garnica I.

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The culture of the olive tree for oil-mill is important in Navarre where practically all the plots devote themselves to it. There took a plot of an important surface in the one that was divided in two zones to be able to realize the control of fly. The olive is of the variety cv. Arróniz in Arróniz's locality. In the plots traps placed type "Olipe" fed with phosphate diamonico to 1 % to a density of a trap for tree on July 27, 2011. Another part of the plot was kept as witness of reference. Weekly the captures were controlled in 17 traps distributed by the whole plot and counts of hurt were realized by putting of *Bactrocera oleae*, so much in the subplot with traps as in another part that was kept as reference. The effect obtained with I cheat he can be considered to be satisfactory enclosedly in this campaign by high proportion of hurts, though ultimately the application of insecticide was necessary against the plague.

MONITORING OF *LACANOBIA OLERACEA* BY LIGHT AND PHEROMONE TRAPS

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Monitoring of the flight activity of *Lacanobia oleracea* (Linnaeus, 1758) using light and pheromone traps was conducted at five localities: two in central Bohemia (Prague – Ruzyně and Milovice nad Labem), two in north Moravia (Olomouc and Pusté Jakartice) and one in south Moravia (Želešice). Measurements occurred from May 1 to October 31. Two trap types were used to attract individuals at each locality: a wing trap and a Minnesota light trap with a 125-W mercury vapor lamp. The efficacy of the pheromone traps was very low when compared with the light traps. The number of *L. oleracea* males captured in the pheromone traps ranged from 0 to a maximum of 23% of all captured males per locality. The attractiveness of the tested pheromone is not sufficient for the purpose of monitoring *L. oleracea* in the Czech Republic. It is recommended that only the net and light traps from the State Phytosanitary Administration be used for the prediction of the occurrence of eggs and young larvae of *L. oleracea*. This work was supported by project NAZV QJ1210165.

INTEGRATED USE OF A SAR ELICITOR AND PHYSICAL MEANS FOR THE MANAGEMENT OF TYLCD ON GREENHOUSE TOMATOES

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Since its introduction into the Mediterranean region, which dates back to the late 1980s, tomato yellow leaf curl disease (TYLCD) has become a major threat for tomato crops in this area. At present the management of the disease relies mainly on insecticides (usually neonicotinoids and pyrethroids) and the screening of greenhouses with insect-proof nets. However, the use of inappropriate mesh size and the poor maintenance of screens frequently lead to inadequate disease control. With the aim of finding suitable alternatives to the repeated application of insecticides, a five-year study program was carried out in the south of Sardinia (Italy).

The effectiveness for the management of TYLCD of a systemic acquired resistance (SAR) inducer (acibenzolar-S-methyl) and two physical tools (UV-reflective mulches and floating row covers), used alone or in different combinations, was assessed under experimental and commercial conditions. Different doses (10-60 mg/liter), number (4-7 treatments), timing (pre- and post-planting) and frequency (weekly or bi-weekly) of application of acibenzolar-S-methyl were tested. To exclude whiteflies from feeding on young tomato plants, rows were covered for 2-3 weeks after transplanting by means of non-woven fabrics. The UV-reflective film used as mulch was highly-reflective, with one metalized side (aluminum) on a white polyethylene base.

The incidence of infected plants was generally reduced by the application of acibenzolar-S-methyl, but marked differences in efficacy were observed depending on the severity of the disease attack and the mode of application. In general, an increase in the efficacy was achieved when a preventive treatment (pre-planting) was applied, and the number and frequency of applications fit well to the trend of disease progression. The use of non-woven floating covers was found to be very effective in reducing TYLCD incidence during the first month of cultivation. However, when the disease pressure on the crop was consistently high, the percentage of infected plants increased rapidly after cover removal. The UV-reflective mulches proved to be less effective than row covers at the beginning of the growing period, but two months after transplanting both physical means showed a similar degree of efficacy in reducing disease incidence.

All the tools evaluated showed a potential for the management of TYLCD on greenhouse tomatoes, but the most interesting results were achieved when the use of floating row covers or UV-reflective mulches was integrated with repeated applications of acibenzolar-S-methyl. In this case the SAR elicitor prolonged and intensified the effects of the two physical means, achieving a level of efficacy comparable to that produced by intense insecticide use.

CONTROL OF THE GRAPEVINE MOTH *LOBESIA BOTRANA* THROUGH THE MANIPULATION OF THE PLANT TERPENOID PROFILE

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The grapevine moth *Lobesia botrana* is one of the key pests of grape. Damages of the vineyard are achieved both by direct larval feeding on reproductive tissue of the plant (flowers, berries) and by secondary infections of microorganisms. Current control systems are either based on pesticides (many of which are currently being phased out) and mating disruption. Mating disruption stops the male moth from finding the female, by saturation of the treated area with sex pheromone. However, this method does not work well in non-delimited areas, or areas where pest population is high. We therefore suggest a method that instead works on the female by modifying the host-finding and the egg-laying behaviors, which in herbivore insects are mostly mediated by host plant volatiles (kairomones). Recent wind-tunnel studies have shown that a blend of 10 synthetic grape volatiles attracts as many moth females as a bunch of green grapes or the entire headspace collection from the same grape bunch. Further investigations demonstrated that even a subset of 3 specific terpenoids (E)-β-caryophyllene, (E)-β-farnesene and (E)-4,8-dimethyl-1,3,7-nonatriene (DMNT) elicits attraction comparable to that of the complete lure in laboratory essays, and gave also promising result when tested in field conditions. In addition, it was shown that the specific ratio among compounds is crucial, since both the subtraction and the percentage variation of any of the three chemicals resulted into an almost complete loss of activity of the blend. In the present work, we previously studied morphology and distribution of the antennal sensilla of *L. botrana* males and females, using Scanning Electron Microscopy (SEM). Afterwards, Single-Cell Recordings (SCR) from receptor neurons housed in sensilla thricodea and auricillica were performed. The neuronal activity induced by various grape volatiles, including the 3 kairomones mentioned above, was recorded and compared to responses to the female main pheromone compound E7,Z9-12:Ac. SCR responses to kairomones were strongly female-specific and s. auricillica-specific, and in the same range of neuron activation as those elicited in males by E7,Z9-12:Ac. Sensilla auricillica play hence a key role in the perception of host plant compounds. Recently we also undertook experiments aimed at the genetic engineering manipulation of the pathway of the three kairomonal terpenoids in *Vitis vinifera* cv. Chardonnay. In the creation of stable transgenic lines, two strategies are being used: the silencing of the genes responsible for the production of the three compounds (lack of the compounds) and their overexpression (alteration of the ratio between the compounds). The plant obtained will be a potential useful tool to investigate further the plant-insect interactions, and are a likely starting point of new insect control strategies based on kairomones manipulation in planta.

ELECTROPHYSIOLOGICAL AND BEHAVIOURAL RESPONSES OF *DROSOPHILA SUZUKII* TO HOST PLANT VOLATILES

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Drosophila suzukii is a highly polyphagous invasive pest endemic to South East Asia, which has recently invaded western countries. Its serrated ovipositor allows this fly to lay eggs on and damage unwounded ripening fruits, and for this reason it is considered a main threat to fruit production. The development of environmentally-safe control methods is urgent for a safeguard of the concerned fruit industry. The aim of this study was therefore to characterize and identify the volatiles of the *D. suzukii* host plants, which are likely to influence its olfactory behaviour, in order to set-up management strategies based on semiochemicals. The olfactory responses of the adult flies for the odour released by intact host fruits (raspberry, blackberry, cherry, blueberry and strawberry) in behavioural assays (Y-shaped glass olfactometer) have been evaluated. *D. suzukii* females were expected to choose between the test material (25 g of fresh fruits) and the control (holding the same amount of fruits wrapped in a trasparent plastic bag). *D. suzukii* females were significantly attracted to the volatiles emitted by the 5 tested fruit species. Volatiles released from the attractive host fruits have been extracted and identified (GC-MS), and their biological activity on *D. suzukii* females screened by means of electrophysiological analysis (GC-EAD). Electroantennographic (EAG) and behavioural assays (Y-shaped glass olfactometer) have been also carried out to test responses of *D. suzukii* mated females to isoamyl acetate, one of the most EAD-active volatiles. Indeed, this is the only compound released from all the fruit species analyzed and able to elicit always significant antennal responses in *D. suzukii* mated females. Analysis of the EAG responses to increasing doses of isoamyl acetate in hexane solutions (from 0.1 pg/µl to 100 µg/µl) showed a dose-response relationship. Moreover, in olfactometer experiments isoamyl acetate loaded in red rubber dispensers at the dosage of 10 µg elicited significant attraction in *D. suzukii* females. The release rate of those rubber dispensers was estimated as 2.4±0.6 ng/hr. Environmentally friendly management against *D. suzukii* would achieve great enhancement by using specific kairomones such as isoamyl acetate. The identification of the most behaviourally-active volatiles emitted by *D. suzukii* host fruits indeed may allow the development of more selective and powerful synthetic lures held in dry traps adaptable to control strategies such as mass trapping and attract and kill.

AREA-WIDE CONTROL OF SUGAR BEET WEEVIL (*BOTHYNODERES PUNCTIVENTRIS* GERMAR) BY MASS TRAPPING WITH AGGREGATION PHEROMONES

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The sugar-beet weevil (*Bothynoderes punctiventris* Germar) (Coleoptera: Curculionidae) is an important pest of sugar-beet throughout central, eastern and southeastern parts of Europe. In the areas with drier climate the weevil represents the most destructive insect pest of sugar-beet. Out of approximately 30,000 ha sown with sugar beet in Croatia, in County of Vukovar-Srijem (CVS) sugar beet is sown on 10,000 ha. As a newly emerged pest in CVS sugar beet weevil is a very important pest during the emergence and early developmental stages. Overwintering adults cause damage by feeding on sugar-beet seedlings. Pesticide applications do not provide successful control due to specific insect feeding habits, morphological traits and low sensibility to insecticides. Some investigations suggested that mass trapping of weevils on newly planted sugar beet fields could be an effective strategy which fits with the requirements of an integrated pest management system. Since adult weevils overwinter in the old sugar beet fields we hypothesized that mass trapping of weevils would be more efficient if it is carried out on overwintering sites on a large area. A three year program of area-wide sugar beet weevil control by mass trapping started in Croatia (in CVS) in 2012. An area of 540 ha (5.4 km^2) was marked and all fields on which sugar beet was planted in 2011 were identified. Altogether 14 old sugar beet fields (69 ha) in the marked area were identified and surveyed in March in order to establish the average infestation by overwintering weevils. Altogether 928 traps baited by aggregation pheromones for sugar beet weevil (Csalomon) were set up on these fields between 13 and 16 March 2012 at the average density of 15 traps/ha. Traps were distributed in the grid at a distance of 35-33 x 20-25 m (depending on the field size and shape). Traps were checked weekly between March 13 and April 24. Captured weevils were counted. The average infestation ranged between 0 and 17.19 weevils/m^2. Established weevil population in the marked area was approximately 2.3 millions of individuals. A total of 158,641 weevils were captured. Considering 0.3 weevils/m^2 as an economic threshold, estimated weevil population was capable to cause economic damage on 767 ha, while captured weevils were capable to destroy 53 ha of newly planted sugar beet fields. In the marked area, 16 fields covering 247.57 ha were planted by sugar beet in 2012. In spite the high capture, 15 traps/ha were capable to catch only an average of 6.8 % of overwintering weevil population. In the condition of strong attack as it was recorded in the marked area, it wasn't enough to avoid the insecticide application. However, the infestation was postponed and the number of insecticide treatments was reduced comparing to the other sugar beet fields outside of marked area. To achieve greater population reduction, the number of traps should be increased and the trap distribution should be rearranged in 2013.

IDENTIFICATION OF TARGET CHEMORECEPTORS USING COMPARATIVE GENOMICS FOR INTEGRATED PEST MANAGEMENT

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Drosophila suzukii (Diptera: Drosophilidae) is an emerging pest of fruits such as grapevine, berries and cherries. This species is endemic to south–east Asia, but it has recently invaded Europe and America and is spreading rapidly. Unusual of Drosophila's behaviour, *D. suzukii* feeds on fresh, unwounded fruits with the help of its serrated ovipositor thus producing heavy economic losses. The most common strategy to reduce a growing insect pest population would be to use pesticides; this may not be effective in Trentino since the use of broad range of chemicals is being restricted, or is impaired by the particular geography of the province. It thus becomes essential to find alternative measures to control this pest that can be permanent in efficacy as well environmental-friendly. As a way, emphasizing on the genome of *D. suzukii* and possible hints from the analysis of its chemosensory receptors can be a breakthrough in understanding the biology of the pest. It is therefore key to explore the chemosensory receptors in *D. suzukii* to understand the complex nature of how its antennae responds to fresh fruit odors, while those of other drosophila does not. In Drosophila, the chemoreceptors consists of large gene families of olfactory and gustatory receptors (OR & GR) and a diverse odorant binding and chemosensory protein families (OBP & CSP). The identification of possible fresh fruit-specific odorant receptors/proteins in *D. suzukii* is relevant for insect pest control. Their discovery will assist in the identification of novel volatile compounds (recognized by such receptors), which would ultimately give new options for control by disruption, mass trapping, or trap crops.

IMPROVING APPLE PRODUCTION IN ALBANIA THROUGH THE USE OF INTEGRATED PEST MANAGEMENT

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The agriculture sector of Albania shows strong potential for development as farmers still lack key knowledge about good agricultural practices and are heavily dependent upon the use of pesticides for pest management. CAB International (CABI), with support from the Swiss Development Corporation (SDC), implemented a 3-year programme (2008 to 2011) designed to reduce poverty by increasing knowledge and productivity through measures of economically, environmentally, socially and institutionally sustainable Integrated Pest Management (IPM). Apple production was chosen as crop system because of its economic importance, especially for farmers in the Korca region where conditions for growing apples are favourable. The goal of this project was to improve farmer knowledge in the Korca region of Albania and support them with the implementation of more sustainable pest management measures. Major outputs of the programme in Albania included the establishment of an Apple Integrated Production Producer Club comprising about 100 members, the development of a 'Technical Guideline for Apple Integrated Production', piloting of an internal farm inspection system, knowledge transfer to members of the Apple IP Producer Club, implementation of a rational pesticide use training programme, establishment of a pesticide sales and distribution system and identification of marketing channels for IP apples. A core part in the project was the implementation of Technical Guideline which requires action by the farmer regarding, pest monitoring and forecasting, fertilization, soil management etc. Through substantial capacity building and implementation of plentiful new IPM techniques, a reduction in the use of pesticides, a switch towards more environmentally friendly pesticides and a higher quality apples harvested could be achieved. Several harmful pesticides were phased out. All in all, the programme contributed to changes in the behaviour of Apple IP Producer Club members, enhanced apple production, an improved support network for apple producers and an emerging market niche for IP apples.

COLEACP PIP A EUROPEAN COOPERATION PROGRAM FOR THE ACP HORTICULTURAL INDUSTRY

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PIP program is funded by the European Development Fund and is managed by COLEACP, the association for ACP (African-Caribbean-Pacific) exporters and EU importers of horticultural produce. Main principles of the program are: ACP fruits and vegetables responding to the concerns of European consumers; contributing to sustainable and safe food for local markets; orientation towards “zero” residues. The program has developed Crop Protocols and Guides on Good Plant Protection Practices for fruits and vegetables published under http://pip.coleacp.org/en/pip/production-guides. They describe all the agricultural and plant protection practices including Integrated Pest Management. For active substances and BCA (biocontrol agents) we give information on: status in the framework of the EU Regulation, EU and Codex MRL (Maximum Residue Limit), registration in ACP countries and GAPs (Good Agricultural Practices) to comply with residues limits. Field trials are implemented in ACP countries to: 1) define the GAPs to comply with residues limits or to request EU or Codex MRLs, 2) register appropriate PPPs (Plant Protection Products).
A search was conducted to identify bio-pesticides with potential for use on tropical horticultural crops. Following efficacy trials were conducted or are planned on: mealy bug and mites for papaya, fruit flies and anthrachnose for mango, various vegetables to control mites, caterpillars, aphids, whiteflies, nematodes and fruit flies; avocado to control false codling moth; passion fruit to control post-harvest diseases; litchi for post-harvest treatment; pineapple to control mealy bugs, nematodes and post-harvest diseases; green beans to control thrips. In addition support was given to some BCA manufacturers in ACP through our capacity building component. At Regulation level the program conducts following activities: 1) Follow-up of EU regulation For ACP imported fresh fruits and vegetables, a special focus on: EU MRLs (changes and new MRLs) and EU and National monitoring system of residues in food imported from ACP PIP beneficiaries are informed on the changes and their potential impact on the GAPs 2) Collaboration with CILSS « Comité permanent Inter-Etats de Lutte contre la Sécheresse dans le Sahel » Countries (Cape Verde, Chad, Benin, Burkina Faso, Guinea, Guinea Bissau, Ivory Coast, Mali, Mauritania, Niger, Senegal, The Gambia, Togo): Mango fruit fly management: fast track procedure for registration approved by Comité Sahélien des Pesticides (CSP) for 2013; Analysis of existing and missing PPPs registrations; Agreement in progress on efficacy trials program with a fast track registration procedure 3) Harmonization of PPP regulations/registration systems in ACP countries. PIP helps the setting of a harmonized system by: ECOWAS (Economic Community Of West African States) - Benin, Burkina Faso, Cabo Verde, Côte d’Ivoire, Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone, Senegal and Togo; EAC (Eastern African Community) - Burundi, Kenya, Rwanda, Tanzania and Uganda ; CPAC (Pesticides Committee for Central Africa Countries) - Cameroon, Chad, Republic of Centrafrique, Congo, Gabon and Equatorial Guinea; Caribbean - Coordinating Group of Pesticide Control Boards of the Caribbean (CGPC)

PICLÉG™: A 'RESEARCH, DEVELOPMENT AND STAKEHOLDERS' ALL-TOGETHER INITIATIVE FOR INTEGRATED PRODUCTION OF FIELD VEGETABLES IN FRANCE

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Although representing an important activity in Europe with a share of 8.9% of the overall output value of the European agricultural industry, field vegetables are often considered as minor crops and concerned by minor uses, as far as availability of registered pesticides is concerned. Vegetables are recognized for their nutritional value and for their impact on human health. Consumers are encouraged to eat at least 5 portions of fruits or vegetables a day. To meet the expectations of consumers and the society, the production of vegetables has to meet high standards with respect to sustainability and safety. To face those challenges, French field vegetables growers called for an ambitious research program on sustainable cropping systems. Under the umbrella of the Ministry of Agriculture, INRA decided, in 2007, to launch a Scientific Interest Group gathering the growers Union (Légumes de France), advisory services (CTIFL, Chambres d'Agriculture, experimental stations), and stakeholders from marketing (FELCOOP, INTERFEL) to processing (UNILET), called "Groupement d'Intérêt Scientifique pour la Production Intégrée des Cultures légumières" (GIS PICLég™). The purpose of the Group is to identify gaps in knowledge for implementing integrated production strategies, deduct research and development questions to be addressed, build-up common collaborative research and development projects, and organize the follow-up of the projects and the promotion of the results towards end-users. So far, 17 projects have been funded for a total amount of more than 10 million Euros, including systemic approach for integrated production and economic analysis in production basins, integrated crop protection against soil-borne pests and diseases at the crop succession scale including biofumigation, insects control through landscape management and chemical ecology, analyzing of trade-offs between fertilization, crop vulnerability and product quality. A brief review of the different processes for build-up and follow-up of the projects within the Interest Scientific Group will be made and discussed.

FROM UNDERSTANDING OF CURRENT CROPPING SYSTEMS TO CO-BUILDING OF PROFITABLE SYSTEMS WITH LOW LEVELS OF INPUTS IN OPEN-FIELD VEGETABLE PRODUCTION IN NORMANDY

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France has fixed an objective of pesticide reduction by 50% by 2018. To reach this ambitious objective in vegetable productions, innovative cropping systems based on integrated production have to be built. In EcoPhytoSys-Légumes project in Basse-Normandie (France), scientists, advisors and growers, joined forces to develop cultivation techniques to reduce cropping systems reliance on pesticides and maintain farms profitability. Research was conducted in 4 stages: (1) characterization of the current cropping systems: a ten years dataset and a survey on 65 growers allowed to identify key factors and to diagnose on which of them improvements have to be directed .Determinants of cropping systems are not only agronomical but also economical, social, and depend on the structure of the farm. There are as many cropping systems as fields. To select its cropping systems the grower takes into account external elements to the farm like market requirements and access (calendar, visual and shape aspects of veggies, healthy status…), societal expectations, policies as well as internal elements like farm resources (fields, money, employees, knowledge…) soil and climatic conditions. (2) review of scientific knowledge and available techniques for pests and diseases control without or with low quantity of pesticides. If litterature on biology and ecology of pests and diseases is abundant, only few data on control techniques based on mechanical, biological or physical control are available for application on farm in oceanic climate in the Nord-West of France. (3) development of methodologies for a systemic approach of the integrated production. We developed, a methodology for a better exploitation of datas on biology and ecology of pests and diseases for the co-conception of cropping systems, and a methodology for a risk analyze of the cropping system according to knowledge on diseases and cultural practices. (4) development of plan and test on farm of promising techniques or combination of techniques. The first prototypes of cropping system with less reliance on pesticides have been built with a special focus on the main key factor of systems: improvement of soil quality. The agronomic levers used are, crop succession, use of intercrop period, risk prediction, water and fertilizers alimentation and biocontrol. We have now to improve these prototypes and test them on farm. That is the aim of a new project (2013-2018) focusing on field vegetables cropping system including the carrot crop in two French producing area: Normandie and Aquitaine.

NEW POSSIBILITIES FOR CONTROL OF AMERICAN POWDERY MILDEW (*SPHAEROTHECA MORS-UVAE*)

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American powdery mildew (*Sphaerotheca mors-uvae*) is one of the most serious diseases of gooseberry and black currant. At present, in Integrated Pest Management (IPM) System, only a few fungicides are registered to control this disease. Therefore, searching for new protection methods is of a special value. The aim of this work was to evaluate the efficacy of the biological product AQ 10 WG containing 5 x 10^9 spores/g of fungus *Ampelomyces quisqualis* and fertilizer Solfan PK (49% potassium as K_2O and 25% phosphorus as P_2O_5) for control of American powdery mildew. The study was conducted in 2010-2012 on gooseberry plantations cv. 'White Triumph' and on black currant cv. 'Ben Lomond', located in central Poland. Five treatments with each product were performed: first before and four after blooming, every 7-13 days. For comparison the standard fungicides were included: Score 250 EC (difenoconazole 250 g/l), Nimrod 250 EC (bupirymate 250 g/l) and additionally on gooseberry - Topsin M 500 SC (thiophanate methyl 500g/l) and on black currant - Signum (piraclostrobin 6,7% and boscalid 26,7%). The evaluations of disease severity were done before and after the harvest on blackcurrant and only before the harvest on gooseberry. Randomly selected samples of 100 shoots per replication (in four replications) were observed using six degree scale: (0-no symptoms, 5-over 50% of shoots or fruits surface covered by fungus). It was found that both products limited the severity of American powdery mildew on gooseberry and black currant as compared to control. The effectiveness of tested compounds on gooseberry shoots ranged from 69.5 to 91.5% and it was similar or lower to that of standard fungicides. However on fruits, AQ 10 WG and Solfan PK limited amount of disease by more than 78% and effectiveness of both products was similar to the standard fungicides. On black currant AQ 10 WG limited powdery mildew on shoots in about 60% but Solfan PK by more than 71%. of The efficacy of tested products on black currants was the same or lower than standard fungicides. The conducted study indicated that biological product AQ 10 WG and fertilizer Solfan PK can be successfully used in control of American powdery mildew especially by a lower threat of disease.

SCAB CONTROL IN ORGANIC PEAR ORCHARDS

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Pear scab is one of the most dangerous diseases on European pear. Epidemiological studies carried out over 10 years showed that in the Italian growing area the primary infections are caused exclusively by ascospores maturing in the pear orchard leaf litter. In the Italian pear growing area the disease is quite erratic and does not occur every year. However such erratic behaviour often makes orchardist to underestimate its potential particularly in organic production where effective fungicides are very few. Field trials comparing fungicides for the control of pear scab primary infections were carried out in organic pear orchards Emilia-Romagna region over the year 2009-2012 with the aim to evaluate their efficacy against the disease of the fungicide formulations authorized in organic production. The field trials were carried out in an organic commercial orchard located in Castelfranco Emilia in the province of Modena on pear cultivar William particularly susceptible to the diseases. The formulations tested are included in the reg. 834/2007. With the exception of the year 2011, in which no symptoms of the disease were observed because of the climate conditions unfavorable for disease development, in the other three years (2009 and 2010) the trials have been completed successfully. A randomised complete block design with four replicates was used with 4-5 plants per plots. The treatments were carried out preventively and when this was not possible, chemicals were applied immediately after the infectious rainy event. Assessments were made both on leaves and fruit in early May and after the primary ascosporic season in early June. The ascoporic primary season were assessed using a volumetric spore trap (Lanzoni VPPS 2000). All the products tested were copper and sulfur based compounds, namely calcium polisulphyde, bordeaux mixture (Poltiglia Disperss) and a ready mixture of sulfur and copper oxychloride (RAMSOL F2), along with potassium bicarbonate (Armicarb) and a laminarine based fertilizer (Frontier), (this latter only tested in 2012 alone and inmixttre with Ramsol F2). Other fungicide tested in 2009-2010 only, were sulfur-based product (Tiowetting, Thiopron and Sulfar). In 2009 and 2010, Ramsol F2, Poltiglia Disperss, Calcium polisulphyde and Armicarb gave the best results effectively containing pear scab. In 2012 all the products tested except Frontier applied alone, effectively protected pear fruits proving to be statistically different from the unsprayed check but not between each other. In contrast, RAMSOL F2 + Frontier gave numerically but not statistically the best result in controlling the disease.

NEONICOTINOIDS AND NON-TARGET SPECIES: EFFECTS OF TANNED WITH CLOTHIANIDIN SEEDS ON SOIL BIOINDICATORS

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Neonicotinoids, a recently-introduced insecticide class that acts on nicotinic acetylcholine receptors, are often used in seed tanning. They not only successfully control soil insects, but also systemically protect plants from other pests. In the last few years, however, they have come to be considered among the agents responsible for mass bee death in the United States (CCD) and Europe. While neonicotinoid toxicity data concern mainly bees, they are limited on non-target species. In particular, there is little research on their effect on soil invertebrate species that play important roles in ecosystem homeostasis (organic matter degradation and humification processes). Neonicotinoids are systemic products that circulate within the plant, which makes it possible that edaphic species may have contact with these products via tanned seeds rather than through direct plant feeding. With a nod to European Directive 2009/128/EC, aimed at sustainable pesticide use, we analyzed the action of clothianidin, a neonicotinoid used primarily in corn seed tanning, on two edaphic non-target species, rough woodlouse *Porcellio scaber* and earthworm *Eisenia fetida*. Both species were evaluated for several lethal and sub-lethal effects: mortality, weight changes, and behavioural responses. The behavioural responses of *P. scaber* were explored according to the methods used on Santagostino (Longhi, 1995), while avoidance tests were used on *E. fetida* for the same purpose. Sexually mature individuals of both species were selected from breeding containers and set up in transparent polyethylene trays partially filled with two soil types, natural and standard (OECD artificial soil used in Earthworm, Acute Toxicity tests, 1984). In each soil tray was placed one of three types of corn seed: (i) seed α, tanned with Maxim-XL ® (fungicide), Mesurol ® (repellent for birds), Poncho ® (insecticide clothianidin-based); (ii) seed β, tanned with Maxim-XL ®; (iii) seed γ, without tanning. *P. scaber* showed a significant difference in mortality between the two soil types; OECD showed itself to be unsuitable for the terrestrial crustacean. In natural soil tests, seed α showed greater survival among the larger individuals and a lower percentage of neonicotinoidi relative to body mass. Seeds β and γ showed a similar limited mortality. For *E. fetida*, a significant difference was found in the mortality of thesis α seed compared to β and γ seeds in natural soil, but no significant differences were detected among the seed types in OECD soil, which were clearly more suitable for earthworms.

TOOLS TO ENHANCE KNOWLEDGE ON SUSTAINABLE USE OF PLANT PROTECTION PRODUCTS WITHIN THE FRAMEWORK OF THE SUSTAINABLE USE DIRECTIVE

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In 2008-2009,a survey in the Emilia Romagna region of north Italy collected information on the farm use of Plant Protection Products (PPPs) and evaluated whether the provisions of the Directive 2009/128/EC for the Sustainable Use of Pesticides (SUD) are applicable. It was concluded that the provisions of the Directive can be implemented, even if some gaps need to be filled and also the behaviour of farmers needs to be improved. Moreover, it was observed that all stages in the use of PPPs on farms could generate risks for the operator and/or the environment. One of the Directive recommendations is to promote training for operators and to adopt good agronomic practices in order to improve sustainable use of PPPs. The findings were used to develop a Guideline for Sustainable Use of PPPs to help the user in identifying the flaws in current practices at farm level as well as their corresponding corrective actions. The Guidelines are accompanied by free on-line software (www.agricoltura-responsabile.it) to be used as a diagnostic tool as well as to provide recommendations for improvements. The project had a stepwise approach: Step 1: Preliminary investigation and survey on a sample of 100 farms. The main objective was to identify the potential environmental and human health pressures of pesticide use at farm level, starting from pesticide delivery to the farm through to the final disposal of the packing materials. Step 2: Based on the data collected in the survey and their analysis, the project participants decided to develop an operational, sustainable-use guideline to be used for training and raising awareness among professionals involved with pesticides. The objectives are to collect recommendations for responsible, safe and sustainable use of these products and at the same time to provide tools to evaluate how they are managed. Step 3: To fulfil the latter objective, the guidelines were equipped with a check list and a free on-line software to assist the user in the analysis of their agricultural practices and to identify the critical points in the pesticide management, the critical issues on the farm, taking into account both the structural aspects of the farm that the behavior of the farmer so as to prevent environmental contamination and to assure a high standard of safety for operators. The tools can be considered both as a support to train technicians and as an operational guide to provide an innovative assistance service with the purpose of improving the safe, responsible and sustainable use of pesticides. The approach adopted, taking into account the variability in farm structure, cropping pattern, risk attitude and economic availability, is not an instrument to identify the most suitable protection strategy for a given crop in a given period, but to help professional users to improve their practices in managing PPPs on farms and to make the most appropriate choices leading to reduced environmental and human risk, without compromising the profitability of agricultural production and food standards.

MANAGEMENT OF ACCASE-INHIBITORS RESISTANT *LOLIUM* SPP. USING ALS INHIBITORS: EVOLUTION OF MULTIPLE RESISTANT BIOTYPES

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One of the major drawbacks of cropping systems characterised by a low diversity in time and space, i.e. without crop rotation and with intense use of herbicides with the same mode of action (MoA), is the frequent evolution of herbicide resistant weed populations. In fact, among the general principles of IPM listed in Annex III of the Directive 2009/128/EC it is stated that "where the risk of pesticide resistance is known […] available anti-resistance strategies should be applied to maintain the effectiveness of products". Often different MoAs are adopted when resistance has already been selected. This is the case frequently observed in cereals for ACCase resistant *Lolium* spp. which is being controlled using ALS inhibitors. Consequently, intensive use of ALS inhibitors can generate resistance to both ACCase and ALS inhibitors which is a serious challenge to wheat growers. To evaluate the long-term effects of ACCase resistant *Lolium* spp. management strategies, three experiments were set up. A three-year experiment included a management based on the continuous use of graminicidal sulfonylureas (iodosulfuron and mesosulfuron); a second three-year experiment included managements based on chemical control: 1) clodinafop + triasulfuron or 2) chlortoluron + clodinafop + triasulfuron, combined with simple agronomic techniques such as conventional tillage, minimum tillage or minimum tillage coupled with stale seedbed preparation. Another seven-year experiment included: 1. the continued use of ALS inhibitors (iodosulfuron and mesosulfuron), 2. the continued application of ACCase inhibitors and 3. a resistance management strategy based on a biennial mode of action rotation between ALS inhibitors and herbicides with other MoAs different from ACCase. *Lolium* spp. seed samples were collected each year from the survivors in each experimental plots and analysed using bioassays. The first experiment outlined a decline in sulfonylureas efficacy after the third application. From the second experiment the best strategy has been observed coupling pre- and post- emergence along with the combination of minimum tillage and stale seedbed preparation. The seven-year experiment indicates that the ALS inhibitors controlled the resistant *L. rigidum* until the third application. Then the efficacy started to decline at different level depending the treatment program used and multi-resistant plants were observed at different rates but in all the tested strategies. The change from continuous use of ACCase inhibitors to continuous use of ALS-inhibiting herbicides appears a short-term tactic whereas a simple resistance management strategy based on a biennial rotation between sulfonylureas and other MoA already delay the selection of multiple resistance but is not sustainable in the medium-long term without the additional use of other Integrated Weed Management (IWM) tools. A simple switch from continuous use of ACCase inhibitors to continuous use of ALS-inhibiting herbicides outlined to be a short-term tactic which in these experiments quickly led to the addition of ALS resistance to the already present ACCase resistance. Moreover in many seasons stale seedbed preparation is not feasible due to the heavy rainfall concentrate in late autumn. The implementation of a simple resistance management strategy based on a biennial rotation between SUs and other MoA coupled with additional simple agronomic practices can delay the development of resistance but additional measures will have to be taken in order to make this approach sustainable over the long-term. It is clear that more diversity through real IPM needs to be implemented to avoid selection of multiple resistance.

FARMING SYSTEM AFFECTS SOIL MICROBIAL COMMUNITIES IN VINEYARD

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The use of conventional farming system has negative effects on the environment, often leading to a loss of biodiversity. The use of mixture of pesticides for the protection of crops can represent a source of contamination and degradation of the environment. Such a behaviour has been investigated at different biological levels, ranging from the aboveground level (plants, birds, spiders, grasshoppers, predatory insects) passing to the belowground level (ants, soil microorganisms) and under different land use types. On the other hand organic farming relies on the use of a limited range of organically approved pesticides, thus causing less disturbances and favouring higher biodiversity compared to the conventional farming system. However the beneficial impact of organic farming has been mostly observed in the case of annual crops, which usually undergo higher levels of disturbances due to management practices, compared to perennial crops. The effect of the farming system in the vineyard environment has been poorly investigated and the understanding of its impact is fundamental for the maintenance of this economically important agroecosystem.

We selected four couples of vineyards cultivated respectively through conventional and organic farming systems in Piemonte (Italy), a region where viticulture is widespread. Four areas were selected, three in the province of Turin and one in the province of Cuneo. Soil samples were collected during 2011 in April and October, corresponding to spring and autumn season when soil temperature was approximately 12-16 °C. Inside each of the eight vineyards an area of 500 m^2 was selected and soil samples were collected according to a W shaped design. Composite samples from each vineyard were then analyzed by automated ribosomal intergenic spacer analysis (ARISA) an ITS based method to characterize the soil bacterial and fungal community structure inside each vineyard. Multivariate analysis and non-parametric MANOVA (NP-MANOVA) were used to assess the effect of area (A1-A2-A3-A4), soil management (C/O), sampling time and site and the interactions among these factors.

Soil bacterial community was mainly affected by the effect of the area considered and this was due to differences in the physicochemical characteristic of the study area. In particular the area of Cuneo was geographically distant and characterized by differences in the granulometry, pH macro and micro elements that caused differences in the bacterial community, thus overwhelming the effect of the farming system. When considering only the three areas in the province of Turin, the effect of area was absent and an effect of the farming (C/O) was visible ($P=0.0386$) and not dependent on the sampling time ($P=0.3607$). In the case of the fungal microbial community an effect of area was present ($P=0.0005$), while an effect of the farming system was not found ($P=0.19$) and it was not time dependent ($P=0.83$). The fungal and bacterial diversity were mainly unaffected by the farming system, while an effect of the area was found.

THE AGROENVIRONMENTAL POLICIES AND ITS IMPROVEMENT ON ENVIRONMENTAL QUALITY IN PORTUGAL

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During the last 20 years, common agricultural policies have been implemented addressing the environmental concerns of agricultural production. Key targets of those policies are the reduction of agricultural practices` impacts on the natural resources, water, soil and biodiversity. Organic farming (OF) and integrated production (IP) are sustainable production systems that are, theoretically, based on principles, tasks and technologies that expectably reduce negative impacts on the environment. Biodiversity and agricultural production are interlinked and their ability to be reciprocally supportive is recognized. The issue biodiversity involves diversity of species and habitats either depending on agricultural practices or negatively affected by farming (e.g. fertilizer and pesticides use). In Portugal, to evaluate how OF and IP are effective in ecological benefits on farmland, a survey was performed with 141 vineyard farmers in the main important regions: Verdes, Douro, Dão and Alentejo in 2005 and 2006, supported by the national project AGRO 545 "The environmental indicators to assess the IPM, the integration production, the organic farming and the sustainable use of pesticides", with the major goal of assessing the impact(s) of farming practices on pest importance and functional biodiversity. A total of 1215 arthropods were captured, belonging to the groups Araneae, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera, Orthoptera, Psocoptera and Thysanoptera. A total of 15388 specimens of weeds were identified, belonging to 63 species or genus, distributed in 26 families Amaranthaceae, Boraginaceae, Cyperaceae, Clusiaceae, Compositae, Convolvulaceae, Cruciferae, Dennstaedtiaceae, Equisetaceae, Scrophulariaceae, Fumariaceae, Geraniaceae, Gramineae, Labiatae, Leguminosae, Malvaceae, Onagraceae, Plantaginaceae, Polygonaceae, Portulacaceae, Primulaceae, Pteridaceae, Chenopodiaceae, Rosaceae, Solanaceae, Umbelliferae. Differences among regions were found due to territorial structure and farm dimension. OF and IP impacts on biodiversity revealed to be low, with small differences to conventional farming. Agricultural impacts on ecosystems seemed to be better evaluated with indicators related to cultural practices, farm characteristics and farmers attitudes. "Total amount of pesticides", "Number of pesticide applications", "Use of herbicides" and "Different species surrounding" performed good results to assess biodiversity and sustainability. Therefore the results revealed that ecosystem assessment should not be based only on production systems as a variable. In fact, sustainable production systems have not been sufficient to ensure environmental quality. Results are important to improve the effectiveness of current and future policy programs and, as expected, OF and IP impacts on the environment have a tendency to be low, but conventional systems revealed a similar tendency, induced by the need of reducing production costs.

SOIL SOLARIZATION FOR A SUSTAINABLE MANAGEMENT OF NEMATODES AND WEEDS IN VEGETABLE CROPS IN SOUTHERN ITALY

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Soil solarization has been known as an effective method for the integrated management of phytoparasitic nematodes and weeds since many years. The interest in this technique has been renewed following the withdrawal of most chemical nematicides and herbicides available on the market. This technique is particularly suitable to vegetable crop systems of Southern Italy, where summer climate is more suitable to raise soil temperatures up to values sufficiently high to cause irreversible damages to nematodes and weed seeds. The effectiveness of repeated soil solarization treatments, as well as of different solarizing materials, on root-knot nematodes, weeds and crop yield was assessed in the greenhouse studies overviewed in this work. Two different trials were carried out in plastic-greenhouse conditions at Metaponto, Southern. In the first experiment solarization was performed for one, two or three consecutive years in a soil infested by the root-knot nematode *Meloidogyne javanica*. In the second experiment, four different solarizing plastic materials, EVA, LDPE, ultrathin coextruded (EVA + LDPE) and corn starch-based biodegradable film, were comparatively evaluated for their solarizing effectiveness. Nonsolarized soil was used as a control in both experiments. In each trial, tomato or melon crop were carried out after the solarization treatment. Crop yield, nematode infestation parameters and weeds were recorded at the end of each crop cycle. Application of soil solarization throughout two or three consecutive years significantly increased crop yield and quality and strongly suppressed nematodes and weeds compared either to non-solarized soil and a single heating treatment. Different plastic films satisfactorily controlled root-knot nematodes and weeds and improved crop yield, with no significant differences among them. In conclusion, these studies confirmed soil solarization as an effective tool for a sustainable and cost-saving management of root-knot nematodes and weeds in greenhouse crop systems of Southern Italy. Use of eco-compatible solarizing plastic films, such as biodegradable and co-extrusive ultra-thin films can furtherly improve the environmental safety of this technique.

BIOLOGICAL CONTROL SYSTEMS IN TOMATO AND AGROINDUSTRY CROPS

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Nowadays the reduction of phytosanitary products, it is one of the aims in the cultures destined for the agroindustry, so much for his commercialization as finished product or ‘trasformado’. In the last campaigns there were realized tests of introduction of thumbtacks ‘depredadoras’, *Nesidiocoris tenuis* and *Macrolophus pigmaeus*, in tomato of industry. The introduction fulfils from the seedbed approximately seven to five days before the plantation with satisfactory results, in spite of the difficulty of evaluating *N. tenuis*'s presence in the moment of the plantation of the tomato. The level of observable thumbtacks with reliability is detected to the month of the plantation. The levels found at the end of the culture reach from four to five thumbtacks for plant. One of the principal plagues has been absolute Tuta with high levels of flight to way during the period of culture and the hurts in the culture have been minimal. Finally the level of settling of them annoy it has come to 92 % of the observed plants. In commercial plots near the test Autographa's invasion observed gamma that *N. tenuis* or *M. pigmaeus* could have controlled efficiently in the test. There has been a presence of mites in the culture from the ends of July that were controlled with abamectina without there being a negative influence in the evolution of them annoy depredators. The culture of horticultural manufacturers for leaf or main ribs has importance in the development of the agroindustry for his conserve or frozen. For the control of the key plagues there has been realized release of the auxiliary *Macrolophus pigmaeus* from seedbed to move to field in the plantation the colonized plants and to evaluate the presence of the same one and of auxiliary others during the culture. The duration of the cultures of borage and spinach beet they are very brief to the being a very rapid culture of leaf. The implantation in this period of time and dates of autumn beginning it impedes the development of the auxiliary ones. In general the result is satisfactory for thistle and borage and slightly satisfactorily for spinach beet. In the latter culture scarcely *M. pigmaeus* has established himself for what scarcely there has been control of caterpillars. To reduce the treatments has meant the entry of auxiliary others for the control of plant louses and trips, fundamentally. In the final result of the vegetable products derived from the test once elaborated presence has not been detected of auxiliary not of plagues. In borage the presence of caterpillars has been looked inside the petioles of the leaves and there has not been detection of the same ones.

QUASSIA AMARA IN PEST CONTROL IN ORCHARD

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Some important pests can appear in the organic orchard because of the lack of effective insecticides (neonicotinoids, organophospates) used in IPM or conventional systems. One of the effective methods is application of extract from Quassia amara wood. The product is used in the control of sawflies (*Hoplocampa* spp.), aphids and other pests. The results trials with Q. amara against *Hoplocmapa testudinea*, *H. flava, H. minuta,* and *Cacopsylla pyri.* The results show that efficacy against *H. testudinea* was higher (70%) than against sawfly species on plums (cca 50%). Efficacy of treatmenst against *Cacopsylla pyri* L1 nymphs was 50%. After treatments on apple sawfly the satisfactory effect on *Rhynchites bacchus* and aphids was recorded.
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FUNGICIDE RESIDUES AND POTATO LATE BLIGHT OCCURRENCE IN TOMATO AS AFFECTED BY SPRAY APPLICATION PARAMETERS AND ADJUVANTS

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The precision spraying and correct choice of spray application parameters for pest control purposes are one of the vital factors affecting biological results required and the level of environmental pollution. Inaccurate pesticide application rate, spray volume and droplet spectrum can lead to the movement of pesticide from the targeted area and reduce pesticide effectiveness or increase of chemical contamination. The aim of this investigation was estimation of two models of spray volume application against potato late blight in tomato and their effect on residues of azoxystrobine and chlorothalonil in fruit. Into consideration were taken also effect of adjuvants and spray techniques using different nozzle types (droplet size). The research was performed for three years from 2009 to 2011 in field tomato Polset F1 cv. cultivated in two rows system on gray-brown soil in Poznan, Poland. Usually 6-8 applications of fungicides were made from mid of June to September during each year. First application was made when first symptoms of *Phytophthora infestans* onto leaves were diagnosed. Amistar 250 SC (azoxystrobine) at recommended dose of 1.0 l/ha and half 0.5 l/ha and Gwarant 500 SC (chlorothalonil) at dose of 2.5 and 1.25 l/ha were applied alternately. Organosillicone adjuvants Slippa (0,1%) and Torpedo II (formulation of four active ingredients for ensure good retention, spreading and maintaining a humid microclimate) at 0,1% were applied with lower dose of fungicides. To spray treatments was used precision field sprayer with two nozzles type: XR 11003 and IDKT 11003 producing fine and course droplet size at pressure 0.3 MPa, respectively. Two models of spray volume application were projected: first – state rate 300 l/ha of water from first to last application and second – variable from 300 to 800 l/ha according to number of leaves and plant area adapted to tomato growth stage. Analysis of pesticide residues was based on sample preparation by the Quick, Easy, Cheap, Rugged, Effective and Safe (QuEChERS) method. The method has been validated for extraction of two fungicides: azoxystrobin and chlorothalonil, which are frequently detected pesticides in Polish tomato samples. As a slight modification, the obtained extracts were frozen to save volatile pesticides before addition of salt mixture. Determination of pesticide residues was made by gas chromatography with nitrogen phosphorus detector and electron capture detector (GC–NPD/ECD). The results of investigation indicate that depending on years the model of spray volume had important role for residues of both fungicides at tomato fruits. Generally variable system of spray volume gave usually less residues than at constant volume of 300 l/ha with exception of chlorothalonil in last year. Finally residues of azoxystrobine as well as chlorothalonil were very significantly lower than appropriate MRL's. The occurrence of potato late blight onto leaves and fruits of tomato were higher at 300 l/ha than at variable system of spray volume. The lack of simple relation between residues of fungicides and infestation of tomato plants or fruits could be clarified mainly by role of adjuvants, number of leaves on tomato plants in particular year, and type of nozzle. Adjuvants usually provide to insignificantly smaller residues of both fungicides. Nozzle type influenced residues of both fungicides, according to number of leaves on tomato plant.

THE ROLE OF AGRONOMIC METHODS IN IPM STRATEGIES FOR WEED CONTROL IN BLUE LUPINE (*LUPINUS ANGUSTIFLOLIUS* L.)

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Species of lupine (*Lupinus* sp.) is known as a valuable high protein plant that can be an alternative to the commonly used soybean meal in feed. In conventional agriculture lupine crop is considered to be very dependent on the protection of herbicide. Lupine is considered to be highly dependent on herbicide use in conventional farming. Some studies indicate the possibility of weed control by harrowing. The European Union will apply IPM strategies, which aims to reduce the use of pesticides including herbicides. The aim of this study was to assess the potential of lupine weed control through the use of harrowing and sowing mixed with cereals as part of IPM strategies. In the years 2010-2012 at the Institute of Plant Protection - National Research Institute were conducted field experiments in Field Research Station IOR-PIB in Winna Gora. In the study were evaluated two methods of weed control: A- mechanically (harrowing after sowing and the emergence of lupine), B - chemical (herbicides applied to the soil and foliage). Both methods of weed control were tested in pure sowings (normal sowing: 100% lupine) and in mixtures with cereal (normal sowing: 60% lupine + 40% barley). The experiment was set up in randomised complete block design with four replications. Soil type was classified as podsolic with a pH 5.5-6.0. Plots were 11 m long with a 1,5 m wide. The biological effect was evaluated as reduction of weed biomass as compared to untreated. The study reported 16 segetal weed species. Dominated: *Chenopodium album* (fat hen), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass), *Matricaria maritima* L. subsp.. *inodora* (false chamomille). In individual years the effectiveness of weed control in the tested systems varied. In 2010 and 2012 the mass of weeds was significantly lower in herbicidal treatments. In 2011, less weed infestation was observed in the plots with harrowing. In general, in this year poor rainfall and low soil moisture after lupine sowing was noticed. Under these conditions, the effectiveness of herbicides applied immediately after sowing was poor and harrowing significantly reduced the number of the dominant weed species. In lupine – barley mixture weed infestation was significantly lower than the pure sowing regardless of the method of weed control. The results showed good perspectives to introduce agronomic methods to weed control in lupine.

THE SOIL MICROBIAL ECOLOGY AND SUSTAINABILITY OF ORGANICALLY AND CONVENTIONALLY MANAGED VINEYARDS

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Microorganisms are involved in many important processes in soil, as nutrient cycling and organic matter decomposition and transformation, which contribute to soil quality and are essential for long-term sustainability of agricultural systems. Recent studies have demonstrated the impacts of organic and conventional production systems on the soil microbial and chemical characteristics. The principal input of conventional agriculture is the large dependence on intensive chemicals, characterized by extensive application of synthetic fertilizers, insecticides, fungicides and herbicides. These agricultural practices have been associated with loss of soil fertility, ground water and environmental pollution, as well as with the loss of soil microbial diversity. On the other hand, organic agriculture eliminates the use of synthetic fertilizers and pesticides, animal drugs and food additives and attempt to close nutrient cycle. The adverse effects of conventional farming system on soil productivity and environmental quality have led to an increasing interest in organic farming that is gaining worldwide acceptance and has been expanding in the last decade. We investigated the effects of conventional and biodynamic management on microbial communities in vineyards soil to establish if agriculture practices affect microbial biodiversity and composition on soil. Another important objective was to identify microbial species or model groups that would be indicative of the organic farming soil status. Three different agricultural practices were evaluated: conventional, organic (biodynamic) and biodynamic with green manure's application. Genomic DNA from soil was extracted and amplified by PCR using 16S rDNA and ITS fragments, respectively to bacteria and fungi, and analysing by DGGE to assess diversity indices, identify shared similarities and compute statistical differences between communities. First results indicate that microbial communities respond sensitively to management practices. Majority of fungal and bacteria species were common to all the analyzed soils, whereas some of them were restricted to different agricultural practices. The presence of specific groups correlate with the management agricultural systems will be investigated a matter using the 454 sequencing method.

THE DATABASE PESAP TO DESIGN POMEFRUIT PROTECTION STRATEGIES

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The sustainability of pomefruit protection strategies can be investigated with performance assessment tools. Such tools require many different input data. Within PURE (www.pure-ipm.eu), the database PESAP (Pests of Europe and control Strategies for Apple and Pear) has been developed for the identification and optimization of current and future pest control strategies in apple and pear. PESAP was applied for data collation, queries and data transfer to models for pest control strategy assessment. Pest control data were collected in 5 major pomefruit production regions in Europe through regional experts and farmers surveys. Per region first the major pests were identified and then the control tools for each identified key pest were listed. Chemical and non-chemical pest control measures were distinguished. The non-chemical measures were biocontrol, cultivation practices, mechanical actions, resistant cultivars and decision support systems. Experts ranked the pests and tools from the farmers' point of view with respect to their practical importance. The main table of PESAP comprises the list of pests and the applied and innovative control tools used in pomefruit. It covers also information on the data sources, regions, EPPO codes and control tools characteristics (e.g. application dose and dates). The PESAP tables are linked for analysis. Queries, using the ranks, were performed for the identification of major pests and the associated current or innovative non-chemical protection tools. The individual tools were combined to toolboxes with strategies for optimizing IPM, using application date as indicator for possible substitution of chemical by non-chemical tools. This requires a detailed treatment calendar (timing, frequency, quantity). PESAP provides input parameters for pomefruit scenario analysis with assessment tools e.g. DEXiPM, PREMISE and SYNOPS. Based on 48 surveyed pests PESAP identified 4 major pests: apple scab, codling moth, brown spot of pear and pear psylla. Apple scab is most severe in the cooler and wetter northern regions, while codling moth is of major importance in the warm southern countries. For each pest and disease, the database revealed per crop and region commonly used tools and innovative, non-chemical tools. Apart from mating disruption against codling moth, non-chemical tools are presently rarely applied. However, alternative tools are available and toolboxes for IPM could be set up. Non-chemical measures as sanitation, plant resistance (apple scab, brown spot of pear) and biocontrol (codling moth, pear psylla) have a high potential for future pest management. PESAP proved to be useful for simple queries and to design alternative control strategies. It was adequate for data transfer into the environmental risk indicator SYNOPS for ecological and economical evaluation of protections strategies. PESAP can be linked to DEXiPM and PREMISE for overall sustainability and economic efficiency assessment, respectively.

CAN RESISTANCE TO ALS-INHIBITOR HERBICIDES BE REVERSED? THE PURE APPROACH

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The widespread use of ALS inhibitors and consequent increase of resistance to this herbicide group prompts new studies on the population dynamics of ALS resistant and susceptible biotypes to check whether the resistance evolution process may be reversed. Theoretically, without herbicide selection pressure to change the R/S allele ratio, an agronomic fitness cost is necessary. This is an important issue tackled by the one of the tasks of the four-year EU project PURE. Several ALS-resistant populations of Echinochloa crus-galli have been found in Italian maize crops, mostly where continuous maize cropping system is present. The aims of the research are: 1) to follow the evolution of R/S allele ratio when the selection pressure of ALS herbicides is removed through the introduction of crop rotation and the use of other herbicide modes of action; 2) the characterization of possible fitness costs of ALS-resistant Echinochloa crus-galli. Echinochloa crus-galli is a polyploid weed species highly competitive in maize and rice crops of the Northern Italy. A continuous maize field with a population of Echinochloa crus-galli highly cross-resistant to all ALS inhibitors had been previously identified. To verify the percentage of resistant plants, 400 seedlings were collected, transplanted in pots in the greenhouse and screened for resistance to nicosulfuron (97% resulted to be resistant). Three weeks after treatment, susceptible and resistant plants were selected and R and S seed stocks with similar genetic background were produced. The two sub-populations were checked for the resistance to four ALS chemical families through a comparative dose-response experiment. The possible fitness costs associated with this broad ALS inhibitors cross-resistance pattern was studied through a growth analysis field experiment conducted comparing the two biotypes. Plants were analyzed in non-competitive and competitive situations (i.e. the S target plant was surrounded by plants of the R biotype and vice-versa) at four plant densities. Leaf material was sampled from each target plant (S and R) and ALS gene was amplified in order to check the presence of mutation(s) responsible for ALS inhibitors resistance. Dose-response experiment confirmed that S population is adequately controlled and R population is highly cross-resistant to all ALS inhibitors tested with R.I.s ranging from 19 for nicosulfuron to >85 for imazamox. Molecular analyses showed that a target-site resistance mechanism is involved. All resistant plants included in the growth analysis experiment possessed a double nucleotide substitution GC-AA, giving an Ala-Asn change at amino acid 122. Preliminary results of the comparative growth analysis showed different growth and development of the two biotypes: R seeds germinated later and R plants development was delayed by about one week in comparison with the S ones. S plants produced almost double the number of panicles than the R ones in non-competitive situation, the effect phased out at high competition level and no differences were observed at 20 plants/m^2. This effect is observable considering both panicle and seed dry weight, whereas no significant differences were observed considering the dry weights of vegetative plant parts. Of course, the results need further confirmation and the experiment will be repeated next year. The four-year crop rotation field experiment is under way.

SECONDARY EFFECT OF COPPER DIFFERENT FORMULATES IN THE CONTROL OF POWDERY MILDEW *SPHAEROTHECA FULIGINEA* (SCHLECHT.) IN EFFICACY TRIALS AGAINST DOWNY MILDEW IN CUCURBITS

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Powdery mildew (*Sphaerotheca fuliginea*) is a very common and dangerous pathogen of cucurbits and the chemical control is based on IBS, sulphur, strobilurins, and other more recently introduced active substances. There are very few evidences in scientific literature of the efficacy of copper in the control of powdery mildew in cucurbits, despite this active substance is sometime considered in the control programs. In the view of reducing the pesticide use and risk according to the Directive 2009/128/EC, the detection of a control action of copper on this disease is very interesting, since there could be the possibility to control both downy and powdery mildew in growing areas where these diseases are both present, for example the Po valley in Italy.In some field trials carried out in 2011 in the Verona Province (Veneto Region, Italy) to control downy mildew of cucurbits on melon (greenhouse) and zucchini (open field), this was really observed for copper sulphate + cymoxanil formulations (4-5 applications, 7 days interval). After these observations, another specific trial was set in 2012 in a zucchini field (5 applications, 7-10 days interval), using only copper based products (Cu-hydroxide, Cu-oxychloride and Cu-sulphate) at label rates compared with a sulphur based strategy. All the trials were arranged in small plots (5-10 plants) with randomized block design. In order to facilitate the primary target (downy mildew) in the melon trial in the greenhouse, an overhead irrigation system was added to the trial area. Moreover, the trials set on zucchini, both in 2011 and 2012 were carried out in September-October and the microclimate conditions were characterized by a high relative humidity during the night and the presence of dew on the leaf surface. The applications were made with knapsack sprayers with hollow cone tips, with a water volume of 500-800 L/ha. In the zucchini trial assessments were made by observing 5 well-formed leaves per plot in the medium part of the stem, directly exposed to the spray and estimating the upper surface affected (%); 30 leaves were observed in melon. The trials were carried out in compliance with the EPPO Standard Guidelines on the Good Experimental Practice (EPPO, 2012). Data were analyzed by means of ANOVA and Tukey HSD test. In the first year trials on zucchini, 7 DALA (days after the last application) and 28 DAFA (days after the first appl.), copper based products gave 8-11% severity (% leaf area affected) in comparison with 62% detected in the untreated plots. In melon, 8 DALA and 36 DAFA, the results were also good: 9-19 % severity in comparison with 83% in the untreated plots. Both the trials had a significant difference between untreated and treated plots. In the second year, 2 assessments were made (1 and 8 days after the third application, 3 applications in total), each of them detecting effectiveness of all the copper based products with statistical significance ($P<0.001$). In the first one, sulphur strategy detected 4% severity while untreated 68% and all the copper products detected an intermediate severity (22-40%) with statistical evidence ($P<0.001$). In the second assessment the severity in the untreated plots was found to be similar to the previous assessment and all the treatments significantly reduced the disease severity (20-36% was found in copper treatments vs 15% in sulphur). The best copper products were those applied at the higher a.i. rates. The results demonstrated that a copper control of powdery mildew is possible, especially if the cultivation and weather conditions facilitate the moisture of leaves and stems, that makes the copper ions available for the toxic action towards the mycelium.

MANAGING FIRE BLIGHT – AN INTEGRATED CONTROL STRATEGY FOR A QUARANTINE BACTERIUM

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Fire blight, caused by *Erwinia amylovora* is the most devastating bacterial disease of apple and pears. It was first detected in Austria in 1993 and spread from then in the country from west to east. 2009 it was concluded that *E. amylovora* has to be considered as established in all provinces of Austria since the eradication of *E. amylovora* failed after a severe outbreak in 2007. No area could be any longer recognised as “protected zone” in respect of that harmful organism. Fire blight has caused economically important losses for the growers over the years. The coexistence of modern fruit production and apple and pear cultivars that have a regional importance for high trees in extensive orchard managements is a challenge for the disease control. Therefore an integrated disease management programme has been developed. It was created by official authorities, associations of growers, nurseries and beekeepers, advisors, fruit marketers, research centers and other relevant stakeholders. A combination of preventive measures, limited use of pesticides (including antagonists) and orchard sanitation during dormant and growing season shall reduce the number of inoculum sources and keep the disease at a low threshold where eradication is not possible. Research activities about fire blight epidemiology, improved detection methods and the efficacy testing of chemical and biological treatments nourish the control strategy. The regular exchange of information and the coordination of activities between all stakeholders are main instruments for the bearing of the disease management.

EFFICACY OF IPM STRATEGIES AGAINST GREY MOULD ON TABLE GRAPE AND THEIR INFLUENCE ON FUNGICIDE RESISTANCE IN *BOTRYOTINIA FUCKELIANA*

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In Southern Italy, grey mould (*Botryotinia fuckeliana* = *Botrytis cinerea*) can cause heavy yield losses, especially in table-grape vineyards covered with plastic films to delay the harvest until December. Under such conditions, several fungicide sprays are often needed, but they can leave high residue concentration in grapes and have a relevant impact on the environment. Furthermore, acquired resistance to almost all allowed fungicides has often been experienced in *B. fuckeliana* on such crop. Two field trials were carried out in table-grape vineyards (cv Red Globe, Trial A; cv Italia, Trial B), to assess the efficacy of protection schedules based on two microbial antagonists, *Bacillus subtilis* and *Bacillus amyloliquefaciens*, in controlling grey mould with the main aim of reducing the use of chemicals and the risk of acquired resistance to fungicides. The microbial antagonists were tested alone, in alternation and in mixture with boscalid or pyrimethanil. Spray schedules were applied on four-replicated twelve-plant plots and compared to untreated check. Prevalence (percentage of infected bunches) and McKinney's index were used as parameters to estimate infection levels. A few days after the last spray, samples of infected berries were collected and the percentages of fungicide-resistant conidia were assessed in the laboratory, by using fungicide-amended media. Favourable climatic conditions to grey mould occurred quite late in the season. After first symptoms appearance (first half of November in trial A; last week of November in trial B), a very rapid increase of the disease evolution was observed in few days. At the time of the first assessment, infections were present on 74% of bunches of the untreated plots in trial A and 88% in trial B, with McKinney's index values of 18% and 48%, respectively. Under such conditions, both microbial antagonists proved to be effective and significantly reduced McKinney's index values, as compared to the untreated check, in both trials; in trial A they reduced also the prevalence values. Similar results were obtained by alternations of the microbial antagonists with boscalid or pyrimethanil. The lowest infection values were observed following the treatments with both the tested fungicides alone or in mixture with *B. subtilis* or *B. amyloliquefaciens*. Satisfactory efficacy levels were reached w ith the strategy based on two early sprays with boscalid, followed by two sprays with *B. subtilis* or *B. amyloliquefaciens* and two sprays with pyrimethanil. The results showed that the tested microbial antagonists are useful in reducing the use of chemicals in appropriate IPM strategies. High frequencies of anilinopyrimidine-resistant conidia (50-100%) were detected on all the theses in both trials, confirming the results of a monitoring programme carried out in the last five years. In trial A, a significant increase of the percentage of boscalid-resistant conidia (23%), was observed only in the thesis treated exclusively (6 sprays) with the fungicide, whereas the increase was lower (0.3%-15%) when it was used in mixture or alternations with one of the microbial antagonists. Further evaluations need to be conducted to confirm the results so far obtained and to get deeper knowledge on the most suitable *B. subtilis* and/or *B. amyloliquefaciens* application mode in IPM strategies aimed at reducing the use of chemicals and the risk of acquired fungicide resistance in *B. fuckeliana*.

SIDE EFFECTS OF FUNGICIDES AND INSECTICIDES ON PREDATORY MITES IN TOMATO GREENHOUSE CROPS

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Compatibility studies of chemical and biological control agents are necessary to be able to give proper recommendations for their integrated use. The side effect of insecticides: Abarex 018 EC (abamectine), Kohinor 200 SL (imidaclopryd), Karate Zeon 050 CS (lambda-cyhalothrin), Nissorun 050 EC (hexytiazox), Ortus 05 SC (fenpyroksymat), Spin Tor 240 SC (spinosad) as well as some selected fungicides: Topsin M 500 SC (thiophanate-methyl), Previcur Energy 840 SL (propamocarb), Bravo 500 (chlorotalonil) on predatory mites: *Phytoseiulus persimilis*, *Amblyseius andersoni* and *Amblyseius swirskii* was tested in laboratory conditions.
The insecticides tested: Abarex, Spin Tor and Nissorun were safe for the applied predators and could be included to the IPM (Integrated Pest Management) programmes in greenhouse grown crops. The following insecticides: Kohinor, Ortus and Karate were highly toxic to the used predators, and the species *A. andersoni* was the most sensitive. The result of the studies carried out revealed that the species *P. persimilis* was the most susceptible to all used fungicides based on the laboratory experiments, especially when the predator was released 1 and 3 days after the fungicide treatments. Generally, applied fungicides showed a lower toxicity to all beneficial organisms when the predatory mites were released 5 days after the application. The fungicide Topsin 500 SC appeared to be selective to the species *A. swirskii*. The fungicide Topsin 500 SC due to its selectivity to *A. swirskii* could be used in the IPM programmes in greenhouse grown crops. Agricultural practice showed that the main goal of plant protection against harmful organisms can't be achieved exclusively by mass application of pesticides. Numerous disadvantages of chemical treatments are related to: a rapid increase in pesticide production costs; disturbance of ecological balance due to mortality of numerous beneficial organisms; arising phenomenon of agrophages' acquired resistance to applied pesticides; increasing contamination of the environment and agricultural products with toxic substances. It is therefore important to determine the toxicity of pesticides for beneficial organisms, which are used to control pests in greenhouse crops. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under the grant agreement n◦265865.

FRUIT.NET: THE CATALAN PROGRAM TO OPTIMIZE THE USE OF PESTICIDES AND RESIDUES MINIMIZATION ALONG THE FRUIT CHAIN

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Catalonia is an important producing area of fresh fruit. Currently, as the major production areas of the world, fruit protection is based primarily on the pesticide applications to control diseases and pests, with a number of fruit that have presence of residues. The social awareness of the negative effect of pesticides use to human health and environment, the EU regulation of maximum limits of residue and the drastically reduction of existing active substances have implied major difficulties for pest and disease control. In this context, the Agriculture Department of Catalonia (DAAM), the Food and Agriculture Research Institute (IRTA), Universities and the fruit sector, created Fruit.Net program during 2010. It is the National Plant Protection Program in Catalonia, has gone a step further, joining forces of all actors involved in plant protection of apple, pear, peach and citrus fruits for optimizing the use of pesticides and residues minimization. Fruit.Net provides all knowledge that exist in relation to the pesticides and alternatives treatments in all different levels of development, research, validation process or commercially available. Moreover, Fruit.Net detects the diseases and pests which have a lack of available treatments or have more problematic control to point them to be studied, and generate a coordinate research plan. Also Fruit.Net designs a complete strategy to control pests, diseases and disorders along all fruit chain that affect each cultivar and will be applied in commercial orchards. All the generate information will be transferred to the end user in meetings, publications and in a specific website. The research program designed by the Fruit.Net Program in 2012 included 26 studies to investigate a wide range of pests, diseases an disorders that affect apple, pear, peach and citrus cultivars including the ones caused by *Carpocapsa pomonella*, *Cacopsylla pyri*, *Frankliniella occidentalis*, *Grapholita molesta*, gray aphid, *Podosphaerea leucotricha*, *Sphaerotheca pannosa*, *Venturia inequalis*, *Monilinia* spp. or scald. Fruit.Net strategies were evaluated in a total of 65 commercial orchards covering a total area of 126 ha of the fruit production of Catalonia including the main varieties of apple, pear, peach and citrus. The results obtained have been highly satisfactory, since the control of pests, diseases and disorders applying the Fruit.Net strategy have shown similar levels comparing with the conventional one, however, the number of chemical treatments applied with the Fruit.Net strategy were reduced around 25%, 20% and 10%, in apple, peach and pear respectively. Moreover, the presence of residues was also decreased on fruit produced under the Fruit.Net strategy.

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