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SUPPLEMENTARY MATERIAL - Descriptions of data sources

Journal: *Agronomy for Sustainable Development*

Analyzing barriers and levers for practice change: a new framework applied to vegetables' soil pest management

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A. Exploratory interviews (end 2017- early 2018)

The ten exploratory interviews aimed at understanding the current state of the sector of vegetable production in Provence. Questions were asked to identify the main stakeholders of this sector, how they interact, the main problems of the sector, the problems' evolution and how the stakeholders deal with it. They also aimed at identifying the place of the soil-borne pest and disease in the main problems and how it interacts with them. Depending on the interviewee, the interviews lasted 1 to 2 hours. An example of an interview guide is available (in French) on request to the corresponding author.

B. Literature review (end 2017-2020)

- Four books and technical articles on soil-borne pest and disease management in a Mediterranean climate and beyond (non peer-reviewed)
 - o Djian-Caporalino C (2010) Nématodes à galles, des ravageurs de plus en plus préoccupants: Résultats de trois ans d'enquêtes dans quinze régions françaises. PHYTOMA - La Défense des Végétaux:43–49
 - o Djian-Caporalino C, Védie H, Arrufat A (2009) Gestion des nématodes à galles : lutttes conventionnelles et lutttes alternatives.: L'atout des plantes pièges. PHYTOMA
 - o Hoefflerlin P, Djian-Caporalino C, Villeneuve F, Delporte M (2018) Les nématodes à galles : Meloidogynes spp. Hors-série, Paris.
 - o Le Bohec J, Giraud M, Fritsch J (1999) Désinfecter les sols autrement. Editions Centre technique interprofessionnel des fruits et légumes
- Three articles and books on the vegetable value chain and its regulation, at the local and national level
 - o Lamine C (2014) Développement des marchés bios, des réseaux et des initiatives - Étude de la croissance des marchés bios porteurs de valeurs et du maintien de la confiance et l'intégrité: France - Etude de cas sur Biocoop
 - o Bernard de Raymond A (2013) En toute saison. Le marché des fruits et légumes en France. Presses universitaires de Rennes
 - o Ctifl (2019) La réglementation de la commercialisation des fruits, légumes et pommes de terre - Règlements (UE) N°543/2011 (Chapitre VI).
- Three internship reports on the diversification, the management of soil-borne pest and disease in sheltered vegetable productions in Provence and the functioning of the major French organic wholesaler of fruits and vegetables

- Furnion C (2014) Assessing the acceptability of alternative cropping systems limiting the pressure of root-knot nematodes: A case study with market gardeners of South-Eastern France
- Marguerie M (2011) Diversification des cultures dans les exploitations maraîchères biologiques : conséquences sur les gestions agronomique et commerciale.: cas de la basse vallée de Durance, PACA
- Torres M (2010) Les systèmes alternatifs de contrôle des pathogènes telluriques en maraîchage: Analyse des modalités techniques et évaluation des risques d'infestations en exploitation agricole
- Three Statistical reports on agriculture in Provence
 - Bio de Provence (2016) La filière maraîchage biologique en PACA. https://www.bio-provence.org/IMG/pdf/fiche_filiere_maraichage_paca_2016_vf.pdf
 - Ctifl (2013) Structure des exploitations fruitières et légumières: Évolutions entre les recensements agricoles de 2000 et 2010. Agreste Les Dossiers
 - Agreste (2014) l'agriculture en provence-alpes-côte d'azur : une mosaïque de systèmes spécialisés. https://draaf.paca.agriculture.gouv.fr/IMG/pdf/82_Paca_INOSYS_cle8f9c32.pdf
- Seven peer-reviewed scientific articles on sheltered vegetable production in Provence, mainly on practices for soil-borne pest and disease management, but also on marketing, labour organization and other determinants of farming practices
 - Collange B, Navarrete M, Peyre G, Mateille T, Tchamitchian M (2011) Root-knot nematode (*Meloidogyne*) management in vegetable crop production: The challenge of an agronomic system analysis. *Crop Prot* 30:1251–1262. <https://doi.org/10.1016/j.cropro.2011.04.016>
 - Navarrete M (2009) How do Farming Systems Cope with Marketing Channel Requirements in Organic Horticulture?: The Case of Market-Gardening in Southeastern France. *Journal of Sustainable Agriculture* 33:552–565. <https://doi.org/10.1080/10440040902997785>
 - Navarrete M, Le Bail M (2007) SALADPLAN : A model of the decision-making process in lettuce and endive cropping. *Agron Sustain Dev* 27:209–221. <https://doi.org/10.1051/agro:2007009>
 - Navarrete M, Le Bail M, Papy F, Bressoud F, Tordjman S (2006) Combining leeway on farm and supply basin scales to promote technical innovations in lettuce production. *Agron Sustain Dev* 26:77–87. <https://doi.org/10.1051/agro:2005062>
 - Navarrete M, Dupré L, Lamine C (2015) Crop management, labour organization, and marketing: Three key issues for improving sustainability in organic vegetable farming. *Int J Agric Sustain* 13:257–274. <https://doi.org/10.1080/14735903.2014.959341>
 - Navarrete M, Djian-Caporalino C, Mateille T, Palloix A, Sage-Palloix A-M, Lefèvre A, Fazari A, Marteu N, Tavoillot J, Dufils A, Furnion C, Pares L, Forest I (2016) A resistant pepper used as a trap cover crop in vegetable production strongly decreases root-knot nematode infestation in soil. *Agron Sustain Dev* 36:37. <https://doi.org/10.1007/s13593-016-0401-y>
 - Navarrete M, Lefèvre A, Dufils A, Parès L, Perrin B (2017) Concevoir et évaluer avec les acteurs des systèmes de culture adaptés à leurs cadres de contraintes et d'objectifs en production maraîchère sous abri.: Mise en pratique et enseignements dans les projets GeDuNem et 4SYSLEG. *CIAG Construire et diffuser des systèmes légumier multi-performants*, 14/09/17, Angers

C. Stakeholder interviews (2018-2019)

The eleven stakeholder interviews were focused on the management of soil-borne pests and diseases in systems of sheltered vegetable production in Provence. The questions concerned the damage level of soil-borne pests and diseases and especially root-knot nematodes (RKN) on vegetable crops, the different ways farmers on the Provençal territory managed them and how the other stakeholders facilitated one or another way of managing them. The guides and duration of the interviews were adapted to the interviewee. The interviews lasted 45mn to 2h. An example of an interview guide is available (in French) on request to the corresponding author.

D. Stakeholder meeting participant observation (2017-2019)

- **Scientific meetings** to present scientific results on vegetable farming in Provence and soil-borne pest managers to other scientists and farmers' advisors: GIS PICLeg meeting¹, MedAgri conference², technical forum on vegetable production by CTIFL³, conference TANDEM INRAE SAD (edition 2017), conference CTIFL on green manure
- **Technical meetings** to present, design and organize the testing of new techniques and cropping systems to better manage the farm and especially the soil-borne pest and diseases: 3 meetings for the project GONEM⁴, PADV⁵ experiment presentation, Groupe DEPHY soil⁶, technical meetings on crop planning GRAB, on-farm technical exchange in two organic vegetable farms
- **Other professional meetings** to exchange around value-chain management and impediments to the implementation of agroecological practices: Webinar Impediments and Levers for biocontrol (Projet PEI Santé du Végétal, Pays de Loire⁷), 2 PADV meetings, roundtable on organic market evolution for fruits and vegetables, GIEE soil conservation⁸

E. Farmers' specific interviews (end 2018 - early 2019)

The twelve farmers' specific interviews were focused on the farmer's issues regarding soil-borne pest and diseases, their way to manage them (e.g. nematicides, trap crops, rotation), the other techniques they use that can influence them (e.g. tillage, amendment spreading), their farm resources (e.g. equipment, workforce), the impediments they encounter to introduce agroecological techniques and the other stakeholders that play a role in their management of soil-borne pest and diseases (e.g. their marketing firms, input suppliers, peer-exchange groups, advisors). We also questioned them on their vision of soil-borne pest and disease management (e.g. need for pest and disease eradication, need to control to an acceptable level), their goals for the farm in a near future (e.g. expansion, taking more holidays), their will to take collective action (e.g. participating to cooperative of machinery or for selling), and what they like in their work. Depending on the interviewee, the interviews lasted 1 to 3 hours. An example of an interview guide is available (in French) on request to the corresponding author.

¹ <https://www.picleg.fr/>

² <https://www.med-agri.com/conferences>

³ <https://www.ctifl.fr/>

⁴ <https://www.picleg.fr/Projets/Les-projets-en-cours/GONEM>

⁵ <https://agricultureduvivant.org/>

⁶ <https://ecophytopic.fr/dephy/reseau-ferme-des-maraichers-provencaux>

⁷ <https://pays-de-la-loire.chambres-agriculture.fr/innovation-rd/agronomie-vegetal/recherche-developpement/approche-systeme/projet-pei-sante-du-vegetal/>

⁸ http://www.giee.fr/fileadmin/user_upload/National/086_eve-giee/PDF-GIEE/PACA/PACA_032_Amelioration_des_performances_agroecologiques_des_cultures_maraicheres_par_la_gestion_des_sols.pdf

F. Stakeholder workshops (end 2018-early 2020)

Workshops n°1 and 2: In each workshop, we presented to one group of farmers the agroecological techniques for RKN management and exchanged with them around impediments and levers to the implementation of those techniques. We also co-designed the solutions to implement *agroecological management of soil health* on a different farm for each workshop.

Workshops n°3 and 4: We made representants of the diversity of the problem's stakeholders types play a serious role game designed to model how the main stakeholders of the problem under study influence farming practice choices regarding soil health management. During the debriefing, we exchanged on the validity of the model compared to the reality that stakeholders experienced in real life and discussed the impediments and levers that were identified during the game sessions. In workshop n°4 we also designed together solutions to facilitate the wider implementation of *agroecological management of soil health* in Provençal vegetable farms.

Workshop n°5: We split the diversity of the stakeholders present and made them build three strategies based on the preceding solutions concept design. Each strategy had a complementary goal: (1) increasing and maintaining soil organic matter and good life balance in the soil, (2) increasing crop diversity, (3) fostering the implementation of *agroecological management of soil health* in Provençal vegetable farms. We discussed the strategies designed in plenary.