PhD thesis topic

Stacking biodiversity at different levels in cereal cropping system: effect on crop performance and pest control

Host institution:
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Beginning of the thesis:
Sept-November 2019 depending of field trails establishment

1. Context of the PhD thesis
To feed the world’s growing population, agriculture has to become more productive and at the same time to ensure social, environmental and economic sustainability. Cropping systems have therefore to evolve in order to be economically efficient and environmentally friendly.
Recent studies highlighted that the increase of diversity at different levels in the cropping systems could improve system productivity and resistance to pests and to climate change (Finckh et al. 2000; Kiær et al. 2009, 2012). Under this frame, the Ecostack project was developed inside the EU Horizon 2020 programme. The overall goal of the project is to develop and support ecologically, economically and socially sustainable crop production via stacking biodiversity within and around fields and promote/support ecosystem service providers.
In the European Union, over 57 million hectares were used to harvest 302 million tonnes of cereals (including rice) in 2016 (European Commission 2017). Cereal cropping systems are therefore of major importance in European agriculture and request a large use of pesticides (European Commission 2013). As aphids are representing one of the major pests in this cropping system, several works particularly focused on the effect of diversity of cereal cropping systems on aphid control in order to limit or reduce pesticide use.

These laboratory and greenhouse works demonstrated that increasing genetic diversity in crops, for example through mixtures of different varieties (i.e. intraspecific diversity), supports lower aphid populations compared with cultures of a variety alone. Certain cultivar combinations result in reduced aphid acceptance for host plants and also increase attraction
of ladybirds and parasitoids mainly through changes in the volatile profile emitted by the plants (Ninkovic et al. 2002, Cowger & Weisz 2008, Shoffner & Tooker 2013). Laboratory and field studies also demonstrated that increasing plant diversity through species association (i.e. interspecific diversity), for example through cereal and legume intercropping, improves productivity and pest control (Kaut et al. 2008, Malézieux et al. 2009). Intercropping has shown to reduce aphid population and to increase population densities of ladybirds, hoverflies and parasitoids compared to monoculture (Xie et al. 2012, Seidenglanz et al. 2011).

Thus both intraspecific and interspecific diversity in cropping systems benefit the delivery of different ecosystem services including provisioning and pest regulation.

Going further, the ecostacking approach, developed in the frame of the Ecostack European project, proposes "combining in a synergistic manner the beneficial services of functional biodiversity from all levels and types" (Hokkanen 2017). Following this concept, combining at the same time intraspecific and interspecific diversification practices in cereal cropping system could potentially provide synergy and enhance of the beneficial services including the pest regulation. Nevertheless very few studies so far investigated the potential interactions between these two levels of diversity in cropping systems and the potential synergetic effect of their combination on arthropods (Koricheva & Hayes 2018).

However, some recent on farm experiments conducted in France on organic wheat cropping systems showed contrasted results of the combination of this two levels of biodiversity. For example combining intra- and interspecific diversity did not outperform each practice individually in reducing aphid populations, thus not clearly showing synergetic effects expected under the “ecostacking” principle (Mansion-Vaquie et al. 2018, 2019). Taken separately intercropping tended, in these field trials, to have lower aphid infestation, while the cultivar mixtures was more infested by aphids than the cultivars grown alone. In addition, wheat yields and grain protein content were negatively impacted in intercropping by 7 to 10%, but not in cultivar mixtures.

Deeper investigation are therefore necessary to further investigate the potential in term of service provision (provisioning, pest regulation,...) of combining these two levels of diversity.

2. Objectives

This PhD project wants particularly to investigate the synergistic effects of stacking plant functional diversity, through the implementation of two agroecological practices in a cereal cropping system: varieties mixtures and species association between a cash crop and a service crop. Crop performance, interactions between crops and arthropods (pest and natural enemies) will be monitored (with a particular focus on potential for pest regulation). Local landscape might also be considered for its potential influence on crop performance and arthropod abundance and biodiversity (Rusch et al. 2010, Tscharntke et al. 2007, Bianchi et al. 2006).

The cropping system investigated will be organic barley systems with sole barley crop, the combination of different barley varieties, and barley-legume intercropping. The project will focus on aphids as main pest and their natural enemies (ladybirds, syrphids, carabids, lacewings, spiders, parasitoids). The PhD student will have to carry out different field surveys and experiments on different farmers’ fields and potentially also in adjacent areas.
Depending on the progress of the project and the abilities and interest of the student, some current cereal foliar diseases as well as weeds could also be monitored during the PhD (Amosse et al. 2013, Mundt 2002).

Experiments will be conducted in the Auvergne-Rhone-Alpes region with focus on organic malting barley production as this production, in development in the area, faces particular challenges in terms of aphid control to prevent the barley yellow dwarf virus transmission.

The experimental design developed and experiments conducted within this PhD project will go in parallel with similar experiments conducted at the same time in other partner countries of the European Ecostack consortium. Results have to be discussed also in regard of the results obtained in others countries. The PhD student will therefore have to interact with different European research partners.

3. Methodology

PhD project will investigate the effects of increased diversity by ‘stacking’ benefits from variety mixtures and intercropping. Experimental plots are intended to be set up in organic farms mainly in the Auvergne-Rhône-Alpes region. Within each plot, “single barley variety” or “barley varieties mixture” treatments will be cross tested with “barley monoculture” or “barley and legume intercropping” treatments. The two barley varieties used in combination for the experiments will have been selected for their regional suitability and relevance and for their capacity to reduce insect colonization based on plant-plant interactions in laboratory screening (prior laboratory screening conducted by the Department of Crop Production Ecology, SLU, Sweden) (Ninkovic et al. 2002).

During on field experiments:
- Performance of barley will be assessed by measuring agronomic traits and components: grain yield, and grain protein content, height of barley, biomass.
- The abundance and population dynamics of insect pests and their natural enemies (ladybirds, hoverflies, ground beetles, lacewings, spiders, parasitoids) will be monitored; possibly the occurrence of some cereal foliar diseases and weeds will be also monitored.
- Predation pressure intensity will be assessed through sentinel preys
- Landscape characteristics surrounding each field trial location will potentially also be recorded.

4. Required knowledge and competences:

- Knowledge in agricultural science and ecology and capacity to combine these disciplines,
- Competences in statistics, and in carrying out multivariate statistical analyses,
- Very good knowledge of spoken and written English language,
- Capacity to work autonomously, and to be part of a research team

5. Research resources and salary

- A thesis committee with supervisors and external experts
- Collaboration with other international teams
- All costs related to the scientific work and organization of the project during the PhD thesis will be covered by the research project. An office, a laptop and a telephone will be available for the PhD student.
- Gross salary of about 1800 Euros gross per months. Duration of the contract is three years.

6. Affiliation of doctoral school: ABIES, AgroParisTech

7. Selection of candidate
Interested candidates should send the following application material by e-mail to Alexander Wezel awezel@isara.fr:
  - Cover letter explaining your motivation and expectations
  - CV, including list of publications (if you have already)
  - One page summary of your MSc thesis
  - Contact information for two reference persons

References:


