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Pre-cropping effects from grain legumes on wheat and oilseed rape: nitrogen fluxes and productivity

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1 Introduction

In the current French arable cropping systems mainly based on cereals and oilseed rape (OSR), grain legume crops provide both a botanic diversification and nitrogen supply, thanks to their ability to fix atmospheric N_2. However, ecosystem services provided by legumes are not well characterised according to the given context, preventing them to be fully valued by a large number of farmers. For instance, the effects of legume crops on the performances of following crops rely usually i) on average estimates, ii) only for some couples of species, and iii) on fragmented data (Jeuffroy *et al.* 2015; Schneider *et al.*, 2017). And the major factors explaining the variability of these effects are not known. This prevents to forecast the crop system and adapted technical management which would have led to optimal services in a given context, such as enhanced production with lower charges.

In order to complement on-going analysis of a series of detailed traits in one location (Guinet 2016), Terres Inovia carries out trials on two locations to address the comparative characterisation of some services provided by grain legume crop to the following wheat or rape (or intercropped wheat).

2 Materials and Methods

Several trials were carried by partners of the UMT Alter'N[1]. The trials managed by the Technical Institute Terres Inovia aim at quantifying some services delivered by pea, faba bean, lentil crops compared with non-legume crop (wheat, rape) in two locations (« Berry » and « Grignon ») in different couple of years.

Several variables were analyzed: yield (quantity and quality), N fixed (%Ndfa, following 15N enrichment in the case of analytical trials), residual mineral soil nitrogen (at 3 dates), crop and grain nitrogen content, soil biological activity indicator (soil nematofauna), and, in one location, N2O emissions. Preceding crops on year n include non-legume crops (wheat and oil seed rape (OSR) in both locations), and legume species (winter pea and pea-wheat intercrop in both locations, winter faba bean and spring lentil only in Berry, spring faba bean and spring pea only in Grignon). Following crops on year n+1 include wheat and oilseed rape without N fertilisation (0N) or with a suboptimal N fertilisation (N1). The objectives of the first analysis are (i) characterize the service of the nitrogen fixation especially through the quantity of nitrogen issued from N fixation; (ii) compare the potential of modifying the yield of the following (or intercropped) crop.

3 Results

Three series of « preceding crops » (Berry16, Berry17 and Grignon17) and a single series of « following crop » (Berry17) of the analytical experiment have been used to analyse variables linked to ecosystem services of harvested grain legumes. Three types of services are here assessed:

3.1 Symbiotic nitrogen entry

Symbiotic fixation rates (%Ndfa) were high in Berry: about 75-80% for pea and lentil (versus 60-70%) and 90% for the faba bean (versus 70-80%). In Grignon, on the contrary, %Ndfa rates were particularly low for monospecific peas, about 40%, but remained higher for the intercropped pea (75%). There is a strong inter- and intraspecific variability is mainly explained by the quantity of fixed nitrogen (QNdfa) and the dry biomass(grains + stems) at harvest. Three groups can be distinguished and associated with three different

[1] *UMT ("Unité Mixte Technologique") is a partnership between a technical institute and research teams; Alter'N is the acronym for "To strengthen the strategic on-farm advice for cropping systems based on legume crops or organic fertilisers with low nitrogen losses and low dependency on synthetic fertilisers". http://www.terresinovia.fr/umt-altern*

situations Berry16, Berry17 and Grignon17. When pooling the data with the data from UMR Agroecology - Dijon (Guinet 2019), there is a correlation (Figure 1) between the harvest biomass and the quantity of nitrogen issued from symbiotic fixation. No particular relation between the %Ndfa and the residual soil mineral nitrogen content before or after winter was observed in trials (Terres Inovia) and in farmers' fields (Pelzer, personal communication).

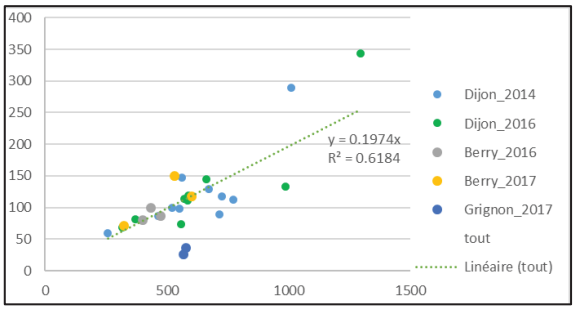

Figure 1. Relationship between the areal biomass at maturity (g/m2) on the x-axis and the quantity of nitrogen from symbiotic fixation (QNdfa) at maturity (kgN/ha) on the y-axis, on a series of situations.

3.2 Nitrogen absorption by the following crop

The service directly derived from the preceding effect of pea enables the following wheat to absorb from 59%N more than the wheat which follows a cereal and it leads to a rape which has absorbed 38% N more than rape crop which follows wheat. The trends confirm previous results of another trial (2009-10) in one location.

3.3 Yield level of the following crop

For the couples harvested in 2016 and 2017, the preceding crop in 2016 campaign has undergone by a normal growth during most of the crop cycle but by strong damages before harvest. The legume crop leads to higher non-fertilized wheat yields the following year compared to a wheat as preceding crop (*figure 2*) and the pea effect is significantly higher than the effect of lentil or pea-wheat association. The latter leads to higher yields of non-fertilized rape compared with faba bean, lentil or wheat, whereas the differences between the other preceding crops effects are not significant. There is a linear relation between the 0N wheat yield and the amount of nitrogen (QN) in crop residues of the preceding crops, but not for the 0N rape yields.

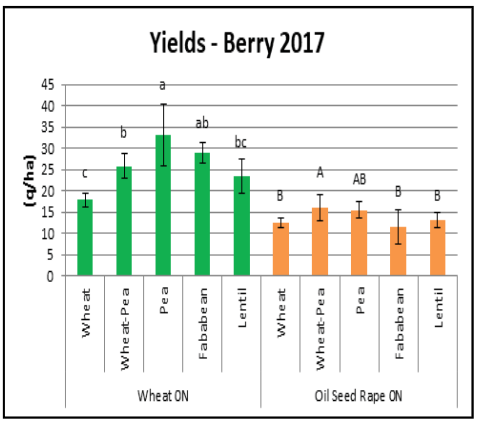

Figure 2. Average yields of non-fertilised wheat and non-fertilised OSR according to their previous crop on the Berry trial for the harvest 2017.

4 Discussion and Conclusions

These first series of results will be complemented with additional couples "year x location" and other related (dis-)services, including N leaching risks, GHG emission reduction, and also soil functioning through a soil bioindicator (Chauvin 2018). Pooling them with the results from the INRA partners' trials will enable us to consolidate the outputs and propose references for characterizing some key services related to the presence of grain legumes in cropping systems.

References

Chauvin C., Schneider A., Villenave C. (2018). Evaluation de l'effet des légumineuses sur le fonctionnement biologique du sol par l'étude d'un bioindicateur : la nématofaune du sol. 2ème Rencontres Francophones des Légumineuses, Toulouse, France, les 17&18 octobre 2018.

Guinet M., 2019. Quantification of N fluxes issued from legume crops and explanatory traits: comparison of 10 grain legume species. PhD thesis, University of Bourgogne Franche-Comte.

Jeuffroy M.-H., Biarnès B., Cohan J.-P., Corre-Hellou G., Gastal F., Jouffret P., Justes E., Landé N., Louarn G., Plantureux S., Schneider A., Thiébeau P., Valantin-Morison M., Vertès F., 2015. Performances agronomiques et gestion des légumineuses dans les systèmes de productions végétales, In : Les légumineuses pour des systèmes agricoles et alimentaires durables (Ed Quae), pp.139-224.

Schneider A., Huyghe C., Voisin A.-S., Gastal F., Vertès F., Jeuffroy M.-H., Justes E., Thiébeau P., Cellier P., Hellou G., Cohan J.-P, 2017. Insertion des légumineuses dans les systèmes de culture: source d'azote symbiotique et de diversification des assolements, In: Guide de la fertilisation raisonnée, 2e édition, Eds France Agricole Comifer, p.526-541.