Mixing Winter oilseed rape (WOSR) and legume to smoother weeds, disturb insects and reduce nitrogen use in spring: possible or not ?

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Introduction

In order to reduce pesticides use and fertilisers applied on WOSR (*Brassica napus*), mixing species could be argued as an interesting innovation. Several studies have shown that this diversification, by modifying biotic and abiotic components, provides important services, such as capturing soil nutrients and preventing their loss, nitrogen fixation by legumes, increasing soil carbon levels and associated improvements in soil physical and chemical characteristics, increasing biological activity and diversity and suppressing weeds and pests (Malezieux et al., 2007). These services can improve resource availability and the growth conditions of the crop (Andersen et al., 2004) or decrease the impact of pests, thereby increasing crop productivity. Nevertheless, the effect of mixing species are not so obvious, since we can find many studies which demonstrate that planting a companion plant in perennial and annual cropping systems may improve pest control (Altieri et al., 1999) while some other studies show that cover crops may also aggravate pest damage or favour new pests if the cover crop provides the pests with a key resource (Hauggard-Nielsen & al., 2005, Andow, 1991, Finch et Collier, 2000) or decrease resource availability (Shili-Touzi et al., 2009). Winter oilseed rape (WOSR) is widely used in French farming systems ($1.5\ 10^6$ ha). This “break”crop is of potential value in terms of market requirements and agronomic potential. However, this crop is known to be very dependent on pesticides use because of numerous pests (weeds, diseases, slugs and insects) (Alford *et al*., 2003). Mixing WOSR with legumes has received few attention and the objectives of this study were to assess the agronomic performances of mixing WOSR and spring-legumes. Considering the literature three hypotheses have been made and tested on weed competition, on disturbance on insects during autumn and on nitrogen use in spring.

Materials and methods

In several regions of France, we have carried out 5 and 6 experiments respectively in 2010 and in 2011, on farmers’ fields (figure 1 and table 1). WOSR was mixed with spring legumes, sown with WOSR in summer and capable to freeze during winter. Farmers’ fields were divided in large plots, where “sole WOSR” was sown at standard densities and 4 mixing spring legumes (white clover, bean, pea, lentil – Table 1) with WOSR were sown broadcast the same day of WOSR. No herbicide has been applied in more than half of the experiments and nitrogen fertiliser has been decided by using the full version of the nitrogen balance. The recommended nitrogen doses are estimated on the “sole-WOSR” plots and are calculated in function of soil depth, mineral soil nitrogen at the end of winter, and plant biomass at the end of winter. Each plot was divided in two subplots, one where the full balance dose minus 60kg/ha was applied (X60) and one where no fertiliser was applied (N0). Each plot was located on a homogeneous area of the field.

Thanks to this on-farms network of experiments, three hypothesis have been investigated: 1/smoother weeds without decreasing crop growth in autumn and increase it in spring 2/ restore nitrogen of frozen legumes to crop in spring and 3/ reduce insect occurrence in autumn. In order to test those hypothesis, measurements of crop growth, pests’ damages and weed competitiveness have been performed either in autumn before winter and at the end of flowering during spring.

Plants: For each plot, whole plants were sampled at 2 different stages: (i) in early winter and (ii) at the end of flowering (BBCH growth stage N°69– end of April). On each field, at each stage, samples were taken from 4 micro-plots of 0.5m². The plants were counted and the roots separated from the aerial parts after washing. For each micro-plot sample, dry biomass and total nitrogen content of green aerial parts and tap roots were determined. Partial Land Equivalent Ratio for WOSR has been calculated in accordance with De Wit and Van den Bergh (1965) for dry biomass (LER_{DM}) and nitrogen accumulation (LER_{QN})

Pests and weeds: Crop attacks by insects in autumn were estimated from 15 randomly chosen plants per micro-plot. In early winter of 2010, we counted the proportion of plants with root maggot damage and the proportion of plants harboring larvae of cabbage stem flea beetle. Weed infestations were assessed

on the micro-plots used for plant sampling, on the same dates. We counted the number of plants of each weed species. We determined total aerial dry biomass of all weeds.

Figure 1: Map of the on–farm fields' network. Red points represent the fields carried out in 2010 and green ones represent the fields carried out in 2011.

		Legume species mixed with WOSR			
Year	*Name and department of the farmers' field*	Horse Bean	Lentil	Pea	White clover
2010	Breuil Bernard (79)	0	×	0	0
	Catenoy (60)	×	0	×	0
	St Michel et Chanveaux (49)	0	×	0	0
	St Privé (89)	×	0	×	0
	Thézac (17)	×	×	×	×
2011	Sainneville (76)	×	×	×	×
	Catenoy (60)	×	×	×	×
	Grignon (78)	×	×	×	×
	St Privé (89)	×	×	×	×
	Ste Blandine (79)	×	×	×	×
	Tréchy (77)	×	×	×	×

Table 1: Legume species mixed with WOSR in the 11 farmers' fields during the two years

Results and discussion

Mixing legumes with WOSR in autumn decreased weed biomass?

The weed biomass was rather low in 6/11 experimental fields; therefore we did not test the smothering effect of legume mixed crop. For **2**/5 experimental fields (Saint-Michel, Thézac, Figure 2), the weed biomass was significantly lower under mixing crop than under sole crop and particularly under lentil and pea. Moreover, despite the differences were not significant in Breuil Bernard and Trechy, we can notice that weed biomass was lower under lentil and horse bean than under the sole crop.

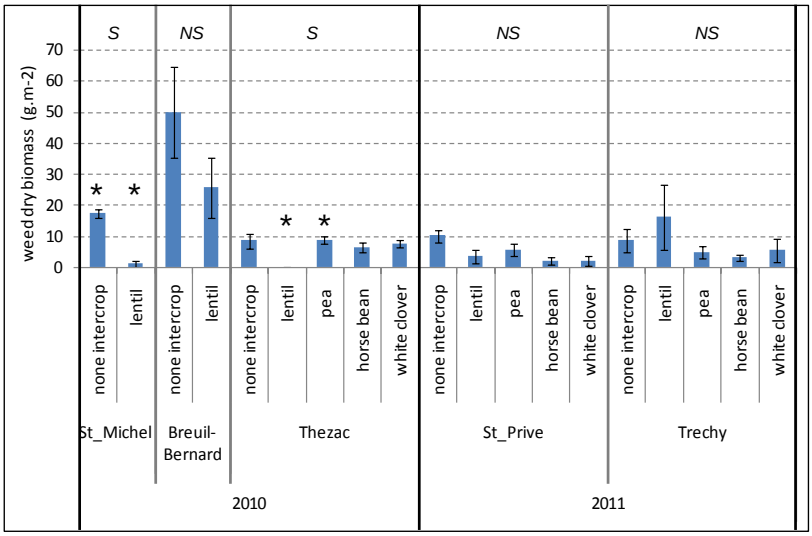

*Figure 2: Variation of Weeds biomass (g/m2) under single crop and mixed crop in autumn and Kruskal-Wallis test results (S: significant difference at p=0.05 and NS: no significant difference at p=0.05, *: modalities which are significantly different with Siegel and Castellan multiple comparison test at p=0.05)*

Diversity of weed species was relatively high (Shannon index vary from 1,27 and 1,57 among the experiments), but was not significantly different in sole crop and in mixing crop and was also not affected by legume species in mixture with WOSR. However, the weed densities did not decrease enough and in spring the weed biomass was very high whatever the mixing crop (data not shown). This suggests that the mixing crop permitted to smoother weeds in autumn as long as the legume species were present. Considering the interspecific competition in autumn, partial Land equivalent Ratio measured on biomass of WOSR in autumn showed often a considerable decline (Figure 3 – LER ranged from 0.40 to 1.56). Therefore, either in autumn 2009 and 2010, many of the legumes crops have induced competition, especially in farmers' fields characterised by high nitrogen in soil (Saint-Michel) or high soil depth (Catenoy).

Mixing legumes with WOSR could restore nitrogen to the crop during spring?

When no fertilizer has been applied during spring 2010, the nitrogen accumulated in spring by WOSR was higher when mixing legumes were sown, specifically under horse bean. It resulted in LER $_{QN}$ often higher than 1. However, these differences between sole WOSR and mixing legumes in spring did not occur systematically. Indeed, in farmers' fields characterised by high nitrogen in soil (Saint-Michel and Pornic), mixing legumes have not accumulated much nitrogen in autumn and have induced competition for light and nitrogen, resulting in a lower LER $_{QN}$ either in autumn or in spring. When the nitrogen accumulation was higher in plots with mixing legumes than in plots with single WOSR, the differences between them ranged from 7,9kg/ha and 38,7 kg/ha whatever the nitrogen fertilisation regime (X60 or N0).

Mixing legumes with WOSR reduced insect occurrence?

For all legumes species tested in every field, the occurrence of root maggot damages and of cabbage stem flea beetles larvae were not significantly reduced on WOSR plants mixed with legumes.

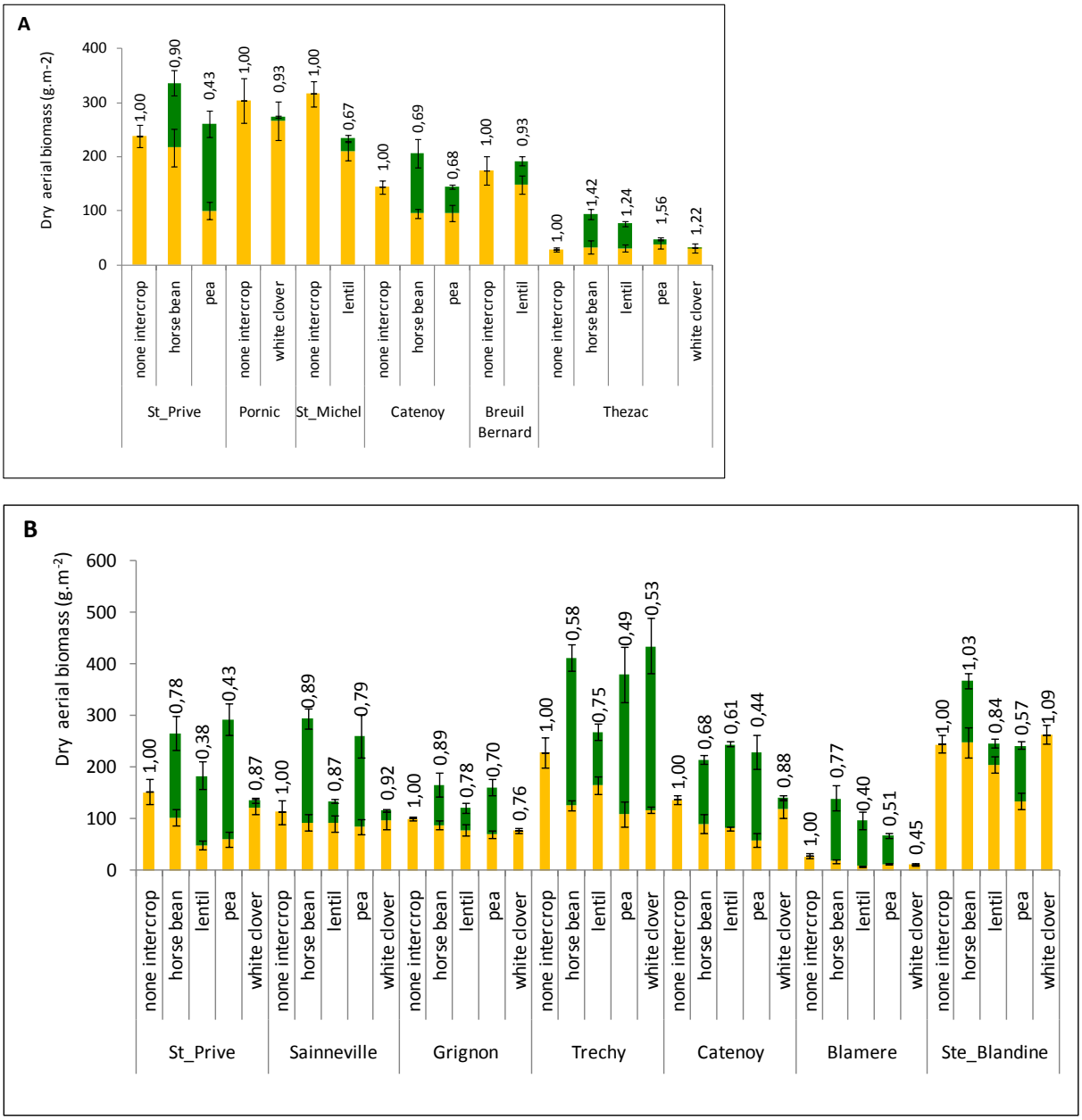

Figure 3: Above ground dry biomass accumulation in 2009 autumn (A) and 2010 autumn (B) for WOSR (yellow bars) and for mixing legumes (green bars). Values are the means +- standard deviation. Partial WOSR Land equivalent ratio (LER $_{DM}$) is mentioned on each bar.

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