Incidence of soil N fertility on the performance of organic forage legume-wheat mixtures.

Celette F., Goulevant G., Amosse C and David C.
Université de Lyon, ISARA-Lyon, 23 rue Baldassini – 69364 Lyon Cedex 07

One of the key issues of organic arable systems is to bring enough nitrogen in the crop rotation to ensure satisfying crop nutrition. Wheat yield in organic agriculture are generally low and variable. Grain yield and grain protein content are strongly affected by N deficiency and weed competition (*Casagrande et al., 2009*). Nevertheless, the autonomy of the organic cropping systems has to be improved while off-farm inputs have to be limited. The use of N_2 fixation from legume plants should then be improved. Previous research had clearly demonstrated the benefits of forage legumes in association to improve N balance and control weed seed bank (*den Hollander et al., 2007*). However, it is also well known that legume N_2 fixation could be limited depending on the soil N fertility. The functioning of such mixtures could then be disturbed by variations of the nitrogen fertility of the environment (*Hauggaard-Nielsen and Jensen, 2001*). The impact of soil N fertility has to be studied in order to manage whether above- and belowground interactions between species and to optimise benefits of the association.

Methodology

Three field experiments (defined as Sites A, B and C) have been carried out in 2009 in South-eastern France. These locations differed by soil and climate conditions (see *Celette et al., 2010* for more detailed description of experimental sites). Two different species of legumes (*Trifolium pratense-Tpra*, *T. repens-Trep*) were sown (800 grains.m^{-2}) at the end of March in the different sites. An additional treatment with wheat grown as sole crop was added as a control treatment (T0). Spring fertilization (100uN) was added on each treatment as a second experimental factor crossed with the legume species. The experimental design consists of 6 treatments, repeated in three complete randomised blocks. Additional irrigation was brought in site B (30 in April, 40mm at the end of May and 40mm in August). On each treatment, weeds (density, biomass & diversity), legumes (density & biomass) and wheat crop (biomass, yield components & protein content) had been monitored on 0.25m² plots (3 replicates per block) every 4-6 weeks.

Results and discussions

Wheat yields and grain protein contents were significantly different from one site to another regarding soil N fertility and climatic conditions (*Figure 1*). Additional N fertilization significantly improved grain yields in sites B and C (p<0.001) but not in site A, due to insufficient rain during the weeks following fertilizer application (less than 5mm in the following week and only 10mm in the following three weeks). Fertilizer application also increased significantly grain protein content in sites A and C (p<0.001) but had no effect in Site B.

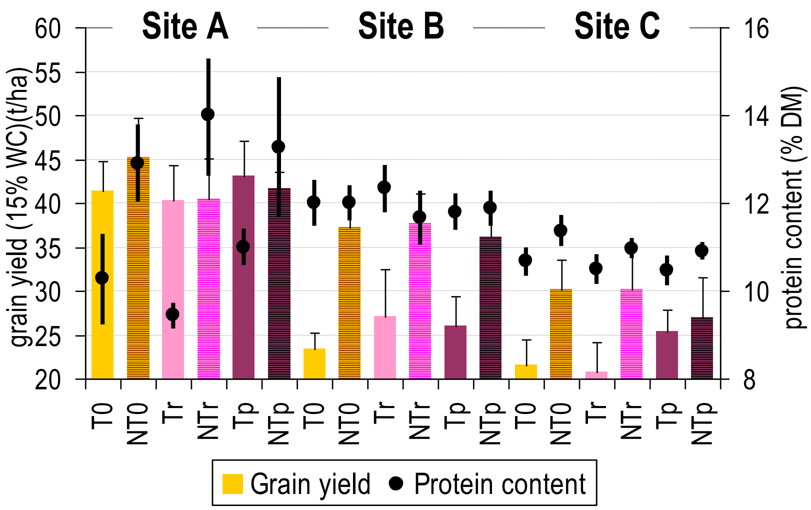

Figure 1: Wheat grain yields (15% water content)(tons/ha) and protein contents (%DM) at harvest time in the different treatments and experimental sites. Bars of error are the 5% confident intervals (Student test).

During the crop cycle, wheat biomass is significantly higher with an application of N fertilizer from tillering in site B but not before flowering in sites A and C ($p<0.05$). This result could be explained by irrigation application few after fertilizer application in site B which made faster the nitrogen availability for the wheat. Consequently, the difference of total wheat dry matter at harvest between fertilized and no fertilized treatments was higher in site B (about $3t.ha^{-1}$) than in sites A (less than $1t.ha^{-1}$) and C (1.5 to $2t.ha^{-1}$). The insertion of legumes did not affect wheat growth both in fertilized and unfertilized treatments. On the contrary, strong interaction was highlighted between the development of the legume cover and the addition of spring nitrogen fertilization. Thus, in situation with a better soil fertility and N availability, legumes growth was generally significantly lower ($p<0.05$ in sites A and B and <0.1 in site C). It was mainly the consequence of a higher and faster growth of wheat crop which led to a more intense competition for soil resources and radiation. Moreover, in a more fertile environment, legume cover loosed its main competitive advantage (N_2 fixation) on the other components of the system (*Hauggaard-Nielsen and Jensen, 2001*) and even weeds infestation was more important in fertilized treatments ($p<0.01$). Consequently, the proportion of legumes in the total dry matter of the crop association, was decreased (up to 80%) in fertilized treatments (*Figure 2*). Trep was systematically more affected than Tpra, confirming that it is more sensitive to a lack of radiation (*Frame*, *2005*).

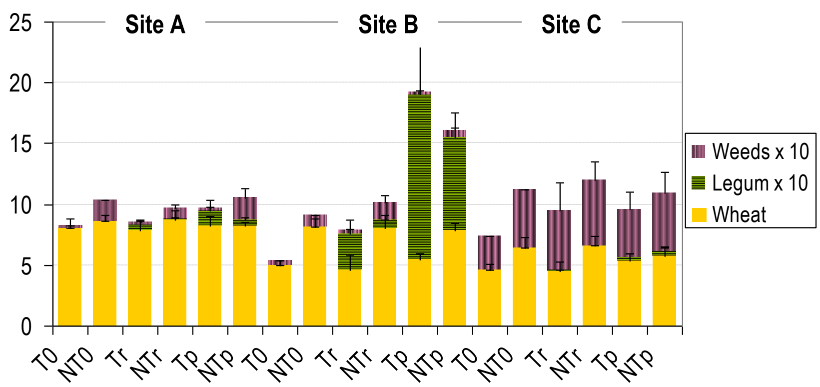

Figure 2: Cumulated dry matter of wheat, legumes and weeds (tons/ha) at wheat harvest time in the three experimental sites (SA, SB and SC) and for treatments with or without N fertilization. Bars of error are the 5% confident intervals (Student test).

The application of N fertilization influenced the partitioning of resources in the crop mixture and increased competition of fertilised wheat with legume cover. Trep, which is the most sensitive specie to radiation competition, because of its form and ecophysiology was particularly affected. This phenomenon has to be taken into account to optimise the mixture and the ecological services provided by legumes. The weeds infestation observed in fertilized situations could also limit the performance of the system in the following year.

References

Casagrande M, et al. 2009. Factors limiting the grain protein content of organic winter wheat in south-eastern France: a mixed-model approach. Agronomy for sustainable development. 29 (4): 565-574.

Celette F., et al. 2010. Associating wheat crop and undersown forage legumes in organic agriculture: Incidence of forage legumes species. Agro2010 congress – Montpellier, France.

den Hollander N, et al. 2007. Clover as a cover crop for weed suppression in an intercropping design: II. Competitive ability of several clover species. European journal of Agronomy. 26 (2): 104-112.

Frame. Forage legumes for temperate grasslands. Enfield, USA: Science Publishers, 2005. 309p.

Hauggaard-Nielsen and Jensen, E. 2001. Evaluating pea and barley cultivars for complementarity in intercropping at different levels of soil N availability. Field Crops Research. 72 (3): 185-196.