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Laurent Bedoussac, Eric E. Justes

The Efficiency Of Durum Wheat And Winter Pea Intercropping To Increase Wheat Grain Protein Content Depends On Nitrogen Availability And Wheat Cultivar

L. Bedoussac and E. Justes

[1] INRA, UMR 1248 AGIR, Auzeville, BP 52627, 31326 Castanet-Tolosan, France, Laurent.Bedoussac@toulouse.inra.fr

Grain protein concentration (GPC) of durum wheat is often a major concern particularly in low input systems where nitrogen acquisition is low due to limited resource of soil mineral N. By consequence, intercropping (IC) which can improve the use of light, nutrients and water resources (Willey, 1979) could be an alternative to the use of mineral fertilizer (Hauggaard-Nielsen, 2003 and Corre-Hellou, 2006). In this paper, we assessed the hypothesis that the performances of durum wheat and winter pea grown in intercrop (IC) to valorise natural resources are better than in sole crops (SC) in low-input systems. Besides, they would however depend on both nitrogen availability and wheat cultivar.

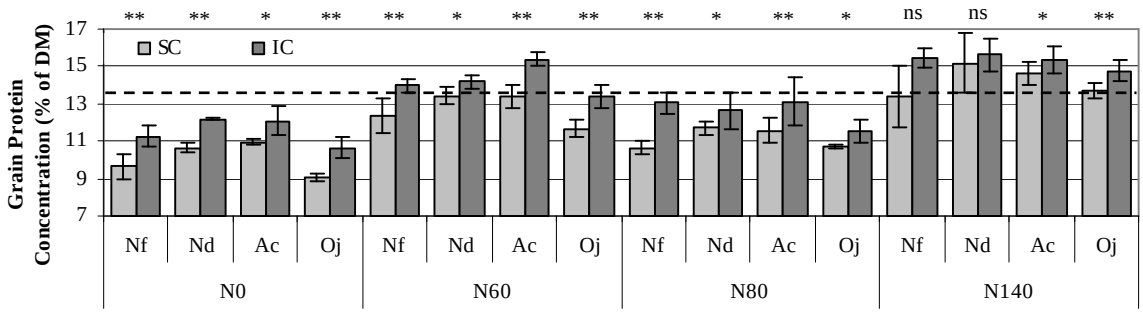
Methodology

An experiment was carried out in Auzeville (SW France) in a clayed loamy soil in 2006-2007. Three main treatments were compared: *i)* durum wheat sown at 280 plants.m^{-2} (W-SC), *ii)* winter pea (cv. Lucy) sown at 60 plants.m^{-2} (P-SC), *iii)* durum wheat-winter pea IC, each specie sown at half of normal density (IC). Four wheat cultivars named Acalou (Ac), Nefer (Nf), Neodur (Nd) and Orjaune (Oj) were evaluated as SC or IC. Four fertiliser-N sub-treatments were applied on W-SC and IC as following: *i)* no fertilizer (N0), *ii)* 60 kg N.ha^{-1} (N60) at stage 'flag leaf visible' to increase wheat grain protein concentration, *iii)* 80 kg N.ha^{-1} (N80) at wheat tillering to increase wheat yield and *iv)* moderate fertilization spitted in 2 applications corresponding to N80 and N60. P-SC was only evaluated without fertilization. The two species were sown in row-intercropping on Nov. 9, 2006. The experiment was a three replicates split-split-plot design with N treatments as main plot, crops as subplot and wheat cultivars as sub-subplot. Each sub-subplot (21 m²) consisted of 11 rows of length 12 m spaced 14.5 cm. Grain yield and grain protein concentration (GPC) were measured at harvest. Analyses of variance were performed and means compared using the least significant difference test (LSD) at a risk of 0.05.

Results

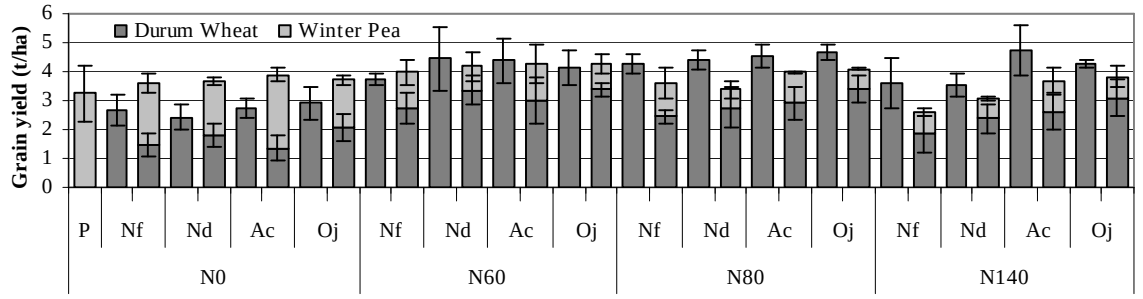
As hypothesised, for all treatments the wheat GPC was significantly higher in IC than SC (Figure 1) excepted for Nf and Nd in N140. Wheat GPC was affected by fertilization for both sole cropping and intercropping and highest values were obtained with N60 and N180. In SC and for same N levels, the cultivars Ac and Nd had significant greater GPC than Nf and Oj. In intercropping the same results were obtained excepted for N80 and N140 where no difference was observed between Nf, Nd and Ac. The increase of GPC between SC and IC was of 8, 11, 12 and 17% for Nd, Ac, Oj and Nf respectively and of 15%, 12%, 13% and 8% for N0, N60, N80 and N140 respectively.

Figure 1: Durum wheat grain protein concentration (% of dry matter) in sole (SC) and intercrop (IC). The dotted line indicates a wheat grain protein concentration of 13.5 % which is the quality required. ** and * indicate a significant difference between IC and SC at a risk of 0.05 and 0.10 respectively and 'ns' indicates that means are not significantly different. Values are the mean (n=3) ± S.E.



For all N treatments and wheat cultivars, grain yield of durum wheat was significantly greater in SC than in IC (Figure 2). However wheat yield in SC was lower than the whole IC yield in N0, but was similar in N60 and greater in N80 and N140. Pea yield in IC was lower when fertilizer-N was applied while wheat grain production was increased by N. Wheat yields in N140 were lower than those of N60 and N80 due to more diseases and flatten. Focusing on wheat cultivars, Nf and Ac were more affected by IC compared to Nd and Oj. Indeed, yield losses in IC (sown at half density) compared to SC were of 42 % for Nf and Ac but only of 28 % for Nd and Oj.

Figure 2: Grain yield (t.ha^{-1} at 0 % of humidity) of durum wheat and winter pea in sole cropping or intercropping for the four wheat cultivars and the four N treatments. Values are the mean (n=3) ± S.E.



Conclusions

The greatest GPC of wheat in IC was mainly due to a greater N uptake of soil mineral N per plant and depended on the wheat cultivar. Moreover these differences were partially due to wheat yield reduction in IC compared to SC and depended on the fertilisation-N (amount and splitting up). The behaviour of wheat cultivar can be related to their genetical characteristics and particularly their height. Indeed we observed that Oj was the tallest cultivar (116 cm at flowering) and the less affected by IC while Acalou was the smallest (89 cm) and the most affected by IC. However, Nf and Nd had intermediate height (98 cm) but were differently affected by IC. By consequence it can be suggested that tillering, growth dynamics or aerial structure could also explain such differences. Moreover, N fertilization modified the complementarities between cereal and legume by increasing wheat growth and then competition against pea. In conclusion, durum wheat-winter pea intercropping seems well adapted to the conditions of Southern France in particular for the unfertilized treatment, confirming the interest of IC for low nitrogen input systems. Moreover, the choice of wheat cultivar is of particular interest to optimise the cropping combinations according to the objective of such IC (yield, GPC, specie proportion,…).

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