Intercroppping, an application of ecological principles, to increase yield and durum wheat grain protein in low nitrogen input systems

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INTERCROPPING, AN APPLICATION OF ECOLOGICAL PRINCIPLES TO INCREASE YIELD AND DURUM WHEAT GRAIN PROTEIN IN LOW NITROGEN INPUT SYSTEMS

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OBJECTIVES

- **Nitrogen acquisition** is often a major concern, particularly in low input systems where mineral **N is a limited resource**.
- Intercropping (IC) can improve the use of environmental resources (light, nutrients and water) resulting **in yield and quality advantages compared to sole cropping** (SC) (e.g. Willey, 1979).
- No reference on winter crops IC was available, despite winter sole crops seems more adapted to Southern Europe conditions.
- *Aim of our study:* **Propose innovative Durum wheat – Winter pea intercropping managements to optimize the use of available resources**
  - ***i)*** **Understanding competition between durum wheat and winter pea for different wheat cultivars**;
  - ***ii)*** **Analyzing the consequences of N availability on the performance of IC (grain protein, yield and species proportion)**.

CONCLUSIONS

- The '**Durum wheat - Winter pea intercropping**' seems well adapted to the Southern France conditions because it allows:
  - ***i)*** **A better use of N resources (and light) during winter and early spring due to the complementarities of the 2 species**
  - ***ii)*** **A higher grain protein concentration of durum wheat at harvest due to:**
    - *a) High pea N_2 fixation rate in IC making available for the IC wheat almost as much soil mineral N per square meter as in the SC;*
    - *b) Fewer wheat ears, grains and yield per area in IC compared to SC due to interspecific competitions (Bedoussac and Justes 2009).*
- IC advantages were greater for the unfertilized or late N-fertilized treatment **confirming the interest of intercropping in low-input farming**.
- Optimal choices in N supply and wheat cultivar depend on the target of the intercrop. Two directions are possible:
  - ***i)*** **Increasing N availability and/or choosing a tall wheat cultivar that could increase wheat proportion**;
  - ***ii)*** **Reducing N supply and/or choosing a short wheat cultivar that could increase wheat grain protein and pea proportion.**

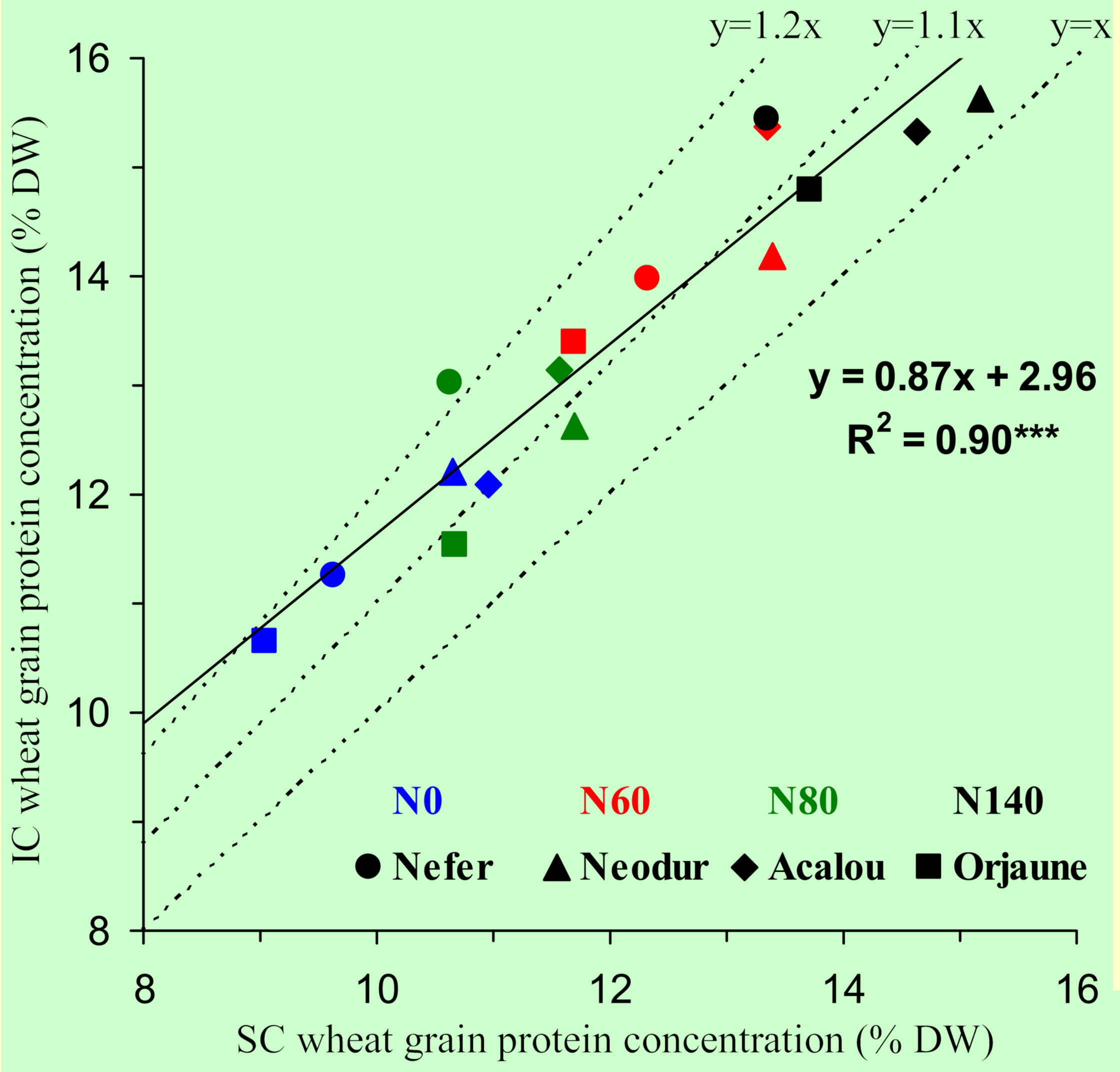
MATERIAL AND METHODS

- An experiment was carried out in Auzeville (SW France) in 2006-2007 on a clay loamy soil. The two species were sown in the 9th of November 2006 in **row-intercropping**. The experiment was based on a split-split-plot design with 3 replicates.
- **Three main treatments were compared:**
  - ***i)*** **W-SC:** Durum wheat (sown at 336 seeds/m²);
  - ***ii)*** **P-SC:** Winter pea (cv. Lucy sown at 72 seeds/m²);
  - ***iii)*** **IC:** Durum wheat-winter pea IC, **each specie sown at half of SC density**.

- **Four wheat cultivars of different height:** ***i)*** **Ac:** Acalou (89 cm); ***ii)*** **Nf:** Nefer (96 cm) ; ***iii)*** **Nd:** Neodur (98 cm) and ***iv)*** **Oj:** Orjaune (116 cm).
- **Four fertilizer-N sub-treatments (Pea SC only in N0) :** ***i)*** **N0:** No fertilizer ; ***ii)*** **N60:** 60 kg N.ha^{-1} (at **FLV** 'flag leaf visible' to increase **wheat grain protein content**) ; ***iii)*** **N80:** 80 kg N.ha^{-1} (at 'ear 1cm' to increase **wheat yield**) and ***iv)*** **N140:** corresponding to N80 and N60.
- **Measurements :** ***i)*** Wheat grain protein content (**GPC**); ***ii)*** Grain yield; ***iii)*** Land Equivalent Ratio (**LER,** see Fig.1 for formula) (Willey 1979) and ***iv)*** Percentage of N derived from N_2 fixation (**%Ndfa**) of pea calculated using the ^{15}N natural abundance method (Amarger et al. 1979).

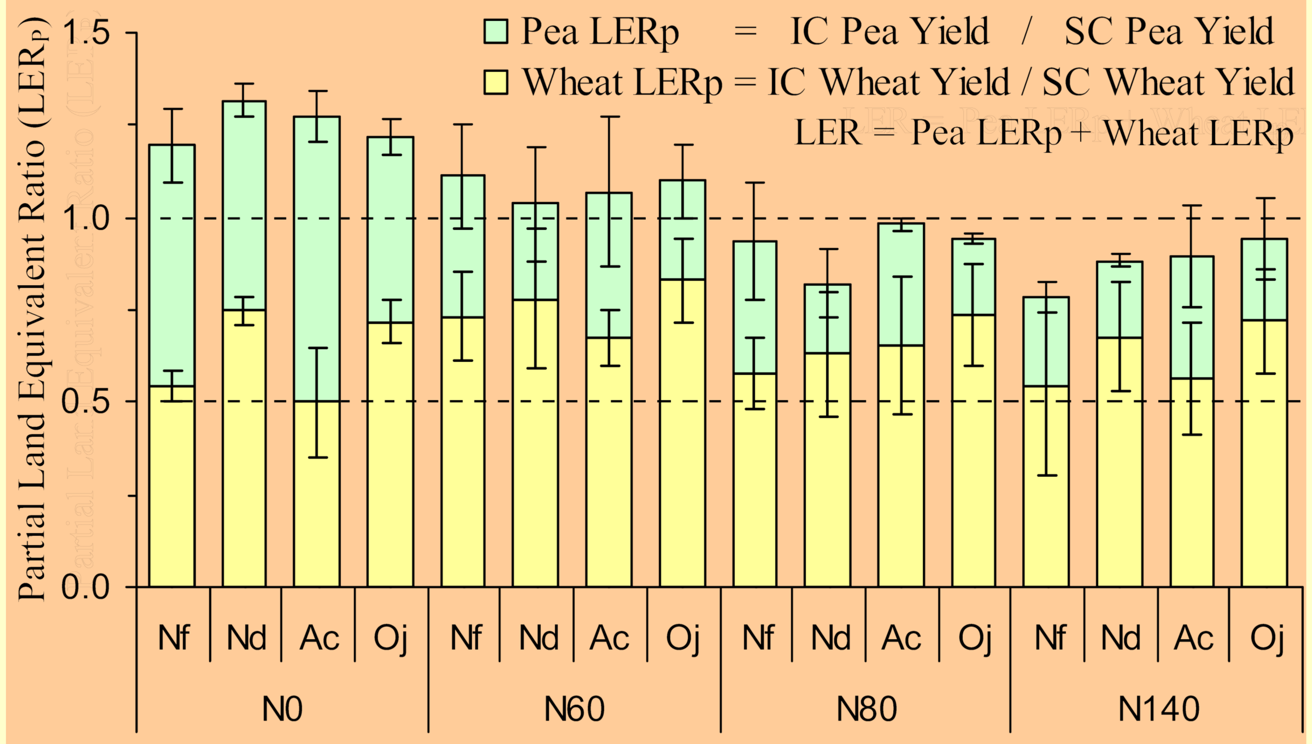
RESULTS

Wheat Grain Protein in IC vs. SC



- **GPC** was 12% **higher in IC** than in SC
- The lowest the **GPC in SC** the highest the increase in **IC**
- IC reduced the gap in cultivars **GPC**
- **Ac** and **Nd** have greater GPC in SC & IC

Land Equivalent Ratio



- **LER** greater than 1 for N0 and N60

→ IC more efficient than SC in N0 and N60

- **Wheat LERp** always higher than 0,5

→ Wheat took more advantage of N than pea

- **Pea LERp** strongly reduced with N supply
- **Nd** & **Oj** Wheat LERp greater than **Nf** & **Ac**
- **Pea LERp** lower for **Nd** & **Oj** than **Nf** & **Ac**

→ Pea yield is more reduced with tall cultivars

→ Complementary use of N resources

Plant N derived from air (%Ndfa) and N derived from soil (QNdfs)

		%Ndfa (% N uptake)	QNdfs (kg N ha^{-1})
SC	N0	52 ± 4	83
IC	N0	84 ± 5	13
	N60	85 ± 7	7
	N80	60 ± 9	19
	N140	70 ± 9	12

- **Pea %Ndfa higher in IC** than in SC
- **Pea %Ndfa** reduced with N80 & N140
- **Pea QNdfs** only 14kg N ha^{-1} in IC

→ Same N available for wheat in IC&SC

- Amarger, N., A. Mariotti, F. Mariotti, J. Durr, C. Bourguignon, and B. Lagacherie. 1979. Estimate of symbiotically fixed nitrogen in field grown soybeans using variations in 15N natural abundance. Plant Soil 52:269-280.
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