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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*
 - Understanding competition between durum wheat and winter pea for different wheat cultivars;
 - 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:
 - A better use of N resources (and light) during winter and early spring due to the complementarities of the 2 species
 - A higher grain protein concentration of durum wheat at harvest due to:
 - 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;
 - 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:
 - Increasing N availability and/or choosing a tall wheat cultivar that could increase wheat proportion;
 - Reducing N supply and/or choosing a short wheat cultivar that could increase wheat grain protein and pea proportion.

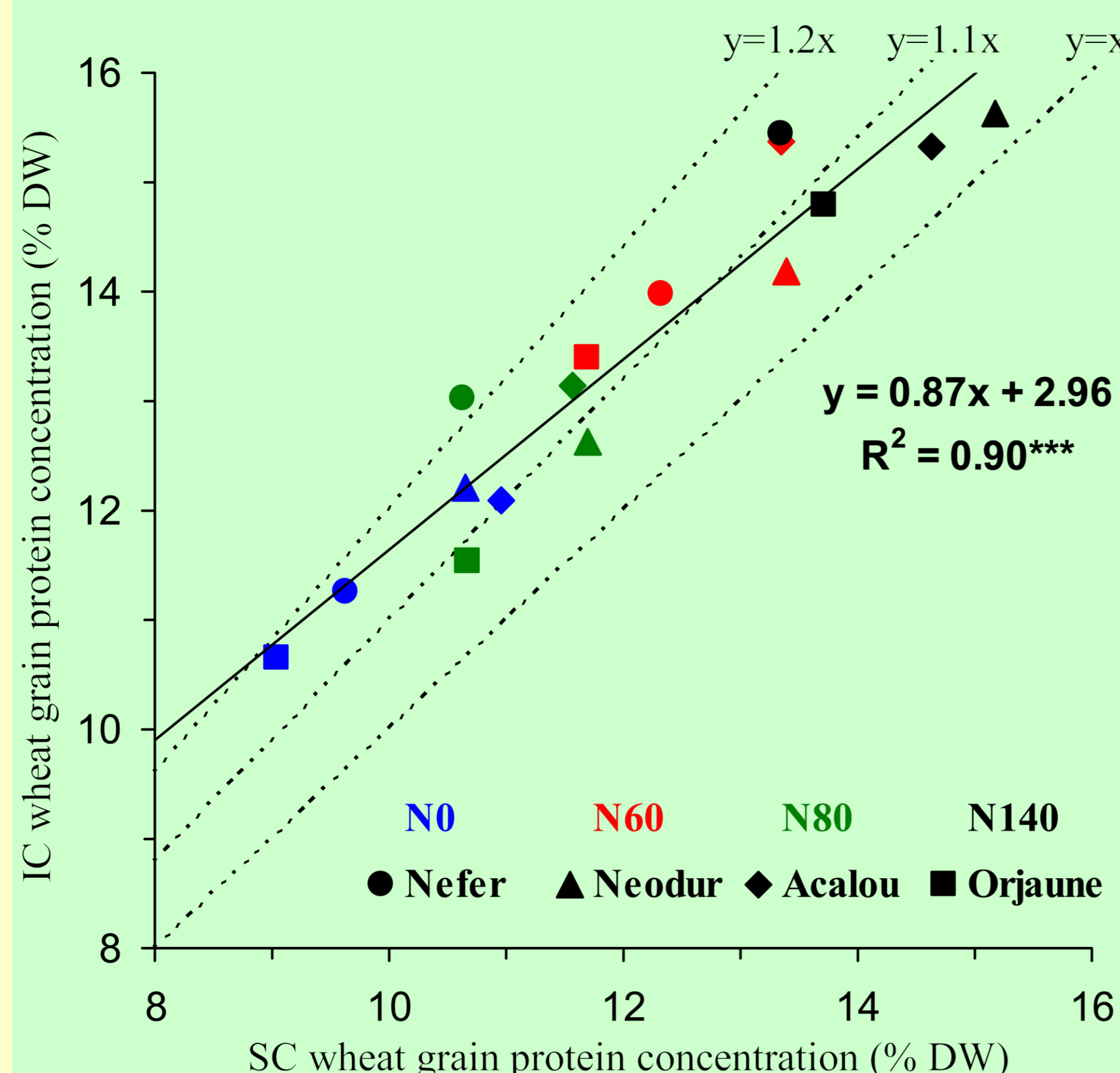
MATERIAL AND METHODS

- 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:**
 - W-SC:** Durum wheat (sown at 336 seeds/m²);
 - P-SC:** Winter pea (cv. Lucy sown at 72 seeds/m²);
 - 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 (**%Nd_{fa}**) of pea calculated using the ¹⁵N natural abundance method (Amarger et al. 1979).



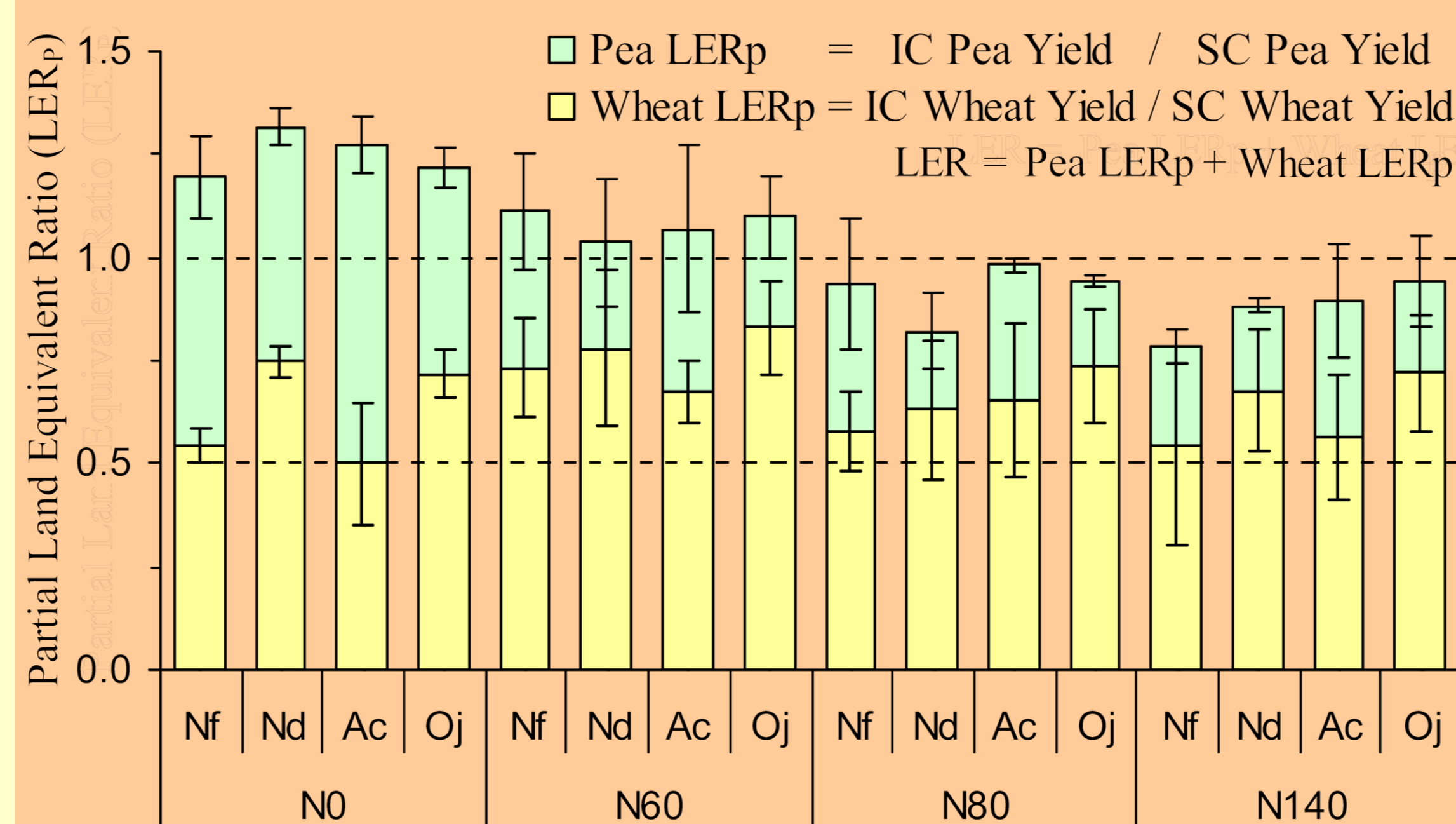
RESULTS

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 LER_p** always higher than 0,5
- **Wheat took more advantage of N than pea**
- **Pea LER_p** strongly reduced with N supply
- **Nd & Oj** Wheat LER_p greater than **Nf & Ac**
- **Pea LER_p** 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 (%Nd_{fa}) and N derived from soil (QN_{dfs})

		%Nd _{fa} (% N uptake)	QN _{dfs} (kg N ha ⁻¹)
SC	N0	52 ± 4	83
	N140	84 ± 5	13
IC	N60	85 ± 7	7
	N80	60 ± 9	19
	N140	70 ± 9	12

- **Pea %Nd_{fa}** higher in **IC** than in **SC**
- **Pea %Nd_{fa}** reduced with N80 & N140
- **Pea QN_{dfs}** 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.
- Bedoussac, L. and E. Justes. 2009. The efficiency of a durum wheat-winter pea intercrop to improve yield and wheat grain protein concentration depends on N availability during early growth. Plant Soil DOI: 10.1007/s11104-009-0082-2
- Willey, R. 1979. Intercropping - its importance and research needs. 1. Competition and yield advantages. Field Crop Abstr. 32:1-10.