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Durum Wheat-Grain Legume intercrops An innovative way to design low inputs cropping systems

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Improve agricultural systems efficiency

• Intensification of agriculture in the last 50 years sometimes leads to:

- **Environmental contamination** (water, soil, air)
- **Resistance to chemicals** (e.g. Griffon 2006)

→ Pesticides use must be reduced

→ Agricultural systems efficiency needs to be improved

→ Diversification of agro-systems is one of the solutions (Malézieux et al. 2008)

→ Higher diversification can be achieved by **intercropping species**

i.e. growing simultaneously 2 or more species in the same field for a significant period but without necessarily sowing or harvesting them at the same time (Willey 1979)

Advantages and Disadvantages of intercrops

• Cereal – grain legume **spring intercrops** are known to:

⬆ Global yield ; ⬆ Cereal grain protein content ; ⬆ Stability over years

(eg. Corre-Hellou 2005, 2006, 2007; Hauggaard-Nielsen et al. 2001, 2003, 2005, 2006, 2009)

→ **Improve the use of available resources (complementary use of light & N pools)**

• We recently demonstrated similar results on **winter intercrops** (durum wheat-winter pea and durum wheat-faba bean intercrops)

(Bedoussac and Justes, Plant and Soil, 2010, Vol. 330, 19:35 and 37:54)

→ **Intercrops could improve agricultural systems efficiency**

• Cereal – grain legume **intercrops** are also known to:

⬇ Insects, Diseases and Weeds which are sometimes main limiting factors

(eg. Vandermeer 1989; Trenbath 1993; Altieri 1999; Kinane and Lyngkjaer 2002)

→ **Intercropping can allow pesticides reduction**

→ **Coherent with actual French/European agricultural policies:**

Reducing pesticides use by 50% in 2018

⬆ European **grain legume** production

But… → **Lack of knowledge and references on winter intercrops**

→ **Contradictory results in the literature about effects on pests**

Objectives and general hypotheses of our work

General aim of our work on intercrops:

Understand intercrop functioning to propose optimal management by improving their efficiency

Objective:

Evaluate intercrop potentialities to reduce pests and diseases injuries

→ **Preliminary results focusing more on the data observed than on a functional analysis of biotic interactions**

Hypotheses:

Intercrop efficiency to reduce weeds, pests and diseases depends on :

- **Species and cultivars**

  i) **Growth dynamics, *ii)* Cover architecture**

- **Farming practices**

  i) **N available, *ii)* Sowing date and densities, *iii)* Sowing pattern**

- **Weather and soil conditions**

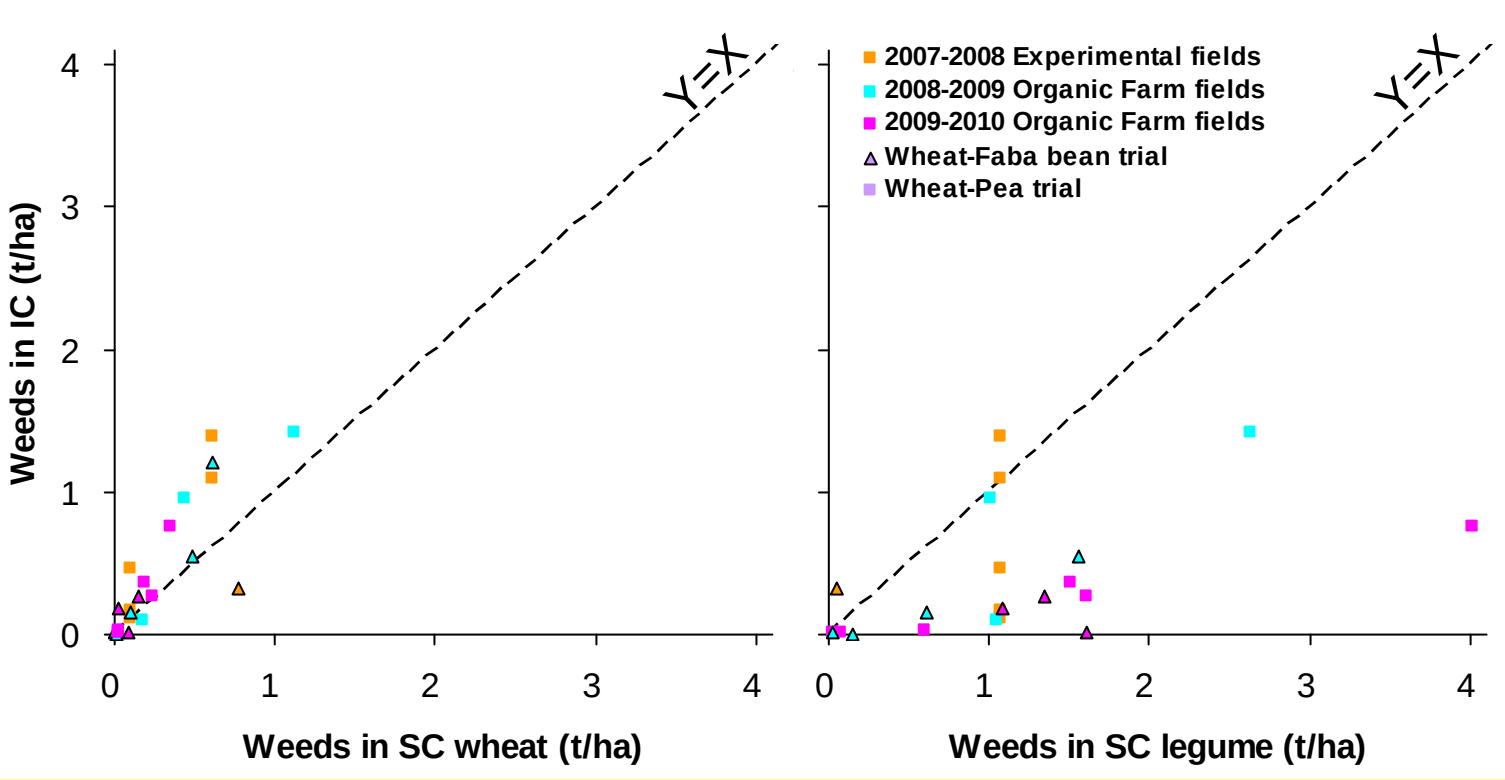
Material and methods: a wide range of field experiments

- 5 years experiments since 2005
- Field Experiments in conventional system and farm plots in organic farming
- Various pedoclimatic conditions in southern France

- 1 pea (cv. Lucy) and 1 faba bean (cv. Castel)
- 6 durum wheat cultivars and 1 soft wheat

- Various densities (substitutive and additive designs) and sowing dates
- Different sowing patterns: row intercropping and mixture on the row
- Various N availabilities: amount and dynamics

Results: 1. Is intercropping efficient to reduce weeds?

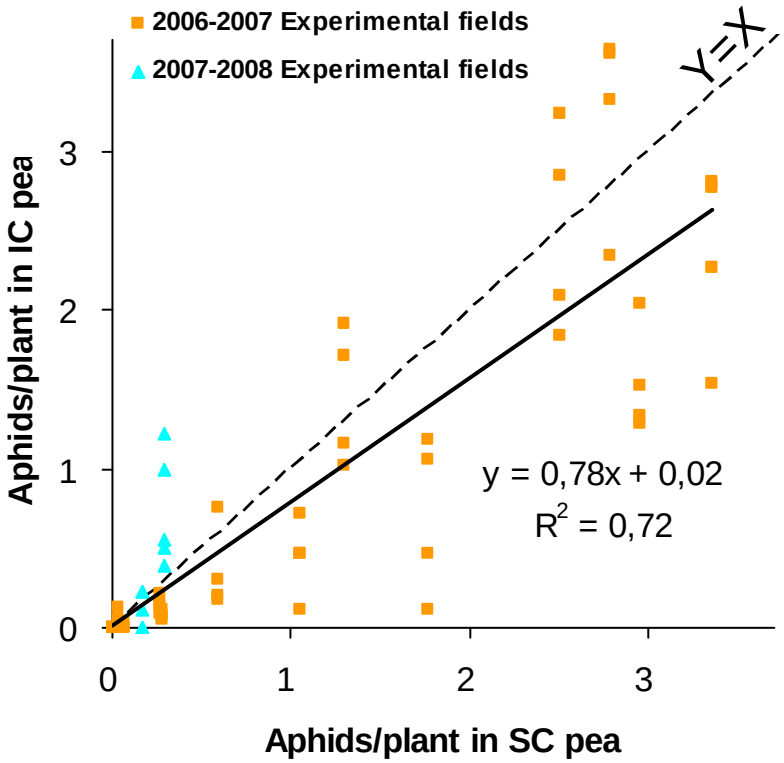


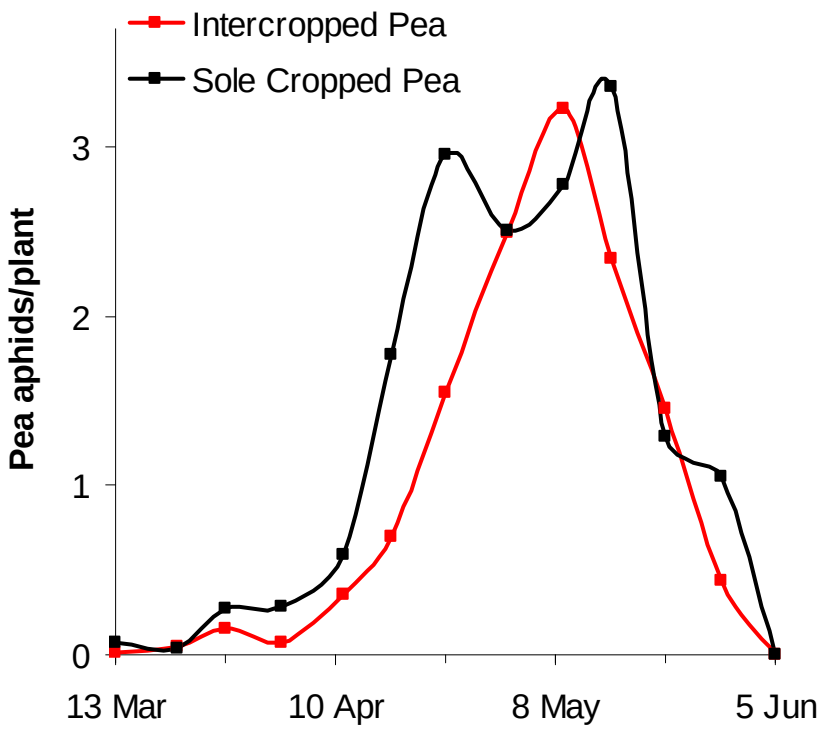
- **Legumes less competitive than wheat for weeds**
- **Intercrop efficient compared to sole crop legume (65% less weeds)**
- **Intercrop not efficient compared to sole crop wheat (54%more weeds)**

→ **Weeds reduction in intercrop mostly due to the wheat because :**

- **Lower inter-row compared to sole crop faba bean**
- **Earlier growth compared to winter pea**

Results: 2. Is intercropping efficient to reduce pea aphids?

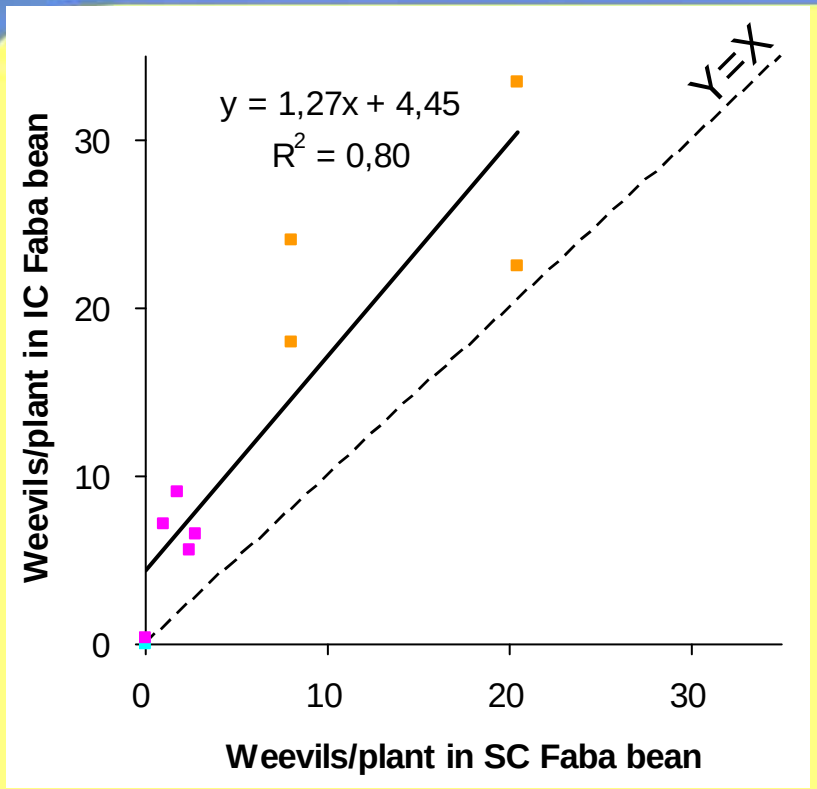


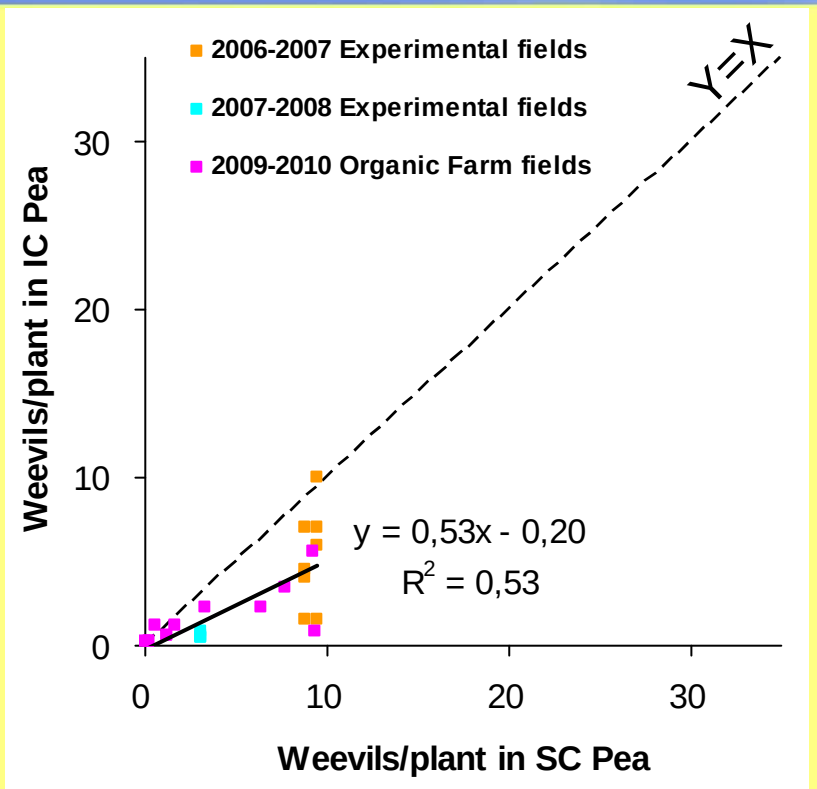


- **Weak population of pea aphids during these experiments**
- **Pea aphids reduced in intercrop (21% on average)**
- **Dynamic of pea aphids modified in intercrop**

→ Intercrop efficient to reduce pea aphids due to habitat modification?
Temperature, Humidity, Plant recognition, Physical barrier, Predator…

Results: 3. Is intercropping efficient to reduce weevils?





- **More weevils on Faba bean than on Pea**
- **Intercrop reduces weevils compared to sole crop pea (52% less)**
- **Intercrop increases weevils compared to sole crop faba bean (95% more)**

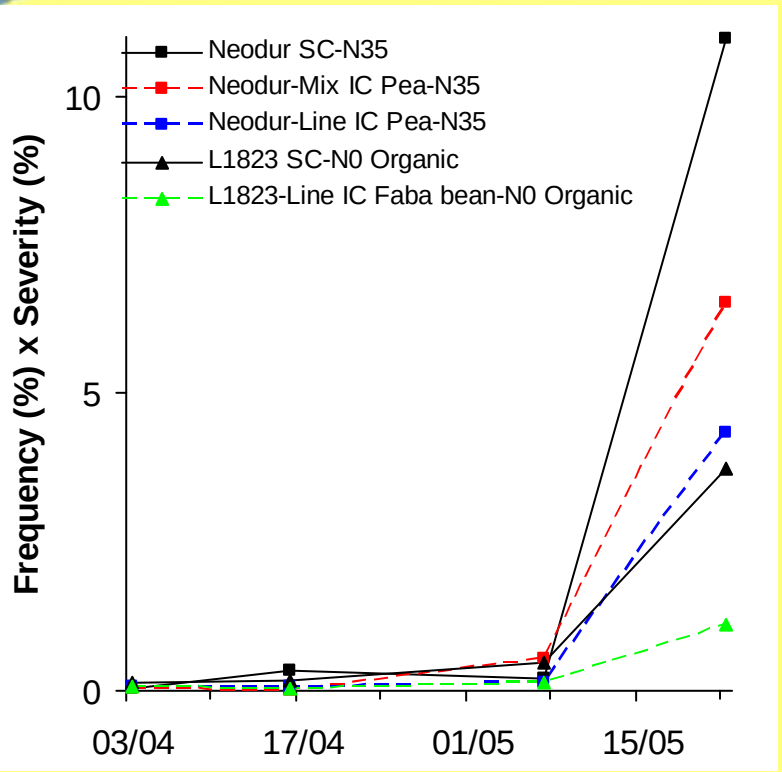
→ **Faba bean more attractive than Pea ?**

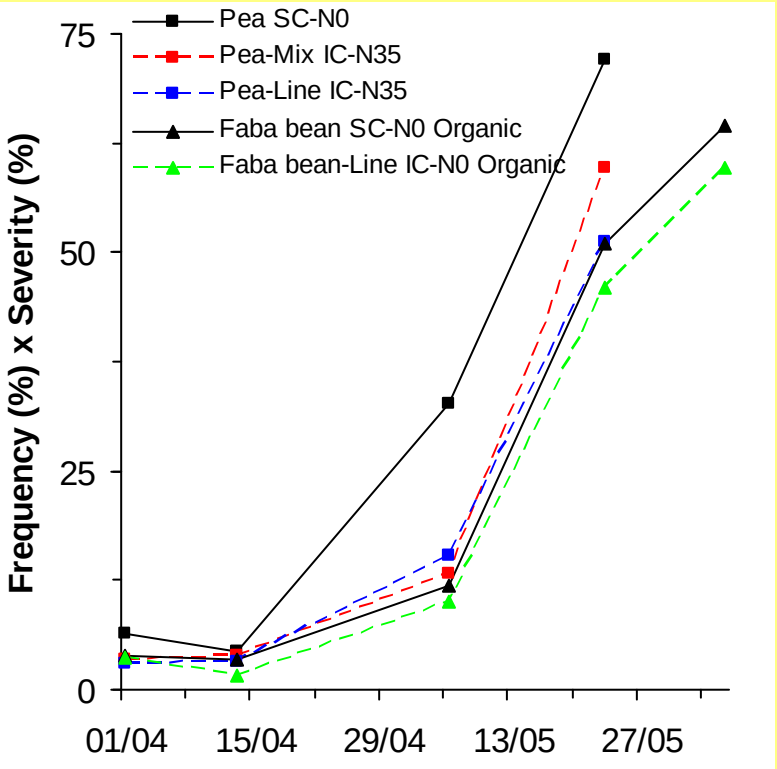
→ **More Faba bean resources due to higher dry weight than Pea ?**

→ **Pea more difficult to be find in intercrop because smaller than wheat ?**

→ **Greatest mobility/adaptability of weevils to a large range of habitats ?**

Results: 4. Intercropping can reduce diseases…





- Low Septoria attack (< 20%)
- Septoria reduced in intercrop

→ **Intercrop efficient to reduce septoria**

- Ascochyta reduced in intercrop pea

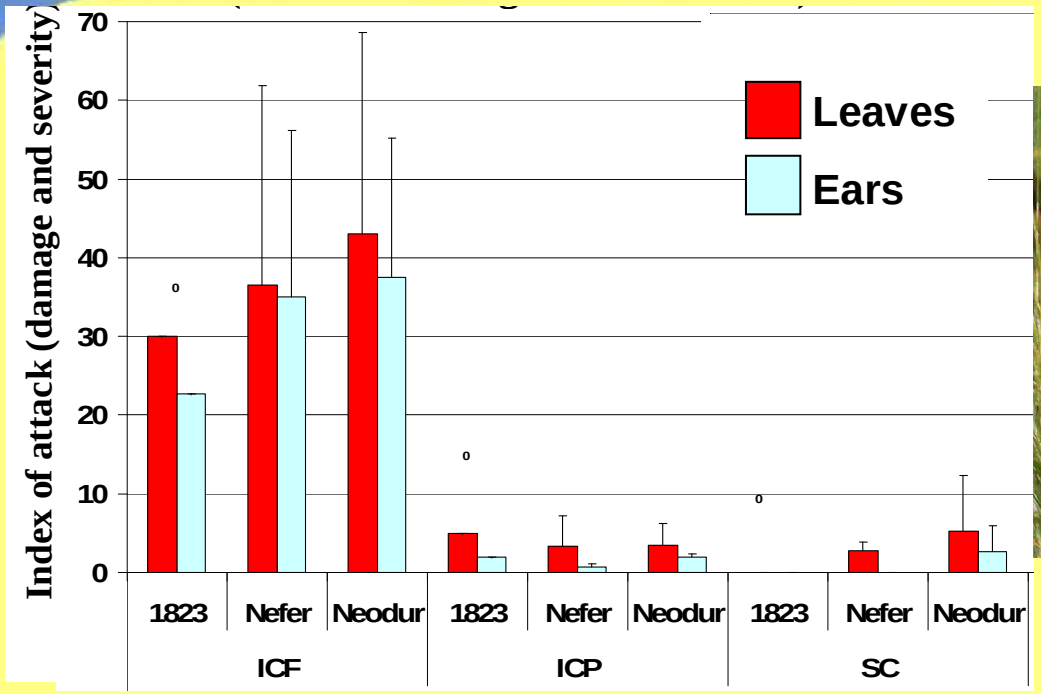
But not in intercrop faba bean

- Ascochyta appeared earlier in Pea

→ **Intercrop efficient to reduce ascochyta**

Barrier effect to propagation, microclimate modification, lower biomass ?

…but can also increase wheat diseases



Intercrop with Fababean increased wheat oidium

- → **High faba bean LAI and Dry weight**
- → **'Barrier effect' for fungicide treatment**
- → **Modification of microclimate (T, H_2O)**

- **No difference was found between SC and Intercrop with Pea**

09/11

Conclusions: Intercropping could be efficient

• to reduce **legume weeds**:

Species complementary for light absorption (Sequential growth; Smaller inter-row)

• to reduce **diseases**:

Barrier effect to propagation ; Microclimate modification ; Less resources?

• to reduce **pea aphids**:

Habitat modification ; Less resources ; Plant recognition more difficult?

• to reduce **pea weevils but not faba bean weevils**:

Faba bean more attractive ; Taller than wheat ; Higher mobility of weevils?

• to increase **yield & wheat protein in low N input systems:**

Complementary resources use: N (Nmin Vs. N_2); Light and Water

Perspectives

• **Further Knowledge needed for designing cropping management systems to reduce weeds, pests and diseases and consequently the use of pesticides**

- Which are the best-adapted species and cultivars?

- What are the effect of sowing densities and sowing pattern?

• **Other question to solve:**

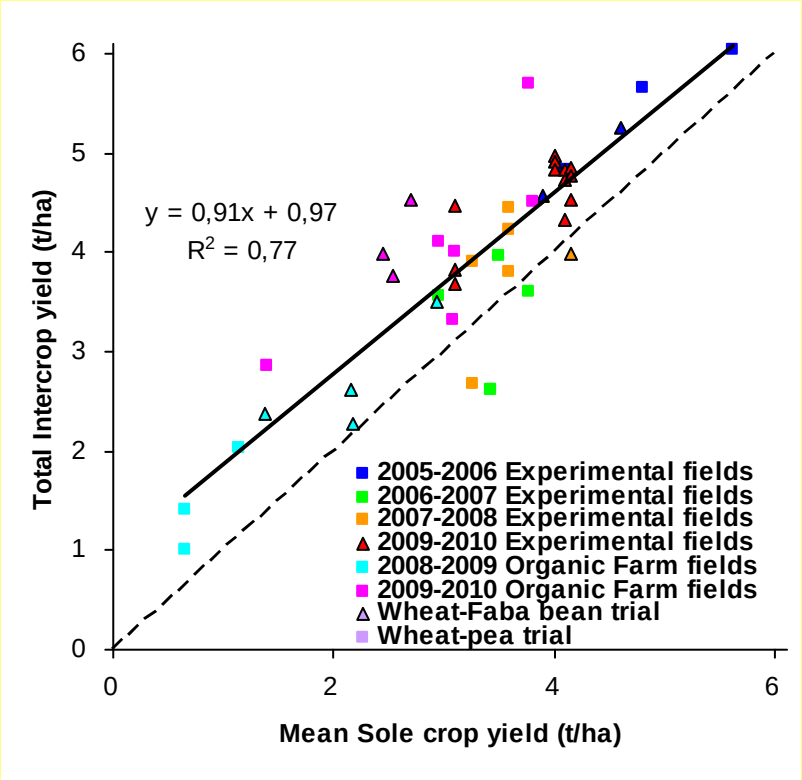
How to introduce Durum wheat-Grain legumes Intercrop in the cropping systems to reduce pesticides use?

Thank you for your attention

For more details:
http://wwwagir.toulouse.inra.fr/agir

Plant and Soil (2010)
Vol. 330, 19:35
Vol. 330, 37:54

Is intercropping efficient to increase yield ?

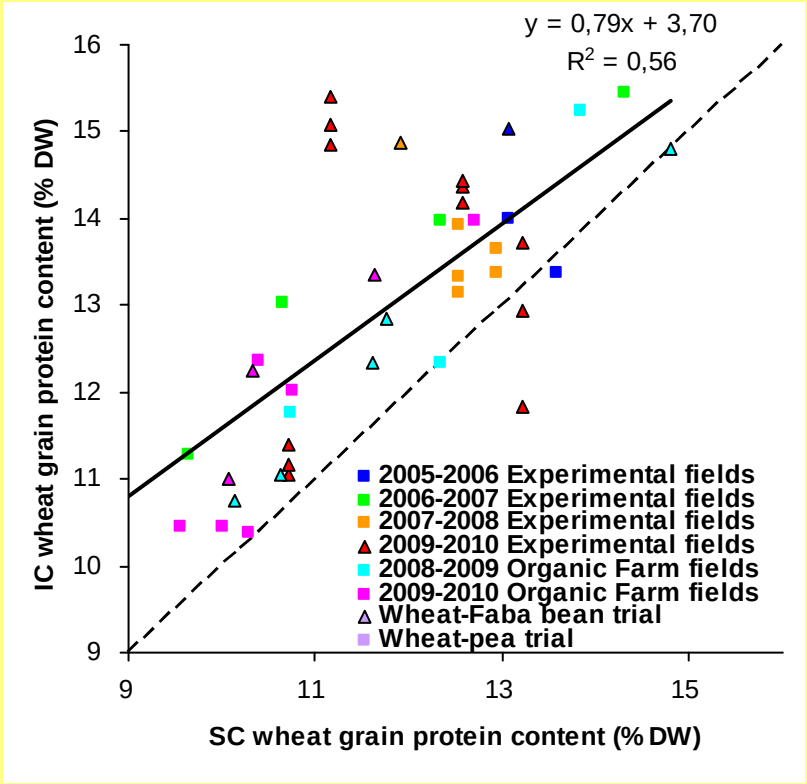


- **IC yield higher than mean sole crop yield (+ 20% on average)**

→ IC efficiency depends on N-fertilization
→ N-fertilization slightly increased wheat yield
→ N-fertilization reduce pea yield

→ IC more suited to low N systems

Is IC efficient to increase wheat protein content ?



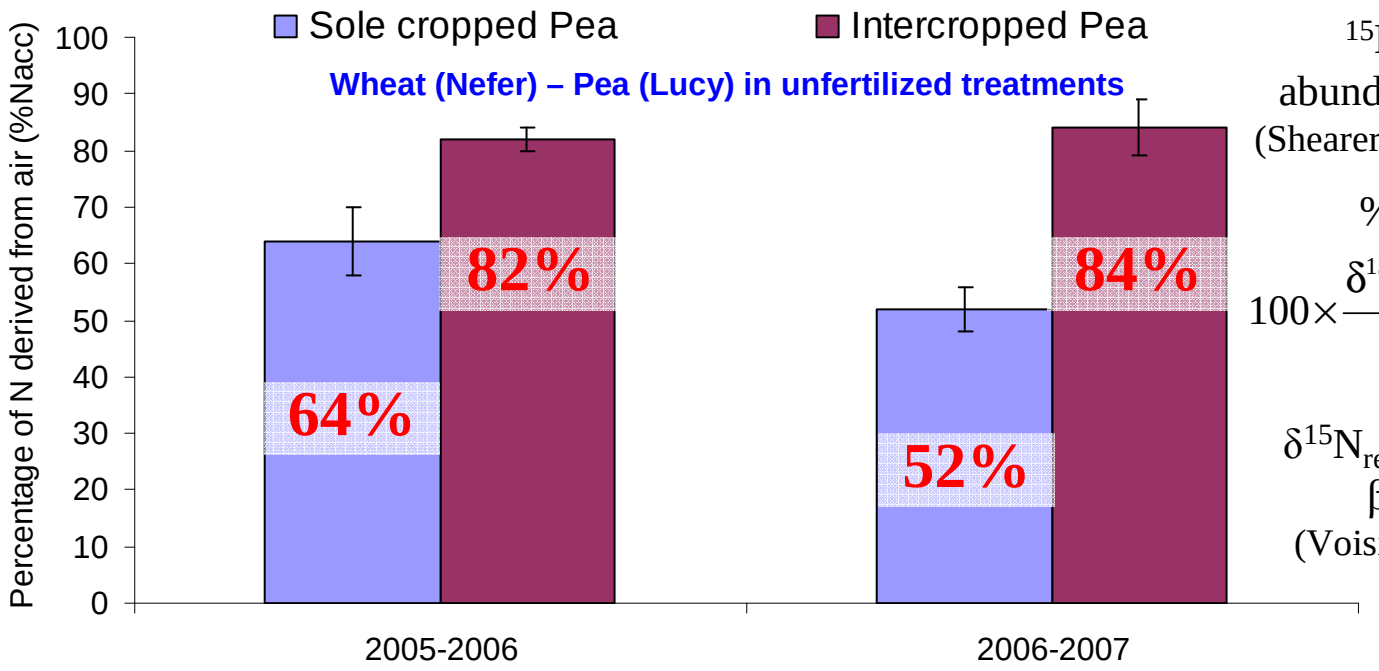
- **IC GPC** higher than in **SC**
- The **lower SC Wheat GPC** the **larger the increase**

→Larger amount of N available per grain in IC because :

- Lower wheat yield in IC than SC (less plants and legume competitin)

- Similar amount of N available (the legume use mostly the N2 from air)

Intercropping increases legume N_2 fixation



^{15}N natural abundance method (Shearer and Kohl 1986)

$$\%Ndfa = 100 \times \frac{\delta^{15}N_{ref} - \delta^{15}N_{pea}}{\delta^{15}N_{ref} - \beta}$$

$\delta^{15}N_{ref}$ = IC wheat

β = -1‰ (Voisin et al. 2002)

- **Pea N_2 fixation in IC > SC**

→ **The more wheat N acquisition the more pea N_2 fixation**

→ **Complementarity for N pools use**

- **High pea N_2 fixation in IC (80-85 %Ndfa)**

→ **14 kg N/ha up taken from soil (only 15% of N available)**

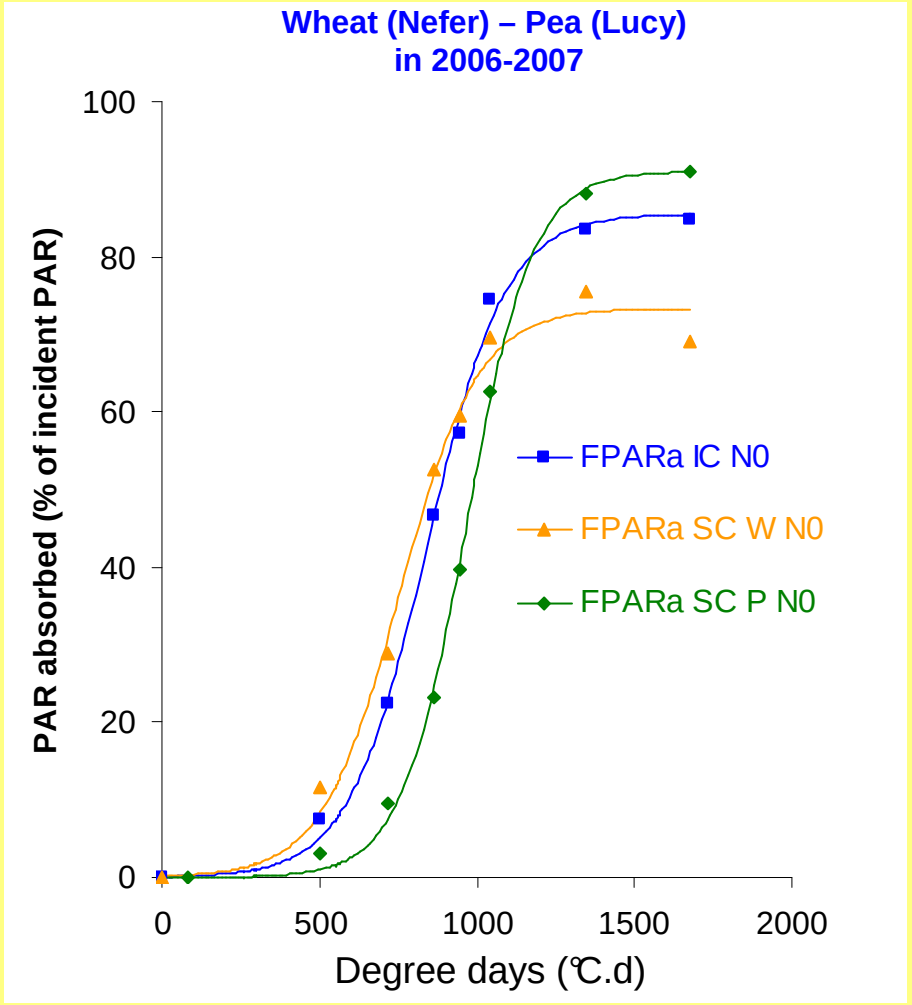
Intercropping improves light absorption

- **Wheat growth earlier than that of pea and then slower**

→ The whole IC absorbed more PAR than the SC

→ **Species complementarities**

→ **≠ in time & height growth**



BUT
IC less efficient than SC wheat with large amount of N

Evolution of cover rate in 2007-2008

07/05/2008

N fertilization