Yield performance of Faba bean– Wheat intercropping on spring and winter sowing in European organic farming system

A. Pristeri[a], C. Dahlmann[b], P. von Fragstein[b], M. J. Gooding[c], H. Hauggaard-Nielsen[d], E. Kasyanova[c] and M. Monti[a]

Abstract - INTERCROP EU PROJECT studied Faba bean–Wheat intercropping at different growing condition on European organic farming systems. During 2003-2005 in spring and winter cropping season different intercropping series were evaluated in Denmark, Germany, Italy and United Kingdom[1]. In this contribution are reported the experimental results on yield performance of one additive and one replacement intercropping series.

INTRODUCTION

Intercropping "growing two or more crops simultaneously in the same field" is a common agricultural practice in the tropics and in the developing countries of the world (Vandermeer, 1989) where yield stability and limited economic risks are the most important aims for small farmers. High complementarities, determined by better nitrogen use efficiency and root and shoot distribution, made of cereal-legume the most intercropping common pattern. In the developed countries, monoculture is traditionally prevalent (Plucknett and Smith, 1986) with exception for pastures and forage production where the advantages of legume-cereal mixture are not limited by mechanization problems of intercropping system. However, the new Common Agricultural Policy favours the diffusion of alternative techniques to increase the environmental safeguard and to reduce artificial inputs in the farming system. In this contest, cereals and legumes growing together it could be an opportunity, particularly for organic farmers, to increase yields and income limiting nitrogen fertilizers and pesticides.

Many cereal-legume intercropping patterns had developed in Europe depending by the traditional crops grown like monoculture in the different countries. In temperate regions, there is a long tradition for intercropping of clover-grass pastures for grazing and silage, and pea-barley mixture for silage (Hauggard-Nielsen and Jensen, 2001). Common bean (*Phaseolus vulgaris L.*) has traditionally intercropped with maize (Zea *mays L.*) in Northwest Spain (Santalla et al., 2001). In Mediterranean dry lands, faba bean (*Vicia faba L.* sub. minor) is normally cultivated in a two years rotation with winter wheat (*Triticum durum L.*) for hay production, whereas in temperate region using spring wheat (*Triticum aestivum* L.) and faba in mixture is a common practice to produce forage and silage. Therefore in these situations growing faba bean and wheat together can allow a better weed control and use of soil resources during winter season in Mediterranean regions and reduced nitrogen losses and groundwater pollution in temperate one. For this reason intercropping wheat and faba are the important tools for improving efficiency of cropping system in European organic farming. In this study, yield performance were determined for different faba bean-wheat intercropping designs compared with the respective sole crop on winter and spring sowing.

MATERIALS AND METHODS

Intercropping (IC) trials were carried out during the period 2003-2005 growing faba bean-wheat mixtures at three experimental fields in Northern and Southern Europe under organic farming system. The experimental sites were: Denmark (DK) (Tåstrup, 55°40'N, 12°18'E); United Kingdom (UK) (Reading, 51º45'N, 0º93'W); Germany (GER) (Kassel, 51°25'N, 9°25'E); Italy (IT) (San Marco Argentano 39°18'N, 21°12'E).

One additive (F100W100) and one replacement (F50W50) intercropping series were evaluated in a spring sowing experiments in DK, GER and in UK growing *Triticum aestivum*. Winter sowing was also evaluated in UK (F50W50) and in IT, in the last one *Triticum durum* was grown. In all sites, IC treatments were arranged in one-randomized block design with 4 replicates including faba and wheat sole crop (SC). A sowing density of 400 plant m^{-2} for cereal and 40 plant m^{-2} for legume were used in the sole crop. according "row by row" sowing pattern the sole crop density was used in F100W100, reduced to half of recommended density in F50W50.

To evaluate yield advantage of intercropping, absolute grain yield of faba and wheat in mixture and sole crop were analysed according to the common procedure of data analysis used in INTERCROP Project which is available elsewhere (Monti et al. 2006).

RESULTS AND DISCUSSION

Considering yield performances of sole crop in the different environments and in the two sowing seasons, faba bean always over yielded wheat ranging 6÷77 % in GER (spring sowing) and IT (winter) respectively. In UK only in the winter sowing the gap

[a] Università "Mediterranea" di Reggio Calabria, Dipartimento GeSAF, Italy (montim@unirc.it; aurelio.pristeri@unirc.it).
[b] University of Kassel, Department of Organic Farming and Cropping Systems, Germany (pvf@wiz.uni-kassel.de; c.ddahlmann7@gmx.de).
[c] University of Reading, Department of Agriculture, United Kingdom (m.j.gooding@reading.ac.uk).
[d] Risø National Laboratory, Biosystem Department, Denmark (henrik.hauggaard-nielsen@risoe.dk).

(+60%) was founded. Higher wheat yield (over than 2 t ha^{-1}) was observed in Northern countries, with small difference between season in UK; lower production characterised winter wheat in the Italian site. In Germany highest yield (over 4 t ha^{-1}) for both faba and spring wheat sole crop were obtained.

Denmark

In this country, intercrop showed a good advantage only in additive series (LER=1.20), but considering an half cut density in replacement the value of partial LER of wheat highlighted that facilitation in the cereal component occurred (Table 1).

Table 1. Grain yield ($g \cdot m^{-2}$) and LER of faba bean and wheat in additive (F100W100), replacement (F50W50) series and sole crop (SC) in Denmark. Mean ± SE values of 2003-2004.

Grain Yield ($g\ m^{-2}$)			LER yield		
Treat.	faba bean	wheat	faba bean	wheat	Total
F100W100	168±6	180±22	0.47	0.73	1.20
F50W50	124±12	163±15	0.35	0.67	1.01
SC	359±22	245±19			

United Kingdom

In spring sowing, faba bean intercropped at normal plant density (F100W100) suffered a competition effect by wheat; but, despite a slight wheat yield decreasing in mixture comparing to the SC, an intercrop advantage (LER=1.44) was showed (Table 2).

Table 2. Grain yield (g·m-2) and LER of faba bean and wheat in additive (F100W100), replacement (F50W50) series and sole crop (SC) in United Kingdom. Mean ± SE values of 2003-2005.

Grain Yield ($g\ m^{-2}$)			LER yield		
Treat.	faba bean	wheat	faba bean	wheat	Total
Spring sowing					
F100W100*	123±37	179±7	0,58	0,86	1,44
F50W50	98±17	172±10	0,46	0,83	1,29
SC	211±13	208±10			
Winter sowing					
F50W50	275±67	96±10	0,82	0,46	1,28
SC	336±38	210±38			

*Mean of 2004-2005

Lower intra and inter-specific competition effect caused a decreasing in advantage (LER =1.29) of the IC series with SC's half establishment (F50W50). In the same series any differences in the intercrop advantage between spring and winter sowing was not found but the single contribute of the two components differed in the two cropping seasons.

Germany

In spring establishment high grain yield variability among years was observed.

Table 3. Grain yield ($g \cdot m^{-2}$) and LER of faba bean and wheat in additive (F100W100), replacement (F50W50) series and sole crop (SC) in Germany . Mean ± SE values of 2003-2005.

Grain Yield ($g\ m^{-2}$)			LER yield		
	faba bean	wheat	faba bean	wheat	Total
F100W100	275±33	217±25	0.61	0.51	1.12
F50W50	254±27	235±27	0.56	0.55	1.11
SC	454±33	430±44			

Despite this variability, weak advantage of the two intercrop series was observed. In additive faba bean provided a larger contribution (Table 3).

Italy

Winter establishment of faba-wheat intercropping of the two series resulted in a slight disadvantage comparing sole crop. Positive contribution of faba bean occurred only in additive mixture (Table 4).

Table 4. Grain yield ($g \cdot m^{-2}$) and LER of faba bean and wheat in additive (F100W100), replacement (F50W50) series and sole crop (SC) in Italy. Mean ± SE values of 2004-2005.

Grain Yield ($g\ m^{-2}$)			LER yield		
	faba bean	wheat	faba bean	wheat	Total
F100W100	148±9	54±6	0.56	0.36	0.92
F50W50	126±10	63±8	0.48	0.42	0.90
SC	264±32	149±29			

In figure 1 the partial LER's of the two components were plotted. Despite large variability observed among sites and years, the adopted intercropping mixtures showed a land use advantage in the large numbers of experimental environment (site x year). At the country level, the magnitude of annual variability was higher in UK, reaching the minimum in DK and in GER.

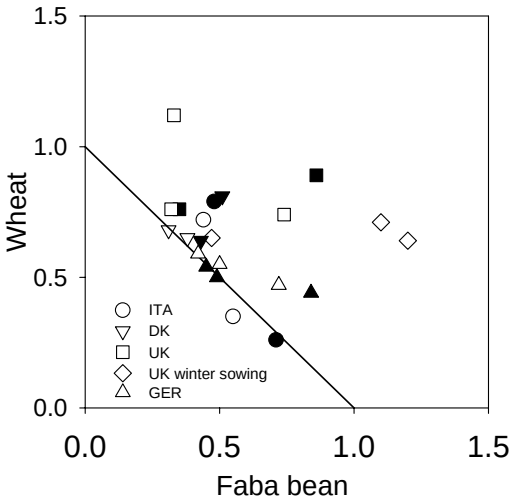

Figure 1. Yield advantage of the additive (filled) and replacement series (unfilled) in the Faba bean-Wheat intercropping across different environments (sites x year) during 2003-05. (—) Total LER =1

Considering the diversity of environments, years variability and different growing seasons, faba bean-wheat intercropping could be an interesting option at monoculture in European organic farming, especially in Northern Countries.

REFERENCES

Hauggard-Nielsen H. and Jensen E.S. (2001). *Field Crop Research* 7**2:** 185-196.

Plucknett, D.L. and Smith, M.J.H. 1986. *BioScience*, 36:40-45.

Santalla M., Rodino A.P., Casquero P.A and de Ron A.M. (2001) *European Journal of Agronomy* **15:** 185-196.

Vandermeer J.H. 1989. The ecology of intercropping. Cambridge University Press, Cambridge, UK.