Intercropping wheat with pea for improved wheat baking quality

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***Abstract* - Field pea (*Pisum sativum* L.) and wheat (*Triticum sativum* L.) were either sole cropped or intercropped in a complete design of five relative proportions and five density levels to determine the effects of interspecific interaction in an intercrop on wheat baking quality. It is shown how pea interspecific competitive ability for factors such as light and water results in an increase in wheat protein content without reducing other important quality parameters. Density and relative crop frequency can be used as "regulators" when specific objectives such as bread making quality are wanted[1]**

INTRODUCTION

Bread-making quality of wheat is mainly related to the protein and gluten content of the grain and flour. However, also the protein and gluten composition has a great impact on the dough properties (water absorption, mixing stability), CO_2 retention capability, and the bread volume (Waagepetersen et al., 2001). Achieving high quality bread wheat is important to increase the consumption of organic bread products.

For wheat production, nitrogen (N) accessibility during growth and grain development is critical in relation to protein accumulation in the wheat kernels. Grain legumes and cereals can complement each other in the use of N sources since both species utilize soil inorganic N sources, but the N_2-fixing legume can also capture atmospheric N. Several grain legume–cereal intercropping studies show how the intercropped cereal obtain a more than proportionate share of inorganic N raising the cereal grain N percentage significantly (e.g. Jensen, 1996). Pea and barley intercrops are widespread in temperate regions whereas pea-wheat (*Triticum sativum* L.) intercrops are rare (Ghaley et al., 2005).

In the intercrop the degree of resource complementarity, the total yield and the participation of yield between the individual species is determined by both inter- and intraspecific competition, which again is influenced by the availability of environmental resources, the relative frequency of the species and the density of components (Hauggaard-Nielsen et al., 2006). Recommended sole crop plant densities are well established for most crops. However, the intercropped species might utilize the growth resources more efficiently than sole crops, and resources may thus support a greater number of plants.

The aim of this study was to determine the effects of wheat-pea intercropping on wheat baking quality parameters using near infrared spectroscopy analyser as a function of 1) the relative frequency of pea and wheat and 2) the population density

MATERIALS AND METHOIDS

The experiments were carried out in 2003 on a sandy loam soil in Denmark with a pH($CaCl_2$) of 6.8, 1.7 % total C and 0.12% total N in 0–20 cm soil depth. The soil has been cultivated for centuries and mainly cropped with cereals for the last four decades. The site was managed with no use of herbicides and with mechanical weeding two times during emergence.

Spring wheat (cv. Vinjett) and field pea (cv. Agadir) were grown as sole crops (SC) and in dual mixed intercrops (IC). The crops were grown in a complete design with all combinations of five relative proportions and five density levels (Table 1) and four replicates.

Table 1. Complete experimental design of wheat and pea sole cropping and mixed dual intercrops. Relative crop proportions (%) are shown according to recommended density, which for wheat and pea was set to be 300 and 100 plants m^{-2}, respectively.

Wheat-pea intercropping relative proportions				
0	0:25	0:50	0:100	0:200
25:0	25:25	25:50	25:100	25:200
50:0	50:25	50:50	50:100	50:200
100:0	100:25	100:50	100:100	100:200
200:0	200:25	200:50	200:100	200:200

The plots were harvested manually (1 m^2) and separated into three fractions, i.e. wheat, pea and weeds. After threshing the grain dry matter yield were determined. Assessments of wheat quality parameters were conducted using a near-infrared spectroscopy analyser (Foss Tecator, Infratec 1241). The near-infrared spectroscopy analyser was calibrated and linked to the Danish NIT network (Buscmann *et al.* 2001).

RESULTS

Interspecific competition from pea IC influenced wheat IC grain yield as expected, with a linear yield

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decline when reducing wheat density and pea relative proportions (Fig. 1). However, sowing wheat IC at recommended density there was no significant difference whether pea was sown up to 50% of recommended density as compared to the respective wheat SC (Fig. 1). In the high wheat SC treatment pea did not influence the wheat yield even at extraordinary high density (200%).

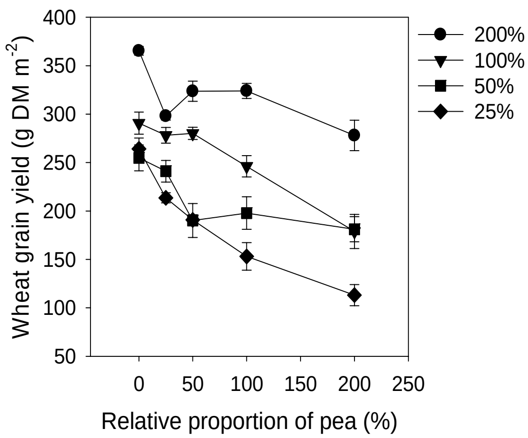

Figure 1. Wheat grain dry matter (DM) yield as a function of relative proportion of pea (%). The symbols indicate the four relative densities sown for wheat (see table 1).

Thus, wheat was the dominant component in the intercrop except at very low sowing densities (25%)(Table 2). Land equivalent ratio (LER) values show that environmental sources for plant growth are used on average 31% more efficiently in the intercrops than in the respective sole crops.

Table 2. Land equivalent ratio (LER)[a] for wheat-pea intercrops (IC) calculated on basis of total grain yield. The partial LER for wheat (L_wheat) and pea (L_pea) show the relative proportions of each crop. Values are mean (n=4) ± S.E.

[b]Wheat-pea	L_wheat		L_pea		LER	
IC frequency	mean	SE	Mean	SE	mean	SE
100:50	0.99	±0.04	0.27	±0.01	1.26	±0.04
50:50	0.77	±0.12	0.51	±0.03	1.28	±0.09
50:100	0.81	±0.11	0.43	±0.05	1.24	±0.09
25:100	0.66	±0.08	0.79	±0.10	1.45	±0.04

[a]LER>1 indicate an IC advantage in terms of the use of environmental resources. LER=L_wheat+L_pea; L_wheat= $Y_{wheatIC}/Y_{wheatSC}$; L_pea= Y_{peaIC}/Y_{peaSC}. [b]For further explanations see table 1.

Reducing the recommended wheat SC sowing density with 50% did not change the grain quality parameters, whereas protein, gluten and specific weight was raised when intercropped with pea (Table 3). However, it seems like the use of recommended density of wheat IC (100%) leaves too little space for pea to develop (Fig. 1) due to the strong interspecific competitive ability of wheat. Thus, it is needed to lower the wheat IC density reducing the wheat grain yield slightly.

A wheat IC protein yield ranging 11-14%, and with a medium to high (27-30%) gluten content picture extraordinary wheat baking quality. The specific weight is more or less the same.

Table 3. Wheat grain baking quality measured by protein and gluten content as well as specific weight when sole and intercropped with pea. Values are mean (n=4) ± SE.

[1]Wheat-pea IC frequency	Protein (% of dry matter)	Gluten (% of dry matter)	Spec. weight ($kg\ hl^{-1}$)
100:0	10.7^{A}	22.7^{A}	78.3^{BC}
50:0	10.8^{A}	22.8^{A}	78.0^{C}
100:50	11.1^{A}	23.5^{A}	78.3^{BC}
50:50	12.8^{B}	27.8^{B}	78.9^{AB}
50:100	12.8^{B}	28.0^{B}	78.8^{AB}
25:100	13.9^{B}	29.7^{B}	79.3^{A}

[1]For further explanations see table 1.

Discussion

Wheat IC was much more competitive for N than pea, and has on an individual plant basis access to a greater pool of plant available soil N than wheat SC. This increased supply of N in conjunction with the competition with pea for factors such as light and water results in a relatively larger increase in wheat protein content than dry matter production without reducing other important quality parameters. However, a relative proportion of pea IC around 40-50% is needed in order to achieve a level of intraspecific competition inducing such improvement in wheat baking quality parameters.

Density and relative crop frequency can be used as “regulators” when specific objectives such as bread making quality are wanted. However, a better understanding of the underlying interspecies dynamics that shape the final outcome of intercropping are needed including standard baking tests of the flour. Furthermore, separation of pea from the wheat grains can cause problems especially if the combine harvester breaks the pea grains. However, the technical solutions are available but at present the seed companies don’t have the logistics.

Conclusions

The existence of both intra- and inter-plant competition between intercropped pea and wheat induce physiological responses which has been shown to improve the wheat grain quality for bread making.

Acknowledgement

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