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Width of clover strips and wheat rows influence grain yield in winter wheat/white clover intercropping

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Abstract

Cereal–legume intercropping offers potential benefits in low-input cropping systems, where nutrient inputs, in particular nitrogen (N), are limited. In the present study, winter wheat (*Triticum aestivum* L.) and white clover (*Trifolium repens* L.) were intercropped by sowing the wheat into rototilled strips in an established stand of white clover.

A field experiment was performed in two fields starting in two different years to explore the effects of width of the wheat rows and clover strips on the competition between the species and on wheat yields. The factors were intercropping (clover sole crop, wheat sole crop and wheat/clover intercropping), rototilled band width, sowing width and wheat density in a factorial experimental design that enabled some of the interactions between the factors to be estimated. The measurements included grain yield, ear density, grain weight, grain N concentration, dry matter and N in above-ground biomass of wheat, clover and weeds and profiles of photosynthetic active radiation (PAR) within the crop canopy.

Intercropping of winter wheat and clover resulted in wheat grain yield decreases of 10–25% compared with a wheat sole crop. The yield reductions were likely caused by interspecific competition for light and N during vegetative growth, and for soil water during grain filling. N uptake in the wheat intercrop increased during late season growth, resulting in only small differences in total N uptake between wheat intercrops and sole crops, but increased grain N concentrations in the intercrop. Interspecific competition during vegetative wheat growth was reduced by increasing width of the rototilled strips from 7 to 14 cm, resulting in higher grain yields and increased grain N uptake. Increasing the sowing width of the wheat crop from 3 to 6 cm increased interspecific interactions and reduced wheat intraspecific competition during the entire growing season, leading to improved grain yields and higher grain N uptake.

Keywords: Intercropping; Winter wheat; White clover; Competition; Crop management; Yield components; Nitrogen uptake

1. Introduction

The area farmed according to organic principles is increasing in many developed countries. The area farmed organically in Denmark thus constituted 6.3%

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of the agricultural area in 2003 (Plantedirektoratet, 2004). The major limits on crop production in organic farming in Denmark are the availability of soil nitrogen (N) and the control of weeds (Olesen et al., 2002). In this context, cereal–legume intercropping may offer some benefits through increased N supply from biological N fixation (BNF) and by improved weed control through a denser crop stand (Anil et al., 1998). There may be additional benefits of intercropping, including better control of pests and diseases (Trenbath, 1993) and reduced soil erosion.

Intercropping of cereals in a perennial stand of white clover has been proposed as a possible option for whole-crop silage production in low-input farming systems (Jones and Clements, 1993). However, it may also have some merits for grain production in organic farming (Clements and Donaldson, 1997; Thorsted et al., 2002). In this system, a cereal crop (e.g. winter wheat [*Triticum aestivum* L.]) is established in a stand of white clover (*Trifolium repens* L.). The clover should supply N to the system and thus to the cereal crop via BNF. The cereal crop may be established by direct drilling into the clover crop. Alternatively, the wheat may be sown into a rototilled band in the clover, which will reduce the competition between cereal and clover during establishment of the cereal crop.

The biomass growth of the cereal crop in a cereal:clover intercrop without high levels of N fertilisation appears to be dominated by below-ground competition, presumably for N (M.D. Thorsted, unpublished data). Below-ground competition may be influenced indirectly through the spatial structure of the cereal:legume intercrop. Factors such as rototilled band width, seed density and sowing width may affect competition and offer possibilities of increasing cereal yield and cereal grain quality. Such spatial factors may offer some of the best options to maximize complementarity of intercrops in low-input farming (Midmore, 1993). The cereal seed density has thus been found to significantly affect the competition between cereals and clover in cereal:clover intercrops (Ross et al., 2003).

The spatial arrangement of individual plants influence crop yields in several ways. A uniform arrangement of crop plants offers a greater chance of the single plant to obtain an equal share of the available resources (light, water and nutrients), resulting in a decreased intraspecific competition. A uniform spatial arrangement of crop plants also increase competitive ability to weeds, since a greater proportion of the weeds will be affected by competition from the crop (interspecific competition) (Weiner et al., 2001). Experiments have thus shown that the biomass of interrow weeds may increase by increased distance from nearest winter wheat row and nearest conspecific neighbours (von Wettberg and Weiner, 2004).

Plant competition below-ground seems to be size symmetric, i.e., plants obtain soil resources proportional to their size (von Wettberg and Weiner, 2003), but above-ground competition have often shown to be size asymmetric (Weiner, 1990). Thus, it may be possible to affect above-ground competition of a cereal:clover intercrop through changes in the spatial structure, and through effects on the above-ground biomass also to affect below-ground competition for water and nutrients.

The experiment presented here was designed to investigate the effects of several factors on the performance of wheat in a winter wheat:white clover intercrop. These include the width of rototilled strip in which the wheat is planted, the width of the sowing band within this strip, and the seed density of wheat. For comparison, treatments without clover or without wheat were included.

2. Materials and methods

The experiment was carried out during two years from 1999 to 2001 in two different fields on a sandy loam soil at Research Centre Foulum in Denmark (56°30′N, 9°35′E). The soil type is a typic hapludult according to the Soil Taxonomy System (Nielsen and Møberg, 1985). Monthly mean temperature, precipitation and potential evapotranspiration are shown for the two main growing seasons in Table 1.

2.1. Experimental design

The experiment was a fully randomised block design with four replicates. The plot size was 3 m × 18 m. The experiment had 4 factors, but only 10 factor combinations were tested, giving a total of 40 plots (Table 2). The first factor, rototilled strip width, consisted of two treatments, 7 and 14 cm. The second