Effects of different preceding crops on the growth, yield components and grain yield of winter wheat and winter barley

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Summary. The effect of different preceding crops on the agronomic performance of winter wheat and winter barley was investigated in three years of field trials in north-western Germany in a high input system. The test crops wheat and barley showed a similar positive yield response following favourable preceding crops (rapeseed, peas, oats) compared with unfavourable preceding crops (wheat, barley) within the same season. Barley gained advantage during the early stages of development (dry weight, tillers per m^2) following rapeseed, whereas wheat showed a response only from ear emergence onwards in two out of three years.

Introduction

The current economic situation is forcing farmers in north-western Germany to change the traditional four- or three-course rotations to very short sequences, for example, rapeseed and winter wheat. Continuous winter wheat could be regarded as financially the most successful `rotation'. Much has been published regarding the effect of different preceding crops and/or crop rotations on grain yield of a following winter wheat or winter barley crop, but very little information is available on the effects of the current level of external inputs in western Europe, which may consist of more than 200 kg/ha nitrogen (N) fertilisation and up to five applications of fungicides. A yield decrease averaging 10-15% is caused by short rotations and/or continuous cereal cropping in experiments in the UK and Germany (6,10). This is a small decrease compared with experiences of short crop rotations in Australian environments (2,5,8). Other results indicate, however, that even in systems with a high external input in Europe a yield depression of between 30 to 40% can occur (7,9). Comparing the influence of different preceding crops on a following cereal in a system with low external input of nitrogen fertilisers, the amount of residual nitrogen is considered to be the most important factor in explaining differences in development and grain yield, whereas with a generally high level of nitrogen the severity of diseases is more important (6,9). Despite the outstanding importance of the influence of the preceding crop on development, growth and yield components of wheat and barley, research data are scarce and recommendations are often based upon survey data. The objective of this research was to evaluate the influence of different preceding crops and management systems on the agronomic performance of winter wheat and winter barley.

Materials and Methods

Description of the site

A long-term rotation experiment was established in 1985 on a sandy loam (Luvisol) at the experimental Farm Hohenschulen' of the University of Kiel, located in the north of Germany some 15km north-west of Kiel (Schleswig-Holstein). Each year winter wheat followed either wheat, rapeseed or peas, whereas winter barley followed wheat, barley, oats or rapeseed.

Weather conditions

The climate of north-west Germany is humid. Precipitation averages 716 mm annually at the experimental site with about 400 mm received from April to September, the main growing season, and some300 mm during October to March. Of the three years the first, 1987, was characterized by a long and cold winter until April 1987, whereas the two following years were extraordinarily warm, especially during the winter months.

Treatments

Three different levels of external input were compared in the experiment and, in agreement with the common husbandry practice, the nitrogen fertilisation was split into three applications, at the beginning of the growing season in spring, at the end of tillering and at ear emergence. The treatments consisted of two levels of nitrogen at the beginning of the growing season, either 60 or 100 kg N/ha followed by 80 kg N/ha (for barley 20 kg N/ha less) and an optional spraying of a fungicide (BCM and Prochloraz) controlling eyespot, *Pseudocercosporella herpotrichoides.* Plant samples of 2x 1 m row in each plot at five stages during the development were taken to measure above ground dry matter and the number of tillers. The take-all, *Gaeumannomyces graminis,* rating was based on a scale introduced by the Biologische Bundesanstalt (BBA)' and ranged from 1 (no visible symptoms) to 9 (total browning and destruction of the root system).

Results and discussion

The results of the changes in time of above ground dry weight (Table 1) indicate seasonal variability between the three years for the test crops wheat and barley. For the test crop wheat, no influence of the previous crop was observed at the sample date before winter. After the long, cold conditions during the winter of 1986-87, there was a significant difference in dry matter between wheat following wheat compared with wheat after rapeseed, but this diminished during the growing season with the dry weight at maturity almost equal in all treatments. Only minor differences in dry matter caused by the previous cropping occurred in the harvest years 1988 and 1989, after winter and at shooting. This result completely contrasted with the results obtained in the first year. In 1988 and 1989 a similar trend, that is, a decrease in the dry weight between wheat after wheat compared with wheat after rapeseed was recorded throughout the later stages. This led to significant differences at ear emergence and maturity. The reaction of barley to different previous crops differed considerably from the results obtained with wheat. The largest relative differences in the above ground dry matter between barley following rapeseed compared with barley grown after wheat was in all three years recorded at early growth stages, that is, after, or even before winter. The described differences in the growth for both test crops were caused only by changes in the number of shoots per m^2, since neither seedling establishment nor plant population density were affected by the previous crop.

Table 1. Changes in time of above ground dry mass (g/m^2) of winter wheat (cv.Kanzler) and winter barley (cv. Tapir) following either wheat or rapeseed, 1987-1989.

Harvest year	Test crop	Preced. crop	Before winter	After winter	Developmental stage EC 30/31[a]	EC 50/51	EC 91
1987	Wheat	Wheat	32	26	143	764	1615
		Rapeseed	34	46	225	916	1600
	Barley	Wheat	69	71	208	904	1779
		Rapeseed	111	112	184	1091	1410
1988	Wheat	Wheat	7	30	145	665	1374
		Rapeseed	6	33	167	823	1706
	Barley	Wheat	25	74	363	694	1440
		Rapeseed	35	125	444	936	1901
1989	Wheat	Wheat	23	103	232	1063	1479
		Rapeseed	22	114	258	1251	1771
	Barley	Wheat	25	119	330	975	1676
		Rapeseed	33	151	390	1140	2163

EC 30/31 = shooting, EC 50/51 = ear emergence and EC 91 = maturity

The test crops, wheat and barley, had lower grain yields following cropping in the same years, with an average yield decrease of 17% for wheat or barley grown after wheat or and 18%

decrease after rapeseed respectively (Tables 2 and 3). The effect of the previous cropping on grain yield was most pronounced in 1988 with differences nearly reaching 30%, supporting some recent results from Europe in systems with high external inputs (6,7,9). The smallest differences for both test crops were recorded in 1987 after the long and cold winter followed by a very wet growing season, reaching only 9% in wheat and 7% in barley.

No single yield component accounted completely for the observed differences in grain yield in 1987 to 1989. With barley, in common with the response in dry matter, a reduction of the number of ears per sq.m was most important, whereas for the test crop wheat the number of kernels per ear was more affected by the previous crop. Tiller production showed an even more distinct reduction, reflected in the number of kernels per ear.

Ear density was the dominant yield component, *as* other components throughout the experiment were not able to compensate for a reduction in the ear density. These results, obtained by the assessment of the growth and development of wheat and barley following different previous crops, generally support the described differences in the grain yield and the yield formation.

Table 2. Grain yield (t/ha) of winter wheat (cv.Kanzler) following wheat, rapeseed or peas 1987-1989.

Harvest year	Wheat	Preceding crop Rapeseed	Peas
1987	7.14	7.79	5.22
1988	6.78	9.19	9.26
1989	6.84	7.85	8.07
Mean	6.92	8.28	7.52

Table 3. Grain yield (t/ha) of winter barley (cv.Tapir) following either wheat, barley, oats or rapeseed, 1987-89.

Harvest year	Wheat	Barley	Preceding crop Rapeseed	Peas
1987	6.55	6.50	6.12	6.98
1988	6.43	6.81	8.87	9.01
1989	8.35	9.22	9.71	9.85
Mean	7.11	7.51	8.23	8.61

The incidence and severity of root rot caused by *Gaeumannomyces graminis* could explain the observed changes in growth and grain yield of winter wheat between 1988 and 1989. Differences in the rating, with more visible symptoms in wheat following wheat compared with wheat following rapeseed or peas, were already present before winter. These differences developed progressively during the growing season and a severe negative influence on water and nutrient uptake was observed from shooting onwards, leading to the observed reduction of kernels per ear and, subsequently, to a yield decrease. In barley the general level of take-all was considerably lower regardless of the preceding crop, especially in the early growth stages. For this reason it is less likely that differences in the severity of take all accounted for the large differences in dry weight and number of shoots per m^2 at early stages during the development (before winter, after winter) in barley caused by previous crops. Because no other pathogens, or differences in the soil nitrogen status were observed, it could be argued that other factors, for example, changes in the soil structural properties and/or phytotoxic substances released by decomposing straw in combination with the extreme weather caused the observed discrepancy. Because winter barley is sown earlier and develops further compared with winter wheat in autumn it seems possible that it is more susceptible to these kinds of influences.

The three management systems including a higher nitrogen dressing and an optional application of a fungicide against eyespot should give some indications about the interaction between previous cropping and external input level. Barley showed only minor, non significant, reaction to changes in the system of external input. Averaged over three years, the grain yield of wheat following either rapeseed or peas was only slightly affected by changes in the management system, which suggests that the optimum level of external input to gain the maximum yield in the given conditions was reached. In wheat following wheat a further increase in nitrogen fertilisation increased the grain yield on average over the three years by 1.25 t/ha (17%). However, the efficiency of use of this nitrogen defined as the relationship between nitrogen fertiliser amount and grain yield, was considerably lower compared with wheat following either rapeseed or peas.

These results emphasize the need for more detailed research considering the interaction between different preceding crops or cropping sequences with the amount and/or distribution of nitrogen fertilisation. Short term economic success, however, cannot be the only scale for this kind of experiment, because the environmental impact of a high input system in cereal production is obvious and has to be taken into consideration. Lower yields of wheat or barley following unfavourable previous crops inevitably lead to higher amounts of residual nitrogen, which might be subjected to leaching and subsequently cause groundwater pollution.

For the explanation of the observed differences in the reaction of barley or wheat to the previous cropping sequence a comprehensive approach is required; this is especially true for barley in which causes other than fungal diseases must be considered.

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