GRAIN OATS - A POOR BREAK CROP FOR WHEAT

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Summary. The growth and yield of continuous wheat were compared with wheat in rotation with grain oats in a phased rotation experiment at Temora in southern NSW from 1990-95. The yield of continuous wheat averaged 2.7 t/ha while wheat grown after oats averaged 2.6 t/ha. Failure of the oats break crop to improve wheat yields did not result from reduced pre-season soil N or water accumulation and occurred despite lower levels of take-all (*Gaeumannomyces graminis*) in the wheat following oats. Allelopathic effects of the straw or carry over of other soil-borne pathogens such as *Pythium* may be responsible for the poor break-crop effect of grain oats.

INTRODUCTION

Grain oats is often grown before wheat in cropping sequences in southern Australia. In addition to its role as a break crop it is considered by farmers to provide consistent and reliable yield with fewer inputs than the oilseed or grain legume alternatives.

The results of recent experiments in southern New South Wales raise questions about the effectiveness of grain oats as a break crop for wheat. These experiments have investigated the growth and yield of wheat following a range of previous crops. The yield of wheat after oats was not significantly greater than that of wheat after wheat, while yields after three winter oilseed crops were significantly increased (1). The failure of wheat to respond to the oat break crop was thought to be related to the carry over of soil-borne diseases on ryegrass weeds (*Lolium rigidum* Gaudin) which were not successfully controlled in the preceeding oat crop. In studies elsewhere in Australia and overseas, the poor performance of wheat after oats has also been attributed to reduced mineralisation of nitrogen in the soil following oats (4, 6). Results of a survey of 20 farms from 1986-1990 in the Cowra region of southern New South Wales showed that the water use efficiency (WUE) of wheat following oats did not exceed that of wheat following wheat while the WUE of wheat following broadleaf crops was significantly improved (5).

This paper reports the results of a phased rotation field experiment which compared the growth and yield of continuous wheat to wheat in rotation with grain oats.

MATERIALS AND METHODS

The experiment was conducted on a red-brown earth (Natric Palexeralf: Soil Survey Staff, 1992) 11 km east of Temora in the Riverina region of New South Wales. Prior to establishment of the experiment in 1990, the site had been a ryegrass/clover pasture for five years. The experiment consisted of a continuous wheat treatment (W-W-W-W-W) as well as a phased crop sequence of wheat and oats in alternate years (O-W-O-W-O and W-O-W-O-W) so that in each year wheat following wheat (W-W) could be compared with wheat following oats (O-W). The experiment was a randomised complete block design with four replicates and individual plots of 40x6 m. Crops were managed with conventional farm machinery according to recommended district practice. Aspects of crop management and crop cultivars are given in Table 1.

Table 1. Aspects of crop management during the experiment.

	1990	1991	1992	1993	1994
Cultivar- Wheat	Rosella	Dollarbird	Rosella	Dollarbird	Janz

- Oats	Dalyup	Dalyup	Dalyup	Dalyup	Dalyup
Sowing date	1 May	27 June	1 May	8 June	14 June
Managementa	C1	B + C2	I	I	I + C1
N applied (kg/ha)b	0	0	0	24S + 43TD	20S
Rainfall (May-Oct) (mm)	388	297	368	396	109

a C1=cultivated once with tynes, B=burnt stubble, I=incorporated stubble with disc

bS=N applied at sowing, TD=N topdressed.

Detailed measurements were made each year in the wheat crop following both wheat and oats. Soil mineral nitrogen (min-N) was measured following emergence of the wheat from five cores taken at random in each plot. Soil water was monitored throughout each season using a neutron moisture meter. At the four-leaf stage, 25 seedlings with intact roots were dug from each plot and assessed for the incidence of *Rhizoctonia solani* Kuhn and take-all caused by *Gaeumannomyces graminis* (Sacc.) a.Arx Olivier var. *tritici* Walker (Ggt). The incidence of both diseases was measured as the percentage of plants with symptoms. Dry matter production (Dwt), tiller density and tissue N content were measured at the start of stem elongation, anthesis and maturity from 0.4 m2 quadrats taken at both ends of each plot. Grain yield was determined from a machine harvest of two 1.55x30 m strips per plot. Samples of grain were analysed for total N using near infrared reflectance spectroscopy.

RESULTS

Growth, yield and N removal by preceding crops

The yield and protein content of the grain removed by the preceding wheat and oat crops throughout the experiment are shown in Table 2. The oats had higher yield but lower protein than the wheat so that the mean N removed in grain was similar.

Table 2. Grain yield (t/ha at 12% moisture) and protein (% in parenthesis) for the preceding oat and wheat crops in each year of the experiment and the mean grain yield and N removed in grain per year.

Crop	Year				Mean	
	1990	1991	1992	1993	Grain Yield	N in grain (kg/ha/yr)
Oats	3.9 (10.5)	3.6 (9.0)	4.1 (7.6)	4.5 (9.1)	4.0 (9.0)	54
Wheat	3.5 (10.2)	3.3 (10.5)	3.1 (10.0)	3.2 (11.5)	3.3 (10.5)	51

Growth and yield of subsequent wheat crops

Wheat crops were successfully established after oats and wheat in all years of the experiment. Previous crop did not affect plant populations established in any year of the experiment although mean density varied from 120 plants/m^2 (1991) to 220 plants/m^2 (1993).

Soil water and min-N measured following emergence, and growth data for the wheat grown after wheat and oats are shown in Table 3. There was no significant difference in the soil Min-N or stored soil water after wheat or oats in any year. The trend toward higher soil min-N after oats in 1992 was not significant. The incidence of Take-all was significantly lower after oats in all years except 1994 when only minor Take-all was observed at the site. There was no overall effect of the treatments on crop yield during the four years but significant differences were evident in individual years. Differences in crop yield were generally evident as differences in dry matter production during vegetative growth. There was no significant difference in the N% of tissues during early growth or the protein content of the grain in any year, and the mean grain protein was 11%.

Table 3. Soil conditions at sowing, disease incidence and growth and yield of continuous wheat (W-W) and wheat following grain oats (O-W) at Temora 1991-94.

	Soil Conditions		Plant Growth and Yield					
Years and Previous Crop			4 leaf stage		Start of stem elongation			
	Min-N 0-30 cm (kg/ha)	Water 0-160 cm (mm)	Disease Ggt	(%) Rhiz.	Dwt (g/m^2)	Tillers (m^2)	N%	Grain yield (t/ha)
1991								
W	12	512	26	-	223	491	2.7	3.3
O	8	509	2*	-	242	489	2.7	3.7*
1992								
W	73	468	15	-	210	760	1.7	3.1
O	50	473	1*	-	110*	620	1.5	2.5*
1993								
W	81	486	29	17	88	475	3.8	3.2
O	91	477	2*	39	89	394*	3.5	3.3
1994								

W	98	475	1	17	96	470	2.7	1.2
O	88	492	0	18	68	390	3.3	0.9*
Mean								
W	66	485	18	17	154	549	2.7	2.7
O	59	487	1*	28	127	473	2.7	2.6

* Indicates means which are significantly different at P=0.05.

DISCUSSION

In three of the four years of this experiment, the oat break crop failed to raise wheat yield above that of continuous wheat, and in two of those years, the yield was significantly lower than that of continuous wheat. This was not related to an inability of the oat crop to reduce take-all infection, which was reduced to negligible levels in all years. Lower soil nitrogen levels at emergence may have contributed to reduced growth of wheat following oats in 1992 but otherwise reduced soil nitrogen or water cannot explain the failure of the O-W treatment to respond positively to reductions in take-all levels. The results suggest that some other factors may be limiting crop growth in the O-W sequence and its impact is evident early in vegetative growth. The significant positive response to the oat break crop in 1991 may have resulted from the combination of reduced take-all incidence and dry October conditions. Alternatively some other management factor in that year may have influenced crop response. Stubble was burnt in 1991 while in all other years stubble was retained and incorporated (Table 1). Oat residues have been shown to be more phytotoxic to wheat than wheat residues (3), and the allelopathic effects of the stubble may reduce the early growth of the wheat seedlings. In addition to allelopathic effects, stubble retention can increase the incidence of some soil-borne fungal pathogens (2). Although the levels of take-all were reduced by oats in this experiment, other soil-borne pathogens such as *Pythium spp.*, shown to be present on many of the wheat cropping soils of southern New South Wales (7), may have been present at the site.

Observations of roots during take-all and *Rhizoctonia* assessment in these experiments revealed that in all years 40-90% of plants showed root symptoms of browning, reduced lateral root growth or rotted cortex. These symptoms are consistent with those caused by *Pythium* but are also similar to the allelopathic effects of crop residues on root systems. The incidence of these symptoms did not differ significantly between W-W and O-W treatments in this experiment, but their occurrence indicates the presence of potential biological constraints to growth at the site.

CONCLUSION

Although grain oats reduced take-all to negligible levels in subsequent wheat crops, the failure to increase yield above that of continuous wheat indicates that it is a poor break crop for wheat. The cause of the growth limitation for wheat in an oat-wheat rotation is not clear but was not related to preseason accumulation of soil mineral N or water. Oats can host soil-borne diseases such as *Pythium* and its residues have been shown to be more phytotoxic to wheat than wheat residues. Further studies are required to identify the exact cause of the growth limitation. The separate issue of growing long-season grazing/grain oats before wheat also needs to be investigated. The results of this study show that the current practice to grow grain oats before wheat may need to be reconsidered.

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