ROTATION WITH CANOLA AND OPTIMISING WHEAT YIELD IN NORTH-EAST VICTORIA

P.J. Haines[1], J.M. Curran[1,2], and D.R. Coventry[1,3]

[1]Department of Agriculture, Rutherglen Research Institute,
RMB 1145, Rutherglen, Vic 3685
[2]64 Hunter Street, Rutherglen, Vic 3685
[3]CSIRO Division of Soils, Private Bag 2, Glen Osmond, SA 5064

Summary. An experiment was established at two potentially high yielding sites in north-east Victoria to determine the effect of rotation with canola on subsequent wheat crops and whether yield could approach the water-limited optimum when the major barriers to production were removed. Canola increased the yield of the following wheat crop by 0.63 t/ha and the crop grown three years subsequently by 0.27 t/ha. Nitrogen fertiliser application and to a limited extent fungicide further increased wheat yield. In two of the wheat crops at the Lilliput site, the yield was close to the potential as determined by growing season rainfall. In 1990 and 1992, above average winter and early spring rainfall caused waterlogging which limited crop yields.

INTRODUCTION

Research over many years into crop production systems in north-east Victoria (2, 3, 7 ,10) has identified some of the major constraints to grain yield. Management strategies to overcome yield limitations have included appropriate crop rotations and agronomy, liming, deep ripping and conservation cropping. However, using the French-Schultz (6) concept for optimising wheat yields based on seasonal rainfall, most growers in this high rainfall cropping zone achieve yields well below the potential. With a potential yield of 6-7 t/ha, the district average remains about 2 t/ha although some growers consistently achieve yields of 3.5-4.5 t/ha. We established an experiment where soil and nutrient constraints had been removed using farmer best practice, and included additional management practices to achieve optimal wheat yield.

Grain legumes or oilseeds grown in rotation with cereals have been shown to increase the yield of the following cereal crop(s) (1, 10). The reason for the increased yield following an oilseed crop has been thought mainly due to a reduction in root diseases but this has not been clearly established. Recent crop rotation research has focussed on the possible interaction between improved root development and soil N and water use by the crops (1, 8). It has also been suggested that the tap root of oilseeds may modify subsoil pore size distribution (biological drilling) which would allow subsequent crops to better explore the subsoil and access water and nutrients that may normally be unavailable to the plant.

The objective of the experiment was to separate the effects of crop rotation with canola over a complete crop rotation cycle, and determine whether the inclusion of canola affected production beyond the following crop. Possible effects of N nutrition on yield were also investigated.

MATERIALS AND METHODS

The experiment was conducted at Lilliput (1987 - 1993) and Browns Plains (1988 - 1991) in the Rutherglen area of north-east Victoria. Soil classifications were Dy 3.22 and Dy 2.12 respectively (9). The sites were selected on areas which had the potential to produce high yields because of superior soil management; lime (up to 2.5 t/ha) was applied 1 or 2 years before the experiment commenced, both sites had been deep ripped to about 40 cm depth, lupins were grown in the preceding year and direct drilling had been routinely used by the landowners to establish their crops. The long-term average rainfall at Rutherglen Research Institute (5 km east of Lilliput and 15 km south-west of Browns Plains) is 593 mm with about 440 mm falling in the growing season (April to November).

Two 4-year crop rotations were used: canola-wheat-lupin-wheat (CWLW) and wheat-wheat-lupin-wheat (WWLW). The Lilliput site was continued for another 3 years beyond the first rotation cycle. There were 3 combinations of nitrogen fertiliser (+N+N, 0N+N, 0N0N) and 3 combinations of fungicide (+F+F, 0F+F and 0F0F) applied in years 1 and 2 of the rotation. Neither N or F was applied to lupin in year 3 of the rotation while treatment combinations for year 4 were the same as in year 2. N fertiliser was applied at the rate of 40 kg N/ha at early tillering and flutriafol (Armour[?]) fungicide was mixed with double superphosphate (100 g a.i./ha) and applied at 65 kg/ha. The experiment was a randomised complete block design (rotation (2) x N (3) x F (3)) with 4 replications and plot size was 15 m by 1.8 m.

The crops were direct-seeded as close as possible to the recommended sowing time for the region: lupin (cv. Gungurru) at a sowing rate of 85 kg/ha; wheat (cv. Matong) at 85 kg/ha; and canola (cv. Tatyoon) at 6 kg/ha. Effective weed control was obtained using appropriate pre- and post-emergent herbicides. The incidence and in some instances severity of take-all *(Gaeumannomyces graminis* var. *tritici*), septoria (*Mycosphaerella graminicola)*, rhizoctonia (*Rhizoctonia solani)* and eyespot (*Pseudocerosporella herpotrichoides*) was assessed for each wheat crop. Soil water content was measured to 1.1 m on a weekly basis from the end of winter up to harvest using a neutron probe.

RESULTS

Growing season rainfall (Table 1) was close to or above average in all years except 1991. In 1988, cropping conditions were favourable with above average rainfall over much of the growing season. The autumn break failed in 1991 which delayed sowing by about 6 weeks. The winter of 1990 was excessively wet which caused waterlogging.

Wheat yield

The mean grain yields for wheat at Lilliput ranged from 2.28 t/ha (1992) to 5.53 t/ha (1988) (Table 1). Inclusion of canola in the rotation significantly increased the yield of wheat in each of the years wheat was grown. Meaned for Browns Plains (data not shown) and Lilliput, wheat yields increased by 0.63 t/ha (21%) immediately following canola and by 0.27 t/ha (7%) for wheat sown 3 years after canola, compared to the WWLW rotation. Grain yield was also increased in each year at Lilliput by N fertiliser; mean increases of 0.37 t/ha for first wheat crops and 1.31 t/ha for second wheat crops after the grain legume. There was no interaction between N and rotation. Fungicide applied with superphosphate at sowing generally had little effect on wheat yield although there was a small yield increase in 1988 and 1992.

Table 1. Summary of effects of rotation, nitrogen and fungicide applications on crop yields (t/ha) from 1987 to 1993 at Lilliput.

	1987		1988	1989	1990	1991	1992		1993
Treatment	Canola	Wheat	Wheat	Lupin	Wheat	Peas	Canola	Wheat	Wheat
+N+N	2.69	3.77	5.85	2.77	3.62	2.05	0.92	2.60	3.50
0N+N	2.53	3.83	5.97	2.85	3.78	2.07	0.75	2.11	3.74
0N0N	-	-	4.79	2.90	3.19	2.03	0.68	2.12	2.11

+F+F	2.78	3.70	5.65	3.04	3.57	2.10	0.95	2.52	3.05
0F+F	2.48	3.87	5.65	2.82	3.57	2.08	0.74	2.18	3.23
0F0F	-	-	5.30	2.66	3.52	1.97	0.65	2.13	3.07
WWLW	-	-	5.12	2.85	3.38	2.05	-		2.99
CWLW	-	-	5.95	2.83	3.68	2.05	-		3.28
l.s.d (P=0.05)									
R	-		0.16	ns	0.11	ns	-		0.18
N or F	ns		0.20	0.17	0.13	0.10	0.23		0.22
F x R	0.22		ns	ns	ns	ns	-		ns
Rainfall (mm)	517		803	645	670	516	901		684
April-Nov	419		552	521	571	356	687		423

Crop disease

There were low levels of takeall (Ggt) at Lilliput at the start of the experiment in autumn 1987 (inoculum bioassay: mean value 0.3, scale 0-5). Over the crop cycle, rotation with canola decreased the incidence of Ggt in wheat at Lilliput and Browns Plains and the severity of infection for all treatments was generally low (e.g. <0.8, scale 0-4). There was no effect of fungicide application on the incidence or severity of take-all. Rhizoctonia was present on many plants but the severity of lesions was also low (mean 1.3, scale 0-5).

Water use

At Lilliput, there was 30 mm more water in the soil profile under wheat at the end of winter in 1990 and a trend to increased soil water in 1988 for the CWLW rotation compared to the WWLW treatment. There was no significant effect of crop rotation or N treatment on soil water use from the end of winter to harvest in either year.

DISCUSSION

Our results showed a significant improvement in wheat yields following canola and support a number of recent studies (1, 8). In addition, this experiment demonstrates the carryover effects of canola on the yield of wheat grown 3 years later. In previous studies the increase in wheat yields following an oilseed has been largely attributed to a reduction in root diseases, although often without supporting data. The level and severity of disease was generally low for all treatments at both sites and could not fully explain the yield increase in wheat following canola. While soil water content at the end of winter was generally greater under wheat for the CWLW than the WWLW rotation, water use by the crop from early spring to harvest was mostly similar for the rotation and N treatments. There may have been better water extraction by crops following canola.

A possible explanation for the wheat yield improvement could relate to the biological drilling potential of canola. Although it is unlikely that a crop such as canola could improve B-horizon porosity in dense, duplex soils (5), both sites were deep-ripped prior to sowing canola. This may have aided the penetration of the canola tap root into the subsoil and prolonged the effects of the ripping. Other explanations for the canola effect such as the possibility of yield-increasing microbial activity stimulated by canola, beyond biocontrol activity, need further investigation.

Using a crop water use efficiency of 15 kg grain/mm available rainfall for north-east Victoria (4), wheat yields were close to the potential yield in 1987 and 1988 but well below in the wet years of 1990 and 1992. In 1987 following lupin, the mean wheat yield of 3.8 t/ha compared favourably with the potential of 4.6 t/ha although rainfall in September-October was only half the long-term average. In 1988, the combination of canola in the previous year, N and fungicide applications increased wheat yield from 4.1 to 6.4 t/ha which was very close to the potential yield of 6.6 t/ha for that season. Higher than average growing season rainfall in 1990 and 1992 resulted in waterlogging which almost certainly limited yields. There is potential for further realising yield increases beyond current best practice management.

REFERENCES

1. Angus, J.F., van Herwaarden, A.F. and Howe, G.N. 1991. Aust. J. Exp. Agric. 31, 669-677.

2. Carter, M.R. and Steed, G.R. 1992. Aust. J. Soil Res. 30, 505-516.

3. Coventry, D.R., Reeves, T.G., Brooke, H.D., Ellington, A. and Slattery, W.J. 1987. Aust. J. Exp. Agric. 27, 679-685.

4. Coventry, D.R., Reeves, T.G., Brooke, H.D. and Cann, D.K. 1993. Aust. J. Exp. Agric. 33, 751-757.

5. Cresswell, H.P. and Kirkegaard, J.A. 1995. Aust. J. Soil Res. 33, 221-239.

6. French, R.J. and Schultz, J.E. 1984. Aust. J. Agric. Res. 35, 743-764.

7. Haines, P.J. and Uren, N.C. 1990. Aust. J. Exp. Agric. 30, 365-371.

8. Kirkegaard, J.A., Gardner, P.A., Angus, J.F. and Koetz, E. 1994. Aust. J. Agric. Res. 45, 529-545.

9. Northcote, K.H. 1979. A Factual Key for the Recognition of Australian Soils. 4th Edn. (Rellim Tech. Publ.: Glenside, SA)

10. Reeves, T.G., Ellington, A. and Brooke, H.D. 1984. Aust J. Exp. Agric. Anim. Husb. 24, 595-600.