HIGH YIELDING CROPS FROM LEGUME-DOMINANT PASTURES

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Abstract

A range of herbicide treatments to remove grasses from annual subterranean clover pasture and their effects on subsequent crops was investigated. Removal of annual grasses increased the legume component of the pasture, which increased soil nitrogen to depth after two, three and four years of the pasture ley. This increased the yields of wheat and canola in the first crop following pasture and in some instances, increased the yields of subsequent wheat crops. All treatments in all years gave increased grain protein levels compared with the regional average, but only in 1993 were the differences between the control and following pure legume pastures significant ($P<0.05$). These results support the hypothesis that improved legume contents of pastures supply additional nitrogen to increase crop yields and grain protein.

Key words: crop yields, nitrogen, subterranean clover, grain protein, rotations, winter cleaning, spray topping

Introduction

The use of pastures containing subterranean clover grown in crop rotations was first advocated during the 1940s and has become an integral part of rotational cropping systems on mixed farms (2). Legume pastures have been widely accepted for their role with increased livestock production (9) and to restore soil fertility depleted during the cropping phase (5,7). However, due to poor livestock returns and poor pasture management, many of the current pastures grown in rotation with crops are dominated by grasses and volunteer annual weed species, with generally low legume contents (10).

The legume content of pastures in the cereal-livestock zone of Victoria is usually too low to meet the nitrogen demands of following cereal crops. This is reflected in static wheat yields and in many instances, a decline in grain protein across the state (6). Two major reasons for the decline in the legume content of pastures are increased cropping intensity and the use of selective herbicides to control in-crop weeds (4). Also many farmers are apathetic about the benefits of pastures to cereals in the cereal-livestock zone (3).

The experiment reported in this paper assessed the contribution of pastures in today's conservation farming systems to improve whole farm productivity and profitability. Scammell (8) first reported results on the effects of chemical manipulation of legume pastures to increase their legume content. Results showed no adverse long-term effects on livestock performance from removing annual grasses with non-selective herbicides. However, increased profitability from improved pastures can only be achieved in a livestock enterprise if the additional feed-on-offer is consumed. This can be achieved by increasing the stocking rate to match the increased herbage production. This paper quantifies the carry-over benefits for crop production from manipulating the composition of a pasture to improve the yield and grain protein of following crops.

Materials and methods

The experiment was conducted on a strongly acidic soil (pH $CaCl_2$= 4.49 in 0-10cm) with a low P status. The soil was classified as a hard setting yellow duplex soil (Dy 3.33) or a Eutrophic, Brown Chromosol. Five herbicide treatments, replicated four times in a randomised block design, were applied to an annual subterranean clover pasture for two (1991-92), three (1991-93) and four seasons (1991-94) but only data from the nil (control), spray top (ST) and winter clean (WC) treatments are reported here. One third of the experiment was returned to a crop rotation in 1993 and the remaining two thirds proportionally returning to crop over the following two years. Full details of the treatments and experimental design are reported elsewhere (8). The herbicide Paraquat? was used for the ST and WC in preference to a selective herbicide to reduce the risk of herbicide resistance. The WC treatment was applied to the pasture when the subterranean clover had reached the sixth true leaf growth stage, except in 1994, when the low numbers of grass weeds eliminated the need to apply herbicide. The ST treatment was applied in spring when the target species showed signs of haying off.

The areas returning to crop were sown with either wheat or canola to compare the herbicide treatments, and the length of pasture ley on following crop rotation. Canola cv. Barossa was sown at 7 kg ha and wheat cv. Dollarbird was sown at 95 kg ha in each year except in 1995 when Katunga wheat was sown. Plots returning to crop were lightly cultivated to 5 cm, and all crops were sown with 10 kg P ha. Selective herbicides were used to control in-crop weeds to ensure the crop yields were a reflection of previous pasture management practices.

Results

Crop yields

Winter cleaning increased ($P<0.05$) the grain yield of both first and second wheat crops, except the first crop in the very dry year of 1994 (Table 1). Wheat yields following the WC treatment were greater ($P<0.05$) compared with the ST treatment in 1993 only (2 year ley) and for the second crop in 1995 following four years ley.

Grain protein increased ($P<0.05$) following the WC treatments in 1993, but not in any other year (data not presented). The low rainfall in 1994 (147 mm May to November) severely decreased the yields of both wheat and canola in all treatments. Severe frost in late September 1996 decreased potential yields by 15 to 20% in all treatments.

Table 1. The effects of two, three and four years of pasture on the grain yield (t/ha) of the following two wheat crops.

?	2 year ley		3 year ley		4 year ley	
?	1993	1994	1994	1995	1995	1996
?	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha
Control	4.0	0.57	0.12	3.4	3.6	2.4
ST	4.3	0.70	0.44	4.3	4.8	2.8
WC	6.1	0.54	0.32	5.3	5.3	3.1
lsd (5%)	1.09	0.16	0.16	0.6	0.59	0.6

Canola yields following WC were increased ($P<0.05$) in 1993 and 1995, and were greater than the ST treatment in 1993 (Table 2). The yield of wheat following canola was greater for the WC treatment than the control in 1995 (three year ley) and 1996 (four year ley) but not in 1994. The yield of wheat after canola was higher than wheat after wheat in 1995 and 1996.

Table 2. The effect of two, three and four years of pasture ley on canola yields and subsequent wheat yields (t/ha).

?	2 year ley		3 year ley		4 year ley	
?	Canola 1993	Wheat 1994	Canola 1994	Wheat 1995	Canola 1995	Wheat 1996
?	t/ha	t/ha	t/ha	t/ha	t/ha	t/ha
Control	1.2	0.14	0.14	4.3	1.7	3.2
ST	1.8	0.14	0.21	4.8	1.8	3.3
WC	3.0	0.12	0.13	6.0	2.3	4.3
lsd (5%)	0.8	ns	0.05	0.6	0.5	0.6

Autumn pasture germination

The two herbicide treatments (WC and ST) decreased grass weed populations in each year (Table 3). At the autumn break in 1993, consecutive years of WC decreased the grass weed populations from 1177/m^2 (control) to 62/m^2. A further application in 1993 decreased grass weed populations at autumn 1994 to 4/m^2 ($P<0.05$), compared with 1923/m^2 in the control. The low grass weed populations at autumn 1994 for WC eliminated the need to apply further herbicide in that year. Consecutive years of ST decreased the grass weed populations from 416/m^2 in 1993 to 164/m^2 in 1995.

Winter cleaning increased the regeneration of subterranean clover in the succeeding years (1993-1995) and densities were significantly greater (Table 3). Spray topping had no effect on subclover densities in any year.

Table 3. Plant density (number/m^2) following the autumn break in 1993, 1994 and 1995.

?	Grass plants (number/m^2)				Sub clover plants (number/m^2)			
?	Control	ST, ST	WC, WC	L.s.d.	Control	ST, ST	WC, WC	L.s.d
1993	1177	416	62	540	1086	936	4170	911
1994	1923	482	4	838	468	428	967	419
1995	1717	164	2	626	915	720	2346	839

Soil nitrogen

Soil mineral nitrogen (N) was consistently greater for all herbicide treatments and at all depths, compared with the control (Table 4). Mineral N in 1993 following two consecutive years of WC was double that of the control at both 0-10 and 10-20 cm depths ($P<0.05$) and while the ST treatments recorded higher soil N levels, they were not significantly different to the control. For both 1993 and 1994, the WC treatments were higher ($P<0.05$) than the control for each depth to 50 cm but only higher than the ST treatments in the 0-10 and 10-20 cm depths. There were no differences between all treatments below 50 cm, however, collectively there was a cumulative difference of 14 kg N/ha in 1994 and 44 kg N/ha in 1995 between the control and WC treatments.

Soil mineral N levels in autumn 1995 following four years of pasture showed a marked increase in N levels at all depths and for all treatments compared with the previous years. There was a large increase in mineral N at the 30-50 cm depth for all treatments in 1995 compared with previous years, indicating an accumulation of N at this depth. Nitrogen levels were also greater at 50-110 cm in both 1994 and 1995, suggesting a movement of N down the profile.

Table 4: Soil mineral N levels (kg N/ha, autumn 1993-95) after two, three and four years of pasture ley.

?	2 year ley		3 year ley			4 year ley		
?	1993		1994			1995		
?	0-20 cm	20-50 cm	0-20 cm	20-50 cm	50-110 cm	0 -20 cm	20-50 cm	50-110 cm
Control	54	*	65.5	27.5	47.3	79.0	73.4	84.7
ST,	67.7	*	53.3	32.3	55.7	99.6	84.9	117.8
WC	110.0	*	88.2	30.1	60.7	115.6	98.0	128.1

* data not available

Discussion

On average, pure legume pastures increased wheat yields by 50% in the first crop after the ley and canola yields by between 30 and 50%, compared with that after a mixed grass subterranean clover pasture. In all years and for all treatments the wheat yields were well above the regional average (2.5 t/ha). Other studies reported a similar trend of increased wheat yields following improved pasture management (1). The increased wheat and canola yields and the consistent high grain protein levels suggests the primary reason for these increases is the additional nitrogen accumulated under the legume pastures. The increased quantities of nitrogen within the soil profile has increased grain protein levels in all treatments, to greater than 11.5%, which is substantially greater than the regional average (<10%).

The high quantities of soil N were achieved by ensuring that the pasture contained a dense legume grass mixture as evident for the control at the autumn break of 1993 which had a combined population of >2000 plants/m^2. This pasture density indicates a highly productive stand well in excess of the 200 legume plants/m^2 that is suggested as the minimum required for an optimum pasture (4). When grass weeds are removed from the pasture through spray topping or winter cleaning, the legume density increases thereby soil N is increased as are following crop yields.

The grass weed populations in the pastures of all treatments were similar to the weed densities in the first crop. The grass weed populations in the first crops following WC in each of the two, three and four year ley were sufficiently low after cultivation (<50 plants/m^2) not to require grass selective herbicides in that year. The experimental site was a low infection paddock for most of the cereal root diseases. There were no visible signs of the root disease, Take-all (*Gaeumannomyces graminis* var. *tritici*)on any of the wheat plants roots sampled throughout the rotation following the pure legume pasture. In the control and spray top treatments there was an occasional plant with roots infected with Take-all, particularly in the second wheat crop, but the results were not significant. The resultant low grass weed populations in the first crops, together with the increased N following pure legume pastures, decreased the gap between the actual and potential yields of the first crop after pasture.

Conclusion

The results from this study indicate significant benefits to the cropping industry through increased yields and higher grain protein levels achieved through the use of improved legume dominant pastures, rotated with wheat. As earlier work (8) had shown that animal production is unaffected by increasing legume dominance, spray topping and in particular winter cleaning, can provide producers with management options that increase the productivity and profitability of both livestock and cereal enterprises.

Acknowledgments

This work was supported by the Grains Research and Development Corporation

References

1. Angus, J.F., Peoples, M.B., Gault, R.R., Gardner, P.A. and Howe, G.N. 1996. *Proc. 8th Aust. Agron. Conf*., Toowoomba, pp. 68-71

2. Bath, J.G. 1951. *J. Agriculture*, *Victoria*, **50**.,601-607.

3. Bellotti, W.D. and Kerby, J. 1993. A survey of farmer attitudes towards pastures in the cereal-livestock zone of SA. SADPI Technical Report, Adelaide.

4. Carter, E.D., Wolfe, E.C., and Francis, C.M. 1982. *Proc. 2nd Aust. Agron. Conf*., Wagga Wagga, pp. 68-83.

5. Donald, C.M, and Williams, C.H. 1954. Aust. Journal. Agric. Research. **5,** 665-687.

6. Hamblin, A., and Kyneur, G. 1993. Trends in Wheat Yields and Soil Fertility in Australia. (Dept. Primary Industries and Energy) (*Australian Govt. Publ. Services*: Canberra).

7. Rossitor, R.C., and Ozanne, P.G. 1970. In: Australian Grasslands. (Ed. R.M. Moore) (*Australian National University Press*: Canberra.) p 199.

8. Scammell, G.J. 1996. *Proc. 8th Aust. Agron. Conf*., Toowoomba, pp. 494-497.

9. Vizard, A.L. and Foot, J.Z. 1993. In: Pasture Management Technology for the 21st Century. (Ed. D.R. Kemp and D.L. Michalk) (*CSIRO*: Melbourne). pp 100-113.

10. (10)Wilson, A.D., and Simpson, R.J. 1993. In: Pasture Management Technology for the 21st Century. (Ed. D.R. Kemp and D.L. Michalk) (*CSIRO*: Melbourne). pp 1-25.