THE TIMING OF LUCERNE REMOVAL IN THE TRANSITION TO A CROPPING PHASE

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Abstract

A three-year old lucerne pasture was removed by cultivation or herbicide, each month between November 1995 and April 1996, and the effects measured on a 1996 wheat crop and a 1997 canola crop. No pre-emergence treatment completely removed all lucerne, so half of each plot was sprayed with a post-emergence herbicide to remove remaining lucerne plants. At the time of wheat sowing, there was 200 kg/ha of soil mineral N in the root-zone where lucerne was removed first, compared with 50 kg/ha where it was removed last. The longer fallow also accumulated a small additional amount of soil water. Wheat yield varied from 5.9 t/ha after early lucerne removal to 4.0 t/ha after late removal. There were no effects on yield due to either the method of pre-sowing removal or the post-emergence removal of remaining lucerne plants. The benefit of early lucerne removal continued, with canola yield decreasing from 2.1 t/ha for early removal, to 1.7 t/ha for late removal. There was also a 0.25 t/ha canola yield increase due to post-emergence removal of lucerne from the previous wheat crop.

Key words: Lucerne, wheat, canola, soil water, soil mineral nitrogen, grain protein

Lucerne-based pastures grown in phase with crops have been rediscovered in south-eastern Australia since the 1994 drought. Their advantages over annual pastures are their greater production (1) and greater contribution of biological N fixation (3, 7). The presence of lucerne in a pasture excludes weeds, confers a stable species composition (2) and minimises soil acidification due to nitrate leaching (4). Lucerne uses more soil water than annual pastures and so is likely to reduce the incidence of waterlogging and downslope salinisation. Its more reliable ground cover is also likely to reduce wind and water erosion.

However the yields of crops grown in phase with lucerne-based pastures have sometimes been less than crops grown after annual pastures. The reason has been the highly effective extraction of soil water by the lucerne, leading to a lack of soil water for the first crop (5, 1). In these cases the lucerne pasture was removed by cultivation several weeks before sowing the crop. Early removal of lucerne pastures should leave more time for soil water to accumulate before sowing a crop. This paper reports the effects of removing lucerne plants at different times before commencing a cropping phase.

Materials and methods

The experiment was conducted on a 3-year old lucerne stand growing on a red-brown earth soil at Junee Reefs in southern NSW. Grasses were removed with a selective herbicide in July 1995. By August 1995 the pasture consisted of a pure stand of 18 plants/m^2. Removing grass at this time controls soil-borne cereal pathogens such as take-all (6). Lucerne was removed, either by cultivation or herbicide application, from field plots at about monthly intervals between November 1995 and April 1996. Cultivation was with a double offset disc and the herbicide consisted of glyphosate (1 L/ha) and 2,4 D amine (700 mL/ha). The experiment was a randomised split-plot design, with 3 replicates, 6 main plots for the times of removal and 2 sub-plots for method of removal. No treatment completely removed all lucerne plants at the first attempt, so in the following month there was a second cultivation or spraying of the survivors. Even the second attempts were not completely effective.

Immediately before sowing on 10 May, all plots were cultivated to reduce any confounding of previous tillage on the wheat crop. Soon after the wheat emerged, shoots from surviving lucerne plants also emerged, with more present in the plots that had been more recently sprayed or cultivated. To investigate the effect of these lucerne plants on the wheat, we then split the treatments by removing all remaining lucerne from half of each plot using Lontrel? (clopyralid at 400 mL/ha) and MCPA (4-chloro-2-methyl) phenoxyacetic acid at 750 mL/ha) at the 4-leaf stage. In the sub-plots that had received no post-emergence herbicide, the lucerne plants persisted for the life of the crop and had reached the height of the wheat canopy by maturity but caused no significant problem with harvesting. Soon after wheat harvest, the remaining lucerne plants were removed (using 1 L/ha glyphosate and 700 mL/ha 2,4 D amine). Canola was grown on the previous plots in 1997. The soil was sampled in layers at the times of wheat sowing and analysed for contents of water and mineral N

Results

Soil water and mineral N

Rainfall was 260 mm between November 1995 and May 1996 when the lucerne was being removed. By May 1996 the soil where lucerne had been first removed was only 76mm wetter than where it had been removed last (Fig. 1). The differences were most pronounced in the subsoil but there was little difference in the top 40 cm, presumably because soil evaporation dried the soil to this depth, irrespective of the surface cover (data not shown). Rainfall during the wheat growing season was 404 mm. Soil water content at the time of wheat harvest was less than at sowing for the plots where lucerne was removed in November, but greater in the plots where lucerne had been removed in April (data not shown).

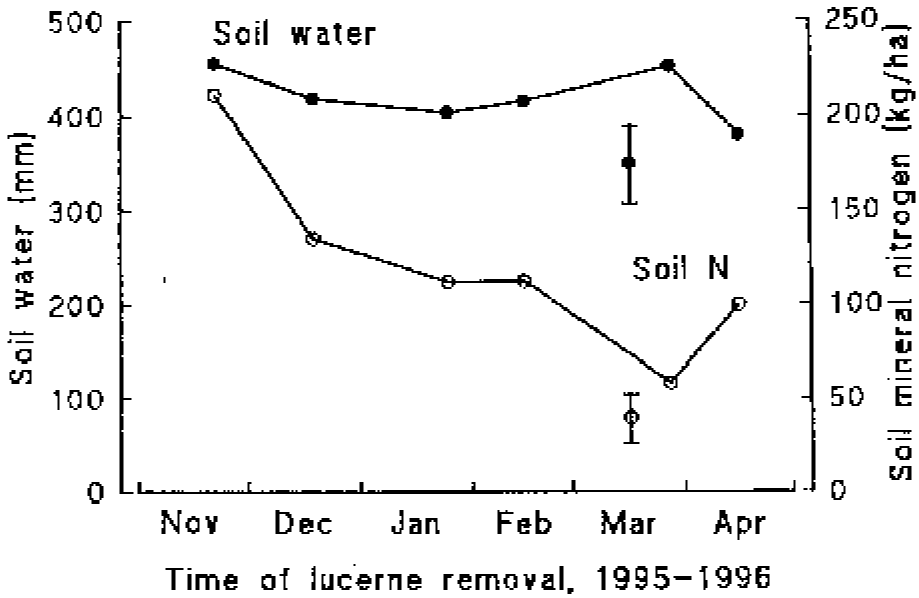

Figure 1: Contents of soil water and soil mineral N in 1.6 m of soil measured in June 1996, in relation to time of lucerne removal.

Soil mineral N at the time of sowing the wheat was greatest where the lucerne was removed earliest and generally decreased with later removal (Fig. 1). At wheat maturity there was 42 kg/ha of soil mineral N remaining in the top 1.6 m where lucerne had been removed in November compared with 77 kg/ha where it had been removed in April.

Crop measurements

The number of wheat plants emerged decreased with later lucerne removal (Table 1). The number of reviving lucerne plants increased with later removal.

Table 1. Density of wheat and lucerne plants (no./m^2) in relation to date of lucerne removal.

?	November	December	January	February	March	April
Wheat	119	127	129	114	108	112
Lucerne	0.1	0.5	3.5	7.9	9.0	7.4

Yields of subsequent crops decreased significantly with delayed lucerne removal, in the case of wheat in 1996 from 5.9 to 4.0 t/ha and in the case of canola in 1997 from 2.10 to 1.76 t/ha (Fig. 2). Wheat yield was unaffected by whether the lucerne was removed by cultivation or herbicide. Wheat yield was also unaffected by the presence or absence of lucerne plants after sowing. Canola yield was unaffected by method of lucerne removal but there was a significant reduction of 0.25 t/ha where lucerne had been retained during the 1996 wheat crop.

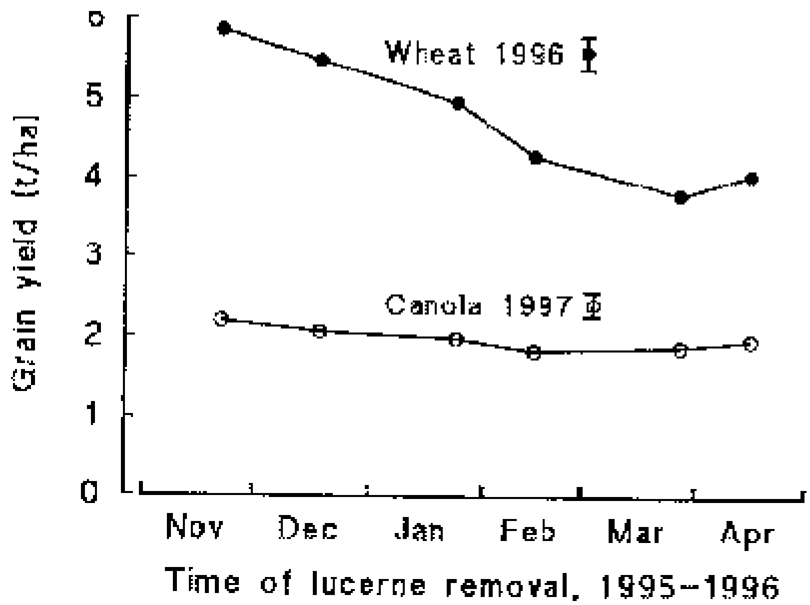

Figure 2: Yield of wheat in 1995 and canola in 1996 (t/ha) in relation to time of removal of the lucerne stand in 1995-96. The error bars indicate lsd, $P<0.05$.

Discussion

Wheat growing on soil from which lucerne had been recently removed had lower yield than when the lucerne was removed earlier, supporting the findings of Holford and Doyle (5) and Angus et al. (1). While the previous studies showed that the yield reduction was due to less available soil water, in this experiment differences in residual soil water did not affect the 1996 wheat because of the above-average rainfall. The absence of an effect of competition by growing lucerne plants on wheat yield supports this conclusion. However competition for water by lucerne plants remaining before and after wheat harvest appeared to cause a canola yield reduction in 1997.

The main reason for the effect of date of lucerne removal on wheat yield was the amount of mineral N in the soil at the time of sowing. For each additional day without lucerne growing, there was an accumulation of 0.75 kg/ha of mineral N. An alternative way to describe this is 0.5 kg/ha for each mm of rainfall in summer and autumn. The two likely reasons for this accumulation were longer periods of wet soil, thus allowing more mineralisation of N, and the absence of plants to take it up.

The additional water and mineral N in the soil at the time of wheat maturity where lucerne was removed in April, compared with November, suggested that a factor other than water and N had affected wheat productivity. The possibility of another limitation is also suggested by the reduced number of seedlings emerged after late lucerne removal compared with early removal. In this case there was little difference in topsoil soil water content and it is difficult to believe that the differences in soil mineral N could have affected seedling emergence. It is possible that allelopathic residues from recently killed lucerne plants were partly responsible for the lower wheat productivity. This possibility supports research showing that saponins contained in lucerne inhibit growth of competing plants (8).

Conclusion

The time of removal of lucerne in the spring, summer or autumn and the completeness of removing the stand may affect following winter crops through residual soil water, mineral N and possibly allelopathic effects. The effect of residual soil water on crop productivity is likely to be strongly season-dependent, but the effects of N and allelopathy are likely to be less season-dependent. Early lucerne removal is likely to reduce all three adverse effects, but will also increase the risk of soil erosion, particularly if the method of lucerne removal involves cultivation. In high-rainfall regions, late lucerne removal may not regularly cause a serious lack of soil water for the following crop but N deficiency is more likely. Additional N fertiliser may be required for the first crop after lucerne. However, since lucerne fixes more atmospheric N_2 than pastures containing annual legumes (7), the need for more fertiliser should not extend to later seasons. The difficulty of completely removing lucerne before cropping cannot be understated and may become a major limitation to its adoption in phase farming systems. Further research is needed to determine the conditions of growth, grazing, herbicides and cultivation that lead to efficient and reliable lucerne removal.

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