Five-year lucerne pasture improves the growth of the following canola crop on a Sodosol with dense subsoil

Caixian Tang, I Davidson, L Harris, JS Gill and Peter Sale

Department of Agricultural Sciences, La Trobe University, Bundoora, Victoria 3086, www.latrobe.edu.au/agriculture. Email: c.tang@latrobe.edu.au

Abstract

This study examined the impact of prior lucerne pasture on the chemical and physical properties and the growth of the following crop of canola (*Brassica napus* L. Grace) on a Sodosol soil. The trial site was located in a high rainfall region of Victoria with an average annual rainfall of 575 mm. The experiment consisted of three treatments: (i) a history of 5 years of lucerne and recent deep ripping, (ii) a history of 5 years of lucerne growth without deep ripping, and (iii) conventional continuous cropping. Prior lucerne pasture increased shoot biomass by 52% at the rosette stage and 85% at flowering as compared to continuous cropping. Lucerne pasture also increased water infiltration and available N in soil. Deep ripping (to 30 cm) did not show additional benefits for plant growth. Irrespective of treatment, shoot biomass correlated positively with concentrations of N and K in the shoots and negatively with bulk density at 30-40 cm. The results suggest that the improved growth of canola plants after lucerne pasture has mainly resulted from increases in soil N availability and water movement in soil profiles.

Key Words

Canola, lucerne, N nutrition, sodicity, subsoil constraints, water infiltration

Introduction

The incorporation of perennial legumes into the cropping system has been shown to change soil properties, and improve the nitrogen nutrition and growth of following crops. The perennial legume lucerne (*Medicago sativa* L.) has been widely recognised in Australia for its high quality forage and its impact on animal production and soil fertility (Davies and Peoples 2003). Lucerne may have the potential to ameliorate duplex soils through its deep penetrating taproots. It has the ability to dewater the soil profile to greater depths prior to the higher rainfall months, which allows storage of more rainfall within the winter season (Ward *et al.* 2002). This also reduces waterlogging and favours the formation of soil structure. The aim of this study was to examine the impact of prior lucerne pasture on the chemical and physical properties and the growth of the following canola crop on a Sodosol in a high rainfall region of Victoria.

Methods

The study was conducted in 2004 at the cropping and livestock property in a high rainfall region of Victoria (37.6? S 144.2? E). The soil was a Sodosol soil with topsoil pH of 5.2-5.8 (0.01 M $CaCl_2$), organic C of 32-39 mg/g and ESP of 4.6% (increased to 7% at 40 cm). The experiment consisted of three treatments: (i) a history of 5 years (1999-2003) of lucerne (*Medicago sativa* cv. Cimaron) with recent deep ripping to 30 cm (LDR), (ii) a history of 5 years of lucerne without deep ripping (LNR), and (iii) conventional continuous cropping of wheat (CC). Canola *(Brassica napus* cv. Grace*)* was sown on raised beds around 25 May. All treatments received 500 kg of gypsum, 1 tonne of lime, 80 kg of mono-ammonium phosphate per hectare.

Plants were sampled at the rosette (137 days after sowing-DAS) and the flowering stages (159 DAS), respectively. Chemical composition was determined in the shoots sampled at 137 DAS. Intact soil cores were taken 65 DAS at various depths for determination of bulk density. Water infiltration, soil strength and rooting depth were measured 142 DAS. Water infiltration was measured according to Jalota *et al.* (1998) while soil strength was estimated using a cone penetrometer (Rimik CP40).

Results

Prior lucerne pasture increased shoot biomass by 52% at 137 DAS and by 85% at 159 DAS as compared with continuous cropping (Fig. 1). In contrast, deep ripping did not show additional benefits on shoot growth. Irrespective of deep ripping, plants grown on the lucerne treatments had 56% higher N (Fig. 1), 25% higher Ca, 35% higher K and 23% higher P concentration than those grown on the CC treatment (data not shown). Shoot biomass at 159 DAS correlated with concentrations of N ($P<0.001$) and K ($P<0.05$) in shoots at 137 DAS.

Penetrometer resistance increased from 1 MPa to >3.5 MPa in the top 20 cm depth. Both LNR and CC peaked at this depth while the resistance in LDR peaked at 24 cm. The resistance then decreased gradually to about 2 MPa at 60 cm. In general, the LDR showed a slightly lower penetrometer resistance in the top 20 cm but higher at 20-40 cm than the other treatments (Fig. 2A). Both lucerne treatments allowed water to infiltrate much more quickly when compared to the CC treatment (Fig. 2B). The LDR had the greatest early stage sorptivity (S_o) of 274 mm/hr$^{1/2}$ compared to LNR of 202 mm/hr$^{1/2}$, which in turn exceeded the CC treatment by 80 mm/hr$^{1/2}$. Soil bulk density was not affected by the treatments in the 0-20 cm depth. At 30-40 cm, however, both the LDR and LNR treatments had lower bulk density than the CC treatment. Irrespective of treatment, bulk density at 30-40 cm negatively correlated with taproot length (Fig. 2C) and shoot biomass ($P<0.01$).

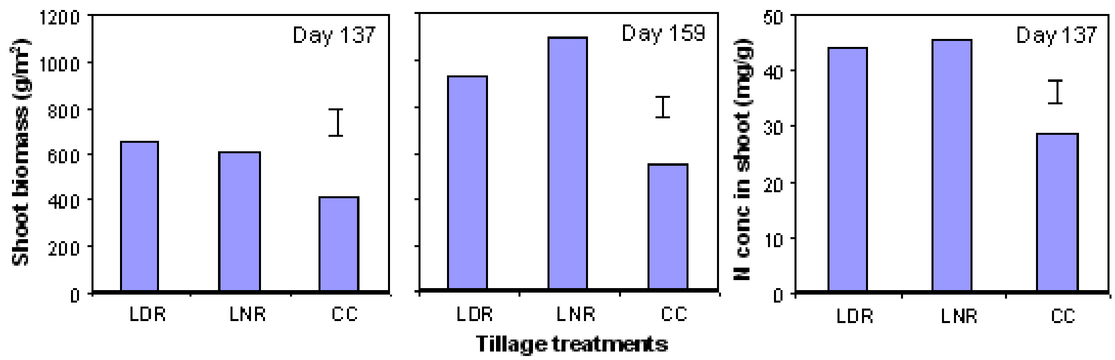

Figure 1. Shoot biomass and nitrogen concentration in shoots of canola crop grown in tillage treatments of 5 year lucerne history with deep ripping (LDR), 5 year lucerne history without deep ripping (LNR) and conventional cropping (CC) at 137 and 159 days after sowing. Bars represent l.s.d. values at P=0.05.

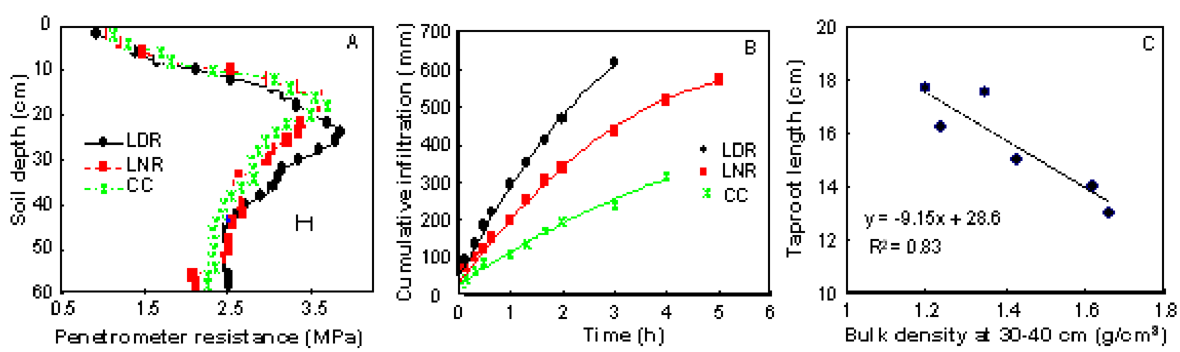

Figure 2. Penetrometer resistance (A), cumulative infiltration (B) and relationship between bulk density and taproot length of canola crop (C) in tillage treatments of 5 year lucerne history with deep ripping (LDR), 5 year lucerne history without deep ripping (LNR) and conventional cropping (CC). The horizontal bar represents l.s.d. value at P=0.05 (A). The measurements were performed at 142 days after sowing.

Discussion and conclusion

The improved growth of canola plants after lucerne pasture had mainly resulted from improved N nutrition. It was evident that the available N content in soils after 5 years of lucerne was nearly 3 times that with continuous cropping, and that shoot biomass positively correlated with shoot N. Prior lucerne pasture improved water infiltration, presumably by creating root channels in the soil profile. This will mitigate against possible waterlogging effects on plant growth. Our preliminary data also suggest that lucerne improves some physical properties in the subsoil. The lack of growth response to deep ripping might be related to the fact that (i) soil structure could not be maintained by ripping due to the dispersive nature of the sodic soil, and that (ii) major constraints to root growth were still operating in the subsoil. Any solution to constraints resulting from dense sodic subsoil will need to create as well as maintain improved soil structure in the subsoil. This can be partly achieved by deep incorporation of organic amemdments, which will be discussed in our companion paper by Gill, Sale and Tang in these proceedings.

Acknowledgements

The research is supported by the Australian Research Council.

References

Davies SL and Peoples MB (2003) Identifying potential approaches to improve the reliability of terminating a lucerne pasture before cropping: a review. Australian Journal of Agricultural Research 43, 429-447.

Jalota SK, Khera R, Ghuman BS (1998) Methods in soil physics. Narosa Publishing House, New Delhi.

Ward PR, Dunin FX and Micin SF (2002) Water use and root growth by annual and perennial pastures and subsequent crops in a phase rotation. Agricultural Water Management 53, 83-97.