Wheat stubble management influences emergence and growth of canola

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ABSTRACT

A field experiment was conducted to investigate reduced emergence and poor early vigour of canola sown into wheat stubble and the consequences for crop growth and yield. Four treatments were established on a site containing 6 t/ha of wheat stubble: a) A cool stubble burn immediately before sowing, b) stubble raked off plots, c) stubble on inter-row ridges only, d) stubble spread evenly across the plot. The canola (cv. Pinnacle) was direct-drilled cross the site. Seedling emergence was reduced in the presence of stubble, and this was associated with increased hypocotyl length, increased insect damage, reduced leaf number and reduced biomass. Nitrogen immobilisation could not explain the early impact on crop growth. At flowering, biomass differences between treatments had diminished, however stubble plots had less stem and leaf biomass and more hypocotyl biomass than the other treatments. The major implication for management in stubble retention systems is that sowing techniques that push wheat stubble away from the seeding row will reduce or eliminate the negative impacts of stubble on the early growth of canola.

KEY WORDS

Stubble retention, canola, hypocotyl, direct drilling, seedling.

INTRODUCTION

Stubble retention was initially adopted in cropping systems to reduce the risk of soil and wind erosion. More recently, residues have been retained to reduce loss of organic matter, increase infiltration and reduce evaporation (4). However, several studies in the United States and Australia have shown yield reductions associated with retained stubble (5, 3, 6). More recently, there has been evidence of reduced growth and yield for canola sown into retained wheat stubble in southern NSW.

A number of factors may contribute to the poor growth of canola in wheat stubble including (a) nitrogen immobilisation, (b) lowered temperatures in the soil and on the stubble surface, (c) increased incidence of root disease (2), (d) phytotoxins liberated from the stubble (1), and (e) insect damage. Of the literature reviewed none have examined these factors in relation to reduction in the growth and yield of canola, hence a field experiment was established to determine the influence of these factors on the growth of direct-drilled canola emerging through wheat stubble.

MATERIALS AND METHODS

Field site

The trial was located on a red-brown earth at Greenethorpe in SE NSW in a paddock with a 10 year history of canola/wheat rotation, the previous six involving stubble retention and direct drilling. In April 2000 the paddock contained 6 t/ha of wheat stubble (cv. Rosella) that had been harrowed. Canola (cv. Pinnacle) was direct-drilled on 1 May 2000 at 1 cm deep with 25 cm row spacing. Inter-row ridges were around 5 cm high and ran north-south. Fertilisers were drilled with the seed (MAP 44 kg/ha) and deep banded at 10 cm (MAP 66 kg/ha, urea 120 kg/ha). The plots were sprayed with herbicides as necessary and were top-dressed with 70 kg/ha of urea on 1 September.

Treatments

A latin square design, consisting of four treatments replicated four times, was established into 6t/ha of wheat stubble. The treatments were: a) a cool burn of 6 t/ha of stubble immediately prior to sowing (BURN), b) stubble raked off plots before sowing (BARE), c) stubble raked off the seed row onto the inter-row ridges after sowing leaving approximately 2 cm of relatively bare ground around the seed row (STUBBLE-RIDGE), and d) 6 t/ha of stubble spread evenly across the plot (STUBBLE-TOP).

Measurements

Seedling emergence was measured regularly on 4 m of row in each plot beginning 9 days after sowing (10 May). Seedlings were considered to have emerged when they became visible above the stubble. Insect damage on cotyledons was noted during the initial emergence counts. Ten days after sowing, 2 cm diameter cores were taken in the seed rows at 0-2.5, 2.5-5.0 and 5.0-10.0 cm depths and soil water content and soil mineral nitrogen determined. Eighteen days after sowing 6 seedlings per plot were removed. Shoot dry weight, leaf number, hypocotyl length and root depth were measured. Shoot nitrogen content was measured using mass spectrometry. Two 0.16 m^2 quadrats were taken in each plot to measure the weight of stubble.

On 31 July at stem extension and 12 September at flowering, two 0.32 m^2 quadrats were removed from each plot. Leaf area, shoot, leaf and hypocotyl dry weights were measured for each plant (July) or for each quadrat (September) and shoot N content determined.

RESULTS

Seedlings in the Burnt and Bare plots emerged faster than seedlings in Stubble-ridges and Stubble-top plots (Fig. 1). While Stubble-ridges reached a seedling density similar to Burnt and Bare 18 days after sowing, Stubble-top had around half the seedling density of the other treatments 52 days after sowing.

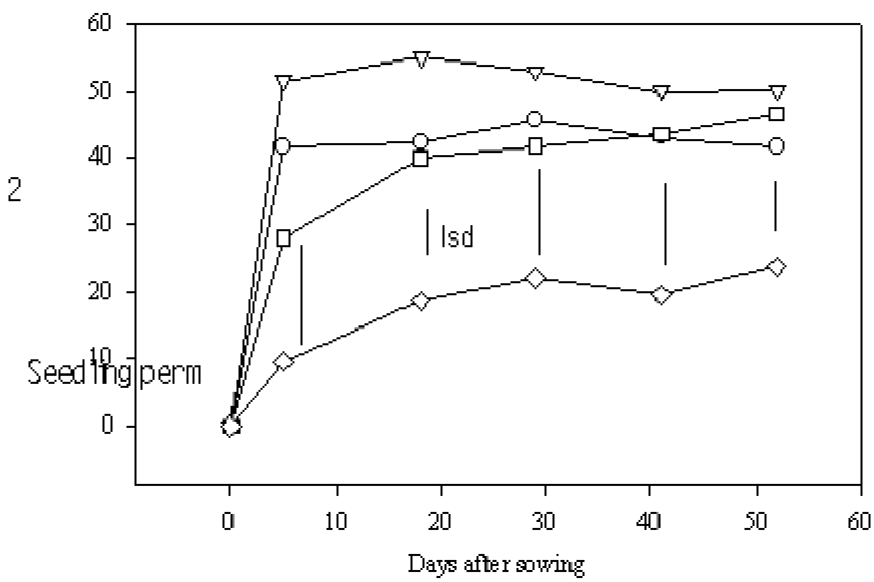

Figure 1. Emergence of canola seedlings through four treatments of wheat straw; Bare ——●——, Burnt——▽——, Stubble-ridges ——■——, and Stubble-top ——◇——. LSDs for p<0.05 are given.

Gravimetric soil water content 10 days after sowing was similar in the top 10 cm of all plots (18 g/g). Eighteen days after sowing, seedlings in Stubble-top had fewer leaves, longer hypocotyls and had more insect damage on the cotyledons (Table 1). Shoot weight was also lower in Stubble-top, although this was not significant. There was no difference in shoot nitrogen concentration.

Soil mineral N in the top 5 cm of soil was 50% less in the Stubble plots 10 days after sowing, which was primarily due to differences in ammonium levels. By July there were no differences between treatments, although concentrations appeared greater in Stubble-top (Fig. 2).

By the end of July, biomass in the Burnt and Bare plots was three times greater than Stubble-top (Table 1). However, individual plant weight was only 1.6-1.9 times higher in Burnt and Bare than the Stubble-top plots, indicating that the plants in Stubble-top were beginning to compensate for lack of plants.

Table 1. Characteristics of seedlings in the four treatments 18 days after sowing (LSD at p=0.05).

	Bare	Burnt	Stubble-ridges	Stubble-top	LSD
Leaf number	1.9	2.0	2.1	1.4	0.3
Shoot weight (mg/plant)	16.2	15.6	14.6	11.0	ns
Hypocotyl length (mm)	42.7	42.2	47.3	62.3	15.4
Insect damage (%)	9.5	6.2	20.4	28.5	17.5
Shoot N (%)	6.0	6.1	6.2	6.1	ns
Stubble (t/ha)	0.7	0.3	5.4	4.7	2.1

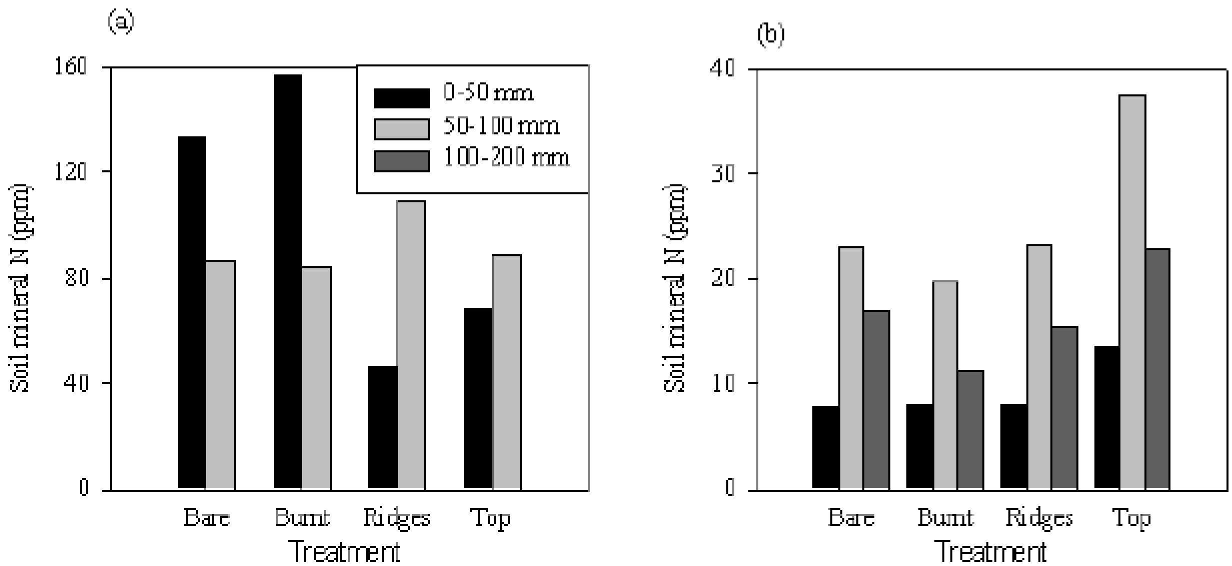

Figure 2. Soil mineral nitrogen at 3 depths under the four treatments (a) 10 days after sowing (depth x treatment $p<0.04$) and (b) on 31 July (depth $p<0.001$).

Table 2. Characteristics of the four treatments in July and September (LSD at p=0.05).

	Bare	Burnt	Stubble-ridges	Stubble-top	LSD
July 31					
Shoot weight (g/plant)	2.5	2.3	1.4	1.3	0.4
Shoot biomass (t/ha)	0.75	0.79	0.52	0.25	0.09
Leaf area (cm^2/plant)	373	373	248	176	79
Leaf area index	2.75	2.94	1.26	0.44	0.78
Hypocotyl length (mm/plant)	3.9	0.9	14.3	25.8	5.8
Hypocotyl occurrence (%)	24.3	7.2	67.3	88.5	14.6
Shoot N (%)	4.8	4.5	4.9	5.2	0.4
Shoot N (kg/ha)	35.3	35.8	25.2	12.9	4.5
Soil moisture (%)	16.7	15.4	17.6	18.1	0.9

September 12					
Shoot biomass (t/ha)	3.32	3.82	2.58	2.27	ns
Leaf biomass (t/ha)	1.11	1.25	1.04	0.97	ns
Stem biomass (t/ha)	2.18	2.57	1.51	1.22	0.97
Hypocotyl biomass (kg/ha)	17.5	0	26.8	80.0	53
Leaf area index	2.16	2.33	1.98	1.78	ns

Leaf area exhibited a similar trend. Average length of hypocotyl per plant was greatest in Stubble-top, followed by the Stubble-ridges and the occurrence of hypocotyls was also higher in these two treatments.. Shoot nitrogen concentration was higher in Stubble-top, but total shoot nitrogen uptake was lower due to lower biomass. Soil water was similar in all treatments. By September 12, flowering had commenced and was delayed by 4 days in the Stubble-top plots. Biomass and leaf area were similar in all plots, although there was a trend for decreased biomass and leaf area in the Stubble-top plots. Stubble-top had a greater proportion of biomass as leaves and hypocotyls and less as stems. There were no significant levels of disease noted in any treatments.

DISCUSSION

The presence of wheat stubble led to a slower rate of seedling emergence and a reduction in seedling density, especially in the Stubble-top plots. A number of factors may be responsible. In particular, the seedlings in the Stubble plots had longer hypocotyls that may have resulted from the changed light regime under the stubble or have been a response to the physical burden and depth of the stubble. The energy reserves diverted to hypocotyl production may have slowed development of seedlings in the Stubble plots and, in some instances, resulted in insufficient reserves for leaf production and seedling death. Low temperatures on the surface of the stubble, leaching of toxins from the stubble and insect damage may have also reduced seedling survival in the stubble treatments and these are under investigation.

Immobilisation by micro-organisms of fertiliser N 10 days after sowing appeared to have occurred in the Stubble treatments. As this did not affect seedling N concentration, N immobilisation seems unlikely to be a problem for canola sown into wheat stubble where adequate N fertiliser is applied.

By July there were large differences in biomass and leaf area between treatments; for instance, Stubble-top had a leaf area index six times less than Burnt. By flowering, the differences in biomass had reduced, indicating a greater growth rate for plants in the Stubble treatments. Although, the partitioning of biomass still differed between the treatments, with greater stem and less hypocotyl biomass in Burnt and Bare. Delayed flowering in the Stubble treatments had also delayed leaf senescence resulting in a similar total leaf biomass and leaf area index in all treatments. Final yields remain to be measured but the effect of delayed development in the Stubble treatments on yield will depend on a number of variables including rainfall and disease.

Stubble-ridges were generally intermediate between Burnt/Bare and Stubble-top. Whilst seedling emergence was initially delayed, final seedling density was similar to the Burnt/Bare plots. Hence this technique seems a practical method for overcoming the negative effects of stubble on emergence of canola, whilst still retaining the positive benefits of stubble cover. However, early growth was reduced and the implications of this for yield remain to be measured.

CONCLUSION

Placement of wheat stubble on top of the seeding row had adverse impacts on the emergence and early growth of canola. Nitrogen immobilisation did not explain the poor early growth. Other factors that may be contributing include: (a) longer hypocotyls leading to decreased energy reserves for leaf production; (b) lower temperatures at the stubble surface; (c) toxins leached from the decomposing residue; or a combination of these. The negative effect of stubble on early growth of canola was greatly reduced by flowering, especially where stubble was pushed away from the seeding row.

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