

Suppressing weeds in conservation farming

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Summary Farmers want to direct drill and retain stubble to improve soil quality and reduce soil erosion. However, uncertainty about the short-term costs associated with weed control limits adoption of conservation farming. Information is required on the impact of conservation farming, crop rotation and level of herbicide use on changes in weed species composition and seedbank replenishment in order to develop effective long-term management strategies.

The first year's results are presented of a three year study initiated in 2001 at Wagga Wagga, to determine the influence of crop sowing system (conventional vs. conservation) and crop species (wheat; grain legume; canola) on both the short-term crop gross margins, and the potential weed seedbank replenishment. Two weed management systems were compared; a low herbicide input, forage-production system (cutting for hay), and a normal herbicide input, grain-production system.

The benefits of forage crops were clearly demonstrated for reducing weed seedbank replenishment, especially in canola and field pea with stubble retained. Differences were observed in weed species spatial patterns of emergence in response to the conservation farming treatments. Herbicides were effective in the canola and field pea grain crops, but less so in wheat due to dry, cold conditions. The gross margins for 2001 were influenced by all treatments. The highest gross margin ($> \$700 \text{ ha}^{-1}$) was in the field pea forage system with 23 cm rows and stubble retained, while grain field pea and wheat were similar (approx. \$400), and the lowest gross margin ($> -\$200 \text{ ha}^{-1}$) was in the forage canola at 46 cm rows with burnt stubble. These preliminary results show that it is possible to make profits and minimise weed seed bank replenishment, depending on crop species, in both conventional and conservation farming systems. This will be verified over two more seasons.

Keywords Forage break crops, herbicide resistance, direct drilling, stubble retention, gross margin.

INTRODUCTION

Conservation farming is based on direct drilling (using a range of openers) and stubble retention, and has the benefits of reduced soil erosion, increased soil organic matter, improved soil structure, timeliness of sowing, reduced machinery wear, and fuel consumption. The costs are the variable and often reduced grain yields (possibly associated with reduced early crop vigour),

and a greater dependency on pesticides for weed and disease control. Wider row spacings needed for trash handling combined with low crop vigour, lead to poorly competitive crops highly dependent on herbicides. The presence of stubble also reduces the choice of herbicides available, which has important implications for the management of herbicide resistance. On the positive side, some evidence suggests that stubble on the surface may retard weed seed germination and reduce weed seedling emergence (Pratley 1995), possibly due to mechanical or allelopathic effects.

Highly variable associations of weed species with changing crop rotation, herbicide use and tillage system have been demonstrated in long-term systems studies overseas (e.g. Derkson *et al.* 1993 and Derkson *et al.* 1996 in Canada). In Australia, there is some evidence of differences in weed species dominance in conservation farming systems compared with conventional systems (Medd 1987, Heenan *et al.* 1994 and Pratley 1995). In a review of data from 16 conservation cropping experiments, weeds were associated with yield responses at only three sites, weed problems were suspected at three sites, not measured at four sites, and not associated with yield responses at six sites (Kirkegaard 1995). Therefore, even though weeds have a major influence on farmers' decisions to cultivate or burn, weed management has not been included in most conservation farming experiments. The real impacts of these systems on weeds is unknown.

Herbicides are still the most common method of control in conventional cropping systems, despite cost (on average $\$70 \text{ ha}^{-1} \text{ annum}^{-1}$, Jones *et al.* 2000), and widespread herbicide resistance. Even though there are many useful control techniques available to growers, chemical and non-chemical (such as forage conservation, green manuring and seed catching), adoption of integrated weed management (IWM) remains a challenge in conventional let alone conservation farming systems.

Therefore, a three year study was initiated to determine the influence of sowing system and crop species on crop the potential weed seedbank replenishment and crop gross margins. The study compared a low herbicide input/forage conservation system (equivalent to organic farming or a herbicide-resistant situation), with a normal herbicide usage grain production system. The first year's results are presented.

MATERIALS AND METHODS

The experiment was located at Wagga Wagga Agricultural Institute in southern New South Wales. Soil type is a red-brown earth. In 2000, Janz wheat was grown over the whole experimental area. The site was surveyed for weeds during the 2000 growing season, and was uniformly infested with diclofop-resistant annual ryegrass, and patches of wild radish and wild oats, as well as a wider range of minor weeds. The wheat yielded 6 t ha⁻¹ at 12% protein. The stubble was mulched using a Mason Stubble Mulcher in early 2001. The plots were marked out prior to sowing in early 2001, and these were 9 m wide × 40 m long.

The treatments were: a) three crop species (wheat, grain legume, canola), b) four sowing systems (23 cm row space and stubble burnt, 23 cm row space and stubble retained, 46 cm row space and stubble burnt, and 46 cm row space and stubble retained), and c) two weed management systems (low herbicide input – forage production system; normal herbicide input – appropriate for each crop – grain production system). The treatments were arranged in a randomised block design with three replicates and resulting in 72 plots.

The appropriate plots were burnt in late March 2001. Following rain in early April, it was noted that self-sown cereal and clover numbers were much higher in stubble retained plots than in burnt plots. All plots were sprayed with a non-selective herbicide (Roundup CT® at 2 L ha⁻¹ on 2nd May. After 17 mm rain on 6 June, all treatments were direct drilled on 9–10 June using a John Shearer Culti-Drill. In the 23 cm row width treatments, wheat was sown at 80 kg ha⁻¹, canola at 5 kg ha⁻¹ with 130 kg ha⁻¹ MAP and field peas (chosen rather than lupin because of the late break) at 130 kg ha⁻¹ with 135 kg ha⁻¹ grain legume super. In the 46 cm row width, all the seeding settings and fertiliser rates were adjusted to maintain equivalent population densities in the different row widths.

Crop establishment was estimated by counting plant numbers in 2 × 50 cm lengths of row. Weed numbers were recorded from 10 semi-permanent quadrats (0.1 m²) in all plots. All plots were treated with 100 mL ha⁻¹ LeMat® to control red legged earth mite. Weeds were not controlled post-emergence in the low herbicide plots. Weeds were controlled in the normal herbicide input plots using the following post-emergence treatments: in peas 380 g ha⁻¹ Lexone DF® and 250 mL ha⁻¹ Select®, in canola 2 L ha⁻¹ Gesaprim 500 SC® and 2 L ha⁻¹ Flowable Gesatop 500FW® and 250 mL ha⁻¹ Select®, in wheat 20 g ha⁻¹ Glean®. Weed and crop biomass was recorded at the late flowering stage of the crop on 24 October from four 1 m × 2 crop row length quadrats per plot. In all the low herbicide input plots, the crops were cut for hay on 30 October,

and this was removed from the plots as large bales. These plots were then sprayed with Roundup CT® at 3 L ha⁻¹. Grain yield was harvested from the remaining normal herbicide input plots. Gross margins were calculated for the various treatment combinations, based on forage prices of \$75 t⁻¹ for field pea, \$25 t⁻¹ for canola and \$50 t⁻¹ for wheat, and grain prices of \$220 t⁻¹ for pea, \$400 t⁻¹ for canola and \$220 t⁻¹ for wheat. Weed biomass data were square root transformed and analysed using a mixed model that reflected split-plot design and spatial correlation between plots.

RESULTS

The 2001 growing season was short (due to a late start and a dry finish) with an annual rainfall of 430 mm compared with a long term average of 534 mm. Mean crop densities in the 23 cm and 46 rows, respectively were: 82 and 48 plants m⁻² in canola, 60 and 56 plants m⁻² in field pea, and 185 and 147 plants m⁻² in wheat.

Annual ryegrass emergence was uniform within the plots and densities tended to be least in the stubble burnt 46 cm row plots (49 plants m⁻²), compared to 99 plants m⁻² in the stubble retained 46 cm rows plots. In contrast, wild oat density was slightly higher in the stubble burnt plots in both row spacings. In the patches of wild radish and fumitory, emergence was greatest in the 23 cm row spacings in both stubble retained and stubble burnt treatments. Wild radish, wild oats and fumitory emergence was greatest in the crop row and less in the inter row.

Weed biomass at flowering gives an estimate of potential weed seed bank replenishment (Figure 1a). The only significant treatment effects were interactions of herbicide input × crop species ($P < 0.01$) and stubble treatment × herbicide input ($P = 0.08$). Row spacing had no significant effect on weed biomass. In the low herbicide input forage treatments, weed biomass was greatest (and therefore worse) in canola and field pea compared with wheat. In the grain crops, weeds were effectively suppressed with herbicides in both pea and canola. Poor weed control was achieved in wheat due to lack of efficacy of Glean® in the dry conditions.

The order of greatest forage production (crop + weed biomass) at flowering in the low herbicide input plots was: pea > wheat > canola, with the corresponding mean values across treatments of 14.4, 12.7, and 10.4 t ha⁻¹. Averaged over all the crops, forage production was greatest in both the 23 cm row treatments and the stubble retained plots. The mean crop grain yields were 2.42 t ha⁻¹ for field peas, 0.98 kg ha⁻¹ for canola, and 2.53 t ha⁻¹ for wheat. In all the grain crops, yields were highest in the stubble burnt treatments. Row spacing had little impact on pea and canola grain yield, while in wheat yields were higher in the 23 cm rows.

The gross margins for the various treatment combinations (Figure 1b) reflect the different levels of forage and grain production and their prices (see Materials and methods).

The highest value (over \$700 ha⁻¹) was in the field pea low herbicide input (forage system), 23 cm row with stubble retained. The lowest value (over -\$200 ha⁻¹) was in the low input, 46 cm row, burnt stubble canola plots. The largest gross margins in the low herbicide input forage plots were pea>wheat>canola, in the 23 cm rows and when stubble was retained. In the normal herbicide input grain production plots, gross margins were similar in pea and wheat but much lower in canola. In all the grain crops, stubble burnt treatments had higher gross margins than stubble retained and 23 cm row had higher values than 46 cm rows.

DISCUSSION

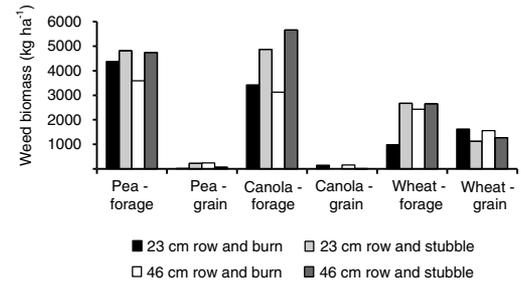
The first year of this 3-year study has clearly demonstrated that it is possible to both minimise weed seed bank replenishment and make money depending on crop species in conventional and conservation farming systems. In the field pea forage-based low input system (equivalent to herbicide-resistant weed situation), the realisation of the high gross margins of this break crops depends on a market demand for the forage, or the value of retaining it on-farm for a profitable animal production system. The low gross margin for wheat and negative gross margin for canola highlight the importance of legume crops in cropping rotations. Grain legumes provide greater flexibility in options for weed management as well as other benefits of nitrogen and organic carbon inputs. The benefit of weed removal in pea and canola forages was clearly demonstrated, while wheat was more competitive and suppressed weed growth more effectively.

In the normal herbicide input grain production system, the gross margin ranking was wheat>pea >canola. Higher gross margins were achieved in the stubble burnt and narrow row spacing treatments. Weed biomass (potential seed bank replenishment) was surprisingly high in wheat, possibly reflecting poor Glean® efficacy or a low level of weed resistance. In contrast, herbicide efficacy was much better in field pea and canola, reflecting a greater margin of herbicide selectivity.

The benefits of strategic burning of heavy cereal stubble for weed control was confirmed. Burning is necessary to a forage break crop. This provides an opportunity for growers to be flexible in their weed control tactics.

The results of this study need to be verified over two more seasons to determine significance of the sowing system on the composition of the weed community.

a. Weed biomass (kg ha⁻¹)



b. Gross margins (\$ ha⁻¹)

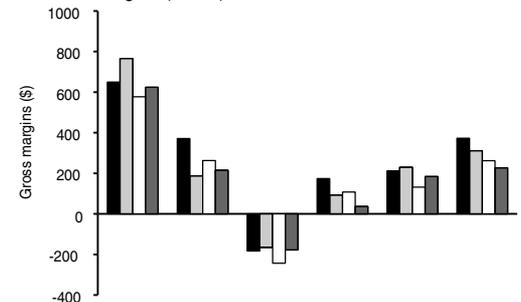


Figure 1. Influence of crop species and tillage practice in forage and grain production systems on a) weed biomass, and b) crop gross margins.

Légère and Samson (1999) determined some associations between management practices and weeds from certain lifecycle groups. They suggest that aspects of weed biology (e.g. seed size, dispersal, production, germination requirements and seedbank longevity) should also be considered when trying to explain such associations. This combined with modelling may provide a better indication of changes in weed species with changes in sowing system, than large and expensive farming systems experiments that run for ten years or more.

The changes in the spatial pattern of weed seedling emergence of some species with a change in soil disturbance observed in this study after only one year, shows that changes in weed species can happen quickly. Changes in sowing techniques and weed control tactics will most probably be required to manage new problems. Further targeted detailed measurements will be taken in this study to help predict in the future some of these observed changes. This will help develop the principles underlying observed responses.

Weed management in farming systems is inherently difficult due to complex interactions of sowing system, crop rotation, weed species and environmental

factors, especially with the widespread development of herbicide resistance in weeds. This study supports the continued need for long-term approaches to weed management in cropping systems, that minimise weed seedbank replenishment (Jones and Medd 2000). This experiment is a very useful extension toll for promoting IWM.

To be adopted by farmers, sustainable cropping systems must be profitable, as well as environmentally and socially acceptable. Farmers must minimise the risks of environmental degradation and food contamination, and still make money. The adoption of conservation farming in continuous cropping will be enhanced if the associated long-term benefits outweigh the short-term costs.

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