

Comparison of grain crops and their associated residues for weed suppression in the southern Australian mixed farming zone

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Summary We evaluated ten grain crops and their residues for their ability to suppress both winter and summer annual weeds in the mixed cropping region of southern Australia due to their competitive abilities and the presence of residues remaining until the subsequent cropping season. Research was conducted in Wagga Wagga NSW, in 2012 and 2013 using replicated RCB designs. Trends in weed suppression among years were similar. Weed pressures and yields were moderate in 2012–13 and lower in 2013–2014, due to rainfall received. Yields averaged 2.3–4 tons ha⁻¹ for all crops in both seasons. Winter weeds were well suppressed in crop in 2013 but annual ryegrass (*Lolium rigidum* Gaud.) was less well suppressed in 2012. Annual weeds established following harvest and included witchgrass (*Panicum capillare* L.) and fleabane (*Conyza* spp.). Witchgrass was most suppressed in grazing wheat and canola stubbles, followed by hybrid canola stubbles in both years. Grazing canola residues suppressed nearly all witchgrass and most fleabane growth for up to 4 months following harvest. Soil analyses for weed suppressive allelochemicals potentially produced by canola residues were performed.

Keywords Conservation tillage, summer annual weeds, stubble tillage, grazing wheat, canola, barley, fleabane, witchgrass.

INTRODUCTION

Conservation tillage (CT) is a system of residue management that avoids the use of cultivation or tillage for establishment of annual broadacre crops. This system maintains crop residues on the soil surface and minimises soil disturbance over time. It has several advantages in that its implementation generally results in reduced soil erosion due to wind and water, reduced operational expenses associated with cultivation or tillage, and conservation of water. Use of CT, also known as stubble tillage, may impact weed establishment, both during the cropping phase and post-harvest in the fallow phase (Liebl *et al.* 1992, Scott *et al.* 2010,

Weston 1990). In CT, emphasis is placed on use of herbicides for both pre- and post-emergence weed management in the remaining stubble, rather than cultivation, potentially leading to increased herbicide resistance in weeds of broadacre crops including annual ryegrass, wild radish and wild oats (Scott *et al.* 2010).

Much experimentation has been performed in the USA, Europe, Australia and South America to document the impacts of CT upon crop yield and performance. However, less information is generally available about the longer term impacts of stubble residues upon weed seed bank dynamics and weed infestation following adoption of CT systems in Australian cereal and grain crops. One of the most notable changes following use of CT is upon weed management because pre-plant tillage and cultivation does not occur (Liebman and Davis 2002). The adoption of CT has been reported by many investigators to result in increased numbers of annual grasses and perennial broadleaf weeds, and decreases in annual broadleaf weeds over time (Liebl *et al.* 1992).

Although numerous international studies and those performed in WA and SA have shown increases in crop yields over time associated with stubble retention, other studies have shown reductions in crop yields in CT systems, particularly in high rainfall years (Scott *et al.* 2010). This may be associated with the presence of decomposing mulch and release of allelochemicals, nutrient unavailability, increases in soil-borne pathogens or unfavourable shifts in weed spectrum over time due to use of conservation tillage. To reduce key weeds associated with production of broadacre crops by CT, some NSW producers have reverted to burning of stubble and use of tillage. In contrast, if stubbles are allowed to remain on the soil surface, researchers have reported issues with stubble build-up leading to poor seed/soil contact in future seeding events, and increased numbers of grass weeds associated with the presence of these residues (Scott *et al.* 2010).

Previous studies have shown the temporal impacts of crop mulches and residues on weed germination, establishment and weed management over time. In particular, cereal and grain residues including those of wheat (*Triticum aestivum* L.), rye (*Secale cereal* L.), triticale (\times *Triticosecale*) oats (*Avena sativa* L.) and barley (*Hordeum vulgare* L.) as well as canola (*Brassica napus* L.) residues have been studied for their ability to suppress weeds when used as cover crops into which broadacre crops are subsequently planted (Liebl *et al* 1992, Putnam *et al.* 1983, Weston 1990, 2005). Up to 95% control of economically important broadleaf weeds and grasses have been reported when significant residues remain on the soil surface. This is thought to be due to both the physical presence of residues and release of allelochemicals over a 60 day period following harvest/kill of the cover crop. In Australian broadacre cropping regions, crops are planted up to 5 to 6 months after harvest into the remaining crop stubbles. We are particularly interested in the ability of selected grain crops to suppress weeds both in crop and in fallow, due to the presence of associated remaining crop stubble.

The purpose of this study was therefore to examine and compare the ability of various grain crops and their residues to suppress weeds until subsequent planting the following year. Experiments were performed over 2 years in low input grain production systems with moderate winter rainfall (<550 mm) without irrigation. This experiment established crops without use of pre-emergence herbicides in relatively clean commercially cropped sites in order to compare and evaluate subsequent weed suppression provided by crop residues without confounding effects of residual herbicides.

MATERIALS AND METHODS

Identical experiments with similar crop/cultivar treatments were established in 2012 and 2013 at adjoining sites at the Graham Centre Field Site in Wagga Wagga NSW. Experiments were established on 30 and 31 May, respectively, as randomised complete blocks with 4 replicates in fertile red kandosol soils receiving average moderate yearly rainfall of ~550 mm. Plots of 2 × 16 m were designed to evaluate the impact of crop residues on winter and summer annual weed establishment. Previous cropping history included precision seeded and harvested commercial wheat and canola. Plots were planted using a cone seeder with 22 cm row spacing and pre-plant application of diammonium phosphate (DAP) at standard commercial rates. A post-emergent herbicide application of clethodim for canola and traloxymid (other cereals) was applied in August 2012 only, to manage infestation of winter annual grasses in and between plots.

Harvest was performed between 15 Nov and 15 Dec as crops matured, using a small plot harvester. Yield was measured as harvested biomass and cereal grain. Weed numbers were recorded in Sept., Nov., Jan. and March/April of each year using a 0.5 m × 10 m rating zone centred in each plot; in this area two 0.5 m² quadrats were evaluated for weed numbers and biomass as well as residual stubble biomass. Data was analysed by performing ANOVA for RCB experiments with 4 replicates; significant differences were separated using LSD (0.05) with differences indicated by letters over figure columns.

Table 1. Crops, cultivars and seeding rates evaluated in Wagga Wagga in 2012 and 2013.

Crop species	Crop cultivar	Grazing or non-grazing	Seeding rate kg ha ⁻¹
Wheat	Wedgetail	grazing	60
Wheat	EGA Gregory	Non-grazing	60
Oats	Graza	grazing	60
Oats	Mitika	Non-grazing	60
Barley	Urambie	Grazing	60
Barley	Buloke	Non-grazing	60
Triticale	Tobruk	Grazing	80
Rye	Ryecorn	Grazing	60
Canola	cb Taurus	Grazing	6.5
Canola	Hyola 50	Non-grazing	3.4

RESULTS

Experimental results in 2012–2013 and 2013–2014 seasons were similar in terms of yield and weed suppression provided by remaining crop residues the subsequent year. Emerging weeds of significance did not differ among years, but in 2012 due to higher winter/spring rainfall, annual ryegrass management was more problematic and required one post-emergent application of an appropriate selective grass herbicide for control in August. In 2013, weed pressures were moderate. Weeds emerging in both years included the winter weeds annual ryegrass and fumitory (*Fumaria muralis* Sond. ex W.D.J.Koch) and summer/autumn annuals included fleabane and witchgrass, which germinated following adequate rainfall.

Yield of cereal and grain crops generally ranged from 2.3–4 tons ha⁻¹ in 2012 and 2013 in Wagga, which was similar to that of regional producers. Weed pressures in crop were not great in 2013 and did not

require the use of post-emergent herbicides for weed suppression. However, in 2012 weed pressures were higher, possibly due to greater timely rainfall amounts received (data not presented for weed numbers in crop).

Crop residues of all types resulted in greater fallow weed suppression, with 50 to 200% increases in weed management in comparison to uncropped borders with no residue, following crop harvest. Weed infestations were rated in January and again in March/April each year. Crop residue presence resulted in reduced fleabane and witchgrass pressures. Of the crops evaluated in 2012/13, greatest suppression of weed seedlings was initially observed in grazing and non-grazing wheat, grazing barley and grazing and non-grazing canola stubbles (Figures 1 and 2). Witchgrass was the major weed infesting plots by May 2013 and 2014. In 2014, grazing wheat and canola plus triticale suppressed witchgrass establishment most effectively. Fleabane was also present in both years; significant suppression of fleabane occurred in grazing wheat and canola plots (Figure 1). In 2012/13, grazing and non-grazing canola plots were nearly weed-free for 90 days or more following harvest. In 2013/14, this period was extended due to low rainfall. Fleabane was the only weed of significance established initially in post-harvest grazing canola stubble; numbers were low in March 2012 and 2013. By May 2014, witchgrass numbers in plots had increased, but canola plots and grazing wheat remained cleaner than other cereal plots, with up to 75% less witchgrass biomass and 50% decreases in seedling numbers than other treatments (Figure 2). In January of both years, up to 45 to 60 days post-harvest, grazing barley and wheat and as well as both canola types showed limited weed infestation. Although weed counts were sometimes not significantly different among treatments, it was visually evident that grazing and hybrid canola plots remained relatively weed free for a period of 90 to 140 days post-harvest in both years.

Residues remaining on plot were assessed following crop harvest. Significant differences were noted in post-harvest crop residue levels in 2013 (Figure 3). In this case, canola, grazing canola, and grazing wheat had less residue remaining in plot than grazing barley, rye and other cereals. We also measured soil moisture availability differences in selected plots in March 2013/14. There were no differences in soil moisture levels from 0 to 12 cm profiles among canola and barley treatments, even though weed infestation and crop stubble biomass remaining were quite different among treatments.

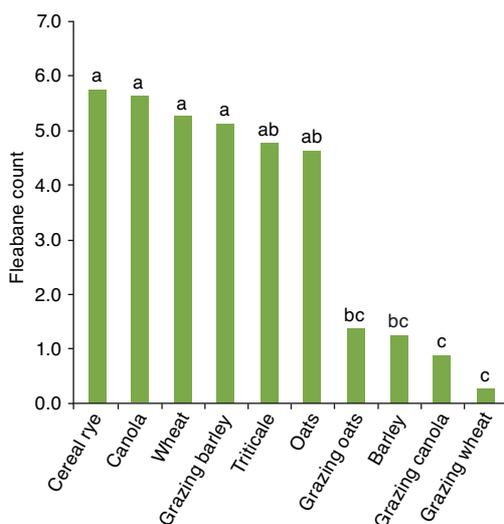


Figure 1. Fleabane counts in plots in March 2014. Areas with no residues averaged 12 plants m^{-2} .

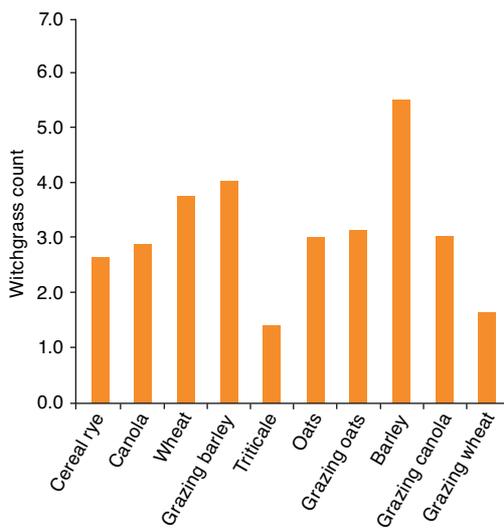


Figure 2. Witchgrass counts in plots in March 2014. Areas with no residues averaged 20 plants m^{-2} .

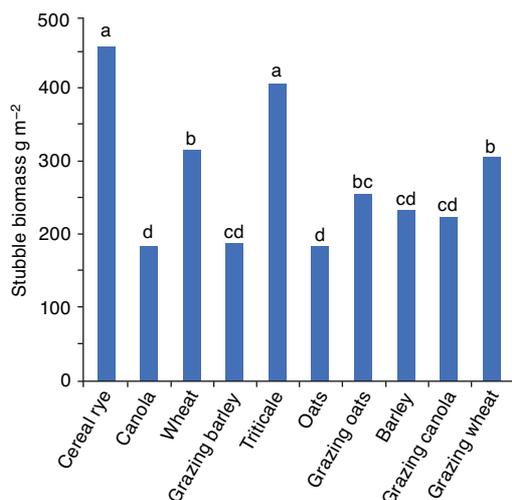


Figure 3. Biomass (g dry matter m⁻²) remaining in test plots in 2013.

DISCUSSION

We observed significant differences in weed infestation in crop (data not presented) and also in post-harvest crop fallows associated with grain crop cultivar and species evaluated. Crops were produced in soils with low to moderate weed infestation and in the absence of residual herbicides. Crops generally proved to be both competitive with weeds during their establishment and growth. In addition, remaining crop residues were suppressive to summer annual weed establishment, compared to borders without stubble. Some crops were clearly more suppressive of in crop weeds, including rye, barley, wheat and canola, likely due to reduced light at the soil surface and competitive canopy architectures. However, once harvest was performed, crop residues were all that remained on the soil surface, and amount remaining was crop/cultivar dependent. Residues are the source of allelochemicals and nutrients that are released over time to the soil rhizosphere from decomposition (Weston 2005). In addition, residue presence on the soil surface can alter moisture availability and soil microbial interactions (Weston and Duke 2003).

We observed significant weed suppression associated with grazing and non-grazing wheat residues, both pre- (data not presented) and post-harvest with grazing wheat exhibiting significant suppression of fleabane and witchgrass up to 130 days post-harvest. Grazing and non-grazing canola provided strong and significant suppression of fleabane and witchgrass for up to 140 days following harvest. Interestingly, these crops

did not have as much residue remaining on the soil surface as other less weed suppressive cereal crops. Grazing cultivars were generally more suppressive of weeds than non-grazing cereal cultivars evaluated. Soil analyses performed in late March indicated that moisture levels were not much different among treatments, especially in 2014 during an extended drought, indicating that differences in weed establishment were not likely associated with differences in soil moisture availability among treatments (data not presented). We are currently evaluating soil samples collected in both years for presence of isothiocyanates (ITCs) and glucosinolates associated with weed suppression in brassica species. (Siemens *et al.* 2002, Weston and Duke 2003); this will determine if canola presence and low weed infestation are associated with higher levels of suppressive secondary products.

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