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The weed suppressive ability of selected Australian grain crops; case studies from the Riverina region in New South Wales

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ABSTRACT

Herbicide resistance in both grasses and broadleaf weeds is on the rise across Australia, with an increasing number of cropping weeds experiencing resistance to multiple herbicides. One contributing factor to this issue is the adoption of conservation agriculture (CA). CA is a system of residue management that avoids the use of cultivation for establishment of annual broadacre crops. Another contributing factor is poor management of herbicide mode of action strategies in broadacre farming. One key tool for integrated weed management (IWM) strategies is the use of competitive grain crop cultivars and post-harvest crop residues, which can effectively suppress or delay weed seedling emergence and provide an initial advantage for the crop in terms of early weed suppression. The ability of various dual-purpose grazing or non-grazing grain crops and their residues to suppress weeds until subsequent planting the following year was compared in two successive field experiments in the Riverina region of New South Wales (NSW), Australia. We evaluated 1) the impact of residues of several grain crops on winter and post-harvest summer annual weed establishment from 2012 to 2014 and 2) in-crop and post-harvest weed suppression in 2014–2015 using a genetically diverse set of canola cultivars, including those found to be highly weed-suppressive in the first trial. Replicated field trials were established in Wagga Wagga, in a moderate rainfall zone (mean 572 mm/year) from 2012 to 2015 using commercially available crop cultivars. Differences in in-crop weed infestation and in post-harvest crop fallows associated with grain crop cultivar and species were observed in each of three years. Significant weed suppression associated with grazing and non-grazing wheat residues was observed after 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. Grazing cereal cultivars were generally more suppressive of weeds than non-grazing cultivars. Early vigour and ability to intercept light and accumulate biomass resulted in suppression of in-crop weed growth in canola trials, with GT-50 the most weed suppressive canola cultivar. Weed biomass differed with cultivar in both years, and appeared to be inversely related to early crop vigour, suggesting the importance of crop biomass in regulating weed competition in the crop. Cultivars CB Taurus and GT-50 were consistently the most weed suppressive when residues remained in plots 150 days post-harvest. These results indicate that establishment of certain species and cultivars of grain crops may effectively suppress weed growth both in-crop and post-harvest, in the absence of post-emergent herbicides. In addition, the choice of canola cultivar for desired weed suppression impacts the subsequent ability of the crop and its residues to successfully interfere with weed growth.

1. Introduction

Since 1975, producers in Australian dryland agricultural systems have relied heavily on herbicides for weed control in broadacre cereal crops such as wheat (*Triticum aestivum* L.). However, during

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the 1990s, the phenomenon of herbicide resistance in weeds of prevalent cereal crops has increased at an alarming rate (Pannell et al., 2004), especially for common weeds such as annual ryegrass (*Lolium rigidum* G.), wild radish (*Raphanus raphanistrum* L.) and wild oats (*Avena fatua* L.) (Scott et al., 2010). To date, this trend has not changed as herbicide-resistant weeds are still on the rise across Australia, including an increasing number of weeds displaying resistance to multiple herbicides or herbicide families (Owen et al., 2013).

A key factor in farmer preference for management practices is the capacity to maintain or improve crop yields and profitability. Conservation agriculture (CA) is a system of residue management that avoids the use of cultivation for establishment of annual broadacre crops. This system maintains crop residues on the soil surface with minimal soil disturbance over time and has clear benefits and costs for dryland and irrigated mixed farming systems of south-eastern Australia (Weston et al., 2014; Scott et al., 2010; Kirkegaard et al., 2014). The benefits arising from the ease of crop management, energy/cost/time savings, and soil and water conservation have led to widespread adoption of CA, particularly on large farms, where producers harness the tools of modern science: highly-sophisticated machines, potent agrochemicals, and biotechnology (Giller et al., 2015). Three important principles of CA include the use of minimal soil disturbance through tillage operations, permanent residue cover, and rotation of primary crops (Chauhan et al., 2012; Giller et al., 2015). The first two principles are interdependent since a protective residue or mulch, for example, cannot be well maintained when the soil has been thoroughly tilled. Thus, CA is deemed to be practiced only when all three principles are carefully and precisely applied (Derpsch et al., 2014).

Weed management in CA can be more challenging than in conventional agriculture because there is limited weed seed burial in CA and frequent infestation of perennial weeds (Chauhan et al., 2012). In addition, herbicides may prove to be less effective for weed management because soil-applied herbicides are generally not incorporated in CA soils, resulting in reduced efficacy on the soil surface (Chauhan et al., 2012). This reduced efficacy has potentially contributed to increased herbicide resistance in weeds of Australian broadacre crops including annual ryegrass, wild radish and wild oats (Scott et al., 2010). However, in comparison, weed seeds that remain present on the soil surface are typically more prone to desiccation and greater predation by insects, especially ants (Chauhan et al., 2012).

Crop residues, when present in uniform and dense stands under CA, can effectively suppress or delay weed seedling emergence and provide an initial advantage for the crop in terms of early weed suppression (Chauhan et al., 2012). For instance, wheat planted in no-till conditions reduced the seedling emergence rate of littleseed canarygrass (*Phalaris minor* R.), when compared with conventional ploughing and sowing (Bajwa et al., 2015). In addition, crop residues can also interfere with weed development and growth through alteration of soil physical, chemical, and biological characteristics based on two possible sources of allelochemicals: secondary metabolites released directly from crop litter or those produced by microorganisms that use plant residues as a substrate (Ferreira and Reinhardt, 2010). For example, McCalla & Norstadt's (1974) review of phenolic acids, which are released from many cereal crop residues, showed that levels required for strong phytotoxicity to successive crops often greatly exceed those later observed in the soil following residue degradation by microorganisms.

Previous studies have also 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*), rye (*Secale cereale*), triticale (x *Triticosecale*), oats (*Avena sativa*) and barley (*Hordeum vulgare*) as well as canola (*Brassica napus*) 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). In Australian broadacre cropping regions, crops are planted up to 5–6 months after harvest into the remaining crop stubbles (Weston et al., 2014). 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.

Another alternative weed management practice for Australian cereal crops is the use of cereal crop cultivars with increased competitiveness. The competitive ability of a crop can be specified either in terms of crop tolerance to weeds or growth inhibition of weeds by resource competition (Bertholdsson, 2010). Competitive cultivars often have better access to light, nutrients, and water resources in limited space due to crop architectural traits, thus suppressing the growth and reproduction of nearby weed species (Worthington et al., 2015). The competitive ability of wheat is influenced by a range of plant attributes such as height, tiller number, and light interception by the canopy or light interception at the soil surface. Previous studies have shown that, increasing plant height improved bread and durum wheat's ability to tolerate and suppress oats while several plant traits associated with early wheat vigour (early canopy cover, greater leaf width and tiller number) were also positively correlated with crop competitive ability (Vandeleur and Gill, 2004; Zerner et al., 2008). In a recent study carried out at two ecologically different locations, differences in weed suppression by selected Australian commercial winter wheat cultivars were largely determined by crop architecture and phenology early in the growing season (Mwendwa et al. 2016). In Greece, the use of competitive cultivars alone has been demonstrated to reduce herbicide usage by 50% in wheat (Travlos, 2012; Andrew et al., 2015). Thus, developing grain cultivars with superior weed competitive ability could complement cultural methods by maintaining acceptable yields and suppressing weed populations (Worthington and Reberg-Horton, 2013; Andrew et al., 2015).

Increased competitive ability among canola cultivars has generally been attributed to early seedling emergence, seedling vigour, rapid root growth and rate of leaf expansion, early root and shoot biomass accumulation and canopy closure and plant height (Asaduzzaman et al., 2014b; Beckie et al., 2008) and our findings generally substantiate the reports of these authors, with canola genotype impacting weed number and total weed biomass (Weston et al., 2014). Recent studies have shown that the ranking of cultivars for competitiveness against weeds is strongly influenced by seasonal conditions, with some cultivars consistently more competitive than others (Lemerle et al., 2014).

The purpose of this study was to compare the ability of various dual-purpose grazing or non-grazing grain crops and their residues to suppress weeds until subsequent planting the following year in the Riverina region of NSW Australia. In addition, based on results from the first experiment, further evaluation of weed suppression in canola and canola residues after harvest was conducted in field experiments over two years using both standard and recently released canola cultivars. To assess the impact of crop cultivars on weed suppression in-crop and the potential of crop residues to suppress weeds after harvest, experiments were performed over three years in a low-input grain production system with moderate winter rainfall (572 mm) without irrigation. Specifically, these experiments established crops without use of pre-emergence herbicides in commercially cropped sites in order to compare and evaluate subsequent weed suppression provided by crop residues without the confounding effects of residual herbicides.