Winter cover crops and their weed suppressive abilities

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Summary The management of annual weeds in cropping systems is a primary issue for growers in the northern grains region of Australia. Cover crops are a non-chemical weed management option that can be used in conservation cropping systems to reduce the reliance on herbicides. The aim of this study was to determine the effectiveness of three winter cover crop species (forage oats, purple vetch, and tillage radish) in suppressing emergence and growth of annual winter weeds at two field sites near Camden, NSW. On average forage oats and purple vetch provided 42% greater suppression of early weed emergence than tillage radish at Bringelly (heavy soil site). At Lansdowne (sandy soil site), forage oats and tillage radish suppressed weed biomass by 67% and 88% more than vetch, at 80- and 120-days post crop emergence, respectively. At Bringelly, forage oats suppressed weed biomass on average 70% more compared to tillage radish and purple vetch at 80 days post crop emergence. There were no differences in weed suppression among the three crop species 120 days post crop emergence at Bringelly. The higher weed suppressive ability of different cover species was related to their ability to produce more biomass during early growth phase. This study has demonstrated that cover crops can be used to supress the emergence and growth of annual winter weeds.

Keywords cover cropping, northern grains region, oats, vetch, tillage radish, weeds.

INTRODUCTION

The management of annual weeds in cropping systems is a primary issue for growers in the northern grain production region of Australia. It is estimated that the total cost of weeds in terms of revenue loss and weed management expenditure to Australian grain growers is approximately $3,318 million, equivalent to $146/ha (Llewellyn, 2016).

As a result of a major shift from conventional farming to conservation agriculture, weed management practices have changed to focus on the use of herbicides. Conservation agriculture, based on minimal soil disturbance and residue retention, has resulted in a reliance on herbicides for weed control in Australian cropping systems (Llewellyn and D'Emden, 2010). Whilst herbicides are the most effective weed management practice, the frequent application of herbicides has led to the widespread evolution of herbicide resistance in several major weed species (Walsh and Powles, 2007).

Cover crops are grown during non-grain crop phases (e.g., fallows) primarily to increase the retention of soil moisture and nutrients for subsequent grain crop production, however the resulting biomass production can restrict the growth of weeds. Cover crops are now being considered as new non-chemical alternative weed management option that through competition can suppress the growth of weeds (Reeves, 1994). Studies have shown that competitive winter cover crops, fodder radish (*Raphanus sativus* cv. Brutus), winter oilseed rape (*Brassica napus* cv. Emerald) and winter rye (*Secale cereale* cv. Protector) can suppress weed growth by more than 70% at the experimental farm of Wageningen University, the Netherlands (Kruidhof *et al*. 2008).

Cover crops may have potential for addressing weed issues in the northern grains region of Australia; however, it is currently unclear what cover crop species are suitable for production in this region and their subsequent impact on weed emergence and growth. The general objective of this research was to evaluate the weed control potential of winter cover species suited to the northern grains region of Australia. Specifically, the aims were to determine the effectiveness of three different winter cover crop species, forage oats (grass), purple vetch (legume) and tillage radish (brassica) in supressing weed emergence and growth.

MATERIALS AND METHODS

To determine the weed suppressive abilities of winter cover crops, field trials were conducted in winter 2021 at two locations with contrasting soil types near Camden, NSW. The first site, Bringelly, is a sloping location with a dark loam soil while the second site, Lansdowne, is a grey sand soil type. At both sites, three winter cover crops, forage oats (*Avena sativa*), purple vetch (*Vicia benghalensis*) and tillage radish (*Raphanus sativus*), and a control with no crop (fallow) treatments included. The cover crops were sown in six rows, 25cm apart in plots of 12×2 m dimensions (24 m^2) on the 8th of March 2021. The treatment plots were laid out in a completely randomised block design with 4 replicates. Standard planting rates of 8, 35 and 40 kg ha^{-1} were used for

tillage radish, purple vetch and forage oats, respectively. The field sites were monitored and observed on a fortnightly basis, with the option of supplementary irrigation when required.

Weed plant emergence counts were taken 42 days after crop sowing (DAS) by counting number of plants along 1 m^2 transect randomly placed at three randomly selected positions in each plot. Cover crop and weed plants were harvested at two different times (80- and 120-days post crop emergence) for shoot dry biomass determination. To achieve this, all plants along a 1 m^2 transect were cut at soil surface level and packed into paper bags. The freshly harvested plants were then kept inside an oven set at 70ºC for 72 hours.

Analysis of variance (ANOVA) was performed on all data using a statistical package GenStat Ver. 19.1 (VSN International – UK). The means of crop and weed biomasses at both times and locations were compared using Tukey's 95% confidence intervals to determine the significant difference among treatments.

RESULTS

Weed emergence The Lansdowne site was dominated grass weeds (annual ryegrass, broom grass) while more broad-leaved species (*Fumaria* sp., capeweed, common sowthistle, chickweed etc.,) were present at Bringelly. At 42 DAS weed densities were substantially higher (85%) at Bringelly than at Lansdowne as indicated by the fallow plot weed count data (Table 1). Weed emergence was 42% lower in oats and vetch treatments compared with tillage radish at Bringelly, however weed emergence was similar in all three cover crops at Lansdowne (Table 1).

Table 1. Weed emergence 42 days after crop sowing at Lansdowne and Bringelly sites.

Treatments	weed emergence (plants m^{-2})	
	Lansdowne	Bringelly
tillage radish	18 ±1.5	125 ±8.3
forage oats	15 ±1.2	66 ±3.3
purple vetch	15 ±1.3	77 ±2.7
fallow	19.6 ±5.8	134.6 ±11.9

Crop and weed biomass – Lansdowne At 80 DAS tillage radish produced the highest biomass, averaging 3.2 t ha^{-1} followed by forage oats (2.5 t ha^{-1}) and vetch (1.6 t ha^{-1}) at Lansdowne (Fig. 1 A). Tillage radish and forage oats both reduced weed biomass by 82% more than purple vetch (Fig. 1 B).

At 120 DAS tillage radish and forage oats produced the highest crop biomass of over 4 t ha^{-1}, which was 44% greater than vetch (1.6 t ha^{-1}) at Lansdowne (Fig. 2 A). Tillage radish and forage oats both reduced the weed biomass 90% more compared to purple vetch (Fig. 2 B).

Crop and weed biomass – Bringelly At 80 DAS tillage radish produced 64% higher biomass compared to forage oats and vetch at Bringelly (Fig. 3 A). Forage oats showed the highest weed suppression, reducing the weed biomass by over 90% compared to vetch and tillage radish (Fig. 3 B).

At 120 DAS tillage radish on average produced 41% biomass compared to forage oats and purple vetch, averaging 3.2 t ha^{-1} at Bringelly (Fig. 4 A). There were no significant differences between oats, tillage radish and vetch in terms their weed suppressive ability.

Figure 1: Biomass of cover crops (A) and weeds (B) at 80 days post crop sowing at Lansdowne site, Camden New South Wales. The different small letters above bars show significant differences ($P \leq 0.05$). In the absence of cover crops, weeds produced 1.8 t ha^{-1} biomass at 80 days post crop sowing.

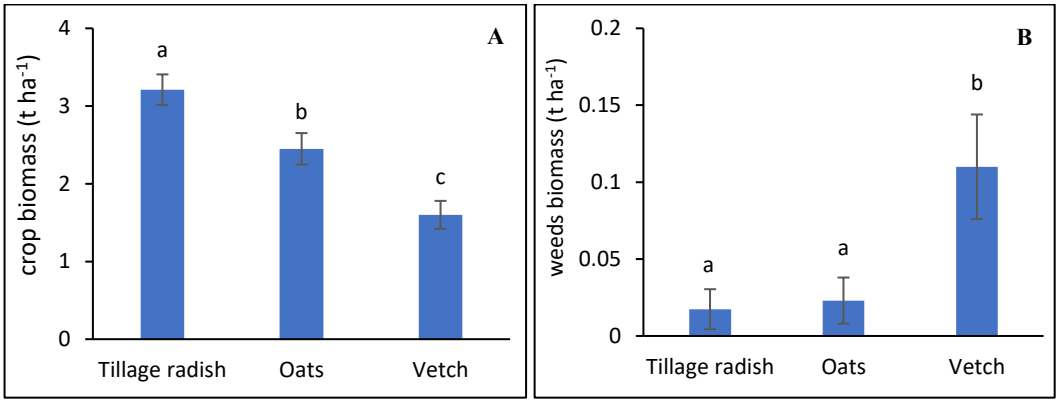


Figure 2: Biomass of cover crops (A) and weeds (B) at 120 days post crop sowing at Lansdowne site, Camden NSW. The different small letters above bars show significant differences ($P \leq 0.05$). In the absence of cover crops, weeds produced 2.9 t ha^{-1} biomass at 80 days post crop sowing.

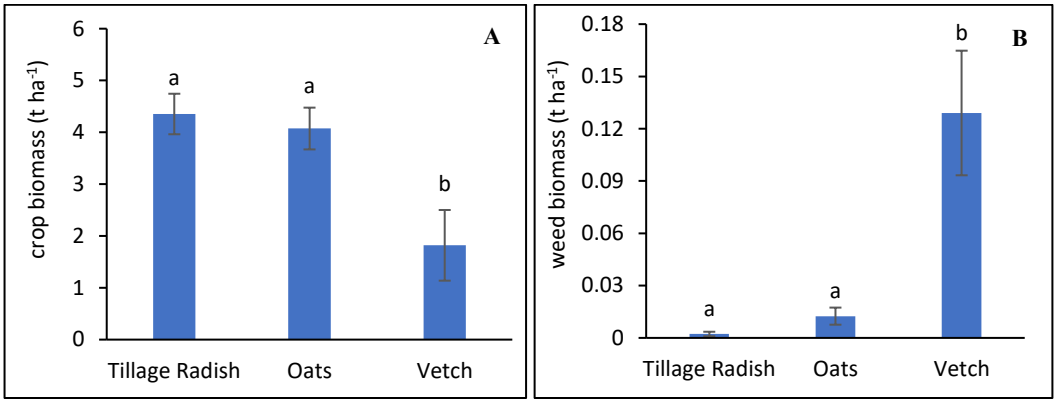


Figure 3: Biomass of cover crops (A) and weeds (B) at 80 days post crop sowing at Bringelly site, Camden NSW. The different small letters above bars show significant differences ($P \leq 0.05$). In the absence of cover crops, weeds produced 1.2 t ha^{-1} biomass at 80 days post crop sowing.

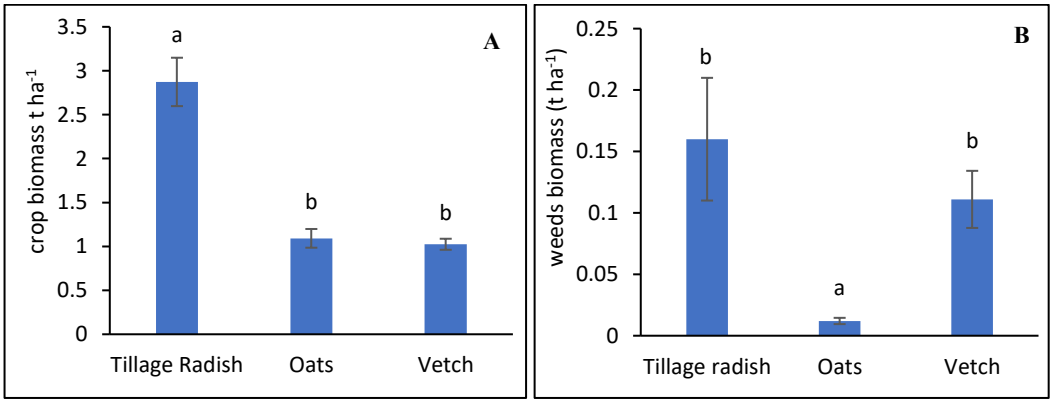
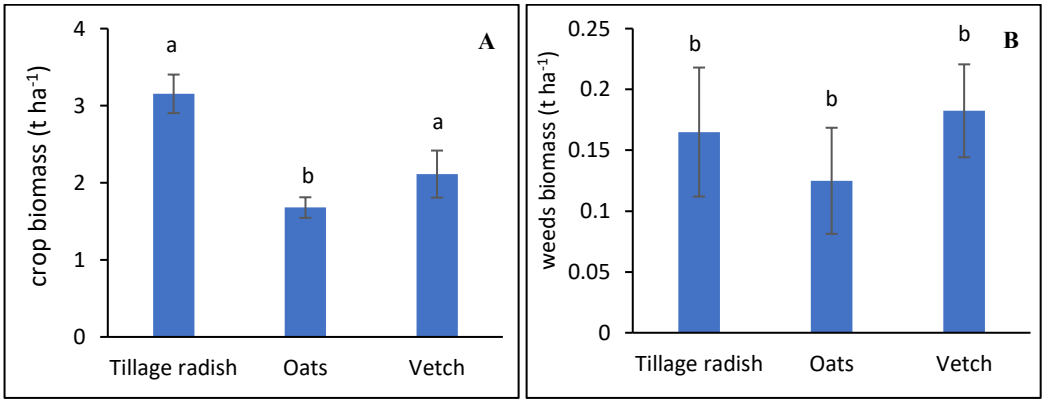


Figure 4: Biomass of cover crops (A) and weeds (B) at 120 days post crop sowing at Bringelly site, Camden NSW. The different small letters above bars show significant differences ($P \leq 0.05$). In the absence of cover crops, weeds produced 2.1 t ha^{-1} biomass at 120 days post crop sowing.



DISCUSSION

The three cover crop species evaluated in these studies have demonstrated the potential for high-level suppression of weed emergence and growth. In general, weed suppression corresponded to the amount of cover crop growth with higher biomass production resulting in lower weed emergence and growth. Even though the biomass of forage oats decreased over time, this species consistently performed better at both locations in terms of its weed suppression ability. In contrast, tillage radish produced a large amount of biomass, but it was only highly competitive against weeds, during the early growth stages (80 DAS). Higher weed biomass in tillage radish plots later in the season (120 DAS) may be in response to the initiation of crop senescing and flowering (Fig. 5). Our results concur with Brennan *et al.* (2005) who reported that mustard (brassica) produced higher early season biomass than oats and legumes. In another study, Ch, *et al.* (2016) found tillage radish, purple vetch and white mustard (*Sinapis alba* L.) suppressed weed growth by 60% at three field locations in Germany.

The Bringelly had much higher background weed densities than Lansdowne. Despite higher densities at Bringelly, forage oats maintained high weed suppression capability during the early crop growth stage at both sites. This indicates that forage oats are a good choice as a winter cover crop species. Winter cover crops are relatively more important in southern parts of the northern grains regions where winter rainfall pattern dominates.

Our research indicates that forage oats and brassica varieties, such as tillage radish are important cover crop varieties to achieve higher biomass production and weed control efficacy at early crop growth stage. However, purple vetch is also effective, but it took longer to establish and has weaker effect on weed growth. This information is useful for grain growers in the northern cropping region of Australia where integration of cover crops in cropping systems holds a great promise.

ACKNOWLEDGMENTS

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