Effect of night cultivation on the emergence and competition of weeds in buckwheat

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Summary The objective of this research project was to identify the effect of night cultivation as a weed management practice to reduce weed populations and their competitive effects within a cropping system. The type of cultivation method used and the degree of soil inversion has been found to alter the number of seeds that are triggered to germinate by a brief exposure to light. For this reason, the project also compared disc tillage and zero tillage systems on potential weed seedling emergence. Buckwheat (*Fagopyrum esculentum* Moench) was chosen as the crop in which to test these effects.

The results of the research indicated the potential for short-term reductions in weed seedling emergence when light is excluded during the process of cultivation and sowing. For example, there was a significant reduction in the number of bladder ketmia (*Hibiscus trionum* L.) and amaranth (*Amaranthus* sp.) seedlings that emerged within 24 days following night soil cultivation and sowing. However, this difference was not observed when measured 37 DAS and later. Disc tillage had significantly higher weed densities and biomasses throughout the experiment than the zero-tillage treatments. The buckwheat crop also suppressed weed populations, such that weeding the crop did not increase yield. These results suggest that night cultivation may yet prove beneficial in an integrated weed management system.

Keywords Night cultivation, emergence, tillage, germination, buckwheat.

INTRODUCTION

Present aims in Australian agriculture include the development of sustainable and environmentally friendly approaches towards weed control. Innovative methods are required to reduce problems associated with soil degradation, erosion, herbicide resistance and soil contamination. The potential for manipulating cultivation and sowing times to reduce the germination and emergence of weeds is one area that has been investigated.

The type of cultivation method used and the degree of soil inversion has been found to alter the number of seeds that are triggered to germinate by brief exposure to light (Botto *et al*. 1998). Research has also indicated that cultivation at night can significantly reduce the number of weeds germinating in crops (Fogelberg 1999). However, there have been few studies of the impacts of night cultivation on weed spectrums and densities under Australian conditions. Stockings *et al*. (2002) showed that night cultivation could slow the rate of emergence of broadleaf and grass weeds but it is not known whether this would translate into increased crop competitive ability and yield. The aim of this research was to test the effects of night cultivation on weed emergence and competition in buckwheat (*Fagopyrum esculentum* Moench), a crop for which there is little information on the effects of weeds.

MATERIALS AND METHODS

An experiment was conducted at the Laureldale Research Station, the University of New England, Armidale, on the Northern Tablelands of New South Wales. The soil type is a high clay chocolate soil (Uf6.32, Northcote 1979). The climate in the Armidale region is dominated by summer rainfall and is classified as cool temperate.

The experiment consisted of seven treatments with four replicates in a randomised complete block design. The treatments consisted of an uncultivated control (no buckwheat sown), and six treatments sown with buckwheat, i.e. night-time zero till (unweeded), day-time zero till (unweeded), day-time zero till (weeded), night-time zero till (weeded), day-time disc cultivated (unweeded), and night-time disc cultivated (unweeded). Weeding was done regularly by hand.

The dimensions of the plots were 6.6 m × 1.4 m with 20 cm spacing between the buckwheat (cv. Kitawase) rows. Buckwheat was sown at 40 kg ha^{-1} with a 3-point linkage twin-cone seeder at a depth of 5 cm.

Round-up Max® (510 g L^{-1} glyphosate) was applied to the entire experimental area nearly three hours prior to cultivation and sowing at a rate of 1.5 L ha^{-1} in 100 L ha^{-1} of water at approximately 11.30 am on 13 January 2003. The disced treatments were ploughed to a depth of 10 cm using a set of discs offset to the 3-point linkage system. The daytime disc treatments commenced at 2.10 pm and the sowing occurred at

2.45 pm in full sunlight. Discing and sowing of the night treatments occurred at 9.15 and 9.35 pm respectively that same evening. The rear tractor lights were covered to minimise light effects, while the front lights were left uncovered during cultivation and sowing.

The weed and buckwheat seedlings in this experiment were slow to emerge due to low summer rainfall in the first two months of the experiment. Supplementary irrigation was therefore applied to encourage weed and crop germination and growth, at 18, 25 and 30 days after the buckwheat was sown.

At 24 and 37 days after sowing (DAS), plants were counted in each of the plots within four randomly placed quadrats each of 0.25 m^2. Seedlings were categorised as either bladder ketmia (*Hibiscus trionum* L.), amaranth (*Amaranthus* sp.), other broadleaf weeds, grasses or the buckwheat crop (*Fagopyrum esculentum*).

Biomass data were collected at 58, 88 and 104 DAS, when two quadrats, each 0.5 m^2, were randomly placed over the centre five rows of buckwheat in each plot. All the plant material within each quadrat was harvested to ground level with hand shears before being dried and weighed. After the final harvest on 26 April 2003, buckwheat seed was separated and also weighed.

The results were subjected to an analysis of variance using the program S-Plus 2000® (MathSoft 1999). Contrast analysis was used to explore individual treatment effects.

RESULTS

When the first counts were made 24 DAS, the emergence of weeds was quite low and the only marginally significant effects (P = 0.058) were those on amaranth (Figure 1), though bladder ketmia responded similarly. At 37 DAS (data not shown), more weeds and buckwheat had germinated, and there were significant treatment effects on both amaranth (P = 0.007) and bladder ketmia (P = 0.014), but not the other species.

At final harvest, after the effects of the 'no crop' treatment were excluded from the analysis, the biomass of amaranth, bladder ketmia, grasses and other broadleaf weeds varied significantly between treatments (P ≤0.012). However, these differences in weed biomass did not translate into significant effects on buckwheat biomass or grain yield.

Contrast analysis indicated that light/darkness had a strong effect (P = 0.047) on the weed count of amaranth at 24 DAS. There were approximately 4.8 amaranth plants m^{-2} in the night treatments compared with 7.6 plants m^{-2} in the day treatments. The difference between the night and day treatments was largely in the two disc treatments where there was considerably more emergence of weeds (Figure 1). Light also increased the emergence of bladder ketmia in the disc treatment 24 DAS (P = 0.058) (data not shown).

The day/night tillage effect did not continue through to 37 DAS, when the number of both amaranth and bladder ketmia seedlings from night treatments matched those in day tillage treatments (P ≥0.42).

Disc cultivation had a major effect on stimulating early emergence of the two main weeds. Effects (P ≤0.038) of disc tillage on the weed counts of both amaranth (80% greater) (Figure 1) and bladder ketmia (50% greater) were seen at 24 and 37 DAS.

The buckwheat crop had a strong competitive effect on weeds generally (other than amaranth),

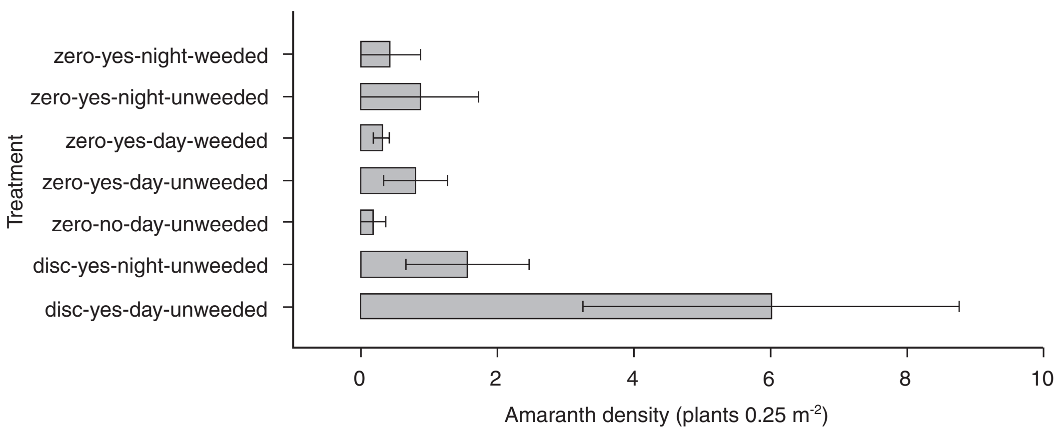

Figure 1. Weed counts for amaranth at 24 DAS. The bars show the mean for each treatment and the error bars indicate the standard error of the mean (disc/zero = tillage type; yes/no = crop present or not; day/night = time of tillage/sowing; and weeded/unweeded = hand weeding).

including the later emerging grasses and other broadleaf weeds ($P \leq 0.017$). As a result, weed biomass was far higher in the treatment where buckwheat was not sown (e.g. see Figure 2 for bladder ketmia). Weed suppression due to the crop ranged from 83% for bladder ketmia to 87% for grasses and 99% for other broadleaf weeds. Weeding the crop did not significantly increase the yield (data not shown).

DISCUSSION

Because of the dry start to this experiment and the need to irrigate with uneven overhead sprinklers, there was a high level of variability in the emergence and biomass data collected. Nevertheless, important results were obtained.

Dark treatment effect The reduction in amaranth and bladder ketmia weed numbers at the first count (24 DAS) indicates the potential for night cultivation to give the sown crop an early growth advantage over some weed species. This initial trend showed generally greater reductions in the two early emerging broadleaf weeds in comparison with the later emerging grasses. Stockings et al. (2002), on the other hand, who conducted their experiment at the same site but later in the season, found that the resident grasses were also suppressed by night cultivation. Different species or groups of species are likely to respond to night cultivation depending on the time of year when sowing occurs (Botto et al. 1998).

It is well known that seasonal patterns of weed emergence may reflect differences in seed dormancy and light dependency combined with changes in environmental factors such as temperature, moisture and nitrate content of the soil (Ascard 1994, Fogelberg 1999). Recent investigations have shown that the effect of night time soil cultivation is also dependent on treatment timing during the season (Fogelberg 1997, Botto *et al.* 1998).

The reduction in weed numbers diminished after the first weed count (24 DAS) and by 37 DAS the difference between the day and night treatments had disappeared. Similar trends occurred in the study by Stockings *et al.* (2002), with the initial differences in weed numbers disappearing by 57 days after the soil was disturbed. Many studies have observed the greatest reductions in weed seedling emergence to occur approximately three weeks after disturbance (Welsh *et al.* 1999). This relatively short time frame for the effective reduction of weed populations in response to night tillage limits the benefits to the weeds germinating at the time of sowing, but these weeds are those that are likely to have the greatest competitive effect on the crop.

Tillage effects A range of factors associated with the tillage treatments may have caused the differences in the results. Research by Botto *et al.* (1998) supports the conclusion that photo stimulation of seed germination by tillage is only caused by photons that reach seeds during cultivation. The germination flush observed in soil cultivated at night, on the other hand, is unlikely to be induced by light that reaches the soil in the days following tillage, but may be triggered by alternative factors.

Tillage practices form an essential component of many weed management programs and for this reason it is necessary to understand the potential negative

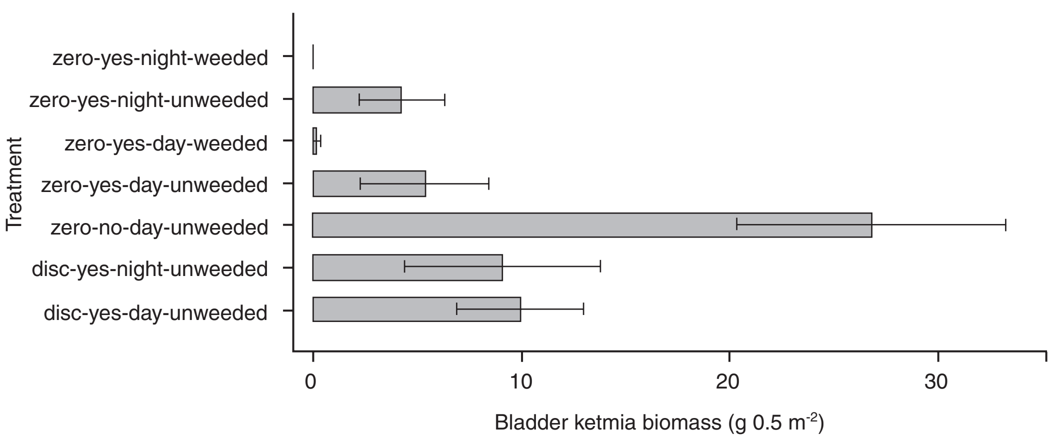

Figure 2. Weed biomass at harvest (104 DAS) for bladder ketmia. The bars show the mean for each treatment and the errors bars indicate the standard error of the mean (disc/zero = tillage type; yes/no = crop present or not; day/night = time of tillage/sowing; and weeded/unweeded = hand weeding).

effects associated with this strategy. The results of this experiment show that the type of tillage used can have significant effects on the weed populations throughout the growing season of a crop. The significantly lower densities of amaranth and bladder ketmia under no till compared to the disced treatments at the first two counts and again at the final harvest indicate the importance of the type of tillage used.

The type of tillage system used can modify the position of weed seeds in the soil profile. Zero-till cropping systems tend to leave seeds in the top 10 mm of the soil. Soil inversion on the other hand caused by disc cultivation has been found to promote weed germination through its effective movement of seeds between depth layers (Cousens and Moss 1990). The first cultivation of soil has been found to bring weed seed to the soil surface, where it is exposed to light before being buried by the second shallower cultivation before sowing (Ascard 1994).

Crop effects The research reported here appears to suggest that buckwheat is highly competitive against weeds such as bladder ketmia and amaranth. Whether this is true for other weeds remains to be examined. The competitive ability of crop species varies considerably and future research with night cultivation should perhaps be aimed at less competitive crops, such as pulses, where suppression of early weed emergence may have most benefit.

Research into the suppressive nature of buckwheat has been minimal, although an experiment by Creamer and Baldwin (2000) showed that it significantly suppressed weeds when grown as a summer cover crop. The rapid growth and thick canopy of buckwheat could possibly provide the key to the competitive nature of buckwheat.

CONCLUSION

This work has shown that night tillage and sowing can suppress early weed emergence in comparison with similar day-time practices. However, the yield of buckwheat was not improved as a result. Given that buckwheat appears to be a strongly competitive crop, future work on night cultivation may best be directed towards less competitive pulses, where the technique may have a more important role to play in an integrated weed management approach.

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REFERENCES

Ascard, J. (1994). Soil cultivation in darkness reduced weed emergence. *Acta Horticulturae* 372, 167-77.

Botto, J.F., Scopel, A.L., Ballare, C.L. and Sanchez, R.A. (1998). The effect of light during and after soil cultivation with different tillage implements on weed seedling emergence. *Weed Science* 46, 351-7.

Cousens, R. and Moss, S.R. (1990). A model of the effects of cultivation on the vertical distribution of weed seeds within the soil. *Weed Research* 30, 61-70.

Creamer, N.G. and Baldwin, K.R. (2000). An evaluation of summer cover crops for use in vegetable production systems in North Carolina. *Horticultural Science* 35, 600-03.

Fogelberg, F. (1997). Photocontrol of weeds: the seasonal variation in weed reduction of night time soil cultivation. Proceedings of the 10th European Weed Research Society Symposium, p. 174.

Fogelberg, F. (1999). Night-time soil cultivation and intra-row brush weeding for weed control in carrots (*Daucus carota* L.). *Biological Agriculture and Horticulture* 17, 31-45.

MathSoft (1999). 'S-PLUS 2000 Guide to statistics, Volume 1.' (Data Analysis Products Division, MathSoft, Seattle).

Northcote, K.H. (1979). 'A factual key for the recognition of Australian soils.' (Rellim, Glenside, SA).

Stockings, G.P., Jessop, R.S. and Sindel, B.M. (2002). A preliminary investigation into the effects of night cultivation and tillage method on weed emergence. Proceedings of the 13th Australian Weeds Conference, eds H. Spafford Jacob, J. Dodd and J.H. Moore, pp. 75-8. (Plant Protection Society of WA, Perth).

Welsh, J.P., Philipps, L., Bulson, H.A.J. and Wolfe, M. (1999). 'Weed control strategies for organic cereal crops', pp. 945-50. (Institute of Agri Technology, Cranfield University, Silsoe, Bedfordshire, UK).