

BRASSICA COVER CROPS FOR WEED CONTROL IN ORGANIC VEGETABLE PRODUCTION

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ABSTRACT

Cover crops (or green manures) are commonly used by organic vegetable growers for soil fertility building and other benefits including weed control. Brassica crops have been reported to control weeds in subsequent crops, usually attributed to the allelopathic effects of glucosinolates (GSL) in the brassica residues, although the effects are inconsistent. New brassica varieties with high GSL levels (*Brassica juncea* cv. Fumus and *Raphanus sativus* cv. Weedcheck) were tested in combination with mechanical weed control and another locally grown forage crop (*Lolium multiflorum* cv. Conquest) for their effects on weed growth during the pre-crop phase and subsequent weed and lettuce growth during the in-crop phase. The cover crops and bare fallow controlled weeds effectively during the pre-crop phase, but did not affect weed and lettuce growth in the following in-crop phase. The cover crops provided better on-going weed control than the bare fallow. Reducing the delay between the pre- and in-crop phases from four weeks to one day did not affect weed and lettuce growth. Weed control was closely related to the amount of light reduction by the cover crops, while competition for nutrients and water appeared to be less important in weed suppression by the cover crops. The use of cover crops requires careful selection of appropriate varieties, attention to good cover crop husbandry (particularly establishment) and an awareness of prevailing weed seed bank levels.

INTRODUCTION

The use of cover crops (or green manures) is a common practice among organic vegetable growers (Beveridge and Naylor 1999, Walz 1999) due to the wide range of important benefits they can provide controlling weeds, improving soil fertility and structure, conserving soil moisture and reducing erosion. Weed suppression by cover crops and their residues may be achieved by resource competition (e.g. light, water, nutrients), allelopathy, niche disruption or a combination of these factors (Creamer and Baldwin 2000). Continuing weed suppression by the cover crop after termination is widely reported (e.g. Ngouajio *et al.* 2003), although some researchers report a lack of follow-on effects (Masiunas *et al.* 1995). Previous research on the weed suppressing capabilities of brassica cover crops (Mason-Sedun and Jessop 1988, Boydston and Hang 1995, Krishnan *et al.* 1998) has been carried out using varieties that had not been specifically developed as weed suppressing cover crops. It is believed that isothiocyanates (ITCs), the breakdown products of glucosinolates (GSLs), are responsible for the allelopathic effects observed (Eberlein *et al.* 1998). A number of new brassica varieties, high in GSLs, have been developed in Australia for biofumigation and weed control in horticultural and other crops. The trials reported here were designed to evaluate the effect of high-GSL brassica crops on weed suppression. Italian ryegrass (*Lolium multiflorum* Lam.), a forage species grown in the New England area of New South Wales, was used to compare with the performance of the lesser known brassica cover crop varieties.

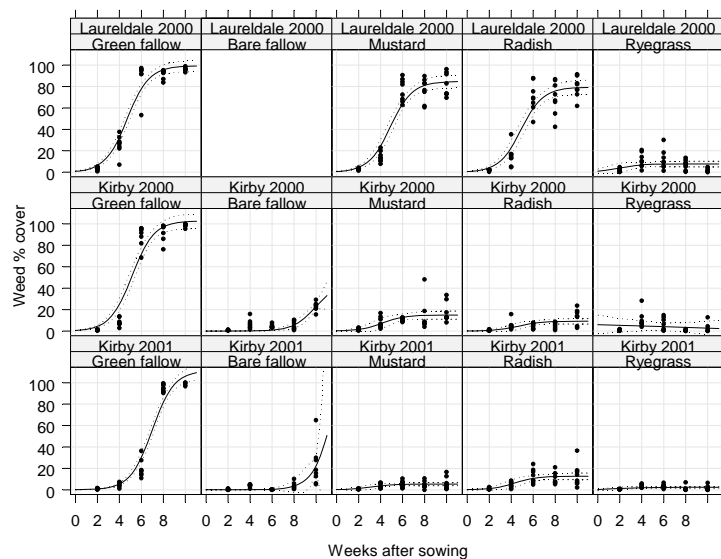
METHODS

Five treatments were tested in the field for their effect on (a) weed suppression during the pre-crop phase (when the cover crops and fallows were present), (b) weed suppression during the in-crop phase (during a subsequent lettuce crop), and (c) lettuce growth during the in-crop phase. The treatments were green fallow (GF), bare fallow (BF), mustard (MU), radish (RA) and ryegrass (RY). The green fallow was left unweeded (the 'control') and bare fallow was weeded using a rotary hoe. The cover crops used in the experiments were mustard (*Brassica juncea* cv. Fumus F-L71), radish (*Raphanus sativus* cv. Weedcheck), and Italian ryegrass (cv. Conquest). At least 4 replicates were used. After 10 weeks, the cover crops were incorporated into the soil by rotary hoeing and lettuces were planted either on the following day or 4 weeks later. Plant-back delay was tested to determine if lettuce growth was inhibited by planting immediately after the brassica cover crops due to possible negative effects such as nitrogen immobilisation or allelopathic suppression. Full details about the methods and results from these trials are available in Kristiansen (2003).

RESULTS AND DISCUSSION

Field trials – pre-crop phase. In most cases, the cover crop growth had a sigmoidal pattern, achieving 50% cover by about 5 weeks after sowing (WAS) and at least 90% by the end of the growing period (data not shown). The main exception was at Laureldale where the two brassicas failed to establish effectively due to poor seed bed preparation in the heavy clay soil. Weed % cover during the pre-crop phase is shown in Figure 1. Weeds in GF increased rapidly from 3 to 5 WAS and reached complete coverage of the plots by between 6 and 9 WAS. At Laureldale, where FU and RA failed to establish effectively, weed growth was not suppressed. In contrast, the other treatments (BF, MU, RA and RY) all strongly suppressed weed growth. In the cover crop treatments, weeds grew initially but then leveled off as the cover crop out-competed the weeds. In the BF treatment, however, weeds were controlled initially but on-going suppression did not occur. The difference is minor in this trial but indicates that cover crops are able to readily control weeds over a substantial period of time with little on-going cost, while tillage provides only short-term control. However, with large weed seed banks, several tillage passes may be an effective method of depleting the seed bank, whereas cover crops may not be able to out compete the weeds. The cover crops rapidly reduced light levels (data not shown), depriving weeds of a key resource for growth. The dense ground coverage produced by RY was reflected in very low light transmittance. MU was the least able to reduce light levels due its tall, open growth habit; however, RA was effective at reducing light levels when it achieved good growth, in part because of its tendency to form a broad, dense and flat rosette before flowering. Reduced light has been cited as an important factor in the suppression of weed emergence and growth (Ballaré and Casal 2000). Competition for soil nutrients and moisture was not directly investigated in these experiments, although water and nutrients were unlikely to be limiting. The continued emergence of weeds in all cover crops up to 8 WAS suggests that allelochemicals were not strongly effective in reducing weed germination and emergence.

Figure 1. Effect of pre-crop treatments on weed % cover. The dots show the data points, the solid lines are the logistic regression curves and the dashed lines are the 95% confidence limits. The bare fallow treatment was not used at Laureldale in 2000.



Field trials – in-crop phase. Despite reports from anecdotal and published information about the carry-over effect of brassica cover crops the effects of the pre-crop treatments on the growth of weeds or lettuce during the in-crop phase were not significant (Figure 2). Biomass production by the cover crops produced about 5,000 kg/ha (except the brassicas at Laureldale), which is consistent with many other reports of cover crop biomass growth (Stivers-Young 1998, Creamer and Baldwin 2000) and weed suppression was effective in the pre-crop phase. Teasdale (1996) has suggested that *surface residues* from cover crops can be expected to provide early-season weed suppression only. Incorporated residues may be less effective due to soil disturbance during tillage promoting a new flush of weeds, the lack of ground cover to prevent light transmission to emerged weed seedlings, and higher nutrient inputs from decomposing residues. It is also possible that the weed seed bank was very high and that the pre-crop treatments had a relatively minor effect on overall seed levels. The brassicas used in our trials were selected based on advice that these crops had shown strong suppression of subsequent weeds and crops (J. Kirkegaard, pers. comm.). However, the delay before planting lettuces may have been too long, as recent research has found that GSL levels decrease rapidly in the soil (~48 hours) (Morra and Kirkegaard 2002), so it is unlikely that the allelochemicals would still be active after 4 weeks.

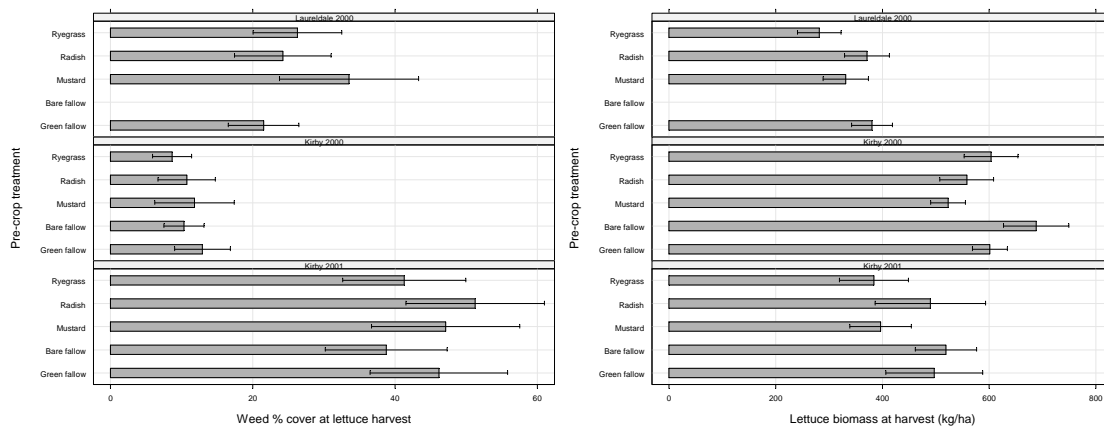


Figure 2. Effect of cover crops on weed (left) and crop (right) growth in the lettuce phase. The mean and standard error are shown.

In a later trial, the effect of planting lettuce immediately after cover crop incorporation was evaluated (Figure 3). Weed % cover was higher in the no delay treatment than the delayed treatment at only 2 weeks after planting (WAP) and there was no difference in final weed density or biomass (data not shown). Lettuce growth was generally not affected by the plant-back delay treatments, except mid-way through the lettuce phase when %cover at 4 WAP was significantly higher for the delayed plant-back treatment (Figure 3), but this difference was only temporary, with lettuce % cover and final biomass (data not shown) being similar for both treatments. Several reports on the effects of brassica cover crop residues on cash crops, including some that cite allelopathic effects in the laboratory, state that inhibition of cash crop growth in the field was generally not observed or that growth was increased (Kirkegaard *et al.* 1994, Santos and Leskovar 1997). Mason-Sedun and Jessop (1988) indicated that incorporating low volumes of brassica residues in soil showed an increase in test plant growth, possibly due to extra nutrients and/or improved soil structure.

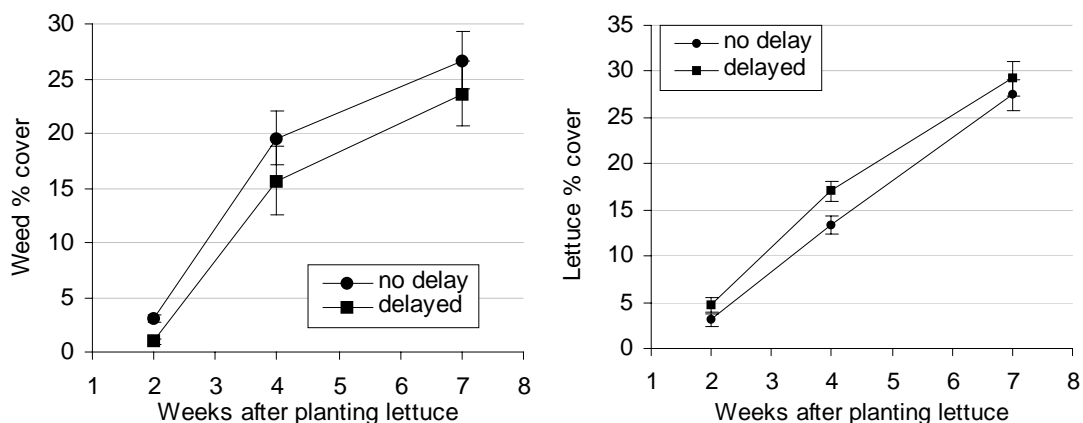


Figure 3. Effect of plant-back delay on weed % cover (left) and lettuce % cover (right) during the lettuce phase. The symbols (● = no delay, ■ = delayed) indicate the mean of each treatment and the error bars indicate the standard error.

CONCLUSIONS

The brassica cover crops used in these trials were varieties that have been developed for weed and pest suppression in horticultural and other cropping systems. Although they suppressed weeds while they were growing, they did not have any effect on weed or crop growth during the subsequent lettuce phase. Weed suppression by the cover crops was correlated with the reduction in light reaching the soil surface. While allelopathy and competition for nutrients and water were not directly measured in the field, indirect observations suggested that these factors were not dominant in suppressing weed growth, a conclusion supported by other published research on the dominance of light in similar resource competition interactions. The bare fallow treatment also provided effective weed control during the pre-crop phase, although it too had no apparent effect on weed and crop growth in the lettuce phase. The bare fallow reduced weed density more than the cover crops and this may have longer-term benefits for weed seed bank decline, or where prevailing weed seed levels are very high. Reducing the period between incorporating the cover crops and planting the lettuce crop from 4 weeks to 1 day did not produce greater weed suppression and did not have a negative impact on lettuce

growth. These trials provide no evidence of the strong phytotoxic effects often attributed to brassica crops, and the rapid breakdown of GSLs reported in the literature suggests that suppression observed in the field may be due to other factors. The two brassicas tested should be sown at the commercially recommended rate, or greater, into well prepared seed beds in order to produce a cover crop that generates sufficient biomass to suppress weeds. The findings also highlight the importance of maintaining good soil nutrient levels, especially nitrogen, when incorporating cover crops. A suitable option may be to grow and incorporate cover crop mixtures, e.g. mustard and vetch. Once weeds are established in a cover crop, organic growers have very few options: hand weeding is likely to be economically unviable and tillage may only provide a partial solution. It is very important, therefore, that the cover crops are managed effectively. Selecting a suitable variety for the local conditions and using a high sowing rate can reduce the risk of cover crop failure. Several areas which require further research include the selection of cover crop species suited to organic systems in specific climatic and cropping situations, and the development of low-till systems that do not rely on herbicides, especially techniques for terminating cover crops effectively.

REFERENCES

- Ballaré, C.L. and Casal, J.J. (2000) 'Light signals perceived by crop and weed plants', *Field Crops Research* 67:149-160
- Beveridge, L.E. and Naylor, R.E.L. (1999) 'Options for organic weed control - what farmers do' (in Marshal, G., (ed.) (1999) *Proceedings of the 1999 Brighton Conference - Weeds*. 15-18 November 1999, British Crop Protection Council, Surrey)
- Boydston, R.A. and Hang, A. (1995) 'Rapeseed (*Brassica napus*) green manure crop suppresses weeds in potato (*Solanum tuberosum*)', *Weed Technology* 9:669-675
- Creamer, N.G. and Baldwin, K.R. (2000) 'An evaluation of summer cover crops for use in vegetable production systems in North Carolina', *HortScience* 35:600-603
- Eberlein, C.V., Morra, M.J., Guttieri, M.J., Brown, P.D. and Brown, J. (1998) 'Glucosinolate production by five field-grown *Brassica napus* cultivars used as green manures.' *Weed Technology* 12:712-718
- Kirkegaard, J.A., Gardner, P.A., Angus, J.F. and Koetz, E. (1994) 'Effect of *Brassica* break crops on the growth and yield of wheat', *Australian Journal of Agricultural Research* 45:529-545
- Krishnan, G., Holshouser, D.L. and Nissen, S.J. (1998) 'Weed control in soybean (*Glycine max*) with green manure crops', *Weed Technology* 12:97-102
- Kristiansen, P. (2003) 'Sustainable Weed Management in Organic Herb & Vegetable Production' Doctor of Philosophy thesis. University of New England, Armidale.
- Masiunas, J.B., Weston, L.A. and Weller, S.C. (1995) 'The impact of rye cover crops on weed populations in a tomato cropping system', *Weed Science* 43:318-323
- Mason-Sedun, W. and Jessop, R.S. (1988) 'Differential phytotoxicity among species and cultivars of the genus *Brassica* to wheat. II. Activity and persistence of water-soluble phytotoxins from residues of the genus *Brassica*', *Plant and Soil* 107:69-80
- Morra, M.J. and Kirkegaard, J.A. (2002) 'Isothiocyanate release from soil-incorporated *Brassica* tissues', *Soil Biology and Biochemistry* 34:1683-1690
- Ngouajio, M., McGiffen, M.E. and Hutchinson, C.M. (2003) 'Effect of cover crop and management system on weed populations in lettuce', *Crop Protection* 22:57-64
- Santos, J.R.A. and Leskovar, D.I. (1997) 'Interference from broccoli; vege residue on *Brassica* germination and seedling growth', *Journal of the American Society for Horticultural Science* 122:715-720
- Stivers-Young, L.J. (1998) 'Growth, nitrogen accumulation, and weed suppression by fall cover crops following early harvest of vegetables', *HortScience* 33:60-63
- Teasdale, J.R. (1996) 'Contribution of cover crops to weed management in sustainable agricultural systems', *Journal of Production Agriculture* 9:475-479
- Walz, E. (1999) 'Final Results of the Third Biennial National Organic Farmers' Survey' Organic Farming Research Foundation, Santa Cruz.