Going organic: a study of weed management in an intensive organic vegetable production system

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Summary The conversion of a ten hectare conventional farmlet in north-west Tasmania to a certified organic intensive vegetable production system over a three year period highlighted weeds as the most challenging management issue. The project objectives were to test and evaluate on a commercial scale, organic production protocols for a range of vegetable crops. Weed management issues were addressed through assessment of weed species present and field evaluation of a range of non-herbicide weeding techniques. Detailed organic weed management protocols are presented for onions (*Allium cepa* L.), carrots (*Daucus carota* L.), and broad beans (*Vicia faba* L.) as examples of non-herbicide weed management in vegetable crops. The field study indicated an increased focus on mechanical weed control methods is essential for organic vegetable cropping if time consuming hand weeding operations are to be minimised or eliminated. Field operator experience in the timing and use of equipment such as flame and brush weeders was shown to be an essential requirement for successful weed management.

Keywords Organic, certification, non-herbicide, commercial, vegetables, onions, carrots, broad beans, brush weeder, flame weeder.

INTRODUCTION

Organic farming is estimated to be growing at 30% a year worldwide and growth is largely market driven (Troeth 2001). Internationally the organics industry is worth approximately $40 billion in trade (Fielke 2001). However, the size of the industry relative to the conventional food production industry is still relatively small. The current export market demand for certified organic produce, especially vegetables, exceeds supply (Kinnear 2000) and in many cases produce attracts premium prices (Fielke 2001). In Australia, organic retail sales are worth over $250 million annually and approximately $40 million worth of organic produce is exported (Rosenbaum 2001). Despite this, growth of the organics industry relative to the conventional industry is very small. In Australia, large scale intensive organic vegetable producers focused on export markets do not exist. There is a lack of information necessary for conventional producers to assess the economic benefits or otherwise of converting a large scale conventional vegetable production system to an organic one. This is thought to contribute to a lack of large scale growth.

It was the market potential for organically produced vegetables, combined with a dearth of data on commercial production of intensively cropped organic vegetables, that resulted in a partnership between a Tasmanian vegetable packer, Field Fresh Tasmania, and the Department of Primary Industries, Water, and Environment (DPIWE). The purpose of the partnership was to undertake project work to examine the feasibility of growing vegetable crops organically at a commercial scale.

The project objectives were to test and evaluate on a commercial scale, organic production protocols for a range of vegetable crops. Weed management was identified as a major issue. This paper describes how the project addressed weed management within the parameters of organic certification standards. It focuses on three potential organic export crops (carrots, onions, and broad beans) and describes potential non-herbicide weed management protocols for those crops

METHODS

The project is in its fourth year of operation and has grown vegetable crops over three seasons, 1999/2000, 2000/01 and 2001/02. The focus of the project work was field evaluation of organic production techniques under commercial cropping conditions. The methodology centred on the conversion of 10 hectares of conventional vegetable production land to a certified organic status. The organic certifying body selected was the National Association of Australian Agriculture (NASAA).

The project site was located at Forth at the very centre of intensive conventional vegetable production in Tasmania. Designed as a 'Paddock to Plate' project, a range of vegetable crops were selected that were considered to have likely export prospects as organic produce. A range of 'best bet' options (either under trial internationally or currently used in market garden organic enterprises) for organic management of these crops was selected and screened using the certification requirements of the certifying body (NASAA 2001). The management options that proved acceptable to

NASAA certification requirements were then field tested on the project farm with the selected crops.

Six cropping units of 1.3 ha were established on the 10 hectares where crops were planted. Each unit was split in two by an irrigation run, and the actual units were separated by a hedgerow planting of myrtus berries (*Ugni molinae* Turcz). The farm was designed to have one paddock rotating through the system as a pasture phase in any cropping season. In 1999/2000 and 2000/01, carrots, and broad beans were grown meeting organic pre-conversion requirements. Five crops were sown in 2001–2002. They were onions, shallots (*Allium cepa* L.), carrots, broad beans, and snow peas (*Pisum sativum* L.). One unit was sown to oats (*Avena fatua* L.) representing a pasture phase.

Weed management was addressed through the use of a number of mechanical weeding techniques.

- **Flame weeding** Seedbeds were prepared six weeks before planting the crop. Flame weeding applications were made at approximately two week intervals.
- **Brush weeding** After flame weeding, brush weeding treatments were conducted at various stages through crop growth on an as needs basis.
- **Manual handweeding** For the control of intra-row weeds, handweeding teams were employed to weed the crop. Manual handweeding consisted of a team of handweeders using hands and hand tools such as hoes.
- **Mechanised handweeding** A self propelled Drangen hand weeding platform was used to mechanically assist handweeders remove intra-row weeds.

Weed surveys were initiated at the project site in 2001/02 to benchmark weed populations in each of the cropping units and assist in forward planning for weed management.

All crops were harvested as commercial crops and subsequently marketed. Weed management improvements have progressively been identified and incorporated into subsequent cropping seasons.

RESULTS AND DISCUSSION

Weed control in the absence of herbicides was the dominant pest management issue in this project. This highlights the need to focus on efficiency improvements in non-herbicide weed management. Weed management is particularly challenging in *Allium* crops such as onions that do not form a canopy. In these crops, this necessitates constant weed control through to harvest.

Weed survey A weed survey of the six established cropping units identified some of the major weed species present. Results for onions, carrots and broad beans are reported in Table 1. This data will be used in future to assist in unit selection for future planting and as a benchmark to assess long term impact of non-herbicide weed management on weed population and species spectrum. The highest number of weed species was found in the onion crop with the lowest number in the broad beans. Throughout crop growth weed management in the canopy forming crops such as broad beans and carrots was much less demanding than crops that did not form a canopy such as onions. This was attributed to the shading out of subsequent weed growth later in the season.

Non-herbicide weed management protocols for onion, carrot, and broad bean crops were established and consist of a range of well timed mechanical techniques (Table 2).

Table 1. Indication of weed species number and examples of major weeds in organic farming units sown to onions, carrots and broad beans.

Crop	No. weed species	Major weeds
Onions	22	*Amaranthus powellii* S.Watson, *Chenopodium album* L., *Trifolium repens* L., *Capsella bursa-pastoris* L.
Carrots	7	*A. powellii*, *Raphanus raphanistrum* L., *Brassica rapa* L., *C. bursa-pastoris*
Broad beans	6	*R. raphanistrum*, *Sonchus oleraceus* L.

Table 2. Non-herbicide weed management protocols for onions, carrots, and broad beans.

Crop	Technique	Crop stage (weeks)	Weed stage (true leaf)
Onions,	Flame weed	4 (pre-plant)	2–4
carrots,	Flame weed	2 (pre-plant)	2–4
broad beans	Flame weed	Post-plant/ Pre-emerge	2–4
Onions	Brush weed	2 (post-emerge)	4
	Brush weed	As needed	4
	Brush weed	As needed	4
	Hand weed	As needed	
	Hand weed	As needed	
Carrots	Brush weed	As needed	4
	Brush weed	As needed	4
	Hand weed	As needed	
Broad beans	Brush weed	As needed	4
	Brush weed	As needed	4

Effective weed management techniques incorporated into the commercial cropping process were:

Flame weeding The application of flame was restricted to newly germinated weeds. This required two applications to treat successive germinations. The final flame weeding treatment that took place was post-sowing and pre-emergence of the crop and was considered essential to flame weeding efficacy enabling crop emergence into a weed free seedbed.

Brush weeding Following crop emergence, brush weeding was used as the main replacement for a post-emergence herbicide use. Brush weeding is a mechanical method of removing small weeds from row crops using rotating brushes of hard nylon bristles (Orr 2001). Brush weeding was found to be very effective at the two to four true leaf weed stage. Operator skill in tractor driving and guiding the brush-weeder was seen as critical to the success of the technique. Incorporating crop guards allowed brushing as close as 20 mm either side of the crop rows however the operation was slower. Increasing the guards to a distance of 32 mm allowed brushing to be done twice as fast (average speed 2 km h^{-1}, 3 hours per hectare). It is expected that further development of operator skill should result in increased speeds of up to 4 km h^{-1}. The technique could also be improved with the installation of remote guidance systems on the weeder thus replacing the operator (McPhee pers. comm.).

Carrot crops were identified as ideal crops to brush weed with only one well timed brush weeding needed before canopy closure. Brush weeding operations were effective on both dry and moist soils. Efficacy was reduced if rainy wet conditions followed allowing the weed seedlings brushed from the soil to re-strike.

Brush weeding needed to be combined with hand weeding to be truly effective. The principle reason was the inability to weed intra-row; a hand weeding following a brushweeding focused on intra-row weed removal.

Manual hand weeding All the commercial crops tested required one or more hand weeding operations. Hand weeding is the non-herbicide weed management operation that poses the greatest risk to the economic viability of a commercial intensive organic vegetable production operation. Benchmarked weeding hours (Table 3) were calculated for onions and carrots planted in 2001/02.

Most time consuming to hand weed were onions which had been planted in a commercial planting configuration of four sets of paired rows; each of the paired rows were 75 mm apart. As a result, intra-row weed problems were increased necessitating increased manual weeding. This highlighted the need to change crop planting configurations if undertaking non-herbicide weed management operations.

Mechanised hand weeding During 2001/02, a Drangen handweeding platform was purchased and preliminary field tests conducted. The platform is a petrol engine powered vehicle with narrow rubber tracks. The tracks can be adjusted to span crop rows or beds. The machine can carry several workers lying face down on benches mounted on the frame. Each worker is able to use both hands to do jobs such as rapid and efficient hand weeding (Bishop 2002). Although the machine will be fully tested in 2002/03, combined with increased efficiencies using the other mechanical techniques it is likely to increase efficiencies of handweeding if the operation is required.

This project demonstrated that non-herbicide weed management protocols could be successfully implemented in carrot, onion, and broad bean crops. Appropriately timed flame weeding was essential to successful weed management in the crops discussed. The timing of brush weeding operations and increased skill in use of this technique presents a viable replacement for post-emergent herbicides in carrot, onion, and broad bean crops. Hand weeding was necessary for the onion and carrot crops and this is likely to pose the greatest threat to the economic viability of commercial production. Hand weeding efficiencies are enhanced through the use of mechanical aids such as the Drangen weeding platform but system development needs to minimise or eliminate the need for hand weeding. Comparative economic analysis of the listed weed management protocols with conventional herbicide based weed management systems is required.

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Table 3. Benchmarked hand weeding hours per hectare for onion and carrot crops across seasons 1999/2000 and 2001/2002.

Crop	(hours of handweeding per hectare)
Onions	2261
Carrots	1772

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