# Sustainable weed control in cucurbit crops: A scoping study

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**Abstract**
Weeds have a significant impact on the production of cucurbit crops in Australia, and yet relatively little work has been conducted to develop integrated and sustainable forms of weed management in these crops. In this project we sought to scope the impact of weeds on cucurbit production, identify current techniques used by growers and assess their effectiveness and sustainability, and explore innovative approaches used in Australia and overseas. The research included a review of Australian and international literature, and consultation with cucurbit growers, herbicide producers and distributors.
Weeds were reported to have a significant impact on cucurbit crop yield and quality, making crop management problematic. Significant weeds include fat hen (*Chenopodium album*), blackberry nightshade (*Solanum nigrum*), caltrop or cathead (*Tribulus terrestris*), pigweed/purslane (*Portulaca oleracea*), African lovegrass (*Eragrostis curvula*), barnyard grass (*Echinochloa* spp.), and nutgrass (*Cyperus rotundus*). A successful integrated weed control strategy usually involves a mix of herbicide use, plastic mulch, cultivation, chipping, crop rotation and farm hygiene. Diligence and timing are important factors in a successful approach.
However, the ongoing success of this approach is not assured, due to lack of herbicide options, noted instances of herbicide resistance, and questions about the long-term sustainability of plastic mulch. Innovation is therefore required to sustain Australia's cucurbit industry. Options include registering new herbicides, developing a viable biodegradable mulch film, and exploring promising techniques such as living and killed mulches, controlled traffic farming, stale and false seedbeds, and thermal weeding.

**Key Words**
Integrated weed management, cucurbit vegetables, weed impact, innovation, scoping study.

## Introduction

Cucurbits represent a significant component of the Australian fruit and vegetable industry. Watermelons are the most valuable cucurbit crop in Australia, followed by pumpkins, zucchini/button squash, rockmelons/cantaloupe, and cucumbers. Production occurs year round, with approximately half of cucurbit production taking place in Queensland. The gross value of the cucurbit industry in Australia was estimated at $339 million in 2008-09 (ABS 2010a; ABS 2010b).

Cucurbit production in Australia is focused on domestic fresh markets, with relatively little processing taking place (Kelly 2007). The most significant export markets include New Zealand, Japan, Hong Kong, Singapore and Papua New Guinea (RIRDC 2010).

Cucurbits occupy relatively large areas of land for production due to their sprawling vines. This habit, the highly disturbed nature of the soils in which crops are often grown (promoting weed germination), and a lack of herbicides able to selectively control broadleaf weeds in these broadleaf crops, can make weed control difficult. Weeds in cucurbit crops reduce crop yield, adversely affect fruit quality, interfere with sowing and harvesting operations, and can act as hosts for pests and diseases.

This scoping study, funded by Horticulture Australia Limited (HAL), was the first step in addressing the high industry priority of exploring possible control options for broadleaf weeds in cucurbits.

## Methods

*Literature review*
The impact of weeds and issues relating to their control were explored through a review of Australian and international literature. While broadleaf weeds were the main focus, grass weeds were also included where relevant. Sources in Australia included academic literature, government extension documents, relevant reports produced by HAL and other grower peak bodies, industry magazines and newsletters, weed-specific organisations such as the Council of Australian Weed Societies, research organisations, and the Australian

Bureau of Statistics. International literature (primarily from the United States) was also sourced for comparative purposes, or to identify weed control techniques not yet evaluated fully in Australia.

*Grower survey*

A questionnaire was developed, and evaluated by several government and consulting horticulturalists and industry representative body staff. Questionnaire topics included farm and grower characteristics, the impact of weeds on cucurbit farm operations, current weed control practices, and emerging and future herbicide and non-herbicide control techniques. The sample frame was constructed from the AusVeg mailing list, by selecting 1,765 growers from 417 post codes identified as encompassing cucurbit producing regions. The mailout was completed by AusVeg. The mail questionnaire was supplemented by an online questionnaire, promoted by AusVeg and the Australian Melon Association.

Despite the number of surveys send to growers, a relatively poor response of 46 completed surveys was received. Reasons for this low response may include 'survey fatigue' within the agricultural sector, ongoing effects of flooding within many cucurbit producing regions, and lack of time due to farm operations.

*Field work*
Project staff travelled to Bundaberg, Qld, in October 2011. The field work goal was to validate the findings of the literature review and survey, and identify issues that had not yet been explored. Three farm visits were conducted with growers identified by the Bundaberg Fruit and Vegetable Growers Association.

*Chemical company survey*
Contact was made with eight herbicide distributors and manufacturers. Representatives were asked to confirm currently registered herbicides for cucurbit situations, whether they were aware of any off-label trials that have shown potential in cucurbit crop situations, whether any currently available herbicides could be tested for weed control in cucurbits, and whether they were aware of relevant forthcoming products.

**Results and Discussion**
*The impact of weeds*
Weed management costs have been estimated to range from 2-22% of total variable expenses for Australian vegetable producers (Henderson and Bishop 2000). However, cucurbit growers find it difficult to estimate the economic impact of weeds, due to lack of recorded information, and the fact that techniques used to control weeds often have a variety of other crop benefits, making it difficult to separate the impact on weeds from other impacts.

Weeds compete with vegetable crops for soil nutrients, moisture and light, restricting crop development and eventual yield. Weeds have been found to reduce yield by up to 40%, particularly if weed infestations are heavy during the early growth stages of the crop (e.g. Macrae et al. 2008). Specific weed impacts on yield include crop damage associated with weed control activity, and difficulties harvesting all fruit in dense weed infestations.

Pests and diseases that impact on both the yield and quality of vegetable crops may be hosted by weeds. In Australian cucurbit crops, there is considerable evidence that weeds, particularly broadleaf weeds that share certain characteristics with cucurbit plants, act as 'infection reservoirs' for several viruses and other diseases (Coutts and Jones 2005).

Weeds have a range of implications for managers of vegetable crops, reducing effective coverage of insecticide applications, making it difficult to identify pests in the crop, interfering with harvesting equipment, and making harvesting much slower for human pickers (Henderson and Bishop 2000). For cucurbit growers, weeds are a particular issue at certain times of the season, for example after fruit set when the crop plants start to die off, and after rainfall. Nutgrass (*Cyperus rotundus*) is significant for the difficulty it causes growers for plastic mulch and drip line removal post-harvest.

*Significant weeds in the Australian cucurbit industry*
The most significant weeds amongst growers contacted included fat hen (*Chenopodium album*), blackberry nightshade (*Solanum nigrum*), caltrop or cathead (*Tribulus terrestris*), pigweed/purslane (*Portulaca oleracea*), African lovegrass (*Eragrostis curvula*), barnyard grass (*Echinochloa* spp.), and nutgrass.

*Current weed control approaches*
The most successful approach integrates black plastic mulch, pre-plant herbicide application, and weed control in the inter-row space early in the life of the crop plants, before the plant vines and roots have a chance to spread and be damaged by control activity. Inter-row weed control may involve shielded spraying or cultivation, depending on grower preference. Chipping or hand weeding is undertaken to control larger weeds that may impinge on harvesting, or those growing out of the crop holes in the plastic. Crop rotation is undertaken primarily for its disease control benefits, with weed control flexibility an important subsidiary benefit. Hygiene practices are implemented to restrict the spread of weed propagules. Diligent growers generally control weeds before they set seed. Appropriate timing of weed control activities may be the difference between a weed-free crop and one that is densely populated with weeds at harvest, and takes into account crop life stage, weather conditions, and control of recently germinated weeds.

However, the ongoing success of this approach is not assured. Five herbicides are registered for weed control in various cucurbit crops in Australia. Of these, three (fluazifop-p, sethoxydim, and quizalofop-p-ethyl) are used for selective control of grass weeds, while clomazone and dimethenamid-p may be used to control a limited range of broadleaf weeds. There is therefore a lack of herbicide options for growers, and with weed resistance already noted for some of these products (e.g. Owen and Powles 2009), growers need to remain aware of the potential for resistance to develop in significant weed species.

The use of plastic mulch is coming under increasing social pressure, due largely to the environmental problems posed by disposal. Disposal options such as ploughing the mulch into the soil, burning or disposing at local land-fill sites are being progressively banned or restricted, and are becoming less acceptable to the community (Henderson and Bishop 2000; Wright 2000). Despite its cost competitiveness, the longer-term future viability of plastic mulch in Australian vegetable production therefore appears doubtful.

*Future weed control options*
Despite the current success of the integrated approach outlined above, alternatives are therefore required. The research identified a range of options used by organic growers in Australia, and under development in Australia and overseas. These options may be incorporated into the current integrated approach favoured by many growers. They include:

- living and killed mulch systems, generally cereal crops, that may prevent weed germination due to their allelopathic effects (Horticulture Australia 2005);
- controlled traffic farming, combined with a permanent crop bed and zero-till system to reduce weed seed stimulation, and therefore weed competition in crop beds (DPIPWE 2010);
- stale and false seedbeds, where germinating weeds are controlled either with a knock-down herbicide or shallow cultivation before the crop is planted (Taylor 2009); and
- thermal approaches including flaming and steam weeding, which may be used as alternatives to knock-down herbicides (Kristiansen and Smithson 2008).

Currently, these approaches are not widely used in Australian vegetable production, and are considered by many non-organic growers to be of limited value and practicality in comparison with their current approach. Growers are, however, very interested in new weed control options if they prove effective, practical, and economically viable. These approaches therefore warrant further exploration given their potential to reduce reliance on herbicides or plastic mulch.

We identified a number of herbicides registered for use in cucurbit crops overseas that may provide growers with a wider range of herbicide options. These include clethodim, halosulfuron, imazosulfuron, s-metolachlor, glufosinate-ammonium, metribuzin, and haloxyfop. However, Australian distributors indicated that the high cost of registration and the relatively small market for these herbicides in the cucurbit industry meant that registration was unlikely without at least some financial support from industry.

Biodegradable mulches are proposed as an alternative to plastic mulches. They are designed to degrade several months after being laid, so that they maintain sufficient weed control and moisture retention in crop, but degrade sufficiently that they may be cultivated into the field post-harvest, leaving no toxic residues or plastics in the soil. These mulches have been under evaluation in Australia for more than a decade, with recent trial work being undertaken near Bowen, Queensland (Heisswolf and Wright 2010). Growers are currently uncertain about the performance of biodegradable mulch, and their ability to apply it to the crop beds without significant expense on new equipment. Nonetheless, they remain positive about the potential of biodegradable mulch, with the majority surveyed suggesting that a replacement for conventional plastic mulch should be a high industry priority.

**Conclusion**

Although growers are currently able to control weeds with some success, innovative approaches need to be explored to ensure the ongoing viability of cucurbit production in Australia. Further information is also required on the most important weeds in cucurbit production, to allow growers to better understand their impact and control. Areas for future research should therefore include: exploring the ecology of significant weeds for cucurbit production, their impact on yield and management, and the costs of control; evaluating a number of innovative approaches to weed control to determine their viability for 'conventional' cucurbit growers in Australia; and trialling and, if appropriate, registering additional herbicides to improve the range of products available to growers.

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