Improved management of residual herbicides

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Summary Residual herbicide carry-over can reduce the yield of subsequent crops in a rotation. A number of replicated field trials were conducted in conjunction with sampling from commercial crops where damage from herbicide residues was reported. Soil herbicide concentration was measured using supercritical fluid extraction and GCMS analysis. Herbicides studied included pendimethalin, clomazone and oxyfluorfen.

A yield response was demonstrated for oxyfluorfen in zucchini crops and pendimethalin in poppy crops. Kabocha did not show any yield response to oxyfluorfen. Crop damage with clomazone in onions was observed in commercial crops, however in the trial concentrations were too low to observe any yield effects of clomazone in onions.

Soil herbicide concentrations that were measured using supercritical fluid extraction and GCMS have shown good correlation with crop yields in trials and commercial crops. Given the relatively low cost and speed of sample analysis this testing procedure has potential to be used as a tool in management of cropping systems.

Keywords Pendimethalin, clomazone, oxyfluorfen, GCMS, supercritical fluid extraction, herbicide residues.

INTRODUCTION

With the increased use of pre-emergent herbicides in horticultural production, significant improvements in weed management have been achieved. Pre-emergent herbicides are an effective tool in weed control strategies, but what is their effect on following crops? There is some evidence of saleable yield reduction in crops following certain herbicide strategies, whilst in isolated cases crop failure has occurred. Conversely, the use of lower rates for particular soil conditions often results in poor weed control. More intensive/varied rotations along with less tolerant, higher yielding varieties may have increased these problems, which become particularly pronounced when new herbicides are used or when herbicides are used in new production regions.

This work was conducted as part of a Horticulture Australia project in collaboration with the University of Tasmania. The field component of this project focused on establishing rates of herbicide breakdown under different field conditions and then measuring the growth and yield response of a number of crops to varying soil concentrations of these herbicides in both commercial crops and replicated trials. Herbicides used in this project were clomazone, pendimethalin and oxyfluorfen.

MATERIALS AND METHODS

Crop yield response trials were conducted at Forthside Vegetable Research Station, at Forth, in Northwest Tasmania. The soil at the site was a ferrosol soil with 3.1% organic carbon, 18% clay and a pH (1:5 water) of 6.2. Trials were set up in a randomised complete block design with three replicates. Herbicides were applied pre-plant and incorporated to a depth of 15–20 cm using a tractor powered roterra. A total of six soil cores (0–10 cm) were taken randomly across each plot on the day of planting for herbicide concentration measurement. Soil samples were frozen and stored before analysis.

Soil herbicide concentrations were quantified using supercritical fluid extraction and detection using GCMS. Extraction conditions using supercritical fluid have been developed and tested on six soils. Percentage recovery of herbicide from spiked soil samples is similar in all soil types indicating the validity of the method for assessing total herbicide concentrations in soils. The extraction conditions are as follows:

- 1 g soil sample mixed with 0.6 g hydromatrix to prevent soil compression.
- Extraction at 380 atmospheres, 50°C oven temperature and 5% MeOH modifier.
- 2 mL min^{-1} flow rate, 2 minute static extraction followed by 30 minute dynamic extraction.
- Trapped in Florisil (100–200 mesh) and eluted with 1.5 mL DCM.

Statistical analyses were conducted using the analysis of variance test in the computer program Statgraphics. Points on the graphs with the same letter are not significantly different at the 5% level according to Duncan new multiple range test.

RESULTS

Results from the field trial show a significant poppy yield reduction when the pendimethalin concentration is above 400 ppb (Figure 1). This is supported by data

collected from different regions in a commercial poppy crop where visual damage occurred at a concentration of 397 ppb and above (Table 1).

Zucchini were sensitive to oxyfluorfen residues in the soil and yield was lower in all treatments compared to the untreated control, however, this was only significant at rates of 400 g oxyfluorfen ha^{-1} (Figure 2). Kabocha showed no yield response to oxyfluorfen at rates of up to 800 g ha^{-1} (Figure 3). Soil samples were taken from these trials to measure the oxyfluorfen concentrations at planting, however this data was not available at the time this paper was prepared.

Soil concentrations of up to 192 ppb did not affect the yield of onion crops (Figure 4), however, data collected from a commercial crops shows an effect on crop growth at concentrations above 420 ppb (Table 2).

DISCUSSION

Poppy crops are known to be particularly sensitive to pendimethalin residues in the soil. Field trials and sampling from commercial crops has shown that pendimethalin concentrations of 400 ppb and above are likely to cause a significant yield reduction in poppy crops.

Field experience has suggested that some cucurbit crops are affected by oxyfluorfen residues in the soil. Field trials showed zucchinis to be more susceptible to oxyfluorfen than Kabocha.

Crop damage due to clomazone residues in the soil have been observed in some commercial onion crops. A field trial showed no crop damage or yield reduction when clomazone was present at concentrations of up to 192 ppb. Data collected from commercial crops suggests that damage occurs at clomazone concentrations above 420 ppb.

Table 1. Effect of pendimethalin concentration on poppy growth in a commercial crop.

Level of damage	Pendimethalin concentration (ppb)
No damage	265
Minor damage	397
Significant damage	680

Table 2. Effect of clomazone concentration on onion growth in a commercial crop.

Level of damage	Clomazone concentration (ppb)
No damage	<50
Minor damage	420
Significant damage	493

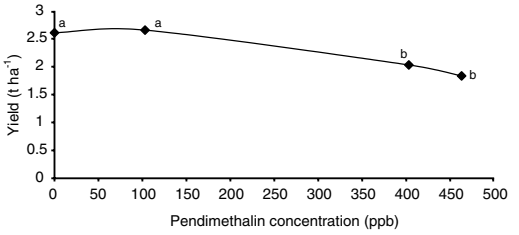

Figure 1. Effect of pendimethalin concentration on poppy yield.

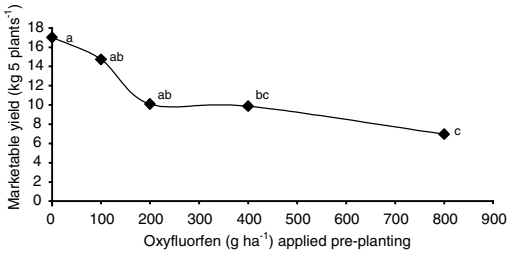

Figure 2. Effect of oxyfluorfen application rate on zucchini yield.

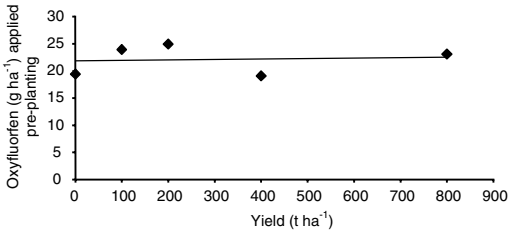

Figure 3. Effect of oxyfluorfen application rate on kabocha yield.

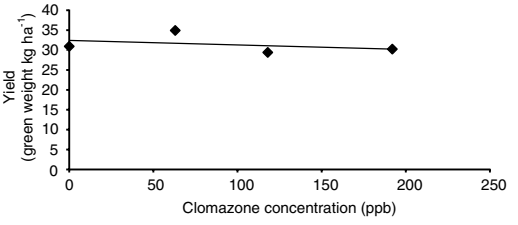

Figure 4. Effect of clomazone concentration on onion yield.

These trials have not evaluated the effect of other factors such as soil moisture, crop nutrition and location of herbicide residues in the soil profile and how these factors interact with crop yield responses to different herbicide concentrations.

Soil herbicide concentrations measured using supercritical fluid extraction and GCMS have shown good correlation with crop yields in trials and commercial crops. Given the relatively low cost and speed of sample analysis this testing procedure has potential to be used as a tool in management of cropping systems.

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