Strategies for controlling weeds in New Zealand apple orchards

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Summary The effect of several weed management systems on the weed flora of an apple orchard was assessed over a 3-year period in Hawke's Bay, New Zealand. The most troublesome species in the herbicide-treated plots were the rapidly maturing annual species and also perennial weeds tolerant of glyphosate that crept in from the adjacent mown strips. Plots treated with bark mulch were colonised by spreading perennial weeds and rapid growing annual weeds from seed dispersed by wind or birds. Mown plots changed over time to become dominated by grass weeds, clovers and a number of rosette weeds such as *Crepis capillaris* (L.) Wallr. Several ground cover species were also evaluated, both with and without selective herbicides. The ground cover species treated with herbicides were soon dominated by weed species that could tolerate both mowing and the selective herbicides used. Fescue (*Festuca rubra* L. var. *rubra*) plots were almost as dense regardless of whether herbicides were used, whereas dichondra (*Dichondra micrantha* Urban) needed winter herbicide applications to remain pure. Hydrocotyle (*Hydrocotyle heteromeria* A.Rich.) plots became swamped with weeds, even those treated with herbicides. Measurements of tree growth showed that young apple trees are substantially affected by competition during the first few years. Thus strategies such as mown ground covers can only be contemplated once trees are well established if major decreases in early growth are to be avoided.

Keywords Orchard, ground cover, *Festuca rubra*, *Dichondra micrantha*, bark mulch, mowing.

INTRODUCTION

In New Zealand, there has been considerable pressure from producer boards over the last few years to move away from weed control strategies in fruit crops such as apples and kiwifruit that rely heavily on use of herbicides. The standard weed control practice for many years has been to mow the area between tree rows and to keep the soil within the tree rows bare using a combination of knockdown and residual herbicides (Harrington *et al.* 1992). Use of residual herbicides is now actively discouraged, and even knockdown herbicides such as glyphosate are less favoured than they once were by producer boards. Growers are being encouraged to investigate the use of mulches or mown ground cover swards under their trees.

Several field trials have already been conducted in New Zealand to investigate use of orchard ground covers (e.g. Harrington 1995, Hartley and Rahman 1998). Other trials have been conducted to determine how best to manage weeds that invade ground covers (e.g. Harrington and Rahman 1998, Harrington *et al.* 1999).

The trial reported in this paper was established in a new apple block within a Hawke's Bay orchard in spring 1998 to investigate a number of different chemical and non-chemical weed management strategies. The trial is still proceeding, and Hartley *et al.* (2000) reported some of the initial results. This paper will concentrate on showing how the weed flora was influenced by each of the strategies used.

MATERIALS AND METHODS

Strips of ground 2 m wide in a Havelock North (Hawke's Bay) orchard were rotary hoed, with a 3 m strip of grass left uncultivated between each row. One-year-old apple trees (A38R2T119 on MM106 rootstock) were planted 3 m apart in the cultivated strips in September 1998. The rows were divided into plots 9 m long and 1.8 m wide, and different weed management strategies were allocated to each plot, with each treatment replicated three times. All the plots had two trees within them from which measurements were taken, and a 'guard tree' at either end.

One treatment involved herbicide applications several times a year, mainly of glyphosate, to keep the soil relatively bare and to simulate normal practice. Another treatment had a bark mulch approximately 15 cm deep laid down over a sheet of corrugated cardboard, and any weeds which established in this were occasionally spot-sprayed with glyphosate. Volunteer vegetation within the plots of a third treatment was managed by mowing every 1–2 months. Fescue plots were established by sowing seeds (30 kg ha^{-1}), while dichondra and hydrocotyle were transplanted using 5 cm diameter plugs at 23 cm spacing. All ground cover plots were mowed every 1–2 months, with half of them receiving no herbicide and half of them sprayed with selective herbicides approximately once a year. During establishment, oxadiazon and oryzalin were used in the dichondra plots, oxadiazon in the hydrocotyle plots and MCPB in the fescue plots. The fescue plots were resown in April 1999 due to poor establishment over the first summer. Further details of establishment techniques can be obtained from Hartley *et al.* (2000).

Once plots were established, annual winter spraying of the dichondra used tribenuron, clopyralid and haloxyfop. The hydrocotyle plots were sprayed with haloxyfop and dicamba, and the fescue plots received haloxyfop and clopyralid.

At regular intervals each year, the percentage cover of weeds and ground cover species within each plot was estimated. The fresh weight of mown clippings from each plot was recorded. Measurements were made of tree performance with data on fruit production, trunk girth and tree height.

RESULTS

Within the first few months after establishing the treatments, most plots became smothered in high densities of annual weed species, especially *Solanum nigrum* L., *Chenopodium album* L. and *Veronica persica* Poir. Other weed species included annuals such as *Polygonum aviculare* L. and *Coronopus didymus* (L.) Smith, biennials such as *C. capillaris*, *Picris echioides* L., and some perennials such as *Trifolium repens* L., *Plantago lanceolata* L., *Bromus willdenowii* Kunth and *Rumex obtusifolius* L.

Some of the selective herbicides used at establishment helped to reduce this initial weed invasion, but often only changed the flora within the plots. The MCPB was applied too late, so few weeds were affected by it. The oxadiazon within the hydrocotyle plots removed the domination by the susceptible *C. album* and *S. nigrum*, but did not control the *V. persica* or the *P. aviculare*. The addition of oryzalin to the oxadiazon within the dichondra plots helped reduce establishment by *V. persica*, but those plants which did establish still resulted in high weed covers in these plots by rapid lateral growth.

Mowing of the plots over the first few months also helped reduce problems from the upright annual species such as *S. nigrum*, though the selective residual herbicides generally achieved this more successfully.

Within four months, mown plots had become dominated by the prostrate perennial *T. repens*, though many other prostrate species were also present, such as *V. persica*, *P. aviculare*, *C. capillaris* and *Modiola caroliniana* (L.) G.Don.

By April 1999, six months after treatment establishment, summer annuals had become less of a problem as they died off naturally, and the prostrate perennial species such as *T. repens* and *M. caroliniana* continued to spread and dominate, as did *Trifolium pratense* L. and *P. lanceolata*. Grass species such as *Lolium perenne* L., *Elytrigia repens* (L.) Nevski, *B. willdenowii* and *Poa annua* L. were also becoming more evident by this time. The fescue plots were re-established after removing weeds present using glyphosate, but these plots were soon dominated by *V. persica* and other grass species which were not affected by the MCPB used.

Over the subsequent years, the mown treatment in which no ground cover was sown nor any herbicides applied became dominated mainly by grass species and white clover. Other prostrate species present included perennials such as *M. caroliniana*, *T. pratense*, *Taraxacum officinale* G.Weber, *Oxalis corniculata* L. and *P. lanceolata*. The periodic mowing also allowed species such as *V. persica*, *C. capillaris* and *Sonchus asper* (L.) Hill to establish and maintain a presence.

A similar weed composition formed within the unsprayed hydrocotyle and dichondra plots. The competition exerted by these weeds resulted in the hydrocotyle completely disappearing from the plots within the first 12 months (Figure 1). However, the dichondra was less affected by the competition and has continued to grow in the unsprayed plots, though it has never dominated the plots. Due to its C_4 physiology, it tends to grow more successfully than most of its C_3 competitors during the dry summer months, resulting in an increased cover by autumn. However, without herbicide assistance in winter, this low-growing species with poor winter growth is usually at low densities by spring (Figure 1).

Unlike hydrocotyle and dichondra, the unsprayed fescue grew aggressively once it managed to establish successfully, and has provided over 95% coverage of the plots since July 2000. As a result, weed species were significantly affected by this ground cover, and overall weed content within these plots has been consistently below 25% since May 2000. The main weed

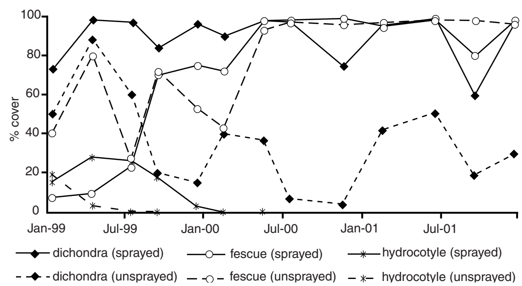

Figure 1. The percentage of ground covered by the planted species during the first three years of the trial.

species in the unsprayed fescue plots since Year 2 has been *C. capillaris*, though other rosette weeds such as *P. lanceolata*, *T. officinale* and *S. asper* have also been present. Other grass species such as *B. willdenowii* have been present at low densities, and the stoloniferous perennial *M. caroliniana* has managed to creep in from the alleyways adjacent to the fescue plots.

Although the unsprayed hydrocotyle did not persist very long, removing grass weeds with haloxyfop in winter, plus some broad-leaved species with dicamba, helped hydrocotyle persist for longer in the sprayed treatment. However, there were still many weed species that survived in these plots, including *M. caroliniana* and *P. lanceolata*. Competition from these remaining weeds, plus an intolerance of summer dryness, resulted in hydrocotyle disappearing from the trial by February 2000.

The mixture of haloxyfop, tribenuron and clopyralid each winter has permitted most weed species to be removed annually from the sprayed dichondra plots. However, *M. caroliniana* is one species not totally controlled by this mixture, and so this recovers during spring to cause some problems. Generally the sprayed dichondra sward has given very good cover of the soil through most of the year, although dichondra plants become damaged by frosts over winter. This can cause a partial opening of the sward by spring, allowing *Veronica arvensis* L. and *V. persica* the opportunity to establish each year. As dichondra seldom grows more than 2–3 cm tall, other weed species do build up during the growing season each year, such as grasses, *C. capillaris*, *T. officinale*, *T. repens* and *P. lanceolata*. Thus winter spraying is needed to keep the dichondra sward pure. A few species other than *M. caroliniana* capable of tolerating these winter herbicides have begun accumulating recently. These include a sedge species (*Carex divulsa* Stokes), *O. corniculata* and *Hydrocotyle novae-zeelandiae* DC.

Due to the aggressive growth of fescue, sprayed plots of this species look little different to unsprayed plots. There are generally very few species capable of tolerating both the fescue and the winter spraying, though new weeds occasionally do manage to establish after mowing.

Clippings collected from the mown plots between October 1999 and February 2000 showed that the least foliage was being produced from within the sprayed dichondra plots, due both to the low weed invasion in them and the prostrate nature of dichondra (Table 1).

Other treatments with minimal weed growth were the mulched plots and those kept bare by continuous spraying (Table 1). The bark mulch stopped most of the initial weed growth seen in other plots. However the bark mulch would have become very weedy within the first 12–16 months if spot-spraying with glyphosate had not occurred. A few perennial weeds such as *R. obtusifolius* managed to emerge through the bark from root systems left alive prior to laying of the mulch. Most weed problems though came from lateral stoloniferous growth from weeds in the adjacent mown alleyway, such as *M. caroliniana* and *T. repens*, and from seeds germinating on top of the mulch. Seeds could have landed on the mulch from wind-blown seed (e.g. *Sonchus oleraceus* L., *S. asper*, *C. capillaris*), in dung from birds perched in the trees (*S. nigrum*), or from inadequately mown weeds growing immediately beside the mulch dropping seeds on the mulch (e.g. *B. willdenowii*, *V. persica*).

In the frequently sprayed plots, a wide range of mainly annual weed species germinate soon after each application of the non-residual herbicides. Densities of these seedlings have decreased over time, and moss has become quite dense during winter. Species with partial tolerance to glyphosate such as *M. caroliniana* and *T. repens* grow along the margins of these plots, and spread laterally into the plots after each application.

Measurements of trunk extension have shown that growth of apple trees was significantly reduced by weed competition in all but the mulched and continually sprayed plots (Table 1).

DISCUSSION

Although the weeds causing problems in each of the treatments were often similar, a number of differences also existed. Annual weed species were more of a problem after the first year only in those plots with minimal competition for emerging seedlings, especially the frequently sprayed plots and those with mulch. The mown plots tended to contain more prostrate perennial species after the first year, especially grasses, rosette weeds and those with stolons. *M. caroliniana* tended to be troublesome in most treatments due to tolerance to most herbicides used and lateral spread from adjacent areas.

With all mown plots, tree growth and fruit yields within the first 12–24 months were severely reduced compared with the frequently sprayed and mulched plots (see Hartley *et al.* (2000) for further data).

However, trees are generally considered to be more susceptible to competition from weeds during the first few years after establishment. Once trees are well established, mown ground covers should cause less of an adverse effect on fruit yields. Harrington *et al.* (1999) showed dichondra planted under 5-year-old apple trees had no adverse effect on fruit yields.

Although the fescue plots kept weeds under control better than the dichondra, the aggressive growth of the fescue is probably as competitive with the trees

Table 1. The mean percentage ground cover of weed species within orchard plots at four times during the trial, the mown clippings from October 1999 to February 2000 (total from six cuts), and mean tree trunk extension during the first growing season.

Treatment	Weed cover (%)				Sward FW ($kg\ m^{-2}$)	Trunk extension (cm)
	Dec-98	Dec-99	Nov-00	Dec-01		
mown sward	99	94	98	90	3.3	42.5
herbicide strip	40	3	6	3	–	73.7
mulch strip	5	6	7	4	–	80.8
dichondra (unsprayed)	97	87	99	90	3.7	43.2
dichondra (sprayed)	88	17	27	22	0.4	43.2
fescue (unsprayed)	95	47	12	22	1.6	38.9
fescue (sprayed)	98	40	8	4	1.5	40.7
LSD (P=0.05)	29.2	16.3	11.1	13.4	0.37	28.1

as many weed species. Data from the clippings (Table 1) suggests that sprayed dichondra is the least competitive of the mown treatments assessed. As herbicides need to be applied to dichondra only in winter while trees are dormant, this treatment has advantages over the continual herbicide application strategy which risks contamination of fruit when spraying during the season.

If moving away from a continual herbicide programme, the best overall weed control strategy in orchards may be to use bark mulch under trees for the first few years to eliminate early competition problems. Occasional spot-spraying would allow the bark to remain weed-free for longer. After 2–3 years, dichondra could be established directly on the decomposing bark, or after clearing the bark. These treatments are presently being assessed at Havelock North.

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