# OPTIMISING TIME OF PLANTING AND HERBICIDE APPLICATION FOR CONTROL OF PROBLEM WEEDS IN MAIZE

T.K. JAMES, A. RAHMAN and M. TROLOVE

*AgResearch, Ruakura Research Centre, Private Bag 3123, Hamilton, New Zealand*

*Corresponding author: Trevor.james@agresearch.co.nz*

## ABSTRACT

Field trials in Waikato, Bay of Plenty and Manawatu investigated the efficacy of pre- and post-emergence herbicides for weed control in maize crops planted early, mid or late season with prior cultivation or into a stale seedbed. Achieving good control of broadleaf weeds was easier than for annual grass weeds. Some weed species germinated over a long period from spring to summer months. The residual activity of pre-emergence herbicides was not sufficient for season-long control of such weeds in the early and mid planted crops and a post-emergence herbicide was essential to control them and to maintain grain yields. When grass weeds were dominant, the pre- and post-emergence combination still did not provide season long control in the early plantings. In late planted crops, weed control was also poor in the absence of a post-emergence herbicide even though few weeds were present at the post-emergence application time. The weed seedbank was reduced where good weed control was achieved.

**Keywords:** maize, herbicide, weed control, post-emergence, grass weeds, weed seedbank.

## INTRODUCTION

Previous studies have shown that adequate control of weeds is critical for the period 4 – 10 weeks after emergence of maize crops (Hall et al. 1992; James et al. 2000). The soil weed seedbank in all the maize growing regions of New Zealand is frequently very large (Rahman & James 1993; Rahman et al. 1996). Furthermore, the major weed flush usually starts earlier than the planting time of maize crops and the sequential emergence continues well into the summer in most years (Rahman & James 1993). Competing weeds can cause severe yield reductions in maize crops, with losses of 30% to 70% recorded in New Zealand studies (Rahman 1988; James & Rahman 1994; James et al. 2000). Grass weeds often tend to be more competitive than the broadleaf weeds (James et al. 2000).

Current practices of weed control in maize involve predominantly spring cultivation (multiple passes) and the use of selective pre-emergence herbicides followed by a selective post-emergence herbicide if necessary. Unfortunately, despite the large herbicide input, this system struggles to control late germinating summer grasses and some broadleaf weeds, such as fathen (*Chenopodium album*), thorn apple (*Datura stramonium*) and apple of Peru (*Nicandra physalodes*). This has become more critical now that growers plant much earlier than in the past due to greater availability of 'cool tolerant' hybrid cultivars.

Considerable information is available on the efficacy of various herbicides currently used in maize crops in New Zealand. What is lacking, however, is the knowledge to optimise the use of these herbicides in relation to crops planted at different times during spring to early summer. The objective of this study was to investigate the performance of herbicide options in maize crops planted at different times with prior cultivation or



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into a stale seedbed and to determine the best scenario for controlling problem weeds and maintaining grain yield.

## MATERIALS AND METHODS

Two trials were carried out during each of the 2004/05 and 2005/06 growing seasons to evaluate the effect of planting time on the efficacy of standard weed control treatments.

Trials 1 and 3 were located near Matata in Bay of Plenty where summer grass (*Digitaria sanguinalis*) was the predominant weed. This site has a sandy soil with a pH of 6.1, an organic matter content of 6.6% and a density of 0.85 kg/litre. Trial 2 was on a property near Hamilton in Waikato where the problem weed was atrazine-resistant fathen. This site has a silty loam soil with a pH of 5.8, organic matter content of 10.6% and a bulk density of 0.73 kg/litre. Trial 4 was located in Manuwatu near Palmerston North. This site has a history of significant amounts of hemlock (*Conium maculatum*). The soil is a silt loam of the Kairanga series, having a typical bulk density of 0.9 kg/litre.

All sites were cultivated by the growers immediately before the trials commenced on 6 and 7 October 2004 for Trials 1 and 2, and 26 September and 18 October 2005 for Trials 3 and 4. The maize (*Zea mays* var. Pioneer 36B08) was planted at 95,000 seeds/ha by hand in Trials 1, 3 and 4, while Trial 2 was planted with a tractor mounted precision seeder at 89,000 plants/ha. DAP starter fertiliser was applied at a rate of 200 kg/ha to each plot. The planting dates for all trials are presented in Table 1. Treatment 1 was planted immediately following initial cultivation. Before Treatments 2 and 3 were planted, the plots were cultivated again with a small motorised rotary hoe. Treatments 4 and 5 were sprayed with glyphosate (Roundup Renew®) at 650 g a.i./ha to kill the existing weeds and then planted without further cultivation (i.e. a stale seedbed). A pre-emergence herbicide application of acetochlor + atrazine (Roustabout + Gesaprim) at 2.5 + 1.5 kg a.i./ha was applied to all treatments on the day of planting. Post-emergence applications of nicosulfuron + adjuvant (Amaze + Amaze Activator) at 60 g a.i./ha + 0.5% v/v were applied to Trial 1 on 22.11.04 (Trt 1) and 23.12.04 (Trts 2–5), Trial 2 on 19.11.04 (Trt 1) and 24.12.04 (Trts 2–4), Trial 3 on 23.11.05 (Trts 1–4) and Trial 4 on 1.12.05 (Trts 1, 2 and 4). The Treatments that did not receive a post-emergence herbicide application (Trials 2 and 3 – Treatment 5; Trial 4 – Treatments 3 and 5) contained few weeds at the time. All herbicides were applied with a $CO_2$ powered back pack sprayer fitted with TeeJet 11003 nozzles at 750 mm spacing delivering 210 litres/ha spray mix at 200 kPa.

**TABLE 1: Method of seedbed preparation and planting dates for the Trials 1–4.**

| Treatment | Planting time | Seedbed preparation | Planting date | | | |
|---|---|---|---|---|---|---|
| | | | Trial 1 | Trial 2 | Trial 3 | Trial 4 |
| 1 | Early | Cultivation | 6.10.04 | 7.10.04 | 26.9.05 | 18.10.05 |
| 2 | Mid | Cultivation | 22.10.04 | 26.10.04 | 24.10.05 | 28.10.05 |
| 3 | Late | Cultivation | 11.11.04 | 19.11.04 | 8.11.05 | 10.11.05 |
| 4 | Mid | Stale seedbed | 22.10.04 | 26.10.04 | 24.10.05 | 28.10.05 |
| 5 | Late | Stale seedbed | 11.11.04 | 19.11.04 | 8.11.05 | 10.11.05 |

Weed control scores (100=no weeds to 0=no weed control) were based on a visual assessment of weed health and ground cover. In Trial 3 the amount of summer grass present on 23 February 2006 was measured by harvesting duplicate 0.1 $m^2$ quadrats from each plot and drying at 80°C for 48 h. Maize populations and grain yields were determined by counting the number of plants in and harvesting cobs from 5-metre strips in the central two rows of each plot. Trials 1–4 were harvested on 13 April 2005, 26 April 2005, 4 April 2006 and 26 April 2006 respectively. Extra cobs were collected to determine the grain

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moisture content at harvest. The shelled grain was weighed and a subsample collected for moisture determination. Grain moisture was determined by drying a 200 g sample at 105°C for 24 h. All grain yields are adjusted to 14% moisture content.

Soil samples were collected from all trials (to 100 mm depth) at the time of grain harvest for bioassay of herbicide residues using oats (*Avena sativa* Var. Hattrick) and turnips (*Brassica rapa* Var. Barkart) as the test species (James et al. 1995). Soil samples were also collected from Trials 3 and 4 (to 100 mm depth) at the time of the first cultivation and again at harvest for weed seedbank enumeration (Rahman et al. 2001a).

All weed control and yield data were subjected to analysis of variance (ANOVA) to separate the means. The arithmetic means and least significant differences (LSD) are presented in the tables. The weed seedbank data were analysed using a paired t-test to determine significant differences in the before planting and after harvest seedbank populations.

## RESULTS AND DISCUSSION

All sites received adequate rainfall throughout the season to keep the soil moist and there was no moisture stress on the plants at any stage. In general, the pre-emergence herbicide failed to adequately control the problem weeds and a post-emergence herbicide was required to achieve acceptable control of all the weeds present.

In the early planted treatment (Trt 1) of Trial 1, the pre-emergence herbicide controlled the summer grass for about 4 weeks. After this time new seedlings emerged, which were controlled by the post-emergence herbicide applied at 6 weeks after planting. However, this combination of pre- and post-emergence herbicides still did not have sufficient residual activity to prevent very late weed emergence, resulting in a lower level of weed control later in the season (Table 2). In the mid and late plantings the pre-emergence herbicide also controlled the summer grass for about 4 weeks. However, the application of the post-emergence herbicide to the mid planting plots (Trts 2 and 4) was delayed due to adverse weather until 8 weeks after planting, which proved too late to adequately control the rapidly growing summer grass. The late planted plots (Trts 3 and 5) were treated at the same time but in this case it corresponded to only 6 weeks after planting and the level of summer grass control achieved was significantly better than for the mid-season planting (Table 2). The poor weed control in the mid-season planting was reflected in the final grain yields with this treatment producing significantly less grain than Treatments 1 and 3. The early and late cultivated plantings had similar yields although the grain from the late planting contained significantly more moisture (Table 2), which would generate higher post harvest drying costs. The stale seedbed treatments (Trts 4 and 5) were heavily predated by greasy cutworm (*Agrotis ipsilon aneituma*), which reduced the maize plant population by about 75% and gave exceptionally low yields from these plots. The greasy cutworm probably lived on the weeds present in the stale seedbed plots until the maize emerged.

Results for Trial 2 were similar to Trial 1 in that the early planted plots required an application of post-emergence herbicide earlier than the mid and late planted plots and by the end of the season there were significantly more weeds in the early planted plots than in the rest of the trial (Table 2). In this trial there was a significant trend towards reduced grain yield with later planting times. This was probably solely due to the effect of planting time and associated weather conditions as in this trial, the level of weed control achieved was excellent in all treatments.

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**TABLE 2: Weed control score (0–100) and maize moisture content (%) and grain yield (t/ha) for Trials 1 and 2.**

| | Weed control score[1] | | | | Grain | | | |
|---|---|---|---|---|---|---|---|---|
| | Trial 1 | | Trial 2 | | Moisture (%) | | Yield[2] (t/ha) | |
| Trt | 23.12.04 | 15.3.05 | 24.12.04 | 18.3.05 | Trial 1 | Trial 2 | Trial 1 | Trial 2 |
| 1 | 94[3] | 80 | 94[3] | 90 | 15.1 | 15.2 | 13.2 | 13.4 |
| 2 | 50 | 69 | 67 | 95 | 22.9 | 20.3 | 10.9 | 11.7 |
| 3 | 55 | 88 | 85 | 98 | 21.7 | 19.8 | 12.6 | 10.6 |
| 4 | 53 | 51 | 83 | 98 | 27.9 | 22.0 | 3.3 | 11.5 |
| 5 | 94 | 71 | 100 | 100 | 26.3 | 21.2 | 3.3 | 10.1 |
| LSD (P<0.05) | | | | | | | | |
| | 18.1 | 15.7 | 9.6 | 4.5 | 2.13 | 3.67 | 1.11 | 1.56 |

[1]Weed control score: 100=no weeds, 0=no weed control.
[2]Yield adjusted to 14% moisture content.
[3]Note that at the time of this assessment the plots in Trt 1 had already been treated with a post-emergence herbicide.

In Trial 3 the weed assessment of 23 November 2005 revealed a moderate infestation of summer grass in Treatments 1–4 (Table 3) but a higher level of control in the stale seedbed treatments (Trt 5). After this assessment, Treatments 1–4 were all sprayed with the post-emergence herbicide. The next assessment made 3 weeks later showed a good level of weed control in all these treatments and there were still few weeds in the late planted stale seedbed treatment (Trt 5). However, by 10 weeks after spraying (3 February 2006) the weed control achieved in the mid planting treatments was significantly (P<0.05) better than in both the early and late plantings. In the early planted crop, the residual activity of the herbicides in the soil was insufficient to control the summer grass throughout the season while for the late planting, the post-emergence herbicide was applied while the maize plants were quite small (only 3 weeks since emergence) and were not able to provide sufficient shading to augment the short period of residual activity of the herbicide. The weed control in the late planted stale seedbed treatment (Trt 5) was poor, as no post-emergence herbicide was used and late germinating summer grass plants were able to establish in these plots. The early planted treatment and the late planted stale seedbed treatment both contained significantly more summer grass than the other treatments and in these two treatments the grain yield was significantly lower than the highest yielding treatment (mid planted, cultivated).

The general level of weed control achieved in Trial 4 was very good (Table 3) and most likely reflects a lower weed pressure at this site. At the February assessment there were more weeds in the late planted treatments (Trts 3 and 5) although the difference was significant only for the cultivated treatment (Trt 3). The lower level of weed control in these treatments is mostly likely a result of the absence of a post-emergence herbicide. There was no significant difference in grain yield between the treatments.

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**TABLE 3: Weed control score (0–100) and maize yield (t/ha) for Trials 3 and 4 and summer grass dry matter yield (kg/ha) for Trial 3.**

| | Weed control score[1] | | | | | Summer grass | Grain yield[2] (t/ha) | |
|---|---|---|---|---|---|---|---|---|
| | Trial 3 | | | Trial 4 | | | | |
| Trt | 23.11.05 | 15.12.05 | 3.2.06 | 1.12.05 | 10.2.06 | 23.2.06 | Trial 3 | Trial 4 |
| 1 | 82 | 97 | 67 | 91 | 96 | 1679 | 13.6 | 13.6 |
| 2 | 88 | 97 | 84 | 90 | 98 | 187 | 15.1 | 13.4 |
| 3 | 84 | 97 | 54 | 98 | 67 | 596 | 13.8 | 13.2 |
| 4 | 86 | 98 | 80 | 91 | 98 | 274 | 14.4 | 14.1 |
| 5 | 95 | 95 | 44 | 100 | 89 | 1518 | 13.7 | 12.9 |
| LSD ($P<0.05$) | 12.3 | ns | 14.9 | 5.4 | 16.9 | 681.2 | 1.38 | ns |

[1]Weed control score, 100=no weeds 0=no weed control.
[2]Yield adjusted to 14% moisture content.

The bioassay results showed that all plots in Trials 1, 3 and 4 were free of detectable herbicide residues at the end of the growing season (data not presented). In Trial 2, the early application of nicosulfuron had no detectable residual effects but turnips did not grow well in soil samples from plots treated with the late application of nicosulfuron indicating that residues were still present. This has implications for susceptible crops sown in autumn following maize where nicosulfuron is applied late in the season.

Where a good level of weed control was achieved, weed seed numbers of the two most prolific weeds in the soil seedbank were lower at the end of the growing season than at the beginning (Table 4). These post-season weed seed numbers would be further reduced over the winter due to decay and predation. Previous trials have shown that between 30 and 50% of weed seed is lost over this period (Rahman et al. 2001b).

**TABLE 4: Soil weed seedbank numbers (number of seeds per $m^2$ in surface 100 mm) for the two most abundant species before planting and after harvest in Trials 3 and 4.**

| | Trial 3 | | | | Trial 4 | | | |
|---|---|---|---|---|---|---|---|---|
| | Summer grass | | Fathen | | Hemlock | | Fathen | |
| Trt | Before | After | Before | After | Before | After | Before | After |
| 1 | 17935 | 30643 | 2040 | 978 | 315 | 90 | **4005** | **3105** |
| 2 | 18488 | 15045 | 553 | 213 | **405** | **135** | **3690** | **2115** |
| 3 | **24055**[1] | **33005** | 1955 | 2508 | 765 | 90 | **4635** | **2835** |
| 4 | **26903** | **10965** | 723 | 255 | **945** | **90** | **3015** | **1620** |
| 5 | **26818** | **30940** | 510 | 935 | 1080 | 360 | 4860 | 5400 |

[1]Pairs of numbers (before and after) in bold are significantly different ($P<0.05$).

The results from these trials demonstrate that good control of summer weeds that have an extended period of emergence can be achieved in maize crops with herbicides. However, this is more difficult for annual grass weeds than for annual broadleaf weeds. In Trials 1 and 3 control of summer grass was inferior in the early planted crops, as the residual activity of the pre-emergence herbicides used (acetochlor in particular) was too short to offer protection from late germinating grass weeds. In a study carried out on two

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maize growing soils in Waikato, Rahman & James (1994) reported that in soil samples collected at 6 weeks after application, foxtail millet (*Setaria italica*) grew to 60% of untreated controls demonstrating the short persistence of pre-emergence herbicides in some situations. If growers anticipate problems with difficult to control weeds, they should not plant early and also consider using a post-emergence herbicide even if there are only few weeds present at the time, as the residual activity of this herbicide will offer further protection from late germinating weeds.

The level of weed control achieved in Trials 2 and 4, where broadleaf weeds were prominent, was very good at all times of planting when a post-emergence herbicide was used. This demonstrates that good control of these weeds can be achieved with a combination of pre- and post-emergence herbicides irrespective of when the crop is planted.

A comparison of the cultivation versus stale seedbed treatments showed no real benefit in terms of weed control. It is widely known that cultivation stimulates weed germination, while in the absence of cultivation weeds emerge over a longer period of time (Rahman et al. 2000) and these late germinating weeds are less likely to be controlled as the residual activity of the herbicides diminishes with time.

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