# Evaluation of pre-emergent herbicides for landscape tree establishment

**C. J. Nazer and J. D. Clark**
Horticultural Services Unit, City Parks Administration, Department of Territories and Local Government, Canberra, A.C.T.

## Summary

**Trials were conducted between 1976 and 1980 in Canberra to evaluate pre-emergent herbicides for landscape tree plantings. They involved napropamide, propyzamide, methazole and simazine alone and in mixtures. Application of the herbicides was made soon after planting native and exotic trees during the summer months. Mixtures of napropamide and propyzamide with methazole or simazine were developed which can be used around common landscape trees during establishment to control many annual weed species for a season or longer from a single application.**

## Introduction

In establishing amenity plantings such as screen plantations, parkland and shrub beds a major problem is encountered from weeds which compete with the plants for water, nutrients and light. Early evidence from experimental plantings in Canberra indicated that without removal of weeds around newly planted trees, growth was only half to three-quarters of that which occurs under weed-free conditions (Boden, 1965). Jack (1970) found that 1-2 years growth of radiata pine (*Pinus radiata* D.Don.) can be lost due to competition during establishment from dense herbaceous weeds. This lost growth is not made up later. Early control of weed competition will maximize early growth of desired plant species and their survival. Survival of trees on open grassland can be very poor without weed control, and the primary consideration behind weed control in amenity planting is usually tree survival.

Whitham (1982) found that various methods of weed control substantially improved the growth of yellow box (*Eucalyptus melliodora* A.Cunn. ex Schauer) in the first year after planting. Several methods are being used in Canberra to control weeds around landscape plantings, including mulches, hand or mechanical cultivation and herbicides, although all methods can have serious disadvantages. Cultivation often causes significant damage to root systems reducing plant growth, and plants can be inadvertently destroyed or damaged during herbicide application. Wood residue mulches are used extensively and provide good control of many weed species whilst conserving soil moisture, but troublesome perennial weeds such as couch (*Cynodon dactylon* (L.) Pers.), phalaris (*Phalaris* sp.) and sorrel (*Rumex acetosella* L.) grow through if not eradicated prior to mulch application. Organic mulch materials can produce leachates which may inhibit the root growth of plants, which may favour root rot fungi (McIntyre, 1973). Non-residual herbicides such as glyphosate and paraquat plus diquat are frequently used to control weeds around the base of small trees. Care during spray application is necessary, however, as these herbicides can injure or kill trees if the foliage or green bark is contacted (Swanson and Shuman, 1982). They are inactivated upon contact with the soil and will not control germinating weed seeds, so that a number of applications may be necessary to maintain a weed-free area.

Pre-emergent herbicides are used to control many weeds in crops, container and amenity plantings, forestry plantings and orchards. Their effectiveness and period of weed control depends upon a number of factors including the herbicide, application rate, soil type, and the time interval between application and incorporation into the soil. The rate of herbicide applied must be high enough to kill germinating weeds, but low enough not to affect the desired plants. A number are safe for use around a range of tree and shrub species after the plant's roots have established (Smith, 1979).

Pre-emergent herbicides seem to offer potential in maintaining a weed-free area around plants for a longer period than that offered by most other methods, and since 1975 a series of trials have been carried out by the Horticultural Services Unit of the City Parks Administration to evaluate their use against weeds competing with commonly used amenity trees in Canberra. Several initial trials (unpublished) involved testing various herbicides at a range of rates around established grevillea (*Grevillea juniperina* R.Br.) and lombardy poplar (*Populus nigra* L. var. *italica* Muenchh.) and a variety of container plants. Only simazine caused any phytotoxic effects in these trials. Knowledge of suitable herbicides and rates developed as the trials progressed, and later trials tested their effectiveness under field conditions. All trials were initiated during summer months.

## Experimental work and results

### *Tuggeranong Trial*

This trial was established in a level plantation of mixed native and exotic trees in Tuggeranong, A.C.T. on a sandy clay loam. The trees were planted 3 months prior to herbicide application and had been watered manually and weeded as necessary. Weed species present in the trial area included phalaris, clovers (*Trifolium* spp.), summer grasses (*Digitaria* spp.), and sorrel. The four tree species used were Sydney golden wattle (*Acacia longifolia* (Andr.) Willd. var. *longifolia*), black wattle (*A. mearnsii* DeWild.), oriental plane (*Platanus orientalis* L.) and English elm (*Ulmus procera* Salisb.). A circular area 1 metre in diameter around 40 trees of each species was sprayed with a mixture of paraquat and diquat to desiccate existing weed growth. Tree stems were protected during this application to avoid damage arising from spray contact. One week later each of the five treatments outlined below were applied to a 1 metre diameter area around 5 trees of each species. The herbicides were applied in water at 6360 L $ha^{-1}$.

| Treatment | Rate (kg ai $ha^{-1}$) |
|---|---|
| **1** napropamide (Devrinol) | 3.35 |
| **2** methazole (Probe) | 2.16 |
| **3** propyzamide (Kerb) | 2.25 |
| **4** simazine (Gesatop) | 2.16 |
| **5** control–no herbicide | |

The herbicides could not be incorporated by irrigation due to the remoteness of the site, but within 1 week of application a total of 17.6 mm of rainfall was recorded at the site.

Visual assessment of the amount of weed cover in the 1 metre diameter area around each tree was carried out 6 months after application and rated as nil, low, medium or high. The results are shown in Table 1. Regular inspections of the trees were carried out throughout the trial to assess phytotoxicity.

The only herbicide which affected the health of any of the trees was simazine, which caused chlorotic damage to leaves of the *Acacia* species several weeks after application. At the final assessment after 6 months three *A. longifolia* and three *A. mearnsii* trees had died from apparent simazine damage.

The results obtained of this trial showed that several of the herbicides inhibited the germination of annual weed species such as *Digitaria*. Six months after treatment most of the weed cover recorded in the treated areas arose from encroachment of perennial weed species.

The deaths of the *Acacia* trees indicated the sensitivity of these plants to simazine and the need to reduce the rate of this chemical in further field trials.

**Table 1** Average weed cover around trees 6 months after herbicide application

| Treatment | Rate (kg ai $ha^{-1}$) | Mean visual assessment of weed cover |
|---|---|---|
| napropamide | 3.35 | 0.40b |
| methazole | 2.16 | 0.50ab |
| propyzamide | 2.25 | 0.35b |
| simazine | 2.16 | 0.25b |
| control | | 0.85a |

Ratings: 0 = nil, 1 = low, 2 = medium and 3 = high
Means not followed by a common letter differ significantly ($P < 0.05$)

### *Hume Trial*

This trial used a section of the Industrial Estate plantation in Hume, A.C.T. which was previously planted with *Eucalyptus* and *Acacia* species. Only a few trees had survived, and it appeared that the lack of effective weed control contributed significantly to the failure. Weeds present in the trial site included a variety of grasses and broadleaf weeds with large patches of skeleton weed (*Chondrilla juncea* L.) and sorrel. The soil type was a sandy loam.

An application of paraquat and diquat was made to the trial area several weeks before planting of the trees to desiccate existing weed growth. A single tine ripper was used to rip tree planting lines about 300 mm deep and 3 m apart. The trial layout was a randomized block design of 20 plots each 62.5 m × 1.0 m with buffer strips 2 m wide between plots.

Five trees of each of Cootamundra wattle (*Acacia baileyana* F.Muell.), river sheoak (*Casuarina cunninghamiana* Miq.), snow gum (*Eucalyptus pauciflora* Spreng. subsp. *pauciflora*), manna gum (*E. viminalis* Labill.) and eurabbie (*E. globulus* subsp. *bicostata* (Maiden *et al.*) Kirkp.) were planted in a single row in each plot into the rip lines at 2.5 m spacings. All individuals of each tree species were selected for similar height at the time of planting.

Each of the following treatments was applied to duplicate plots 2 weeks after the trees were planted.

| Treatment | Rate (kg ai $ha^{-1}$) |
|---|---|
| **1** napropamide (Devrinol) + methazole (Probe) | 3.5 + 2.4 |
| **2** napropamide + simazine (Gesatop) | 3.5 + 1.6 |
| **3** methazole + simazine | 2.4 + 1.6 |
| **4** napropamide + simazine + methazole | 3.5 + 0.8 + 2.4 |
| **5** napropamide + simazine + propyzamide (Kerb) | 3.5 + 0.8 + 2.5 |
| **6** napropamide + methazole + propyzamide | 3.5 + 2.4 + 2.5 |
| **7** napropamide | 3.5 |
| **8** methazole | 2.4 |
| **9** simazine | 1.6 |
| **10** control–no herbicide | |

Within 4 days of application a total of 15 mm of rainfall was recorded at the site.

The percentage weed cover was assessed 12 months after application on a random selection of ten 1 $m^2$ sites in each plot by recording the percentage cover of annual grasses, annual broadleaf weeds, skeleton weed and sorrel. Assessment of plant growth inhibition and death was carried out by measuring the height of the plants 12 months after herbicide application and recording the number of dead plants in each treatment 3, 6 and 12 months after application.

Considerable weed germination and growth occurred in the control plots during the trial but the herbicide mixtures applied (particularly those with three herbicides) considerably reduced weed cover even after 12 months (Table 2).

The mean heights of the trees 12 months after herbicide application are shown in Table 3. Using plant height as an indicator, most of the herbicide treatments appear to have enhanced the growth of the trees when compared to the control, although some treatments appear to have slightly inhibited the growth of the trees of certain species.

About 15% of the trees died (especially during the latter part of the trial period) apparently as the result of droughting. Overall, the survival of trees in the herbicide treated plots was greater than in the untreated control, suggesting that reduced weed competition enhanced tree survival (data not provided).

### *Field Application Trial*

At this stage of the experimental work several potentially useful herbicide mixtures had been determined. For these treatments to be effective a number of conditions must be met, and this trial was set up to determine how readily a planting contractor and his staff could meet these application conditions.

The site was a section of a large plantation in Tuggeranong, A.C.T. with a sandy clay loam soil. The weeds present included a variety of broadleaf weeds and grasses. A single tine ripper was used to rip 300 mm deep rip lines 2 m and 3 m apart, and a 1 m wide band was sprayed along rip lines with glyphosate (Roundup at 10 L $ha^{-1}$) to provide 250 planting sites.

Five plant species were used in the trial: yellow box, manna gum, bottlebrush (*Callistemon citrinus* (Curtis) Stapf.), river sheoak and silver wattle (*Acacia dealbata* Link.) Two weeks after glyphosate application 50 plants of each species were planted along the rip lines and watered. A mixture of napropamide at 3.5, methazole at 2.4, and simazine at 0.8 kg ai $ha^{-1}$ was applied in 2545 L $ha^{-1}$ of water to a 1 m diameter area around 25 plants of each species (i.e. to half of the plants). Rainfall was relied upon to incorporate the herbicides into the soil as the site could not be irrigated, and within 1 week of application a total of 9.2 mm of rainfall was recorded at the site.

Visual assessment of the amount of weed cover in the 1 metre diameter area around each plant was carried out 6 months after application. The amount of weed cover was rated as nil, low, medium or high depending upon weed coverage. Regular inspections of the

**Table 2** Mean percentage weed cover 12 months after herbicide application

| Treatment | Rate (kg ai ha$^{-1}$) | Mean percentage weed cover annual grasses | annual broadleaf weeds | perennial broadleaf weeds | overall |
|---|---|---|---|---|---|
| napropamide + methazole | 3.5 + 2.4 | 15.5cd | 11.0a | 28.5bc | 55.0cd |
| napropamide + simazine | 3.5 + 1.6 | 11.5cde | 13.75a | 34.7ab | 60.0bcd |
| methazole + simazine | 2.4 + 1.6 | 16.0cd | 5.5a | 38.0a | 59.5bcd |
| napropamide + simazine + methazole | 3.5 + 0.8 + 2.4 | 8.25cde | 9.25a | 29.0bc | 46.5de |
| napropamide + simazine + propyzamide | 3.5 + 0.8 + 2.5 | 5.5e | 18.0a | 23.5c | 47.0de |
| napropamide + methazole + propyzamide | 3.5 + 2.4 + 2.5 | 6.5de | 13.25a | 21.25c | 41.0e |
| napropamide | 3.5 | 14.5cde | 25.25a | 27.25bc | 67.0bc |
| methazole | 2.4 | 32.75b | 15.5a | 22.75c | 71.0b |
| simazine | 1.6 | 16.25c | 15.5a | 39.25a | 71.0b |
| control | — | 63.25a | 15.5a | 21.25c | 100.0a |

Means not followed by a common letter differ significantly ($P<0.05$)

**Table 3** Mean height of trees 12 months after herbicide application

| Treatment | Rate (kg ai ha$^{-1}$) | Mean height *Acacia baileyana* | *Casuarina cunninghamiana* | *Eucalyptus pauciflora* | *Eucalyptus viminalis* | *Eucalyptus globulus* subsp. *bicostata* |
|---|---|---|---|---|---|---|
| napropamide + methazole | 3.5 + 2.4 | 1.09 | 0.82 | 0.54 | 1.01 | 0.97 |
| napropamide + simazine | 3.5 + 1.6 | 1.00 | 0.77 | 0.67 | 0.74 | 0.91 |
| napropamide + simazine + methazole | 3.5 + 0.8 + 2.4 | 1.01 | 0.84 | 0.62 | 1.09 | 1.03 |
| napropamide + simazine + propyzamide | 3.5 + 0.8 + 2.5 | 1.17 | 0.93 | 0.75 | 1.07 | 0.88 |
| napropamide + mathazole + propyzamide | 3.5 + 2.4 + 2.5 | 1.12 | 0.86 | 0.83 | 1.22 | 1.28 |
| napropamide | 3.5 | 1.27 | 0.66 | 0.63 | 1.15 | 0.89 |
| methazole | 2.4 | 1.17 | 0.76 | 0.47 | 1.17 | 0.81 |
| simazine | 1.6 | 1.10 | 0.64 | 0.62 | 1.05 | 0.89 |
| control | | 0.89 | 0.56 | 0.73 | 0.85 | 0.92 |

**Table 4** Mean visual assessment rating of the amount of weed cover around 25 plants of each species 6 months after herbicide application

| Treatment | Rate (kg ai ha$^{-1}$) | Mean weed cover |
|---|---|---|
| glyphosate | 3.6 | 1.8a |
| glyphosate + napropamide + methazole + simazine | 3.6 + 3.5 + 2.4 + 0.8 | 0.4b |
| control | no herbicide | 2.6a |

Ratings: 0 = nil, 1 = low, 2 = medium and 3 = high
Means not followed by a common letter differ significantly ($P<0.05$)

plants were carried out throughout the trial to assess phytotoxic damage by the herbicide treatments.

The results of the weed control ratings for each of the treatments in the trial are shown in Table 4.

A major purpose of conducting this trial was to evaluate whether inexperienced field staff with minimal training could apply the herbicides accurately on a rate per unit area basis. Operators were given a short demonstration of the calibration of the spray unit and the correct application technique. That these field staff were able to apply the herbicide accurately was evidenced by the satisfactory weed control obtained and the absence of any phytotoxicity to the plants.

### *Curtin Trial*

This trial was established to further test the herbicides napropamide, methazole, propyzamide and simazine for their effectiveness in controlling weeds without injuring newly planted *Eucalyptus*, *Acacia* and *Casuarina* species under different conditions from the previous trials. The site was at Curtin, A.C.T. with a sandy clay loam soil. Before the trial commenced the weeds present in the area included couch, sorrel, barnyard- grass (*Echinochloa crus-galli* (L.) Beauv.), summer grass (*Digitaria sanguinalis* (L.) Scop.), flatweed (*Hypochoeris radicata* L.), ribwort (*Plantago lanceolata* L.), capeweed (*Arctotheca calendula* (L.) Levyns.), black-berry nightshade (*Solanum nigrum* L.) and pigweed (*Portulaca oleracea* L.)

The trial layout was a randomized block design of nine blocks each containing five plots 15 m×1 m with buffer strips 2 m wide between plots. All plots were sprayed with glyphosate (Roundup at 10 L ha$^{-1}$) to kill the existing weeds. Two weeks after spraying a single tine ripper was used to produce a 300–400 mm deep rip line along the centre of each plot. The plots were then rotary hoed to allow easier planting in the dry soil.

Three plant species commonly used in tree plantations throughout Canberra were used in the trial: manna gum, Cootamundra wattle and river sheoak. All individuals of each species were similar in height at the time of planting. Ten trees of each species were planted in a single row in the centre of each plot spaced 1.5 m apart. Three blocks were planted with each of the three species.

Each of the five treatments outlined below was applied to one plot in each of the nine blocks. Treatments were randomized within each block.

| Treatment | Rate (kg ai $ha^{-1}$) |
|---|---|
| 1 napropamide + methazole + propyzamide | 3.5 + 2.4 + 2.5 |
| 2 napropamide + methazole + simazine | 3.5 + 2.4 + 0.8 |
| 3 napropamide + propyzamide + simazine | 3.5 + 2.5 + 0.8 |
| 4 weed-free control | |
| 5 unweeded control | |

The herbicide mixtures were applied in water at the rate of 2000 L $ha^{-1}$ 5 days after the trees were planted. They were incorporated into the soil with the equivalent of 15-20 mm of rainfall using sprinkler irrigation the day after application.

The trees were artificially watered four more times during the summer using sprinkler irrigation with the equivalent of 15-20 mm of rainfall being applied on each occasion. The weed-free control plots were manually weeded using a chip hoe, care being taken to avoid damaging the stems and surface roots of the trees.

The percentage weed cover in each plot was assessed 2, 6 and 12 months after herbicide application on a random selection of five 1 $m^2$ sites between trees in each plot, recording the percentage cover of annual grasses, annual broadleaf weeds, couch and sorrel. Assessment of tree growth was carried out by measuring the height of the trees 12 months after herbicide application. The number of damaged and dead trees in each treatment was recorded 1, 2, 6 and 12 months after herbicide application. Tree damage was rated as slight or severe, depending upon the amount of leaf burn (necrosis and chlorosis) and leaf fall.

There was no real difference in the response of the weeds to the three herbicide treatments (Table 5). In the 6 month period following application no weed germination was recorded in any of the herbicide treated plots, the only weeds present being couch and sorrel which originated from plants growing outside the plots. Twelve months after treatment the overall weed cover recorded in the three herbicide treatments was less than 4% (Table 5). Considerable weed germination and weed growth occurred in the unweeded control plots throughout the duration of the trial.

Twelve months after treatment the heights of the trees in the unweeded control treatment were significantly lower than the sample species in the herbicide treatments and weed-free control (Table 6), between which there were no significant differences.

In the first two months of the trial eight manna gum trees in the herbicide plots suffered leaf burn (necrosis and chlorosis) and in some cases considerable defoliation. Only one of the eight affected trees died. More damage and death was recorded in the treatment containing napropamide, methazole and simazine than in the other two treatments.

The three pre-emergent herbicide treatments used in the trial effectively controlled weed seed germination for 6 months. Tree growth was significantly improved by herbicide treatments or manual weeding relative to the unweeded control. Combinations of napropamide plus propyzamide with methazole or simazine resulted in less injury to trees than a combination of napropamide, methazole and simazine.

**Table 5** Mean percentage weed cover 2, 6 and 12 months after herbicide application

| Treatment | Rate (kg ai $ha^{-1}$) | Mean percentage weed cover: annual grasses | | | broadleaf weeds | | | overall cover | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Months after application | | 2 | 6 | 12 | 2 | 6 | 12 | 2 | 6 | 12 |
| napropamide + methazole + propyzamide | 3.5 + 2.4 + 2.5 | 0.0b | 0.0b | 0.6b | 0.0a | 0.0b | 0.7b | 0.0b | 0.0b | 1.3b |
| napropamide + methazole + simazine | 3.5 + 2.4 + 0.8 | 0.0b | 0.0b | 0.4b | 0.0a | 0.0b | 0.9b | 0.0b | 0.0b | 1.3b |
| napropamide + propyzamide + simazine | 3.5 + 2.5 + 0.8 | 0.0b | 0.0b | 0.2b | 0.0a | 0.0b | 1.2b | 0.0b | 0.0b | 1.4b |
| unweeded control | | 47.4a | 58.5a | 38.9a | 3.7a | 15.9a | 18.6a | 51.1a | 74.4a | 57.5a |

Means not followed by a common letter differ significantly ($P<0.05$)

**Table 6** Mean height (metres) of trees 12 months after herbicide application

| Treatment | Rate (kg ai $ha^{-1}$) | *Eucalyptus viminalis* | *Acacia baileyana* | *Casuarina cunninghamiana* |
|---|---|---|---|---|
| napropamide + methazole + propyzamide | 3.5 + 2.4 + 2.5 | 1.87a | 2.43a | 1.89a |
| napropamide + methazole + simazine | 3.5 + 2.4 + 0.8 | 1.86a | 2.23a | 1.93a |
| napropamide + propyzamide + simazine | 3.5 + 2.5 + 0.8 | 1.92a | 2.32a | 1.83a |
| weed-free control | | 1.73a | 2.53a | 1.66a |
| unweeded control | | 1.44b | 1.83b | 1.16b |

Means not followed by a common letter differ significantly ($P<0.05$)

## Discussion

The use of pre-emergent herbicides to maintain a weed-free area for an extended period around newly planted trees can offer a suitable alternative to the repeated use of non-residual herbicides, hand chipping or mulching.

The herbicides may be applied to a 1–2 m wide strip along tree rows or to a 1–2 m diameter area around each tree. The main advantages of combining a number of pre-emergent herbicides is that a broader spectrum of weed species can be controlled. Mixtures of herbicides can also allow lower herbicide application rates to be used, which may result in less phytotoxicity to the desired plants.

Perennial as well as annual weeds should be controlled prior to tree planting and herbicide application, although invasion of the treated area by perennial weeds such as couch and sorrel may still occur.

The pre-emergent herbicides tested should be applied after tree planting to prevent the soil surface being disturbed and to avoid soil containing a high concentration of herbicide being used to backfill around the roots of trees during planting. Since most of these herbicides have little or no effect on the leaves or green stems of plants they can be applied after planting without the risk of injury.

Pre-emergent herbicides are usually rapidly broken down on the soil surface, and for maximum results need to be incorporated into the soil soon after application. If rainfall does not occur within 1-2 weeks following application, they should be incorporated by irrigation or shallow cultivation. The use of a mulch over the soil surface may also delay herbicide degradation.

Whether a pre-emergent herbicide will cause phytotoxic effects will depend upon factors such as plant species, length of time plants have been established, soil type and growing conditions. In general, newly planted stock are more likely to suffer injury than established plants. The chance of injury is usually greater on light, sandy soils deficient in organic matter. It is important that the soil should be firmed around the roots when planting to prevent these herbicides being leached down into the root zone and taken up by the plants.

## Acknowledgements

The authors are grateful for the technical assistance provided by P. Matthews, A. Wotzko, G. King, J. Groves and P. Buckley at different stages of the experimental work.

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