Metsulfuron over tōtara seedlings spray trial
-Results after 14 months-

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1. Introduction

This report sets out and discusses the results of a field trial that applied the herbicide Metsulfuron-methyl, over seedlings of a New Zealand native conifer tree species – *Podocarpus tōtara*.

Successful establishment of indigenous forest species in New Zealand is expensive. Controlling competing vegetation, including vigorous weed species, is often required for the site preparation before planting and often for a minimum of 2-5 years after planting, or until canopy-closure has occurred. And in many instances ongoing monitoring and control of invasive weed species will also be required. The use of herbicides can be a cost-effective option to control weeds during native forest establishment and for its ongoing maintenance. However, the application of many herbicides can present a health risk to many of the species of native plants and animals.

Some herbicides are considered to be 'selective' in terms of what plant species they effectively control. And some plant species demonstrate varying degrees of resistance (or tolerance) to the deleterious effects of different herbicides and their relative application rates.

Field observations in Northland suggest that naturally regenerating tōtara seedlings and saplings frequently survive applications of the herbicide Metsulfuron-methyl, that have targeted weed species such as gorse in pastoral and forestry settings.

Metsulfuron-methyl is a commonly used, cost-effective herbicide that controls a wide range of problem weed species including wild ginger (*Hedychium gardnerianum*). If tōtara is tolerant of this herbicide, it may present more options for practical and cost-effective establishment and maintenance of tōtara timber plantations. However, thorough testing of this possibility is required before it could be recommended.

No trials of Metsulfuron-methyl over tōtara are known[1]. Recently, SCION conducted an initial screening trial of a range of herbicides applied over a range of native plant species (Nairn 2020). However, Metsulfuron-methyl was not one of the herbicides tested.

This report details the results of two field trials involving the application of Metsulfuron-methyl over tōtara seedlings in Northland. These results demonstrate 100% seedling survival 14 months after the spray treatment. The results and implications of these field trials are discussed below in more detail and further testing is recommended. The content of this report does not constitute advice or recommendations regarding the use of Metsulfuron-methyl over tōtara seedlings.

2. Background – pre-trial field observations

Observations of naturally regenerated tōtara saplings and trees surviving aerial and handgun spray applications of the herbicide Metsulfuron-methyl are common in Northland. The image below shows naturally regenerated tōtara that has survived aerial spraying of Metsulfuron-methyl and penetrant at the recommended label rates for gorse control. Applied in November 2019, and six months later (and in summer drought conditions), the gorse, kanuka and tree ferns have died, but the tōtara, apart from some 'burnt' growing tips, appeared to have survived the spray.

[1] A literature review of the current knowledge on phytotoxicity of herbicides to indigenous tree species of New Zealand. Nairn, J. *et al.* 2020. Scion Research. p.19

Figure: 1 - Example of naturally regenerated tōtara surviving an aerial spray application of Metsulfuron-methyl at rates targeting and effectively controlling gorse and kanuka and black tree ferns (tall trunks).

Figure: 2 – Example of tōtara surviving herbicide sprays used for site preparation for forestry planting

Similarly, the tōtara seedlings in the image above - a newly planted pine block, (taken in June 2020) appear to be surviving, despite having being subject to a pre-plant aerial spray in May 2019, and then a post-plant aerial release spray in Nov 2019. A mix of herbicides and additives was used in this instance, including Metsulfuron-methyl. Some apparent damage to the growing tips of the tōtara is evident, but survival and recovery appears likely.

These examples suggest that tōtara may have some resistance to some herbicides including Metsulfuron-methyl. If so, this attribute may present useful options for herbicide release of developing tōtara plantations.

The observation of some discolouration and obvious ill-health on some sprayed tōtara, particularly damage to the new growing tips of foliage, suggests that application rate may be a significant factor in relative tolerance.

3. Spray trial establishment

Prompted by these observations, and as part of the Our Forests Our Future project funded by The Tindall Foundation with support from Pāmu Farms, Tāne's Tree Trust has initiated two preliminary field trials of Metsulfuron-methyl applications over tōtara seedlings. These involved a knapsack spray application over potted seedlings and the same over seedlings in the field one year after planting. These two separate trials were established on the 8thMay 2020 and ran concurrently. They are referred to below as;

1) – Potted seedling trial
2) – Planted seedling trial

Respective establishment methodologies are outlined below. Essentially both trials test the relative effect of a spray application (of Metsulfuron-methyl including surfactants and marker-dye) at both the rate recommended by the manufacturer for gorse control, and an application at half that recommended rate, against a control group which was not sprayed at all.

The two different application rates were intended to replicate a) – most common current farm practice (i.e. full rate), and b) – explore the effects of a more limited exposure e.g. – such as might occur from spray-drift contact rather than the seedling being directly targeted (half-rate).

Details of these trial are set out below.

1. <u>Potted seedling spray trial</u>

Details:
A tray of tōtara seedlings in 5cm pots, was donated from Kukupa Plant Nursery. They ranged in height from 150mm to 320mm high.

Three different treatments (including the control (which was no-treatment)) were applied to a total of 45 seedlings – i.e., to 15 seedlings in each treatment.

Treatments:

1: "Full" - Full recommended label-rate for gorse control Metsulfuron-methyl (5g/10 litres) + 10ml Pulse (penetrant) + 10 ml blue colour dye-marker applied by knapsack to saturation over tōtara seedling (i.e. – until spray drips from the tips of the seedling's needles[2]).

[2] N.B. - Knapsack application rate was not calibrated to check delivery coverage. The spray was simply applied until a complete wetting of the foliage was observed and the solution was dripping from the tips of the plant's needles.

2: “Half” -Metsulfuron-methyl applied at half recommended label-rate for gorse (2.5/g10litres) +10ml Pulse + 10ml blue dye. Applied by knapsack to saturation over and around tōtara seedlings.

3: “Nil” - No spray treatment. (Control).

Seedlings were selected randomly to each treatment group. Spray treatments were applied to each group while well distanced from other groups to ensure no risk of spray-drift occurred. For practical handling the treated groups were then reassembled into a single (and clean) seedling tray but kept in an arrangement layout segregated by group and the tray labelled to identify the treatment groups (i.e. – Full, Half & Nil). The seedlings were kept in pots, in the same tray and subject to same environmental conditions.

Monitoring and assessment

Individual heights of seedlings above ground/soil level in their respective pots were measured and recorded. Monthly survival and health condition assessments comprised a score of individual seedling health condition according to the following basic subjective rating: 0= Dead, 1= poor, 2= satisfactory/fair, 3= vigorous. The addition of a “B” following the number denoted bronzing or yellowing colour change of the foliage.

Figure: 3- The potted seedling trial following the spray treatment at the establishment of the trial. From left to right, the 3 treated groups are labelled “Full, Half, Nil” – referring to the herbicide application rates applied. Note the blue colouration of the marker-dye additive, on the seedlings of the two sprayed groups – left and centre.

2. Planted seedling spray trial

Pāmu Farms granted permission to conduct pilot field-trials within an area of native planting on the Puketōtara Station in Northland.

Trial site details
The tōtara and manuka seedlings were planted around one year previously, in a mixed planting pattern at 2220 stems/ha. All tōtara seedlings were planted in combi-guards, with a woollen mulch-mat, and had been released sprayed once (with Simazine and Haloxyfop).

Grasses were well controlled, but gorse (*Ulex europaeus*) was thickly regenerating in patches, with gorse seedlings mostly less than knee height, but up to hip height in places, and just starting to compete with some of the tōtara seedlings. Survival of the whole block was patchy due to the severe summer drought in the region (2019/2020). But all the seedlings in the trial area were in reasonable health. Although, some had brown growing tips and some slightly pale yellowy-green foliage colouration, but otherwise appeared healthy enough to suggest their likely survival. The trial area was subjectively selected to include healthy tōtara seedlings in both gorse and grass situations. Planted manuka that was also present was ignored.

Trial site Location: Puketōtara Pāmu farm – block 43/01
Coordinates: 1674236.65 6101454.38 (NZTM2000)

Methodology:
A square area that contained 6 rows of 6 tōtara seedlings in one of the planted blocks (43/1) was selected and cordoned-off. Three treatments (including the control) were systematically applied to the tōtara seedlings along each of the 6 rows: Treatment sequence was; Treatment 1,2,3, 1,2,3. There was a total of 36 seedlings involved with this field trial – i.e., 12 seedlings in each treatment including the control.

Treatments:

> **1:** Full recommended label-rate for gorse - Metsulfuron-methyl (5g/10 litres) + 10ml Pulse (penetrant) + 10 ml blue colour dye-marker applied by knapsack to saturation over tōtara seedling (until spray drips from the tips of the seedling's needles) and approximately a 1.2m area diameter around each seedling.
>
> **2:** Metsulfuron-methyl applied at half recommended label-rate for gorse (2.5/g10litres) +10ml Pulse + 10ml blue dye. Applied by knapsack to saturation over and around tōtara seedlings (approx. 1.2m diameter).
>
> **3:** No spray treatment. (Control).

Marking of treated seedlings
All seedlings in the trial were marked with tōtara timber stakes (approx. 30mmx 15mm x 400 mm high).
Treatment 1 had only one blue spray-painted band on stake.
Treatment 2 had two blue spray-painted bands on stake.
Treatment 3 had no blue spray-painted bands.

Survival and health assessment
Monthly survival checks also scored individual health condition according to the following basic subjective rating: 0= Dead, 1= poor, 2= satisfactory/fair, 3= vigorous. The addition of a "B" following the number denoted bronzing or yellowing colour change of the foliage.

Images of the planted seedling trial establishment are set out below.

Figure: 4 - Southwestern corner of trial site with grass and gorse present. This corner of trial area has most grass present and least gorse. No Kikuyu grass.

Figure: 5 – At the establishment of the field trial some of the tōtara seedlings already had some die-back on tips, and yellowish foliage. This is thought to have been due to the severe summer drought, but otherwise all seedlings appeared reasonably healthy and their continued survival appeared to be most probably. Conditions scores were assigned to each individual seedling for comparison through the trial period.

Figure: 6 – An example of Treatment: 1 with a tōtara timber stake (beside the combi-guard) as marker -i.e. one blue-band sprayed on stake. Tōtara seedlings were directly spot-sprayed along with the surrounding gorse. N.B. – photo taken before spraying – hence no blue marker dye evident on the foliage.

4. Results - 9- & 14-Months following herbicide application

Regular monitoring of the two parallel trials has produced interesting results. The basic results are presented in this section, without any statistical analysis, but with some observations, comments, and discussion following the summary.

Both seedling trials were monitored at 3monthly intervals for 9 months. The potted seedling trial was also monitored 14-months after establishment, and then the seedlings were planted out on 18 July 2021.

Figure: 7 – Due to the time of application (May) the effect of the herbicide was slow. It took about four months (Sept) for the gorse to brown-off. However, as seen in the photo above (at 9 months following establishment), even applications at half-rate of herbicide (i.e. - Treatment: 2) effectively killed the gorse, but not the tōtara seedling.

The following tables sets out the relative mean values, at 3 x three-month intervals, then for the potted seedlings also at 14mths, for the two treatments and the controls. Potted seedlings were monitored for height and health condition, but the planted seedlings were only monitored for survival and scored for health condition.
All seedlings in the trial have survived so far – i.e., 100% survival has resulted.

Table: 1 – Potted seedling spray trial mean heights (mm) at 3-month intervals

Treatment**	Height* at establish-ment	Height* 3months after	Height* 6months after	Height* 9 months after	**Height* 14 months**	**Nett height* changes at 14mths**
1.- Full spray rate	226	227	220	240	**278.7**	**53mm**
2.- Half rate	223	225	227	282	**289.3**	**66.3mm**
3.- No spray (control)	212	216	244	269	**266.3**	**54.3mm**

* All heights in mm and mean values of the 15 seedlings in each treatment group (1-3).
** Treatment groups comprise 15 seedlings – see details outlined further above.

Figure: 8 – Photo of the potted seedling trial 9 months after treatments. From left to right; Treatment: 1 – sprayed with full label rate mix, Treatment: 2 – sprayed with half label rate spray mix, Treatment: 3 – Control, i.e., not sprayed with any herbicide at all. 15 seedlings in each treatment group.

Table: 2 – Potted seedling spray trial mean health condition score at 3-month intervals

Treatment**	Condition* at establishment	Condition* 3months after	Condition* 6months after	Condition* 9 months after	Condition at 14 months after	**Nett*** change at 14 months**
1.- Full spray rate	2.93	1.67	2.0	2.27	2.73	**-0.2**
2.- Half rate	2.6	2.0	2.0	2.67	2.4	**-0.2**
3.- No spray (control)	2.87	2.53	2.7	2.47	2.53	**-0.34**

* Mean health condition score based on 0-3 rating – 0= Dead, 1= Poor, 2= Satisfactory/fair, 3= vigorous.
** Treatment groups comprise 15 seedlings – see details outlined further above.
***Mean of the individual seedling's nett score changes.

Table: 3 – Planted seedling spray trial mean health condition score at 3-month intervals

Treatment**	Condition* at establishment	Condition* 3months after	Condition* 6months after	Condition* 9 months after	**Nett*** change at 9 months**
1.- Full spray rate	1.75	1.67	1.83	2.25	**0.5**
2.- Half rate	2.0	1.67	1.75	2.0	**0.0**
3.- No spray (control)	2.5	2.08	2.67	2.75	**0.25**

* Mean health condition score based on 0-3 rating – 0= Dead, 1= Poor, 2= Satisfactory/fair, 3= vigorous.
** Treatment groups each comprise 12 seedlings – see details outlined further above.
*** Mean of the individual seedling's nett health condition score changes.

5. Summary of results

A key result is that, so far, all the tōtara seedlings in the trial survived the application of Metsulfuron-methyl at both full and half dose rates recommended by the manufacturer to control gorse. Moreover, application of the herbicide at half-rates appears to have had no significant effect on height growth of the seedlings when compared to the control.

The following summarises the results 9 months following establishment of the trial.

- 100% survival at 9 months following the application of the field trial herbicide spray (and controls) and 100% survival of potted seedling trial 14 months after establishment . No seedlings in either trial failed. However, some individual seedlings have a health condition score of 1 (i.e., Poor). – N.B. Some of the planted seedlings started with a score of 1.

- Mean health condition scores of seedlings in all treatments and controls had diminished 3 months after establishment of the trial but has trended up for all treatments and controls since.

- Nett change in mean health condition scores between establishment and 14-month monitoring, shows a deterioration for Treatment 1 (full-rate spray) over the potted seedlings, but an improvement in mean health scores for Treatment 1 over the planted the seedlings.

- Nett mean health condition scores for Treatment: 2 (Half-rate spray dose), show negligible difference 14-month following the establishment of the trial.

- Mean height growth of the potted seedlings that were sprayed at full dose rates (Treatment: 1) is noticeably less than Treatment: 2 (Half-rate) and the un-sprayed Control (Treatment: 3).

- Mean height growth of the Treatment: 2 (Half-rate spray) in the potted seedlings is little different (-in fact slightly greater) than the un-sprayed control (Treatment: 3).

6. Observations, comments, and discussion

Field observations confirmed that the herbicide effectively killed the gorse present in the spots where it was applied – even at half recommended dose rates (i.e. -Treatment: 2) see Figure: 7 above). While the tōtara seedlings appeared to be affected by the herbicide, none died in the 9-month period of the trial. At this point the health of the seedlings generally appears to be on an improving trend. It seems likely they will survive.

Bronze-coloured foliage

Overall, the herbicide appeared to have a more noticeable visual effect on the health of the seedlings than is reflected in the results tabulated above. The foliage of many seedlings turned to a and bronze-like colour and growing tips appeared burnt or stunted. Visual differences between the treatments were clearly apparent in the grouped arrangement of the potted seedlings. However, the pattern was not so consistent in the planted seedlings, with some of the un-sprayed planted seedlings also presenting similar bronzed foliage and affected growing tips. This could be a result of spray-drift, insect damage, sun exposure, and/or lingering impacts from the summer drought conditions. Nevertheless, it appeared that the spray did have an adverse impact on seedling health.

Half-rate treatment without deleterious effect

The results to date from the potted seedling trial suggest that tōtara seedlings can survive knapsack spray applications of Metsulfuron-methyl at full dose rates recommended to kill gorse, but that does have some adverse effect on their health and height growth. This is consistent with field observations and experiences on farms in Northland. However, perhaps a surprising result is that the half dose rate applications of the herbicide, were effective in killing the gorse in the spots where it was applied but had negligible effect on the nett mean health condition or height growth of the tōtara seedlings. In fact, 9 months after spraying, the potted seedlings had slightly higher mean height values than the un-sprayed control. Even more curious, their foliage appears to generally have a darker (and healthier) green colour.

Releasing

The control group in the planted seedling trial has not had any herbicide releasing since before the establishment of the trial. By the 14thOctober (5 months after establishment) the seedlings in the control group (un-sprayed) were in danger of being over-topped by the surrounding gorse, and by 9-months the gorse was up to chest-height and had well closed over 5 of the 12 un-sprayed tōtara seedlings. It is reasonable to assume that within the next few months unless some action to release these seedlings is taken, where gorse is present, it will completely overtop and cover the seedlings in this control group. In contrast, the two treated groups do not yet require any immediate releasing from gorse competition.

It is unknown whether the seedlings of control group will be fatally smothered by the overtopping gorse, or whether they will survive the competition for light, water, and nutrients, and eventually grow through the gorse. The results of this trial do not inform on whether any ill-effects of the herbicide with Treatment: 1 will be balanced by potential ill-effects from lack of releasing. Longer-term monitoring would be required.

Time of year/growth season

The trial was established in May, which is outside of the vigorous growth season recommended as being the most effective time to apply the herbicide. The effects of the herbicide on plant growth, survival or tolerance, may be different when applied at a different time of the year/growth season. The herbicide also appears to have delayed the growth spurts of the treated seedlings compared

with the controls and stunted or withered the tips new growing shoots during the hot summer conditions. The longer-term effects on the seedling health and growth remain unknown.

Potential forest establishment/management implications

The results of this Northland trial document an incidence of tōtara seedlings showing some resistance to knapsack applications of Metsulfuron-methyl (with penetrant), applied in late autumn, at various dose rates. This apparent resistance/tolerance suggests that this herbicide might have potential for use as an effective release spray around tōtara seedlings. For example, with careful application that tries to avoid directly spraying the tōtara seedlings, there may be relatively little risk of killing the tōtara by accidental contact such as from wind-drift etc. Or, by applying the herbicide at lower dose-rates than the recommended label rates for gorse, some weed-release effects may still be achieved (reduced vigour etc.) with negligible long-term effect on the tōtara seedlings.

However, any of these possibilities would need to be confirmed by further trials and documentation before they could be recommended.

These trial results bring to mind observations made on farm sites where gorse and kanuka has been sprayed and killed and revealed surviving tōtara seedlings and saplings that were present underneath the canopy at the time of spraying - the tōtara being released and growing on. However, what is unknown is whether the tōtara would have dominated anyway, and whether the spray was a clear advantage to them or not. Damaged growing tips may lead to poor form (e.g., development of multi-leaders etc.).

Control of difficult weeds

Kahili Ginger is a difficult to control weed in parts of Northland. Metsulfuron-methyl is the only effective herbicide to control it. The results of this trial suggest that this herbicide may be useful if tōtara forest establishment is wanted in areas afflicted with this or other problem weed species.

7. Conclusions

Encouraged by casual field observations this trial has explored the potential tolerance of tōtara seedlings to the herbicide Metsulfuron-methyl. The results set out above appear to support that observation.

Metsulfuron-methyl is potentially a useful herbicide in the control of difficult weed species during the early establishment phases of a tōtara seedlings and saplings. However, a better understanding of the relative resistance of tōtara seedlings and saplings to this herbicide is required before any recommendations can be made concerning its use or dose rates.

Further research trials are recommended. These should involve a larger sample size, application of the herbicide to the seedlings during their most active spring growth phase and monitoring performance over a longer time frame. Consideration should also be given to excluding the potential effects of insect damage to the seedlings in the sample during the trial period.

Figure: 9 – Photo of the potted seedling trial 14 months after treatments. From left to right; Treatment: 1 – sprayed with full label rate mix, Treatment: 2 – sprayed with half label rate spray mix, Treatment: 3 – Control, i.e., not sprayed with any herbicide at all. 15 seedlings in each treatment group.

8. Acknowledgements

Tāne's Tree Trust wishes to thank Gordon Williams and Jared Mc Glone of Pāmu Farms for providing the on-farm trial site and permitting access to regularly monitor the trial. Also, Terry Scott of Kukupa Plant Nursery, who generously donated a tray of tōtara seedlings for the trial. Support from the Tindall Foundation via the Our Forests Our Future programme is also gratefully acknowledged.

9. References

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