Resilient Forests Research Programme

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Technical Note

Accelerator Trial series update – treatment outcomes

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Summary: Tree growth and nutritional responses to the treatments applied at several of the Accelerator trials are encouraging, indicating the potential to significantly raise productivity beyond business as usual. Of particular interest is the impact of the initial site management decision made at the Rangipo site, which indicate that conventional site practices during afforestation need to be reconsidered with respect to site needs. The variation in the performance of the different genotypes has also revealed valuable information confirming the potential gains from appropriate matching of genotype to site. Future site treatments are also discussed.

Introduction

The Accelerator Trials were established under the GCFF programme to support the forestry sector's target of sustainably increasing the productivity of New Zealand's forest estate [1]. This is to be achieved at each of six trial sites (Fig. 1) through detailed assessments of tree growth and health followed by the application of interventions that address the limitations to productivity, with a specific focus on treatments that overcome the site-specific limitations to productivity for current and future rotations.

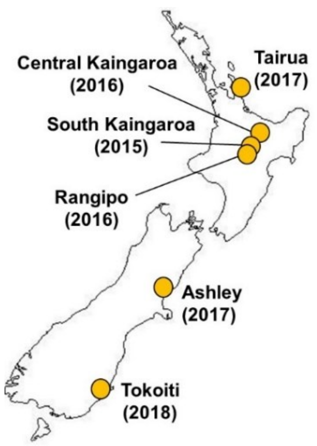

Figure 1 Location of the six Accelerator Trials and year of establishment.

Considerable detail regarding the design, conditions and initial treatments at each of the sites has been provided in previous technical and file notes[2-5], and will therefore not be reported again. This report will focus on the tree growth and nutrition data collected in 2020, and discusses future plans for the sites.

Southern Kaingaroa Trial (est. 2015)

Response to treatments

This site is nitrogen (N) limited, and therefore manipulating N availability forms the current treatment plan at this site. The responses to the biuret (totalling 20 kg N ha^{-1} over three applications) and urea treatments (totalling 100 kg N ha^{-1} over two applications) are shown in Fig.2.

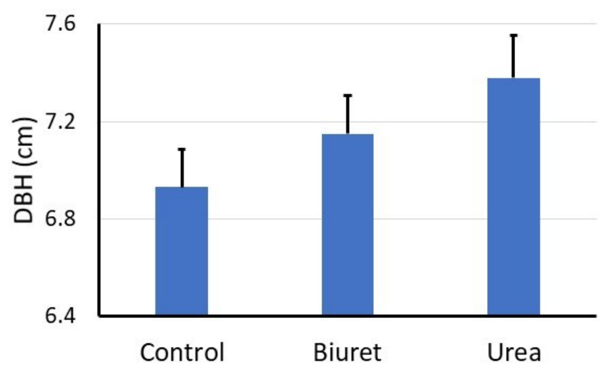

Figure 2 Variation in DBH with N treatment at Southern Kaingaroa.

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This programme is also funded by Scion.

As expected, the urea treatment significantly enhanced growth relative to the control, and also outperformed the biuret treatment – but as the mass of nitrogen addition was 5 times greater than with biuret, this difference was also not surprising.

Foliar samples were collected from trees growing in the different treatment blocks to assess the impact of the treatments on N and phosphorus (P) concentrations. The variation in foliar N concentrations was similar to that observed for growth (Fig. 3).

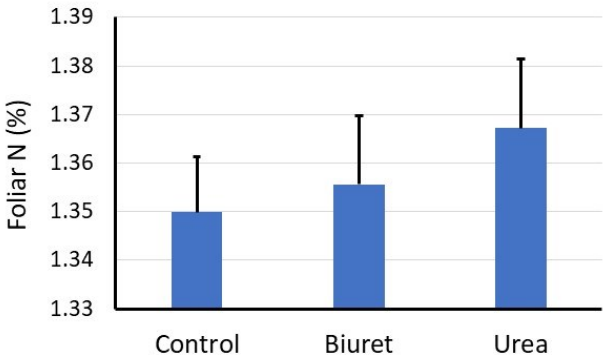

Figure 3 Variation in foliar N concentrations with N treatment at Southern Kaingaroa.

For P, the urea treatment produced a sharp decline in foliar concentration that was due to a dilution effect as measurements indicated needle masses had increased, but the biuret treatment essentially maintained foliar P concentrations despite promoting increased growth and foliar mass (Fig. 4).

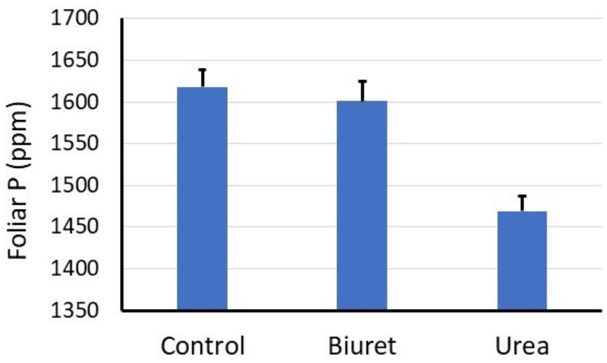

Figure 4 Variation in foliar P concentrations with N treatment at Southern Kaingaroa.

Variation in growth with genotype
The stock planted at this site varied considerably with genotype, as shown in Fig. 5. The attenuata x radiata hybrid (AxC) continued to perform poorly most likely due it's susceptibility to dothistroma. Likewise, Clone 31 continued to be the best performing tree at this site.

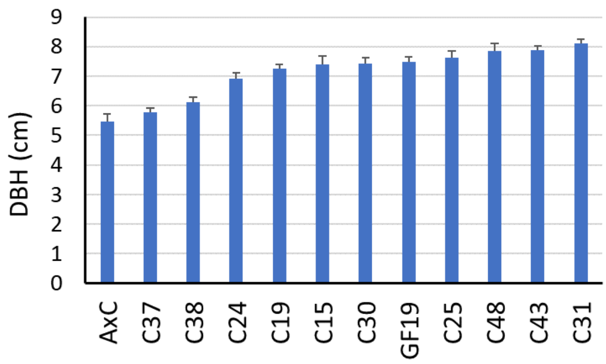

Figure 5 Variation in DBH with genotype after 5 years at Southern Kaingaroa.

Future work
Simulations with NuBalM[6] indicated that 500 kg N are needed to reach the productivity target for this site, so gradual additions will continue for the foreseeable future, with regular monitoring of foliar nutrients being undertaken to determine the timing of the addition of other key nutrients.

Central Kaingaroa Trial (est. 2016)

Response to treatments
The lupins introduced at this N limited site established well, but were heavily browed by rodents and therefore have low coverage. This disruption, combined with the short time frame since lupin seed was applied has meant there has been no discernible impact on productivity.

Variation in growth with genotype
The attenuata hybrid and Clone 37 were again the two poorest performing trees at this site, while Clone 31 was again the best – however, at this site Clone 31 was better than the next best performing genotype by a greater margin than at Southern Kaingaroa. The relative rankings of the other genotypes varied somewhat between the sites, but the differences were not considerable.

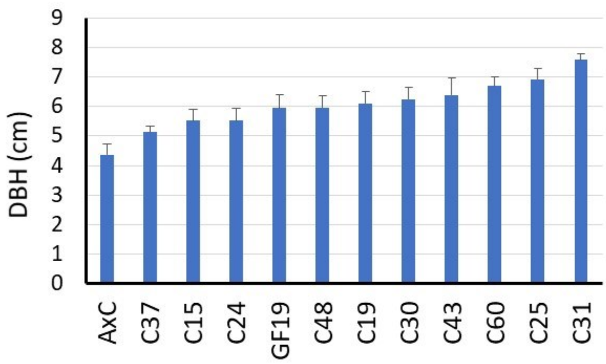

Figure 6 Variation in DBH with genotype after 4 years at Central Kaingaroa.

Future work
Monitoring will be undertaken in Spring to assess the extent of lupin re-emergence and coverage. If this is not considered to have a suitably positive impact on site nutrition and productivity an alternative nutrient strategy will be developed and deployed.

Rangipo Trial (est. 2016)

Response to treatments
The Rangipo trial was established on a moderately fertile ex-farm site. Initial treatments varying the standard cultivation practice of ripping and utilising higher initial stocking rates (1282 sph compared to 833 sph). The original concept was to test which treatment combination would enable rapid exploitation of this relatively fertile site. As observed in previous measurements, the ripping treatment has produced a significant decrease in tree growth rates, while the greater stocking rates has also significantly increased the growth rate of individual trees (Fig. 7).

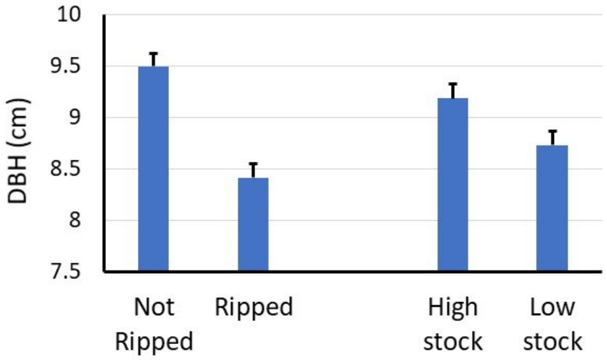

Figure 7 Variation in DBH with cultivation and stocking treatments after 4 years at Rangipo.

However, these results must be treated with caution as due to operational practicalities the ripping and stocking treatments could not be applied randomly across the trial area, and instead were established as discrete blocks. This issue limits the statistical power of the results as it creates the potential for localised variations in site properties to influence treatment outcomes, but was essentially unavoidable.

Examination of the foliar data from this site showed that ripping also had consistent negative effects on foliar N and P concentrations (Figs. 8 and 9). Nutrient concentrations also tended to be greater at the high stocking rate, but this effect was not significant.

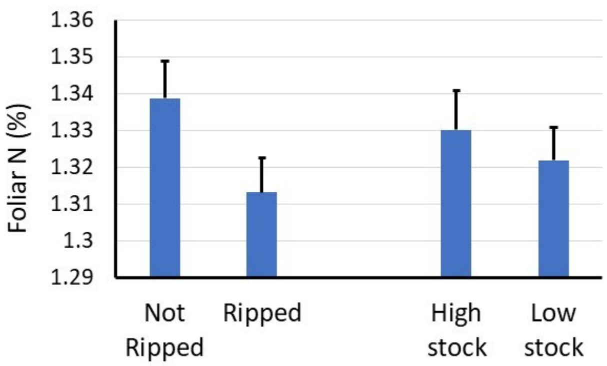

Figure 8 Variation in foliar N concentrations with cultivation and stocking treatments after 4 years at Rangipo.

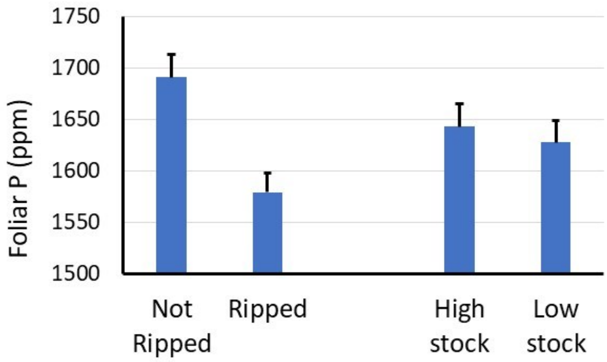

Figure 9 Variation in foliar P concentrations with cultivation and stocking treatments after 4 years at Rangipo.

Observations of the greater weed competition and general disturbance to the soil structure associated with the ripping treatment provide some explanation for the negative response to this ripping treatment, but it is more difficult to explain the positive responses to the higher stocking rate. One potential explanation is that the denser stocking has allowed the supporting soil microbiome to transition more rapidly to one that is best suited for radiata pine, allowing the trees to more efficiently access the pools of nutrient available at this site.

Variation in growth with genotype
As at the two Kaingaroa sites, the attenuata hybrid and Clone 37 were the two poorest performing genotypes and Clone 31 was the best at Rangipo (Fig. 10). Given these three sites are in relatively close proximity (c.f. Fig. 1) it is suggested that this outcome is driven primarily by climate and climate driven events (e.g. dothistroma incidence). However, it should be noted that the relative ranking of some genotypes (in particular the GF19 rated “control” seedlot) does vary, indicating it has a higher degree of site specificity, as is best suited to the greater nutrient availability at Rangipo.

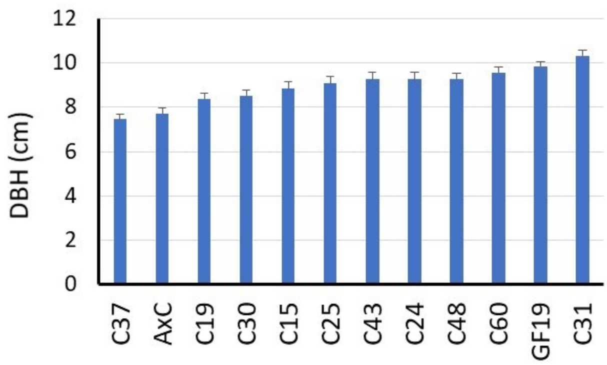

Figure 10 Variation in DBH with genotype after 4 years at Rangipo.

Future work
Given the now consistent positive effects of not ripping and greater stocking rate on tree performance, the impact of these treatments on supporting soil properties will be explored to understand if this provides a mechanism for the observed treatment effects. These data will be important to any effort to replicate these important

outcomes in other afforestation scenarios, and to understand the threshold at which competition in the higher stocked plots will become deleterious.

Ashley Trial (est. 2017)

Variation in growth with genotype
The attenuata hybrid was well suited to the dry Ashley site, as it was the second top performing genotype (Fig. 11).

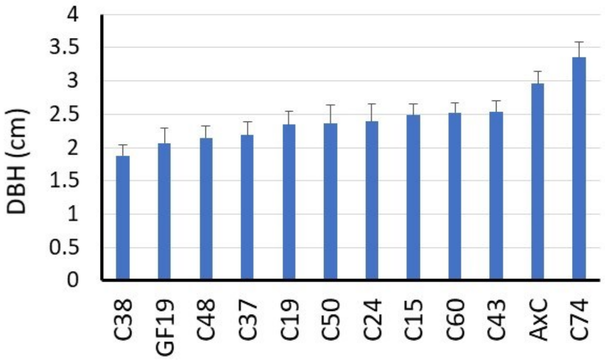

Figure 11 Variation in DBH with genotype after 3 years at Ashley.

Clone 31 was not available when this site was planted, so unfortunately it is not known if it would have continued to be a strong performer in these conditions. However, the strong performance of the attenuata hybrid does support the expectations for this genotype, and exploration of the drivers of the relative success of the tree (and Clone 74) at this site are planned.

Future work
This site will be used for additional study within the "Forest Flows" MBIE programme, and consequently will host an array of diagnostic instruments to understand water movement and availability within the soil. This will be coupled with direct measurement of plant stress levels; once baseline data are collected and previously discussed treatments to enhance drought tolerance (aminoethoxyvinyl glycine hydrochloride[7] and pyrazinecarboxamide[8] will be deployed.

Tairua Trial (est. 2017)

Variation in growth with genotype
The attenuata hybrid also performed well at the P-limited Tairua site, but it was the performance of Clone 37 that particularly stood out as this genotype was ranked in the bottom third at all other sites (Fig. 12).

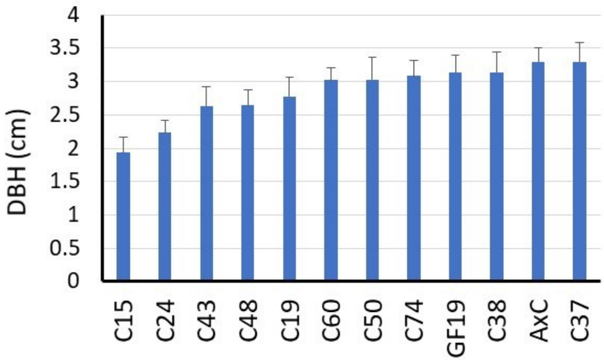

Figure 12 Variation in DBH with genotype after 4 years at Tairua.

Future work
Sampling to explore soil and microbial factors will be undertaken to investigate why Clone 37 appears so well suited to conditions at Tairua. Beyond this, P additions will take place shortly to match the increased P demand of the growing tree crop. This activity is supported by simulations with NuBalM, and treatments will initially take the form of mineral P applications augmented with other elements. This approach is being used to ensure nutrient limitation does not simply shift to another element. Applications will be made to the base of the trees to maximise the potential for nutrient uptake in an attempt to overcome the highly P retentive nature of the soils, and also to limit the uptake of additional nutrients by the weed population, which is extensive at this site.

Tokoiti Trial (est. 2018)

Response to treatments
The cultivation treatments applied immediately prior to planting at this site have produced the desired outcome of increased organic matter in the soil to increase water storage capacity (Fig. 13), but it was also evident that these alterations to forest floor and soil properties have negatively impacted the initial growth of the tree stock (Fig. 14). Survival rates were also lower in the cultivated plots (Fig. 15), but examination of the data indicated that this was predominantly due to greater mortality in two specific areas where poor drainage is likely the key issue.

Figure 13 Soil organic horizon extends to approximately 30 cm depth in uncultivated plots at Tokoiti (left panel), but following cultivation the organic horizon extends to ~45cm. (right panel)

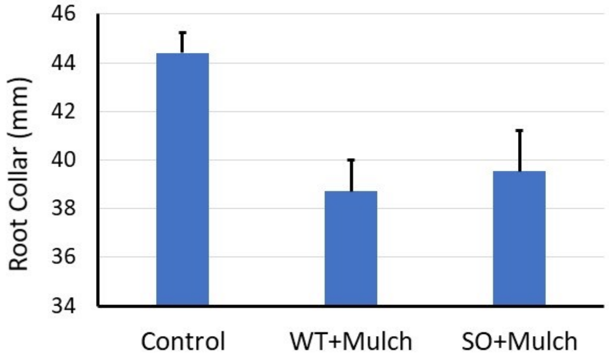

Figure 14 Variation in root collar diameters with the cultivation treatments (Control = whole tree harvesting followed by standard windrowing; WT+Mulch = whole tree harvesting followed by mulching to 400 mm depth; SO+Mulch = stem only harvesting followed by mulching to 400 mm depth) after 2 years at Tokoiti.

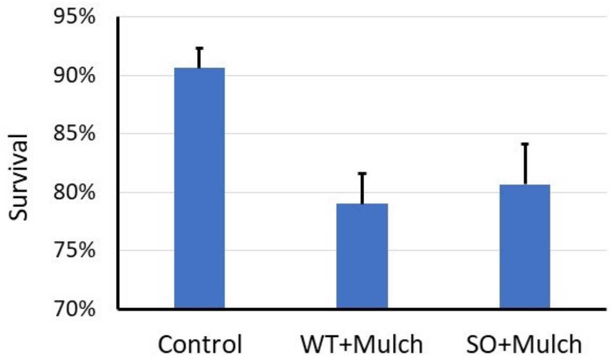

Figure 15 Variation in tree survival with the cultivation treatments (Control = whole tree harvesting followed by standard windrowing; WT+Mulch = whole tree harvesting followed by mulching to 400 mm depth; SO+Mulch = stem only harvesting followed by mulching to 400 mm depth) after 2 years at Tokoiti..

Future work

A site visit is being planned to diagnose the cause of the reduced tree growth, following which a treatment regime will be developed to assist the trees in recovering from this initial setback.

General Comments

As the growth data presented here is from relatively young trees and does not indicate tree form, it is not yet possible to relate any observed variations with treatment and genotype selection to the final value of the tree crop. For example, although GF19 displays generally good growth rates, issues with the form of this seedlot can reduce the realised value.

At the five oldest sites the trees have had sufficient time to express their genetic variability, so it is now informative to assess the relative performance of the genotypes. This was achieved by comparing the Z-scores for each genotype, which provides a standardised metric indicating how that genotype is performing relative to the mean value for all genotypes at that site (Table 1). This indicates each genotype performs above the mean at at least one site, and confirms the scope of the gains from appropriately matching genotype to site.

Table 1: Comparison of standardised genotype performance by site (Z-scores). Light pink and dark pink shading represent slightly and substantially below average performance respectively, light green and dark green represent slightly and substantially above average performance respectively.

Genotype	Southern Kaingaroa	Central Kaingaroa	Rangipo	Tairua	Ashley
AxC	-1.88	-1.96	-1.49	1.04	1.30
C15	0.34	-0.61	-0.14	-2.15	0.13
C19	0.15	0.08	-0.69	-0.18	-0.23
C24	-0.22	-0.60	0.37	-1.45	-0.12
C25	0.61	1.06	0.14		
C30	0.36	0.26	-0.53		
C31	1.16	1.82	1.63		
C37	-1.54	-1.06	-1.81	1.04	-0.62
C38	-1.15			0.68	-1.40
C43	0.90	0.42	0.36	-0.52	0.27
C48	0.85	-0.08	0.39	-0.49	-0.73
C50				0.42	-0.18
C60		0.78	0.73	0.39	0.21
C74				0.55	2.30
GF19	0.42	-0.10	1.05	0.65	-0.93

Acknowledgements

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