Date: June 2017
Reference: **GCFF TN013**

Technical Note

Screening trials comparing foliar treatment responses to Industry genotypes – 2016/17

Summary:

The effects of potential future mid-rotation spray treatments on enhancing growth of young *Pinus radiata* plants were investigated in a nursery pot trial at SCION. Eleven of the latest forest industry genotypes were treated with the most promising fertiliser products from the 2016 screening trials. The growth responses of different genotypes were compared with GF19 after the applications of 11 foliar fertiliser treatments.

Like last year, treatments provided significant measurable gains over untreated controls. Fertilisers increased the proportion of biomass allocated to stem, and therefore the efficiency of crop productivity. Based on the cost of fertiliser product for height gain, foliar applied urea-nitrogen at 16 kg in solution was again 10 fold more efficient than the conventional granular urea treatment. Across genotypes, the fertiliser treatments Phos-Pot ™ (Gro-Chem NZ) and Perk Supa ™ (Key Industries NZ) at 2 l/ha provided significant cost effective gains in young plant productivity.

Response of different genotypes depended on:
- Preceding nutritional status → plants without micronutrient deficiencies or toxicity responded better to N and P;
- Plant vigour → faster growing plants responded more to fertiliser;
- Biomass allocation → data indicated that improved genotypes allocate proportionally more to stem for similar plant size.

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Introduction

This project was initiated to learn and gain evidence of the effects of foliar fertiliser treatments on growth of some of the latest industry P. radiata genotypes.
The initial strategy was to engage with industry and raise an awareness that some genotypes might respond differently to mid-rotation fertiliser treatments and then seek interested collaborators so it would be possible to test this concept. A request was sent out to several key Forest Growers and the consensus was that a majority of the planting material for the Central North Island was produced in a limited number of nurseries.
As such, the best foliar fertiliser options from the 2016 screening trials were applied to 11 of the current year's genotypes and compared with GF19. Seed-lots and clones were provided by two of the major Central North Island nurseries. The overall goal was to determine the potential of foliar fertiliser treatments for enhancing growth in mid-rotation stands while minimising environmental effects and improving cost-

supported by forestgrowers commodity levy
FOREST OWNERS ASSOCIATION
This programme is also funded by Scion and the Ministry of Business, Innovation and Employment, New Zealand.

effectiveness compared with conventional practices.

Methods

Plant material was gathered from the key nurseries (above). Assessment of these latest industry genotypes was undertaken using pot trials as this is a fast and economic method to screen a large number of treatments under controlled conditions, particularly compared to operational trials in mid-rotation stands.

Six fertiliser products, some with two different rates were applied to 8 different seed-lots, 3 contrasting clones and a benchmark control (GF19). The fertiliser treatments and their properties are given in Appendix 1. All genotypes were supplied in Aug 2016 and planted separately into four litre liver pails containing a standard Dalton's potting mix.

Spray treatments were mixed in a solution of water and applied to plant foliage using the Scion track-sprayer on 12th Oct 2016. Each application was repeated 6 separate times on 6 sets of different plants.

In total 11 treatments were applied to 12 different genotypes. Each treatment was represented by 216 plants. Each genotype by treatment interaction was represented by 18 individual plants, and the trial consisted of 2396 plants in total.

Following operational practices, the target spray volume application rate was calibrated to 100 l/ha and was shown to be highly consistent across the 54 individual spray applications made for this study. The application rate varied from 95.5 – 107.1 l/ha, with an average of 101.9 +/- 2.03 (standard deviation; SD).

Response measures

Foliage chemistry and biomass allocation of selected genotypes were compared. The plant size of all genotypes was measured and changes over the course of the growing season (Oct 2016 through to May 2017) were investigated.

Foliage samples were collected in late summer from contrasting genotypes. This was to assist with explanations of contrasting growth responses (see later).

Initial measures of plant size were used to account for variations un-related to treatment effects and the response variable, volume index ($0.3*ht*\pi r^2$) was calculated and log transformed to improve compliance with analysis of covariance.

Biomass measurements

Biomass measurements were conducted on three genotypes that represented contrasts of plants and nursery conditions. Six seedlings were selected across each treatment x genotype interaction. This subset was based on two small seedlings from the 10% volume index quantile, two averaged sized from the 50% quantile, and two large plants from the 90% quantile range of each treatment. This allowed the analysis to take into account the effect of plant size on allocation, while avoiding the influence of uncharacteristic extremes.

A total of 108 plants were removed from their containers, their roots washed free of soil, the above and below ground components separated, bagged and then dried in an oven @ 70^{o} C until constant weight achieved. Stems and branches were stripped of their needles and these two components were again oven dried and weighed separately.

Results

The Spring period had above average rainfall of 311 mm rain evenly spread over the three months from Oct 2015 till end of Jan 2016.

Plant size and growth responses

Prior to treatment the mean height and diameter (+/- SD) of the plants were 35.7 (+/- 5.6) cm and 8.6 (+/- 1.7) mm. Plants on average were of similar height but the diameters were larger than those used in last year's screening trial. Of the 2396 plants, 2157 survived until final assessments in May. A mortality rate of 9% occurred randomly amongst all treatments of the trial, similar to last year.

Initially, the height of three treatments was larger than the controls (p<0.1). Assessment of height and diameter growth increment helped to account for these differences. Treatments grew up to a maximum of 69 cm in height and 12 mm in diameter prior to the final assessment in May.

Height growth

In May, 82% of treatments had plant heights significantly greater than the control (Fig 1). Conventional granular urea application (435 kg/ha) provided the greatest height gains across genotypes followed by foliar N (urea at 16 kg/ha), GIB 47 ($GA_{4/7}$ at 6.6 g/ha), and Perk Supa at 5 and 2 l/ha (Fig. 1). Positive height growth responses were shown by all treatments compared with the controls.

Diameter growth

In May, 18% of treatments had greater diameter growth ($p<0.05$) than the controls (Fig. 2). Again the conventional urea application was associated with the most diameter growth (24.6% gain), followed by the Perk Supa 5 l/ha treatment (Fig. 2). Essentially, treatments supplying nitrogen provided the greatest gains in diameter over the controls this season.

Volume increment

Combining height and diameter into a volume index for each treatment attributes the relative gains of these criteria collectively. Volume increment was increased by a maximum of 15.7% over the untreated controls by the conventional urea treatment (Fig. 3). Perk Supa 5 l/ha ranked next best and then foliar N and the plant hormone $GA_{4/7}$ (Fig. 3).

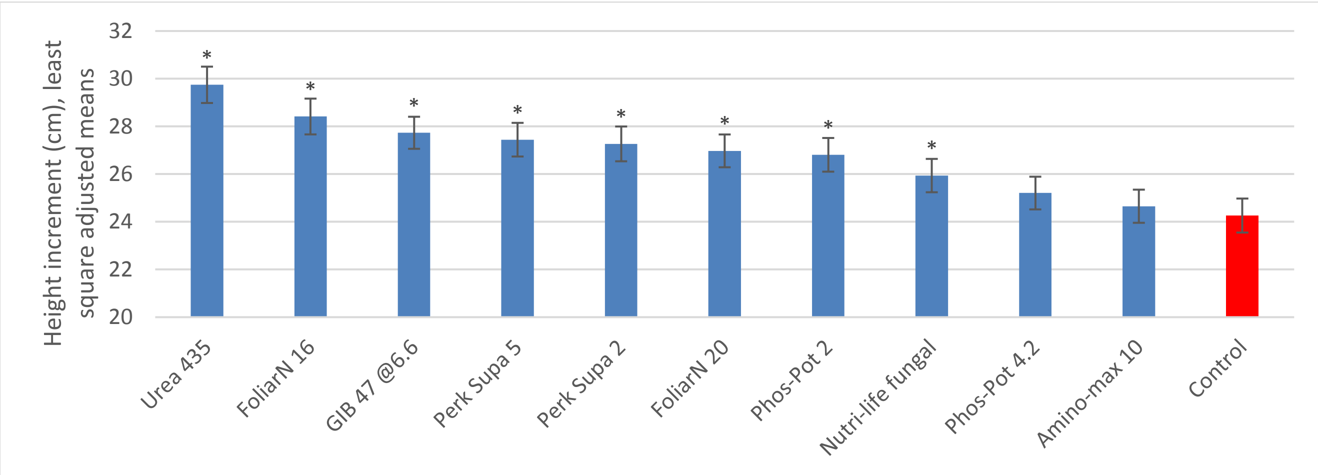

Figure 1. Mean seedling height growth as at the end of season measure. (p <0.05 = *). Bars = 1 StdErr of the mean.

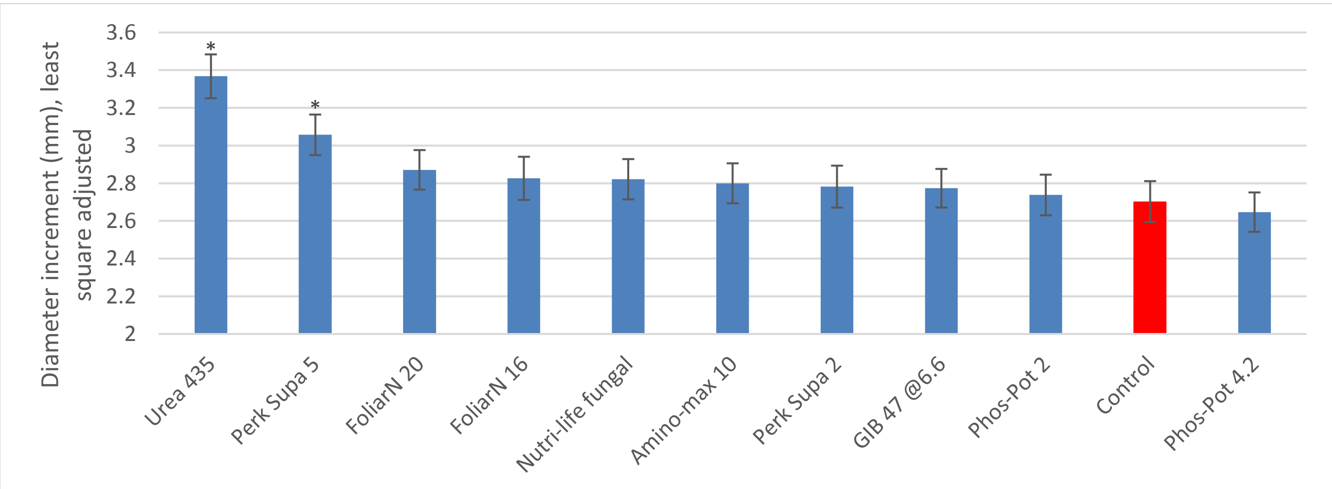

Figure 2. Mean seedling diameter growth as at the end of season measure (p <0.05 = *).

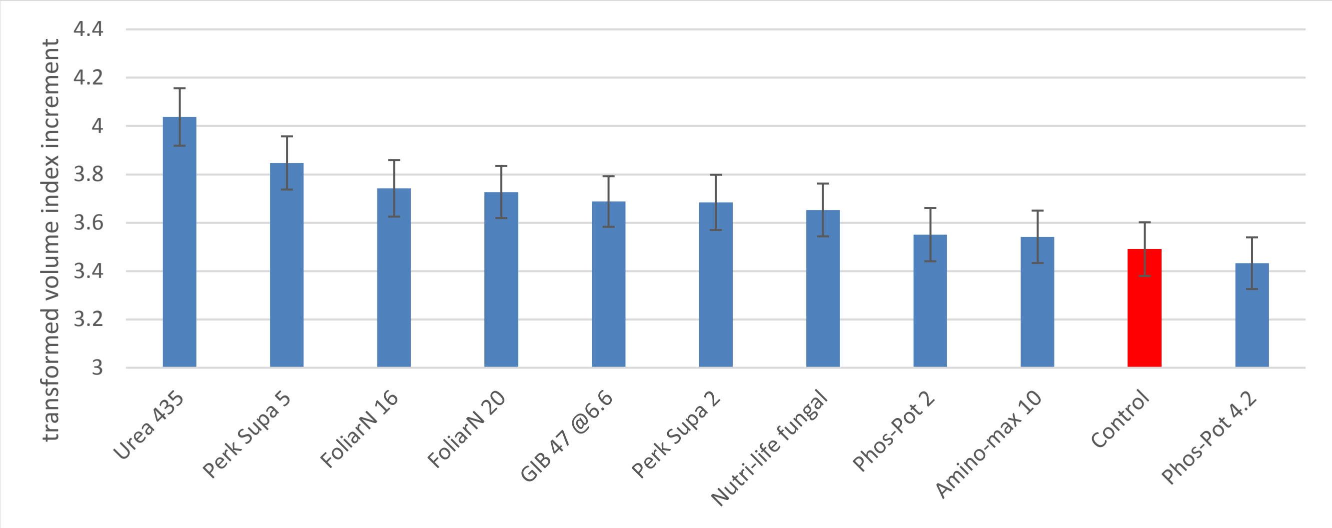

Figure 3. Mean Volume index growth as at the end of season measure across genotypes.

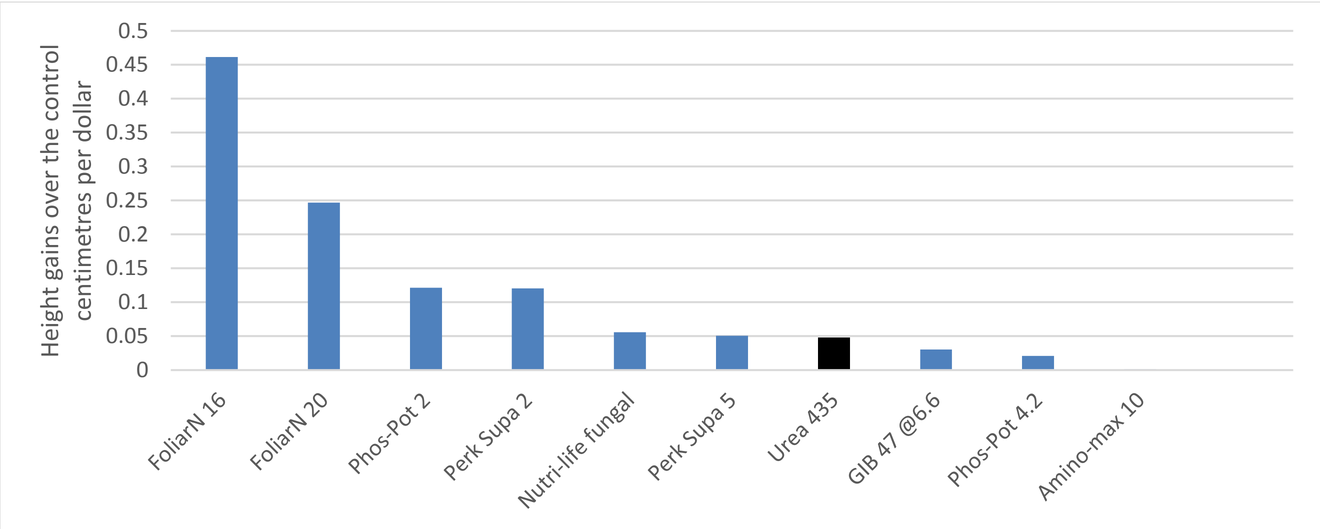

Figure 4. Mean height gains represented on a per dollar basis compared with the untreated controls across all eight different genotypes on average.

Growth gains on a cost of product basis

Height gains over the untreated controls were divided by the cost of products. Costs were based on the purchase price for small quantities/volumes and this approach was applied consistently across treatments. Foliar N was again, like last year, approximately 10 fold cheaper than the conventional fertiliser of granular urea for growth gains provided (Fig. 4). Obviously, there will be further gains by Forest Growers who purchase more products for cheaper prices.

Genotype height growth responses

Based on the untreated control treatment, GF19 provided more incremental growth than both the ArborGen seedlots and the Timberlands clones (Fig.5).

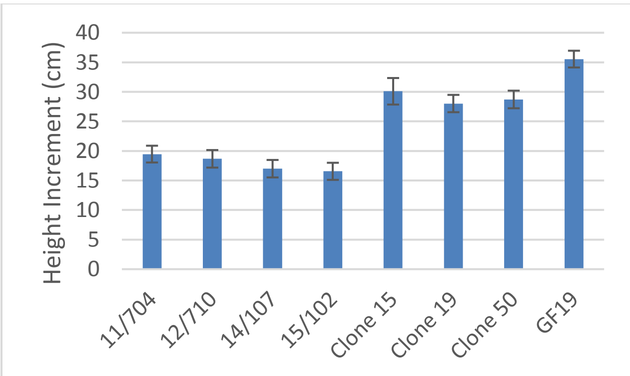

Figure 5. Four months plant height growth as represented by climate and potting mix provided by the untreated control treatment.

Genotypes appeared to respond differently to fertiliser treatments (Fig. 6). Seedlot 15/102 showed the greatest relative gains to the applied treatments on average. Seedlot 11/704, clone 15, and clone 19 appeared to be insensitive to treatment. This is potentially a function of adequate nutrient supply provided by the nursery conditions where they were raised, or that they met a nutrient deficiency limit (see later).

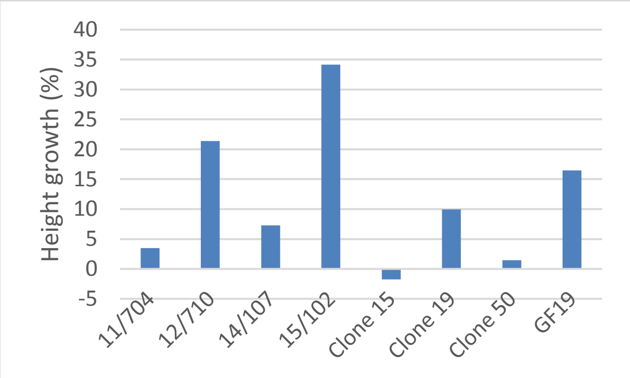

Figure 6. Response of plants in addition and relative to growth of the untreated control averaged across the 10 treatments.

Genotype by fertiliser interactions were clearly indicated because the seedlots responded more to nitrogen than phosphorus, compared with clone 19 and GF19 which responded more to phosphorus than nitrogen (Fig. 7). However, this may partially be a function of nursery nutritional influences preceding treatment.

For example, the applications of a phosphorus based product, to protect plants from Red Needle Cast infection, may have influenced the greater response to N of the ArborGen seedlots (pers. Comm. Mark Ryan).

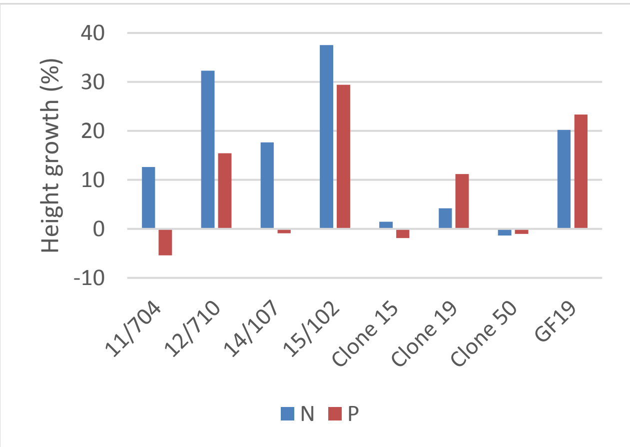

Figure 7. Response of plants in addition and relative to growth of the untreated control averaged across the N (urea 435 kg/ha, foliar N 15.65 kg/ha) compared with the P (Phos-Pot at 2 l/ha, Perk Supa at 2 and 5 l/ha) treatments.

Foliage nutrition

Based on the contrasting responses of seedlot 12/710 and clone 50 to fertiliser treatments, foliage samples were sent for nutrient analysis. Results indicated that K (Fig. 8) and Mn (not shown) were not significantly different in 12/710 or clone 50. Foliage N to P ratio was not significantly different across the two genotypes either. Foliage nitrogen appeared to be about 30% of optimal on average across both genotypes compared with foliage P. Aluminium was significantly lower in clone 50 (not shown).

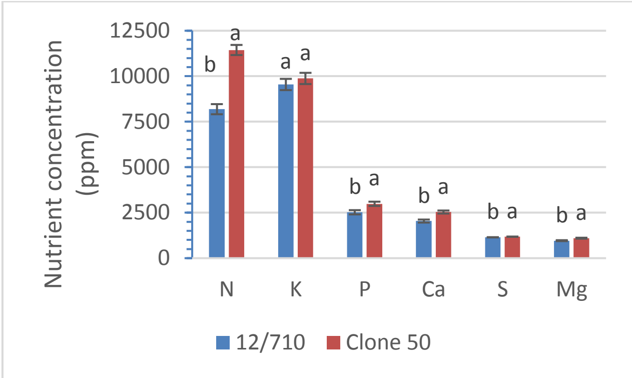

Figure 8. Macro nutrients in the foliage of seedlot 12/710 and clone 50. Elements with the same letter are not significantly different ($p < 0.05$) as per pairwise comparison for each individual element across genotypes.

Biomass and differences in allocation

The size of the plants chosen for biomass assessment were not significantly different across treatments ($p = 0.24$), but differed by genotype ($p < 0.0001$). This suggests an unbiased sample population based on treatment comparisons and inherent contrasts between genotypes.

All fertiliser responses showed greater dry weight above ground biomass (Stems + branches + foliage) on average than the untreated controls (not shown); i.e. “more shoots relative to roots”. All treatments with the exception of Perk Supa and Phos-Pot showed a decreasing proportion of above ground biomass with increasing plant size (not shown). This potentially indicates some specific factor limiting growth. Treatments which maintained the proportion of above ground biomass for increasing plant size also contained potassium (see Appendix 1). In the other treatments, proportionally more roots and less foliage were observed for increasing plant size, suggesting additional nutritional demand. Also, with increasing plant size the proportion of biomass allocated to stem was increased for all fertilisers as indicated by the positive slope of the product regression trends, except for Gibberellic acid ‘GIB 47’ (Fig. 9).

Biomass allocated to stem is the most economically valuable component to a forest manager. Allocation to this component appeared to be increased by all fertiliser treatments, but not significantly (Fig. 10). This is probably only a function of how few biomass samples were harvested (n = 18). It's important to note that no fertiliser products reduced the fraction of biomass allocated to stem compared with the untreated controls (Fig. 10).

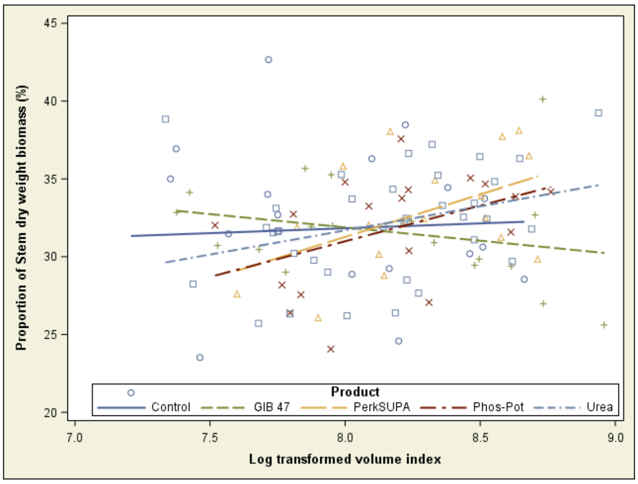

Figure 9. Stem and branch dry weights of plants treated with a range of fertiliser 'products', as listed in the legend insert, in Oct 2016 and harvested in May 2017.

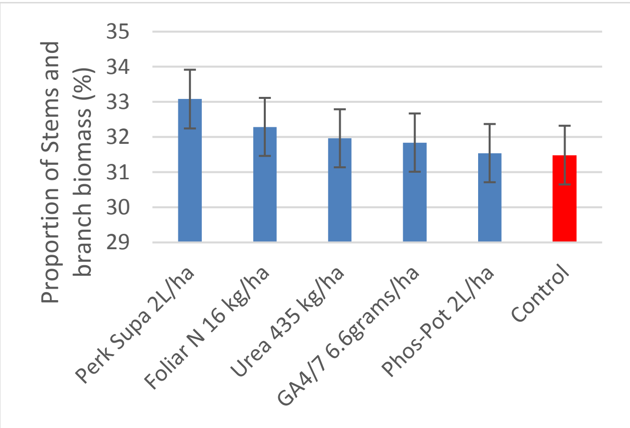

Figure 10. Stem and branch components for identified products. Least square adjusted mean values are plotted as at the end of season harvest. Bars indicate one standard error of the mean.

Genotype effects on biomass allocation

There were large differences between the three genotypes compared. In general the GF19 and the ArborGen seedlot 12/710, were most similar (Fig. 11). The 12/710 seedlot produced 7.8% more stem weight for a given size than the GF19. Recently ArborGen seedlots have generally been selected for greater wood density (pers. Comm. Mark Ryan), and this explains some of the observed differences in stem dry weight indicated by the slopes of the regression trends (Fig. 11). Also increased branch sizes of older physiological materials may partially explain the observed trends.

Seedlot 12/710 maintained a consistent proportion of stem biomass allocated with increasing plant size (Fig. 12). GF19 provided a slightly reduced allocation to stem with increased volume index and clone 19 showed gains as per the positive regression trends illustrated, although clone 19 plants did not attain the large volume indices.

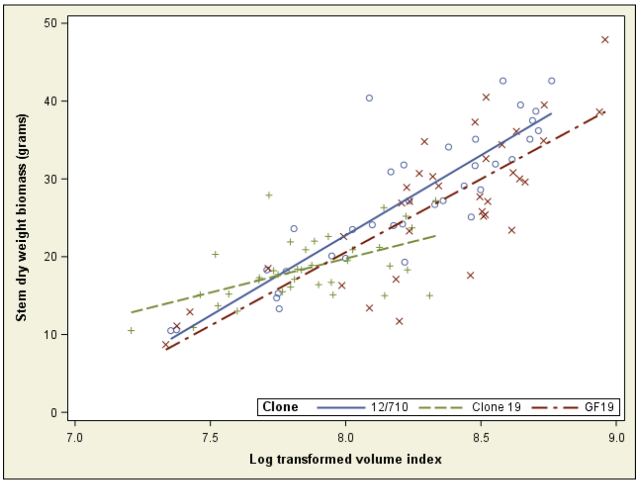

Figure 11. Stem and branch dry weights across three different genotypes 'Clone', treated with a range of fertilisers sprayed onto foliage in Oct 2016 and harvested in May 2017.

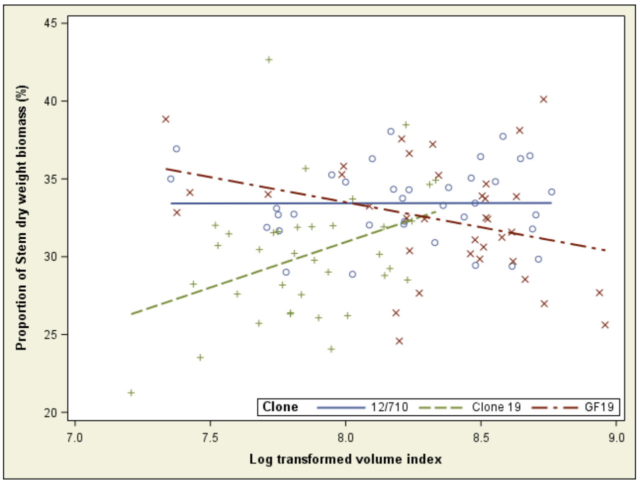

Figure 12. Proportion of stem and branch dry weights across different plant sizes for three contrasting genotypes treated with a range of spray products in Oct 2016 and harvested in May 2017 across.

Discussion and Conclusions

Full benefits of the different fertiliser products are not yet fully understood, however, a single application of the products again significantly influenced plant growth parameters. This year has been particularly wet with well above average rainfall, and this influenced growth patterns and final fertiliser responses as measured by height and diameter. Unlike last year, most productivity gains were height responses. This supports the idea that increased height growth is partially related to plant moisture availability.

At the end of the season, genotypes were shown to be nitrogen deficient by foliage analysis and did visually appear pale in colour. This suggests that any gains obtained from the treatments were likely to be fully expressed by the measured responses, because all plants reached a similar nutritional limit in late summer.

Some genotypes such as 12/710, clone 15, and clone 50 were non responsive to either N or P. This suggests growth is limited by micro nutrients or by some other resource. This work also provides evidence that adding an inappropriate fertiliser such as P to seedlot 12/710 can lead to negative growth effects, confirming the critical need for forest managers to understand plant nutrient conditions before treatment with fertilisers.

This study provides more evidence and support for several of the treatments which show good potential as new spray options. Advantages such as a 10 fold increase in nitrogen cost efficiency when applied as a liquid foliar application are well supported. Foliar application is likely to become an efficient option for forest managers to redress nutrient limits once site specific Productivity Gaps are identified.

Treatment options require additional testing under operational settings and a series of field trials have been established at Mid-rotation sites (see Tech-Note XX).

Based on the finding of these studies:

- Gibberellic acid ($GA_{4/7}$) at rates of less than 6 grams/ha is a promising option for manipulating wood quality through early initiation and also perhaps extending the growing season.
- An optimal rate of PerkSupa was confirmed to be 2 l/ha as tested rigorously across a range of the latest industry genotypes.
- We confirm that foliar nitrogen applied in late spring (Oct/Nov) at a rate of 16 kg/ha urea in solution provides improved growth responses compared with conventional treatments at 435 kg/ha of granular urea on a cost basis.

Acknowledgements

Funding for this research came from the “Growing Confidence in Forestry’s Future” research programme (C04X1306), which is jointly funded by the Ministry of Business Information and Employment (MBIE) and the Forest Growers Levy Trust, with the support of the NZ Forest Owners Association (FOA) and the NZ Farm Forestry Association (FFA). The authors are also grateful for the additional technical support provided by Scion staff, and the supply of genotypes by ArborGen and Timberlands.

Appendix 1.

Treatment	Product	Rate applied	N	P	K	Approximate Cost/ha
			(kg/ha)			
1	Control	-	-	-	-	$0.00
2	Urea	435 kgs	200	-	-	$115.00
3	Urea	15.65 kgs	7.2	-	-	$9.00
4	Urea	19.56 kgs	9.0	-	-	$11.25
5	Amino-Max	10 Litres	0.57	-	-	$353.80
6	PerkSUPA	2 Litres	-	0.46	0.76	$25.00
7	PerkSUPA	5 Litres	-	1.15	1.90	$62.50
8	Phos-Pot	4.2 Litres	0.08	0.46	0.80	$44.52
9	Phos-Pot	2 Litres	0.04	0.22	0.38	$21.20
10	Nutri -life Fungal	50 grams	-	-	-	$330.64
11	GIB 47	6.6 grams	-	-	-	$113.52