FUTURE FORESTS RESEARCH

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number: RSPTN-031
Date: June 2012

Growth Responses of Radiata Pine Clones to Nitrogen and Phosphorus Fertiliser Application

Summary

Driven by high expectations of improved growth and uniformity, clonal forestry is increasingly being adopted for radiata pine in New Zealand. However, to what extent clone and/or fertiliser application (and their interactions) may play a role in operational clonal plantations remains uncertain. This technical note is the first New Zealand report on the clone-by-fertiliser interactions from a trial planted with large numbers of clones.

We found application of N and P fertilisers generally improved the growth of clones grown on a Pinaki sand soil type (Woodhill Forest, northwest of Auckland) with low soil fertility. Large variations in growth existed among 40 clones, with 1537, 1840, 2214, 2202 and 2469 performing consistently better than others across the control and fertilised plots. In addition, significant differences were found in growth responses of clones to the application of N and P fertilisers. Four types of clones were identified with different growth efficiency and fertiliser response in this study. The implications of these results for management of clonal plantations are:

- Implication 1 – high efficiency and high response clones should be deployed to maximise the productivity if forest growers and managers can afford to apply fertiliser;
- Implication 2 – high efficiency and low response clones can also be deployed if forest growers and managers would like a low input production system.

For matching the clones to specific soils, however, it is necessary to characterise the responses of the current deployment population of radiata pine to fertiliser application. A robust site/soil classification system also needs to be developed in the near future for site specific management to optimise or maximise the product output from plantations through managing the interaction between site, genetics and management inputs (e.g. fertilisers).

Author: Jianming Xue, Scion

Introduction

Due to improved growth, uniformity and wood characteristics, clonal forestry is increasingly being adopted for radiata pine in New Zealand [1, 2]. A current barrier to the widespread deployment of clonal plantations is the higher cost per cutting versus mass control pollinated or improved open pollinated seedlings[3]. In order to offset higher costs of clonal materials at planting, it is necessary to manage clonal plantations with a high level of silvicultural inputs to maximise growth rates and improve product class distribution at harvest[3, 4]. Fertiliser application is one of the commonly prescribed management practices currently in radiata pine plantations[5], and likely will be a prescription for many clonal plantations in the future. Therefore, intensive silvicultural practices, including fertiliser application, will be required to capture the full growth potential of clonal plantations.

As forest managers move toward site-specific management, an understanding of how clones respond to site resources (such as nutrient availability) and silvicultural regimes is necessary for matching the most appropriate planting stock to local conditions, to maximise productivity in intensively managed radiata pine forests. Different growth responses to fertiliser application and weed control have been observed among a small number of

radiata pine clones planted in a national trial series [6]. However, no information of clone-by-fertiliser interactions is available from trials planted with large numbers of clones [7, 8]. It is important to realise that even if such interactions occur at a low rate, they may remain an issue if they randomly occur in any of the relatively small number of high-performing clones that are selected and deployed over a wide geographic area.

It remains uncertain to what extent clone-by-fertiliser interactions play a role in operational clonal plantations. While potential interactions of clone-by-environment or clone-by-silviculture clearly represent a challenge for the management of clonal plantations, they may also present management opportunities. For instance, if highly responsive clones are identified prior to planting, appropriate silvicultural systems may be implemented to take full advantage of their potential growth responses [9].

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number: RSPTN-031
Date: June 2012

Our research objective was to determine growth response, needle retention, stem form and wood qualities of radiata pine clones with and without fertiliser application. Only growth and needle retention data are currently available and therefore are presented in this technical note.

Materials and Methods

Trial Location and Site Characteristics

The study site is located at Northern Woodhill Forest (36°33'S, 174°14'E) northwest of Auckland, with elevation of 17 m a.s.l. and slope of 5 – 15°. The mean annual rainfall at this site is 1140 mm and average annual temperature 14.5°C. The soil, a well drained Pinaki sand, is low in total C, N and P, extractable cations and CEC.

Trial Design and Genetic Material

The trial has four control plots (no fertiliser application) and four plots where fertiliser was applied. For the fertiliser-applied plots, 50 kg N ha^{-1} as urea was applied in 2004 and 2006 respectively, and 44 kg P ha^{-1} as reactive rock phosphate was applied in 2004 and 31 kg P ha^{-1} as triple super phosphate in 2005.

Three ramets of each of 40 radiata pine clones were randomly planted in each of these eight plots. Of the 40 clones, 20 were created through fascicle cuttings from the seedlings of control-pollinated families selected for high volume growth rate and improved stem form (GF24-31), but of unknown nutritional characteristics.

The remaining 20 clones were created through fascicle cuttings from the seedlings of open-pollinated families (GF7) selected for different nutrition-related UMCY (upper and middle crown yellowing) symptom scores and diameter growth.

The trial was established in July 2004 with a planting space to give a final stocking of 1000 seedlings ha^{-1}.

Growth Measurements and Data Analyses

Height and DBH were measured for individual trees in all eight plots in July 2010 (year 6). Tree stem volume (VOL) was calculated from both DBH and height. Needle retention was assessed as the number of needle age classes evident in the lower third of the green crown of individual trees.

Results and Discussion

There were significant fertiliser and clone effects, and fertiliser-by-clone interactions for tree height, DBH and volume and needle retention (Table 1). Clone had a stronger effect than fertiliser on tree growth (height, DBH and volume), while fertiliser had a stronger effect than clone on needle retention. The interactions of clone-by-fertiliser were significant but relatively smaller for all measured parameters (Table 1.)

Table 1. Analysis of variance results of tree growth and needle retention. The first value in each cell is the F-value. The higher the value, the more highly significant the effect.

	Tree height (m)	Tree DBH (cm)	Tree Volume (cm^3)	Needle retention (years)
Fertiliser	3.16	5.94	6.99	42.05
	$p<0.05$	$p<0.01$	$p<0.01$	$p<0.0001$
Clone	13.25	11.51	8.67	7.17
	$p<0.0001$	$p<0.0001$	$p<0.0001$	$p<0.0001$
F x C	11.51	1.39	1.45	1.45
	$p<0.05$	$p<0.05$	$p<0.05$	$p<0.05$

F x C – fertiliser-by-clone interaction

Across fertilised and unfertilised plots, clones 1537, 1840, 2214, 2202 and 2469 had higher volumes than other clones, while P25C2, P12C1, S04C46 and S16C2 were smaller (data not shown).

Application of N and P fertiliser significantly increased tree height, DBH and volume, and needle retention (Table 2).

Table 2. Effect of fertiliser application on tree growth and needle retention. The differences between control and fertiliser treatments are significant at *P* < 0.05) for all four measurements.

Treat-ment	Tree height (m)	Tree DBH (cm)	Tree Volume (cm^3)	Needle retention (years)
Control	7.28	10.69	24203	2.27
Fertiliser	7.42	11.17	27011	2.49

The interaction of clone-by-fertiliser was mainly due to the contrasting reponses of clones P26C2, S15C6, 1927, and 2853 to fertiliser application (Figure 1).

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number: RSPTN-031
Date: June 2012

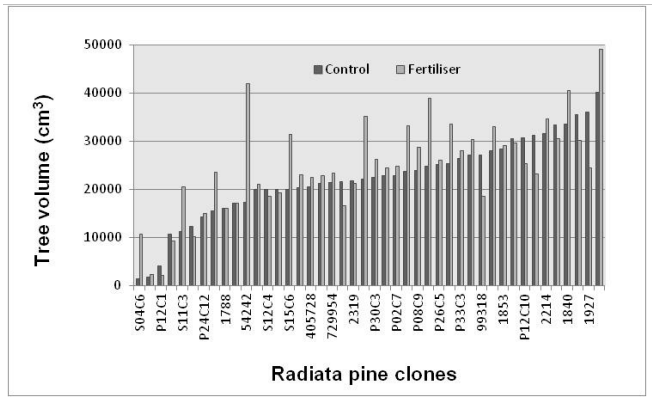

Figure 1 Tree volume responses of radiata pine clones to fertiliser application.

Based on the tree volume of clones grown at the control plots, which reflected the clonal efficiency of nutrient use under low fertility conditions, and the volume response of clones to fertiliser application, four types of clones were identified (Figure 2):

Group 1 (6 clones) – High efficiency and high response (to N & P), including clones 1537, 1840, 2214, P33C10.

Group 2 (7 clones) – High efficiency and low response (to N & P), including clones 1927, 2002, 2233, 2853.

Group 3 (7 clones) – Low efficiency and high response (to N & P), including clones S11C3, P32C1, S15C6, 2293.

Group 4 (7 clones) – Low efficiency and low response (to N & P), including clones P12C1, 2168, 1788, 2084.

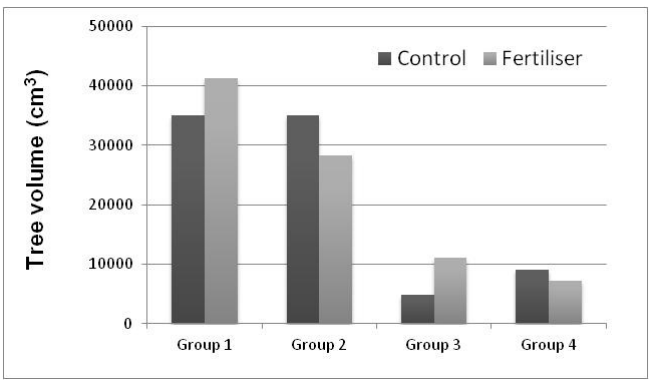

Figure 2. Four types of clones with different nutrient use efficiency and fertiliser response. There are a, b, c, d clones in Groups 1-4, respectively.

The results have significant implications for management of clonal plantations. For the high input production system, after deployment of high efficiency and high response clones, applying appropriate fertilisers can take full advantage of the potential growth responses of clones to additional nutrients. For the low input production system, high efficiency and low response clones can also be deployed to maintain reasonable growth without fertiliser application.

Conclusions

- Overall, application of N and P fertilisers improved the growth of clones under low soil fertility conditions.
- Large variations were found among the clones in growth, with some clones performing consistently better than others under both low and high soil fertility conditions.
- There were significant differences to fertiliser application in growth responses of clones.
- Four types of clones were identified with different growth efficiency and fertiliser response in this study. The results have important implications for management of operational clonal plantations across sites with different N and P supply.
- It is suggested that the response of the current deployment population of radiata pine to fertiliser application is explored to determine the range of clonal variation in response to fertilisers.
- It is also important to develop robust site/soil classification systems in the near future for site specific management to optimise or maximise the product output from plantations through managing the interaction between site, genetics and management inputs (e.g. fertilisers).

Acknowledgements

We would like to thank Carter Holt Harvey Forests for providing the site for this study, Peter Beets, Doug Graham, Stephen Pearce and Graeme Oliver at Scion for establishing and measuring the trial, and Paul Charteris and Peter Clinton at Scion for valuable comments on this technical note.

Future Forests Research Ltd, PO Box 1127, Rotorua. Ph: 07 921 1883 Email: info@ffr.co.nz Web: www.ffr.co.nz

References

1. Sorensson, C.T., and Shelbourne C.J.A., *Clonal forestry*. In: Colley, M. (ed.) Forestry Handbook, 4th Edition. New Zealand Institute of Forestry, Inc. pp. 92-96. (2005).
2. Baltunis, B.S., Wu, H.X., Dungey, H.S., Mullin, T.J., and Brawner J.T., *Comparisons of genetic parameters and clonal value predictions from clonal trials and seedling base population trials of radiata pine*. Tree Genet. Genomes **5**, pp. 269–278. (2009).
3. Wright, J., Dougherty, D., *Silviculture for your varietal loblolly pine plantation*. Forest Landowner **66**, pp. 26–29. (2007).
4. Dougherty, D., *Improved returns on forestlands: a financial analysis of MCP and varietal seedlings on private land in the southeastern United States*. Forest Landowner **66**, pp. 15–18. (2007)
5. Burdon, R.D., *Genetic variation in nutrition and edaphic requirements in Pinus radiata: The evidence, implications and research proposals*. Scion Report 56, pp1-26. (1992).
6. Olykan, S.T., Xue, J.M., Clinton, P. W., Skinner, M.F., Graham, D.J., Leckie, A.C., 2008: *Effect of boron fertiliser, weed control and genotype on foliar nutrients and tree growth of venile Pinus radiata at two contrasting sites in New Zealand*. Forest Ecol. Manag. **225**, pp. 1196-1209. (2008).
7. Paul, A.D., Foster, G.S., Caldwell, T., McRae, J., 1997. *Trends in genetic and environmental parameters for height, diameter, and volume in a multilocation clonal study with loblolly pine*. Forest Sci. **43**, 87–98. (1997).
8. Baltunis, B.S., Huber, D.A., White, T.L., Goldfarb, B., Stelzer, H.E., *Genetic analysis of early field growth of loblolly pine clones and seedlings from the same full-sib families*. Can. J. Forest Res. **37**, pp. 195–205. (2007).
9. Roth, B.E., Jokela, E.J., Martin, T.A., Huber, D.A., White, T.L., *Genotype×environment interactions in selected loblolly and slash pine plantations in the southeastern United States*. Forest Ecol. Manag. **238**, pp. 175–188. (2007).