FUTURE FORESTS RESEARCH

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number: RSPTN-030
Date: May 2012

UMCY Symptoms in Radiata Pine Vary by Site and Clone

Summary

Upper mid crown yellowing (UMCY) is a visible magnesium (Mg) deficiency symptom widespread in semi-mature radiata pine stands throughout New Zealand, particularly on pumice soils in the central North Island. If severe, it will cause crown dieback, growth loss and a reduction in wood density. The site and genetic factors associated with variation in UMCY symptoms in radiata pine are not well understood. This technical note provides an update on UMCY research based on a nationwide clonal trial series covering a range of soils and climates.

From five trials assessed in this study, we found UMCY symptoms caused needle loss and reduced tree growth by approximately 10% compared to trees without visual symptoms. UMCY symptom scores varied significantly across sites, and were related to site altitude and especially soil Mg (r = -0.69), Olsen P (r = -0.65), K (r = -0.53) and K/Mg ratio (r = 0.62). Large variation in UMCY scores associated with foliar K/Mg ratio and Ca, Mg and other nutrient concentrations also existed among the clones tested. Site-to-site correlations were strong for UMCY scores of the tested clones, indicating clonal stability in expression of the symptom across the sites. Some sensitive clones (e.g. S02C1, P07C10) have potential uses as indicator clones for Mg deficiency. The implications for management of operational clonal plantations in New Zealand are:

- Implication 1 – UMCY tolerant clones should be deployed to sites with low soil Mg and high soil K/Mg;
- Implication 2 – Integrated management of site and clone resources is required for minimising UMCY problems in radiata pine stands.

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Background

Magnesium (Mg) deficiency in radiata pine results in needle-tip yellowing and, if severe, crown dieback, growth loss [1] and a reduction in wood basic density (Beets, unpublished). In semi-mature stands it is commonly referred to as upper mid-crown yellowing (UMCY) [2, 3].

Large differences in the severity of UMCY symptoms occur over small spatial scales at Puruki forest ($38^0$26'S, $176^0$13'E) in the first rotation, arising partly because of genetic differences in nutritional traits between trees, but suspected variations in site factors have eluded detection [3]. Several trials established in a second-rotation radiata pine stand at Puruki forest have confirmed that soil and genetic factors are associated with variation in Mg deficiency symptoms observed on the pumice soils [3].

However, information is lacking on site and genetic variation in UMCY symptoms across a range of sites with different soils and climates. To better understand the occurrence of UMCY symptoms and to develop cost-effective strategies for managing soils and genotypes to overcome this problem on a national basis, a clonal trial series covering a range of soils and climates nationwide, was established under the current PEEF programme to test generality of UMCY results obtained from Puruki forest. This clonal trial series will provide good opportunities to assess growth, health, and wood quality characteristics in relation to soils and genotypes.

The purpose of these trials was to quantify the effect of site and clone on occurrence of UMCY symptoms and determine the factors associated with site and clonal variation in UMCY symptoms.

Materials and Methods

Trial Design and Genetic Material

- A nationwide clonal trial series was established in 2002-05 at 14 sites covering a range of soils and climates (Figure 1).

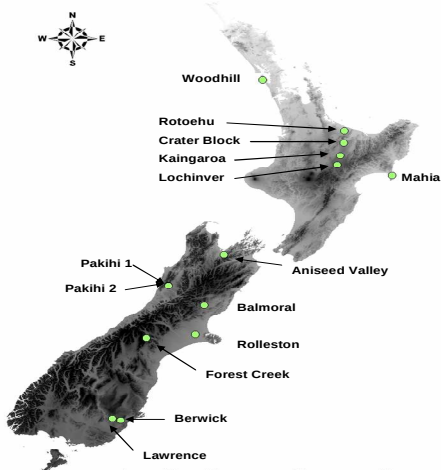

Figure 1. Locations of 14 trials.

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- For each of 14 trials, there are 4 plots.

- Three ramets of each of 40 radiata pine clones were randomly planted in each plot.
  - Of the 40 clones, 20 clones were created through fascicle cuttings from the control-pollinated families selected for high volume growth rate and improved stem form (GF24-31) but 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 symptom scores and diameter growth.

UMCY Symptom Scoring and Data Analysis
Five of 14 sites more susceptible to Mg deficiency (Lochinver, Kaingaroa, Crater Block, Berwick and Lawrence), were selected for assessment of UMCY symptoms in the springs of 2010 and 2011 (at age 5-8).

UMCY symptom was scored at a scale of 1-5 for young trees before canopy closure as below [3]:

1) Year 1 & 2 needles entirely green and healthy.
2) 2nd year needles are yellow tipped and current needles are green and healthy.
3) 1 year old needles are yellow tipped over part of the shoot and current are green.
4) 1 year old needles are yellow tipped over entire length of the shoot and current are green.
5) 1 year old needles are yellow tipped over entire length of the shoot and current have yellow needle tips.

In the statistical analysis we tested the relationships between UMCY scores and site, soil or foliar variables, and between sites in UMCY scores.

Results

Site and Clonal Differences in UMCY Symptoms
The severity of UMCY symptoms varied significantly among the sites, with the highest mean score at Lochinver and the lowest mean score at Crater block (Table 1).

Table 1 Site, age, mean DBH, tree height and UMCY score. Standard deviation is provided in parentheses. Sites with the same letter in the final column do not differ in mean UMCY score.

Site	Age[1]	Dbh (cm)	Height (m)	UMCY	UMCY diff
Crater Block	6 (5)	120	6.5	1.46 (1.07)	D
Berwick	8 (8)	143	7.3	1.74 (1.03)	C
Lawrence	8 (8)	167	7.9	2.12 (1.22)	B
Kaingaroa	5 (6)	27.9	2.3	2.35 (1.43)	B
Lochinver	7 (8)	28.5	2.3	2.82 (1.49)	A

[1] Age – when UMCY symptoms were scored, and when tree growth was measured (age in parentheses).

Large variations in UMCY symptom scores were also found among the clones tested in this study (Figure 2). Six clones had high scores but most were clustered with moderate to low scores.

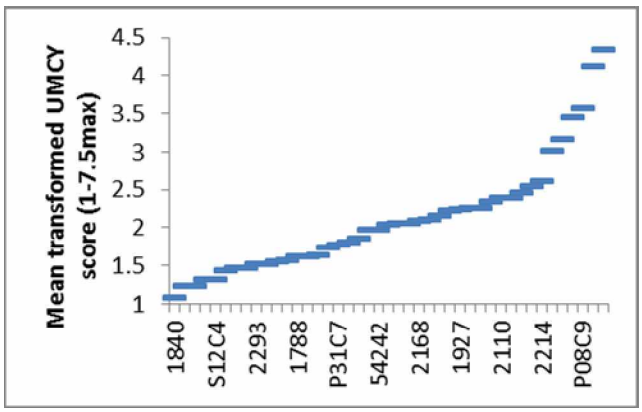

Figure 2. Distribution of UMCY symptoms for a range of clones (mean values across five sites).

Clones S02C1 and P07C10 consistently showed severe UMCY symptoms across sites. This implies they had the potential to be used as indicator clones for Mg deficiency. Other clones susceptible to UMCY symptoms were P08C9, 2084 and S07C8.

Clone 1840 had the extreme low UMCY symptom score, indicating tolerance to Mg deficiency. Other clones with low UMCY symptoms were 2469 2583, 1678, S12C4, 2526, 1608, P02C7, 2293, P26C5.

Site-site Correlations for UMCY Symptoms
Overall, there were good correlations among the sites for UMCY symptom scores (data not shown). A very strong correlation was found between Berwick, a South Island site, and Kaingaroa, a North Island site for clonal UMCY scores (Figure 3). This provides

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support for the robustness of the scoring method and also suggests a strong clonal effect on expression of UMCY symptoms.

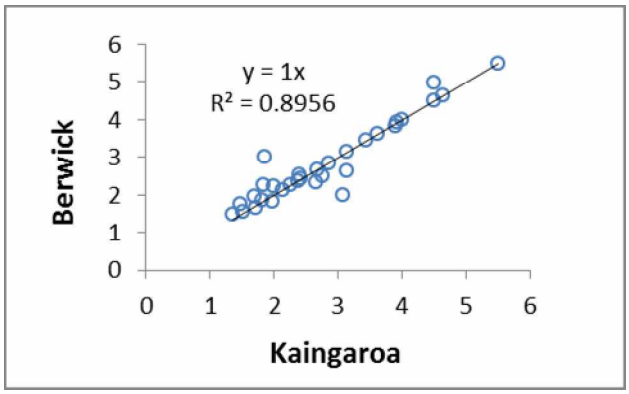

Figure 3. Correlation between Berwick and Kaingaroa for UMCY scores of 32 paired clones.

The 20 clones in this study were originally created from materials tested at the Puruki trials. We found good correlations between Puruki and four of five sites (except Kaingaroa) for UMCY scores of these clones (Table 2). This provides further evidence of strong clonal stability in expression of UMCY symptoms across sites.

Table 2 Correlations and *p*-values (testing the significance of the correlation) for the UMCY scores of 3-year-old trees at Puruki paired with 5-8-year-old trees at each of five trials in this study.

Site	Puruki
Crater Block	r = 0.57, p = 0.01
Lawrence	0.51, 0.003
Berwick	0.47, 0.007
Lochinver	0.43, 0.015
Kaingaroa	0.29, **0.11**

UMCY Symptoms in relation to Soil and Foliar Chemistry and Other Site Factors

Soil samples on a plot basis were collected one year after establishment for soil chemistry analysis. The nutrient concentrations and ratios indicate that none of the sites has an optimal nutrient balance for all critical elements (Table 3). We found across sites there were good correlations between UMCY symptom scores and the following soil factors:

- Mg r = - 0.69 (n=20), p<0.001
- Olsen P r = - 0.65 (n=20), p<0.01
- K r = - 0.53 (n=20), p<0.01
- K/Mg ratio r = 0.62 (n=20), p<0.01
- N/P ratio r = 0.48 (n=20), p<0.05
- Ca/Mg ratio r = 0.44 (n=20), p<0.05

Table 3. Mean values of soil properties for five sites. Bold values represent better soil properties.

Site	C	N/P	Exch Mg	Olsen P	Exch K
Crater Block	4.25	6.26	**2.88**	**37.2**	**1.03**
Lawrence	4.05	6.67	1.72	10.7	0.45
Berwick	7.88	9.17	1.13	10.6	0.33
Lochinver	5.26	**9.53**	0.22	3.2	0.27
Kaingaroa	**8.02**	9.19	0.29	9.1	0.47

Foliar nutrient data were available only from the Kaingaroa trial, where UMCY scores were assessed during the same year (i.e. 2009) following foliage sampling for nutrient analysis. The analyses of the Kaingaroa data using a needle weight adjusted comparison showed smaller needles were associated with higher UMCY scores. Similarly, we found that across sites, trees with UMCY symptoms had reduced height and diameter by approximately 10% when compared to trees without symptoms.

UMCY symptoms were found to be negatively correlated with foliar concentrations of Ca, Zn, Mg and K in decreasing order. A combination of foliar K/Mg ratio and Na explained 80% of the variation in UMCY scores at this site. However, data from more sites are required to validate our findings.

Although a limited number of sites were assessed in this study, we found that 79% of the site variation in UMCY scores could be explained by the altitude of sites (p= 0.06). A model incorporating the trial age, stocking rate and altitude explained 86% of the site variation in UMCY scores (p = 0.03).

Conclusions

- There were significant site differences in UMCY symptoms, which were associated with the site altitude and soil chemistry, especially soil Mg, Olsen P, K and K/Mg ratio.

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- A wide range of clonal variations was observed for UMCY symptoms, which were more related to clonal foliar K/Mg ratio than the concentration of any single nutrient.
- Our findings on UMCY symptoms were consistent with previous work reported from Puruki trials. This, together with a relatively small site-by-clone interaction, indicated the clonal stability in expression of UMCY symptoms across sites.
- Some sensitive clones (e.g. S02C1, P07C10) could be used as indicator clones for Mg deficiency.
- Severe UMCY symptoms caused needle loss and reduced tree growth.
- This study implies that the appropriate clones need to be deployed to specific sites by forest owners and managers to manage UMCY problems in radiata pine stands.

Acknowledgements

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