FUTURE FORESTS RESEARCH

RADIATA MANAGEMENT TECHNICAL NOTE
Site Productivity

Number: RSPTN-018
Date: June 2011

Tree Growth and N Leaching Response to Fertiliser (2)

Summary

Early results from a study examining nitrogen (N) leaching response following N fertiliser application on plots at ten sites (200 kg/ha of N as urea in November 2009) are presented. Data on soil water nitrate-N concentrations extracted using suction-cup lysimeters for the first nine months of the study show that prior to fertiliser application, concentrations were at or close to the detection limit (0.02 mg/l) at four of the ten sites, slightly higher (less than 0.5 mg/l) at three sites and 2-3.5 mg/l at two sites. The higher levels are thought to reflect the presence of the N-fixer gorse or, at one site, a farming history. A further site has been too dry to yield soil water for analysis.

Nitrogen fertiliser rapidly increased soil water nitrate-N concentrations at two South Island sites, but has so far had no effect on concentrations at three central North Island sites. The remaining five sites have been too dry to allow soil water samples to be collected for much of the period since fertiliser application. Further sampling is needed to indicate whether fertiliser has had any effect on nitrate-N levels at these sites. Sampling will continue for at least another 12 months to provide a fuller picture on the effect of N fertiliser on nitrate-N leaching. After a soil water model has been parameterised and calibrated, drainage data from the model will allow determination of nitrate-N leaching rates on an annual basis. Nitrogen leaching data generated in this study will be used to develop and test the robustness of the leaching component of a nutrient balance model that has the potential to be used as a decision support tool to assist forest managers to reduce the negative ecological effects associated with forest operations.

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Background

As described in a previous Technical Note (RTN-008), a new study has being initiated to improve our understanding of both the growth response and environmental consequences of applying N fertiliser to forests. The research areas that the project will focus on are:

- Quantifying the tree growth response to N fertiliser across the forest estate, and how this varies with soil and climate.
- Determining the relationships between foliar and soil indices of N availability and other variables, and growth responses to enable improved prediction of N response.
- Determination of nitrate-N leaching losses in response to N fertiliser application, and how this varies with soil, rainfall and stand characteristics.

In this Tech Note, data on background soil water nitrate-N concentrations and initial effects of fertiliser on nitrate-N levels are presented.

Methods

The study uses 17 of the 35 sites from the Long Term Site Productivity II (LTSP2) trial series for radiata pine. Each of these sites has a permanent 40 x 40 m sample plot, half of which has received a complete weed control treatment for 4-5 years depending on the rate of canopy closure. This trial series was selected because soil and climatic parameters for the sites are already well characterised. At the start of this study, the forest stands at the sites were 8-10 years old. At the LTSP2 sites used in the present study, an additional plot (as similar as possible in terms of site physical characteristics), was located near the existing plot, and at ten of these sites, four suction-cup lysimeters (Fig. 1) for extracting soil water for measurement of nitrate-N concentrations were installed in both the existing and new plots. In the existing plots the lysimeters were located in the half of the plot that had not received ongoing weed control but did incorporate local management regimes of thinning and pruning.

The lysimeters have been installed to a depth of 0.6-1.0 m (depending on site). Information on soil water content is being collected and a water balance model will be used to estimate the amount of water drainage from the sites. Leachate nitrate-N concentrations will be multiplied by the estimated amount of drainage to determine the amount of nitrate-N leached in kg/ha/yr. Ammonium-N and total-N will also be determined in the samples periodically, to provide information on background levels and fertiliser effects on leaching of these forms of N, and also of N in organic form.

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Figure 1. A suction cup lysimeter. The silicon tubes with bungs are used to apply a vacuum and extract soil water.

Lysimeter samples are collected at approximately 6-weekly intervals. Two or three collections were made prior to N fertiliser application to provide background data, after which the new plot at each of 17 sites was fertilised with 200 kg/ha of urea in November 2009. Trees were measured (height and DBH) prior to fertiliser application and will be measured annually to determine the growth response to N fertiliser. The growth response will be reported later.

The ten sites with lysimeters are located on seven different soil orders that vary in texture from sands through to clay loams (Table 1). Annual rainfall at the sites with lysimeters ranges from 776 to 2122 mm.

First Season Results

At the sites with lysimeters, soil moisture contents at the start of sampling ranged from 57% (Mamaku) to 22% (Bulls), with most sites having contents above 30%. Soil moisture contents generally declined as the season progressed, and at some sites fell below 10% by mid-summer, and had not recovered at the most recent sampling in mid-April 2010. Average soil moisture contents were generally lowest (13-18%) on the sandy soils (Kaingaroa, Bulls, Eyrewell) (Fig. 2). At the other extreme the soil moisture content at Mamaku averaged 58% and never fell below 53%. Low soil moisture contents resulted in many lysimeters not yielding samples after January.

Table 1. Site soil and rainfall characteristics

Site	Soil Order	Texture	Rain Fall[1]	Lys[2]
Mahurangi	Ultic	Silty clay	1739	
Riverhead	Ultic	Clay loam	1520	
Woodhill Tikitere	Recent Pumice	Sand Sandy loam	1563 1875	 √
Kaingaroa	Recent	Gravelly sand	1611	√
Mamaku	Podzol	Loamy sand	2122	√
Bulls	Brown	Sand	966	√
Waimarino	Alloph[3]		1707	√
Karioi	Alloph[3]	Sandy loam	1196	√
Hochstetter	Podzol	Silt loam	3454	
Mawhera	Podzol	Silt loam	3718	
Bottle Lake	Raw	Sand	640	
Ashley	Pallic	Silt loam	851	√
Eyrewell	Brown	Stony sand	776	√
Otago Coast	Brown	Stony silt loam	886	√
Catlins	Brown	Clay loam	1190	√
Longwoods	Alloph[3]	Silt loam	1290	

[1] From Bioclim, [2] √ indicates sites with lysimeters, [3] Allophanic

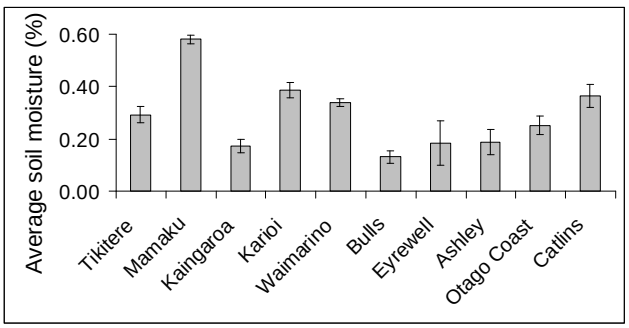

Figure 2. Average soil moisture contents at sites with lysimeters.

Average soil water nitrate-N concentrations in non-fertilised plots ranged from 0.02 mg/l (which is the detection limit of the analysis) to 3.5 mg/l (Fig. 3). Because the soil was too dry, soil water for the Otago Coast site was able to be collected on only one occasion, so data for this site are not presented in Fig. 3. Four central and southern North Island sites (Tikitere, Kaingaroa, Karioi and Waimarino) had average soil nitrate-N values at, or close to, the detection limit.

Average values above the detection limit, but still low (less than 0.5 mg/l) were recorded at Mamaku, and

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the two South Island sites Ashley and Catlins. Considerable amounts of gorse (a nitrogen fixing species) are present at Ashley and some gorse is present at Mamaku, which would have caused or contributed to the greater values at those sites. Average concentrations at Bulls (2 mg/l) and Eyrewell (3.5 mg/l) were higher than other sites. At Bulls, the forest was planted from pasture and the higher concentration there probably reflects previous inputs from agriculture. Gorse was present at Eyrewell and would have contributed to the greater average concentration there, though there is currently less gorse at Eyrewell than at Ashley.

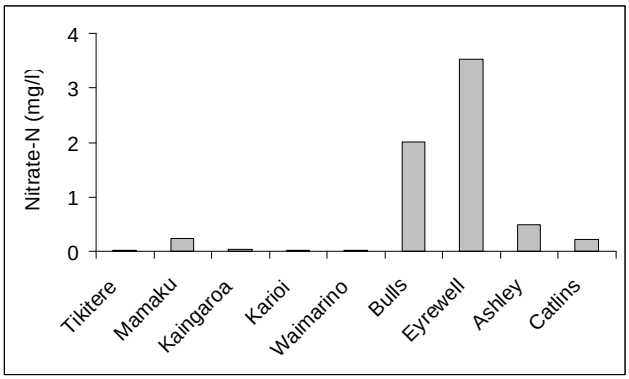

Figure 3. Average soil water nitrate-N concentrations. Values are for unfertilised plots.

At two sites, Ashley and Catlins, fertiliser appears to have greatly increased nitrate-N concentrations. At Ashley, concentrations increased to 10-40 mg/l (Fig. 4), while at Catlins they increased by a lesser amount to 2-6 mg/l (Fig. 5). At both sites, nitrate-N concentrations increased shortly after the fertiliser was applied. In contrast to the remaining sites with lysimeters, both the Ashley and Catlins sites have imperfectly drained soils. At Mamaku, Kaingaroa and Karioi there is so far no evidence that fertiliser has caused an increase in soil water nitrate-N concentrations.

The remaining five sites have been too dry to allow soil water samples to be collected for much of the period since fertiliser has been applied, and further sampling is needed to indicate whether fertiliser has had any effect on nitrate-N concentrations. Sampling will continue for at least another 12 months to provide a fuller picture on the impact of N fertiliser on N leaching.

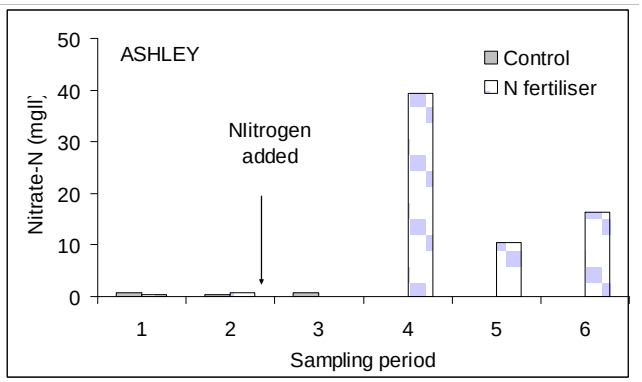

Figure 4. Soil water nitrate-N concentrations at Ashley in unfertilised and fertilised plots. Sampling was at six-weekly intervals from August to April.

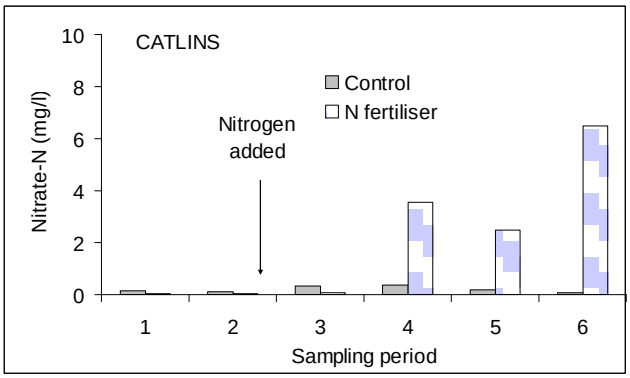

Figure 5. Soil water nitrate-N concentrations at Catlins in unfertilised and fertilised plots. Sampling was at six-weekly intervals from August to April.

Conclusion

After the soil water model has been parameterised and calibrated, drainage data from the model will allow determination of nitrate-N leaching rates on an annual basis. Once soil water contents increase over winter, measurements of total and ammonium-N will be made to provide data on the effect of fertiliser on leaching on ammonium and organic forms of N. Nitrogen leaching data generated in this study will be used to develop and test the robustness of the leaching component of a nutrient balance model that has the potential to be used as a decision support tool to assist forest managers to reduce the negative ecological effects associated with forest operations.

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