# Effects of establishment silviculture on carbon and nitrogen isotope compositions and tree growth in a F<sub>1</sub> hybrid pine plantation of southeast Queensland

#### P. Ibell<sup>1</sup>, Z. Xu<sup>2</sup>, T. J. Blumfield<sup>2</sup>, M. Nester<sup>3</sup>, K. Bubb<sup>3</sup>.

<sup>1</sup>Centre for Forestry and Horticultural Research, Griffith School of Environment, Griffith University, Nathan, Queensland; <sup>2</sup>Centre for Forestry and Horticultural Research, School of Biomolecular and Science, Griffith University, Nathan, Queensland.\*Telephone No +61-7 3735 3638; Fax No +61-7 3875 7549. Email <u>P.Ibell@griffith.edu.au</u>; <sup>3</sup>Policy Division, Forestry Plantations Queensland, Gympie.

Keywords: establishment weed control, fertilization, water use efficiency (WUE), F<sub>1</sub> hybrid pine, C and N isotope composition.

Abstract The effects of routine and luxury weed control and fertilization treatments on diameter, height, carbon ( $\delta^{13}$ C) and nitrogen ( $\delta^{15}$ N) isotope composition in foliage were assessed in an 8-year-old, F<sub>1</sub> hybrid pine (*Pinus elliottii var. elliottii Pinus caribaea var. hondurensis*) plantation, on typical sandy soils in southeast Queensland. The aim of this research was to identify how weed control and fertilization treatments affect nitrogen nutrition and water use in F<sub>1</sub> hybrid pine plantations, together with tree growth. The results have indicated that a lack of weed competition has shown greater potential for height and diameter at breast height (D<sub>bh</sub>) increment and  $\delta^{15}$ N in the foliage. A strong correlation between growth and  $\delta^{15}$ N existed for all canopy positions, demonstrating that foliar  $\delta^{15}$ N may prove to be a better indicator of growth indices in the canopy than total foliar N concentrations alone. These differences could be in part due to discrimination against <sup>15</sup>N by soil micro-fauna, during the processes of decomposition and mineralization and as a result of leaching of lighter <sup>14</sup>N, where no weed cover exists. These results indicate that in an 8-year-old F<sub>1</sub> hybrid pine plantation, luxury weed control treatments significantly affected foliar  $\delta^{15}$ N, but not foliar  $\delta^{13}$ C, nor foliar N or C concentrations. It is therefore concluded that luxury weed control treatments result in both greater height and D<sub>bh</sub> increment and an increased pool of <sup>15</sup>N abundance available for tree uptake as reflected in the foliage of 8-year-old F<sub>1</sub> hybrid pine trees at this site.

#### Introduction

In 2005 there were approximately 5,500 hectares of F1 hybrid pine established by FPQ (Forestry Plantations Queensland 2006). The  $F_1$  hybrid pine is the predominate plantation pine grown in the subtropics of southeast Queensland. How carbon (C) and nutrient assimilation is affected by silvicultural practice is a continually developing field of research (Binkley et al. 2004). It is known that successful plantation establishment is attributed to appropriate weed control and fertilization practices at early plantation establishment (Smethurst and Nambiar 1989; Wagner et al. 2006). The effects of silvicultural practices on C assimilation, nutrition and water use have been reviewed by various researchers (Vitousek and Matson 1985; Woods et al. 1992). This paper purports to investigate if and how weed control and fertilization practices affect total foliar C and N concentrations and  $\delta^{13}$ C and  $\delta^{15}$ N in F<sub>1</sub> hybrid pine foliage as indexes of water (Ehleringer et al. 1993) and N uptake (Lajtha and Michener 1994).

#### Materials and methods

Foliage was collected from an 8-year-old  $F_1$  hybrid pine plantation site known as Experiment 350GYM, located in Toolara State Forest, southeast Queensland, Australia. The site has a subtropical climate with dry winters and wet summers with an approximate annual rainfall of 1256 mm. Soil types throughout the study area are alluvial and vary from grey to yellow podzolics and earths. The experiment is a randomized complete block design. For the purposes of this investigation four treatments have been selected. Specifically the four treatments selected were:

- 1 Routine weed control and routine fertiliser (RWC+RF);
- 2 Luxury weed control and routine fertiliser (LWC+RF);
- 3 Routine weed control and luxury fertiliser (RWC+LF);
- 4 Luxury weed control and luxury fertiliser (LWC+LF).

#### **Fertiliser treatments**

The routine fertiliser treatment included an application of 50 kg/ha of phosphorus (P) as Mono-ammonium phosphate (MAP) 10 weeks after planting. The MAP was applied at the rate of 226 kg/ha and was reported to provide 10% elemental N and 21.9% of P.

In addition to the 50 kg/ha of MAP, the luxury fertiliser treatment included a special mix of 5 kg/ ha Cu, 5 kg/ha Zn, and 5 kg/ha B applied as a basal dressing and 50 kg/ha of potassium (K) in the form of Muriate of Potash applied at 120 g/tree at a distance of approximately 20 cm from each tree. No extra N fertiliser was applied.

#### Weed control treatments

Pre-planting weed control was applied with a tractor mounted multiboom delivering 7.2 l/ha glyphosate and 10 l/ha simazine. Woody weed control was also carried out 6 months prior to planting with D50 and grazon applied at 10 l/ha and 1.5 l/ha respectively. Routine weed control treatment was applied in accordance with routine practice at approximately at 6, 12 and 16 months. Luxury weed control was carried out every two months in the first 6 months with sprays thereafter varying from 3-5 months. All luxury weed control treatments were completed by the third year after planting.

#### Growth data

Growth data including tree diameter at breast height  $(D_{bh})$  and height were assessed for their responses to the selected treatments in 2004.

#### **Foliage samples**

Foliage samples were collected in 2006 from each of the five canopy positions from 4 selected trees in each plot by taking fully expanded leaves. Foliage at each position was composited to make one sample. The positions collected were 1. north side top position; 2. north side mid section; 3. north side inner most needles; 4. south side mid section; and 5. north side lower section.

Samples were refrigerated until returning to the laboratory and then dried in an oven at between 40-55  $^{\circ}$ C for five days. After drying, samples were grounded to a fine powder. Approximately five mg of the ground material was then pelletized and analyzed for total C, N and isotope compositions, on a GV Isoprime, Mass Spectrometer, Manchester UK.

#### Statistical analysis

All data were analyzed using SAS version 9.1, using a general linear model (GLM) with a least squared means, post-hoc analysis, and with a factorial ANOVA and least significant difference, post-hoc analysis in Statistix 8. The objective was to ascertain the significance of the effects of the treatments on growth and the selected foliar parameters. Correlations were carried out between foliar parameters at each canopy position and tree growth, and between the foliar parameters.

#### Results D<sub>bh</sub>

An ANOVA analysis for  $D_{bh}$  indicated that there were significant main effects between treatments. Results indicated that LWC+RF (15.3 cm) was greater than LWC+LF (14.9 cm) and that RWC+RF (12.3 cm) was greater than RWC+LF (12.2 cm). No significant interaction between weed control and fertiliser treatments existed (P<0.05).

#### Height

An ANOVA analysis for height indicated that there were significant main effects between treatments. LWC+RF (10.02 m) was greater than LWC+LF (9.62 m) and RWC+RF (8.72 m) was

greater than RWC+LF (8.54 m). No significant interaction between treatments occurred (P<0.05).

## Total C and $\delta^{13}C$

There were no significant differences in foliar C and  $\delta^{13}$ C between treatments (P<0.05). There were significant differences in foliar  $\delta^{13}$ C among the canopy positions (Figure 3).



Figure 3: Foliar  $\delta^{13}$ C across the five sampling positions for each treatment.

### Total N and $\delta^{15}N$

Foliar N concentrations showed no significant difference among the four treatments. In contrast,  $\delta^{15}N$  showed a significant difference (P<0.05) for weed control (Figure 4).



Figure 4: Foliar  $\delta^{15}$ N across the four treatments.

Foliar N concentrations and  $\delta^{15}$ N showed significant differences (P<0.05) among the canopy positions sampled (Figures 5 and 6).



Figure 5: Foliar N concentrations across the five sampling positions for each treatment.



Figure 6:  $\delta^{15}N$  composition across the five sampling positions for each treatment.

#### Correlation between canopy parameters and tree growth

A significant positive correlation between height and canopy  $\delta^{15}N$ , and between  $D_{bh}$  and canopy  $\delta^{15}N$ , indicated that foliar  $\delta^{15}N$  was strongly correlated to both height and  $D_{bh}$  across all canopy positions (Table 1). Foliar N correlated to  $\delta^{15}N$  at canopy positions 1, 2 and 3; and to  $D_{bh}$  at positions 1 and 3.  $\delta^{13}C$  correlated to total foliar C concentration in canopy position 1 and foliar N concentrations at canopy positions 3 and 4.

Table 1: Correlation coefficient (r) and P values for  $\delta^{15}N$  and tree growth.

Position	Height	$\mathbf{D}_{\mathbf{b}\mathbf{h}}$
1	0.832 P=0.000	0.838 P=0.000
2	0.704 P=0.002	0.630 P=0.009
3	0.732 P=0.001	0.689 P=0.003
4	0.738 P=0.001	0.777 P=0.000
5	0.725 P=0.002	0.756 P=0.001

#### Conclusion

The use of luxury weed control and routine fertiliser (LWC+RF) at the Toolara site, increased tree height, D<sub>bh</sub> and total foliar N concentrations compared with luxury weed control and luxury fertilizer. Although there were no significant difference in foliar N concentrations between the treatments, foliar N is considered as sufficient above 0.8%. Both N and  $\delta^{15}$ N showed significant differences among the canopy positions. While foliar N concentrations accumulated in the top canopy position, strong correlations between  $\delta^{15}$ N and tree growth (height and D<sub>bh</sub>,), among all of the canopy positions infer that  $\delta^{15}N$  is a more sensitive indicator of tree growth than foliar N concentrations. This investigation has demonstrated that levels of  $\delta^{15}$ N within the canopy relate to tree growth and vary as a result of weed control management. It is believed that weed management affects available N sources within the soil, which is subsequently reflected in plant foliage over time.

Water use efficiency (WUE) (as measured by  $\delta^{13}$ C) and total foliar N and C concentrations were not significantly affected by weed control or fertilization treatments in an 8-year-old, F<sub>1</sub> hybrid pine plantation. However the significant positive correlations between  $\delta^{13}$ C and total foliar N concentration at canopy positions 3 and 4 indicates a relationship between water use efficiency and nitrogen in the foliage.

#### Acknowledgements

Thanks to Mr. Paul Keay and staff of FPQ as well as fellow students and Griffith University staff for their assistance. **References** 

- Binkley D, Stape J L and Ryan M G 2004 Thinking about efficiency of resource use in forests. Forest Ecology and Management 193, 5-16.
- Ehleringer J R, Hall A E and Farquhar G D 1993 Stable Isotopes and Plant Carbon -Water relations. Academic Press, San Diego.
- Forestry Plantations Queensland 2006 DPI Forestry Pocket Facts 2006, Brisbane.
- Lajtha K and Michener R H 1994 Stable Isotopes in Ecology and Environmental Science. Blackwell Scientific Publications, Oxford.
- Smethurst P J and Nambiar E K S 1989 Role of weeds in the management of nitrogen in a young *Pinus radiata* plantation. New Forests 3, 203-224.
- Vitousek P M and Matson P A 1985 Disturbance, Nitrogen Availability and Nitrogen Losses in an Intensively Managed Loblolly Pine Plantation. Ecology 66, 1360-1376.
- Wagner R G, Little K M, Richardson B and McNabb K 2006 The role of vegetation management for enhancing productivity of the world's forests. Forestry 79, 57-79.
- Woods P V, Nambiar E K S and Smethurst P J 1992 Effect of annual weeds on water and nitrogen availability to Pinus radiata trees in a young plantation. Forest Ecology and Management 48, 145-163.