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The nutrient status of grasslands and adjacent *Pinus patula* and *Eucalyptus grandis* plantations on the eastern escarpment of South Africa.

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DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before any degree or examination in any other University.

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(Signature of candidate)

_____day of June 2005

ABSTRACT

The replacement of indigenous grasslands by commercial forestry plantations on the mountainous eastern escarpment of South Africa, has inevitably led to alteration of nutrient cycling. The overall objective of this study was to determine the nutrient status (soil, litter and foliar nutrient concentrations) of *Pinus patula* and *Eucalyptus grandis* plantations and adjacent grasslands. The 2, 13 and 30 year old *P. patula* plantations and adjacent Driekop grassland were located relatively high up on the escarpment (altitudes ranging between 950–1610 m) and were underlain by dolomite while the 2, 8 and 13 year old *E. grandis* plantations and adjacent Brooklands grassland were located lower down (altitudes ranging between 900–1100 m) and were underlain by granite. It was assumed that the nutrient status of the soil under the plantations and the adjacent grasslands were similar prior to afforestation. Samples were collected once in winter (August 2002) and once in summer (January 2003). Soil samples were collected to a depth of 20 cm and litter material, to a maximum depth of 20 cm. Lower canopy foliar samples were collected within the lowermost metre of the canopies and upper canopy foliar samples were collected within the uppermost metre of the canopies. The data were analysed in the laboratory for various elements and soil physical parameters.

The soil pH was lower under the *P. patula* (pH 4.8-5.2) and *E. grandis* plantations (pH 4.6-5.3) when compared with the soil under the adjacent grasslands (pH 5.3-5.6). The soil under the *P. patula* plantations had lower exchangeable base cation concentrations (204-300 mg kg^{-1}) compared with the adjacent Driekop grassland (452-645 mg kg^{-1}), while there were no clear trends when comparing the exchangeable basic cation concentrations in the *E. grandis* plantations and the adjacent Brooklands grassland. The soil aluminium saturation was similar between the plantations, ranging between 39.7 and 63.3% in the *P. patula* plantations and 27.4 and 75.6% in the *E. grandis* plantations. The grasslands had lower soil aluminium saturations, ranging between 17.7 and 35.7% in the Driekop grassland and 17.5 and 39.1% in the Brooklands grassland. Exudates from mycorrhizal associations chelate

acidic cations, rendering plantations more tolerant of acidic soils. Soil total nitrogen, phosphorus and carbon in the plantations were similar to the adjacent grasslands. Higher nitrogen mineralisation rates in the *P. patula* plantations corresponded with higher litter and foliar total N concentrations relative to the adjacent Driekop grassland, while there were no clear trends when comparing rates of N mineralisation in the *E. grandis* plantations and the Brooklands grassland. The concentrations of foliar amino acids and protein were significantly higher ($p<0.01$) in the plantation foliage, when compared the grassland foliage. The amino acid arginine, occurred in higher proportions relative to other amino acids in plantation foliage, when compared with the relative proportions found in the grasslands. Relative to nitrogen, foliar ratios indicated that phosphorus and potassium were the most limiting nutrients for the plantations, which possibly resulted in N storage in the form of protein and amino acids.

The soil and foliage were the more sensitive indicators of the nutrients status than litter. Differences in nutrients concentrations between the lower and upper canopies in both plantations were minor and no major trends were found. Therefore the sub division of lower and upper canopies is not recommended for further foliar nutrient analyses. Age related trends were unclear as a result of higher soil clay contents found in the 13 year old *P. patula* plantation and the 8 year old *E. grandis* plantation as well as the various silvicultural practices implemented. In terms of the relative impacts of *P. patula* and *E. grandis* plantations, the results of this study imply that the upper 20 cm of soil was more impacted under the *P. patula* plantations than under the *E. grandis* plantations, in terms of reduced base cation and increased acid cation concentrations. The *P. patula* plantations are shallow rooters and thus the base cation status of the upper soil horizons may affect the sustainability of the *P. patula* plantations.

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