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Impact of the Replacement of Natural Hybrids by a More Productive Hybrid (*Eucalyptus urophylla x E. grandis*) on Nutrient Accumulation in Eucalypt Stands in the Congo

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Introduction

More than 40 000 ha of *Eucalyptus* have been planted on the savannas around Pointe-Noire (Congo). In order to improve the productivity of these plantations, breeders have developed genetically improved planting stock that is more productive. For some years, the clones of natural hybrids (*E.* PF1 and *E. tereticornis* x *E. grandis*) originally planted, have been replaced by the clones of artificial hybrid *E. urophylla* x *E. grandis* (UG). Some UG clones achieve a MAI 50% higher than *E.* PF1 1-41, the most productive clone of natural hybrids. This increase in biomass production may lead to a higher nutrient uptake and greater nutrient removal at harvesting (7-8 years old). Forest managers must take care of the nutrient requirements to achieve sustainable production of plantations in these sandy and very poor soils. The objective of this study was to compare *E.* PF1 1-41 and 3 UG clones according to nutrient accumulation at harvesting.

Material and Methods

The plantations were established on the coastal plain around Pointe-Noire, Congo (4°S, 12°E). The climate is subequatorial with a rainy season from October to May and a dry season from June to September. Mean annual rainfall is about 1200 mm, and mean annual temperature is 25°C with seasonal variations of about +5°C and -5°C. The soils are Ferralic Arenosols according to FAO classification.

The UG clones were harvested at 8 years, in a clonal experiment testing 23 UG clones and *E.* PF1 clone 1-41, among which 3 UG clones were sampled. Two of the UG clones (18-50 and 18-52) were full sibs. The clones 1-41 were sampled from a monoclonal plantation located 1 km from the main clonal trial. Both stands are on similar soil type and were managed under the same silvicultural regime.

Twelve trees per clone, representing six basal area classes, were harvested, and the major components separated: stembark and stemwood gathered to diameters of 7 cm (limit for pulpwood) and 2 cm (limit for firewood), living branches, dead branches and leaves.

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Samples were dried at 65°C, ground and homogenised. Total N was analysed by acid-base volumetry after Kjeldahl mineralisation. Phosphorus was determined by colorimetry using the Murphy and Riley reagent. Calcium, K and Mg were analysed by atomic absorption spectrophotometry.

Biomass and nutrient content predictive models were developed using GLM procedure of SYSTAT 9.0 software. The models obtained were then applied to the inventory of the stands to evaluate the biomass and nutrient content for each component on a per hectare basis.

Results

Marked differences in growth and production were observed among clones. Although clones 18-52 and 18-50 were full sibs, the former, which was the most productive, produced a MAI 18% higher than clone 18-50, as observed in clonal tests (Saya *et al.* 2001). As expected, UG clones produced better MAIs than *E.* PF1.

Large differences in total biomass were observed between the two hybrids and among UG clones, even between the full sibs 18-50 and 18-52. The best clone (18-52) produced 20%, 25% and 43% more than clones 18-50, 18-65 and 1-41, respectively. Stemwood represented the main part of the aboveground biomass. Its proportion of total biomass was similar between hybrids: 86.8% for the clone 1-41 *vs* a mean of 86.6% for UG clones. By contrast, marked differences between hybrids were observed for bark and leaves: the percentage of bark was 50% higher in the clone 1-41 than in UG clones, but the percentage of leaves was 36% lower in the clone 1-41 than in UG clones. The clone 1-41 exhibited the lowest percentage of living branches but there were great variations among UG clones.

The accumulation of P and Ca was generally lower in UG clones than in the clone 1-41: on average 27% and 17%, less respectively. The opposite pattern was found for N (+19%), K (+18%) and Mg (+13%). Nitrogen accumulation increased with clone production, but not proportionally. The nutrient content was always lower in the stemwood of UG clones than in the clone 1-41 for P (-71%) and Ca (-50%). UG also exhibited systematically lower content of Mg (-38%), Ca (-29%), N (-22%), P (-17%) and K (-13%) in the bark, but much higher accumulation of all nutrients in the living branches and the leaves.

Nitrogen removal (in stemwood and bark up to stem diameters of 7 and 2 cm) increased with biomass production and corresponded, on average, to 70% of the total aboveground N content. The nutrient removal by UG clones was much lower (vs clone 1-41) for P (-66%), Ca (-45%) and K (-26%). Differences were observed among UG clones. In particular, the nutrient content removed with clone 18-65 was the lowest for P but the greatest for K.

The contents of Ca in slash (leaves, branches and bark up to stem diameter of 7 cm) were of the same order of magnitude for both hybrids. By contrast they were higher for K (+102%), P (+70%) N (+33%) and Mg (+31%) in UG clones. Nevertheless, variability was observed among UG clones. In particular the clone 18-52 was characterised by the highest amounts of nutrients in slash, except for K.

Discussion and Conclusion

This study showed a marked inter-clonal variability in biomass and nutrient content. Key points are:

- The biomass of stemwood ranged from 109-139 t ha^{-1} in the UG clones sampled at 8-years-old compared to 97 t ha^{-1} for the clone 1-41.
- Biomass allocation differed between clones UG and 1-41. Whereas the proportion of bark was higher for the clone 1-41, the dry matter of leaves and living branches represented a greater part of the aboveground biomass for UG clones.
- Phosphorus and Ca content in aboveground biomass of UG clones were lower than in 1-41, even for clones 18-50 and 18-52, whose wood production was much higher. Differences in nutrient content between both hybrids were large in bark but rather low in wood. The amount of nutrients in the canopy was higher in UG clones than in clone 1-41.

Clones of the natural hybrid *E.* PF1 are progressively replaced by UG clones in the industrial plantations around Pointe-Noire. This study emphasises that, although the production of wood with the best UG clones was much higher than with the *E.* PF1 clones, the accumulation of P and Ca in the biomass was lower and only slightly higher for N, K and Mg. Moreover, the amount of nutrients returning to the soil in slash was higher for UG clones than for the clone 1-41. Although no data have been collected yet, the higher biomass of leaves suggests that the amount of litter produced during the rotation was likely to be higher for UG clones than for the clone 1-41. This feature might be positive for the maintenance of soil fertility through the effect of soil organic matter. However, effect on sustainability of the more productive UG clones will be closely related to the mineralisation of organic matter (litter and slash) and to nutrient losses by drainage after stand harvest (Nzila *et al.* 2001). Moreover, the long-term availability of N in soils is a matter of concern since the input-output budget during the first rotation after afforestation is clearly unbalanced for the clone 1-41 (Laclau *et al.* 2001). The N deficit will therefore increase over successive rotations (Bouillet *et al.* 2001) and this will have to be remedied through higher nitrogen inputs in these plantations in order to maintain their high productivity.

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