Productivity and carbon allocation in pure and mixed-species plantations of Eucalyptus grandis and Acacia mangium in Brazil

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Abstract

Nitrogen fertilizer inputs are required in fast growing eucalypt plantations to meet tree requirements, and to compensate for the large nitrogen outputs associated with wood exportation at the end of the short rotations. Due to the economic and potential environmental cost of fertilizers, mixed-species plantations (MSP) with N-fixing species (NFS) such as Acacia sp. might be an attractive option to improve the long-term soil N (and possibly soil carbon) status. In such MSP, increases in N availability may influence the productivity and C partitioning of the non-N fixing species. To investigate the effects of NFS on nutrient cycling, wood production, C sequestration, and soil fertility, a randomized block design including monocultures of Eucalyptus grandis (100%E) and Acacia mangium (100%A), and mixtures of these species (50%E:50%A) was set up in southern Brazil. Our specific goals in the present study were to compare the production and C allocation patterns of these plantations, during the two last years of the 6-yr rotation. We hypothesized that 1) a large part of the differences in wood production between monospecific stands would be explained by differences in C allocation; and 2) the C allocation patterns of each species would be strongly modified in mixed- species plantations compared to mono-specific plantations due to inter-specific interactions and shifts in soil N status. Biomass increase (growth, G) in the different plant compartments was assessed by means of inventories and allometric relationships. Total aboveground net primary productivity (ANPP), and the productivity of each aboveground plant compartment were estimated from measurements of G and litterfall (L) (ANPP=G L). Total belowground C allocations (TBCA) were estimated using a mass-balance approach as soil CO2 efflux C minus the C input from aboveground litter plus changes in the C stored in roots, in the forest floor litter layer, and in soil. Over this first rotation, mixing NFS with eucalypt did not increase wood production: at the end of the 6 yr-old rotation, total aboveground biomass was the highest in the 100%E stands (68.2 tC/ha), lowest in the MSP 50%E:50%A (62.0 tC/ha), and intermediary in the 100%A (66.0 tC/ha). Although 100%E stands had a stronger growth than 100%A during the first 4 yrs of the rotation, the reverse was observed at the end of the rotation: during the two last yrs, total growth was 15.9 tC/ha/yr for 100%A, and 12.7 and 10.4 tC/ha/yr for 100%E and 50&#65533;0%A, respectively. These differences in growth were explained by differences in ANPP (19.2, 17.8 and 15.2 tC/ha/yr, for 100%A, 100%E, and 50&#65533;0%A, respectively), and differences in the ratio litter production/ANPP (0.17, 0.29, and 0.31 for 100%A, 100%E, and 50&#65533;0%E, respectively). Furthermore, the ratio TBCA/ANPP was the lowest in 100%A, and the highest in the MSPs (0.44, 0.62, and 0.78, for 100%A, 100%E, and 50&#65533;0%E, respectively). These results suggest that inter-specific interactions have a strong effect on the C allocation pattern observed at the stand level in MSPs.

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