Competition for light and light use efficiency for Acacia mangium and Eucalyptus grandis trees in mono-specific and mixed-species plantations in Brazil

Details

Meeting	2010 Fall Meeting
Section	Biogeosciences
Session	Carbon Sequestration in the Biosphere: Biogeochemistry and Biophysics I Posters
Identifier	B41A-0299
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Index Terms	Agricultural systems [0402] Biogeochemical cycles, processes, and modeling [0414] Carbon cycling [0428] Modeling [0466]

Abstract

Mixed plantations with N-fixing species might be an attractive option for limiting the use of fertilizer in highly productive Eucalyptus plantations. A randomized block design was set up in southern Brazil, including a replacement series and an additive series design, as well as a nitrogen fertilization treatment, and conducted during a full 6 years rotation. The gradient of competition between Eucalyptus and Acacia in this design resulted in very different conditions of growth of Acacia, from totally dominated up to dominant canopies. We used the MAESTRA model to estimate the amount of absorbed photosynthetically active radiation (APAR) at tree level. This model requires the description of the scene and distinct structural variables of the two species, and their evolution with time. The competition for light is analysed by comparing the inter-specific values of APAR during a period of 2 years at the end of the rotation. APAR is further compared to the measured increment in stem wood biomass of the tree, and their ratio is an estimation of the light use efficiency for stemwood production at tree-scale. Variability of these LUE are analysed in respect to the species, the size of the tree, and at plot scale (competition level). Stemwood production was 3400, 3900 and 2400 gDM/m2 while APAR was 1640, 2280 and 2900 MJ/y for the pure Eucalyptus, pure Acacia and 50/50 mixed plantation, respectively, for an average LAI of 3.7, 3.3 and 4.5, respectively. Individual LUE for stemwood was estimated at an average value of 1.72 and 1.41 gDM/MJ/tree for Eucalyptus and Acacia, respectively, and at 0.92 and 0.40 gDM/MJ/tree when they were planted in mixed 50/50 plantations. LUE was highly dependant on tree size for both species. At the plot scale, LUE for stemwood were 2.1 gDM/MJ and 1.75 for Eucalyptus and Acacias, respectively, and 0.85 for the mixed 50/50 plantation. These results suggest that the mixed 50/50 plantation, which absorbed a higher amount of light, produce less stemwood since half of the canopy (Acacias) are dominated, and the other half does not benefit much in terms of tree growth compared to absorbed light. The eventual benefit of the nitrogen-fixing species is not visible in the mixture with 50% of each species. More attention has to be paid to introducing acacias in an additive series with the same density of eucalyptus trees as in the monospecific stands.

Cite as: Author(s) (2010), Title, Abstract B41A-0299 presented at 2010 Fall Meeting, AGU, San Francisco, Calif., 13-17 Dec.