SExI-FS - A Tree Growth Simulation Model To Explore Mixed Tree Designs And Their Production Potential

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Introduction

Watershed management has been a major topic for the last decade related to the issues of "deforestation" and "reforestation". Recent studies have given options in the forms of farmer-managed Agroforestry for maintaining the hydrological functions. This raises questions on what is the best implementation and what is the best management scenario to achieve both the desired land cover functions and profitability to the farmers.

The complexity of growth under mixed-tree stands of an agroforestry requires an integrated model to predict the prospects and sustainability of a plot design in an agroforestry scenario. A Spatially-Explicit Individual Forest Simulator (SExI-FS) was developed as a model tool for predicting the dynamic growth of mixed-tree stands and gives the information of its potential productivity and other aspects regarding the tree growth competition.

Figure 1. SExI-FS focuses on tree-tree interaction and was developed using object oriented design. Included on the software are 3D visualization and interactive graphical user interfaces. Here users can explore the scenario interactively.

Objective and Methods

The objective of this research is to explore the plot design of agroforestry implementation and predict the performance and productivity of each species component.
The species tested are the combination of Rubber (*Hevea brasiliensis*) with Durian (Durio zibethinus) and *Acacia mangium*. In this case study, the performance of Rubber under domination of *Imperata cylindrica* was also explored

Various planting designs are evaluated using SExI-FS software (http://www.worldagroforestrycentre.org/sea/Products/AFModels/sexi) parameterized with experimental data from Indonesia and Vietnam.

Rubber and Durian

Durian (*Durio zibethinus*) is the common fruit species in Southeast Asia and has been cultivated both as monoculture and also as intercropping with other fruit and wood species. The productivity of durian integration with other tree species has not been known much.

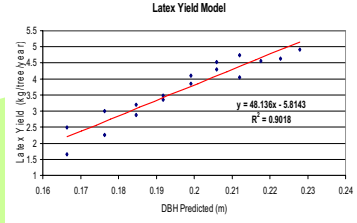


Figure 2. Rubber growth is calibrated for GT1 clone against the average tree size (DBH) simulated by SExI-FS. Latex yield is based on data reported by Thao et. al (2006) (Thao, P.D., Thanh, D. K., Kieng, N. N., Son, M. v.. 2006. Establishment Of Yield Prediction Model For Gt 1 And Pb 235. International Natural Rubber Conference-Preprints: 96-105).

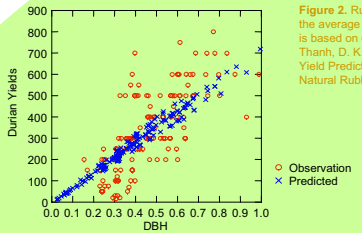


Figure 3. Durian yield was observed in Jambi, Sumatra trough local ecological knowledge methods against measured tree size (DBH). Durian yield model is = (14.05*CP + 76.3*CF + 438.48)*DBH, r = 0.54. Where CP is and index of light condition and CF is and index of crown condition.

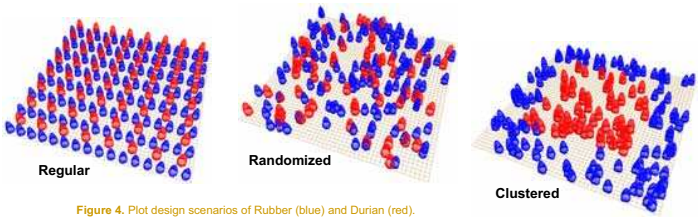


Figure 4. Plot design scenarios of Rubber (blue) and Durian (red).

There are 3 plot design scenarios (Figure 4):
1. Regular plantation
2. Randomized
3. Clustered

Simulated Plot size is 48x48 m, with 128 Rubber trees and 64 Durian trees. There are no mortality and natural regeneration. The competition is only based on aboveground factor..

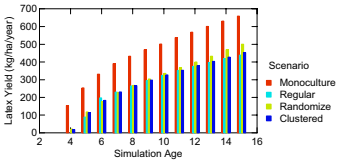


Figure 6. Simulated latex yields per year for each scenario compared to Monoculture. Higher plot density reduces the yields of Rubber of approximately 40%.

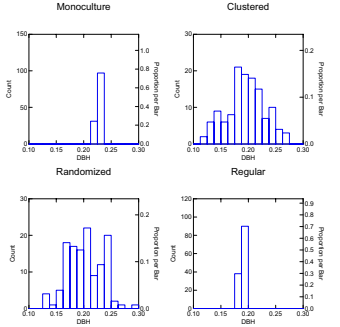


Figure 7. Size distribution of Rubber trees after 15 years of simulation.

Yields of different plot design scenarios are shown in Figure 8. Here Durian yield is higher in Regular plantation scenario and lower in Randomized scenario, while Latex yield shows opposite result, lower in Regular plantation and higher in Randomized scenario. Both are on the same yield ratios in Clustered scenario. In Regular plantation, Durian is seen to have more space ratio compared to Rubber, here Durian can grow better. In Random plantation, Rubber gets advantages for it higher growth rate to more competitive to Durian. On the other hand, for Clustered scenario, although the trees are randomly distributed but they are clustered by species, so the competitions are more within the species.

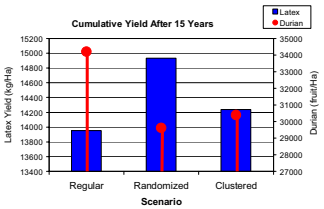


Figure 8. Cumulative Rubber yields after 15 years of simulation compared to Durian yields that are harvested on the year 15.

Rubber and *Imperata*

Below are the simulation results of Rubber plantation under domination of *Imperata cylindrica*.

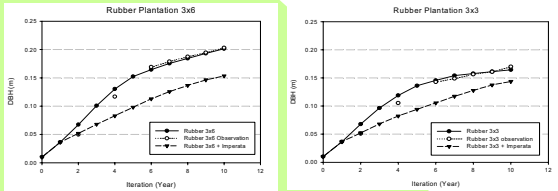


Figure 9. Rubber growth on 3x6 and 3x3 spacing plantation based on actual data and SExI-FS simulation; data from GT1 clone at Sembawa Research Station.

Figure 9 (left graph) shows the effect of *Imperata* on Rubber growth, the harvest size (15cm DBH) is delayed by about five years, and this is close to the observations at ICRAF experiments in West Kalimantan. Increasing the plot density to 3x3 spacing does not reduce *Imperata* effect (right graph).

Rubber and *Acacia*

Acacia mangium has been selected among other fast-growing species for its better ability to compete with *Imperata*. This case study presents the performance of *Acacia* and Rubber (with *Imperata*) on different management scenarios.

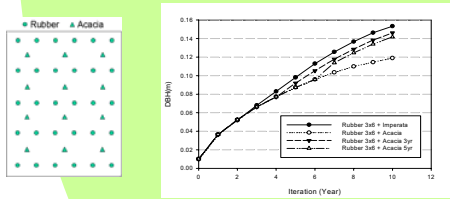


Figure 10. Rubber plantation 3x6m with alternating *Acacia* rows (left) and the simulation output (right).

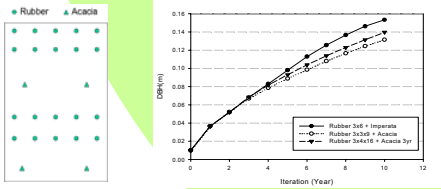


Figure 11. Double row rubber planting patterns 3x3x9 and 3x4x16 with *Acacia* between double rows of rubber (left) and its simulation output (right)..

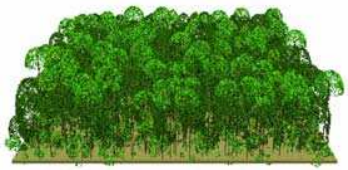
Figure 10 and Figure 11 show the effects of *Acacia* on Rubber trees under different patterns. Removal of *Acacia* after three or five years does not allow rubber trees to recover. This, however, contradicts to the observations in West Kalimantan where rubber recovered slightly after the removal of *Acacia*. The double-row pattern actually shows reduced growth of Rubber trees compared to normal single row pattern (Figure 10). This could be due to the combined effects of competition from *Acacia* and increased inter-Rubber tree competition.

Conclusion

The plot design of an agroforest has effects the performances of the trees. At the same time it also affects the yield of the tree production. Species selection is also important for designing the plot scenario.

The other factors which are not tested here are mortality and natural regeneration. Randomized scenario is proned to higher mortality as it will have less management.

Other scenarios can be simulated based on local preference, and it is possible to include other profitable fruit species in the plot. Plot management scenario is site specific. Under SExI-FS users may define tree-by-tree management scenario. Farmers will likely have their preferences regarding the scenario suitable to their plots, therefore the recommendation should be confirmed to the farmers and it should take into account the local condition.



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