APPLICATION OF MIXED MODELS TO STUDY WOOD PROPERTIES OF TEAK PLANTED IN GHANA

アジチュム ジェリー オポン

Name : アジチュム ジェリー オポン (ADUTWUM JERRY OPPONG)

Title : APPLICATION OF MIXED MODELS TO STUDY WOOD PROPERTIES OF TEAK PLANTED IN GHANA
（混合モデルの適用によるガーナ産チーク材の木材性質に関する研究）

Category：Kou

Thesis Summary

Trees develop in space and time. Wood occupies space (area and height) and is formed sequentially in time from the start (planting), annual growth to end of wood formation (cutting). During tree growth and development, the primary meristem (responsible for height growth) and secondary meristem (responsible for diameter growth) are unified by a signaling system controlled by endogenous and exogenous factors. As a result, wood exhibits complex heterogeneity in their properties, especially wood specific gravity and heartwood color. Wood quality data typically include both spatial and temporal interdependencies that can reveal key dynamical and statistical information of tree growth process. This study investigated the spatiotemporal process of wood formation and its development in Teak (*Tectona grandis* L.f) planted in Ghana.

Mixed-effect models were developed and applied to address both spatial and temporal correlations embedded in wood data to gain insight into the processes underlying the observed patterns in wood properties variations. Mixed models contain both fixed and random effects. The fixed effect models the signal while random effect models the noise in the data and captures the covariance structure of the noise. Data from six height levels, two aspects (opposite sides of the same tree), and ten relative radial positions (time factor) were used to illustrate the implementation of the repeated measures analysis method. Spatial correlation can be seen in the among height levels and between aspect whereas temporal correlation is embedded in the within aspect. The spatial correlation models the development of the apical meristems while the temporal correlation models the development of the vascular meristems.

The spatial and temporal correlations were mostly significant, implying that models chosen to clarify the variation in wood properties should account for the correlations inherent in the wood data. This research further showed that the spatial correlation among height levels increased from bottom to top, a phenomenon attributed to the maturation mechanism of the apical meristems. The decreasing temporal correlation from the center (pith) to the cambium (bark) was attributed to the decreasing influence of the crown on the cambium meristems. The correlation between opposite sides of the same tree was relatively low, suggesting a strong environmental influence on genetical responses in cambial activities and wood formation. In many cases, the radial growth rate had little influence and statistically insignificant effect on

wood specific gravity and heartwood color. Age and height were found to be decisive factors that control the wood specific gravity in teak.

The results of this research revealed remarkable correlations (physiological correlations) involved in the variation in wood properties within trees. The r2 of spatial correlations, which measures the developmental relationship between the wood formed by the same cambium separated by azimuthal aspect, was generally smaller than 0.30. This suggested that the endogenous factors (developmental patterns of cambial activity and gene expression) in each aspect of the same tree are different and thus wood traits formed by the same cambium separated by aspect can have some degree of independent development. Also, the low spatial correlations can be a signal that external conditions (for example, weather, soil fertility, sunlight) under which the trees developed are not constant in space. Similarly, spatial correlations among height levels were low a phenomenon attributable to the relative distance between height levels which was measured in meters.

In conclusion, these correlations could be used to predict the spatial distribution of biomass and yield by exploiting the correlation at lower height levels of teak planted in Ghana. The models would better predict the growth and physiology of the teak trees planted in other countries. Given this relationship, spatial and temporal correlations should be considered as important background information on the wood-forming process and it is not only explained by the model, but it can be used by wood researchers to create a more accurate distribution of the overall wood.