Shade tolerance of tropical forage legumes for use in agroforestry systems

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Abstract

The benefits of raising livestock in conjunction with tree plantations include the better use of land resources, an increased and diversified income, soil stabilisation and the potential for higher plantation yields through better weed control, nutrient cycling and nitrogen accretion. However, the significant acceptance of tree-pasture (silvopastoral) systems has been impeded by the belief that productive pasture cannot be maintained under tree canopies.

The aims of this project were to identify forage legume species suitable for use in silvopastoral systems in order to improve pasture quality under differing rainfall regimes in the tropics. A total of 35 species and cultivars of tropical pasture legumes were tested for shade tolerance beneath four levels of shade under shadehouse conditions, with a range of agronomic and ecophysiological parameters measured, including biomass production, root:shoot ratio, root nodulation, foliar nutrient content, time to flowering, seed production and light response curves.

Production of both above and below-ground biomass was strongly depressed by shading, although the extent of this varied between species. Many of the most promising species yielded well under both the control and the shaded treatments, indicating that they may be suitable for use in both younger, less shaded plantations and older, heavily shaded plantations. Concentrations of leaf N were affected by shading with increased N found under shade treatments compared to the control. There were no similar effects on leaf P concentrations. Root nodulation was strongly affected by shading and was greatly reduced or entirely absent under shaded treatments, suggesting that fixation of atmospheric nitrogen may be lower under shade than in the open. Shading prolonged the vegetative growth in many species, delaying flowering and greatly reducing seed production, although the size of individual seeds was maintained at the expense of seed numbers. An increase in the fraction of readily germinable seed and a decrease in the fraction of hard seed were found in several species when the seed was produced under shade under shade. Light curves were not always correlated, with the production of dry matter with several species that appear shade-tolerant from dry matter production producing light response curves suggesting otherwise.

Field trials were conducted in both the wet and seasonally dry tropics to examine the growth of selected legume species under timber plantations that were already established for a number of years, and under a relatively young Nelder wheel plantation of African Mahogany (*Khaya senegalensis*). Field trials, particularly the Nelder wheel trial, demonstrated the dynamic nature of pasture growth, particularly in the seasonally dry tropics, and the need for continuous monitoring of such trials to form a more complete picture. *Arachis pintoi* was clearly the best performing species unde a five-year-old mixed rainforest species/*Eucalyptus pellita* plantation in the wet tropics. In the seasonally dry tropics *Clitoria ternatea* and *Centrosema brasilianum* proved to be the best performing cultivars beneath both a conventional, 12-year-old African Mahogany stand and the Nelder wheel, with pasture production depressed by increasing tree densities. Pasture production was found to decrease exponentially with increasing tree density in the Nelder wheel plantation. Both *Clitoria ternatea* and *Centrosema brasilianum* were observed to climb trees during the trial, indicating the potential of vigorous climbing species to smother young or small trees. Soil moisture content was also found to decrease as tree density increased, suggesting that in the seasonally dry tropics light may not always be the limiting factor for growth.

Sixteen species were identified which are potentially useful, shade tolerant or shade adapted, pasture species for use beneath tree plantations in both the wet and the seasonally dry tropics. The most promising species suited to the wet tropics were *Arachis pintoi, Centrosema acutifolium, C. macrocarpum, C. pubescens, Calopogonium mucunoides, Desmodium intortum, D. ovalifolium, D. canum, D. heterophyllum, D. uncinatum* and *Pueraria phaseoloides.* The most promising species suited to the seasonally dry tropics were *Arachis stenosperma, Centrosema brasilianum, Clitoria ternatea, Macroptilium atropurpureum* and *M. lathyroides.*

Many of the species identified as being shade tolerant, or relatively productive under shade have a climbing habit which can cause concern due to the potential smothering of young or small trees. When climbing species are removed the remaining species suited to the wet tropics are *A. pintoi, D. canum, D. heterophyllum, D. intortum* and *D. ovalifolium,* and those to the seasonally dry tropics are *A. stenosperma* and *M. lathyroides*. However climbing species may still be of use beneath older plantations or

where a higher level of pasture management is acceptable to prevent the smothering of trees through a greater control of the intensity and frequency of grazing or cutting.

Additional research is required to examine the long-term persistence and performance of the species identified in this study as plantations age and shade levels increase. The compatibility of suitable legume species with shade tolerant grasses is an important aspect, which will affect the production and persistence of the legume species, that has seen relatively little research in the past.

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