ABSTRACT

A simple conceptual framework for analyzing yield development in cocoa is proposed. Studies were carried out to establish the physiological determinants of growth in juvenile cocoa and yield development in immature and mature cocoa.

The CO_2 and H_2O exchange of intact cocoa leaves were primarily affected by both environment (mutual shading and vapour pressure deficit tightly coupled to leaf temperature and relative humidity) and ontogeny (leaf age) and not by sink strength (pod load or flushing). Large variations were detected among the cocoa clones grown under glasshouse or field conditions in P_m (3.43-7.38 μmol CO_2 m^{-2} s^{-1}), dark respiration (1.48-2.30 μmol CO_2 m^{-2} s^{-1}), quantum yield (0.0271-0.0592 μmol CO_2 μmol^{-1} photon), and convexity (0.87-1.00), parameters derived from fitting non-rectangular hyperbola to individual photosynthetic light response data. For young non-bearing cocoa, vegetative shoot growth is positively related to P_m such that fast growing clones tended to express higher P_m.

The importance of light interception and distribution within the canopy in limiting productivity in cocoa germplasm was highlighted. For immature cocoa (at 48 months after transplanting) planted at conventional density (1096 trees ha^{-1}), precocity and yield were linearly related to fractional intercepted radiation (f). Large variations were detected among the Inter-Upper Amazon hybrids in the rate of canopy development (f, 0.50 to 0.82) and yield efficiency (ratio of yield/intercepted radiation, 0.085-0.133 g MJ^{-1}). However, precocity and yield efficiency were independent of inherent tree vigour expressed as trunk girth but negatively related to susceptibility to infection by vascular-streak-dieback. A genotype x density interaction was detected such that some less vigorous genotypes were planted at a sub-optimal density. Production efficiency could be enhanced through the selection for semi-dwarf genotypes for intensive cultivation, which require less pruning and have a higher harvest increment.

For mature cocoa planted at high density (3333 trees ha^{-1}), yield was not related to f but to light distribution through the canopy quantified as the light extinction coefficient (k, 0.61-0.95). Canopies with lower k (characterised by greater axillary branching) permitted greater light penetration; allowing the lower shaded leaves to make greater photosynthetic contribution to dry matter production.

Results from simulation developed in this study confirmed the importance of incoming solar radiation, light extinction coefficient and leaf nitrogen content in influencing radiation use efficiency, nitrogen use efficiency and dry matter production. Daily canopy gross photosynthesis increased with increasing solar radiation and saturated at a leaf area index of between 3-4. High solar radiation reduced radiation use efficiency whilst low leaf nitrogen content increased nitrogen use efficiency.