THE EFFECT OF LIGHT ON GROWTH OF CASSAVA AND SORGHUM I
LIGHT DISTRIBUTION AND EXTINCTION COEFFICIENT

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ABSTRACT

To study the light distribution and to calculate the extinction coefficient cassava and sorghum were grown in Redland Bay research station with plant spacing 75 x 75 cm2 for cassava and 50 x 10 cm2 for sorghum. The amount of Photosynthetically Active Radiation (PAR) intercepted by the canopies was measured at 25 cm interval and leaf area index (LAI) was determined for each stratum. The data collected was used for determination of extinction coefficient (K) of the whole canopy and each stratum. Cassava had an even distribution of LAI with depth whereas sorghum has more leaf area index at 50-70 cm layer and less at the bottom. Total LAI of cassava was 3.16 and 2.59 for sorghum. Transmission declined more rapidly in cassava with total interception 93 % whereas sorghum tend to have less rapid decline with total interception of 82 %. Light extinction coefficient (K) in cassava is higher than in sorghum with value 1.01 and 0.57 respectively. At the bottom layers (0 - 25 cm) K for sorghum (0.71) and cassava (0.84) are the highest value than K of the upper layers. With critical LAI 5.26 sorghum can be grown in a higher density than cassava (with critical LAI of 2.97) and still yield high productivity whereas cassava productivity is favoured at low LAI.

Key Words : Light distribution, extinction coefficient vertical distribution of LAI, Cassava, Sorghum

INTRODUCTION

Light distribution in plant canopy is an important factor affecting the efficiency of conversion of radiation to dry matter. Ludlow and Wilson (1971 in Muchow, 1982) indicated that efficiency is lower when the average intensity of radiation per unit area is greater and it will get higher if a given amount of PAR (Photosynthetically active radiation) is distributed over several units of LAI (leaf area index) at a low intensity. This characteristic of light distribution in the canopy can be discussed by using light extinction coefficient (K).

Cassava and sorghum have different type of canopy structure. Cassava has a low leaf angle (to horizontal surface) which is called "planophile", while sorghum has erect leaves, called "erectophile". Under this condition, it is expected that the light distribution in sorghum canopy would be better and it is the reason for its high productivity.

This experiment was conducted to find the extinction coefficient (K) of sorghum and cassava which have different type of canopy structure. In part II of this report, the value of K's are correlated with the productivity and efficiency of light conversion.

MATERIALS AND METHOD

Cassava and sorghum were planted on 30 November 1988 and 13 January 1989 respectively at Redland Bay Research Station, University of Queensland. The crop is being grown with no additional nutrient and water supply.

Row spacing is 75 cm in cassava with 75 cm between plants and 50 cm in Sorghum with 10 cm between plants. Each crop were grown in 6 replication.

Above ground samples was harvested on 1st March for the study of light penetration in the canopies in relation to leaf area distribution. Samples area per plot was 1.5 m x 1.5 m (2 rows) for cassava and 1.0 m x 1.0 m (2 rows) for sorghum. Harvests and measurements other than this one is discussed in report II.

Before each harvest was made, the amount of photosynthetically active radiation (PAR) intercepted by the canopies was measured at 25 cm height intervals in the fully developed cassava and sorghum canopy. The crop was then harvested by layers (25 cm) and leaf area index (LAI) was determined for each stratum. This information was used for determination of extinction coefficient (K) of the species.

RESULTS AND DISCUSSION

K values

Profiles of LAI and radiation transmission through the canopy of cassava and sorghum are shown in Fig. 1 and 2.

Total LAI was slightly different between sorghum and cassava with the value 3.16 for cassava and 2.59 for sorghum, but cassava had a very even distribution of LAI with canopy depth, whereas sorghum had more leaf area index in the top (50 - 75 cm layer) and less in the bottom (0 - 25 cm layer).

Radiation transmission declined rapidly with height in cassava more then in sorghum. In cassava, at the halfway down of its canopy (0 - 62.5 cm) transmission of radiation was almost the same as that of the halfway down (0 - 50 cm) of sorghum (45.5 % and 40 % respectively) but sorghum had more leaf area index above this height (1.31 compared to 0.74 in cassava), so radiation intercepted at this layer was distributed more to leaf surface in sorghum than in cassava.

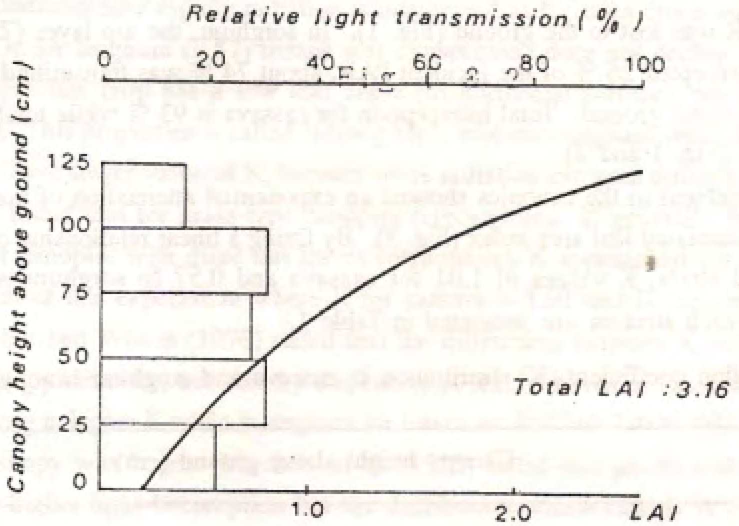

Fig. 1. Relationship between light transmission and distribution of LAI with depth in Cassava.

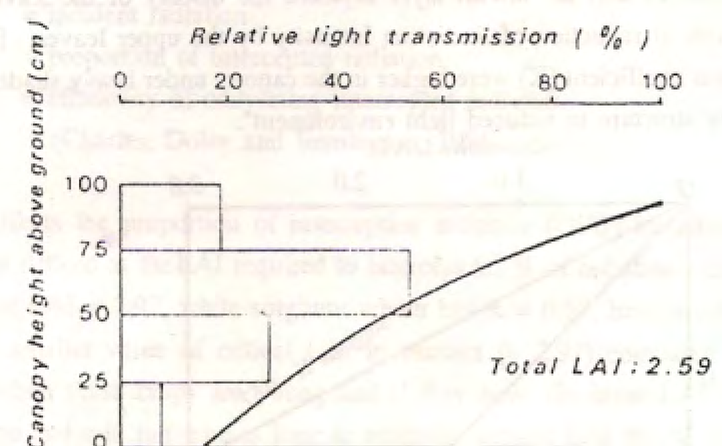

Fig. 2. Relationship between light transmission and distribution of LAI with depth in Sorghum.

In cassava, the top layer (100 - 125 cm) which had LAI of 0.38, intercepted approximately 22 % of the incident radiation (PAR) and about 78 % was transmitted to the lower layers and only 7 % of this PAR was lost to the ground (Fig. 1). In sorghum, the top layer (75 - 100 cm), with LAI of 0.44, intercepted 26 % of the incident PAR, about 74 % was transmitted to the lower layers and 16 % was to the ground. Total interception for cassava is 93 % while total interception for sorghum is 84 % (Fig. 1 and 2)

Light measurement in the canopies showed an exponential attenuation of horizontal light flux density with accumulated leaf area index (Fig. 3). By fitting a linear relationship of cumulative LAI to ln I/Io for all strata, K values of 1.01 for cassava and 0.57 fo sorghum was abtained. The values of K for each stratum are presented in Table 1.

Table 1. Light extinction coefficient (K) distribution in cassava and sorghum canopy.

	Canopy height above ground (cm)					
	0 - 25	25 - 50	50 - 75	75 - 100	100 - 125	Average
Cassava	0.84	0.69	0.67	0.42	0.65	1.01
Sorghum	0.71	0.12	0.51	0.68	-	0.57

Fig. 3 show that K at the lowest layer, for both crops, had the highest value.

This indicated that the lowest layer adjusted the display of the leaves to absorb more radiation as a result of reduction of Radiation Intensity by the upper leaves. Fukai (1984) discovered that extinction coefficient (K) were higher in the canopy under heavy shade, "indicating an adaptation in canopy structure to reduced light environment".

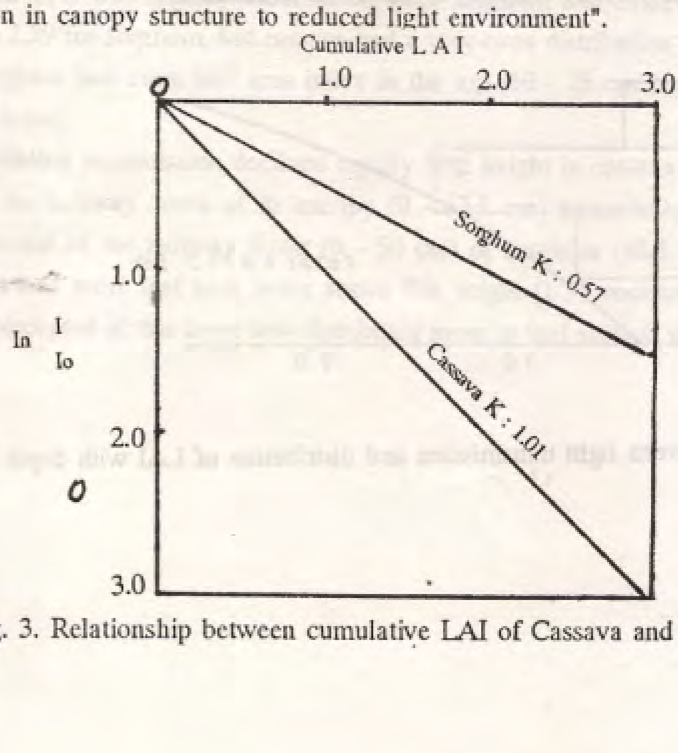

Fig. 3. Relationship between cumulative LAI of Cassava and Sorghum and ln I/Io

Figure 3 shows that K is the slope of the relationship between light transmission and LAI. Therefore K indicates how rapidly radiation is intercepted as it passes down through a crop canopy. The smaller K for sorghum (0.57) means that transmission does not decline as much as cassava. This is because this crop has a low leaf angle (to horizontal surface), which means it tends to have flat leaf. This properties is called "planophile", whereas sorghum which has erect leaves, called "erectophile" have lower value of K, because more radiation can pass through the canopy. Loomis *et al.* (1967) found that for grass-type canopies (erectophile). K generally fell in the range 0.3 - 0.5, while for canopies with more flat leaves (planophile), K approached 1.0. This finding agrees with the result of this experiment where K for cassava = 1.01 and K for sorghum = 0.57.

Fischer and Wilson (1976) stated that the differences between K value is not only determined by canopy structure, but also by dispersion of leaf. Leaves of cassava tend to be clumped together resulting in higher K while in sorghum the leaves are distributed more even, hence light distibution within the canopy was better. Muchow et al. (1982) stated that plants with greater values of K tend to have higher light interception but the distribution within canopy is poor.

The effect of K to Crop Growth Rate

Crop growth rate (CGR) is determined by the proportion of intercepted radiation and denoted by the formula :

$$CGR = Q \times Qi/Q \times Ec$$

Where : Q = incident radiation

Qi/Q = proportion of intercepted radiation

Ec = efficiency of converting intercepted radiation

(Charles, Doley and Remington, 1986).

K affects the proportion of interception radiation (Qi/Q) by affecting the critical LAI. Critical LAI is defined as the LAI required to intercept 95 % of radiation. Cassava with K = 1.01, have a critical LAI = 2.97, while sorghum which has K = 0.57, have a critical LAI = 5.26.

The smaller value of critical LAI in cassava (= 2.97) compared to sorghum (= 5.26), means that when these crops are young and if they have the same LAI, cassava will intercept more radiation and will not take as long to reach the critical LAI (95 % interception). With this value of critical LAI, sorghum can be grown in a higher density than cassava and still get high productivity. Cassava at low LAI is favoured at more of the incident radiation is intercepted.

K also affects the efficiency of converting intercepted radiation to dry matter (Ec) by affecting the distribution of light on the individual leaves in the canopy. Ludlow and Wilson (1971, in Muchow, 1982) stated that efficiency will be high if total photosyntetically active radiation (PAR) is distributed over several unit of LAI at a low intensity per unit area. Efficiency is lower when the same amount of PAR is distributed over less unit of LAI, as the average intensity per unit area is greater. Sorghum which having smaller K (= 0.57) and associated with erect leaves has a lower intensity of light on most of its leaves and therefore its canopy is more efficient in converting intercepted radiation to dry matter, while in cassava which has higher K (=1.01) and associated with horizontal leaves, most of incident radiation is intercepted at top layer. Therefore the upper canopy was saturated and not efficient in converting intercepted radiation to dry matter.

Light use efficiency in relation to total dry matter production of cassava and sorghum is discussed in detailed in part II of this report.

CONCLUSION

Fitting a linear relationship of cumulative leaf area index to light transmission for all strata gave K values of 1.01 for cassava and sorghum 0.57. The smaller K value for sorghum (0.57) means that light transmission does not decline as much as in cassava. This is because sorghum has a large leaf angle (to horizontal surface), which means it tends to have erect leaf. While cassava which has flat leaf have higher value of K (1.01), because more radition is intercepted by upper leaves and less radiation would be available for lower leaves.

K will affect the proportion of interception radiation (Qi/Q) by affecting the critical LAI. Cassava with K = 1.01, have a critical LAI = 2.97, while sorghum which has K = 0.57, have a critical LAI = 5.26. The smaller value of critical LAI in cassava (= 2.97) compared to sorghum (= 5.26), means that cassava will intercept more radiation and will not take as long to reach the critical LAI (95 % interception). With this value of critical LAI, cassava will get high productivity only at lower density.

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