INFLUENCE OF LIGHT INTENSITY ON CHLOROPHYLL DISTRIBUTION AND ANATOMICAL CHARACTERS OF CASSAVA LEAVES[1] /

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Resumen

Se estudió la influencia de la intensidad lumínica sobre las características morfológicas y anatómicas de hojas de cuatro cultivares de yuca promisorias. Con poca luminosidad, se observó una reducción significativa del peso específico de la hoja (SLW) y un aumento en la relación de área foliar (LTR). Las características anatómicas de una variedad de alta producción (H-165) se compararon con las de la variedad de baja producción (M-4), creciendo con poca luminosidad. El parénquima esponjoso fue más grueso en H-165 que en M-4 bajo condiciones normales de luz y con poca luz en ambos casos hubo una misma en el grosor de la capa del mesofilo. De la misma manera, las estomas en H-165 estaban más hundidas que en M-4 bajo condiciones normales de luz, pero al reducir la luminosidad en ambas variedades se encontraron en la superficie de la hoja. En las cuatro variedades estudiadas se experimentó una reducción en el número de estomas por unidad de superficie foliar bajo poca luminosidad. Asimismo, la concentración de clorofilato aumentó significativamente en relación a la clorofila a bajo condiciones de poca luz.

Introduction

In recent years, mixed cropping is gaining importance in the tropical agriculture in view of increasing the productivity per unit land area by making use of the solar radiation more effectively. Besides monocropping, cassava (*Manihot esculenta* Crantz) is traditionally grown as intercrop with coconut palms in the State of Kerala, which contributes about 80% of cassava production in India. The work conducted at CTCRI, Trivandrum suggested that the light intensity available for the growth of cassava plants in the established coconut plantation was 10 to 15% of the normal sunlight which resulted in significant yield reduction ranging from 65 to 94% depending upon the gentoypes (9). Further investigations were made to compare the anatomical and morphological characters of cassava leaves exposed to normal and shaded environments.

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Materials and methods

Four promising varieties of cassava Viz., M-4, H-165, H-1687 and H-2304 were grown in open area (normal light) with a mean diurnal light intensity of 40 000 lux and in shaded area (low light) with a mean diurnal light intensity of 6 000 lux. The shade was created artificially by screening the sunlight. The experiment was conducted during 1982 cropping season. All the observations were made between 2nd and 3rd month stage and the experiment was terminated by 4th month. Anatomical studies were made using sections 10 to 15 thickness following the usual dehydration, embedding and staining procedures (6). Chlorophyll pigments (total, Chl. a and Chl. b) were estimated by the method of Arnon (1).

Results and discussion

The specific leaf weight (SLW) for the varieties grown under normal light ranged from 3.9 to 4.7 mg/cm^2 while under low light (shade) the SLW was reduced significantly in all the four varieties by 57 to 62% (Table 1). The leaves grown under shade were thinner and dark green in colour when compared to normal light. However the intensity of anthocyanin in the petioles of M-4 and H-2304 was very low in contrast to their characteristic dark red petioles found in normal light. The finding suggested that besides the quality of light (5), the quantum of light is also essential for the synthesis of the flavonoid pigments despite the exact role of anthocyanin in cassava is yet to be investigated.

Distribution of chlorophyll pigments also varied significantly in different treatments (Table 2). The leaves grown under low light (6 000 lux) recorded higher concentration of total chlorophyll per unit leaf weight (mean value = 3.72 mg/g fresh leaf) when compared to the leaves grown in normal light (mean value = 2.58 mg/g fresh leaf). However, the concentration of total chlorophyll per unit leaf area was higher under normal light (3.30 mg/dm^2 leaf) when compared to low light (2.82 mg/dm^2 leaf). The significant increase in chlorophyll concentration

Table 1. Effect of light intensity on certain leaf characteristics of cassava.

Variety	Specific leaf weight mg/cm^2		Leaf area ratio cm^2/g	
	Normal light	Low light	Normal light	Low light
M-4	3.9	1.6	84.0	135.7
H-165	4.7	1.9	71.1	118.4
H-1687	4.3	1.6	80.0	114.6
H-2304	4.2	1.8	79.9	128.0

under low light on leaf weight basis was mainly due to increase in leaf area ratio (67% over control). As there was little difference in total leaf area between the two treatments, the chlorophyll content of the whole plant will be higher under normal light when compared to low light. Among the two fractions of chlorophyll, the low light favoured increase concentration of chlorophyll, the low light favoured increase concentration of chlorophyll-b, consequently the ratio of chlorophyll-a to chlorophyll-b was reduced significantly which may be also an important factor for the causes of low productivity of cassava under shade. Similar observations on increased concentration of chlorophyll-b under low light was already made (3) in other crops. The role of chlorophyll-b in the primary photosynthesis is mainly to trap the photon and transfer to chlorophyll-a where the process of energy conversion (photosynthetic phosphorylation) takes place. Hence any significant reduction in the ratio of chlorophyll-a to chlorophyll-b found in normal leaves may bring out reduction in the photosynthetic efficiency.

The cassava leaves grown under low light intensity were found to be thin and papery which may affect the leaf water potential and osmotic regulatory mechanism. Though the leaf blades were slightly broader under low light, the leaf area ratio (leaf area per unit leaf weight) was very high, which may affect the productivity as LTR was also considered an important physiological parameter in crop production (8).

Table 2. Effect of light intensity on distribution of chlorophyll pigments in cassava.

Characters	Leaf weight basis (mg/g fresh leaf)				Leaf area basis (mg/dm^2 fresh leaf)			
	M-4	H-165	H-1687	H-2304	H-4	H-165	H-1687	H-2304
1. Total Chlorophyll								
Normal light	2.18	2.74	2.54	2.86	2.60	3.85	3.18	3.58
Low light	3.30	3.36	3.94	4.26	2.43	2.84	2.72	3.32
2. Chlorophyll-a								
Normal light	1.04	1.34	1.22	1.42	1.24	1.88	1.53	1.78
Low light	1.48	1.50	1.74	1.90	1.09	1.27	1.20	1.48
3. Chlorophyll-b								
Normal light	1.16	1.40	1.30	1.46	1.38	1.97	1.63	1.83
Low light	1.82	1.86	2.22	2.36	1.34	1.57	1.54	1.84
4. Ratio of Chl-a/Chl-b								
Normal light	0.90	0.96	0.94	0.97	0.90	0.95	0.94	0.97
Low light	0.81	0.81	0.78	0.81	0.81	0.81	0.78	0.80

By evaluating a set of promising cultivars of cassava under uniform shade, Ramanujam *et al* (9), observed significantly higher yield in H-165 when compared to M-4. Under normal light also, the former is a higher yielder than the latter. The leaf anatomy of H-165 and M-4 under both the light intensities were compared. The results suggested that the leaves of H-165 were found to be thicker than M-4 under normal light (Table 3) and interestingly, the spongy parenchymatous layer was found to be characteristically thicker in H-165 than in M-4. The chloroplast was present in both palisade and spongy parenchyma of both the varieties. The different layers of the leaves grown under shade were distinctly thinner when compared to the leaves grown under normal light (Figures 1, 2). There was a reduction in the distribution of chloroplast in the palisade but the size appeared to be almost the same as in the control. The spongy parenchyma also showed a reduction in the chloroplast distribution, but there was an increase in the size of the chloroplast. Under shade (low light), the leaves of both the clones were almost of same thickness and similar in the distribution of different layers. The most significant reduction was noticed in the thickness of spongy parenchyma of H-165 (Table 3) where, it was 60.0 in the leaves grown in open while 25.6/u in the leaves grown in shaded conditions. Rarefication was noticed in palisade and spongy layers.

The size of the stomata and distribution was studied in detail for all the four varieties (Table 4). The stomata were found on the lower surface of the leaves for all the cultivars under both the treatments confirming the earlier report (10). Comparison was made between M-4 and H-165 for stomatal distribution which revealed that under normal light, they

Table 3. Leaf anatomy of M-4 and H-165grown under normal light and low light.

	Normal light (40 000 lux)		Low light (6 000 lux)	
	M-4	H-165	M-4	H-165
1 Thickness of Epidermis (μ)	20.0	20.0	14.0	13.2
2 Radial length of palisade (μ)	68.0	68.0	41.2	39.2
3 Thickness of spongy parenchyma lower epidermis (μ)	41.2	60.0	26.4	25.6
4 Thickness of leaf (μ)	129.2	148.0	81.6	78.0

Fig. 1. T.S. of leaf of M-4 from normal light, x 150.

Fig. 2. T.S. of leaf of M-4 grown in shade, x 150

were found on the surface in M-4 (Figure 3) while in H-165 they were slightly sunken with relation to other epidermal cells (Figure 4). However, under low light, the stomata were found on the surface in both the varieties. There was significant reduction in the number of stomata per unit leaf area due to low light (Figures 5, 6). The mean stomatal number per unit leaf area in M-4 was 56.3 and 48.7 under normal and low light respectively.

Plants adapted to bright sunlight are found to show different leaf morphology under low light (2, 3, 4, 7). Crockston *et al.* (4), demonstrated that higher light intensity promoted the development of palisade and spongy mesophyll tissues resulting thicker leaves. Cassava being a sun loving crop, the associated anatomical and morphological changes are apparently brought out by low light.

Adaptation to lower light intensity appears to be a genetical character which would make effective use

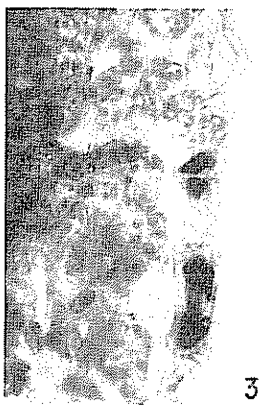

Fig. 3. Stomata on the surface in M-4, x 650

Fig. 4. Sunken stomata in H-165, x 650

Table 4. Influence of light intensity on distribution and size of stomata.

Variety	Treatment	Number of stomata*		Lenght of stomata (μ)	
		Range	Mean	Range	Mean
M-4	Normal light	55–59	56.3	20–24	21.6
	Low light	45–56	48.7	16–24	18.8
H-165	Normal light	45–59	50.2	16–24	22.0
	Low light	38–46	41.8	16–20	19.2
H-1687	Normal light	51–57	54.1	20	20
	Low light	45–56	50.2	16–20	18.4
H-2304	Normal light	47–53	50.9	20–24	23.2
	Low light	38–50	42.4	16–24	19.2

* Under the microscopic field of 40 x 10

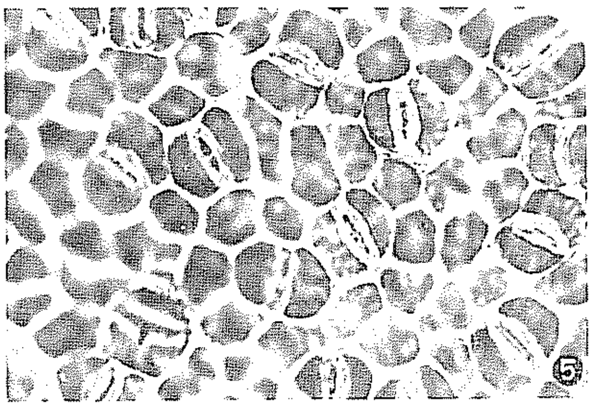

Fig 5. Stomatal distribution in normal leaves, x 500.

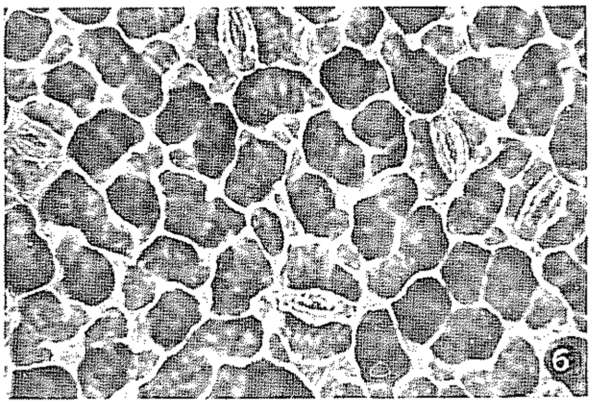

Fig 6. Stomatal distribution under shade, x 500

of available solar radiation. All the four varieties of cassava used in the present study showed definite anatomical changes under low light resulting in a significant reduction in photosynthetic efficiency, as the volume of the photosynthetic apparatus per unit leaf area was curtailed significantly under shade.

Crockston *et al.* (4) recorded 38% reduction in photosynthesis of bean leaves due to shading mainly because of increase in stomatal and mesophyll resistance to diffusion of CO_2. It was also demonstrated that the reduction in stomatal number would increase stomatal resistance. Besides, the reduction in the thickness of palisade and spongy parenchyma observed under low light may also result in increased mesophyll resistance to CO_2 uptake, ultimately the efficiency of the cassava leaves for CO_2 assimilation will be affected.

The present findings explain the causes for low yield of cassava under shaded environment. Inspite of its poor yield under mixed cropping system, large scale cultivation of cassava in coconut garden is prevalent in Kerala due to limited and holding. As none of the high yielding clones of cassava showed complete adaptation to uniform shade, further studies on this line is essential to find out the critical light intensity for cassava to achieve reasonable yield under mixed cropping system in addition to developing shade tolerant clones.

Summary

The influence of light intensity on morphological and anatomical characteristics of the leaves of four promising cultivars of cassava was investigated. Significant reduction in specific leaf weight (SLW) and increase in leaf area ratio (LTR) were observed under low light in all the cultivars. The anatomical features of the leaves of a high yielding variety (H-165) was compared with a low yielding variety (M-4) under two light intensities. The spongy parenchymatic layer

was thicker in H-165 than in M-4 under normal light while under low light both the varieties showed reduction in the thickness of mesophyll layers. Similarly the stomata in H-165 were found sunken when compared to that of M-4 under normal light but under low light they were found on the surface in both the varieties. There was a significant reduction in the number of stomata per unit leaf area under low light in all the four varieties studied presently. The concentration of chlorophyll-b increased significantly when compared to clorophyll-a under low light.

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Reseña de libros

CROSSLEY, P., KILGOUR, J. and MORRIS, J. Small farm mechanization for developing countries. John Wiley, 1983. 253 p.

Uno de los problemas más apremiantes que encara la agricultura en los países tropicales en vías de desarrollo, es el de aumentar el rendimiento de los cultivos, sin que esto signifique un incremento significativo en el costo de producción. La tecnología moderna ha puesto a disposición de los agricultores una amplia gama de equipos y de maquinaria, para hacer más eficiente el proceso de producción. Sin embargo, una buena parte de estos equipos han sido diseñados para las regiones extratropicales, en donde las condiciones edáficas, topográficas, climáticas y económicas difieren mucho de las condiciones del trópico. Además, el precio de estos equipos es alto, en relación con las posibilidades financieras de la mayoría de los agricultores tropicales. Por otra parte, la experiencia ha mostrado que muchos de estos agricultores, sin una debida asesoría técnica, han adquirido equipos costosos y poco adaptados a sus necesidades, lo que ha acarreado pérdidas no sólo a sus economías particulares, sino también a la de sus países, crónicamente deficitarios en divisas extranjeras. A todo esto hay que agregar el fuerte aumento en el costo de los combustibles, con que funcionan la mayoría de estas máquinas. Todo esto plantea la necesidad de una selección muy rigurosa del equipo más apropiado para cada situación, de tal suerte que haya una buena relación entre costo y beneficio.

Por tal motivo considero que este libro puede ser un elemento importante para los técnicos en mecanización agrícola y para muchos agricultores, en el momento de escoger el equipo y la maquinaria más apropiados para determinada actividad. El libro refleja un conocimiento profundo de los autores sobre los problemas de la mecanización agrícola en los trópicos, el que logran comunicar de manera sencilla y clara. No se limitan sólo a discutir problemas de mecanización y de maquinaria agrícola, sino que también en algunos casos recomiendan como la tecnología más apropiada es el uso de fuerza animal o humana.

La obra está dividida en tres partes fundamentales y cada una de ellas a su vez subdividida en capítulos, según el siguiente desglose:

Parte I **Necesidades de la agricultura**

Capítulo 1. Condiciones y labores de campo
Capítulo 2. Labores en la finca.
Capítulo 3. Condiciones de transporte.

Parte II **Equipo para la mecanización**

Capítulo 4. Fuerza humana y animal.
Capítulo 5. Características de transmisiones y de máquinas pequeñas
Capítulo 6. Tracción, dirección y frenos
Capítulo 7. Características de los implementos

Parte III **Escogencia del equipo según las diferentes labores.**

Capítulo 8. Economía de la mecanización en pequeñas fincas
Capítulo 9. Funcionamiento del equipo de motor en el campo
Capítulo 10. Operación segura y eficaz del equipo.
Capítulo 11. Valoración y modificación de equipos.
Capítulo 12. Mantenimiento y producción local de equipo

El análisis del contenido del libro muestra que en su preparación, se le ha dado importancia no sólo a los problemas de escogencia de equipo, sino también a los detalles más importantes sobre el funcionamiento y mantenimiento de éste, aspectos que muchas veces no se les da la consideración que merecen. Otro aspecto que se considera en la obra, es el ambiente en que operará el equipo, información vital para su escogencia.

Por el contenido y por la claridad y sencillez con que está escrita esta obra considero que no debe faltar en la biblioteca de las escuelas de agricultura de los países tropicales, así como en las de los técnicos especializados en mecanización agrícola. También puede ser de interés para los agricultores que poseen empresas de tamaño mediano a grande.

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