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NITRATE REDUCTASE AND SPECIFIC LEAF WEIGHT OF COCOA AND LIGHT PROFILES IN ARECANUT-COCOA MIXED CROPPING

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ABSTRACT

The pattern of light penetration through arecanut canopy and its effect on specific leaf weight (SLW), chlorophyll content and nitrate reductase (NR) activity of cocoa in six different spacings of arecanut-cocoa mixed cropping was studied. The PAR was maximum under wider arecanut spacings. The cocoa leaf NR activity and SLW also were higher over the season in such spacings. The chlorophyll content however did not show any definite trend.

INTRODUCTION

Some tropical crop plants like coffee, cocoa and tea need to be grown under the shade of taller trees. Cocoa is traditionally planted under forest trees in West Africa and South America. However, cocoa was introduced in India as an intercrop under the canopy of taller trees of arecanut and coconut (Shama Bhat and Bavappa, 1972). In an arecanut garden, 37 to 50 per cent sunlight is reported to pass through the canopy which can be utilised for the growth of other perennial or annual crop species tolerant to shade (Sannamarappa and Muraleedharan, 1982).

An experiment laid out in 1970 to study the effect of different

spacing of cocoa and arecanut as a mixed crop with six treatments showed that the yield of arecanut and cocoa were maximum in 3.3×3.3 m spacing (Sannamarappa and Muraleedharan 1982). There is no data available on the physiological aspects in such multiple cropping systems, namely, light profiles and other physiological responses. Hence, a seasonal study on the changes in some physiological parameters affected by light intensity was studied and is reported in this paper.

MATERIALS AND METHODS

Samples was collected from the agronomy experiment laid out in 1970 with arecanut (*Areca catechu* L. var. South Kanara) and cocoa (*Theobroma cacao* L. var. Forestero). There were six spacing treatments as shown in Table 1. Fertilisers were applied in the recommended dosage. The soil is lateritic. Mature leaves (third to fifth) were taken as samples at 10 ha randomly from different parts of individual trees and pooled for analyses. Specific leaf weight (SLW) was estimated from a known leaf area after oven drying

*Table 1. PAR profile under arecanut and cacao canopies**

Treatment	Spacing	Canopy	PAR μ Einstein M^{-2} Sec^{-1}		
			9.00	12.00	15.30 h.
T-1	2.7 × 2.7 m	Areca	100**	240	266
	5.4 × 5.4 m	Cacao	15	42	28
T-2	3.3 × 3.3 m	Areca	80	1410	307
	3.3 × 3.3 m	Cacao	7	64	103
T-3	3.9 × 3.9 m	Areca	43	950	600
	3.9 × 3.9 m	Cacao	29	22	45
T-4	2.7 × 2.7 m	Areca	133	285	127
	2.7 × 5.4 m	Cacao	10	28	22
T.5	2.7 × 2.7 m	Areca	73	470	135
	2.7 × 2.7 m	Cacao	18	42	14
T-6	1.8 × 5.4 m	Areca	206	1510	255
	3.6 × 5.4 m	Cacao	16	33	35
Total sunlight intensity			650	1710	810

*Measurement taken on 23rd March.

**Average of 5 readings in each treatment and variation was within 10 per cent of mean values.

to constant weight. Nitrate reductase (NR) activity was assayed by *in vivo* procedures (Jaworski, 1971). The assay medium (5 ml) contained in final concentration 0.1 M KNO_3, 0.02 M K-phosphate buffer pH 7.5 and 0.3 per cent n-propanol. Chlorophyll was extracted in 85 per cent (v/v) acetone and determined on an ECIL spectrophotometer (Association of Official Analytical Chemists, 1975).

The photosynthetically active radiation (PAR) was measured with a LI-COR quantum radiometer at two levels in an arecanut garden, (1) under arecanut but above cocoa canopy; and (2) below cocoa canopy. Measurements of light intensity in any open area were also noted.

RESULTS AND DISCUSSION

For the optimum growth and yield of cocoa, 50 per cent shade was reported to be the best (Murray, 1964). The yield of cocoa was found to be maximum in 50:50 arecanut and cocoa combination at 3.3×3.3 m spacing. The PAR profile at different times of day is given in Table 1. The mid-day light profile revealed a maximum PAR in treatments T–2 and T–6. However, in the afternoon, the PAR was maximum in T–3. This partly explains the higher yields obtained in T–2 (Sannamarappa and Muraleedharan, 1982). Very little PAR penetrated the cocoa canopy, maximum being in T–1 having wider cocoa spacing.

The seasonal changes in SLW, NR activity and total chlorophyll contents were measured (Table 2). The SLW and NR activity generally showed higher values in T–1 and T–6 followed by T–2. The other treatments showed lower activity and SLW in cocoa leaves. The chlorophyll content did not show any definite trend though marginally higher in T–3 on most of the sampling dates.

The environmental factors especially of light intensity have a profound influence on leaf morphology and physiological functions (Cooper and Qualls, 1967; Barnes et al., 1969; Pearce et al., 1969). Leaves developed under shade are thinner having lower SLW than those receiving higher light intensity (Boardman, 1978, Pearce et al., 1969). The results obtained in cocoa conform to these earlier reports. Higher SLW was associated in cocoa grown at spacing allowing maximum light intensity namely T–2 and

T–6. The higher SLW in T–1 may possibly be due to lesser self-shading of cocoa canopy due to wider spacing of cocoa plants.

Table 2. SLW, NR activity and chlorophyll content in cacoa leaves in different spacings

Treatment	Months						
	Feb	Apr	Jun	Jul	Sep	Oct	Jan
	SLW (mg/cm^2)						
T–1	5.89	7.14	5.91	7.34	7.69	—	6.58
T–2	6.23	5.77	5.90	6.48	6.97	4.93	6.28
T–3	4.54	4.19	4.68	4.54	7.11	5.60	4.59
T–4	4.25	5.21	4.35	6.01	4.70	4.89	5.86
T–5	5.00	4.16	4.71	4.46	5.57	4.98	4.04
T–6	5.72	5.82	5.58	5.81	7.38	5.47	5.44
SE	0.26	0.39	0.36	0.39	0.49	0.42	0.47
	NR activity (μ M $No_2^- g^{-1}$ fresh weight h^{-1})						
T–1	6.8	14.0	9.8	7.8	9.0	—	5.0
T–2	5.9	9.1	10.9	6.2	5.6	13.3	5.3
T–3	7.0	5.8	3.4	3.8	7.8	11.6	4.2
T–4	6.4	7.8	4.0	5.4	5.6	11.6	—
T–5	5.7	7.7	5.0	4.4	7.0	11.6	5.0
T–6	5.7	9.1	7.0	6.3	6.4	9.9	5.4
SE	0.25	1.15	1.32	0.52	0.56	0.43	0.28
	Total chlorophyll (mg g^{-1} fresh weight)						
T–1	1.71	1.29	1.62	2.15	2.67	—	2.55
T–2	1.41	1.01	1.66	2.05	2.37	2.35	1.86
T–3	2.17	1.49	1.88	1.98	2.91	2.51	2.02
T–4	1.90	1.25	1.67	2.56	3.05	1.60	2.12
T–5	1.69	1.00	1.75	2.56	3.05	2.23	1.80
T–6	1.61	0.76	1.90	2.21	2.61	2.05	1.90

Similarly NR activity was enhanced in T–1, T–2 and T–6 (Table 2). This key enzyme of nitrate assimilation is markedly influenced by light (Beevers and Hageman, 1969) and reduced light intensity either by artificial or natural shading decreased the activity in corn (Hageman et al., 1961). Thus, the study of morphological and physiological parameters is very vital in multiple cropping with arecanut, as these parameters are ultimately expressed in terms of yield. The study of light penetration pat-

tern and physiological performances of various crop species with respect to their shade tolerance characteristics and optimum spacing combinations is imperative in future research.

ACKNOWLEDGEMENT

Grateful thanks are due to Mr. K. Shama Bhat, Joint Director for permission to draw samples from the agronomy experimental plot at CPCRI Regional Station, Vittal.

REFERENCES

Association of Official Analytical Chemists, 1975. *Methods of Analysis*, 12th edn., Washington, D.C.

Barnes, D.K., R.B. Pearce, G.E. Carlson, R.H. Hart and C.H. Hanson, 1969. Specific leaf weight differences in alfalfa associated with variety and plant age. *Crop Sci.* 9: 421–423.

Beevers, L. and R.H. Hageman, 1969. Nitrate reduction in higher plants. *Ann. Rev. Plant Physiol.* 20: 495–522.

Boardman, N.K. 1978. Comparative photosynthesis of sun and shade plants. *Ann. Rev. Plant Physiol.* 28: 355–377.

Cooper, C.S. and M. Qualls, 1967. Morphology and chlorophyll content of shade and sun leaves of two legumes. *Crop Sci.* 7: 672–673.

Hageman, R.H., D. Flesher and A. Gitter, 1961. Diurnal variation and their light effects influencing the activity of nitrate reductase and nitrogen metabolism in corn. *Crop Sci.* 1: 201–204.

Jaworski, E. 1971. Nitrate reductase assay in intact plant tissues. *Biochem. Biophys. Res. Commun.* 43: 1274–1279.

Murray, D.B. 1964. A shade and fertiliser experiment with cocoa, III. Report on Cacao Res. 1953 Trinidad, pp. 32–36.

Pearce, R.B., G.E. Carlson, D.K. Barnes, R.H. Hart and C.H. Hanson, 1969. Specific leaf weight and photosynthesis in alfalfa. *Crop Sci.* 9: 423–426.

Sannamarappa, M. and A. Muraleedharan, 1982. Multiple cropping. In: *The Arecanut Palm* (Eds.) K.V.A. Bavappa, M.K. Nair and T. Prem Kumar, pp. 133–149.

Shama Bhat, K. and K.V.A. Bavappa, 1972. Cocoa under palms. *Proc. Conference Cocoa and Coconuts in Malaysia* (Eds.) R.L. Wastie and D.A. Earp, The Incorporated Society of Planters, Kuala Lumpur, Malaysia, pp. 116–121.

DISCUSSION

Q : Why were all the physiological parameters not estimated in the study?

Ans: This study was limited to nitrate reductase activity, specific leaf weight and chlorophyll content under the different light profiles in a mixed cropping system.