

(101)

FINAL REPORT

1. Institute Code No. **Phy.XIX(231)**
2. I. C. A. R. Code No. **Pl-84/9-ICI-F00/0311**
3. Name and Address of Research Institute/Centre: **Central Plantation Crops Research Institute, Kasaragod & Regional Station, Vittal**
4. Project Title: **Crop productivity in coconut and cocoa.**
5. Name and Designation of Project Leader: **V.Rajagopal, SG, Project Leader (Plant Physiology)**

6. Name(s) and Designation(s) of Project Associates including Project Leader and work to be done:

Sl. No.	Name and Designation	Time spent	Work done
1.	V.Rajagopal, SG, Project Leader	5	Planning, execution, compilation of data, water relation aspects (Kasaragod & Kayangulam)
2.	D.Balasinha, SG, Associate	3	Leaf characteristics (SLW, ECW etc.) (Ksd, Vittal)
3.	KV Kasturi Bai, SG, -do-	3	Stem reserves, yield component (Ksd)
4.	B.Sumathukutty Amma, SG -do-	3	Dry matter, stem reserves (KLM)

7. Location of Research Project with complete address (Division/Section/Sub-Centre)
Division of Plant Physiology, CPCRI, Headquarters, Kasaragod and CPCRI Regional Station, Vittal & Kayangulam - Agronomy and Soil Science sections also associated.

8. Date of start 1984

9. Date of termination 1990-91

10. (a) Objectives (Not more than 150 words)

The main objective of the project is to characterize yield stability in relation to varying water availability in coconut. The project envisages detailed investigations on the water depletion pattern from the soil and its relationship with the dry matter production and nut yield. Studies will be carried out for comparison of coconut genotypes with irrigation levels and also with different rainfall pattern represented by Kasaragod and Kayangulam. Stress tolerance, if any, among the genotypes will be identified by studying leaf characteristics like stomatal regulation and water potential components, growth parameters, dry matter production, partitioning, yield attributes and yield. The ultimate goal thus is to understand the soil-water plant relationships in a plantation crop like coconut.

(b) Practical Utility including background information (Not more than 150 words)

The unprecedented drought in 1983 resulted in drastic fall in the yield of some plantation crops like coconut, pepper and cardamom. However, certain genotypes in these crops fared better than others, though the reason for such an adaptation to drought with better yield was not known. Hence, in the present project studies on the response of coconut genotypes to irrigation levels/rainfall pattern in terms of various physiological criteria for stress tolerance have been included. Investigations on soil moisture depletion pattern, dry matter production and yield would indicate the stability of a genotype under the given moisture regimes. Identification of such genotypes which can withstand drought would be of immense value in predicting yield stability even under adverse situations.

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

KASARAGOD-670 124, KERALA

R P F III

Project No. **Phy.XIX(231)**

Date of Start: 1984

1. Technical Programme

Plans Palms under irrigation and fertilizer trials at Kasaragod will be made use of for studying the physiological parameters. There are two experiments in the sub-project (i) WCT palms with different quantity/frequency of irrigation (IW/CPE ratios of 1.0, 0.75 and 0.50) with one level of fertilizer dose (M2) and (ii) WCT, TxD and DxT palms irrigated at IW/CPE of 0.75 with two levels of fertilizers (Mo and Mn). At Kayangulam, apparently healthy palms of WCT and DxT under rainfed conditions alone, with three (WCT) or two (DxT) N levels will be utilized for the studies.

Techniques/Instruments:

Soil moisture will be determined at different depth either with neutron probe or gravimetrically. Steady state ~~porometer~~ porometer, plant water console, osmometer will be employed for the determinations of stomatal regulation and leaf water potential. Epicuticular wax content will be determined colorimetrically. Leaf area, dry matter production, partitioning, yield attributes, nut yield will be recorded periodically.

Observations to be recorded:

- (i) Leaf characteristics (diffusive resistance, SLW, ECW etc.
- (ii) Dry matter production, partitioning, stem reserves
- (iii) Yield attributes, nut yield, nut characters.

FINAL REPORT

Coconut : The influence of the agrometeorological parameters of radiation, temperature and vapour pressure deficit (VPD) on the development of stress was studied, by employing the steady state porometer. Between 10.00 and 12.00 hours there were increases in radiation, temperature and VPD. During the period the stomatal resistance reached a maximum and the leaf water potential was reduced (Fig 1). During the wet season there was low radiation, temperature and VPD which resulted in the palms showing low stomatal resistance, whereas during the dry season the reverse situation occurred. West Coast Tall palms responded to dry weather through a high leaf diffusive resistance, while the hybrid dwarf x tall was susceptible to stress conditions.

The effect of different frequencies of irrigation on the leaf water relations and dry matter production of the West Coast Tall palms was studied during two growing seasons. Irrigation was applied in amounts of 60 mm at a ratio of irrigation water to cumulative pan evaporation (I/E) of 1.0, 0.75, 0.50 and 0.0. Measurements were made of stomatal resistance, leaf water potential, epicuticular wax content and vegetative and reproductive dry matter production. Irrigation treatments resulted in a four to five fold increase in the soil water deficit at I/E ratios of 0.5 and 0.0 as compared to 1.0. Coconut palms experienced

severe moisture stress at an irrigation level of 0.50 resulting in a greater stomatal resistance (111%) and epicuticular wax content (32%) and reduced transpiration rate (10%) leaf water potential (68%) and reproductive dry matter production (22%) compared with well watered palms (Table 1). Based on the relationship between the soil water deficit and the stomatal resistance, the critical soil water deficit for irrigation scheduling was deduced to 110 mm (Fig.2).

The high soil water deficit, coupled with evaporative conditions in the atmosphere during the period of stress (March) had differential effect on West Coast Tall (WCT), WCT x Cnoughat Orange dwarf (COD) and COD x WCT palms in red sandy loam and laterite soil. In general, the palms suffered more in red sandy loam than in laterite soil as indicated by the stomatal resistance and leaf water potential components. The extraction and utilization of water in laterite soil is generally higher than in red sandy loam soil. Both the hybrids had higher stomatal resistance during stress in laterite soil than in sandy loam, which resulted in the maintenance of higher turgidity (Table 2). It was also evident that COD x WCT was most sensitive to water stress only under sandy loam soil. The lower ECW content and the higher electrolyte leakage during stress period as compared to the other two genotypes corroborated this finding.

This could be attributed to higher depletion of soil water (28.9%) between pre-stress to stress period in sandy loam than in laterite soil (4.6%) by COD x WCF. In terms of transpirational loss of water, this hybrid showed 65% decrease during stress period compared to pre stress in sandy loam, as against only 35% decrease in laterite soil for the corresponding period. In both WCF and COD x WCF the dry weight of nut was higher in laterite soil than in sandy loam soil (Table 3). Irrespective of the type of soil, the nut weight was higher in WCF than in COD x WCF, however the partitioning of dry matter differed. The dry weight of husk was greater in WCF than in the hybrid in both the soils, whereas the copra dry weight was higher in the hybrid than in WCF only under laterite soil.

Studies conducted to compare the response of coconut under rainfed conditions at two places such as Kasaragod and Kayangulam differing in rainfall pattern revealed that both WCF and COD x WCF had higher leaf diffusive resistance at Kasaragod than at Kayangulam, indicating relatively high degree of stress at Kasaragod. Even the growth and dry matter production also was effected by this. The total canopy area, leaf dry weight, total nut weight and its partitioning into husk, shell and ~~weight~~ copra was found to be higher at Kayangulam than at Kasaragod (Table 4). This shows that Kasaragod is high drought intensity area as compared to Kayangulam. At Kasaragod in sandy loam soil, the ^{de}productive dry ^bmatter was found to be more affected than the vegetative dry ^{matter} irrespective of the genotype under rainfed condition than irrigated condition.

Table 1 : Leaf water relation characteristics in coconut palms under different levels of irrigation

(Values are mean of six palms)

Treatments	Stomatal resistance ($S.cm^{-1}$)	Transpiration Rate $\mu g cm^{-2} S^{-1}$	Water potential M Pa	ECW $\mu g.cm^{-2}$
T1	3.6	4.1	-0.9	85.2
T2	5.0	4.1	-1.1	97.4
T3	7.6	3.7	-1.3	112.8
T4	15.2	1.7	-1.4	116.8
C.D.5%	2.0	1.3	0.2	12.3

Table 2 : Stomatal resistance and Transpiration rate during stress period as percentage increase (+) or decrease (-) on pre stress period and leaf turgor potential during stress in coconut genotypes under two soil conditions

Parameter	Sandy loam			Laterite		
	WCT	WCTxCOD	CODxWCT	WCT	WCTxCOD	CODxWCT
Stomatal resistance	+355	+202	+156	+216	+330	+382
Transpiration rate	- 40	- 43	- 65	- 47	- 40	- 35
Leaf turgor potential (M Pa)	0.320	0.200	0.210	0.710	0.640	0.680

Table 3 : Nut dry matter and its partitioning into different components in WCF and COD x WCF grown in sandy loam and laterite soil type.

Parameters	Sandy loam		Laterite	
	WCF	CODxWCF	WCF	CODxWCF
Total nut dry wt. (gm.nut ⁻¹)	583.4	487.4	762.3	650.6
Husk dry wt. (g. nut ⁻¹)	267.7	187.2	403.1	277.5
Shell dry wt. (g. nut ⁻¹)	131.5	135.9	161.6	155.7
Copra dry wt. (g. nut ⁻¹)	184.3	164.4	197.6	217.4

Table 4 : Canopy growth, dry weight of leaves, nut and dry matter partitioning in the nut in WCF and CODxWCF palms grown in Kasaragod and Kayangulam under rainfed condition.

Parameters	Kasaragod		Kayangulam	
	WCF	CODxWCF	WCF	CODxWCF
Total canopy area (m ²)	150.0	146.0	186.3	174.3
Total leaf dry weight (kg)	62.3	60.0	76.0	70.7
Total nut dry weight (gms)	583.4	487.4	752.9	602.6
Husk dry wt. (gms)	267.7	187.2	361.5	283.0
Shell dry wt. (gms)	131.5	135.9	170.7	145.1
Copra dry wt. (gms)	184.3	164.4	220.7	174.5
oil (%)	68.8	66.6	69.3	65.8

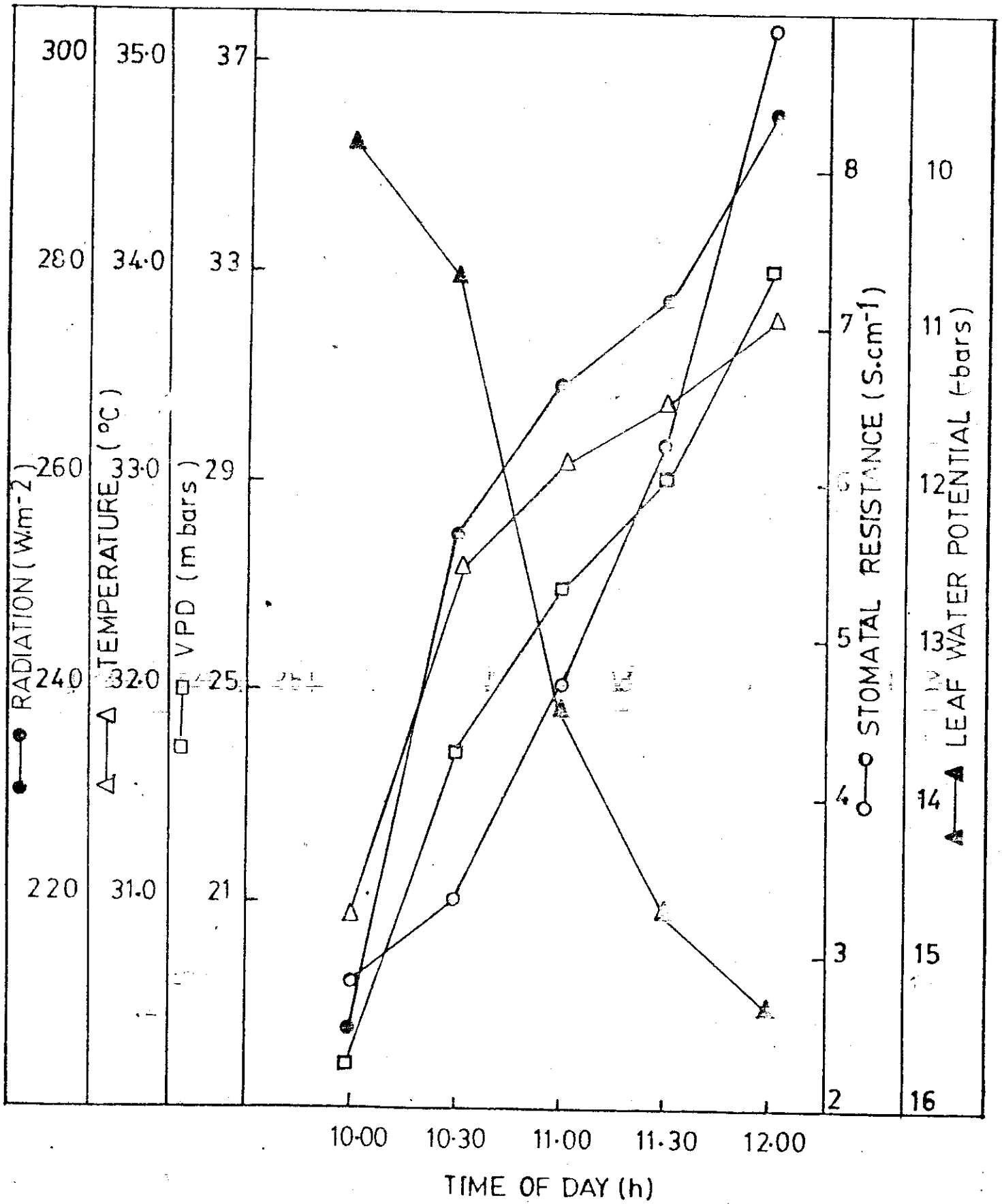
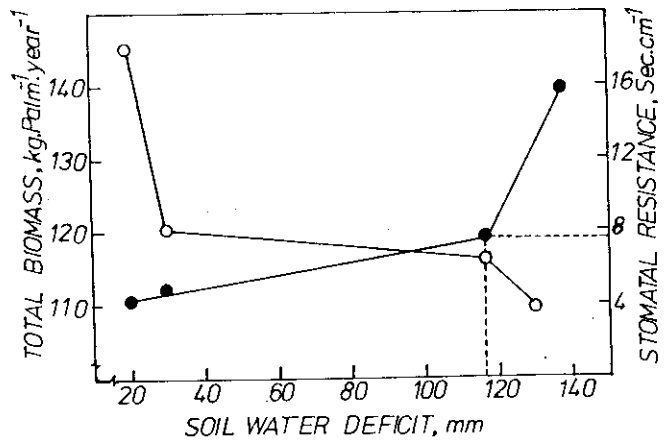


Figure 1

Irrigation of coconut palms

Fig. 2 Stomatal resistance in coconut palms (●) as a function of changes in the soil water deficit (right scale). Horizontal dotted line indicates $\frac{1}{2}$ max value for the stomatal resistance, while the vertical dotted line denote the corresponding level of soil water deficit (i.e. critical level). Relationship between the soil water deficit and total biomass (○) is drawn on the left scale. Each point represents mean of six palms



CENTRAL PLANTATION CROPS RESEARCH INSTITUTE

KASARAGOD-670 124, KERALA

R P F III

Project No. Phy.XIX(231)

Date of Start: 1984

12. Final Report: 19 84 —19 90-91

Cocoa.

Effect of drought on growth: During the drying period the unirrigated (drought) cocoa plants had lower RWC, leaf water potential and osmotic potential. These parameters did not show any appreciable changes during the season in irrigated plants. There was considerable accumulation of proline in leaves of droughted plants which may have an adaptive significance. The NR activity also declined with progress of drought, which however recovered with onset of rains. The contents of chlorophylls was lower in droughted plants as compared to irrigated plants.

The net result of such drastic water relation components and metabolism is reflected in the adverse effect on growth of cocoa plants. The crop growth rates in all the vegetative parts were adversely affected by drought resulting in a decrease in stem girth and total dry weight by about 30% as compared to irrigated plants. The canopy area development was even more severely affected i.e., to an extent of nearly 50%.

Growth analysis and partitioning: The changes in primary and derived growth variables were studied in cocoa upto 5 years. In the classical growth analysis, it is assumed that RGR is the product of LAR and NAR. In the present study the ~~max~~ values used were from destructive sampling. Any limitations on NAR and LAR obviously affect RGR upto certain stage of development. In cocoa a steady state level is reached at the beginning of reproductive phase. Thus any increase in leaf area beyond this optimum level may not have any additive effects on dry matter accumulation.

The growth and productivity of cocoa as seen from the data obtained, is modulated by light interception efficiency and LAR; both of which reach optimum levels with reproductive phase monitored. There is high correlation between SLW and yield capacity.

The accumulation of carbohydrates and total N was slow initially and rapid after second year of growth. The stem was major organ of nutrient storage. The carbon content is influenced by light, LAI and water stress. The ratio of distribution of C and N between vegetative and reproductive parts is dependent not only on C-assimilation but the reserve capacity. Thus, it is important to know the size of productive organs e.g., roots and leaves and reserve pool to predict yield. The shoot : root ratio is related to the C:N ratio which in turn will be influenced by C and N differences. There is a change of C/N from 8.9 to 11.1 with onset of reproductive phase.

Biomass estimation by regression analysis: Growth correlations were studied in cocoa by using destructive sampling data. Highly significant correlations between canopy, stem girth, leaf area and dry weight of plant parts were found. It is thus possible to estimate the total dry biomass by using independent characters viz., canopy, stem girth, and height using regression equations:

$$y = -8.41 + 0.47 x_1 + 0.26 x_2 + 2.69 x_3 \quad (R^2 = 0.92)$$

where x_1 is canopy area (cm^2), x_2 stem girth (cm) and x_3 stem height (m).

Yield components: The increments in growth parameters at prebearing age will influence the yields. Once the stem area is fixed, it is difficult to enhance further productivity in cocoa. This is seen in the lack of correlations between stem height, girth or canopy area to yield at later stages of growth. However, there was significant correlations of yield with growth parameters at prebearing phase.

Harvest index and related characters in cocoa accessions:

Harvest index (HI) and 12 other growth parameters were studied in 24 accessions of cocoa and correlated. The HI ranged from 0.02 to 0.19 with accessions NC 31, Amel x Na 33, Landas 364, Amel x PA7 and Landas 357 having higher values. The accessions had high biomass, yield and canopy photosynthesis (P_N). HI was significantly correlated with canopy P_N ($r = 0.46$), no. of branches ($r = 0.44$), bean dry weight ($r = 0.81$), and biomass ($r = 0.29$). Yield was similarly correlated with plant biomass ($r = 0.71$) and no. of pod bearing branches ($r = 0.66$).

A stepwise regression analysis for HI and no. of pods with other selected characters were attempted. The maximum contribution for HI was by dry bean weight ($y = 0.032 + 0.021 \text{ BDW}$; $r^2 = 0.66$) and leaf area ($y = 0.1014 + 0.0365 \text{ BDW} - 0.0006 \text{ LA}$; $r^2 = 0.90$). The no. of pods had an r^2 value of 0.81 ($y = 9.03 + 29.008 \text{ BDW}$) with bean dry weight. The P_N did not show significant differences among accessions. However, canopy P_N was higher in high yield groups. Yield was correlated with canopy P_N ($y = 16.97 + 28.715 \text{ BDW} + 0.032 \text{ CPN} - 29.03 \text{ WUE}$; $r^2 = 0.84$).

Effect of spacing treatments: The net P_N , canopy/leaf areas and potential canopy P_N were studied in cocoa growth under arecanut palms at 6 planting densities. The microclimatic variables, P_N , stomatal conductance and transpiration rate did not show significant treatment effects. As light was equal or more than the saturating levels, P_N of leaves were not affected. However, canopy/leaf areas and canopy P_N were significantly higher in wider spaced cocoa trees. LAI did not differ significantly between treatments which was in the range of 7.1 to 9.8. Thus, variation in leaf area and whole plant photosynthetic potential are powerful determinants of productivity in cocoa.

Pruning trial in cocoa: Five canopy shapes were maintained viz., single storey (T_1), double storey (T_2), pruned to cone shape (T_3), severe pruning (T_4) and flat pruned canopy (T_5). The growth, photosynthetic characteristics and yield data were collected. Due to pruning the no. of branches and canopy area were significantly reduced. The light interception efficiency with high incident PAR was observed in these treatments. The stomatal conductance and T_r were enhanced in T_4 and T_5 resulting in decreased WUE. P_N did not show significant variations between treatments. Yield was highest in T_1 in 1989 and 1990 followed by T_2 . Because of predominance of leaf area and canopy P_N , optimum canopy area maintenance helps in increasing productivity.

P_N and related parameters were examined in leaves of cocoa in these treatments to determine the extent to which these parameters respond to light transients during sunflecks. The time course study of P_N in habitually sun and shade leaves when transferred to either shade or sun conditions revealed that P_N was affected within 10-20 seconds to varying light regimes. This shows that the P_N was highly adaptive to the shade conditions and intermittent light flecks in canopy improve the photosynthetic efficiency.

The pattern of P_N effect was similar in four treatments (T_1 to T_4) to varying light regimes. However, the P_N was lower with increased PAR which may be due to photoinhibition of leaves, as the canopy is exposed in T_5 . The response of T_r , was similar to P_N . On the contrary stomatal conductance did not respond rapidly parallel with P_N or T_r . Thus the changes seen in P_N and T_r are not attributable to conductance changes, and may be because of light responses of photochemical reaction centres.

14. Publications

- (1) Rajagopal, Ramadasan,A., Kasturi Bai,K.V., & Balasimha,D., 1989. Influence of irrigation on leaf water relations and dry matter production in coconut palms. Irrigation Sci. 10: 73-81.
- (2) Balasimha,D. & Nair,B.P. 1989. Biomass estimation of cocoa plant by regression analysis. J.Plant.Crops. 17: 57-58.
- (3) Balasimha,D.1988. Water relations, growth and other indicators of plant water stress in cocoa under drought. 10th Intn. Cocoa Res. Conf. pp.215-217.
- (4) Balasimha,D.1991. A whole plant structure : function model for cocoa. J.Plant. Crops 18(Suppl.): 65-71.
- (5) Balasimha,D. 1990. Net photosynthesis of cocoa grown under arecanut in mixed cropping system. PLACROSYM IX, 5-7 Dec.1991, Bangalore.
- (6) Vijayakumar,B.G., et.al., 1991. Influence of weather an arecanut and cocoa yield. J.Plant. Crops. 18(in press).
- (7) Kasturi Bai,K.V., Voleti,S.R., & Rajagopal,V. 1988. Water relations of coconut palm as influenced by environmental variables. Agric. Forest Meteorol. 43: 193-199.

.....

13. Approximate expenditure incurred in the Project: (Give reasons for variation, if any, from original estimated cost)

14. Publications and material (one copy each to be supplied with this proforma)

- a) Research papers **Annexure attached**
- b) Popular articles
- c) Reports
- d) Seminars and workshops (Relevant to the Project) in which the Scientists have participated:

- e) Material developed (such as new varieties of crops or breeds of farm animals, implements, products, etc.)

15. Details (Nos. etc.) of Field/Laboratory Note books and final material and their location

Plant Physiology Sections

-
16. Comments/suggestions of Project Leader regarding possible future line of work that may be taken up arising of this project:

The studies on the effect of drought stress on growth and development and water relations of cocoa and coconut has given an understanding of the relative responses of various components. Future work should concentrate on the threshold levels of these physiological/biochemical parameters to levels of irrigation in order to minimise the water use for optimum yield potential.

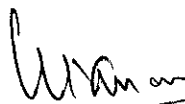
-
17. Signatures with name of Project Leader and Associates:

V. Rajagopal	V. Rajagopal
D. Balasubrah	D. Balasubrah
K. V. Kasturibai	K. V. Kasturibai

-
18. Signature (with comments, if any) of Head of Division/Section/Station:

V. Rajagopal

-
19. Signature (with comments, if any) of Director:



Director

CENTRAL PLANTATION CROPS RESEARCH INSTITUTE
P. O. KUJLU, KASARAGOD 670124
