

THE INFLUENCE OF DRIP IRRIGATION AND FERTILIZER LEVELS ON YIELD AND PHOTOSYNTHETIC CHARACTERISTICS OF COCOA IN MIXED CROPPING SYSTEM WITH ARECANUT

A. ABDUL HARIS, D. BALASIMHA, S. SUJATHA, RAVI BHAT and
K. B. ABDUL KHADER

*Central Plantation Crops Research Institute
Regional Station, Vittal - 574 243, Karnataka.*

(Manuscript received : 13-07-98; revised : 24-04-98; accepted : 19-11-98)

ABSTRACT

A study was carried out to determine the influence of drip irrigation and fertilizer levels on the bean yield and photosynthetic characteristics of cocoa mixed cropped in arecanut. The trial was laid out in a split plot design with three irrigation levels as main plot and four fertilizer levels as sub-plot treatments. Four year data after yield stabilization revealed that drip irrigation @ 20 litres of water per tree per day and a fertilizer dose of 100 g N:40 g P₂O₅: 140 g K₂O per tree per year would be optimum for cocoa. This was also supported by better photosynthetic characteristics.

Key words: Drip irrigation, Fertilizer levels, Cocoa, Mixed cropping and Photosynthesis

INTRODUCTION

Cocoa is grown in coconut and arecanut plantations in Kerala and Karnataka with a view to generate additional income. Under the prevailing conditions in Dakshina Kannada district, monsoon season is followed by a prolonged dry period of six months (December-May) and invariably both arecanut and cocoa need to be irrigated during dry period. In arecanut, significant increase in yield (45 per cent) and water use efficiency (44 per cent) were noted with drip irrigation (Abdul Khader, 1983). Various methods of irrigation have been tried in cocoa earlier (Jadin *et al*, 1976; Khan *et al*, 1988). However, information on the nutritional and irrigation requirement of cocoa is not available, especially in areca and cocoa mixed cropping system. The purpose of the study is to evaluate the nutritional and irrigation

requirements of cocoa under drip and to examine the influence of irrigation and fertilizer levels on photosynthetic characteristics.

MATERIALS AND METHODS

A field experiment was started in a 27 year old areca garden planted at a distance of 2.7 m x 2.7 m. Cocoa (*Theobroma cacao* L.) seedlings were interplanted in the areca (*Areca catechu* L.) garden at 2.7 m x 5.4 m spacing in alternate rows. The experiment was laid out in a split plot design with five replications. Main plot treatments were three drip irrigation levels *viz.* 10 litre/day/tree (I₁), 20 litre/day/tree (I₂) and 30 litre/day/tree (I₃). Sub plot treatments consisted of four fertilizer levels *viz.* 0:0:0 (F₁), 50:20:70 (F₂), 100:40:140 (F₃) and 150:60:210 (F₄) grams of N:P₂O₅:K₂O per tree per year, respectively. The soil of the

experimental site is a well drained sandy clay loam with slightly acidic pH.

Irrigation was given through drippers during December-May. The I₁ treatment had two emitters of 2 lph discharge. In I₂ treatment two emitters of 2 lph and one emitter of 4 lph discharge were used while I₃ had three emitters of 4 lph discharge. Urea, rock phosphate and muriate of potash as N, P and K sources, respectively were applied in two split doses (1/3rd in June and 2/3rd in October). Pruning was done every year in July-August and pruned biomass was recorded. Plant girth was recorded at a height of 25 cm from ground level. Canopy area was measured as described by Balasimha and Nair(1989).

Stomatal resistance (r_s), transpiration (E) and Net photosynthesis (Pn) were measured in the leaves of one cocoa tree per treatment using LI-6200 portable photosynthesis system (Li-cor Inc., Nebraska USA). Microclimatic parameters *viz.* light (PAR), vapour pressure deficit (VPD), air temperature (T air) and relative humidity (RH) were also recorded. In each case, fully expanded healthy third or fourth leaf

from the distal portion of most recently hardened flush (about one month old) was used. Six measurements were taken in each tree around the canopy. Leaf water potential(ψ) was measured with Scholander pressure chamber. These studies were conducted during 1993-97 for cocoa after yield stabilization. The data were analysed statistically using MSTAT C package.

RESULTS AND DISCUSSION

Girth of cocoa plants

Different irrigation levels had significant influence on the girth of main stem of cocoa during the first year of experimentation with I₂ level recording maximum girth (Table 1). Among the fertilizer levels, F₃ level recorded significantly higher girth compared to F₁ and F₂. However, during the 8th year fertilizer levels had shown significant influence on girth. There was significant increase in girth with all fertilizer levels over F₁ and it was maximum at F₃ level (5.09 cm/year). Among the irrigation levels, girth increment between first and eighth year of experimentation was maximum with I₂ level (5.01 cm/year).

Table 1. Plant girth (cm), canopy area and pruned biomass as influenced by irrigation and fertilizer levels in cocoa

Treatment	Plant girth		Canopy area (m ² /plant)	Pruned biomass (kg/plant)
	1989-90	1996-97		
Irrigation levels				
I ₁	6.25	38.6	18.15	8.48
I ₂	6.62	42.1	20.24	8.49
I ₃	6.49	40.1	19.81	7.65
CD (5%)	0.31	NS	NS	NS
Fertilizer levels				
F ₁	6.35	37.3	18.48	6.97
F ₂	6.24	40.7	19.38	7.70
F ₃	6.69	42.3	19.65	8.98
F ₄	6.53	40.7	20.08	9.17
CD (5%)	0.27	2.55	NS	1.89

Canopy area and pruned biomass

Differences in canopy area recorded during 8th year was non significant with respect to both irrigation and fertilizer levels (Table 1). Pruned biomass recycled did not differ significantly with irrigation levels. However among the fertilizer levels, F₃ and F₄ levels recorded significantly higher biomass over F₁ level. F₄ level recorded maximum biomass of 9.17 kg/tree. This may be due to the fact that more fertilizers especially nitrogenous fertilizers promoting more vegetative growth.

Photosynthetic parameters

Increase in irrigation level increased both net photosynthesis (Pn) and transpiration (E) (Table 2). Stomatal resistance was higher at lower level of irrigation (I₁). Similarly, increase in fertilizer dose increased Pn and E upto F₃ level and decreased stomatal resistance. Maximum Pn was recorded in F₃ level in cocoa. This may be due to favourable influence of nutrients especially potassium (Mengel, 1985). Linder and Rook (1984) also reported decreased rate of photosynthesis in tree crops when K is

Table 2. Photosynthetic parameters in cocoa (Pooled data of 1993-97)

Treatment	Pn ($\mu\text{mol}/\text{CO}_2/\text{m}^2/\text{s}$)	E ($\text{mmol}/\text{m}^2/\text{s}$)	r _s (s/cm)	WP (Mpa)
Irrigation levels				
I ₁	3.433	2.908	4.547	-1.01
I ₂	3.790	3.583	3.152	-0.97
I ₃	4.012	3.955	2.931	-0.95
CD (5%)	0.203	0.285	0.340	0.04
Fertilizer levels				
F ₁	3.299	3.405	3.729	-0.99
F ₂	3.846	3.553	3.507	-0.96
F ₃	4.062	3.612	3.349	-0.97
F ₄	3.772	3.358	3.587	-0.98
CD (5%)	0.264	NS	NS	NS

* Microclimatic parameters : PAR-622.4 $\mu\text{mol}/\text{m}^2/\text{s}$
Air temperature - 34.38°C
Relative humidity - 48.61%

Table 3. Chlorophyll fluorescence indices in cocoa (pooled data of 1993-95)

Treatment	F0	Fm	Fv	Fv/Fm
Irrigation level				
I ₁	664	2369	1709	0.712
I ₂	629	2394	1767	0.728
I ₃	642	2466	1822	0.733
CD (5%)	24.9	NS	NS	NS
Fertilizer levels				
F ₁	667	2328	1648	0.702
F ₂	640	2433	1793	0.729
F ₃	639	2467	1829	0.735
F ₄	625	2412	1795	0.732
CD (5%)	27.7	96.4	102.1	0.015

limiting. The chlorophyll fluorescence indices indicated that the photosystems were affected at F_1 level (Table 3). Higher values of F_0 , F_m , and F_v were recorded in I_3 and F_3 treatments indicating higher photosynthetic efficiency. Similarly the ratio F_v/F_m which indicates photosystem II activity showed higher in F_3 level.

Stomata normally close in response to reduced soil moisture and increased VPD, (Jarvis, 1980; Kasturi Bai *et al*, 1988; Balasimha and Rajagopal 1988). Similar results on soil water deficits and water relations have been reported in relation to different frequencies of irrigation in coconut (Rajagopal *et al*, 1989). It is evident from the data that due to the higher rs, Pn was reduced in cocoa which ultimately reflected in decreased yield.

Dry bean yield (kg/ha) of cocoa during 1993-94 to 1996-97.

Among irrigation levels, yield differences were significant in 1994-95 and 1995-96 (Table 4). Dry bean yield was maximum with I_2 level in all the years except in 1996-97. This suggests that about 20 litres of water per day per tree through drip irrigation would be sufficient for cocoa in realizing higher

yields. Though there was an increasing trend in yield with higher doses up to F_3 level, differences were non significant among fertilizer levels in all the years.

Pooled yield data (1993-1997)

Yield data averaged over four years indicated that both irrigation and fertilizer levels influenced the bean yield significantly (Table 4). Higher bean yield was noted with I_2 level (876 kg/ha). The increase in yield with I_2 and I_3 levels over I_1 was 26 per cent and 21 per cent, respectively. There was no significant yield difference between I_2 and I_3 levels. Among the fertilizer levels F_3 level recorded 13.5 per cent higher dry bean yield over F_1 . However, yield variation among F_2 , F_3 and F_4 levels was not-significant.

Irrigation and Fertilizer interaction on yield

Pooled data over four years recorded significant interaction due to irrigation and fertilizer levels (Fig. 1). At I_1 level, there was no significant yield difference among the fertilizer levels. In contrast, the $I_2 F_3$ combination was significantly superior over other combinations recording maximum yield (1002 kg dry bean per ha). This is also

Table 4. Dry bean yield of cocoa (kg/ha) over different years

Treatment	1993-94	1994-95	1995-96	1996-97	Pooled yield of four years (1993-97)
Irrigation levels					
I_1	729	764	650	632	694
I_2	912	984	910	696	876
I_3	854	917	880	705	839
CD (5%)	NS	167	179	NS	91
Fertilizer levels					
F_1	771	824	759	653	752
F_2	826	850	823	684	796
F_3	887	951	879	697	853
F_4	842	929	791	677	810
CD (5%)	NS	NS	NS	NS	68

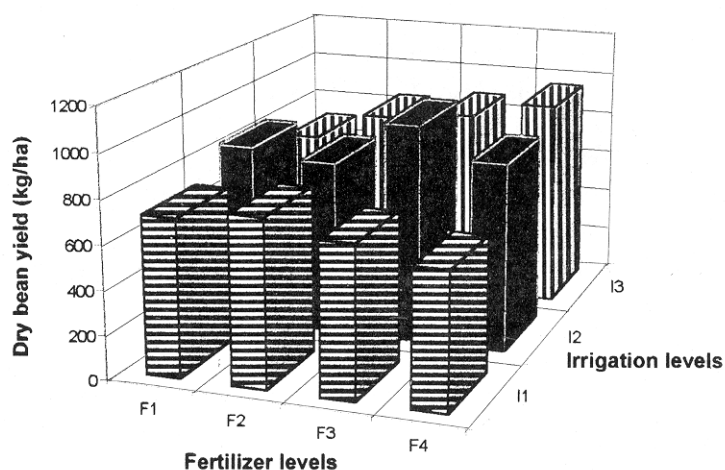


Fig. 1. Interaction effect of irrigation and fertilizer levels on cocoa yield.

supported by measured net photosynthesis which was maximum in F_3 level. Other physiological parameters such as higher chlorophyll fluorescence values also support better performance of plants at F_3 level of fertilizer application.

Thus in the light of above observations, it can be concluded that the $I_2 F_3$ treatment combination of 20 litres of water per day per tree and 100:40:140 g N, P_2O_5 , K_2O per tree per year is optimum for cocoa plants under South Kanara conditions.

REFERENCES

- ABDUL KHADER, K.B., 1983. Effect of depth of irrigation based on cumulative pan evaporation, mulching and drip irrigation with fertilizer levels on growth and yield of arecanut. Ph.D Thesis, UAS, Bangalore, pp. 325.
- BALASIMHA, D. and RAJA GOPAL, V. 1998. *Indian J. Agric. Sci.* **58**: 213-216.
- BALASIMHA, D. and NAIR, B.P., 1989. *J. Plantn Crops* **17**: 57-59.
- JADIN, P., CHANCHARD, A and BOIS, J.F., 1976. *The Cafe Cacao*. **20**: 173-200.
- JARVIS, P.G., 1980. Adaptation of Plants to Water and High Temperature Stresses (Eds) Turner N.C. and Kramer P.J., Wiley, New York, pp. 105-122.
- KASTURIBAI, K. V., VOLETI, S.R. and RAJAGOPAL, V., 1988. *Agric. Forest Meteorol.* **43**: 193-199.
- KHAN M.N., PATTERSON, G.R. and MATLICK, B.K., 1988. *Proc. of 10th International Cocoa Conf.* Santo Domingo, pp. 185-191.
- LINDER, S and ROOK, D.A., 1984. In: Nutrition of Plantation Forest. (Eds.) G.D. Bowen and E.K.S. Nambiar, pp. 211-226.
- MENGEL, K., 1985. Potassium in agriculture Ed. (C.D. Munson). *Proc. International Symposia.* Atlanta Georgia USA, pp. 397-409.
- RAJAGOPAL, V., RAMADASAN, A., KASTURIBAI, K.V. and BALASIMHA, D., 1989. *Irrig. Sci.* **10**: 73-81.