Indian Journal of Agricultural Sciences **58** (3) : 213–6, March 1988

Stomatal responses of cocoa (*Theobroma cacao*) to climatic factors

D. BALASIMHA[1] and V. RAJAGOPAL[2]

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

Received : 6 August 1987

ABSTRACT

The stomatal response of cocoa (*Theobroma cacao* Linn.) leaves to ambient humidity, light and temperature was studied under low and high soil-moisture regimes. The stomatal diffusion resistance increased with decrease in relative humidity, which was magnified by soil-moisture stress. However, the effects of light and temperature were not so pronounced as that of humidity. Stomatal regulation by internal (stress) and external factors (humidity) led to a decrease in transpiration rate, which was a major strategy for water conservation in cocoa plants.

An increase in evaporative demand was owing to lowered humidity, which changes the stomatal resistance (Lange *et al.*, 1971). Both light and temperature also influence the stomatal response (Raschke, 1970; Burrows and Milthorpe, 1976). There are limited studies on such relationships in plantation crops (Squire, 1978; Kasturibai *et al.*, 1987). The stomatal response may be complex due to the interaction between the environmental factors and soil-moisture status. This experiment was undertaken to study stomatal responses to major climatic variables in field-grown trees of cocoa (*Theobroma cacao* Linn.) under different soil-water conditions.

MATERIALS AND METHODS

The material and methodology described by Balasimha *et al.* (1987) was followed. The experiment was conducted on 12-year-old, field-grown cocoa trees during April–May 1984, 1985 and 1986. Climatic variables were measured under well-watered and stress situations between 10.00 hr and 12.00 hr (Table 1). The mean soil-moisture content was 19.1% in high and 12.9% in low moisture situations at 0–100 cm soil depth. The relative humidity was below 55% (low) and 55–75% (high). The climatic variables, leaf temperature, stomatal diffusive resistance and transpiration rates were measured, using LI-COR 1600 steady state porometer (Lambda Instruments, USA). Leaf-water potential was determined by Scholander's pressure chamber (Soil Moisture Equipments Corporation, USA). From all directions of outer canopy 5–10 leaves were measured and 5 measurements were taken for each leaf. The data were statistically analysed.

RESULTS AND DISCUSSION

The stomatal diffusion resistance of cocoa was higher under low relative humidity (6.92 sec/cm) than at high relative humidity (3.70 sec/cm), which was further magnified by soil-moisture stress (8.78 sec/cm; Fig. 1). But the transpiration rate was 2.93 $\mu g/cm^2$ under low relative humidity, 3.06 $\mu g/cm^2$ under high relative humidity and 2.77 $\mu g/cm^2$ under low humidity and moisture stress (Fig. 1). Thus the water balance was protected under dry climate, as shown by high stomatal resistance and low transpiration rate in the leaves. Our results confirm those on excised tissues

[1]Scientist S-2; [2]Scientist S-2, Central Plantation Crops Research Institute, Kasaragod, Kerala 670 124

Table 1. Changes in climatic variables during the experimental period

Time (hr)	Ambient temperature (°C)		Photosynthetically active radiation (μE/sec/m)		Relative humidity (%)	
	High*	Low	High	Low	High	Low
10.00	30.2	33.4	1,183	1,255	62.6	53.0
10.30	30.7	34.8	1,466	1,400	57.7	46.7
11.00	32.1	35.4	1,563	1,490	47.9	44.3
11.30	33.6	36.1	1,625	1,505	44.8	40.1
12.00	35.7	36.1	1,610	1,511	40.8	39.8

*High and low soil-moisture conditions

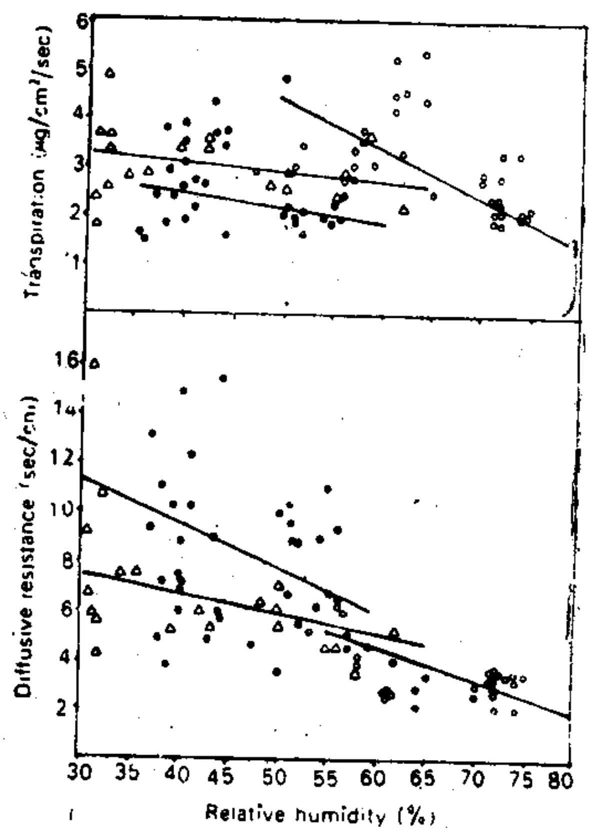

Fig. 1. Relationship between relative humidity with stomatal diffusion resistance and transpiration rate. Symbols represent readings at following conditions : low photosynthetically active radiation (PAR), high humidity and high soil moisture (○); high PAR, low humidity and low soil moisture (●); high PAR, low humidity and high soil moisture (Δ)

and other intact plant species (Lange *et al.*, 1971; Schulze *et al.*, 1972; Aston, 1976; Kasturibai *et al.*, 1987). But these are contrary to those of Kaufmann and Levy (1976) on *Citrus* spp., who did not find such response of relative humidity. Under high humidity and soil moisture, the leaf-water status was maintained at higher levels (Fig. 2).

Stomata of intact leaves generally open in response to increase in photosynthetically active radiation (PAR) (Burrows and Milthorpe, 1976). In cocoa leaves, however, the effects of humidity and soil-moisture stress decreased the effect of light (Fig. 3). It indicates that

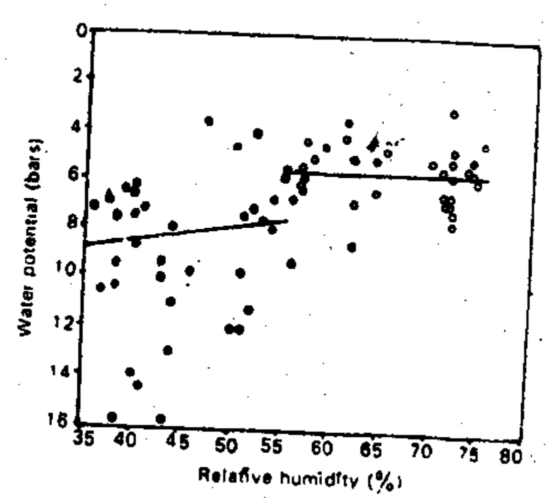

Fig. 2. Relationship between leaf water potential and relative humidity (symbols same as in Fig. 1)

Table 2. Correlation coefficients among the climatic and plant variables

		Transpiration	Stomatal resistance	Relative humidity
Photosynthetically active radiation	1	0.52**	0.55**	—0.81**
	2	0.04	0.54*	—0.70**
	3	0.12	—0.21	—0.25
Relative humidity	1	—0.52**	—0.65**	
	2	—0.18	—0.58**	
	3	—0.24	—0.16	
Stomatal resistance	1	—0.19		
	2	—0.58**		
	3	- 0.82**		

*P = 0.05; **P = 0.01
The serial numbers represent high relative humidity and high soil moisture (1) low relative humidity and high soil moisture (2); low relative humidity and low soil-moisture conditions respectively

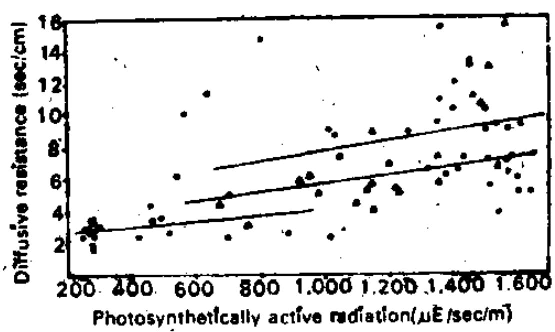

Fig. 3. Relationship between photosynthetically active radiation and stomatal diffusion resistance (symbols same as in Fig .1)

light does not have stronger influence than relative humidity. The correlation coefficients among various environmental factors and plant responses indicate that ambient temperature did not influence stomatal responses in cocoa, but showed a high significant positive correlation (0.90**) with leaf temperature (Table 2).

Among relative humidity, light and temperature, relative humidity plays a significant role in controlling stomatal movement. The stomatal response to atmospheric or soil drought reduces transpiration rate, and thus delays the development of water stress in the leaves.

ACKNOWLEDGEMENT

We thank Mr B. P. Nair for statistical analysis.

REFERENCES

Aston, M. J. 1976. Variation of stomatal diffusive resistance with ambient humidity in sunflower (*Helianthus annuus*). *Australian Journal of Plant Physiology* **3** : 489–501.

Balasimha, D., Rajagopal, V., Daniel, E. V., Nair, R. V. and Bhagavan, S. 1987. Comparative drought tolerance of cocoa accessions. *Tropical Agriculture* **64** (*in press*).

Burrows, F. J. and Milthorpe, F. L. 1976. Stomatal conductance in the control of gas exchange. *Water Deficits and Plant Growth*, vol. 47, pp. 103–52. Kozlowski, T. T. (Ed.) Academic Press, New York.

Kasturibai, K. V., Voleti, S. R. and Rajagopal, V. 1987. 'Impact of agrometeorological parameters on stress development in coconut.' Paper presented at the National Seminar on Agrometeorology of Plantation Crops, held on 12–13 March 1987 at Pilicode.

Kaufmann, M. R. and Levy, Y. 1976. Stomatal response of *Citrus jambhiri* to water stress and humidity. *Physiologia plantarum* **38** : 105–8.

Lange, O. L., Losch, R., Schulze, E. D. and Kappen, L. 1971. Responses of stomata to changes in humidity. *Planta, Berlin* **100** : 76–86.

Ludlow, M. M. 1980. Adaptive significance of stomatal responses to water stress. *Adaptation of Plants to Water and High Temperature Stress*, pp. 123–38. Turner, N. C. and Kramer, P. J. (Eds). Wiley-Interscience, New York.

Raschke, K. 1970. Temperature dependence of carbon dioxide assimilation and stomatal aperture in leaf sections of *Zea mays*. *Planta, Berlin* **91** : 336–63.

Schulze, E. D., Lange, O. L., Buschbom, U., Kappen, L. and Evenari, M. 1972. Stomatal responses to changes in humidity in plants growing in the desert. *Planta, Berlin* **108** : 259–70.

Squire, G. R. 1978. Stomatal behaviour of tea (*Camellia sinensis*) in relation to environment. *Journal of Applied Ecology* **15** : 287–301.

Indian Journal of Agricultural Sciences **58** (3) : 216–8, March 1988

Assessment of incidence and crop loss due to pod-borers of pigeonpea (*Cajanus cajan*) of different maturity groups

C. P. YADAVA[1], S. S. LAL[2] and J. N. SACHAN[3]

Directorate of Pulses Research (ICAR), Kalyanpur, Kanpur, Uttar Pradesh 208 024

Received : 31 December 1986

ABSTRACT

A 2-year experiment was conducted on 4 varieties ('H 77-216', extra early; 'UPAS 120', early; 'Bahar', medium late; and 'T 7' late) of pigeonpea [*Cajanus cajan* (Linn.) Millsp.] of different maturity groups. The pest complex infesting reproductive stage of the crop and losses caused by pod-borers individually and jointly were studied. The pest complex infesting early-maturing varieties was different from that infesting late-maturing ones. *Mylabris phalerata* Pallas, *Cydia critica* Meyrick and *Maruca testulalis* Geyer were the more common species on early varieties, whereas *Heliothis armigera* Hubner and *Lampides boeticus* Linn. on the late varieties. *Melanagromyza obtusa* Malloch and *Clavigralla gibbosa* Spinola were common on both early-('H 77-216' and 'UPAS 120') and late-maturing varieties. Among the late varieties, 'Bahar' showed almost negligible damage but 'T 7' showed significant damage due to *H. armigera*. This was mainly due to escape of peak activity of the borer. Grain damage (%) due to pod-borers was significantly influenced by varieties, borer species and variety × insect interaction. The grain damage (%) was low in early varieties (13.0% in 'H 77-216' and 13.6% in 'UPAS 120') compared with late varieties (26.7% in 'Bahar' and 34.8% in 'T 7').

Pigeonpea [*Cajanus cajan* (Linn.) Millsp.] is attacked by a wide variety of insect pests (Davies and Lateef, 1975; Lal *et al.*, 1980). but the complex of insects feeding on and in the pods causes the maximum loss. This study was taken up to determine the incidence of pest complexes infesting reproductive stage and losses caused by pod-borer complex in 4 varieties of pigeonpea of different maturity groups.

[1]Scientist S-2; [2]Scientist S-3; [3]Scientist S-4 and Principal Investigator