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Influence of environmental variables on canopy- air temperature in castor beans (*Ricinus communis* L.) under low and high moisture regimes

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ABSTRACT

Field experiments on rainfed castor beans *(Ricinus communis L.)* were conducted for two years to study the influence of weather and soil parameters on canopy temperature (Tc) stress degree days (SDD) under contrasting high (> 50 mm) and low (<50 mm) soil moisture conditions.

A positive influence of air temperature on Tc and a negative influence on SDD were found to be more significant under high soil moisture conditions than under low moisture. The saturated vapour pressure deficit also showed significant relationship with SDD under high moisture conditions. Combined influence of air temperature, saturated vapour pressure deficit and plant extractable soil water on either Tc or SDD is also more significant under high soil moisture conditions.

Keywords: Canopy temperature; stress degree days; plant extractable soil water; castor beans.

Crops grown under rainfed conditions in semi-arid regions often experience moisture stress due to erratic distribution of rainfall. Monitoring of soil water status, therefore, is an essential component of rainfed farming studies. Remote sensing tools like infrared thermometers and spectral radiometers, which are easy to handle and less time consuming serve the purpose of monitoring crop water stress more effectively than the traditional practice of stress monitoring using soil moisture estimated by gravimetric method.

Ever since the use of canopy temperature as an indicator of plant water status, efforts have been made to understand the influence of meteorological parameters on canopy temperature. The influence of radiation (Idso, 1982; Feldhake and Edwards 1992), vapour pressure deficit (Carlson *et al,* 1972; Ehrler, 1973; Wanjura and Upchurch, 1997; Kushu *et al,* 1991) and wind (O'Toole and Hatfield. 1983) on canopy temperature have been reported in literature. Most of these studies were confined to crops in the extra tropical regions. As the canopy temperature gives a measure of plant's response to its environment, an experiment, was carried out to assess the influence of weather parameters on canopy temperature measurements in rainfed castor grown in the semi-arid tropical region of Hyderabad.

MATERIALS AND METHODS

Field experiments on castor beans (var. Aruna) were conducted at Hayatnagar Research Farm of the Central Research Institute for Dryland Agriculture, Hyderabad, in the years 1992 and 1993. The crop was planted on three different dates, spaced at intervals of 3 weeks so as to expose the crop to different environments. The three dates of sowing were June 22, July 14 and August 05 in year 1992 and July 02, July 28 and August 20 in year 1993 and treatments were replicated four times in randomised block design. The experiment was laid on alfisols with limited topsoil depth and water holding capacity. The climate of the experimental site is semi-arid with mean annual rainfall and potential evapotranspiration of 767 mm and 1754 mm, respectively.

The crop was raised, adopting the recommended package of practices like optimum plant density (70,000 plants ha^{-1}), recommended fertiliser dose (50 kg N and 30 kg P ha^{-1}), etc. Crop was planted in rows against the slope for conserving moisture and arresting soil erosion. Seeds were hand dribbled at an intra-row spacing of 25 cm in rows of 60 cm width. Fertiliser was applied in two splits, one as basal and another as top dressing. Intensive interculture and plant protection measures were also followed.

Canopy temperatures (T_c) were measured around mid-day period (1200-1230 hrs IST) with the help of Telatemp AG-42 infrared thermometer on selected days at an interval of 7 to 10 days Canopy temperature and CATD, the canopy air temperature differentials (T_c-T_a) were recorded viewing the canopy at an angle of 30° from the horizontal from five randomly selected spots, preferably from four corners and centre of the plot (size 20 x 7.5 m), to avoid orientation bias. These measurements were initiated after the canopy is fully developed, so as to avoid the infrared emissions from soil background. Stress degree day was calculated as the difference between canopy and air temperatures.

Plant extractable soil water (PESW) of the cropped field on the dat

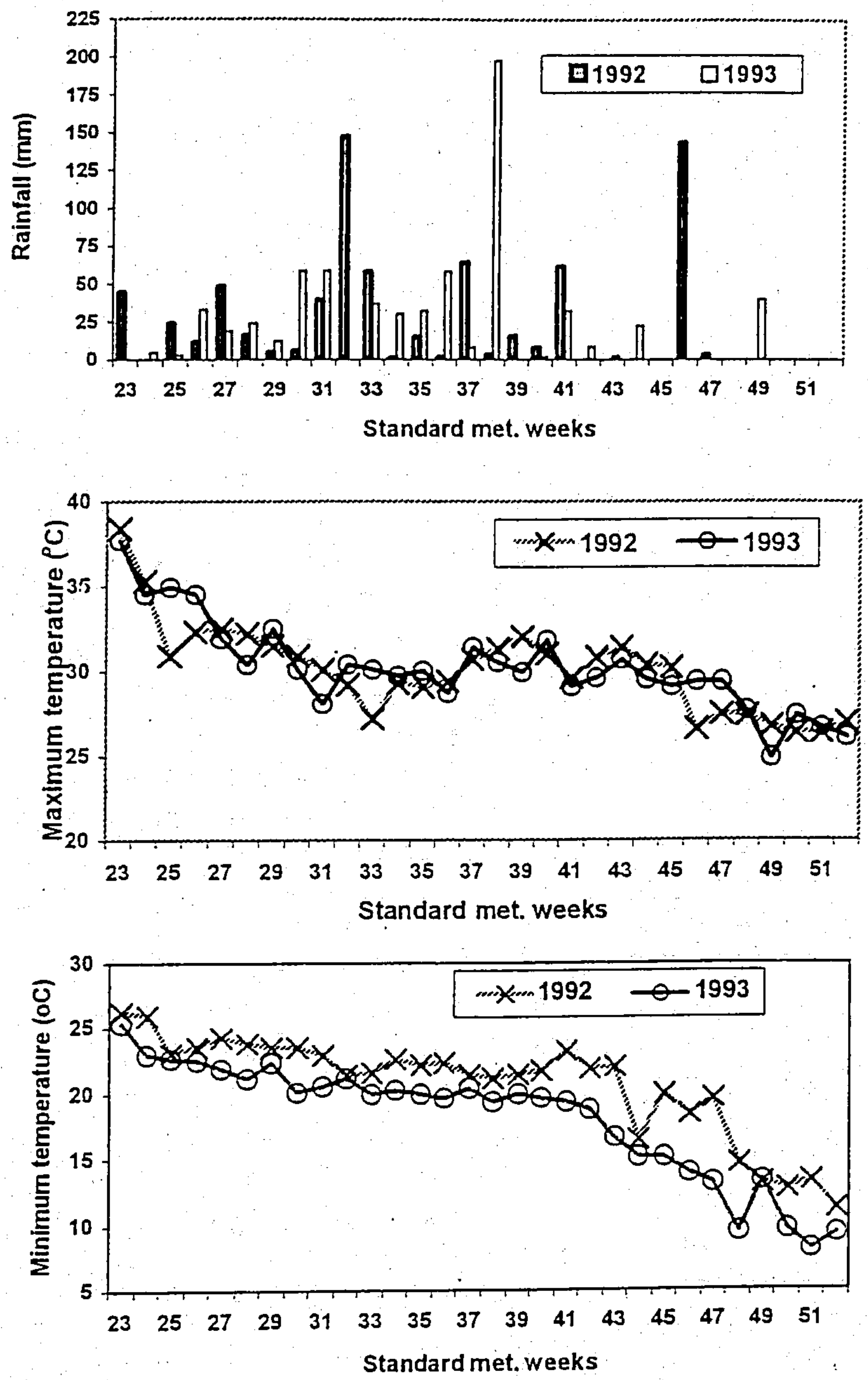

Fig.1.: Weekly march of rainfall, maximum and minimum temperature at Hayatnagar Reseach Farm during the crop growing period in years 1992 and 1993.

of recording of canopy temperature was obtained as output from the Ritchie's single layer water balance model (Ritchie, 1972). PESW for the profile is estimated based on the difference between total soil water (TSW) and the amount of water in the profile when the profile is at the lower limit (LL) of plant extractable water, i.e. permanent wilting point (PWP). PWP and field capacity for the experimental soils were considered as 45 and 145 mm, respectively per 1 m of the profile. The weather data required for running the model were collected from the automatic weather station located at the research farm. The leaf area indices were calculated by taking plant samples periodically in the crop.

The days on which the PESW in the field was more than 50mm/ 60 cm of profile were treated 'as high moisture condition' and *vice versa*. In this study the canopy temperature and stress degree days under high moisture conditions were separated from those under low moisture conditions for quantifying their relative responses to weather conditions. The canopy temperature and stress degrees of the crop for the two situations were separately regressed with the weather parameters.

RESULTS AND DISCUSSION

Weekly march of rainfall, maximum and minimum temperature at the research farm for the years of 1992 and 1993 are presented in Fig. 1. Annual rainfall of 766 and 755 mm were received in years 1992 and 1993, respectively. As canopy temperature is not the outcome of a single factor but a resultant of complex combination of plant, meteorological and soil factors, it is necessary to study the influence of these parameters on canopy temperature both individually and in combination.

Influence on canopy temperature:

The relations between canopy temperature and weather parameters are figured in Table 1.

Ambient air temperature positively influenced the canopy temperature under both high and low moisture conditions which is in agreement with the observations of Ehrler (1973); Jackson (1982) and Sagar *et al* (1988).

The combined effect of plant extractable soil water (PESW), air temperature and saturated vapour pressure deficit on canopy temperature is highly significant under both the high and low soil moisture conditions and also in both the years. The combination of these three factors also showed higher influence on canopy temperature under high soil moisture conditions than under low soil moisture conditions in both th

Table 1. : Effect of weather parameters on canopy temperature and stress degree days under high and low soil moisture conditions

Year	High soil moisture conditions			Low soil moisture conditions		
	Equations	R^2	F value	Equation	R^2	F value
a. Canopy temperature						
1992	$8.2 + 0.003 X_1 + 0.7 X_2 - 4.1 X_3$ (0.1) (89.9) (10.0)	0.88	30.2**	$11.9 - 0.08 X_1 + 0.6 X_2 - 0.6 X_3$ (22.4) (64.6) (13.0)	0.74	7.4**
1993	$11.8 - 0.03 X_1 + 0.7 X_2 - 1.9 X_3$ (38.3) (51.8) (9.9)	0.79	15.9**	$5.9 - 0.06 X_1 + 0.8 X_2 - 1.3 X3$ (0.0) (99.1) (0.9)	0.77	7.8**
b. Stress degree days						
1992	$8.2 + 0.003 X_1 - 0.3 X_2 - 4.1 X_3$ (0.2) (81.1) (18.8)	0.80	15.8**	$11.9 - 0.08 X_1 - 0.4 X_2 - 0.6 X_3$ (46.2) (27.1) (26.7)	0.58	3.6
1993	$11.8 - 0.03 X_1 - 0.3 X_2 - 1.9 X_3$ (0.8) (66.6) (32.6)	0.53	4.8*	$5.9 - 0.06 X_1 - 0.2 X_2 - 1.3 X_3$ (72.8) (25.0) (2.2)	0.58	3.2

* and ** indicate significance at 5% and 1% probability
Figures in parentheses are percentage influence of respectively variables

where X_1, X_2 and X_3 are plant extrable soil water, air temperature and saturated vapaer presure deficit respectively.

years 1992 and 1993. These three parameters explained 79-88% in canopy temperature under high moisture condition and 74 to 77% variation under low moisture condition. In Hatfield *et al.* (1984) also canopy temperature was influenced more by meteorological parameters, under irrigated conditions.

Influence on stress degree days

Air temperature, PESW and SVPD negatively were related to the stress degree days under both high and low moisture regimes in years 1992 and 1993 (Table 1), similar to the observations made by Idso *et al.* (1981).

The combined effect of SVPD, PESW and air temperature, in regression equations for predicting stress degree days, was significant under high soil moisture conditions in both years but was nonsignificant under low moisture conditions. The R^2 values were between 0.53 to 0.80 under high moisture condition and 0.58 under law moisture condition. Martin *et al.* (1994) also showed higher significance in the relationship between stress degree days and multiple (more than one) weather variables when compared to the relationship between stress degree days and any single variable.

CONCLUSIONS

Under high soil moisture conditions, temperature can significantly explain the variability in both canopy temperature and stress degree days whereas under low soil moisture conditions PEWS and air temperature significantly influence both canopy temperature and stress degree days.

REFERENCES

Carlson, R.E., Yarger, D.N. and Shaw, R.H. 1972. Environmental influences on the leaf temperatures of two soybean varieties grown under controlled irrigation. *Agron. J.*, 64: 224 – 229.

Ehrler, W.L. 1973. Cotton leaf temperature as related to soil water depletion and meteorological factors. *Agron, J.*, 75: 805 – 810.

Ehrler, W.L., Idso, S.B., Jackson, R.D. and Reginato, R.J. 1978. Wheat canopy temperatures: Relation to plant water potential. *Agron J.*, 70: 251 – 256.

Hatfield, J.L., Vauclin, M., Vieira, S.R. and Bernad, R. 1984. Surface temperature variability patterns within irrigated fields. *Agric. Water. Manage., 8:429-437.*

Idso, S.B. 1982. Non – water – stressed baselines: A key to measuring and interpreting plant water stress. *Agric. Meteorol.*, 27: 59 – 70.

Idso, S.B., Jackson, R.D., Pinter, Jr. P.J., Reginato, R.J. and Hatfield, J.L. 1981. Normalizing the stress–degree– day parameter for environmental variability. *Agric. Meteorol.*, 24: 45 – 55.

Kirkham, M.B., Johnson, D.E., Kanemasu, E.T. and Stone, L.R. 1983. Canopy temperature and growth of differentially irrigated alfalfa. *Agric. Meteorol.*, 29: 235 – 246.

Khushu, M.K., Mavi, H.S. and Kachroo, D. 1991. Canopy temperature in rice (*Oryza sativa)* under different transplanting dates. *Indian J. Agron.*, 36: 243-245.

Martin, D.L., 1994. Models for predicting the lower limit of the canopy-air temperature different of two cool season grasses. *Crop Sci.*, 34: 192-198.

McKinney, N.V., Schapaugh, Jr. W.T. and Kanemasu, E.T. 1989. Canopy temperature, seed yield, and vapour pressure deficit relationships in soybean. *Crop Sci.*, 29: 1038 – 1041.

O' Toole, J.C. and Hatfield, J.L. 1983. Effect of wind on the crop water stress index derived by infrared thermometry. *Agron. J.*, 75: 811 – 817.

Olufayo, A., Baldy, C., Ruelle, P. and Konate, J. 1993. Diurnal course of canopy temperature and leaf water potential of sorghum under Mediterranean climate. *Agri. For Meteorol.*, 64: 223 – 236.

Ritchie, J.T. 1972. Model for predicting evaporation from a row crop with incomplete cover. *Water Resourc. Res.*, 8: 1204 – 1213.

Sagar, R.M. 1988. Estimation of corn canopy temperature and water budget using automated weather station data. M.Sc. Thesis, University of Nebraska, Lincoln, pp 91 – 95.

Stricevic, R. and Caki, E. 1997. Relationship between available soil water and indicators of plant water status of sweet sorghum to be applied in irrigation scheduling. *Irrig. Sci.*, 18: 17 – 21.

Tanner, C.B., 1963. Plant temperatures. *Agron. J.*, 55: 210 – 211.