SHORT COMMUNICATION

EFFECT OF WEATHER PARAMETERS ON PHOTOSYNTHESIS IN FOUR CASTOR BEAN GENOTYPES

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Field experiments on rainfed castor were conducted during two consecutive years to study the individual and combined effects of weather parameters, viz. vapour pressure deficit (VPD), light intensity (LI) and temperature on net photosynthetic rate (Pn). Response of net photosynthetic rate to low and high regimes of these weather parameters was also studied. The study indicated that Pn is positively correlated with LI and negatively with VPD. Predictability of net photosynthetic rate in all the genotypes increased many folds by considering the combined effect of light and vapour pressure deficit. Interactive effects of weather parameters on net photosynthetic rate showed that the adverse effect of higher vapour pressure deficit was more aggravated under either higher light intensity or temperature regimes than under lower light intensity or temperature regimes. The positive effect of LI on Pn was stronger under lower VPD and lower temperature conditions than under higher VPD and higher temperature conditions. Temperature showed significant adverse effect only under either higher LI or higher VPD regimes.

***Key words*: Castor bean, light intensity, net photosynthetic rate, temperature, vapour pressure deficit.**

The castor crop is grown under rainfed conditions in Andhra Pradesh and it is the most preferred crop for rainfed farming in this region because of its drought hardy nature. Its productivity fluctuates with the aberrations in weather. Understanding of physiological responses to its environment will be useful in improving the productivity of castor crop (Subramanian and Venkateshwarlu 1995). Radiation, temperature and humidity are three main weather factors, which influence net photosynthesis of a crop. The effect of these three weather parameters on net photosynthetic rate of castor under controlled conditions, i.e. in growth chambers has been reported (Dai *et al.* 1992). The present study attempts to examine the effect of weather parameters on net photosynthetic rate in castor bean under field conditions.

Studies were conducted at Hayatnagar Research Farm, Hyderabad, India (17° 20' N, 78° 35' E) during the crop seasons of 1994-95 and 1995-96. The soil of the experimental site is classified as an alfisol according to soil taxonomy. Four genotypes of castor, viz. VP-1, 48-1, GCH-4 and Aruna, which are different in characters like plant height, leaf numbers and duration (120-150 days), were planted on two different dates at an interval of one month. Seeds were hand dibbled with 30 x 60 cm spacing. The experimental design was split plot with treatments of two dates of sowing and four genotypes, in four replications.

The net photosynthetic rate was measured using portable infrared gas anlyser (LICOR - 6200) on young and fully expanded leaves. Three plants (continuously in a row) in each plot from each of the four replications were earmarked (tagged) for the observations of photosynthesis. From each plant, three observations of photosynthesis were made on same leaf at an interval of 2 to 3 weeks starting from 21 to 30 days after sowing. The time of measurements of photosynthesis was between 1030 to 1200 hrs. The light intensity (μmol m^{-2} s^{-1}) and temperature (°C) recorded by the assimilation chamber, were used for

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working out the photosynthesis and weather relationships. The vapour-pressure deficit of the assimilation chamber was calculated on the basis of relative humidity (RH) and temperature (T) of the chamber using formulae from Smithsonian Meteorological Tables (1971).

$$ES = 0.1 * \exp[54.88 - 5.03 \ln(T+273) - 6791/(T+273)]$$

$$EA = ES * RH$$

$$VPD = ES - EA$$

where ES and EA are saturated and actual vapour pressure (k Pa) and VPD is the vapour-pressured deficit (k Pa).

In this study, lower and higher regimes of light intensity are defined as the light intensities ≤ 1500 µmol/m^2/s and $>$ 1500 µmol/m^2/s, respctively. Likewise, the lower and higher vapour presssure deficit regimes are vapour pressure deficits ≤ 2 k Pa and > 2 k Pa and lower and higher temperature regimes of temperatures ≤ 32°C and >32°C.

The regression equations between net photosynthetic rate of each genotype and simultaneous records of weather data like quantum radiation and vapour pressure deficit, individually and combinedly (Table 1) reveals that the quantum radiation has significant positive relationship with Pn in all genotypes and is not varying much in different varieties. This agrees with the observation of studies on photosynthesis and irradiance relationships in other crops (Krall *et al.* 1991, Zhao and Oosterhuis 1998). Increase in photosynthetic rate with increase in light intensity in a single variety of castor was observed in previous experiments (Subramanian and Venkateswarlu 1995). The Pn in all the genotypes showed significant negative relationships with VPD, which is in agreement with the observations made by Dai *et al.* (1992) in castor crop and Long and Woolhouse (1978), Turner *et al.* (1985), Gomes *et al.* (1987) in other crops. Considering both light and humidity factors together, the predictability of the photosynthetic rate (R^2 value of regression euqation) in all genotypes increased many folds compared to the predictability considering either of those factors individually.

The effect of a particular weather parameter out of the three weather parameters (VPD or LI or temperature) on Pn was further studied under two different regimes of the other two parameters. For this purpose, each weather parameter is categorised as low and high regimes of the respective weather parameter.

The results indicated that sensitivity of photosynthesis to higher vapour pressure deficit is more pronounced under higher light intensity (higher R^2 value) compared to that under lower light intensity (Table 2). The decrease in Pn per unit increase in VPD was more under higher light regime compared to that under lower light regime. This result is also in line with the resutls reported in castor under controlled conditions by Dai *et al.* (1992). The higher decrease in Pn with increasing VPD under higher light intensity than under lower light intensity might have resulted due to decreasing leaf water potential under

Table 1. The relationships between Pn and weather variables in four selected castor genotypes

Genotype	Radiation (X_1)		Vapour pressure deficit (X_2)		$X_1 + X_2$	
	Equation	R^2	Equation	R^2	Equation	R^2
VP-1	Y_1= 10.0+0.007 X_1	0.10**	Y_1= 29.5-4.2 X_2	0.25**	Y_1=14.1+0.014X_1 6.7 X_2	0.61**
48-1	Y_2= 11.4+0.005 X_1	0.08**	Y_2= 28.0-3.8 X_2	0.21**	Y_2= 17.1+0.011 X_1-6.0 X_2	0.50**
GCH-4	Y_3= 10.8+0.006 X_1	0.15**	Y_3= 28.3-3.6 X_2	0.26**	Y_3= 16.9+0.011 X_1-5.5 X_2	0.67**
Aruna	Y_4= 10.1+0.006 X_1	0.13**	Y_4= 26.4-3.4 X_2	0.21**	Y_4= 16.2+0.011 X_1-5.9 X_2	0.63**

Table 2. Response of Pn to VPD under two different light intensities and temperature conditions in four castor genotypes.

Genotypes	Regression equation	R^2	Regression equation	R^2
	Higher light intensity (>1500 µmol/m²/s)		**Lower light intensity (≤1500 µmol/m²/s)**	
VP-1	Y_1= 39.2 - 6.6 X_1	0.58**	Y_1= 25.9 - 4.1 X_1	0.13**
48-1	Y_2= 36.9 - 6.0 X_2	0.53**	Y_2= 20.8 - 1.7 X_2	0.02NS
GCH-4	Y_3= 35.4 - 5.3 X_3	0.58**	Y_3= 22.6 - 2.8 X_3	0.13**
Aruna	Y_4= 35.2 - 5.4 X_4	0.62**	Y_4= 24.5 - 4.0 X_4	0.10*
	Higher temperature (>32°C)		Lower temperature (≤32°C)	
VP-1	Y_1= 30.7 - 4.6 X_1	0.28**	Y_1= 28.1 - 3.9 X_1	0.10**
48-1	Y_2= 27.9 - 3.8 X_2	0.31**	Y_2= 26.5 - 2.5 X_2	0.02NS
GCH-4	Y_3= 28.3 - 3.7 X_3	0.30**	Y_3= 26.5 - 2.3 X_3	0.03NS
Aruna	Y_4= 27.5 - 3.9 X_4	0.28**	Y_4= 21.5 - 0.22 X_4	0.0NS

Y_1, Y_2, Y_3 and Y_4 are Pn in genotypes VP-1, 48-1, GCH-4 and Aruna, respectively
X_1, X_2, X_3 and X_4 are VPD in genotypes VP-1, 48-1, GCH-4 and Aruna, respectively

increasing light intensity causing plant water stress in castor grown under dryland conditions. The higher VPD further aggravates the plant water stress induced by higher light intensity and thus results in lower photosynthesis. Like in high light intensity regime, the VPD also had significant negative relationship under high temperature regime. Under low temperature regime, the VPD does not show significant relationship with Pn in any of the genotypes, except VP-1. The rate of decrease of Pn with increasing VPD was more under higher thermal regime than that under lower thermal regime. Despite the steep decrease in Pn under higher light intensity conditions compared to that under lower light intensity, photosynthetic activity remains higher under high light intensity up to 5 k Pa vapour pressure deficit than under lower light regime. The positive effect of quantum radiation might be overriding the adverse effect of increasing VPD up to certain vapour pessure deficit. It is interpreted from these results that higher light coupled with lower vapour pressure deficit is optimum weather condition for obtaining higher photosynthetic rate in castor beans.

The effect of LI on Pn is positive under both the high and low humidity conditions (Table 3). However, the relationship between Pn and LI was relatively more significant (high R^2) under lower VPD than under high VPD. Mitchell *et al.* (1999) in a multiple-site experiment on spring wheat also reported similar results. The rate of increase of Pn with increased LI was many folds higher under lower VPD than under high VPD. It can be inferred that Pn under lower VPD is more than under high VPD at any given light intensity, except a smaller range of light intensity lesser than 600 µmol/m²/s.

The response of Pn to LI under varying temperature regimes also followed the same trend as that under varying VPD regimes and it is more significant under low temperatures than under high temperatures. The rate of increase of Pn with increased LI was more under low temperature conditions than high temperature in all the genotypes, similar to the observation of Mitchell *et al.* (1999). This might be possible due to the lower transpiration loss under low temperature. High LI coupled with either low VPD or lower temperature appears to be optimum weather conditions for obtaining higher photosynthetic rate in castor beans.

The relationship between Pn and temperature was not that significant under low light. However, under higher light intensities, it has significant adverse efect on Pn in all the genotypes (Table 4). The sensitivity of Pn to temperature under higher light varies from genotype to genotype and it is least in variety Aruna. Under varying light regimes, the response of Pn to temperature is not at all significant under low VPD. Under

Table 3. Response of Pn to LI under two different VPD and temperature conditions in four castor genotypes.

Genotypes	Regression equation	R^2	Regression equation	R^2
	Higher VPD (>2k Pa)		**Lower VPD (≤2k Pa)**	
VP-1	Y_1= 16.4 + 0.0009 X_1	0.0NS	Y_1= 2.9 - 0.02 X_1	0.48**
48-1	Y_2= 10.2 + 0.004 X_2	0.08*	Y_2= 8.5 + 0.01 X_2	0.25**
GCH-4	Y_3= 10.4 + 0.005 X_3	0.08*	Y_3= 7.0 + 0.01 X_3	0.51**
Aruna	Y_4= 10.6 + 0.004 X_4	0.07*	Y_4= 7.0 + 0.01 X_4	0.45**
	Higher temperature (>32°C)		Lower temperature (≤32°C)	
VP-1	Y_1= 6.1 + 0.008 X_1	0.13**	Y_1= 5.9 + 0.01 X_1	0.36**
48-1	Y_2= 9.8 + 0.005 X_2	0.10**	Y_2= 0.8 + 0.02 X_2	0.46**
GCH-4	Y_3= 8.4 + 0.006 X_3	0.18**	Y_3= 8.4 + 0.01 X_3	0.49**
Aruna	Y_4= 8.7 + 0.006 X_4	0.14**	Y_4= 4.2 + 0.02 X_4	0.55**

X_1, X_2, X_3 and X_4 are LI in genotypes VP-1, 48-1, GCH-4 and Aruna, respectively

Table 4. Response of Pn to temperature under two different light intensities and VPD conditions in four castor genotypes.

Genotypes	Regression equation	R^2	Regression equation	R^2
	Higher light intensity (>1500 µmol/m²/s)		**Lower light intensity (≤1500 µmol/m²/s)**	
VP-1	Y_1= 74.3 - 1.5 X_1	0.15**	Y_1= 38.6 - 0.6 X_1	0.13**
48-1	Y_2= 64.3 - 1.2 X_2	0.18**	Y_2= 26.0 - 0.26 X_2	0.02NS
GCH-4	Y_3= 63.3 - 1.2 X_3	0.20**	Y_3= 21.8 - 0.14 X_3	0.13**
Aruna	Y_4= 50.9 - 0.9 X_4	0.09**	Y_4= 35.1 - 0.5 X_4	0.10*
	Higher VPD (>2kPa)		Lower VPD (≤2kPa)	
VP-1	Y_1= 40.8 - 0.6 X_1	0.09**	Y_1= 21.1 - 0.03 X_1	0.0NS
48-1	Y_2= 36.7 - 0.55 X_2	0.05**	Y_2= 18.5 - 0.01 X_2	0.0NS
GCH-4	Y_3= 48.6 - 0.8 X_3	0.11**	Y_3= 17.7 - 0.1 X_3	0.0NS
Aruna	Y_4= 47.5 - 0.8 X_4	0.07**	Y_4= 9.0 - 0.3 X_4	0.0NS

X_1, X_2, X_3 and X_4 are air temperatures in genotypes VP-1, 48-1, GCH-4 and Aruna, respectively

high VPD conditions, temperature adversely influences the Pn in all the genotypes. probably, high temperature must be further aggravating the adverse effect of low humidity, i.e. high VPD on Pn.

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