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Short communication

Response of CERES sorghum model for different agroclimatic conditions

M. C. VARSHNEYA, R. N. SABALE, N. L. BOTE, S. S. SALUNKE, D. B. MORE and P. V. THANEDAR

Centre of Advanced Studies in Agricultural Meteorology (CASAM), College of Agriculture, Pune - 411 005

The CERES (Crop Environment REsources Synthesis) sorghum model is a dynamic crop growth model, which predicts status of crop on real time basis as a function of exogenous parameter. It consists of four major subroutines, namely; water balance, nitrogen balance, phenology and growth. These models are user friendly and require a minimum of readily available crop, soil and weather data. CERES models contain several genetic coefficients which describe the development of any genotype influenced by environmental factors such as minimum and maximum temperature and day length (Ritchie *et al.*, 1988; Ritchie and Amato, 1990; Ritchie and Algarswamy, 1989 a and b; Varshneya *et al.*, 1996).

Possibilities of application of the model, under tropical conditions, were studied by conducting a field experiment. Modifications in LAI and partitioning in the model was found necessary to minimize the errors (Varshneya *et al.*, 1998). The effect of air temperature, rainfall and solar radiation on the yield of sorghum, in Pune was also investigated.

Weather data of last 28 years (1970-1998) available at Department of Agricultural Meteorology, CASAM, Pune, was used in this study. Similarly, data on sorghum growth and development and of soils in the format of minimum data set of CERES-sorghum model for the year 1998 was used. Data on average yield of sorghum of Pune district for the period *kharif* season (1970-1998) was collected from Agricultural Department, Government of Maharashtra, Pune. Global solar radiation for last 28 years was calculated by using Angstorm equation. Input file for weather, management, soils, and crop referred by More (1998) was used. Weather files of different years were prepared and predicted values by the model for phenology and growth parameters were determined. Effect of weather parameters viz. maximum temperature (Tmax), minimum temperature (Tmin), annual rainfall and solar radiation was studied by developing linear regression equations between weather parameters and phenology, yield and yield altributes simulated by the model.

Effect of maximum temperature (Tmax)

At Pune, the mean maximum temperature (1970 - 1998) was 31.7°C, which varied between 30.7 (1975) and 32.6°C (1992). There is an increasing trend in mean maximum temperature (Fig. 1).

The rgression equation developed with mean maximum temperature

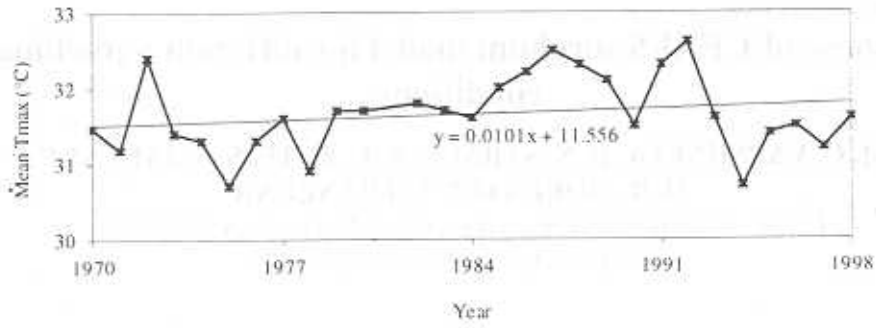

Fig. 1: Trend of mean maximum temperature (1970-1998)

Table 1 : Regression equation between mean maximum temperature (Tmax) and simulated phenology, yield and yield attributes of sorghum

Sr. No.	Regression equation	r^2
1	PI = -0.6444Tmax + 44.015	0.60**
2	AN = -2.0223Tmax + 116.74	0.74**
3	PM = -5.7732Tmax + 262.84	0.14
4	BM = -1637.1Tmax + 59058	0.10
5	Y= -996.36Tmax + 33725	0.11
6	GPSM = - 4911.8Tmax (PI-B) + 154951	0.56**
7	GPSM = -1171Tmax (B- AN) + 51564	0.07
8	GPSM = 889.67 Tmax (AN-PM) - 7340.7	0.04

Where PI is Pamile initiation, B is besting AN is anthesis, PM is physiological maturity; BM is dry biomass; Y is grain yield (kg ha^{-1}) and GPSM is grain number per sq. m. (kg ha^{-1})

(Table 1) revealed that it had highly significant negative influence on number of days for panicle initiation (PI) and anthesis (AN). The growth parameters such as grain number per sq. meter (GPSM) was also inversely related with Tmax during PI to booting (B) phase. Maximum temperature had nonsignificant effect on other growth parameters tested. As the temperature increased by 1°C panicle initiation attained earlier by 0.64 days and anthesis by 2 days. Similarly, as temperature increased by 1°C during panicle initiation to boot phase, grain number per sq. m. decreased by 4911.8 m^{-2}. These results are in confirmation with Karande *et al.*, 1996 and Kenjale *et al.*, 1996.

***Effect of minimum temperature* (Tmin)**

The mean minimum temperature (1970 - 1998) was 17.6 °C, which varied between 16.9 (1971) and 18.5°C (1979). The mean minimum temperature for last

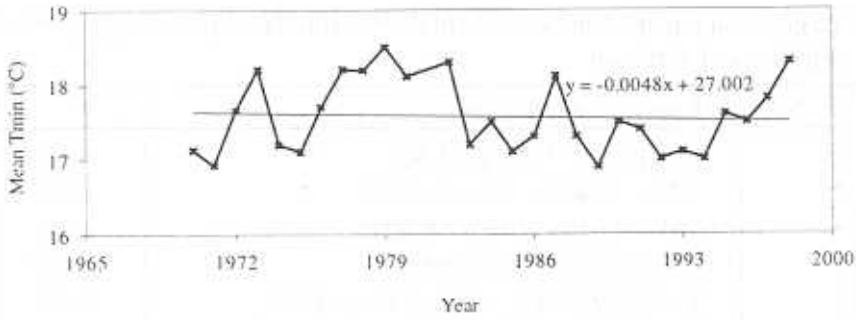

Fig. 2 : Trend of mean minimum temperature (1970-1998)

Table 2 : Regression equation between mean minimum temperature (Tmin) and simulated phenology, yield and yield attributes of sorghum

Sr. No.	Regression Equation	r^2
1	PI = - 0.7663Tmin + 42.668	0.23
2	AN = - 2.5722Tmin + 115.81	0.45*
3	PM = - 6.7312Tmin + 238.78	0.13
4	BM = -1336.6Tmin + 40121	0.05
5	Y = -829.53Tmin + 22538	0.05
6	GPSM = 1324.2 Tmin (PI - B) - 9446.4	0.01
7	GPSM = -1247.3Tmin (B - A) + 45184	0.04
8	GPSM = - 1811.4Tmin (A - PM) + 55852	0.06

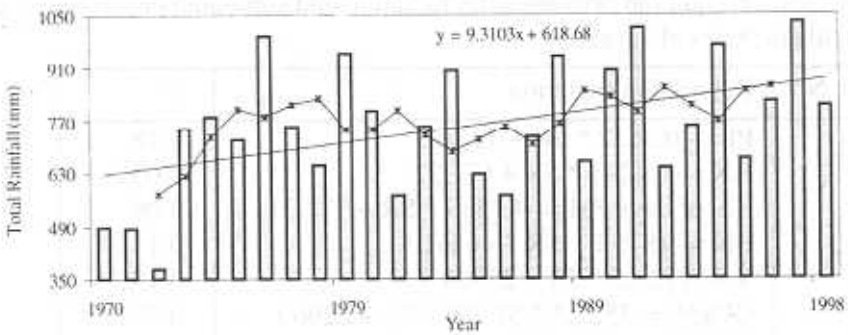

Fig. 3: Trend of rainfall (1970-1998)

Table 3 : Regression equation between rainfall and simulated phenology, yield and yield attributes of sorghum

Sr. No.	Regression equation	r^2
1	PI = 0.0015 * RF + 25.505	0.02
2	AN = -0.0012 * RF + 60.392	0.01
3	PM = 0.0243 * RF + 86.304	0.18
4	BN = 11.789 * RF + 6991	0.41*
5	Y= 6.3591 * RF (AN - PM) + 4027	0.17
6	Y = 7.0325 * RF (S - PM) + 2094.6	0.41*
7	GPSM = 18.643 * RF (AN - PM) + 16206	0.18
8	GPSM = 17.783 * RF (S - PM) + 11704	0.32

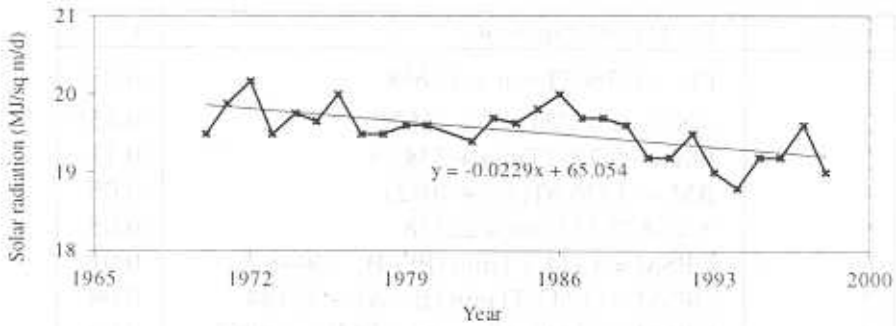

Fig. 4: Trend of solar radiation (1970-1998)

Table 4. Regression equation between solar radiation and simulated phenology, yield and yield attributes of sorghum

Sr. No.	Regression Equation	r^2
1	PI = - 0.3632 * SR + 32.462	0.18
2	AN = -0.4293 * SR + 67.932	0.03
3	No. of days PM = -4.1583 * SR + 173.31	0.09
4	BN = -1875.1 * SR + 46561	0.17
5	Y = -1129.5 * SR + 25903	0.18
6	GPSM = -3525.3 * SR (PI - B) + 82960	0.38*
7	GPSM = -43.66 * SR (B - AN) + 19791	0.00
8	GPSM = -2386.7 * SR (AN - PM) + 64105	0.18

28 years was showing a decreasing trend (Fig. 2).

Among phenological stages only anthesis (AN) was found to be significantly and inversely proportional to mean minimum temperature (Tmin). While others were negatively but non-significantly influenced by Tmin. Minimum temperature had non significant influence on yield and yield attributes (Table 2).

It may be estimated from the equation that as the minimum temperature increased by 1°C anthesis was attained 2.5 days earlyer.

Effect of rainfall (RF)

The annual average rainfall (1970 - 1998) of Pune was 677.9 mm, which ranged between 378.3 mm. (1972) and 1029.9 mm (1997). The trend line drawn on the basis of five yearly moving averages shows an increasing trend (Fig. 3).

Rainfall was found to have non-significant influence on phenology of sorghum. Biomass (BM) and yield were significanty directly influenced by rainfall (Table 3). It may be estimated that as rainfall increased by 100 mm biomass increased by 1178 kg ha^{-1} and grain yield increased by 703 kg ha^{-1}, when rainfall increased between sowing to PM.

Effect of solar radiation

The mean solar radiation at Pune (1970-1998) was 19.5 MJ m^{-2} d^{-1} which ranged between 17.6 (1996) and 20.4 MJ m^{-2} d^{-1} (1972). There is a decreasing trend of mean solar radiation for last 28 years, which is in conformity with the increasing trend in rainfall (Fig. 4).

Solar radiation was found to have negative influence on phenology and growth parameters but it was significant only in case of grain number per sq. meter (GPSM). As the solar radiation increased by 1 MJ m^{-2} d^{-1} during (PI-B) phase GPSM was found to decrease by 3525 (Table 4).

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