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Calibration and validation of DSSAT model for *kharif* groundnut in north-Saurashtra agro-climatic zone of Gujarat

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ABSTRACT

The DSSAT model was calibrated and validated for *kharif* groundnut (cv. GG-2 and GG-20) using past experimental data (2007 to 2009) of Dry Farming Research station, J.A.U., Targhadia, Rajkot (20^0 18È N 70^0 56È E), Gujarat with two dates of sowing (D_1: Onset of monsoon 1st July; D_2: After 15 days of D_1 15th July). The yield and yield attributes, phenological stages, harvest index, shelling percentage as simulated by model were compared with the observed data. The results revealed that the model underestimated the LAI and haulm yield for both the cultivars and overestimated rest of the parameters. The average error percent of pod yield for cv. GG-2 as simulated by DSSAT model was 2.2 % and for cv. GG-20 it was 1.6 %.

Key words : Crop growth model, DSSAT, groundnut, simulation, calibration, validation.

Groundnut is the major oilseeds crop of Gujarat with 1.92 million ha area and 3.36 million tonnes of production with 1836 kg ha^{-1} productivity (Anon., 2011). Groundnut crop is grown in areas receiving the rainfall between 500 and 1250 mm and performs better in the sandy loam and loamy soils. In Saurashtra, groundnut is grown in black calcareous soils. The major groundnut growing districts in Gujarat are Junagadh, Jamnagar, Amreli, Bhavnagar, Rajkot, Mehsana and Bhuj. In Gujarat, groundnut is mainly grown in *kharif* season and Junagadh is the most productive among all the districts (Sahu *et al.*, 2004). Majority of the groundnut cultivars are insensitive to photoperiod and therefore grown in all the three seasons, viz. summer, kharif and rabi. In Saurashtra region, about 80 % of the crop is grown under rain-fed condition and due to vagaries of monsoon the year-to-year yield fluctuations are more. The productivity of groundnut is curtailed due to biotic and abiotic stresses. Weather is one of the important factor, which affects all stages of groundnut growth and finally the yield. The crop growth simulation models show considerable potential to evaluate crops, crop varieties, cropping pattern and genetic potential pattern for yield (Boote et al., 1987). In this paper attempt has been made to calibrate and validate the DSSAT model for groundnut in Saurashtra, Gujarat.

MATERIALS AND METHODS

The experimental data (2007-09) of *kharif* groundnut Dry Farming Research Station, J.A.U., Targhadia, Rajkot, Gujarat. Comprising date of sowing (*kharif*: D_1-1st July., D_2-15th July.) and varieties (GG-2 and GG-20) were used in this study. The package and practices for cultivation was followed as per the recommendation of Crop parameters such as pod yield, haulm yield, phenology, LAI, harvest index and shelling percentage were used for calibration of the DSSAT 4.5 model. The genetic coefficients of groundnut were estimated by repeated interactions until a close match between simulated and observed phenology and yield was obtained in respective treatments. The values of genetic coefficients as derived from calibration of the model are presented in Table 1.

Generally, correlation coefficient (r) and regression coefficient (R) are determined to evaluate the association between the observed and predicted values despite the fact that their magnitudes are consistently not related to accuracy of prediction. Hence, to achieve accuracy, the test criteria suggested by Wiltlmott (1982) were followed while evaluating the performance of the models. The observed (O) and simulated (P) values were used to

Table 1: Genotypic characteristics of GG-2 and GG-20 used in DSSAT.

Parameter	Description of parameter coefficients controlling development aspects	GG-2	GG-20
CSDL	Critical Short Day Length below which reproductive development progresses with no day length effect (for short day plants) (hours)	11.84	11.84
PPSEN	Slope of the relative response of development to photoperiod with time (positive for short day plants) (1/hours)	0.00	0.00
EM-FL	Time between plant emergence and flower appearance (R1)	27.4	12.5
FL-SH	Time between first flower and first pod (R3) (photothermal days)	7.0	6.0
Fl-SD	Time between first flower and first seed (R5) (photothermal days)	25.5	14.3
SD-PM	Time between first seed (R5) and physiological maturity(R7) (photothermal days)	52.0	78.5
FL-LF	Time between first flower (R1) and end of leaf expansion (photothermal days)	58.0	65.0
LFMAX	Maximum Leaf photosynthesis rate at 30 ^{0}C, 350 vpm CO_2 and high light ($mgCO2/m^2$.S)	1.20	1.33
SLAVR	Specific leaf area of cultivar under standard growth condition (cm^2/g)	265.	225.
SIZLF	Maximum size of full leaf (three leaflets) ($cm^{2)}$	19.0	23.0
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	0.81	0.76
WTPSD	Maximum weight per seed (g)	0.360	0.880
SFDUR	Seed filling duration for pod cohort at standard growth conditions (photothermal days)	25.0	44.0
SDPDV	Average seed per pod under standard growing conditions (#/pod)	1.65	1.65
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photothermal days)	15.5	27.0

calculate error percent (PE), mean absolute error (MAE), mean bias error (MBE) and root mean square error (RMSE).

$$MAE = \sum_{i=1}^{n}[1P_i - O_i 1]/n \qquad MBE = \sum_{i=1}^{n}[P_i - O_i]/n$$

$$RMSE = \left[\sum_{i=1}^{n}(P_i - O_i)^2/n\right]^{1/2}$$

PE = {(simulated – observed) / observed} * 100

RESULTS AND DISCUSSION

Phenological stages

The observed days to anthesis for two cultivar GG-2 and GG-20 were respectively 32 and 34 days whereas model simulated 35 and 39 days. The test criteria computed by MAE, MBE, RMSE and PE for two cultivars GG-2 and GG-20 (Table 2) suggested that model performance was better for GG-2 as compared to GG-20 for simulation of days to anthesis. For simulating days to first pod the performance parameters for cv. GG-2 were higher than that for cv. GG-20 (Table 2) although the model overestimated the days to first pod formation. The observed days to first seed for two cultivar GG-2 and GG-20 were 51 and 53 days respectively while model simulate 55 and 56 days respectively. The test criteria for two cultivars GG-2 and GG-20 (Table 2) suggested that model performance was better for GG-20 as compared to GG-2 for simulation of days to first seed. Days to maturity for GG-2 and GG-20 were observed to be 103 and 109 days while model simulated 109 and 116 days respectively. Thus, the model overestimated the days to maturity. For LAI the performance criteria was good for cv. GG-20 than cv. GG-2. The results of phenological stages of groundnut

Table. 2 : Test criteria of various parameters of groundnut

Parameters	Observed		Simulated		MAE		MBE		RMSE		PE	
	GG-2	GG-20	GG-2	GG-20	GG-2	GG-20	GG-2	GG-20	GG-2	GG-20	GG-2	GG-20
Days to anthesis (DAS)	32.2	34.2	35.0	38.7	2.83	4.50	2.83	4.50	3.34	2.83	8.7	13.2
First pod (DAS)	36.2	39.0	40.0	42.5	3.83	3.50	3.83	3.50	3.93	3.83	10.5	9.0
First seed (DAS)	51.0	53.0	54.5	55.8	3.50	2.83	3.50	2.83	4.45	3.50	6.9	5.3
Days to maturity (DAS)	103.3	109.2	108.7	116.0	5.33	6.83	5.33	6.83	5.50	5.33	5.2	6.2
LAI	5.9	5.8	5.1	5.2	0.78	0.60	-0.78	-0.60	0.87	0.78	-13.6	-10.3
Haulm yield (kg ha^{-1})	4801.0	4774.3	4243.8	4614.0	115.36	308.33	-557.17	-160.33	1128.80	115.36	-11.6	-3.54
Pod yield (kg ha^{-1})	1351.7	1602.2	1381.3	1627.3	27.44	122.17	30.00	25.16	178.16	27.44	2.2	1.6
Harvest index	28.9	33.6	32.6	35.3	3.69	2.29	3.06	1.65	4.15	3.69	12.8	5.1
Shelling percent (%)	68.7	70.8	73.2	73.8	4.50	3.00	4.50	3.00	4.77	4.50	6.6	4.2

simulated by CROPGRO peanut model was in conformity with those of Ujinwal and Patel (2008); Babu (2006); Nokes and Young (1991).

Yield and yield attributs

The pod yield obtained for two cultivars GG-2 and GG-20 were 1351.7 and 1602.2 kg ha^{-1} while model simulated slightly higher 1381.3 and 1627.3 kg ha^{-1} respectively. The test criteria computed by MAE, MBE, RMSE and PE for two cultivars GG-2 and GG-20 (Table 2) suggested model performance was good for GG-20 as compared to GG-2. However, for simulating haulm yield the performance parameters for cv. GG-2 was higher than that for cv. GG-20 (Table 2). For simulating harvest index the test parameters for cv. GG-20 were better than cv. GG-2. Harvest index for GG-2 and GG-20 was observed to be 28.9 and 33.6 while model simulated 32.6 and 35.3 respectively. Thus, the model overestimated the harvest index. For shelling percent the performance criteria was good for cv. GG-20 than cv. GG-2. The results are in good agreement with the finding of Yadav *et al.*, (2012); Pandey *et al.,* (2001); Singh *et al.,* (1994) for yield and yield attributes of groundnut as simulated by PNUTGRO model.

CONCLUSION

Days to anthesis, first seed, first pod, days to maturity, leaf area index, pod yield, haulm yield, harvest index and shelling percentage were satisfactorily simulated by DSSAT model, however LAI and haulm yield were underestimated and rest of the parameters was overestimated by the model with reasonable agreement (± 15). DSSAT model has proved to be valuable tool for predicting groundnut yield. This shows the robustness of DSSAT model. Therefore, the validated DSSAT can further used for applications such as prediction of crop growth, phenology, potential and actual yield, performance of groundnut under climate change study etc. The model may also to be used to improve and evaluate the current practices of groundnut growth management to enhance groundnut production.

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