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Validation of CROPGRO-peanut model in middle Gujarat agroclimatic region

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ABSTRACT

A field experiment was conducted during the *kharif* seasons of 2009 and 2010 to evaluate the CROPGRO-Peanut model for phenological and yield attributes of three groundnut cultivars V_1-M 335 (Virginia spreading type), V_2-GG 20 (Virginia semi-spreading type) and V_3-GG 5 (Spanish bunch type) sown under three environments. Model output showed that the simulated values of phenology, growth parameters and pod yield of the groundnut cultivars were close to the corresponding observed values.

Keywords: *Glue cultivar coefficient estimator, DSSAT v. 4.5, CROPGRO- Peanut.em*

India is a world leader in groundnut farming and cultivates around 7.74 million hectares and produces 7.61 million tones of groundnut with the productivity level of 991 kg ha^{-1}, with an increase in groundnut cultivation from 6.8 million hectares from 1980-81 to 8 million hectares, from 1993-94 onwards the production of groundnut is fluctuating between 7 to 9 million tones indicating the fluidity of production trend in groundnut in the recent years. Among oilseed crops, groundnut is the single largest source of edible oils in India, constituting about 50% of area and 45% of oil production. In India, about 80% of the groundnut area lies in a low to moderate rainfall zone (parts of peninsular region and western and central regions) with a short period of duration (90-120 days). Most of the groundnut production is concentrated in five states viz. Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka, and Maharashtra. These five states account for about 86% of the total area under peanut cultivation, amongst these states Gujarat and Andhra Pradesh account for more than half of the cultivated area. Gujarat state alone occupies 1.95 million hectares (28.9%) of the total area of the country producing 3.39 million tones (42.4%) of the total production of the country with a productivity of 1777 kg ha^{-1} (Anonymous, 2010). Nevertheless, there are constraints about substantial yield gaps between yields realized by farmers and those recorded from research stations or potential yield estimations. Yield fluctuates strongly due to climate variation and uneven adoption of improved technology. The objectives of the study were to quantify the production potential of groundnut in middle Gujarat Agroclimatic condition with special regard to dates of sowing to varying rainfall distribution during the growing season. Water deficit is a major constrain in groundnut production, especially during the critical period of pod set which results in reduced pegging. For the purpose, the Decision Support System for Agrotechnology Transfer (DSSAT) crop growth model Vs. 4.5 was evaluated and validated using two years of observed phenological growth and yield data.

MATERIALS AND METHODS

For evaluation and validation of the CROPGRO-Peanut model, data on plant growth and development, soil characteristics, weather and crop management were collected as required for determining the cultivar coefficients of V_1-M 335 (Virginia spreading type), V_2-GG 20 (Virginia semi-spreading type) and V_3-GG 5 (Spanish bunch type), following the procedures described in IBSNAT and Hoogenboom *et al.,* (1999). The data were collected by conducting field experiments laid out at the Agronomy farm, B. A. College of Agriculture, AAU, Anand (22°35" N of latitude and 72°55" E longitude, elevation of 45.1 m) during the *kharif* seasons of 2009 and 2010 at the onset of monsoon followed by successive interval of 15 days in sowing environments during *kharif* 2009 2nd July (D_1), 17th July (D_2), 1st August (D_3) and *kharif* 2010 15th June (D_1), 30th June (D_2), 14th July (D_3). The cultivar coefficients were estimated by repeated iterations by running the GLUE coefficient estimator using the observed phenology, yield and yield attributes for all the sowing environments during both the years until a close match between simulated and observed phenology, growth and yield was obtained as presented in Table. 1. Validation of accuracy of the procedure used to estimate the cultivar coefficients of each peanut cultivar was determined by

Table 1: GLUE derived cultivar coefficients for groundnut cultivars at Anand.

COEFF	DEFINITIONS	V_1 (M 335)	V_2 (GG 20)	V_3 (GG 5)
CSDL	Critical Short Day Length below which reproductive development progresses with no day length effect (for short day plants) (hour)	11.84	11.84	11.84
PPSEN	Slope of the relative response of development to photoperiod with time (positive for short day plants) (1/hour)	0	0	0
EM-FL	Time between plant emergence and flower appearance (photothermal days)	22.3	18.5	19.1
FL-SH	Time between first flower and first pod (photothermal days)	9.6	7.1	7.5
Fl-SD	Time between first flower and first seed (photothermal days)	16.1	22.4	21.6
SD-PM	Time between first seed and physiological maturity (photothermal days)	71.78	64.26	54.33
FL-LF	Time between first flower and end of leaf expansion (photothermal days)	77	91	78
LFMAX	Maximum leaf photosynthesis rate at 30 ^{0}C, 350 vpm CO_2, and high light (mg CO_2/m^{2-s})	1.03	1.02	1.09
SLAVR	Specific leaf area of cultivar under standard growth conditions (cm^2/g)	244	231	240
SIZLF	Maximum size of full leaf (three leaflets) (cm^2)	14.9	13.1	13.7
XFRT	Maximum fraction of daily growth that is partitioned to seed + shell	0.65	0.92	0.89
WTPSD	Maximum weight per seed (g)	0.375	0.442	0.400
SFDUR	Seed filling duration for pod cohort at standard growth conditions (photothermal days)	44.6	26.0	29.0
SDPDV	Average seed per pod under standard growing conditions (#/pod)	1.66	1.78	1.49
PODUR	Time required for cultivar to reach final pod load under optimal conditions (photothermal days)	7.0	4.0	6.5
THRSH	The maximum ratio of seed at maturity. Causes seed to stop growing as their dry weights increase until shells are filled in a cohort. (Threshing percentage).	86	94	88
SDPRO	Fraction protein in seeds (g(protein)/g(seed))	0.27	0.27	0.27
SDLIP	Fraction oil in seeds (g(oil)/g(seed)	0.51	0.51	0.51

comparing the simulated values of development and growth characteristics with the corresponding observed values, and by the values of the mean error percentage (EP), standard deviation (SD), mean bias error (MBE) root mean square error (RMSE) and percent error (PE).

RESULTS AND DISCUSSION

The comparisons between the simulated values from model calibration and the corresponding observed values for days to anthesis, first pod formation stage, maturity days, leaf area index, pod yield and haulm yield are depicted in Fig. 1. The simulated days to anthesis was in good agreement with the observed values for both the seasons, with relatively low in mean error percentage, standard deviation, mean bias error (MBE) root mean square error (RMSE) and percent error (PE) of (-1.4, 3.6, -0.4, 1.0 and 3.7) respectively, for the dates of sowing and cultivars across the years followed by first pod formation

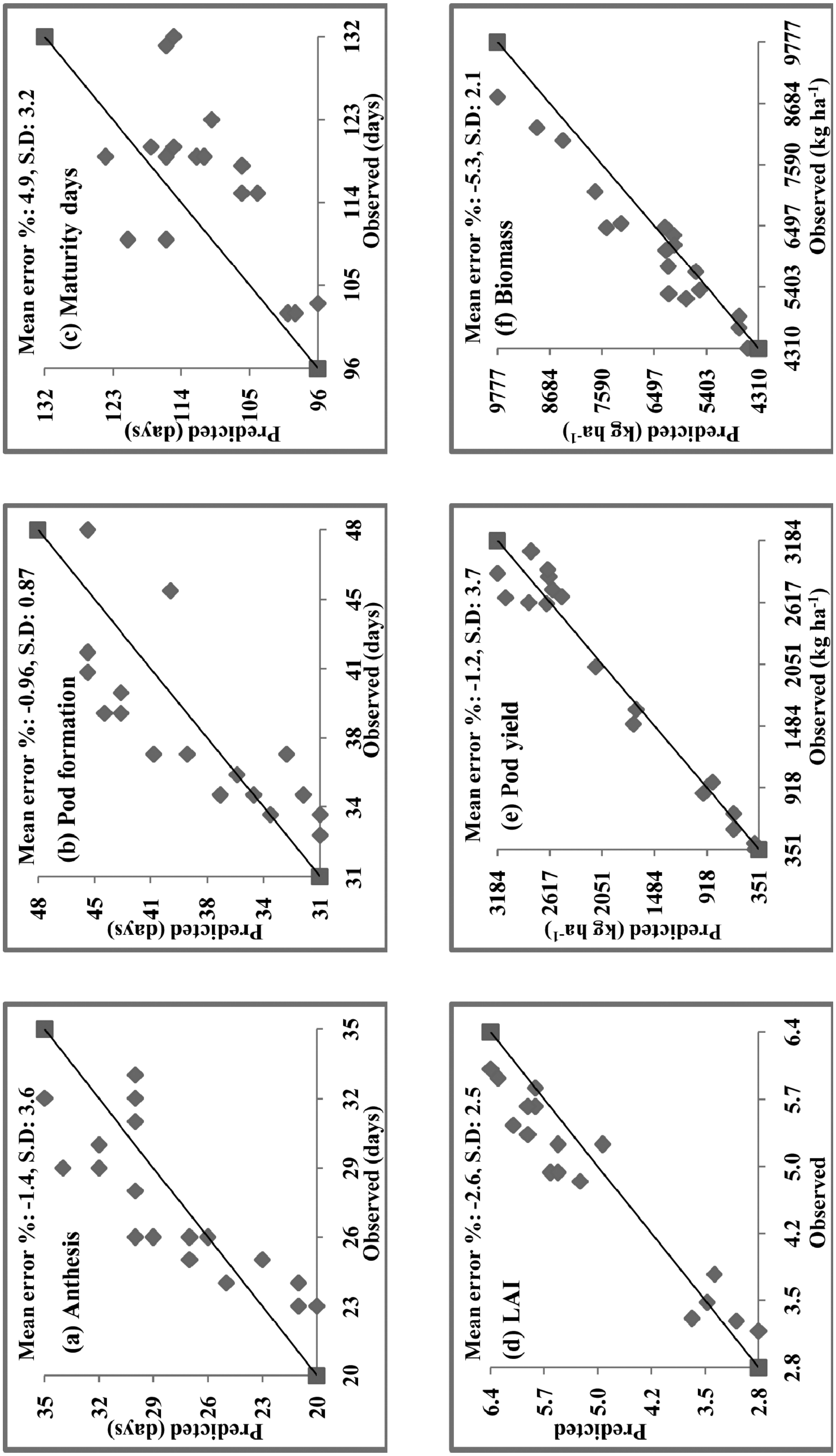

Fig 1: Mean observed and simulated anthesis days (a), first pod formation days (b) and maturity day (c), leaf area index (d), pod yield (e) and final biomass (f) for dates of sowing and variety.

days and maturity days. However, the simulation for all the three developmental stages excepting for maturity days, tended to be slightly underestimated for the dry season of *kharif* 2009 and slightly overestimated for the good rainy season of 2010. This could be due to cool temperatures during pre-flowering stage in the dry season that caused a delay in flower initiation and extended the days to flowering and consequently days to first pod formation stage and maturity days (Dugan *et al.,* 2001). Therefore the best fit for model calibration, thus, caused the predicted values to be between the observed values of the two seasons. Similarly for leaf area index the differences in observed and simulated values was relatively low with a MEP, SD, MBE, RMSE and PE of -2.6, 2.5, -0.2, 0.2 and 4.6, respictively indicating a fairly good simulation.

The simulation of pod yield and final biomass also showed good agreement with the observed values, as shown in Fig. 1. The differences in observed and simulated pod yield was relatively low with a MEP, SD, MBE, RMSE and PE of -1.2, 3.7, -17, 66 and 3.5. Similarly the differences in observed and simulated final biomass was relatively low with a MEP, SD, MBE, RMSE and PE of -5.3, 2.1, -355, 389 and 6 respictively for all the dates of sowing and variety across the years, indicating a fairly good simulation. These results indicated that the calibration of the model based on the reduced data set, consisting of observing dates of developmental stages and plant growth data for three sampling dates respectively, for both the seasons *kharif* 2009 and *kharif* 2010, provided estimates for the cultivar coefficients of the tested peanut cultivars that performed fairly well in simulating crop growth and development over time as well as final pod yield and final biomass (Putto *et al.,* 2009 and Pandey *et al.,* 2001).

Overall performance of the model based on the test criterion clearly indicated that simulation for pod yield was very closer compared to rest of the phenological and growth observations. The decrease in pod yield with delayed sowing as observed in experiment was well simulated by the model. However, under high rainfall situations, the model simulated moderately higher pod yield levels. Thus the model could be used to predict the yield accurately under normal rainfall and different management conditions.

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