Plant Archives Vol. 25, Supplement 1, 2025 pp. 1245-1249 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org
DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2025.v25.supplement-1.169

CALIBRATION AND VALIDATION OF INFOCROP MODEL FOR PHENOLOGY OF DIFFERENT MUSTARD CULTIVARS AT MIDDLE GUJARAT INDIA

Sumitkumar R. Patel*, B. I. Karande and Manoj Lunagaria
Dept. of Agricultural Meteorology, B. A. College of Agriculture,
Anand Agricultural University, Anand-388110, Gujarat, India
*Corresponding author Email: srpatel911@gmail.com
(Date of Receiving : 04-08-2024; Date of Acceptance : 25-10-2024)

ABSTRACT

The InfoCrop model was calibrated and validated with experimental data of three cultivars of mustard *viz.,* (Bio 902, GM 3 and GDM 4) sown on 10th October, 20th October, 30th October and 10th November conducted during 2020-2021 at Agronomy farm, B. A. College of Agriculture, AAU, Anand (Gujarat) during *rabi* season. The model performance was evaluated using MAE, MBE, RMSE and it was observed that InfoCrop model was able to predict the phenology with (error % ± 5).
Keywords **:** InfoCrop model, calibration, validation, mustard cultivars, date of sowing.

Introduction

InfoCrop model was developed by Aggrawal and his co-workers from the Centre for Application of System Simulation, Indian Agricultural Research Institute (IARI), New Delhi (Aggarwal *et al.,* 2004), this model was written in FST (Fortran Simulation Translator) language (Van Kraalingen, 1995). It is a mechanistic and dynamic CSM, which can deal with interaction among weather, crop/variety, soil and agronomic management practices. It can estimate the potential yield and yield gap as well as assess the impact of climate variability and climate change on major agricultural crops like mustard, chickpea, sugarcane, rice, wheat, sorghum, groundnut, pigeon pea, cotton, millet and potato.

Mustard production can be increased by using a model as a management tool for optimization of input requirement and crop management practices. There are limited studies on simulation of growth and yield of mustard crop using a Info Crop model in Gujarat. The objective of this study was therefore to Calibration and validation of InfoCrop model for different mustard cultivars.

Materials and Methods

A field experiment was conducted on plot number A-15 at Agronomy farm near Agrometeorological observatory, B. A. College of Agriculture, AAU, Anand. The research farm is located at the latitude of 22°35' N and longitude of 72°55' E. The altitude of the farm is 45.1 m above mean sea level. The soil of the experiment field was loamy sand. The treatment combinations consisting of four levels of sowing dates (10th October, 20th October, 30th October and 10th November) in a main plot and three varieties (Bio 902, GM 3 and GDM 4) of mustard in a sub-plot were tested under split plot design with four replications.

Input data required to run InfoCrop model

For simulation of the InfoCrop model, the minimum data set required as an input is weather data, site data, soil data, cultivar coefficients, plant data and management data. InfoCrop model required weather data in InfoCrop file format which was done by using weather converter provided in model. Weather converter required site data and daily weather data to generate the weather file. Site data included latitude (degree), longitude (degree) and altitude (meter). Daily weather data required were bright sunshine hours, maximum temperature (°C), minimum temperature

(°C), vapour pressure (kPa), wind speed (m/s), rainfall (mm).

Soil data required were pH, EC (ds/m), slop (%), thickness layer, sand (%), silt (%), clay (%), saturation fraction (0 to 1), field capacity in fraction (0 to 1), wilting point in fraction (0 to 1), saturated hydrolic conductivity (mm/day), bulk density (Mg/m^3), organic carbon (%), initial soil moisture at sowing time (0.1 to 0.4).

Crop data required were crop name, sowing depth (mm), seed rate (kg/ha) and sowing date. Crop/variety management data required were thermal time for germination (degree day), thermal time for seedling emergence to 50% flowering (degree day), thermal time for 50% flowering to maturity (degree day), base temperature (°C), maximum temperature (°C), optimum temperature (°C), relative growth rate of leaf area (°C/d), specific leaf area (dm^2/mg), index of greenness of leaves (scale 0.8-1.2), extinction coefficient of leaves at flowering (ha soil/ha leaf fraction), radiation use efficiency (g/MJ/day), potential root growth rate (mm/d), sensitivity of crop to flooding (scale 1 to 1.2), Index of nitrogen (scale 0.7 to 1.0), Slope of storage organ ($number/m^2$) to dry matter during storage organ formation (storage organ/kg/day), potential storage organ weight (mm/grain), nitrogen content of storage organ (scale 0 to 1.5), sensitivity of storage organ setting to high temperature (scale 0 to 1.5).

Calibration and Validation of the Model

When a model is utilised in situations other than those for which it was built, some differences between measured data and simulated outputs are common. As a result, it's critical to properly analyze these disparities and then fix them so that simulation outputs match measured facts (Whisler *et al.*, 1986). Simply, calibration of the model involves adjusting certain model parameters or relationships to make the model efficiently work for any desired location. The perfect crop input parameter values were fine-tuned to get these results. Other crop values were taken from InfoCrop variety master (default) or other literature sources. Other inputs, such as weather and management data were used based on what was observed in the field. When using a crop model, one has to estimate the crop varietal characteristics. The model requires variety-specific genetic coefficients across the crop. The genetic coefficients for three mustard cultivars (Bio 902, GM 3 and GDM 4) have been calibrated. The method for determining genetic coefficients entails running the model using a range of values of each coefficient until desired level of agreement between simulated and observed values are achieved. The genetic coefficients for mentioned cultivars are given in Table 1.

Table 1 : Calibrated genetic coefficient of following mustard cultivars

Genetic coefficient	Bio 902 (V_1)	GM 3 (V_2)	GDM 4 (V_3)	Source
Phenology				
Thermal time for sowing to germination	151	123.8	123.8	M
Thermal time for germination to 50% flowering	935.3	907.8	849.3	M
Thermal time for 50% flowering to physiological maturity	868.8	908.5	919	M
Base temperature	5	5	5	L
Optimum temperature	24	24	24	L
Maximum temperature	35	35	35	L
Sensitivity to photoperiod	1	1	1	D
Growth				
Relative growth rate of leaf area	0.008	0.008	0.008	D
Specific leaf area	0.0020	0.0021	0.0021	C
Index of greenness of leaves	1	1	1	D
Extinction coefficient of leaves at flowering	0.6	0.6	0.6	C
Radiation use efficiency	2.95	3.41	2.86	M
Potential root growth rate	35	35	35	D
Sensitivity of crop to flooding scale	1	1	1	D
Index of nitrogen fixation	1	1	1	D
Source: Sink balance				
Slope of storage organ to dry matter during storage organ formation	3000000	3000000	3000000	D
Potential storage organ formation	8	8	8	D
Nitrogen content of storage organ	0.039	0.039	0.039	D
Sensitivity of storage organ setting to low temperature	1	1	1	D
Sensitivity of storage organ setting to high temperature	1	1	1	D

*M= Measured, L= Literature, D= Default and C= Calibrated

InfoCrop model was calibrated using observed data of the first date of sowing (10th October 2020) for all cultivars. After calibration, the model was validated for the remaining sowing dates (20th October 2020, 30th October 2020 and 10th November 2020) for all cultivars. In present investigation crop growth and yield parameters were calibrated which were days to emergence, days to 50% flowering, days to physiological maturity, peak LAI, seed yield and biomass yield.

To achieve accuracy, the test criteria suggested by Willmott (1982) were followed while evaluating the performance of the models. Here, accuracy means the degree to which model predictions approach the magnitude of their observed counterparts. For judging the performance of the InfoCrop model, validation results were tested using various statistical parameters *viz*., mean absolute error (MAE), mean bias error (MBE), root mean square error (RMSE), normalized root mean square error (nRMSE), and refined index of agreement (d_r).

$$\text{MAE} = \frac{\sum_{i=1}^{n} |(Si - Oi)|}{n}$$

$$\text{MBE} = \frac{\sum_{i=1}^{n} (Si - Oi)}{n}$$

$$\text{RMSE} = \sqrt{\frac{\sum_{i=1}^{n} (Si - Oi)^2}{n}}$$

$$\text{nRMSE} = \sqrt{\frac{\sum_{i=1}^{n} (Si - Oi)^2}{n}} \times \frac{100}{\bar{O}}$$

$$\bar{O} = \sum_{i=1}^{n} \frac{Oi}{n}$$

Where, Oi = observed, Si = simulated and $\bar{O}$ = observed average,

Refined index of agreement (*dr*) is a standardized scale that ranges from -1 to 1 for the degree of model prediction error. A value of dr 1.0, indicates that the model is perfect or excellent, value of dr 0.5, indicates that the model is very good, when dr = 0, the model is good, when dr = - 0.5, model is fair and values of dr near -1 denotes poor agreement. (Willmott *et al*. 2012)

d_r = Refined index of agreement:

When,

$$\sum_{i=1}^{n} |Si - Oi| \leq c \sum_{i=1}^{n} |Oi - \bar{O}| \text{ with c=2,}$$

$$d_r = 1 - \frac{\sum_{i=1}^{n} |Si - Oi|}{c \sum_{i=1}^{n} |Oi - \bar{O}|}$$

When,

$$\sum_{i=1}^{n} |Si - Oi| > c \sum_{i=1}^{n} |Oi - \bar{O}| \text{ with c=2}$$

$$d_r = \frac{c \sum_{i=1}^{n} |Oi - \bar{O}|}{\sum_{i=1}^{n} |Si - Oi|} - 1$$

$$\text{Error \%} = \{(S - O)/O\} \times 100$$

Where, O= observed and S= simulated

Results and Discussion

Days to Emergence

Simulated days to emergence were compared with observed data for all treatment. The observed days to emergence varied from 6-8 days while simulated one ranged from 6-9 days (Table 2 & Fig. 1 (a)). This result showed that the model was able to simulate days to emergence reasonably well for all treatments (d_r =0.16). The RMSE was 1.29 days. While nRMSE was 19.36%. MAE and MBE were 1 day and 0.78 day respectively.

Days to 50% Flowering

InfoCrop model satisfactorily simulated days to 50% flowering. The observed and simulated values varied from 43 to 52 and 48-53 days respectively. Simulated days to 50% Flowering in different treatment was also in satisfactory with RMSE, nRMSE, MAE and MBE of 3.42 days, 7.10%, 3.00 days, 2.33 days respectively and Refined index of agreement was good with value of 0.21 (Table 2 & Figure 1 (b)). Boomiraj *et al*. (2010) reported similar results of RMSE for flowering days and Gill *et al*. (2016) also reported that InfoCrop model successfully simulated flowering days.

Days to Physiological Maturity

The observed and simulated days to physiological maturity are presented in Table 2 and depicted in Figure 1 (c). Observed days to physiological maturity ranged from 94 to 102 and simulated days ranged from 98 to 106 DAS under different cultivars with deviations of 0 to 5 days. The model performed good for days to physiological maturity with minimum deviation. The model simulated days to maturity was slightly overestimated, these trends showed that the model was able to simulate days to physiological maturity reasonably well for all treatments (Figure 1 (c)). Simulated days to physiological maturity showed good agreement with the observed values with RMSE (3.25 days), nRMSE (3.31%), MAE (2.78 days) and MBE (2.78 days). Refined index of agreement (d_r) was good with the value of 0.43. Result of RMSE was in close agreement with the findings of Boomiraj *et al.* (2010) for maturity days.

Maximum Leaf Area Index

Observed and simulated maximum LAI comparison for different treatments presented in Table 2 and depicted in Figure 1 (d). Observed LAI for different sowing dates and varieties were ranged from 3.59 to 5.15 and simulated LAI varied from 3.8 to 4.3. There was a deviation in the range -16.50% to 14.21%. The model underestimated the maximum LAI except for the D_3V_3 and D_4V_3 treatments. Adak *et al.* (2009) and Choudhary *et al.*, (2014) also reported that model underestimated peak leaf area index. RMSE value very low (0.51), while nRMSE was 11.57% which indicated that model performed poor for LAI. MAE and MBE values were 0.43% and -0.32 respectively. Refined index of agreement (d_r) was good with the value of 0.42. Boomiraj *et al.* (2010) and Kumar *et al.* (2017) reported similar results of RMSE for peak leaf area index.

Table 2: Validation results for different phenophases and leaf area index by InfoCrop model for different treatments

Treatment	Days to emergence			Days to 50% flowering			Days to physiological maturity			Maximum LAI		
	O	S	Diff	**O**	**O**	**O**	O	S	Diff	O	S	Diff.
D_2V_1	7	6	-1	50	48	-2	102	106	4	4.74	4.1	-13.50
D_2V_2	6	6	0	47	51	4	102	104	2	5.15	4.3	-16.50
D_2V_3	6	6	0	43	48	5	100	103	0	4.32	4.2	-2.78
D_3V_1	7	9	2	48	48	0	99	106	1	4.24	3.8	-10.38
D_3V_2	6	7	1	48	53	5	99	104	2	4.81	4.1	-14.76
D_3V_3	6	8	2	46	50	4	97	100	5	3.78	3.8	0.53
D_4V_1	8	8	0	52	51	-1	97	100	2	4.23	4.0	-5.44
D_4V_2	7	9	2	50	53	3	94	101	5	4.48	4.1	-8.48
D_4V_3	7	8	1	49	52	3	94	102	4	3.59	4.1	14.21
RMSE (days)	1.29			3.42			3.25			0.51		
nRMSE (%)	19.36			7.10			3.31			11.57		
MAE (days)	1.00			3.00			2.78			0.43		
MBE (days)	0.78			2.33			2.78			-0.32		
d_r	0.16			0.21			0.43			0.42		

(O= Observed value, S= Simulated value, Diff. = Difference)

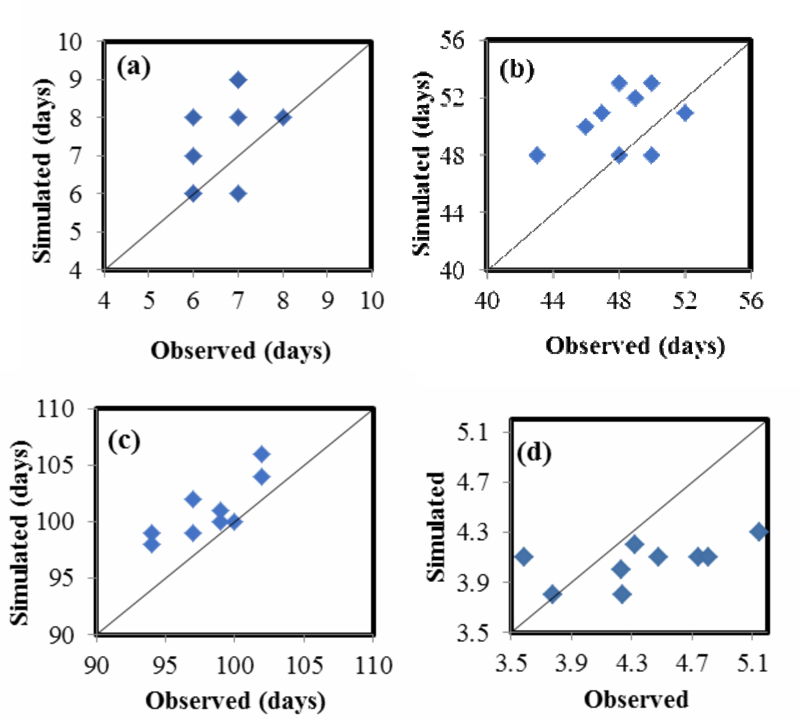

Fig. 1: Mean observed and simulated (a) days to emergence, (b) days to 50% flowering (c) days to physiological maturity and (d) maximum LAI

Conclusion

Results from this simulation study revealed that Info Crop model can successfully simulate phenology and LAI. Hence Info Mustard crop model use as a management tool for optimization of input requirement and crop management practices.

Acknowledgements

Authors are thankful to All India Coordinated Research Project on Agrometeorology (AICRPAM), AAU, Anand for providing crop data.

References

Adak, T., Chakravarty, N.V.K., & Saxena, R. (2009). Growth and yield prediction in mustard using InfoCrop simulation model. *Journal of Agrometeorology*, **11**(2), 156-161.

Aggarwal, P.K., Kalra, N., Chander, S., & Pathak, H. (2004). InfoCrop: A generic simulation model for annual crops in tropical environments. *Indian Agricultural Research Institute*, New Delhi, 132.

Boomiraj, K., Chakrabarti, B., Aggarwal, P.K., Choudhary, R., & Chander, S. (2010). Assessing the vulnerability of Indian mustard to climate change. *Agriculture, Ecosystems and Environment*, **138**(3-4), 265-273.

Choudhary, D., Singh, R., Pannu, R.K., Singh, D., Sheoran, P., & Kumar, A. (2014). Validation and sensitivity analysis of InfoCrop model v.1.0 for phenology, yield and yield attributing characters of Indian mustard cultivars in Western Haryana region. *Journal of Agrometeorology.* 16 (special issue II), 159-163.

Gill, K.K., Kaur, B., Sandhu, S.S., & Kaur, P. (2016). Simulating mustard crop phenology and productivity with InfoCrop-Mustard model under temperature increase scenarios. *Journal of Agrometeorology*, **18**(2), 240-244.

Kumar, Y., Singh, R., Kumar, A., & Nayak, M.K. (2017). Calibration and validation of Info-crop for phenology, growth and yield attributing characters of Indian Mustard varieties in semi-arid region of Haryana. *Vegetos* **30**(4), 1-5.

Van Kraalingen (1995). The FSE system for crop simulation, version 2.1. Quantitative Approaches in Systems Analysis Report no. 1. AB/DLO, PE, Wageningen.

Whisler, F.D., Acock, B., Baker, D.N., Fye, R.E., Hodges, H.F., Lambert, J.R., & Reddy, V.R. (1986). Crop simulation models in agronomic systems. *Advances in Agronomy*, **40**, 141-208.

Willmott (1982). *Validation of the model*. Chapter no. 8 in CERES-Wheat book, Draft no. 1.

Willmott, C.J., Robeson, S.M., & Matsuura, K. (2012). A refined index of model performance. *International Journal of Climatology*, **32**(13), 2088-2094.