



International Journal of Research in Agronomy

E-ISSN: 2618-0618

P-ISSN: 2618-060X

© Agronomy

www.agronomyjournals.com

2024; 7(12): 637-641

Received: 19-10-2024

Accepted: 21-11-2024

Sumitkumar R Patel

Department of Agricultural
Meteorology, B. A. College of
Agriculture, Anand Agricultural
University, Anand, Gujarat, India

BI Karande

Department of Agricultural
Meteorology, B. A. College of
Agriculture, Anand Agricultural
University, Anand, Gujarat, India

Manoj Lunagaria

Department of Agricultural
Meteorology, B. A. College of
Agriculture, Anand Agricultural
University, Anand, Gujarat, India

Corresponding Author:

Sumitkumar R Patel

Department of Agricultural
Meteorology, B. A. College of
Agriculture, Anand Agricultural
University, Anand, Gujarat, India

Calibration and validation of InfoCrop model for yield and yield attributing characters of different cultivars of mustard at Anand

Sumitkumar R Patel, BI Karande and Manoj Lunagaria

DOI: <https://doi.org/10.33545/2618060X.2024.v7.i12h.2235>

Abstract

The present investigation was laid out on the Agronomy farm, B. A. College of Agriculture, AAU, Anand (Gujarat) during *rabi* season of the year 2020-2021. Three cultivars Bio 902, GM 3 and GDM 4 were sown on 10th October, 20th October, 30th October and 10th November. The model was calibrated for three mustard cultivars (Bio 902, GM 3 and GDM 4) under 10th October sowing and validated with rest of sowing window (20th October, 30th October and 10th November). The model performance was evaluated using RMSE, nRMSE, MAE, MBE and Refined index of agreement (*d_r*) and it was observed that InfoCrop model could predict the test weight, seed yield, biomass yield and harvest index with reasonably good accuracy.

Keywords: InfoCrop, calibration, validation, mustard, dates of sowing and varieties

1. Introduction

Crop simulation models (CSMs) are mathematical representation of a real-world system. CSM has been widely used in India to quantify the change in yield potential at different levels of management and climatic variability. These are useful tools in taking critical decisions with respect to optimization of input use in agriculture. Boote *et al.* (1996) ^[3] classified the application of CSMs into three primary categories which are for research knowledge analysis, crop production decision management and policy analysis.

InfoCrop model was developed by Aggarwal and his co-workers from the Centre for Application of System Simulation, Indian Agricultural Research Institute, New Delhi (Aggarwal *et al.*, 2004) ^[1]. This model was written in FST (Fortran Simulation Translator) language (Van Kraalingen, 1995) ^[9]. 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 and also assess the impact of climate variability and climate change on major annual 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. The scientific information on simulation of growth and yield of mustard crop using a model in Gujarat is very limited or lacking. Hence, keeping in view the importance of the study, the present investigation was carried out.

2. 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 replication.

2.1 Input 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/m³), 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 (dm²/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/m²) 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).

2.2 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) [10]. 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 cultivar

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 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) [11] 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).

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

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

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

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

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

Where, O_i = observed, S_i = simulated and $\bar{O}$ = observed average

Refined index of agreement (d_r):

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

3. Results and Discussion

3.1 Test weight

The validation results of observed and simulated values for test weight are presented in Table 2 and depicted in Figure 1 (a). An observed and simulated value for test weight was ranged 3.47 to 5.47 g and 3.8 to 5.2 g, respectively. Deviation ranged from -4.95% to 13.57%. Model slightly overestimated test weight within acceptable error percentage for all treatments except D_2V_1 , D_2V_2 and D_4V_2 . Model performance was good indicated

by RMSE and nRMSE had values 0.29 g and 6.89% respectively. MAE and MBE for test weight were 0.26 g and 0.14 g respectively. Refined index of agreement (d_r) found very good with the value of 0.75. Values of RMSE and MAE had good agreement with the results reported by Keerthi *et al.* (2017)^[6] and Kumar *et al.* (2017)^[8] for seed yield.

3.2 Seed Yield

The observed seed yield and model simulated seed yield presented in Table 2 and depicted in Figure 1 (b). The observed and simulated seed yield values under treatments were ranged from 1228 to 2056 kg/ha and 1400 to 1966 kg/ha respectively, with a deviation of -15.18% to 14.01%. However, the seed yield was slightly overestimated by the model except for D_2V_1 and D_4V_3 . The simulated seed yield showed fairly good agreement with the observed values with RMSE, nRMSE, MAE and MBE of 168 kg/ha, 10.15%, 151 kg/ha, 61.33 kg/ha respectively. Refined index of agreement (d_r) found very good with the value of 0.64. According to Graham *et al.* (2018)^[5], Kumar *et al.* (2010)^[7] and Gill *et al.* (2016)^[4] InfoCrop model was satisfactory simulate mustard seed yield. Result of RMSE was tantamount of Boomiraj *et al.* (2010)^[2] findings. For the seed yield RMSE, MAE and MBE tantamount with the findings of Keerthi *et al.* (2017)^[6] and Kumar *et al.* (2017)^[8]

3.3 Biomass Yield

On field produced biomass and simulated biomass comparison for different treatments presented in Table 2 and depicted in Figure 1 (c). Observed and predicted biomass were ranged from 6090 to 8720 kg/ha, 7122 to 8254 kg/ha respectively. The deviation between observed and simulated biomass values under various treatments ranged from -5.58% to 16.87%. Highest deviation (16.87%) was observed under D_4V_3 . Model overestimated the biomass for all treatments except D_2V_1 and D_2V_2 . The simulated biomass yield showed good agreement with the observed values as evident from the acceptable range of statistical indices, such as RMSE, nRMSE, MAE and MBE of 625.28 kg/ha, 8.36%, 554.44 kg/ha and 411.78 kg/ha respectively. The refined agreement index (d_r) was very good with a value of 0.57. Graham *et al.* (2018)^[5] reported that InfoCrop model satisfactory simulated mustard biomass yield. Statistical results of biomass simulation were identical to results reported by Kumar *et al.* (2017)^[8] and Keerthi *et al.* (2017)^[6].

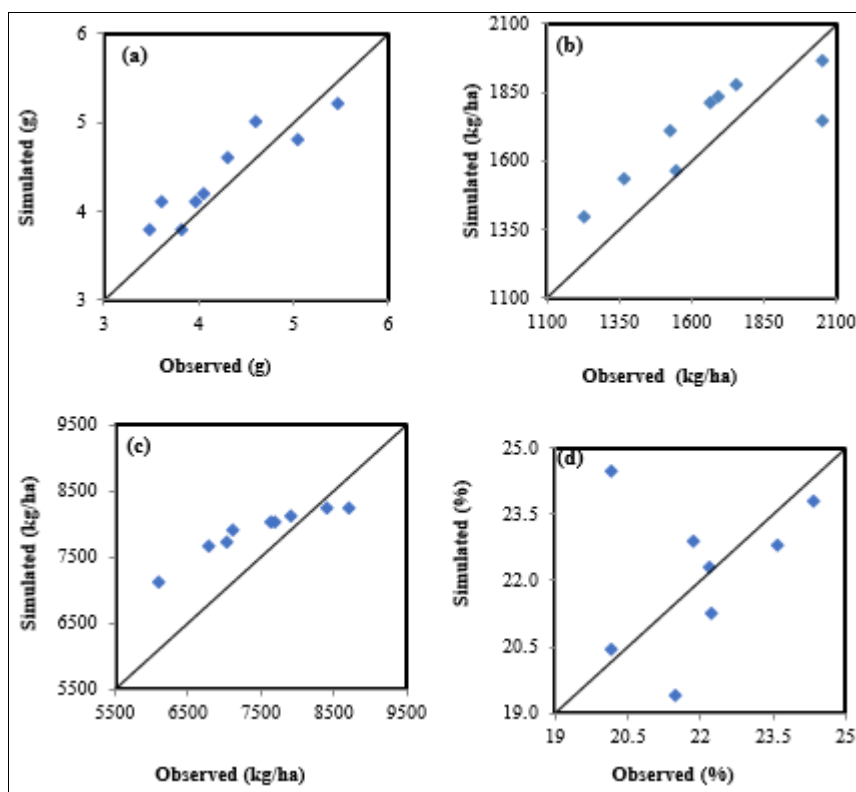
3.4 Harvest Index

The validation values for harvest index are shown in Table 2 and depicted in Figure 1 (d), along with a comparison of observed and predicted values of harvest index. Observed and simulated harvest index was 20.16-24.39% and 18.13-24.49%, respectively. Error ranged from -18% to 21.48%. Comparison of observed and simulated harvest index revealed both over-estimation and under-estimation by the model showed in Figure 1 (d). Points above the 1:1 line indicate overestimated and below trend line indicate underestimated values. RMSE and nRMSE had values 2.15% and 9.79% respectively. MAE and MBE for harvest index were 1.02% and -0.28 respectively. Refined index of agreement (d_r) found good with the value of 0.20. Results of RMSE, MAE and MBE were in close agreement with the findings of Kumar *et al.* (2017)^[8].

Table 2: Validation results for test weight, seed yield, biomass yield and harvest index by InfoCrop model for different treatments

Treatment	Test weight (g)			Seed yield (kg/ha)			Biomass yield (kg/ha)			Harvest index (%)		
	O	S	D (%)	O	S	D (%)	O	S	D (%)	O	S	D (%)
D ₂ V ₁	5.05	4.8	-4.95	2056	1966	-4.38	8409	8254	-1.84	24.36	23.82	-2.22
D ₂ V ₂	5.47	5.2	-4.94	1754	1880	7.18	8720	8233	-5.58	23.58	22.83	-3.18
D ₂ V ₃	4.60	5.0	8.70	1663	1811	8.90	7895	8122	2.88	22.19	22.30	0.50
D ₃ V ₁	4.05	4.2	3.70	1694	1833	8.21	7642	8011	4.83	21.85	22.88	4.71
D ₃ V ₂	4.30	4.6	6.98	1527	1710	11.98	7682	8041	4.67	22.2	21.27	-4.19
D ₃ V ₃	3.97	4.1	3.27	1366	1533	12.23	7108	7894	11.06	21.5	19.42	-9.67
D ₄ V ₁	3.47	3.8	9.51	1547	1566	1.23	6766	7655	13.14	20.18	20.46	1.39
D ₄ V ₂	3.83	3.8	-0.78	1228	1400	14.01	7031	7721	9.81	22.11	18.13	-18.00
D ₄ V ₃	3.61	4.1	13.57	2056	1744	-15.18	6094	7122	16.87	20.16	24.49	21.48
RMSE	0.29			168.00			625.28			2.15		
nRMSE(%)	6.89			10.15			8.36			9.79		
MAE	0.26			151.00			554.44			1.56		
MBE	0.14			61.33			411.78			-0.28		
d _r	0.75			0.64			0.57			0.20		

(O= Observed, S= Simulated and D= Deviation)

**Fig 1:** Mean observed and simulated (a) test weight, (b) seed yield (c) biomass yield and (d) harvest index

4. Conclusion

Results from this simulation study revealed that InfoCrop model can successfully simulate yield and yield attributes. Hence Infocrop mustard model use as a management tool for optimization of input requirement and crop management practices.

5. Acknowledgements

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

6. References

1. Aggarwal PK, Kalra N, Chander S, Pathak H. InfoCrop: A generic simulation model for annual crops in tropical environments. Indian Agricultural Research Institute, New Delhi; 2004:132.
2. Boomiraj K, Chakrabarti B, Aggarwal PK, Choudhary R, Chander S. Assessing the vulnerability of Indian mustard to climate change. *Agric Ecosyst Environ.* 2010;138(3-4):265-273.
3. Boote KJ, Jones JW, Pickering NB. Potential uses and limitations of crop models. *Agron J.* 1996;88(5):704-716.
4. Gill KK, Kaur B, Sandhu SS, Kaur P. Simulating mustard crop phenology and productivity with InfoCrop-Mustard model under temperature increase scenarios. *J Agrometeorol.* 2016;18(2):240-244.
5. Graham A, Singh V, Sahu Y. Validation and sensitivity analysis of InfoCrop simulation model for growth and yield of Indian mustard varieties at Allahabad. *Int J Environ Agric Biotechnol.* 2018;3(6):268-295.
6. Keerthi P, Singh R, Dhaka AK, Divesh C. Growth and yield prediction of Indian mustard using InfoCrop model at Hisar, Haryana. *J Agrometeorol.* 2017;19(3):259-261.

7. Kumar G, Chakravarty NVK, Kurothe RS, Sena DR, Tripathi KP, Adak T, *et al.* Effect of projected climate change on mustard (*Brassica juncea*). J Agrometeorol. 2010;12(2):168-173.
8. Kumar Y, Singh R, Kumar A, Nayak MK. Calibration and validation of InfoCrop for phenology, growth and yield attributing characters of Indian Mustard varieties in semi-arid region of Haryana. Vegetos. 2017;30(4):1-5. doi: 10.4172/2229-4473.
9. Van Kraalingen. The FSE system for crop simulation, version 2.1. Quantitative Approaches in Systems Analysis Report no. 1. AB/DLO, PE, Wageningen; 1995.
10. Whisler FD, Acock B, Baker DN, Fye RE, Hodges HF, Lambert JR, Reddy VR. Crop simulation models in agronomic systems. Adv Agron. 1986;40:141-208.
11. Willmott. Validation of the model. In: CERES-Wheat book, Draft no. 1; 1982. Chapter 8