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Calibration and validation of CERES-wheat model for wheat in middle Gujarat region*

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ABSTRACT

CERES (Crop Environment Resource Synthesis)-wheat model (DSSAT v 3.5-Decision Support System for Agrotechnology Transfer) was calibrated and validated for wheat cv. GW-496 at Anand using experimental data collected under different management practices (Date of sowing x Irrigation) during 1995-2007. Results showed that optimum sowing date (D_2–15th Nov.) validation was found better as compared to early (D_1–1st Nov.) and late (D_3–30th Nov.) sowings. The validation of model for different irrigation regimes showed that the performance of model was poor in treatment having less irrigation (I_1 and I_2). The model performance was found good and satisfactory in treatments having 6-7 irrigations (I_3 and I_4). On an average, the performance of model for I_4 treatment was found good. This showed that model worked better under optimum sowing with optimum irrigation. The various test criteria for evaluation of model showed that highest correlation was observed in D_2I_3 treatment. The lowest MAE was observed in D_3I_3 treatment. Similarly, lowest MBE (12.77), lowest RMSE (46.04) and highest index of agreement (1.0) were observed in D_1I_4 treatment. The error per cent by CERES-wheat model showed that in majority of the cases the models had underestimated wheat yield. Per cent error ranged between -0.020 to -56.02. The average per cent error was found lowest in D_1I_4, D_2I_4 and D_3I_3 irrigation treatments as compared to other treatments. This showed that the model worked good in all model test criteria. In a nutshell, the validation results showed that the model worked better under optimum sowing with optimum irrigation as compared to early/late sowing and moisture stress conditions.

Key words : CERES-wheat, DSSAT, simulation

Crop growth simulation models are quantitative tool based on scientific knowledge that can evaluate the effect of climatic, edaphic, hydrological and agronomic factors on crop growth and yield. Boote *et al*. (1996) classified the application of crop simulation models into three primary categories : (i) for research knowledge synthesis, (ii) for crop production decision management and (iii) for policy analysis. Crop yield simulation modeling in any crop helps to have target oriented approach in achieving regional food security. Crop simulation models have been used to determine potential yield of any crop in which possibilities for the yield improvement can be assessed. The estimated yields serve as a reference for calculating the required various agronomic inputs and for assessing their environmental impacts. Bell and Fischer (1994) studied potential yields of wheat in the Yaqui valley of Maxico for the period 1968-90 by CERES-wheat model. Aggarwal and Kalra (1994) made such a comparison of climatic potential versus actual wheat yields in New Delhi, India. Aggarwal (2000) studied climatically potential grain yield of wheat and yield gaps in India. Crop simulation modeling after thorough calibration helps in various agronomic decisions in reference to yield improvement such as selection of optimum sowing window coupling with different irrigation regimes. Aggarwal and Kalra (1994) examined the effect of sowing date on yield of wheat in India using WTGROW model. Results revealed that maximum grain yield was obtained during 1 to 15th November sowing.

MATERIALS AND METHODS

The CERES-wheat model was calibrated and validated with the data sets generated during *rabi* seasons of 1995-96 through field experiment laid out in strip plot design with four replications on loamy sand soils of the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand. The main treatments were three dates of sowing with an interval of two weeks from 1st Nov. to 30th Nov. (D_1–1st Nov., D_2–15th Nov. and D_3–30th Nov.) and the sub-plot treatments were irrigation levels ranging between three irrigations in I_1 and six irrigations in I_4 coinciding with critical stages of crop growth. The sub-plot details were : I_1 –CRI, BT and ML, I_2–CRI, TL, FL and DS, I_3–CRI, TL, BT, FL and ML and I_4- CRI, TL, BT, FL, ML and DS (CRI–Crown Root Initiation, TL–Tillering, BT–Booting, FL–Flowering, ML–Milking and DS–Dough stage). The calibrated model has been validated for 13 consecutive years (1995-2007).

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Table 1: Genetic coefficients for wheat cv. GW-496 at Anand condition

Parameters	Genetic coefficients
PHINT	72.90
P1V	0.5
P1D	1.5
P5	3.5
G1	5.5
G2	4.2
G3	5.2

RESULTS AND DISCUSSION

Calibration of the CERES-Wheat model

The CERES-wheat model has been calibrated by conducting field experiments during the year 1995-96 for validation of phenology, biometric parameters and yield. The calibration of genetic coefficients as mentioned in the present model for wheat cv. GW-496 had been carried out as per Hunt's (Hunt *et al.*, 1993) method. The calibrated genetic coefficients based on field experimental data for wheat cv. GW-496 in middle Gujarat region (Anand) condition are mentioned in Table 1.

Validation of the model for dates of sowing

The calibrated genetic coefficients have been used to validate the CERES-wheat model for the years 1995 to 2007. The results of comparison of actual and simulated wheat yield under different dates of sowing are presented in Table 2. Results showed that optimum sowing date (D_2–15th Nov.) validation was found better as compared to early (D_1–1st Nov.) and late (D_3–30th Nov.) sowings. However, the more number of years have underestimated the grain yield of wheat in normal sown crop as compared to early/late sown crop, but the magnitude of underestimation was lower in D_2 sown crop as compared to D_1 and D_3 sowings. This shows that model works better under optimum sowing conditions.

Validation of the model for different irrigation regimes

Validation results showed that the performance of DSSAT model was found very poor in I_1 and I_2 irrigation treatments. The model performance was found good and satisfactory in I_3 and I_4 irrigation treatments. On an average, the performance of I_4 treatment was found good. This shows that model works better under optimum sowing with optimum irrigation. The comparison of mean actual and simulated wheat yield over the year. In nutshell, the validation results show that model works better under optimum sowing with optimum irrigation as compared to early/late sowing and stress treatments (Table 2).

Table 2: Test criteria in evaluation of model with respect to seed yield of wheat (kg ha^{-1})

Treatment	OMY	SDo	SMY	SDs	r	Student 't' (Prob.)	MAE	MBE	RMSE	Index of agreement (D)
D_1I_1	3441.69	841.99	3120.69	333.07	-0.22	0.26^{NS}	765.92	-321.00	1157.38	0.89
D_1I_2	3732.08	808.82	3907.77	286.48	-0.07	0.48^{NS}	738.62	175.69	633.47	0.97
D_1I_3	4556.46	709.26	4240.92	473.66	0.24	0.16^{NS}	613.54	-315.54	1137.69	0.87
D_1I_4	4559.62	688.71	4572.38	626.51	0.12	0.96^{NS}	633.23	12.77	46.04	1.00
D_2I_1	3995.46	732.21	3010.85	476.44	0.14	0.00*	1061.54	-984.62	3550.08	-0.03
D_2I_2	4313.92	735.93	3849.92	330.74	0.50	0.02*	572.46	-464.00	1672.98	0.69
D_2I_3	5119.15	587.33	4525.69	590.06	0.55	0.00*	607.62	-593.46	2139.76	0.82
D_2I_4	5127.69	741.49	5078.54	548.44	0.43	0.81^{NS}	523.31	-49.15	177.23	1.00
D_3I_1	3518.69	1000.67	2711.31	396.00	-0.14	0.02*	1160.00	-807.38	2911.06	0.71
D_3I_2	3970.08	791.30	3519.23	301.68	-0.06	0.08^{NS}	790.54	-450.85	1625.55	0.70
D_3I_3	4490.69	549.77	4288.00	638.87	0.44	0.27^{NS}	463.00	-202.69	730.82	0.46
D_3I_4	4647.00	579.82	5029.08	643.90	0.38	0.07^{NS}	601.77	382.08	1377.60	0.77

OMY : Observed mean yield (kg/ha), SMY : Simulated mean yield (kg/ha), SDo : Standard deviation of observed, SDs : Standard deviation of simulated, r : Correlation coefficient, MAE : Mean absolute error, MBE: Mean bias error, D : Index of agreement.

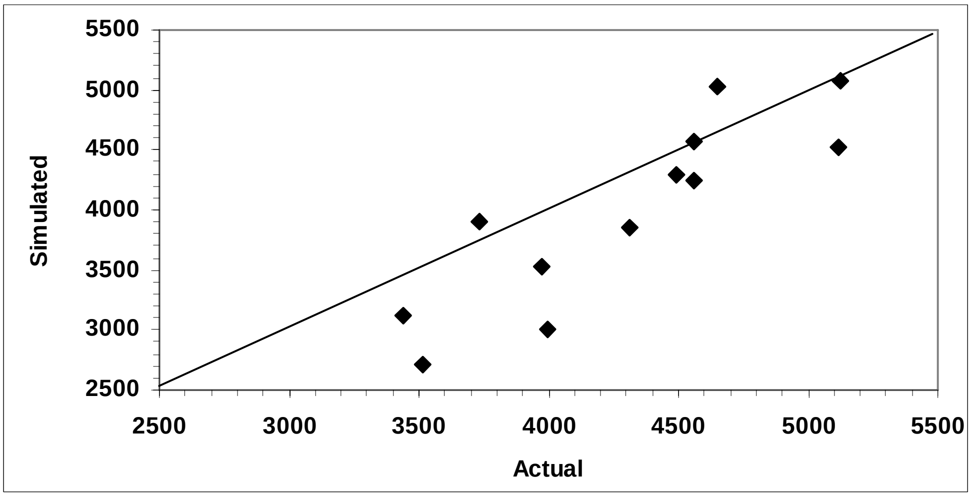

Fig. 1: Comparison of mean actual and simulated wheat yield (kg ha^{-1}) under different treatments.

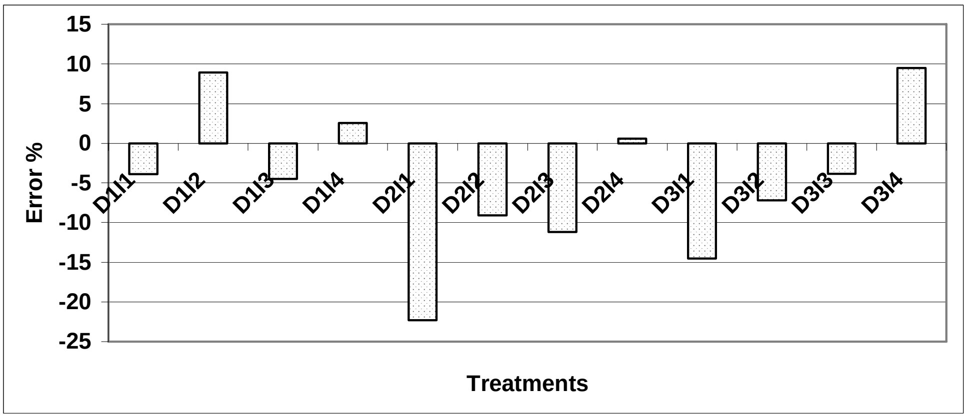

Fig. 2 : Average error per cent by CERES-wheat simulated grain yield from observed mean.

Evaluation of the model

The various test criteria for evaluation of model have been computed treatment-wise and presented in Table 2. Results showed that highest correlation was observed in D_2I_3 treatment. The lowest MAE (Mean Absolute Error) was observed in D_3I_3 treatment. Similarly, lowest MBE (Mean Bias Error) (12.77), lowest RMSE (46.04) and highest index of agreement (1.0) were observed in D_1I_4 treatment. This shows that validation of I_4 irrigation treatment was found better as compared to other treatments Fig.1 shows that model under estimated the wheat yield in most of the cases .

The treatment-wise average error per cent is depicted in Fig. 2. The average per cent error was found lowest in D_1I_4, D_2I_4 and D_3I_3 irrigation treatment as compared to other treatments. This shows that model works satisfactorily under optimum sowing with optimum irrigation as compared to early/late sowing and stress treatments.

REFERENCES

Aggarwal, P. K. (2000). Application of systems simulation for understanding and increasing yield potential of wheat and rice. Landbouwuniversitcit Wageningen (Wageningen Agricultural University) Wageningen : The Netherlands.

Aggarwal, P. K. and Kalra, N. (1994). Analyzing the limitations set by climatic factors, genotype and water and nitrogen availability on productivity of wheat. II. Climatically potential yields and management strategies. *Field Crops Res*., 38 : 93-103.

Bell, M. A. and Fischer, R. A. (1994). Using yields prediction to assess yield grains : A case study for wheat. *Field*

Crops Res., 36 : 161-66.

Boote, K. J., Jones, J. W. and Pickering, N. B. (1996). Potential use and limitations of crop models. *Agron. J.,* 88 : 704-16.

Hunt, L. A., Pararajasingham, S., Jones, J. W., Hoogenboom, G., Imamura, D. T. and Ogoshi, R. M. (1993). Gentale : Software to facilitate the use of crop models to analyze field experiment. *Agron. J.*, 85 : 1090-94.