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Validation of InfoCrop model for rice cultivar under eastern plain zone of Uttar Pradesh

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ABSTRACT

The InfoCrop v 1.1 model was calibrated and validated with experimental data of 3 cultivars of rice (NDR-97, NDR-359 and Swarna Sub-1) conducted during 2002-2012 at Kumarganj, Faizabad (U.P.). The model performance was evaluated using MAE, MBE, RMSE and it was observed that InfoCrop model was able to predict the growth parameters like days taken to anthesis, maximum leaf area index, biomass and yield with reasonably good accuracy (error % less than 10).

Key-words: InfoCrop-rice model, calibration, validation, rice cultivars, date of sowing and eastern plain zone.

InfoCrop simulates the effects of weather, soils, agronomic management including planting, nitrogen, residues and irrigation with major pests on crop growth and yield. It is a dynamic crop-yield model, developed by Aggarwal and his co-workers from the centre for Application of Systems Simulation, IARI, New Delhi. InfoCrop has incorporated 13 crops including rice and wheat. It has capacity to evaluate the production of major annual crops and has an inbuilt data base of Indian soils (Aggarwal *et al.,* 2006).

In Uttar Pradesh rice cultivation is risk prone due to erratic rainfall in term of delayed monsoon, intermittent drought or terminal drought and even floods particularly in north eastern part of state. Simulation models which help in evaluating the growth and yield of a crop is therefore the need of the day. Looking these aspects the present study has been undertaken to assess the InfoCrop model for different cultivars of rice grown in entire U.P.

MATERIALS AND METHODS

The InfoCrop model requires daily weather data of maximum and minimum air temperature (^{0}C), solar radiation (k Jm^{-2} d^{-1}), vapour pressure (kPa), wind speed (ms^{-1}) and rainfall (mm). The daily meteorological data were collected from the Agromet observatory, N.D. University of Agriculture and Technology, Kumarganj Faizabad (Uttar Pradesh).

The field experimental data collected during 2002-2010 for three rice cultivars namely, NDR-97, NDR-359 and Swarna Sub-1 were used to derive genetic coefficients. The details of the coefficients derived and further used in the model for validation and other applications are given in Table 1. For calibration and validation of InfoCrop model two years (2011 and 2012) data were used.

The performance of model was evaluated using statistical measures as given by Willmott (1982). These include mean absolute error (MAE), mean bias error (MBE) and root mean square error (RMSE) which was calculated as follows;

$$\mathrm{MAE} = \sum_{i=1}^{n} \left[1 P_i - O_i 1\right] / n$$

$$\mathrm{MBE} = \sum_{i=1}^{n} \left[P_i - O_i\right] / n$$

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

Besides the above test criteria, error percent was also calculated in different treatment under study to express the deviation more scientifically.

This is as follow:

Error % = {(simulated – observed) / observed} * 100

Table 1: Genetic coefficient derived for rice cultivars under EPZ climatic condition of U.P. used in InfoCrop model

Parameters	NDR-97	NDR-359	Swarna Sub-1
A. Phenology			
Thermal time (^{0}C days)			
Sowing to germination	50	60	55
Germination to 50% flowering	1650	1689	1530
50% flowering to physiological maturity	430	455	380
Optimal temperature (^{0}C)	32.0	32.0	32.0
Maximum temperature (^{0}C)	45.0	45.0	45.0
Sensitivity to photoperiod	1.0	1.0	1.0
B. Growth			
Relative growth rate of leaf area (^{0}C day^{-1})	0.009	0.009	0.009
Specific leaf area (dm^2 mg^{-1})	0.0022	0.0023	0.0027
Index of greenness of leaves	1.0	1.0	1.0
Extinction coefficient of leaves at flowering	0.6	0.8	0.5
Radiation use efficiency (g MJ^{-1} day^{-1})	2.8	2.4	2.6
Root growth rate (mm day^{-1})	12.0	12.0	12.0
Sensitivity of crop to flooding scale	1.0	1.0	1.0
Index of N fixation	1.0	1.0	1.0
C. Source: Sink Balance			
Slope of storage organ number/m^2 to dry matter during storage organ formation (storage organ/kg^{-1} day^{-1})	56000	56000	56000
Potential storage organ weight (mg^{-1} grain^{-1})	25	28	26
Nitrogen content of storage organ (fraction)	0.012	0.014	0.012
Sensitivity of storage organ setting to low temperature	1.0	1.0	1.0
Sensitivity of storage organ setting to high temperature	1.0	1.0	1.0

Table 2: Validation of InfoCrop model for days to anthesis of rice cultivars under different dates of transplanting (Mean data of year 2011 and 2012)

	NDR-97			NDR-359			Swarna Sub-1		
	30th June	15th July	30th July	30th June	15th July	30th July	30th June	15th July	30th July
Observed	57.0	56.0	52.5	69.0	66.5	62.5	94.5	95.5	99.0
Simulated	59.0	59.5	54.5	71.5	70.5	65.5	96.5	99.0	104.0
Error (%)	3.4	5.9	3.7	3.5	5.7	4.6	2.1	3.5	4.8
MAE	2.5	3.8	2.7	3.1	5.4	3.7	3.5	4.3	6.7
MBE	2.5	3.8	2.7	3.1	5.4	3.7	3.5	4.3	6.7
RMSE	2.7	4.0	2.9	7.1	11.2	8.1	3.7	4.9	7.2

Table 3: Validation of InfoCrop model for days to physiological maturity of rice cultivars under different dates of transplanting (Mean data of year 2011 and 2012)

	NDR-97			NDR-359			Swarna Sub-1		
	30th June	15th July	30th July	30th June	15th July	30th July	30th June	15th July	30th July
Observed	82.0	83.0	80.5	98.0	97.0	98.5	113.5	119.5	128.5
Simulated	86.5	89.0	83.5	101.5	100.5	101.5	121.0	126.5	133.0
Error (%)	5.2	6.7	3.6	3.4	3.5	3.0	6.2	5.5	3.4
MAE	4.5	5.9	3.4	3.3	4.2	2.9	6.3	5.2	3.6
MBE	4.5	5.9	3.4	3.3	4.2	2.9	6.3	5.2	3.6
RMSE	4.9	6.7	3.8	9.9	10.8	7.8	7.6	6.4	5.9

Table 4: Validation of InfoCrop model for leaf area index of rice cultivars under different dates of transplanting (Mean data of year 2011 and 2012)

	NDR-97			NDR-359			Swarna Sub-1		
	30th June	15th July	30th July	30th June	15th July	30th July	30th June	15th July	30th July
Observed	2.3	3.0	3.1	2.4	3.1	3.4	3.4	4.0	4.5
Simulated	2.3	2.7	3.0	2.3	2.9	3.1	3.4	3.8	4.3
Error (%)	0.0	-11.1	-3.3	-4.3	-6.9	-9.7	0.0	-5.3	-4.7
MAE	0.18	8.12	6.20	0.21	3.46	6.52	0.18	4.7	6.2
MBE	0.18	8.12	6.20	-0.22	3.46	6.52	0.18	4.7	6.2
RMSE	0.21	9.32	2.32	0.57	4.54	8.81	0.31	5.4	6.8

Table 5: Validation of InfoCrop model for biomass production of rice cultivars under different dates of transplanting (Mean data of year 2011 and 2012)

	NDR-97			NDR-359			Swarna Sub-1		
	30th June	15th July	30th July	30th June	15th July	30th July	30th June	15th July	30th July
Observed	8469.5	9857.0	10691.0	10305.0	11989.0	12515.5	9527.0	11082.0	12076.0
Simulated	8251.5	9582.0	10532.5	10263.0	11784.5	11991.0	9281.0	11143.5	11926.0
Error (%)	-2.6	-2.9	-1.5	-0.4	-1.7	-4.4	-2.7	0.6	-1.3
MAE	217.16	222.43	189.47	257.01	345.76	372.26	227.16	124.56	215.28
MBE	-217.16	-222.43	-189.47	-257.01	-345.76	-372.26	-111.5	124.56	-215.28
RMSE	252.42	272.23	220.36	613.93	824.36	992.20	257.57	198.80	204.54

Table 6: Validation of InfoCrop model for grain yield of rice cultivars under different dates of transplanting (Mean data of year 2011 and 2012)

	NDR-97			NDR-359			Swarna Sub-1		
	30th June	15th July	30th July	30th June	15th July	30th July	30th June	15th July	30th July
Observed	3859.5	4595.0	4576.0	4497.5	5045.0	4975.5	3838.5	4369.0	4169.0
Simulated	4143.0	4743.0	4820.5	4690.5	5377.0	5006.5	4124.0	4526.5	4436.5
Error (%)	6.8	3.1	5.1	4.1	6.2	0.6	6.9	3.5	5.8
MAE	225.3	198.6	202.4	185.33	212.46	110.54	233.5	198.4	201.4
MBE	225.3	198.6	202.4	185.33	212.46	110.54	233.5	198.4	201.4
RMSE	244.85	212.48	218.44	625.7	678.8	426.2	245.27	202.66	212.62

RESULTS AND DISCUSSION

Days to anthesis

Data pertaining to days to anthesis (days) revealed that the model simulated the days to anthesis with reasonably good accuracy for all cultivars and three dates of transplanting. The error percent varied between 2.1% in case of Swarna Sub-1 variety transplanted on 30th June to 5.9% in case of NDR-97 sown on 15th July. The MAE, MBE and RMSE analysis also support that the model slightly overestimated in all the cases (Table 2).

Days to physiological maturity

Data pertaining to days to physiological maturity (days) revealed that the model simulated the days to physiological maturity with reasonably good accuracy for all cultivars and three dates of transplanting. The error percent varied between 3.0% in case of NDR-359 transplanted on 30th July to 6.7% in case of NDR-97 sown on 15th July. The MAE, MBE and RMSE analysis also support that the model slightly overestimated in all the cases (Table 3).

Maximum leaf area index

Maximum leaf area index was underestimated by the model for all cultivars in all dates of transplanting. The error percent ranged between 0 to -11.1%, both extremes were observed with rice variety NDR-97. The other statistical parameters like MAE, MBE and RMSE also suggested underestimation. Adak et al. (2009) also reported that the InfoCrop model underestimated the maximum LAI under the accepted range of error percentage. Hence this model be used with care for predicting LAI (Table 4).

Biomass at maturity (kg ha^{-1})

InfoCrop model simulated the biomass yield quite close for NDR-359 variety with minimum mean error percentage (-0.4 %) transplanted on 30th June among the varieties under present investigation (Table 5). However, the model underestimated the biomass yield for all genotypes in all dates of transplanting. The similar result has also been reported by Akula, (2003).

Grain yield (kg ha^{-1})

The model quite satisfactorily simulated the grain yield as observed (Table 6) with error percent of less than 7% in all the treatments. The lowest error percent of 0.6 was observed for NDR-359 variety transplanted on 30th July. It was found that the model overestimated the grain yield in all the cases of variety and dates of transplanting within the acceptable range of error percentage. Based on MAE, MBE and RMSE it is concluded that the evaluation of the model revealed that the yield simulation was found well with an accepted level for all the cultivars and sowing dates. The similar result has also been reported by Akula *et al.,* (2005).

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