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Performance of CERES-rice model for prediction of different rice cultivars at Navsari

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सार – धान की तीन फसलों नामत: V_1 - जया V_2 - गुर्जरी तथा V_3 - GNR-2 जिनका प्रतिरोपरण तीन विभिन्न तारीखों नामत: D_1- 12 जुलाई, 2012, D_2- 27 जुलाई, 2012 तथा D_3- 11 अगस्त, 2012 तथा दो नाइट्रोजन स्तरों नामत: N_1 - 75 kg/ha और N_2 - 100 kg/ha के लिए CERES - धान मॉड्ल वैधता की जॉच करने के लिए नवसारी कृषि विश्वविद्यालय के कॉलेज फार्म में 2012 की खरीफ ऋतु के दौरान फील्ड प्रयोग किए गए। यह प्रयोग स्प्लिट प्लॉट डिज़ाइन मे किया गया। इसके बाद मॉड्ल की वैधता फील्ड प्रयोग से प्राप्त प्रेक्षित ऑकड़ो से स्थापित की गई। CERES धान मॉडल की प्रतिक्रिया से यह पाया गया कि प्रतिशत त्रुटि PE (-4.25%) के साथ पैनीकल इनोशिएशन, एनथिसीस (-3.4%) और दाने के भरने के आरंभ (1.05%) के संबंध में 100 kg N स्तर पर प्रतिरोपण की तीसरी तारीख पर cv. गुर्जरी के लिए जोनोटाइप पूर्वानुमान सटीकता बेहतर रही। परन्तु अन्य विवेचनों की तुलना में परिपक्वता स्तर के लिए प्रतिरोपण की तीसरी तारीख में PE (-0.97%) के साथ समान N स्तर में cv. GNR-2 को बेहतर पाया गया।

ABSTRACT. Filed experiment was conducted during *kharif* season of 2012 at college farm of Navsari Agricultural University, (Gujarat) to investigate the CERES-Rice model validation for three rice cultivars, *viz*., V_1 - Jaya, V_2 - Gurjari and V_3 - GNR-2 with three different dates of transplanting, *viz*., D_1- 12 July, 2012, D_2- 27 July, 2012 and D_3-11 August, 2012 and two nitrogen levels, *viz*., N_1-75 kg/ha and N2-100 kg/ha. The experiment was laid out in a split plot design. The model was subsequently validated against observed data from field experiment. From the response of CERES-Rice model it was found that among the genotypes prediction accuracy for cv. Gurjari at third date of transplanting at 100 kg N level was better in respect to panicle initiation with percent error PE (-4.25%), anthesis (-3.40%) and beginning of grain filling (1.05%). But for physiological maturity stage, cv. GNR-2 was found better at third date of transplanting at same N level with PE (-0.97%) as comparison to other treatments.

Key words – CERES-Rice model, Genetic coefficient, Rice genotypes, Transplanting dates, Nitrogen levels.

1. Introduction

India is the second largest producer of rice in the world after China. It has an area of 43 million hectares with the production of 99 million tones and 3.45 t/ha productivity (Anonymous, 2012). Crop simulation models are principal tools needed to bring agronomic sciences into information sciences. With these crop models, it is possible to simulate a living plant through the mathematical and conceptual relationship which governs its growth in the Soil - Water - Plant - Atmosphere continuum. Crop simulation models explain much of the interaction between the environment and the crops. These models predict the performance of a particular cultivar, sown at any time in any climate and would lead to information on transfer of agro-technology. CERES-Rice model is a process based management-oriented model that can simulate the growth and development of rice crop (Ritchie *et al*., 1998). In the present study, the CERES (Crop Environment Resources Synthesis) Rice model developed by IBSNAT has been used to simulate the phonological occurrence of rice genotypes at different transplanting date and nitrogen levels.

2. Materials and method

Crop growth simulation models, if properly validated against data have the potential for tactical and strategic decision making in agriculture. However, before using model for any purpose, it needs to be calibrated and

TABLE 1

Genetic coefficients for three different cultivars of rice at Navsari condition

Genetic Conflict	Description	Genotypes of rice		
		Jaya	Gurjari	GNR-2
P1	Time period (expressed as growing degree days [GDD] in °C above a base temperature of 9 °C) from seedling emergence to end of juvenile phase during which the rice plant is not responsive to changes in photoperiod. This period is also referred to as the basic vegetative phase of the plant.	740.0	710.0	700.0
P2R	Extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in °C) for each hour increase in photoperiod above P2O.	100.0	150.0	150.0
P2O	Critical photoperiod or longest day length (in hours) at which the development occurs at maximum rate. At values higher than P2O the development rate is slowed (depending on P2R), there is delay due to longer day length.	550.0	500.0	550.0
P5	Time period in GDD in °C from beginning of grain-filling (3-4 days after flowering) to physiological maturity with base temperature of 9 °C	11.5	11.0	11.5
G1	Potential spikelet number coefficient as estimated from number of spikelets per g of main culm dry weight (less lead blades and sheaths plus spikes at anthesis. A typical value is 55.	58.0	55.0	55.0
G2	Single dry grain weight (g) under ideal growing conditions. *i.e.*, non limiting light, water, nutrients, and absence of pests and diseases.	0.0240	0.0250	0.0280
G3	Tillering coefficient (scalar value) relative to cultivars under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.	1.00	1.00	1.00
G4	Temperature tolerance coefficient. Usually 1.0 for cultivars grown in normal environment.G4 for japonica type rice grown in warmer environments would be ≥ 1.0. Tropical rice grown in cooler environments or season will have G4 < 1.0	1.00	1.00	1.00

validated for the location/crop/variety. To generate required crop management data, a field experiment was conducted at College Farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (20° 57′ N, 72° 54′ E and 10 m above mean sea level), Gujarat, India, during *kharif* season of the year 2012. For the present study CERES-Rice model was calibrated based on past three years experimental crop data (2009, 2010 and 2011) and subsequently validated with crop data of the year 2012. In the present investigation genetic coefficients (Table 1) were developed with past three year data of rice genotypes. The different test criteria, *viz*., mean of observed and simulated values, root mean square error (RMSE), mean bias error (MBE), mean per cent error (PE), and chi square test (X^2) were used to evaluate the performance of model for phenological characters of all three rice cultivars.

3. Results and discussion

Validation of simulation modeling was done on the parameter of panicle initiation (DAT), anthesis (DAT), grain filling (DAT) and physiological maturity (DAT). The findings of experiment have been categorized and presented as follows:

3.1. *Panicle initiation*

The observed and simulated data on days taken to panicle initiation (DAT) at different dates of transplanting and nitrogen levels of rice genotypes have been presented in (Table 2). It is quite obvious that in cv. Jaya the simulated days to panicle initiation were in good agreement with the observed values at 75 kg nitrogen level with relatively low root mean square error (RMSE), mean bias error (MBE), percent error (PE) and Chi square test value (X^2) of 4.96, -4.66 and 11.11, 24.66 respectively, followed by 100 kg nitrogen level with RMSE = 5.91, MBE = -5.66, PE =12.58, X^2 = 35 (NS) respectively. But in case of cv. Gurjari, good agreement was found with the observed values at 100 kg nitrogen levels with relatively low RMSE, MBE, PE and X^2 value of 4.54, -4.00, 8.74 and 20.66 respectively. Also in cv. GNR-2 the simulated days to panicle initiation was in

TABLE 2

Comparison of observed with simulated value for panicle initiation DAT at different dates of transplanting and nitrogen levels

Varieties	Nitrogen levels	Transplanting dates D$_1$ (12 Jul 2012) Observed	D$_1$ (12 Jul 2012) Simulated	D$_2$ (27 Jul 2012) Observed	D$_2$ (27 Jul 2012) Simulated	D$_3$ (11 Aug 2012) Observed	D$_3$ (11 Aug 2012) Simulated	RMSE	MBE	PE	$X^2_{(5.99)}$
Jaya	N$_1$(75 kg/ha)	45	41 (-8.88%)	43	40 (-6.98%)	46	39 (-15.21%)	4.96	-4.66	11.11	NS (24.6)
	N$_2$(100 kg/ha)	48	43 (-10.42%)	46	42 (-8.7%)	47	39 (-17.02)	5.91	-5.66	12.58	NS (35.0)
Gurjari	N$_1$(75 kg/ha)	55	48 (-12.72%)	51	47 (-7.85%)	49	45 (-8.16%)	5.19	-5	10.05	NS (27.0)
	N$_2$(100 kg/ha)	57	50 (-12.29%)	52	49 (-5.77%)	47	45 (-4.25%)	4.54	-4	8.74	NS (20.6)
GNR-2	N$_1$(75 kg/ha)	48	44 (-8.33%)	48	43 (-10.02%)	48	41 (-14.58%)	5.47	-5.33	11.41	NS (30.0)
	N$_2$(100 kg/ha)	52	46 (-11.54%)	50	44 (-12.0%)	45	41 (-8.88%)	5.41	-5.33	11.05	NS (29.3)

RMSE: Root mean square error, MBE: Mean bias error, PE: Percent error, X^2: Chi square test value, NS: Non-significant, S: Significant

TABLE 3

Comparison of observed with simulated value for anthesis at different dates of transplanting and nitrogen levels

Varieties	Nitrogen levels	Transplanting dates D$_1$ (12 Jul 2012) Observed	D$_1$ (12 Jul 2012) Simulated	D$_2$ (27 Jul 2012) Observed	D$_2$ (27 Jul 2012) Simulated	D$_3$ (11 Aug 2012) Observed	D$_3$ (11 Aug 2012) Simulated	RMSE	MBE	PE	$X^2_{(5.99)}$
Jaya	N$_1$ (75 kg/ha)	79	76 (-3.79%)	77	74 (-3.89%)	81	72 (-11.11%)	5.74	-5	7.27	NS (33.0)
	N$_2$ (100 kg/ha)	82	78 (-4.78%)	80	76 (-5.0%)	83	72 (-13.25%)	7.14	-6.33	8.74	NS (51.0)
Gurjari	N$_1$ (75 kg/ha)	90	84 (-6.66%)	86	82 (-4.65%)	85	89 (4.70%)	4.76	-2	5.47	NS (22.6)
	N$_2$ (100 kg/ha)	94	86 (-8.51%)	89	84 (-5.6%)	88	91 (-3.40%)	6.78	-6.66	7.50	NS (32.6)
GNR-2	N$_1$ (75 kg/ha)	89	80 (-10.11%)	85	78 (-8.23%)	84	75 (-10.71%)	8.38	-8.33	9.75	NS (70.3)
	N$_2$ (100 kg/ha)	89	81 (-8.98%)	87	78 (-10.34%)	85	81 (-8.88%)	7.32	-7	9.44	NS (53.6)

RMSE: Root mean square error, MBE: Mean bias error, PE: Percent error, X^2: Chi square test value, NS: Non-significant, S: Significant

TABLE 4

Comparison of observed with simulated value for beginning of grain filling DAT at different dates of transplanting and nitrogen levels

Varieties	Nitrogen levels	Transplanting dates						RMSE	MBE	PE	$X^2_{(5.99)}$
		D_1 (12 Jul 2012)		D_2 (27 Jul 2012)		D_3 (11 Aug 2012)					
		Observed	Simulated	Observed	Simulated	Observed	Simulated				
Jaya	N_1 (75 kg/ha)	85	82 (-3.52%)	89	81 (-8.98%)	88	79 (-10.22%)	7.16	-6.66	8.20	NS (51.3)
	N_2 (100 kg/ha)	88	84 (-4.54%)	87	82 (-5.74%)	89	78 (-12.35%)	7.34	-6.66	8.35	NS (54.0)
Gurjari	N_1 (75 kg/ha)	96	90 (-6.25%)	93	88 (-5.37%)	92	94 (2.17%)	4.66	-3.0	4.96	NS (21.6)
	N_2 (100 kg/ha)	99	92 (-7.07%)	94	90 (-4.25%)	95	96 (1.05%)	4.59	-3.3	4.88	NS (22.0)
GNR-2	N_1 (75 kg/ha)	95	86 (-9.47%)	91	84 (-7.69%)	91	81 (-10.98%)	8.75	-8.6	9.48	NS (76.0)
	N_2 (100 kg/ha)	96	87 (-9.37%)	94	85 (-9.57%)	86	80 (-6.97%)	8.12	-8.0	8.83	NS (66.0)

RMSE: Root mean square error, MBE: Mean bias error, PE: Percent error, X^2: Chi square test value, NS: Non-significant, S: Significant

TABLE 5

Comparison of observed with simulated value for physiological maturity at different dates of transplanting and nitrogen levels

Varieties	Nitrogen levels	Transplanting dates						RMSE	MBE	PE	$X^2_{(5.99)}$
		D_1 (12 Jul 2012)		D_2 (27 Jul 2012)		D_3 (11 Aug 2012)					
		Observed	Simulated	Observed	Simulated	Observed	Simulated				
Jaya	N_1 (75 kg/ha)	115	110 (-4.34 %)	111	108 (-2.70%)	105	101 (-3.80%)	4.08	-4	3.70	NS (16.6)
	N_2 (100 kg/ha)	118	112 (-5.08 %)	114	108 (-5.26%)	106	100 (-5.66%)	6	-6	5.32	NS (36.0)
Gurjari	N_1 (75 kg/ha)	122	116 (-4.91 %)	119	116 (-2.52 %)	115	117 (1.73%)	4.04	-2.33	3.40	NS (16.3)
	N_2 (100 kg/ha)	125	118 (-5.6 %)	121	113 (-6.61 %)	117	119 (1.70 %)	6.24	-4.33	5.16	NS (39.0)
GNR-2	N_1 (75 kg/ha)	119	114 (-4.20 %)	118	113 (-4.23 %)	106	103 (-2.83 %)	4.43	-4.33	3.87	NS (12.6)
	N_2 (100 kg/ha)	121	116 (-4.13%)	120	110 (-8.33 %)	103	102 (-0.97 %)	6.48	-5.33	5.65	NS (42.0)

RMSE: Root mean square error, MBE: Mean bias error, PE: Percent error, X^2: Chi square test value, NS: Non-significant, S: Significant good agreement with the observed values at 100 kg nitrogen level with comparatively low in RMSE, MBE, PE and X^2 (5.41, -5.33, 11.05, 29.33 respectively) followed by 75 kg nitrogen level. The results are in good agreement with the findings of Kumar and Tripathi (2009) who observed that accuracy of simulated value decreased with late sowing in all genotypes. Chi square test values showed non-significant difference between observed and simulated value for all treatments.

3.2. *Anthesis (DAT)*

The observed and simulated value on days taken to anthesis (DAT) at different dates of transplanting and nitrogen levels of rice genotypes have been presented in (Table 3). The simulated results of days taken to anthesis (DAT) showed that the model satisfactorily simulated actual field value in cv. Jaya at 75 kg nitrogen level with RMSE = 5.74, MBE = -5, PE = 7.27 and X^2 = 33 respectively, followed by 100 kg nitrogen level. The value of RMSE, MBE, PE and X^2 for cv. Gurjari at 75 and 100 kg nitrogen level were 4.76, -2.0, 5.47, 22.66 and 6.78, -6.66, 7.50, 32.66 respectively. These values showed good agreement with observed value at 75 kg nitrogen level as compared to 100 kg nitrogen levels. However, in cv. GNR-2 the simulated days to anthesis (DAT) was in good agreement with the observed values at 100 kg nitrogen level with comparatively low RMSE, MBE, PE and X^2 value of 7.32, -7, 9.44, 53.66 respectively. X^2 values show non-significant difference between observed and simulated value for all treatments. Results are found to be in accordance with Kaur and Hundal (2001) and Swain *et al.* (2007).

3.3. *Grain filling (DAT)*

The observed and simulated days taken to grain filling (DAT) under different dates of transplanting and nitrogen levels of rice genotypes have been shown in (Table 4). It is revealed that in cv. Jaya the simulated days to grain filling (DAT) was in good agreement with the observed values at 75 kg nitrogen level with RMSE, MBE, PE and X^2 values of 7.16, -6.66, 8.20 and 51.33 respectively, followed by 100 kg nitrogen level. But in cv. Gurjari the simulated value was in good conformity with the observed values at 100 kg nitrogen level with comparatively low RMSE, MBE, PE and X^2 values of 4.59, -3.3, 4.88 and 22 respectively, followed by 75 kg nitrogen level. In cv. GNR-2 the simulated days to grain filling (DAT) was in good agreement with the observed values at 100 kg nitrogen level with comparatively low RMSE, MBE, PE and X^2 values of 8.12, -8.0, 8.83 and 66.0 respectively, followed by 75 kg nitrogen level. Chi square values showed non-significant difference between observed and simulated values for all treatments.

3.4. *Physiological maturity (DAT)*

The observed and simulated data on days taken to physiological maturity (DAT) at different dates of transplanting and nitrogen levels of rice genotypes have been presented in (Table 5). In cv. Jaya the simulated days to physiological maturity (DAT) was in good agreement with the observed values at 75 kg nitrogen level with relatively low RMSE, MBE, PE and X^2 values of 4.08, -4.00, 3.70 and 16.66 respectively, followed by 100 kg nitrogen level with RMSE = 6, MBE = -6, PE = 5.32 and X^2 = 36. Similarly in cv. Gurjari the better agreement was found with the observed values at 75 kg nitrogen level with comparatively low RMSE, MBE, PE and X^2 values of 4.04, -2.33, 3.40 and 16.33 respectively, followed by 100 kg nitrogen level. For the rice cultivar GNR-2 the good agreement was found with the observed values at 75 kg nitrogen level with comparatively lower RMSE, MBE, PE and X^2 values of 4.43, -4.33, 3.87 and 12.66 (NS) respectively, followed by 100 kg nitrogen level. The results obtained in this study are comparable to that of Dass *et al.* (2012) for rice maturity Chi square values demonstrated non-significant difference between observed and simulated values for all treatments.

4. Conclusions

The good agreement was recorded between observed and simulated days for different phonological stages under different date of transplanting and nitrogen levels in all three cultivars. Various test criteria revealed that the model performance in respect of phenology was satisfactory with minimum error. Hence, it is useful to predict the phonological occurrence of rice genotypes to help farmers make broad scale decision on the rice crop management operation.

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