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Short Comminucation

Evaluation of CERES-Rice model for Upper Brahmaputra Valley Zone of Assam

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Rice (*Oryza sativa*) is the single most important food crop of Assam.In spite of technological advancement, rice is a risky enterprise under unfavorable climatic environment, which seems to be increased in future due to increase in climate change related weather variability. As rice is sensitive to weather and various rice cultivars response to different environment in dissimilar way, it is desirable to identify the potential of the crop and to better understanding of cultivars, soil and weather interactions. For this purpose, crop growth models such as those in Decision Support System for Agro technology Transfer (DSSAT) have been used successfully in many places around the world for a wide range of conditions and applications (Hoogenboom *et al.,* 2010).Usually in many cases the models are found site as well as crop specific and are not always relevant for other regions. Thus their applicability needs to be evaluated; generally when such models are introduced into a new region. The CERES- Rice model has been successfully adopted in Indian condition and successfully calibrated by many workers (Kumar *et al.*, 2007, Singh *et al.*, 2015, Vysakh *et al.*, 2016) to predict phenology and grain yield of rice accurately. Thus, the present study was undertaken to calibrate and validate CERES-Rice model for two rice cultivars (Luit and TTB-404) for Upper Brahmaputra Valley Zone (UBVZ) of Assam.

Field experiments were conducted during *kharif,* 2015 in the Instructional cum Research (ICR) farm of Assam Agricultural University, Jorhat situated at the latitude of 26°47' North,longitude 94°12' East and altitude 87 m above mean sea level. The experiment was laid out in factorial RBD (with three replication) with four dates of sowing at the interval of 15 days from 27 June to 10August, 2015 with two cultivars *viz.*Luit and TTB-404. Twenty five days old seedlings were used in transplanting for both the cultivars at 21July, 5 August, 20 August and 4 September, 2015. The crop was grown following recommended agronomic practices. The daily meteorological data were recorded in the agrometeorological observatory situated adjacent to the experimental plot.

CERES–Rice model of DSSAT version 4.5 was used to analyze phenological development and grain yield of two rice varieties *viz.,* Luit and TTB-404. All the inputs files required for running the model *viz.* weather file, soil file and crop files were created using weather records and soil profile information of the station and the field experiments conducted during different years. A total of six crop data sets generated from field experiments either during *kharif,* 2015 or in previous years (unpublished) in the same field were used to calibrate the CERES-Rice model for both the varieties. Out of six data sets used, four data sets were generated during *kharif,* 2015 for both the varieties. Another two sets of crop data used were generated during 2013 and 2014 in case of Luit and TTB-404, respectively. Eight genetic coefficients that influence the occurrence of growth and phenology in CERES-rice model for both the variety (Luit and TTB-404) were derived iteratively following previous workers (Neog *et al.*, 2006; Shamim *et al.,* 2012; Deka *et al.,* 2016). The coefficients were adjusted until there was close match between observed and simulated days to anthesis, physiological maturity and grain yield, as shown in the Table 1.

The performance of the model was validated by comparing the observed and simulated outputs i.e. anthesis date, physiological maturity date and yield at harvest. Root mean square error (RMSE) and index of agreement (d-stat) were used for evaluation of model simulation performance following previous workers (Singh *et al.*, 2015). A low RMSE value and d-stat value that approaches one are desirable during calibration and validation.

Calibration of CERES-Rice model

A comparison between observed and simulated phenological events and grain yield during calibration of

Table 1: Calibrated genetic coefficients of rice cultivars Luit and TTB-404

Genetic coefficient	Description	Calibrated genetic coefficient	
		Luit	TTB-404
P1	Basic vegetative phase, it is the time period expressed as growing degree days [GDD] in °C above a base temperature of 9°C.	350.0	723.2
P2R	Photoperiod sensitivity coefficient (°C), extent to which the phase development leading to panicle initiation is delayed.	65.0	195.3
P5	Time period in GDD (°C) from beginning of grain filling to physiological maturity with a base temperature of 9°C.	300.0	295.7
P2O	Critical photoperiod (hour) or the longest day length in hours at which the development occurs at a maximum rate.	12.10	11.80
G1	Potential spikelet number per panicle.	43.0	46.0
G2	Single grain weight (g).	0.020	0.022
G3	Tillering coefficients.	0.60	1.00
G4	Temperature tolerance coefficient	0.65	0.95

the model in both the varieties showed that the deviation of observed from the simulated values for anthesis (50% flowering) was varied from -1 to +5 and -1 to +4 in case of Luit and TTB-404, respectively (Table 2). Similarly, deviation of observed values from the simulated values in case of physiological maturity was within an acceptable limit of 10 per cent for both the varieties. The model was adjusted in such a way that it would able to simulate anthesis and maturity day accurately with RMSE of 2.31 and 2.85 days and d-stat 0.65 and 0.51 for Luit and RMSE of 2.30 and 7.50 days and d-stat of 0.62 and 0.59 for TTB-404, respectively. Model was calibrated for simulating grain yield accurately with low RMSE values 245 and 387 kg ha^{-1} and higher d-stat values 0.78 and 0.78 for the cultivar Luit and TTB-404, respectively (Table 2).

Validation of CERES-Rice model

There was a good agreement between observed and simulated days to attain different phenological events for both the varieties. The model could able to predict anthesis day almost accurately, with percentage deviation of 10 per cent in different transplanting dates, with an RMSE value 2.91 and 2.0 and d-Stat of 0.50 and 0.60for Luit and TTB-404 respectively (Table 3).Like anthesis, the physiological maturity day was also well predicted by the model in both the varieties. The percentage deviation between observed and predicted values was within 3.7 per cent for different transplanting dates in both the varieties. The RMSE and d-stat values for Luit and TTB-404 were 1.41 and 0.80 and 3.53 and 0.56, respectively.The result of this study corroborates with the study carried out by Deka *et al.* (2016), from three years of field experiment on *Ranjit* cultivar in Upper Brahmaputra Valley zone of Assam.

The model was able to simulate the grain yield accurately in Luit with per cent deviation of observed values from the simulated values within 10 per cent with an RMSE of 325 kgha^{-1}and d-stat of 0.9. The model underestimated the grain yield in case of TTB-404. The RMSE and d-stat for the yield of TTB-404 were 449 kgha^{-1}and 0.34, respectively (Table 3). However, the predicted yield was closer to the measured one in case of TTB-404 which was transplanted on 12-July, 2015 with percent deviation of 3.6 per cent. The model underestimate the grain yield of TTB-404, resulting higher deviation from observed value (in the order of 14.2%) and low d-value (0.34) in case of TTB-404 transplanted on 1st August, 2015. Since days to flowering and physiological maturity were more stable within the variety, the minimum deviations were observed among different dates of transplanting in both the cultivars. On the other hand grain yield were highly susceptible to environmental condition and field management operations, thus shows more variations (Phakamas, 2015).Shamim *et al*. (2012) performed similar field experiment under middle Gujarat Agroclimatic Zone on four aromatic rice cultivars.

It may be concluded from the above findings that the CERES-Rice model was found to be good enough to predict the phenological events of both the rice varieties – Luit and TTB-404 for Upper Brahmaputra Valley zone of Assam, thus enable farmers to take decision on phenological aspects of crop management operations. Though grain yield was accurately predicted by the model in case of Luit, it failed to

Table 2: Observed and simulated phenological events and grain yield of rice cultivar Luit and TTB-404 (Calibration of the model)

Date of transplanting	Days to anthesis		Days to physiological maturity		Grain yield (kg ha^{-1})	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
			Luit			
17 Aug, 2013	47	48	74	72	3309	3021
26 Aug, 2013	44	49	75	77	2916	3220
21 July, 2015	50	52	77	73	3160	3053
05 Aug, 2015	49	49	76	71	3263	2952
20 Aug, 2015	47	48	73	73	3240	3361
04 Sept, 2015	47	48	77	77	2386	2634
RMSE		2.31		2.85		245
d-stat		0.65		0.51		0.78
			TTB-404			
13 July, 2014	80	84	110	107	4358	4169
03 Aug, 2014	81	80	111	105	4709	4635
21 July, 2015	79	80	109	109	4989	4523
05 Aug, 2015	80	81	111	118	5354	5995
20 Aug, 2015	80	82	110	122	4842	5338
04 Sept, 2015	85	84	118	128	4298	4770
RMSE		2.30		7.50		387
d-stat		0.62		0.59		0.78

Table 3: Observed and simulated phenological events and grain yield by CERES-Rice model for rice cultivar Luit and TTB-404 (Validation of the model)

Date of transplanting	Days to anthesis		Days to Physiological maturity		Grain yield (kg ha^{-1})	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
			Luit			
17 Aug, 2012	49	50	76	76	3276	3272
26 Aug, 2012	46	50	80	78	2046	2505
RMSE		2.91		1.41		325
d-stat		0.50		0.80		0.90
			TTB-404			
12 July, 2015	82	84	112	108	4054	4040
01 Aug, 2015	80	82	115	112	4500	3864
RMSE		2.0		3.53		449
d-stat		0.60		0.56		0.34

estimate accurately in one planting date in case of TTB-404, which might be due to less number of observations. Therefore, the CERES-Rice model needs further validation with more numbers of years of balanced set of data in order to increase confidence level prior to the application of the model.

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