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Short Communication

Calibration of DSSAT-CERES-Rice model for rice cultivars under different N-levels in Meghalaya, India

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Optimum levels of all the inputs given to the crops result in better performance. But optimizing the inputs needs comprehensive understanding of the physiological processes. Crop simulation models often become handy to identify the complex management factors of these physiological processes (Sarkar and Kar, 2006). Models found to give decision support to the managers and farmers to decide right level of management to minimise different risks and possible to have mid-course corrections in the event of contingent situations.The main goal of a crop simulation model is to estimate crop production, resource use and environmental impact as a function of local weather and soil conditions and crop management (Hoogenboom, 2000). Genetic potential is an independent factor specific to crop and variety, any universal model cannot be possible unless, such models specifically calibrated/tested and analyze for sensitivity to changes of various parameters. Hence variety specific study for model calibration and simulation is always important.

Dry matter production and its conversion to economic yield is a cumulative effect of various physiological processes occurring during the plant life cycle. High solar radiation during the growing season and abundant supply of nitrogen favoured accumulation of high biomass and yield (Akita, 1989). Nitrogen is one of the most yield-limiting nutrients in lowland rice production, and proper N management is essential for optimizing rice grain yield (Fageria *et al*., 1997). Using higher N rates for increasing rice yield is a promising management recommendation. Increased uptake of nitrogen influences the number of tillers, panicles and spikelets per square meter (Yoshida, 1972). When N-fertilizer is applied in proper amount and at the correct time, N-fertilizer recovery can be achieved up to 50–70% of total nitrogen applied (Peng *et al.,* 1996). Considering the aforesaid aspect an experiment was conducted with three popular rice varieties in this region (Umiam, Meghalaya, India) viz. CAU-R1, Shahsarang-1 and Lumpnah-1 under four levels of N-fertilizers and calibrated the DSSAT-CERES-Rice model against the observed data.

In the present study, three rice varieties (CAU-R1, Shahsarang-1 and Lumpnah-1) cultivated under four N-regimes (60, 80, 100, 120 kg ha^{-1}) *kharif* in 2016 at Umiam, Meghalaya were used for calibration of the DSSAT-CERES-Rice model.The field experiments were conducted in 2-factorial randomized block design with three replications. For successful use of CERES-Rice model, minimum data sets (MDS) on crop management, 10 years weather data file (UMIM.WTH), soil file (UM.SOL) and other parameters were entered as input for running the model. The genetic coefficients of the rice cultivars were calculated with the help of GENCALC (Genotype Coefficient Calculator) as per standard procedure of iteration for the models and calibrated the model for the cultivars. The statistical models such as regression coefficient (R^2), index of agreement (d-stat) and root mean square error (RMSE) as available in the DSSAT model framework were considered for evaluating out the accuracy of simulation for different N-regimes.

Calibration of CERES-Rice model for the rice cultivars

Cropping system model DSSAT-CERES-Rice requires a set of eight eco-physiological coefficients for simulation of growth and grain yield of any cultivar. The genetic coefficients estimated for the current varieties were shown in Table 1.

Calibration of DSSAT-CERES-Rice model was done with the help of observed experimental data during the *kharif* season 2016. The genetic coefficients were estimated for the cultivars CAU-R1, Shahasarang-1 and Lumpnah-1 and created the cultivars files for simulation.

Time period (GDD) from seedling emergence to end of juvenile phase or P1 was similar for CAU-R1 and Shahsarang-1 (500.0) and for Lumpnah-1 (600.0). These differences indicate that the Lumpnah-1 takes more heat units for the completion of vegetative phase of the crop

Table 1: Genetic coefficients of rice varieties computed through CERES-Rice Model

Symbol	Genetic coefficients of rice varieties		
	CAU-R1	Shahsarang-1	Lumpnah-1
P1	500.0	500.0	600.0
P2R	90.0	90.0	90.0
P2O	350.0	350.0	350.0
P5	12.0	11.5	11.5
G1	48.0	48.0	48.0
G2	0.270	0.270	0.270
G3	0.90	0.90	0.90
G4	1.0	1.0	1.0

Where

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.

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.

P2O: Critical photoperiod or longest day length (in hours) at which the development occurs at maximum rate. At values higher than P20 the development rate is slowed (depending on P2R), there is delay due to longer day length.

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

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 heading. A typical value is 55.

G2: Single dry grain weight (g) under ideal growing conditions, i.e., non limiting light, water, nutrients, and absence of pests and diseases.

G3: Tillering coefficient (scalar value) relative to IR64 cultivars under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.

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.

compared to other two varieties. Lumpnah-1 showed long juvenile phase because of its longer duration. Photoperiodism coefficient (GDD) or P2R and critical photoperiod coefficients (hour) or P2O were similar for all the three varieties. Grain filling duration coefficient (GDD) or P5 was higher in CAU-R1 (12.0) variety and for Shahsarang-1 and Lumpnah-1 it was similar (11.5). The growth coefficients were (G1, G2, G3 and G4) same for all three varieties (48.0, 0.270, 0.90 and 1.0).

CERES-Rice model underestimated the phenological stages of the 2 cultivars *viz*. CAU-R1 and Shahsarang-1. The model predicted the days from sowing to anthesis and sowing to maturity with a difference of 1 to 8 days compared to the observed values for these two varieties. Dass *et al*. (2012) also reported under estimation of days to flowering and physiological maturity for rice varieties by using CERES-Rice model (Table 2). As indicated by R^2 and d-stat values, the simulated maturity duration for all the varieties was found to be in good agreement with the observed values.

The simulated and observed values of grain yield were in good agreement for CAU-R1 and Lumpnah-1 but not in case of Shahsarang-1. The R^2 value for maturity yield of Shahsarang-1 indicated lack of trend in differences between observed and simulated values; however, relatively good values of d-stat (0.53) indicated the agreement of the simulated value to the observed one. The simulated values of above ground biomass to the observed values were not in good agreement for all the varieties. In case of Lumpnah-1, though R^2 was high (0.97), indicating a good trend, the index of agreement was only 0.25 indicating a poor prediction.

Though DSSAT-CERES-Rice underestimated phenological stages of CAU-R1 and Shahsarang-1, however, it could predict the yield very close and was very effective to predict the phenological stages of rice cultivars. R^2, RMSE and d-State indicated that DSSAT-CERES-Rice model can be effectively used for yield prediction of the rice varieties under the present experiment, however further experiment may be considered to refine the calibration of model so that both yield and phenological stages can be closely predicted. With the present calibration, it was also found that the model was successful in prediction of yield at different N-regimes. Further study can be also planned for sensitivity of the models against different climatic parameters and other management practices of modified cultivation environment.

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Table 2: Model performance for the rice cultivars

Levels of N	Anthesis day		Maturity day		Yield (kg ha^{-1})		Above ground biomass (kg ha^{-1})	
	Sim	Obs.	Sim.	Obs.	Sim.	Obs.	Sim.	Obs.
CAU-R1								
N=60 kg ha^{-1}	84	90	128	130	3479	4194	8232	9769
N=80 kg ha^{-1}	84	89	126	130	4130	4345	10087	10216
N=100 kg ha^{-1}	84	89	124	130	4600	4543	11713	10509
N=120 kg ha^{-1}	84	92	123	141	5162	4503	13413	10445
R^2	-		0.83		0.81		0.46	
RMSE	6.12		9.8		498.8		1777.5	
d-Stat	0.24		0.56		0.39		0.37	
Shahsarang-1								
N=60 kg ha^{-1}	88	92	136	141	3884	3517	8081	7909
N=80 kg ha^{-1}	88	93	131	139	3884	3617	9869	9730
N=100 kg ha^{-1}	88	93	130	138	4241	4397	11365	8897
N=120 kg ha^{-1}	88	94	129	138	4671	4520	12977	11953
R^2	-		0.62		0.25		0.29	
RMSE	2.1		5.9		266.6		1606.6	
d-Stat	0.31		0.8		0.53		0.009	
Lumpnah-1								
N=60 kg ha^{-1}	97	95	152	141	2991	3183	7727	9363
N=80 kg ha^{-1}	97	94	144	141	3515	3333	9562	10087
N=100 kg ha^{-1}	97	99	139	142	3520	3777	11125	9163
N=120 kg ha^{-1}	97	99	139	142	3661	4070	12417	10540
R^2	-		0.84		0.72		0.97	
RMSE	5.05		7.70		197.0		1349.8	
d-Stat	0.16		0.95		0.85		0.25	

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