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Calibration and validation of DSSAT model v4.6 for different rice cultivar at Navsari

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Abstract
The DSSAT model was calibrated and validated for *kharif* rice for *cv.* NAUR-1 and GNR-3 using past experimental data (2011 to 2015) and experiment was conducted on college farm, Navsari Agricultural University, Navsari. The genetic coefficients were developed through interactive process for rice genotypes are presented in (Table 1). The different test criteria *viz.*, mean of observed and simulated values, root mean square error (RMSE), mean bias error (MBE) and mean percent error (PE) were used to evaluate the performance of model for simulation of yield and yield attributes characters of two rice cultivars for grain yield, above ground biomass, physiological maturity as simulated by model were compare with the observed data. The result revealed that model underestimated the above biomass production and physiological maturity for the both the cultivar and overestimated for grain yield. The lowest percent error (PE) of grain yield and physiological maturity are showed -6.48 and -2.26 at 75 kg/ha nitrogen level and 2.46 for above ground biomass at 100 kg nitrogen level.

Keywords: CERES-Rice model, simulation, calibration, validation

Introduction
Rice (*Oryza sativa* L.) is one of the most important crop/food for more than three billion people (*i.e.*, approximately 50% of the World's population) (Khush, 2005) [5]. The United States Department of Agriculture (USDA) estimates that the world rice Production during 2016-17 is estimated about 496.0 million metric tons (FAO, 2016) [2, 4]. In Gujarat, rice is cultivated on an area of 0.76 million ha with total production of 1.76 million tonnes and productivity 2189 kg ha-1 (Anon., 2016) [2]. The crop is mainly grown in *kharif* and in *summer* season in Navsari, Valsad, Surat, and the Dang districts of South Gujarat where perennial canal irrigation facilities are available. Among these, Navsari district occupies 87,500 ha area with production of 2, 36,600 tonnes and productivity of 2.70 t ha^{-1} (Anon., 2013) [1]. As crop growth simulation models are useful tools for considering the complex interactions between a range of factors that affect crop performance, including weather, soil properties and crop management. The CERES-Rice model simulates crop growth, development and yield. Hence, the present field experimentation was carried out for selecting suitable aromatic cultivar and appropriate time of transplanting using CERES-Rice models. Crop growth simulation models, properly validated against data have the potential for tactical and strategic decision making in agriculture. Such validated model can also take the information generated through site specific experiment and trial to other sites years (Ritchie *et al.* 1988) [6]. CERES-Rice model was used to simulate the growth and development of rice as affected by varying levels of nitrogen. However, before using model for any purpose, it needs to be calibrated and validated for the location/ crop/ variety.

Materials and Methods
The field experiment was conducted on Plot No.F-23, College farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat during *kharif* season of the year 2016. The Navsari Agricultural University campus is geographically located at 20° 57' N latitude and 72° 54' E longitude at an altitude of 16 m above the mean sea level. Two different cultivars are transplanted on different dates. The different phenological phases of plant development and the observations thereof were recorded by visiting the field frequently from raising of seedlings to harvesting. The genetic coefficients of rice were estimated by repeated interactions until a close match between simulated and observed phenology and yield was obtained in respective treatments. The values of genetic coefficients as derived from calibration of the model are presented in Table 1. The different test criteria viz., mean of observed and simulated values, root mean square error (RMSE), mean bias error (MBE) and

mean percent error (PE) were used to evaluate the performance of model for simulation of yield and yield attributes characters of two rice cultivars.

To achieve accuracy, the test criteria suggested by Wiltmott (1982) [10] were followed while evaluating the performance of the models. The observed (O) and simulated (P) values were used to calculate error percent (PE).

PE = {(simulated-observed)/observed)}*100

$$\mathrm{MBE} = \sum_{i=1}^{n} [P_i - O_i]/n \quad \text{and } \mathrm{RMSE} = [\sum_{i=1}^{n} (P_i - O_i)^2/n]^{\frac{1}{2}}$$

Table 1: Genetic coefficients for two cultivars of rice at Navsari

Cultivar	Parameter					
	P1	P2R	P2O	G1	G2	G3
NAUR-1	640.0	125.0	400.0	47.0	0.0220	0.87
GNR-3	650.0	130.0	410.0	48.0	0.0230	1.00

Result and Discussion

Grain yield

The observed and simulated grain yield of rice as influenced by different treatments are presented in (Table 2). Among two different dates of transplanting, the per cent error of simulated grain yield over observed were found very low (-6.48) in *cv*. NAUR-1 at 75 kg/ha and simulated grain yield found closest with observed values with per cent error (-6.48) as compared to GNR-3 cultivars. In case of nitrogen levels the simulated yield at 100 kg nitrogen level was having higher per cent error (-8.57), than that of 75 kg/ha N level. In cv. NAUR-1 the simulated values for grain yield was in good agreement with the observed values at 75 kg nitrogen level with relatively low in RMSE, MBE and PE of 3.27, 2.31, -6.48, 0.41 respectively, followed by 100 kg nitrogen level. Similar results are found to be in association with Sreenivas and Reddy (2013) [9].

Above ground biomass

The observed biomass was found to decrease with delay in transplanting and simulated yield also decreased, The observed and simulated biomass production of rice as influenced by different treatments are presented in (Table 2). Among two different dates of transplanting, the per cent error of simulated above ground biomass over were found very low (2.46) in *cv*. GN3-1 at 100 kg/ha. In case of nitrogen levels the simulated value for biomass production at 75 kg nitrogen level was having higher per cent error (8.41), than that of 100 kg/ha N level. In *cv*. GNR-3 the simulated values for above ground biomass was in good agreement with the observed values at 100 kg nitrogen level with relatively low in RMSE, MBE and PE of 2.67, -1.98, -6.48, 2.46 respectively, followed by 75 kg nitrogen level. The results are in good agreement with the finding of Shamim *et al.*, (2012) [7].

Physiological maturity

The observed and physiological maturity of rice as influenced by different treatments are presented in (Table 2). Among two different dates of transplanting, the per cent error of simulated physiological maturity underestimated observed were found very low (2.26) in *cv*. GNR-3 at 75 kg/ha and simulated physiological maturity found closest with observed values with per cent error (2.55) as compared to NAUR-1 cultivars. In case of nitrogen levels the simulated yield at 100 kg nitrogen level was having higher per cent error (3.93), than that of 75 kg/ha N level. In cv. GNR-3 the simulated values for physiological maturity was in good agreement with the observed values at 75 kg nitrogen level with relatively low in RMSE, MBE and PE of 4.52, -3.25, 2.26 respectively, followed by 100 kg nitrogen level. Similar results are observed by singh *et al.*, (2015) [8] and Dass *et al.*, (2012) [3].

Table 2: Comparison of observed with simulated value for grain yield, above ground biomass and physiological maturity at different dates of transplanting and nitrogen level

Variety	Transplanting dates	Grain yield (q ha^{-1})				Above ground Biomass (q ha^{-1})				Physiological Maturity (DAT)			
		Nitrogen level (kg/ha)											
		75 (kg/ha)		100 (kg/ha)		75 (kg/ha)		100 (kg/ha)		75 (kg/ha)		100 (kg/ha)	
		Obs	sim	obs	sim	obs	sim	obs	sim	Obs	sim	obs	sim
NAUR-1	18	49.12	51.89 (+5.63)	46.25	53.52 (+8.67)	85.86	81.00 (-5.32)	86.48	83.00 (-4.02)	120	114 (-5.00)	118	115 (-2.54)
	28	47.46	51.17 (+7.81)	47.53	51.47 (+8.28)	87.91	79.00 (-12.13)	86.97	80.00 (-9.58)	121	115 (-7.25)	120	114 (-5.00)
	RMSE	3.27		4.11		7.07		5.50		6.00		4.74	
	MBE	2.31		3.12		-6.51		-3.48		-4.50		-3.00	
	PE	-6.48		-7.82		8.41		6.41		3.00		3.93	
GNR-3	18	52.78	56.57 (+7.18)	55.12	58.45 (+6.04)	89.97	87.00 (+3.30)	91.56	90.00 (-4.10)	89.97	87.00 (+3.30)	91.56	90.00 (-4.10)
	28	50.53	55.00 (+8.84)	53.89	55.07 (+2.18)	90.15	86.00 (-4.60)	88.78	86.00 (-3.13)	90.15	86.00 (-4.60)	88.78	86.00 (-3.13)
	RMSE	4.14		2.94		3.60		2.67		4.52		3.60	
	MBE	3.75		1.96		-2.52		-1.98		-3.25		-1.75	
	PE	-7.40		-8.57		4.11		2.46		2.26		2.55	

RMSE: Root mean square error, **MBE:** Mean bias error, **PE:** Percent error, *obs= observed value *sim= simulated value

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