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Comparative Evaluation of WOFOST and CERES-rice Models in Simulating Yield of rice Cultivars at Navsari

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ABSTRACT

A field experiment was conducted during kharif season of 2015 to assess the prediction performance of CERES-Rice and WOFOST modelfor grain and straw yield of three rice cultivars viz., (V_1:Jaya, V_2: Gurjari and V_3: GNR-2) sown under four different environments viz., (D_1: 10/07/2015, D_2: 25/07/2015, D_3: 09/08/2015 and D_4: 24/08/2015) with two nitrogen levels N_1:75 and N_2:100 kg NPK/ha^{-1}.Results showed that the prediction of WOFOST model for grain yield of rice cultivars under different treatments more close to the corresponding observed value with percent error PE between (18.66%)as camper to CERES-rice model with PE (28.56%), but for straw yield CERES-rice model give moreclose prediction than WOFOST model with PE (20.99%) and (27.33%) between predicted and observed value.

Keywords: WOFOST, CERES, simulation, rice cultivars, date of sowing, nitrogen levels.

INTRODUCTION

Crop Simulation model is a computer model used to simulate reality it can be used to simulate crop growth, development and estimate yield of crop as a function of weather condition and management practices. Before using any model, it needs proper calibration and validation. Once model is properly validated, it can be used for various application viz., predicting growth, development and yield of crops, to study response of various climatic parameters and management practices on crops. The crop growth simulation model has been defined as a simplified representation of the physical, chemical and physiological mechanisms underlying plant and crop growth processes. Crop simulation models are able to provide an answer for “if then” type of question. (Mote and Kumar, 2016) reported that crop simulation model accurately simulates crop growth development and yield for different rice cultivars under different environment. Sometimes model simulations were under/overestimated yield and yield attributing parameters, but the trend follows good association between actual and simulated response. Now a day’s various crop simulation models are used like

CERES, WOFOST, WTGROWS, INFOCROP etc. Among these models in present study CERES-rice and WOFOST model were used for prediction of grain and straw yield of different rice cultivars under different environment and nitrogen levels.

MATERIALS AND METHODS

Minimum data requirement

To generate the required experimental and crop management data, a field experiment was conducted at Agronomy farm of N. M. College of Agriculture, Navsari Agricultural University, Navsari (20° 57' N, 72° 54' E and 16 m above mean sea level), Gujarat, India, during rainy season of the year 2015. Daily data on weather parameters, like sunshine hours, rainfall, minimum temperature and maximum temperature, required for the model were recorded at weather station located in the vicinity of the experimental field. The soil profile data needed for the model was retrieved from the publication of earlier research work on characterization of Navsari

Table 1: Genetic coefficients of three different cultivars used in CERES-rice model

Genetic Coefficient	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	710	700
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	150	150
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	500	550
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	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	55	55
G2	Single dry grain weight (g) under ideal growing conditions. i.e., non-limiting light, water, nutrients, and absence of pests and diseases.	0.024	0.025	0.028
G3	Tillering coefficient (scalar value) relative to cultivars under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.	1	1	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	740	710	700

soils (Jalalpur series). The initial soil characteristics were determined by collecting samples from the profile depth extending up to 45 cm depth and analyzing in the college laboratory. All records of inputs applied were maintained. Treatments of the field experiment included three rice cultivars (V_1:Jaya, V_2: Gurjari and V_3: GNR-2) sown under four different environments viz., (D_1: 10/07/2015, D_2: 25/07/2015, D_3: 09/08/2015 and D_4: 24/08/2015) with two nitrogen levels N_1:75 and N_2:100 kg NPK/ ha-1. Both The model were validated with 2015 year experimental data and calibration with past years 2012, 2013 and 2014 data. The main aim was to find out which model give accurate prediction of rice cultivars under different environment and nitrogen levels. Both the model was run separately for each variety under different dates of transplanting and nitrogen levels. The calibration of both models are based on certain Genetic coefficients. Genetic coefficients of all three rice cultivars used in the both model safter carefully adjustment. However, the adjusted Genetic coefficients for all three rice cultivars of CERES-rice model given in (Table 1) and WOFOST model in (Table 2).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 allthree rice cultivars.

RESULTS AND DISCUSSIONS

Grain yield

Among the dates of transplanting grain yield was higher D_1 transplanted crop (41.39 q ha^{-1}) with compared to rest of the transplanting dates, with delay of transplanting after D_1 (10h July) grain yield was decreases. (Mote, 2013) also reported that the grain yield is decreases due to delayed of date of transplanting. The difference between the $D_1$and D_4 transplanting was (19.15 q ha^{-1}) Table 3. In case of models, prediction ofgrain yield by WFOST model were reasonably close to the observed values overall PE in all date of transplanting varied between (-7.13 to - 20.33%) as compared to CERES-rice model (-44.03 to +9.66%). In case of cultivars both models under predicted but WOFOST give better prediction as compared to CERES-rice model, overall variation between observed and predicted values by WFOST and CERES-rice models for all cultivars varied between (-5.10 to -17.07%) and (-12.80 to -20.11%). But in case of Nitrogen levels prediction of CERES-rice model was closer at N_1 level with PE (+9.66) followed by N_2(-10.07) compared to WOFOST model (-10.75%) and -12.84%). different test criteria viz., RMSE, MBE, and PE between the predicted and corresponding observed values for grain yield also showed that the performance of WOFOST is more better than CERES-rice model with root mean square error

Table 2: Genetic coefficients of three different cultivars usedin WOFOST model

Coefficient	**Description**	**Cultivars**		
		Jaya	**Gurjari**	**GNR-2**
TSUMI	Temperature sum from emergence to anthesis	2043	2179	1958
TSUM2	Temperature sum from anthesis to maturity	842	810	710
LAIEM	Leaf area at emergence	0.21	0.211	0.205
RGRLAI	Maximum relative increase in LAI	0.06	0.058	0.058
CVL	Efficiency of conversion into leaves	0.751	0.746	0.731
CVO	Efficiency of conversion into storage organ	0.630	0.621	0.610
CVR	Efficiency of conversion into roots	0.731	0.743	0.723
CVS	Efficiency of conversion into stem	0.714	0.732	0.700
RML	Relative maintenance respiration rate of leaves	0.0180	0.0180	0.0173
RMO	Relative maintenance respiration rate of storage organs	0.0140	0.0140	0.0120
RMR	Relative maintenance respiration rate of roots	0.120	0.100	0.0100
RMS	Relative maintenance respiration rate stems	0.080	0.090	0.090

(RMSE), mean bias error (MBE) and percent error (PE) of (6.19,-3.92 and 18.66) and CERES-rice model (9.48, -4.93 and 28.56) respectively.

Straw yield

In different dates of transplanting straw yield was maximum in D_1 transplanted crop (83.85 q ha^{-1}) with compared to rest transplanting of date. The difference between the D_1 and D_4 transplanting was (22.19 q ha^{-1}) Table 3. In case of prediction of straw yield CERES-rice model was predicted more accurately with PE varied between (-1.43 to +32.67%) in different date of transplanting as compared to WOFOST model (-8.09 to +23.66%). Similarly in case of cultivars also CERES-ricemodel give better prediction with PE between (-3.66 to 3.45%) as compared to WOFOST model (-13.72 to-19.54%). Also in different nitrogen levels prediction

Table 3: Comparison between observed values and simulated values by CERES-Rice and WOFOST model for grain yield and straw yield of different rice cultivars under different environment

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})		
	Observed	CERES Simulated	WOFOST simulated	Observed	CERES Simulated	WOFOST simulated
Transplanting dates						
D_1- (10/07/2015)	41.93	45.98 (+9.66%)	36.98 (-11.81%)	83.85	64.23 (-23.40%)	64.01 (-23.66%)
D_2 -(25/07/2015)	38.42	34.55 (-10.07%)	34.43 (-10.39%)	79.45	80.58 (+1.42%)	61.61 (-22.45%)
D_3 -(09/08/2015)	29.61	19.75 (-33.30%)	27.50 (-7.13%)	66.85	88.69 (+32.67%)	59.53 (-10.95%)
D_4-(24/08/2015)	22.78	12.75 (-44.03%)	18.15 (-20.33%)	61.66	54.7 (-11.29%)	56.67 (-8.09%)
SEm±		0.92			0.92	
C. D.		3.19			3.19	
C. V.		11.8			5.37	
Varieties						
V_1 –Jaya	32.17	28.7 (-20.11%)	30.53 (-5.10%)	68.21	70.56 (+3.45%)	58.85 (-13.72%)
V_2–Gurjari	35.01	27.97 (-13.22%)	29.03 (-17.07%)	75.88	73.55 (-3.07%)	61.05 (-19.54%)
V_3 -GNR-2	32.38	28.1 (-12.80%)	28.23 (-12.82%)	74.77	72.03 (-3.66%)	61.47 (-17.79%)
SEm±		32.17			0.55	
C. D.		35.01			1.57	
Nitrogen levels						
N_1-(75 kg ha^{-1})	32.02	27.92 (+9.66%)	28.58 (-10.75%)	70.23	71.08 (+1.21%)	59.03 (-15.95%)
N_2-(100 kg ha^{-1})	34.36	28.59 (-10.07%)	29.95 (-12.84%)	75.67	73.01 (-3.52%)	61.88 (-18.22%)
SEm±	0.45	--		0.45	--	
C. D.	1.28	--		1.28	--	
CV%	8.1	--		3.69	--	
RMSE		9.48	6.19		15.31	19.94
MBE		-4.93	-3.92		-0.90	-12.50
PE		28.56%	18.66%		20.99	27.33

of CERES-rice model was closer at N_1 level with PE (+1.21%) followed by N_2 (-3.52%) compared to WOFOST model (-15.5%) and -18.22%). different test criteria viz., RMSE, MBE, and PE between the predicted and corresponding observed values for straw yield also showed that the performance of CERES-ricew as accurately than WOFOST model with root mean square error (RMSE), mean bias error (MBE) and percent error (PE) of (15.31,-0.99 and 20.99) and WOFOST model with (19.94,-12.50 and 27.33) respectively.

CONCLUSION

Prediction of grain and straw yield of rice cultivars under different treatment by CERES and WOFOST with more or less same percent error but prediction for grain yield was more accurately by WFOST model. In case of straw yield, CERES model give close prediction for all cultivars under different transplanting dates but under nitrogen levels accuracy of WFOST wasbetter.

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