

Validation of Simulation Modeling for Growth Parameters of Rice Genotypes using CERES 3.5 v for Eastern Uttar Pradesh

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Abstract

The investigation was carried out during *kharif* season of 2005-06 to investigate the CERES v 3.5 model validations for rice at different dates of transplanting and different genotypes. Treatment consisted of three genotypes i. e. Sarjoo-52, NDR-359 and Pant Dhan-4 and two dates of transplanting i.e. July 5, 2005 and July 25, 2005. The experiment was laid out in randomized block design. The simulation modeling was subsequently validated against observed data from field experiment. The model was found to be able to predict the phenological occurrence of the crop well enough to help farmers to make broad scale decision on the crop management operation, which can be directly linked to crop phenology in the CERES rice model. From the response of simulation modeling it can be concluded that accuracy of simulated value decreases with late transplanting in all the genotypes. Among the genotypes prediction accuracy of Pant Dhan-4 was found to be better in respect of tillers, flowering, panicle initiation and physiological maturity on both transplanting dates, while NDR-359 and Sarjoo-52 was found to be better on 25 July transplanting for all the characters. Response of simulation modeling was recorded better in Sarjoo-52 for panicle initiation on both transplanting date followed by Pant Dhan-4 and NDR-359. But over all the statistical model performed well on the tillers, flowering and physiological maturity.

Key words : CERES-Rice, Statistical model, Genetic coefficient, Growth parameters.

CERES (Crop Estimation through Resource and Environment Synthesis) model were the result of an attempt made in the user oriented, general simulation models for various crops, these models predict the enactment of a particular cultivar, sown at any time in any climate, which would lead to transfer of agro-technology information. The privilege of crop modeling has been illustrated in the works of Nix (1976). CERES-Rice model is a process based management oriented model that can simulate the growth and development of rice as affected by various levels of nitrogen (Ritchie et al. 1998). The impartial of the present study was to evaluate CERES-Rice version 3.5 for its ability to simulate and validate crop growth parameters. The coefficients in the statistical model and the validity of the estimates depend to a large extent on the design of the model, and on the representativeness of the input data. Model is also an equation or set of equations which represent the behavior of a system. The significance of the effect

of weather and climate on crop production has brought about numerous research projects and publication dealing with crop-weather relationship at different scales. Various statistical and mathematical techniques for developing these relationships have been used and the term "Crop Weather Model" emerged (Yaranttan 1971). Models are written in simulation language continuous system modeling program (CSMP) with FORTRAN used in subroutines as given by Leffelan and Ferrari (1989).

Methods

An experiment was carried out during *kharif* season of 2005-06 at agrometeorological instructional farm of N. D. University of Agriculture and Technology, Kumarganj, Faizabad (UP) (26°47' N latitude, 82°12' E longitude and 113 m altitude from mean sea level). The area is under semi-arid zone, receiving a mean annual rainfall of about 1,130 mm

Table 1. Genetic coefficients used in simulation modeling for different genotypes.

Var#	Var name	Eco #	P ₁	P ₂ R	P ₅	P ₂ O	G ₁	G ₂	G ₃	G ₄
IN0020	NDR-359	IB0001	600	150	410	12.0	42	0.02	1	0.80
IN0021	Sarjoo-52	IB0001	670	200	400	12.7	45	0.02	1	0.80
IN0022	Pant Dhan-4	IB0001	620	160	300	12.0	45	0.02	1	0.80
Var#	Identification code or number for a specific cultivar.									
Var-name	Name of cultivar.									
Eco#	Ecotype code for this cultivar points to the ecotype in the ECO file (currently not used).									
P ₁	Time period expressed as growing degree days (GDD) in °C above a base temperature of 9° from seedling emergence 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.									
P ₂ O	Critical photoperiod or the longest day length (in hours) at which the development occurs at a maximum rate. At values higher than P20 developmental rate is slowed, hence there is delay due to longer day lengths.									
P ₂ R	Extent to which phasic development leading to panicle initiation is delayed (expressed as GDD in °C) for each hour increase in photoperiod about P20.									
P ₅	Time period in FDD from beginning of grain filling (3 to 4 days after flowering) to physiological maturity with a base temperature of 9°C.									
G ₁	Potential spikelet number coefficient as estimated from the number of spikelets per g of main calm dry weight (less lead blades and sheaths plus spikes) at anthesis. A typical value is 55.									
G ₂	Single grain weight (g) under ideal growing conditions, i.e. nonlimiting length, water, nutrients, and absence of pests and diseases.									
G ₃	Tillering coefficient (scalar value) relative to IR64 cultivar under ideal conditions. A higher tillering cultivar would have coefficient greater than 1.0.									
G ₄	Temperature tolerance coefficient. Usually 1.0 for genotypes grown in normal environment. G ₄ for japonica type rice growing in warmer environment would be 1.0 or greater. Likewise, the season would be less than 1.0.									

out of which about 82.5% of the total rainfall is received during south-west monsoon season alone (Tripathi et al. 1999).

Input data requirement of the dynamic simulation model is divided into following five groups.

Site Data : Course of time and location ; latitude, longitude and altitude.

Weather Data : Sunshine (h), maximum and minimum temperature (C), rainfall (mm), wind speed (m/s), humidity (%) and pan evaporation (mm).

Soil Data : Soil classes, soil evaporation, soil albedo, runoff curve, soil profile, drainage coefficient, soil layer thickness, field capacity, wilting point, bulk density organic carbon (%) and sand, silt and

Table 2. Statistical regression model for rice genotype at different dates of transplanting for different crop characters regression model for 5 July transplanting. Y=Dependent variable, X₁=Average temperature, X₂=Vapor pressure, X₃ = Rainfall, X₄=Sunshine.

Genotype	Characters	Constant parameter	Coefficients				R ²
			X ₁	X ₂	X ₃	X ₄	
Sarjoo-52	Tillers / m ²	759.18	-59.44	107.69	1.23	15.18	0.67
	50% flowering (days)	88.64	0.13	-0.99	0.004	-0.44	0.58
	Physiological maturity (days)	84.66	0.34	0.03	-0.021	0.009	0.62
Pant Dhan-4	Tillers / m ²	6872.00	-68.80	90.46	0.81	2.70	0.78
	50% flowering (days)	72.72	-0.03	-0.16	0.02	0.0006	0.53
	Physiological maturity (days)	10.22	-0.03	-0.08	-0.001	0.0001	0.65
NDR-359	Tillers / m ²	150.25	-65.74	85.24	0.65	-1.51	0.77
	50% flowering (days)	40.65	1.93	-0.98	-0.021	0.0005	0.63
	Physiological maturity (days)	100.22	-0.03	-0.08	-0.001	0.0001	0.65

Table 3. Statistical regression model for rice genotype at different dates of transplanting for different crop characters regression model for 25 July transplanting. Y = Dependent variable, X₁=Temperature, X₂ = Vapor pressure, X₃ = Rainfall, X₄ = Sunshine.

Genotype	Characters	Constant parameter	Coefficients				R ₂
			X ₁	X ₂	X ₃	X ₄	
Sarjoo-52	Tillers / m ²	440.57	-60.21	98.78	1.04	7.11	0.77
	50% flowering (days)	77.63	-0.48	0.11	0.011	0.002	0.58
	Physiological maturity (days)	107.81	-0.28	-0.18	-0.007	-0.0001	0.53
Pant Dhan-4	Tillers / m ²	-862.37	-59.87	111.74	1.30	17.57	0.81
	50% flowering (days)	86.41	-0.15	0.671	0.025	0.001	0.45
	Physiological maturity (days)	102.87	0.29	0.54	-0.01	3.68	0.51
NDR-359	Tillers / m ²	-779.26	-54.6	103.84	1.10	12.10	0.71
	50% flowering (days)	91.91	-0.41	0.60	0.24	0.0004	0.45
	Physiological maturity (days)	102.17	0.24	0.15	-0.014	0.0003	0.54

Table 4. Comparison of simulation with statistical prediction for (tiller/m²) at different date of transplanting. **Figures in parentheses show the error percent of statistical prediction over observed values. * Figures in the parentheses show the error percent of simulated over observed values.

Genotypes	Observed	5 Jul		Observed	25 Jul	
		Statistical prediction	Simulation prediction		Statistical prediction	Simulation prediction
Pant Dhan-4	505.5	415.2	410.4	490.6	452.5	415.5
		(17.8)**	(18.8)*		(7.7)**	(15.3)*
Sarjoo-52	480.6	376.2	360.6	470.5	438.6	365.6
		(21.6)**	(24.9)*		(6.8)**	(22.2)*
NDR-359	510.4	407.1	390.5	495.3	442.5	380.5
		(20.0)**	(23.4)*		(10.0)**	(23.1)*

clay (%).

Plant Data : Date of transplanting, date of emergence, date of floral initiation, date of anthesis, date of physiological maturity, plant population, plant height, LAI, leaf weight, culms weight, dry matter, grain weight, grain yield and grain ear per head.

Management Data : Date and amount of irrigation, fertilizer application, herbicide / insecticide application, weeding, row spacing, transplanting depth (mm), variety name and genetic coefficient data.

CERES rice makes use of six genetic coefficients that summarize various aspects of the performance of particular genotypes. Genetic coefficients used for simulation modeling in the study are given in Table 1. Statistical regression model was developed from past five years weather parameters (2000 to 2004) incorporating average temperature, vapor pressure, rainfall and bright sunshine hours for different crop characters of all three rice genotypes which are given in Tables 2 and 3 for July 5 and July 25 transplanting

Table 5. Comparison of simulation with statistical prediction for 50% flowering DAT at different transplanting dates.

Genotypes	Observed	5 Jul		Observed	25 Jul	
		Statistical prediction	Simulation prediction		Statistical prediction	Simulation prediction
Pant Dhan-4	65.6	71.1 (9.2)**	75 (14.3)*	63.1	66.1 (4.7)**	73 (15.6)*
Sarjoo-52	63.7	65.28 (3.1)**	75 (17.7)*	64.1	67.59 (4.6)**	73 (10.4)*
NDR-359	63.8	68.84 (7.9)**	73 (14.4)*	65.8	67.97 (3.0)**	72 (9.4)*

Table 6. Comparison of observed with simulated value for panicle initiation (DAT) at different transplanting dates. *Figures in parentheses show the error percent of simulated over observed values.

Genotypes	5 Jul		25 Jul	
	Observed	Simulation prediction	Observed	Simulation prediction
Pant Dhan-4	55.4	45 (18.7)*	53.4	41 (23.2)
Sarjoo-52	54.2	45 (16.7)	52.5	40 (23.8)
NDR-359	56.3	43 (23.6)	53.8	40 (25.6)

dates respectively.

Results and Discussion

Validation of simulation modeling was done on the parameter of no. of tillers/m², 50% flowering (DAT), physiological maturity (DAT) and panicle initiation (DAT) whenever statistical modeling was done for no. of tillers/m², 50% flowering (DAT) and physiological maturity (DAT).

Response of Simulation Modeling

Comparisons of observed with simulated value for no. of tillers/m² in rice are presented in Table 4. It is obvious that in 5 July transplanting of Pant Dhan-4 was found to have precise predicted value through simulation model over observed value (18.8%) followed by NDR-359 (23.4%) and Sarjoo-52 (24.9%), while in 25 July transplanting also Pant Dhan-4 was found to be close to statistical value over observed

value (15.3%) followed by Sarjoo-52 (22.2%) and NDR-359 (23.1%).

In 5 July transplanting, simulation prediction has least error to Pant Dhan-4 (14.3%), NDR-359 (14.4%) and Sarjoo-52 (17.7%) was observed for 50% flowering (DAT). Whenever in 25 July transplanting NDR-359 was reported close simulation prediction value over observed (9.4%) followed by Sarjoo-52 (10.4%) and Pant Dhan-4 (15.6%) (Table 5).

It is quite discernible that in 5 July transplanting close simulated value was found over observed value in Sarjoo-52 (16.7%) followed by Pant Dhan-4 (18.7%) and NDR-359 (23.6%), while in 25 July transplanting minimum alteration found in Pant Dhan-4 (23.2%) followed by Sarjoo-52 (23.8%) and NDR-359 (25.6%) for Panicle initiation (DAT) (Table 6).

Physiology maturity (DAT) has been clarified in Table 7, in 5 July transplanting adjacent simulated value was found in respect of Pant Dhan-4 (9.8%) followed by NDR-359 (10.3%) and Sarjoo-52 (12.6%) over observed value. While in 25 July transplanting minimum difference found in Pant Dhan-4 (13.1%) followed by Sarjoo-52 (19.8%) and NDR-359 (21.6%).

Response of Statistical Modeling

Data on comparison of observed along with statistical value for no. of tillers / m² in rice are presented in Table 5. In 5 July transplanting Pant Dhan-4 was found to have close predicted value through statistical model over observed value (17.8%) followed by NDR-359 (20.0%) and Sarjoo-52 (21.6%), while in 25 July transplanting Sarjoo-52 was found to be close to statistical value over observed value (6.8%) followed by Pant Dhan-4 (7.7%) and NDR-359 (10%).

Table 7. Comparison of simulation with statistical prediction for physiological maturity (days) at different transplanting date.

Genotypes	Observed	5 Jul		Observed	25 Jul	
		Statistical prediction	Simulation prediction		Statistical prediction	Simulation prediction
Pant Dhan-4	94.1	97.28 (3.1)**	99 (9.8)*	88.4	87.4 (1.1)**	100 (13.1)*
Sarjoo-52	95.3	95.23 (0.10)**	104 (12.6)*	90.2	95.57 (5.5)**	108 (19.8)*
NDR-359	93.4	97.28 (4.3)**	102 (10.3)*	89.6	82.1 (7.8)**	109 (21.6)*

Validation of observed with statistical value for 50% flowering in rice is presented in Table 5. It is revealed that in 5 July transplanting Sarjoo-52 have close statistical predicated value over observed (3.1%) followed by NDR-359 (7.9%) and Pant Dhan-4 (9.2%), while in 25 July transplanting NDR-359 was found to close statistical value over observed value (3.0%) followed by Sarjoo-52 (4.6%) and Pant Dhan-4 (4.7%).

Data related to verification of observed with statistical value for physiological maturity in rice are presented in Table 7. Sarjoo-52 (0.10%) was found to be close to statistical value over observed followed by Pant Dhan-4 (3.1%) and NDR-359 (4.3%) in 5 July transplanting, while in 25 July transplanting statistical value was found least error in Pant Dhan-4 (1.1%) over observed value followed by Sarjoo-52 (5.5%) and NDR-359 (7.8%).

Conclusion

The accuracy of simulated value decreases with late transplanting in all the genotypes in all character of the crop. For statistical modeling, among the genotypes Pant Dhan-4 was found finer over other genotypes in respect of no. of tillers/m² and physiology maturity in both dates of transplanting, whenever Sarjoo-52 was found to have closest accuracy for prediction of 50% flowering in early date of transplanting and NDR-359 was found to be superior for late transplanting over other genotypes. Among the genotypes Pant Dhan-4 was found to be better in

respect of tillers/m², flowering (DAT), physiology maturity (DAT) and panicle initiation (DAT) on both transplanting dates; hence NDR-359 and Sarjoo-52 found to be enhanced on the 25 July transplanting in case of simulation modeling. Over all the performance of statistical model performed well on the tillers/m², flowering (DAT) and physiological maturity (DAT) over simulation modeling.

It is also evident that prediction from statistical modeling is much accurate in the observed value than the simulation modeling in both dates of transplanting. Among the dates of transplanting prediction for 25 July is much closer to the observed value as compared to the 5 July transplanting.

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