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# SIMULATION MODELING OF KHARIF RICE CULTIVARS AT DIFFERENT DATES OF TRANSPLANTING USING CERES 4.5V MODEL FOR COOCHBEHAR DISTRICT, WEST BENGAL

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**ABSTRACT**

The field experiment was carried out during Kharif season of 2012 and 2013 to investigate the CERES 4.5v model validations for rice at different dates of transplanting and different varieties. Treatment consisted of six varieties viz. IET-6223, IET-14461, MTU-1010, IET-17430, MTU-7029 & MTU-1075 and five dates of transplanting viz. 01st July; 10th July; 20th July; 30th July and 09th August. The Experiment was laid out in split plot design with 3 replications. In all the dates of transplanting with respect to cv. IET-6223, IET-14461, MTU-1010 and G.B.-1; simulated days to panicle initiation, anthesis and total physiological maturity were in good conformity with observed values. The simulation modeling was subsequently validated against observed data from field experiment. The model suggested that, in 10th July transplanting in cv. IET-6223, IET-14461, MTU-1010, G.B.-1; the simulated days to panicle initiation were in good conformity with observed values. IET-14461 showed good agreement between observed value and simulated with low RMSE value as in case of other cultivars (0.0 to -1.1%)

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## INTRODUCTION

Rice (Oryza sativa) is the most important staple food in South East Asian countries (IRRI, 2006). Rice is leading food crop providing 25 % of world supply of calories and 20 % of proteins. In India rice is grown in both kharif and rabi season under diverse ecological and climatic conditions apart from socio-economic diversities of the state. In India 33 % of total rice land has got irrigation facilities and rest is totally dependent upon rainfall (Harishankar *et al* ., 2015) .Crop modelling can play a significant part in systems approaches by providing a powerful capability for scenario analyses. Crop simulation models can integrate knowledge of physiological processes and morphological traits to help explain yield formation in environments varying in physical, biological and agronomic factors. These simulations can be used to evaluate key interactions quickly and identify traits with the greatest impact on yield potential .Some techniques used for dynamic simulation model in rice validated the simulation of plant growth and crop production. (Goydrian, 1982). Hoogenboom (2000) observed a significant impact of weather and management factors on crop growth and development by the crop simulation models. The farmers are facing the problem of growing Kharif rice, which is mostly rainfall dependent. To assess the crop dependence on weather, dynamic crop models can be used successfully (Jones et al., 1998; Hoogenboom *et al.,* 1999).

Crop Environment Resources Synthesis (CERES) models were the result of an attempt made by the user oriented general simulation models for various crops. These models predict the performance of a particular cultivar, sown at any time in any climate and would lead to information on transfer of agro-technology. CERES-Rice model is a process based management-oriented model that can simulate the growth and development of rice crop (Ritchie *et al*., 1998). The simulation of CERES-Rice model is based on a specific point and time that predicts the crop growth in an independent of location, management and cultivar, however, the reality of agricultural environment contains soil, climate and human activity variabilities. These models predict the performance of a particular cultivar, sown at any time in any climate, which would lead to transfer of agro-technology information. The advantage of crop modeling has been illustrated in the works of Nix (1976). CERES-Rice crop simulation model V4.5 has been used for analyzing the effect of climatic variability on rice growth and yield. Also to explore the study the effect of delayed monsoon in rice growth and yield and to evaluates better adaption strategies.

CERES-Rice model (DSSAT v 4.5) was calibrated and evaluated for rice cv.MTU 1010 at Agricultural Research Institute, Rajendranagar, Hyderabad. For this, purpose, field experiment was conducted with 11 dates of planting and four nitrogen levels i.e. 100, 200, 250, and 300 kg/ha at 50kg/ha interval during the year 2007-2010 by Sreenivas and Reddy (2013). The model predicted days to heading, days to physiological maturity, grain yield and biomass were with RMSE of 0 days, 0.9days, 285 days kg/ha and 567 kg/ha respectively.

## MATERIALS AND METHODS

A Field experiment was conducted at the Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal for two consecutive years during *kharif* season of 2012 and 2013 25⁰57'47" to 26⁰36'2" North Latitude, 89⁰54'35" to 88⁰47'44" East Longitude) in the *terai* agro-climatic zone of West Bengal. The Experiment was laid out in split plot design with 3 replications comprising five main plots: dates of transplanting ($D_1$ = 01st July; $D_2$ = 10th July; $D_3$ = 20th July; $D_4$=30th July; D5=09th August) and six sub plots: cultivars ($V_1$ IET-6223; $V_2$: IET-14461; $V_3$: MTU-1010; $V_4$: IET-17430; $V_5$: MTU-7029; $V_6$: MTU-1075). The topography of the land, where the investigations were undertaken, was medium in situation endowed with good drainage facilities. The soils of the experimental fields were sandy loam in texture, a true representative of the region. The climate of Cooch Behar district is sub-tropical in nature with distinctive characteristics of high rainfall, high humidity and a prolonged winter. The rainy season is characterized by hot and humid weather, heavy precipitation from south-west monsoon with cloudy overcast days and fewer hours of bright sunshine. The climate of this district is characterized by a highly humid atmosphere and abundant rains. The average annual rainfall of the district is 3391 mm and coefficient of variation (CV) is 22 percent with average number of rainy days is 103. In the CERES-Rice model, the entire programme is divided into weather file, soil file, crop file or genotype coefficient file and crop management file. The details of different files are as follows. Weather files – This file demands one year daily weather data on sunshine (hr), maximum and minimum temperature (Ú C), rainfall (mm) and humidity (%) .

Soil file- This file demands soil data allied to 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 clay (%).

Plant file: This file demands soil data related to date of sowing, 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 file- Data on Row spacing, Plants per hill,date and amount of irrigation, fertilizer application, herbicide / insecticide application, weeding, row spacing and sowing depth (mm) by the previous crop are needed for this particular file.

Genotype coefficient file - The file required the cultivar specific coefficient. Eight genetic coefficients are required for describing the various aspects of performance a particular genotype for running the CERES-Rice v 4.5 models the values of genetic coefficients as derived from calibration of the model are presented (Table 1).

P1 Time period (expressed as growing degree days [GDD] in ÚC above a base temperature of 9ÚC) 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 ÚC) 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 P2O the development rate is slowed (depending on P2R), there is delay due to longer day length.

P5 Time period in GDD inÚC 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 anthesis. 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 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 e"

1.0. Tropical rice grown in cooler environments or season will have G4 < 1.0

The test criteria as suggested by Wiltlmott (1982) were followed while evaluating the performance of the models. Here, accuracy means the degree to which model predictions approach the magnitude of their observed counterparts. They are listed as: Summary measures, Difference measures and Descriptive measures (Wiltlmott (1982).

Summary measures, include the mean of observed (O) and simulated (P) values, standard deviation of observed (So) and that of predictions (Sp). These measures describe only the quality of the simulation.

Difference measures locate and quantify the errors. They include Mean Bias Error (MBE) and Root Mean Square Error (RMSE). The MBE and RMSE elucidate the magnitude of the average error but do not provide information about the relative size of the average difference between the observed and predicted. But, MBE indicates the direction of the error magnitude. A negative MBE means the predictions are smaller than the observation and positive MBE means over prediction.

$$MBE = \sum_{i-l}^{n} [P_i - O_i] / _n$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n} (X_{obs,i} - X_{model,i})^2}{n}}$$

## RESULTS AND DISCUSSION

The result of present investigation entitled simulation modeling of growth attributes for rice varieties at different dates of transplanting using CERES 4.5 v for coochbehar,west Bengal has been presented in this part. The results have been presented through tables. The salient findings of experimental have been categorized and presented under:

**Table 1: Genetic coefficients for six different cultivars of rice at CoochBehar (*terai* agro-climatic) condition**

| VAR# | VAR-NAME | ECO# | P1 | P2R | P5 | P2O | G1 | G2 | G3 | G4 |
|---|---|---|---|---|---|---|---|---|---|---|
| IB0016 | IET-6223 | IB0001 | 400 | 110 | 310 | 12 | 58.5 | 0.0241 | 1 | 1 |
| IN0026 | IET-14461 | IB0001 | 420 | 100 | 360 | 11.4 | 51 | 0.0203 | 1 | 1 |
| IB0022 | MTU 1010 | IB0001 | 450 | 110 | 320 | 11.3 | 72 | 0.025 | 1 | 1 |
| IB0027 | G.B-1 | IB0001 | 440 | 110 | 330 | 11 | 64 | 0.0226 | 1 | 1 |
| IB0012 | MTU-7029 | IB0001 | 740 | 115 | 330 | 11..0 | 68 | 0.0213 | 1 | 1 |
| IB0028 | MTU-1075 | IB0001 | 680 | 120 | 340 | 11.2 | 62.5 | 0.022 | 1 | 1 |

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).

**Table 2.1: Comparison of observed with simulated value for Panicle initiation day ( DAT) of rice cultivars at different date of transplanting Transplanting date**

| | IET- 6223 | | IET-14461 | | MTU-1010 | | G.B-1 | | MTU-7029 | | MTU-1075 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | Sim. | O | Sim. | O | Sim. | O | Sim. | O | Sim. | O | Sim. |
| 1st July | 29 | 32(10.3) | 33 | 34(3) | 39 | 38(-2.5) | 40 | 39(-2.5) | 56 | 53(-5.3) | 56 | 50(-10.7) |
| 10th July | 32 | 30(-6.2) | 33 | 33(0) | 38 | 36(-5.2) | 37 | 37(0.0) | 55 | 51(-7.2) | 55 | 48(-12.7) |
| 20th July | 30 | 29(-3.3) | 32 | 32(0) | 38 | 35(-7.8) | 35 | 36(2.8) | 54 | 50(-7.4) | 54 | 47(-12.9) |
| 30th July | 29 | 28(-3.4) | 31 | 31(0) | 36 | 34(-5.5) | 34 | 36(5.8) | 54 | 49(-9.2) | 51 | 46(-9.8 |
| 9th Aug. | 28 | 27(3.7) | 29 | 31(6.9) | 35 | 34(-2.8) | 32 | 35(9.3) | 52 | 47(-9.6) | 50 | 45(-10.0) |
| RMSE | 1.73 | | 1.00 | | 1.95 | | 1.73 | | 4.27 | | 6.07 | |
| PE | 5.85 | | 3.16 | | 5.24 | | 4.87 | | 7.87 | | 11.40 | |
| MBE | -0.11 | | 0.40 | | -0.97 | | 0.62 | | -1.56 | | -2.25 | |

RMSE : Root mean square error, MBE : Mean bias error, PE : Per cent error,O : Observed value, Sim :Simulated Value

**Table 2.2: Comparison of observed with simulated value for Anthesis day ( DAT) of rice cultivars at different date of transplanting Transplanting date**

| | IET- 6223 | | IET-14461 | | MTU-1010 | | G.B-1 | | MTU-7029 | | MTU-1075 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | Sim. | O | Sim. | O | Sim. | O | Sim. | O | Sim. | O | Sim. |
| 1st July | 60 | 63(5.0) | 63 | 65(3.2) | 66 | 70(6.0) | 70 | 71(1.4) | 86 | 86(0.0) | 85 | 83(-2.3) |
| 10th July | 62 | 61(-1.6) | 62 | 64(3.2) | 67 | 67(0.0) | 68 | 69(1.4) | 88 | 85(-3.4) | 84 | 81(-3.5) |
| 20th July | 60 | 59(-1.6) | 62 | 63(1.6) | 68 | 66(-2.9) | 66 | 67(1.5) | 86 | 84(-2.3) | 84 | 80(-4.7) |
| 30th July | 59 | 58(-1.6) | 62 | 62(0.0) | 67 | 65(-2.9) | 66 | 68(3.0) | 87 | 85(-2.3) | 82 | 81(-1.2) |
| 9th Aug. | 58 | 58(0.0) | 62 | 62(0.0) | 66 | 66(0.0) | 65 | 68(4.6) | 86 | 86(0.0) | 83 | 83(0.0) |
| RMSE | 1.55 | | 1.34 | | 2.19 | | 1.79 | | 1.84 | | 2.45 | |
| PE | 2.59 | | 2.16 | | 3.28 | | 2.67 | | 2.13 | | 2.93 | |
| MBE | 0.00 | | 0.32 | | 0.01 | | 0.48 | | -0.32 | | -0.48 | |

RMSE : Root mean square error, MBE : Mean bias error, PE : Per cent error,O : Observed value, Sim :Simulated Value

**Table 2.3: Comparison of observed with simulated value for Physiological maturity ( DAT) of rice cultivars at different date of transplanting Transplanting date**

| | IET- 6223 | | IET-14461 | | MTU-1010 | | G.B-1 | | MTU-7029 | | MTU-1075 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O | Sim. | O | Sim. | O | Sim. | O | Sim. | O | Sim. | O | Sim. |
| 1st July | 84 | 85(1.1) | 90 | 90(0) | 92 | 93(1.0) | 96 | 94(-2.0) | 113 | 113(0) | 110 | 109(-0.9) |
| 10th July | 87 | 83(-4.6) | 89 | 89(0) | 93 | 91(-2.1) | 93 | 93(0) | 116 | 113(-2.5) | 111 | 101(-9.) |
| 20th July | 87 | 83(-4.6) | 90 | 90(0) | 95 | 92(-3.1) | 94 | 94(0) | 116 | 115(-0.8) | 111 | 111(0) |
| 30th July | 87 | 83(-4.6) | 92 | 91(-1.1) | 95 | 93(-2.1) | 95 | 96(1) | 116 | 121(4.3) | 113 | 115(1.7) |
| 9th Aug. | 88 | 86(-2.2) | 93 | 94(-1.1) | 96 | 97(1.0) | 97 | 100(3.0) | 119 | 124(4.2) | 114 | 120(5.2) |
| RMSE | 3.26 | | 0.63 | | 1.95 | | 1.67 | | 3.46 | | 5.31 | |
| PE | 3.76 | | 0.70 | | 2.07 | | 1.76 | | 2.99 | | 0.95 | |
| MBE | -0.60 | | 0.00 | | -0.21 | | 0.08 | | 0.20 | | -0.12 | |

RMSE : Root mean square error, MBE : Mean bias error, PE : Per cent error,O : Observed value, Sim :Simulated Value

In simulation modeling validation was intended for, panicle initiation (DAT),Days to anthesis and physiological maturity (DAT). Data pertaining to comparison of observed with simulated values for panicle initiation at different date of transplanting of rice have been represented in table no: 2.1

It was observed that in 10th July transplanting in cv. IET-6223, IET-14461, MTU-1010, G.B.-1; the simulated days to panicle initiation were in good conformity with observed values. It was quite obvious from data that cv. IET-6223 at $D_1$ (1st July) to D5 (9th August) the observed value with difference per cent (0.0) at D5 followed by D3, D4, D2 observed value is more than simulated value. But in $D_1$, observed value was less than simulated value (10.0). The values of RMSE, PE, and MBE for IET-6223 are 1.73, 5.85, (-0.11) and 0.48 respectively. In cv.

IET-14461 good agreement with observed with simulation as compared with all cultivars with low RMSE and PE value. From $D_2$ to $D_4$ observed value was similar with simulated value. The values of RMSE, PE and MBE for IET-6223 are 1.00, 3.16 and 0.40 respectively. In cv. MTU-1010 all observed values was more than the simulated value with (-2.86%) to (-7.89 %.) The values of RMSE, PE, and MBE for MTU-1010 are 1.95, 5.24, (-0.97) and 0.54 respectively. In cv. G.B.-1 close prediction was observed as compared to observed data at different date of transplanting .The values of RMSE, PE and MBE for G.B-1 are 1.73, 4.87 and 0.62 respectively. It was observed that in cv. MTU-7029 all observed values were more than simulation the values with (-5.36%) to (-9.62%). The values of RMSE, PE and MBE for MTU-7029 are 4.27, 7.87, and (-1.56) respectively.

The observed and simulated values on days taken to anthesis (DAT) at different cultivars at different dates of transplanting have been presented in Table 2.2.

The results revealed that under 09$^{th}$ August (D5) transplanting the comparison with observed with simulated for anthesis was similar in all cultivars. It explains the well establishment of the model at least up to the period of anthesis. In cv. IET-6223 close prediction with observed and simulate from $D_2$ to $D_5$ (0.00 % to -1.69 %). The value of RMSE, PE and MBE for IET-6223 were 1.55, 2.59, and 0.00 respectively. In cv. IET-14461 the observed value was less than the simulated values from $D_1$ to $D_3$. However, in D4 and D5 the observed value was equal to simulated value for the same cultivar. The value of RMSE, PE and MBE for IET-6223 was 1.34, 2.16 and 0.32 respectively. It represents that model is fitting well up to the date of anthesis in respect of MTU-1010. The model underestimated the value for $D_1$ to $D_5$. The value of RMSE, PE, and MBE for MTU-1075 is 2.45, 2.93 and (-0.48) respectively.

Data pertaining for validation of measured with simulated values for physiological maturity for different cultivars at different date of transplanting have been presented in Table 2.3 The model provided good estimate for crop maturity. The observed values of all cultivars ranged from 84 to 119 where as corresponding estimated values for maturity (DAT) ranged from 83 to 120. In transplanting 20$^{th}$ July ($D_3$) prediction was in conformity with all the cultivars. IET-14461 showed good agreement between observed value and simulated with low RMSE value as in case of other cultivars (0.0 to -1.1%) also. The value of RMSE, PE, and MBE for IET-14461 were 0.63, 0.70 and 0.00 respectively. The model underestimated maturity value for IET-6223 from $D_2$ to $D_5$. The value of RMSE, PE and MBE for IET-6223 were 3.26, 3.76 and (-0.60) respectively. The results were in good agreement with the finding of Kumar *et al*. (2010). There was also close prediction between observed and simulated value in MTU-1010 (1.09 to -3.16 %). In cv. MTU-729 prediction was between observed and simulated value ranging from 0 % to -0.86 %. The value of RMSE, PE and MBE for IET-6223 were 3.46, 2.99, and 0.20 respectively.

In cv. MTU-1075 model under estimated value from $D_1$ to $D_2$ and overestimated from $D_4$ to $D_5$ with maximum RMSE value

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