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Prediction of grain yield of rice using simulation model in Chhattisgarh plains

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Abstract
Rice production in the Chhattisgarh is influenced by heat stress due to late sowing for optimization of yield, sowing at the appropriate time to fit the cultivar maturity length. The DSSAT model was used to determine to assess the production potential for Raipur districts under three Rice varieties (Swarna, Mahamaya and MTU-1010) and three dates of sowing D_1(01June2016), D_2 (15June2016) and D_3 (30 June2016). Evaluation with simulated data of three dates of sowing at Raipur districts of Chhattisgarh. It was found that shows higher grain yield Swarna (51.6-57.8 qha^{-1}) followed by Mahamaya (39.1-47.9 qha^{-1}) and MTU-1010 has shows lowest grain yield (35.6-41.7 qha^{-1}) under all three dates of sowing and D_2 (45.1-49.6) more suitable period for Raipur due favorable weather condition. In other D_1 shows higher grain yield followed by D_3. Therefore, D_2 was observed the optimum production potential yield for Swarna variety for Raipur districts of Chhattisgarh state under normal condition. Further model evaluation might also be needed for other cultivars which are released for this region.

Keywords: Potential yield, DSSAT model, rice crop, Chhattisgarh state, sowing dates

Introduction
Rice (*Oryza sativa* L.) is one of the most important food crops of the world, representing the staple food for more than half of the world population (Confalonieri and Bocchi, 2005) [1]. Rice belong to family Poaceae originated from South East Asia, where more than 90 percent of world's rice is produced and consumed (Li and Xu, 2007) [3]. Two countries, China and India, growing more than half of the world total rice production. Out of 24 species of rice only two species *Oryza* glaberima and *Oryza* sativa are cultivated.India is the second largest producer of rice after China having an area of 43.83 million hectare with the production of 104.80 million tonnes (Anonymous, 2014-15). Crop growth simulation models, properly validates against data have the potential for tactical and strategic decision making in agriculture. CERES-Rice model (Crop Environment Resources synthesis) is a dynamic crop simulation model developed by Godwin *et al*. (1992) to simulate plant physiological processes. To generate required crop management data, a field experiment was conducted at college of agriculture IGKV, Raipur (21°16'N Latitude, 81° 36'E Longitude and an altitude of 289.5 m above mean sea level) Chhattisgarh, India, during *kharif* season of the year 2016. The treatment consisted of three cultivars viz. V_1(Swarna), V_2(Mahamaya) & V_3(MTU-1010) with three dates of sowing D_1(01 June2016), D_2 (15 June2016) & D_3 (30 June2016). For the present study CERES- Rice model was calibrate past five years experimental crop data (2011 to 1015) and subsequently validated with crop data of the year 2016. The genetic coefficients were already calibrated through other researcher for genotypes are presented in (table-1). The different test criteria viz., mean of observed and simulated value, root mean square error (RMSE), coefficients of determination (r^2) and percent error were used to evaluate the performance of model for simulation of yield and yield attributes characters of all three rice cultivars.

Materials and Methods
Study area
Chhattisgarh state, Raipur district situated in Eastern India is located 21°16'N Latitude, 81° 36'E Longitude and an altitude of 289.5 m above mean sea level, during *kharif* season of the year 2016.

The DSSAT v4.6
Simulation model for this study the DSSAT v4.6 (Decision Support System for Agro-Technology Transfer) model was used. It is an integrated computer system developed by IBSNAT (International Benchmark Sites Network for Agro Technology).

It simulates plants growth, plant development and yield on a day by day basis (Jones *et al*., 1998; Tsuji, 1998) [2]. Wheat simulation models proved to be an important tool for knowledge acquisition, determination of quantitative relationships, hypothesis testing, dynamic prediction and decision support (Wu *et al*., 2013) [6]. It has being used as a research and teaching tool while used to assess the potential yields of rice crop during the year of 2016-17. Attempts were made to work out under normal condition on rice yields with different three dates of sowing D_1 (01 June2016), D_2 (15 June2016) & D_3 (30 June2016) for Raipur district.

Input data

Weather information

Daily weather data of the study area used in study were collected from the Department of Agricultural Meteorology, Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh) in the year of 2013-14.Preparation of weather file for Simulation model require weather data to be stored in specific format of DSSAT 4.6 and where given the file extension of WTH. Data. In DASST v 4.6 uses used weather parameters in a sequence of Julian day solar radiation, maximum and minimum temperature and rainfall.

Soil data

Soil data from experimental field collect including Soil texture, soil classification, soil depth (cm) colour, field capacity, runoff curve number, pH buffer determination method and determination of nitrogen, phosphorus and potassium were collected from the Department of Soil Science & Agricultural Chemistry, IGKV, Raipur.

Genetic coefficient

Already calibrated and validated genetic coefficients of rice three varieties which grown in Chhattisgarh where collected from Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya Raipur (Chhattisgarh) where following as.

Results and Discussion

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). CERES-Rice model was used to simulate the growth and development of rice. However, before using model for any purpose, it needs to be calibrated and validated for the location/ crop/ variety. To generate required crop management data, a field experiment was conducted during kharif season of the year 2016. The treatment consisted of three cultivars viz., V1 (Swarna), V2 (Mahamaya) and V3 (MTU-1010) with three dates of sowing viz., D1 (30 June), D2 (15 July) and D3 (30 July).The genetic coefficients were all ready developed through other researcher, rice genotypes are presented in (Table 4.17). The different test criteria viz., coefficient of determination (r2), root mean square error (RMSE), and percent error were used to evaluate the performance of model for simulation of yield and yield attributes characters of all three rice cultivars.

Crop phenology

Crop phenological stages play a great role in defining crop growth duration, biomass partitioning and finally crop production. Two major crop phenological stages viz. anthesis and physiological maturity were compared.

The observed and simulated anthesis of rice as influenced by different treatments is presented in (Table 2 and fig. 1). Among three different dates of transplanting, the percent error of simulated anthesis over observed anthesis were percent error found very low (-8.3) in first date D1 (30 June) of transplanting. Among all the cultivars simulated anthesis for V1 (Swarna) was found observed values closest with percent error (4.8) as compared to other cultivars. The average errors as computed by RMSE, were 5.09, 13.89 and 16.27 for V1 (Swarna), V2 Mahamaya) and V3 (MTU-1010) respectively. The average coefficient of determination (r2) were 0.41, 0.937 and 0.99 for V1 (Swarna), V2 (Mahamaya) and V3 (MTU-1010) respectively. Similarly observed and simulated physiological maturity of rice as influenced by different treatments is presented in (Table 4.3 and fig.2). Among three different dates of transplanting, the percent error of simulated physiological maturity over observed physiological maturity were percent error found very low (-5) in first date D_1 (30 June) of transplanting. Among all the cultivars simulated physiological maturity for V_1 (Swarna) was found closest observed values with percent error (-3) as compared to other cultivars. The average errors as computed by RMSE, were 7.36, 6.351 and 13.77 for V_1 (Swarna), V_2 (Mahamaya) and V_3 (MTU-1010) respectively. The average coefficient of determination (r^2**)** were 0.416, 0.751 and 0.35 for V_1 (Swarna), V_2 (Mahamaya) and V_3 (MTU-1010) respectively.

Grain yield

The observed and simulated grain yield of rice as influenced by different treatments is presented in (Table 4.3 and fig 3). Among three different dates of transplanting, the percent error of simulated grain yield over observed were found (-9) in second date D_2 (15 July) of transplanting. Among all the cultivars simulated grain yield for V_1 (Swarna) was found closest with observed values with percent error (-12) as compared to other cultivars. The average errors as computed by RMSE, were 662.4, 1000.5 and 712.9 for V_1 (Swarna), V_2 (Mahamaya) and V_3 (MTU-1010) respectively. The average coefficient of determination (r^2**)** were 0.359, 0.014 and 0.056 for V_1 (Swarna), V_2 (Mahamaya) and V_3 (MTU-1010) respectively.

The different between observed and simulated yields were not particularly great. Most differences between simulated yield and observed yield were lower than 10 %. The simulated results are considered acceptable if the different between simulated yield and actual yield is lower than 10 %. Loague and Green (1991). Also similar results are found to be in association with Sreenivas and Reddy (2013) [4].

Table 1: Genetic coefficients for three cultivars of rice at Raipur

Varieties	P1	P2R	P5	P2O	G1	G2	G3	G4
Swarna	541.0	150.0	523.0	10.5	50.0	.0140	1.00	1.00
Mahamaya	429.0	150.0	302.0	10.5	41.0	.0220	1.00	1.00
MTU1010	399.0	150.0	329.0	10.5	40.0	.0170	1.00	1.00

Table 2: Observed with simulated value for Anthesis (DAT) and Physiological maturity (DAT) at different dates of transplanting

Treatments	Anthesis (DAT)			Physiological maturity (DAT)		
	Observed	simulated	Error %	Observed	simulated	Error %
Dates of transplanting						
D_1(30June)	72	78	-8.3	102	107	-5
D_2(15July)	68	75	-10.2	99	106	-7
D_3(30July)	62	75	-20.9	96	109	-13
Varieties						
V_1(Swarna)	83	79	4.8	114	119	-3
V_2(Mahamaya)	64	77	-20	98	104	-6
V_3(MTU-1010)	56	72	-20	85	99	-16

Table 3: Observed with simulated value for Grain yield (q ha-1) at different dates of transplanting

Treatments	Grain yield (q ha^{-1})		
	Observed	simulated	Error %
Dates of transplanting			
D_1(30June)	43.4	48.6	-12
D_2(15July)	45.1	49.6	-9
D_3(30July)	37.9	49.3	-30
Varieties			
V_1(Swarna)	51.6	57.8	-12
V_2(Mahamaya)	39.1	47.9	-22
V_3(MTU-1010)	35.6	41.7	-17

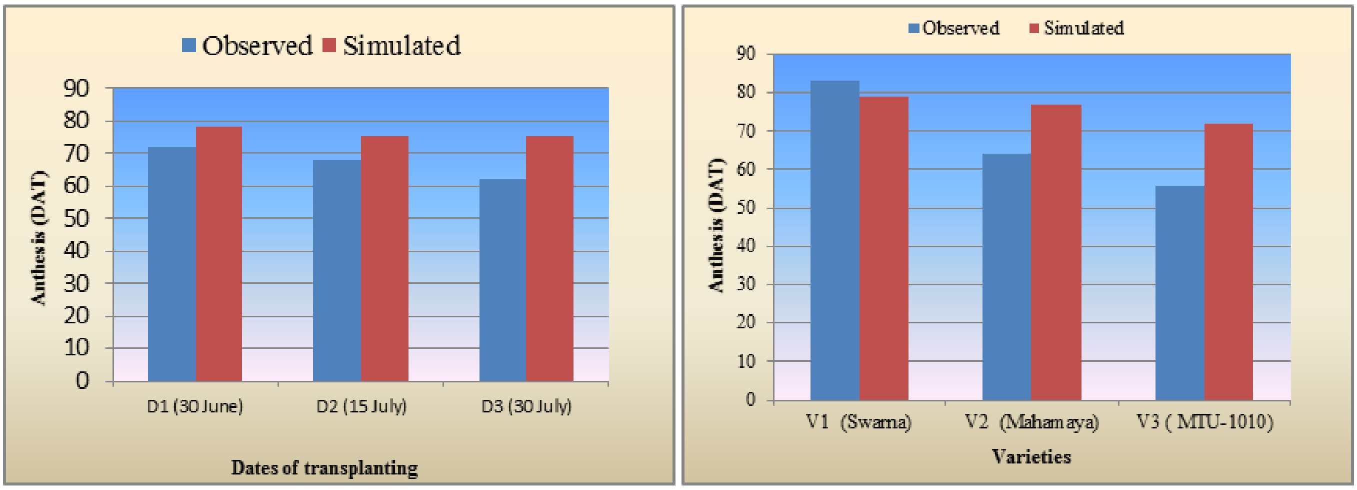

Fig 1: Observed with simulated value for Anthesis (DAT) at different dates of transplanting and different varieties.

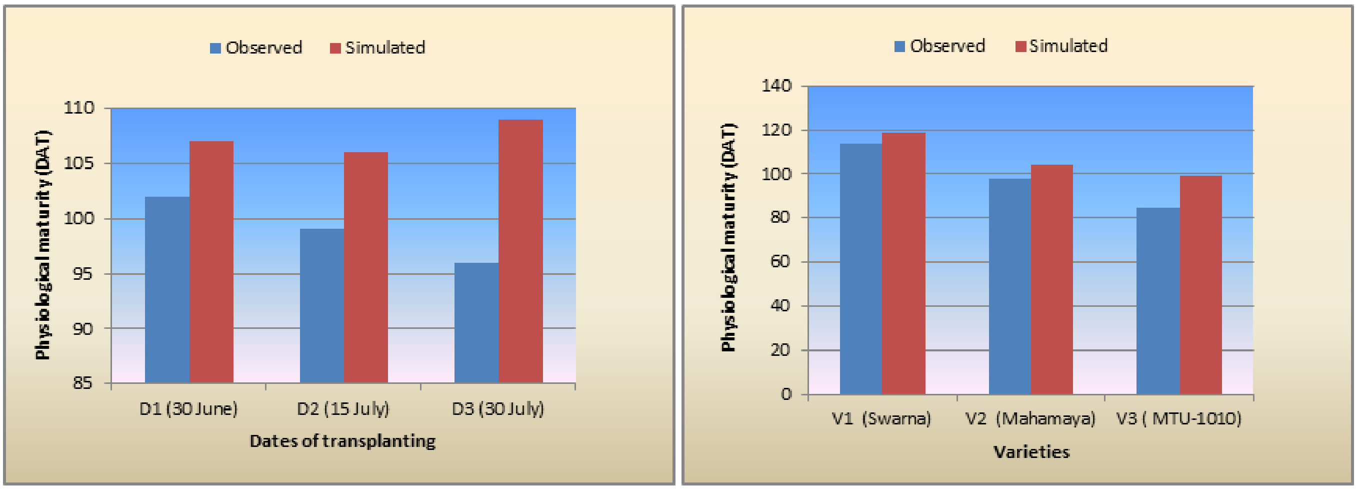

Fig 2: Observed with simulated value for Physiological maturity (DAT) at different dates of transplanting and different varieties.

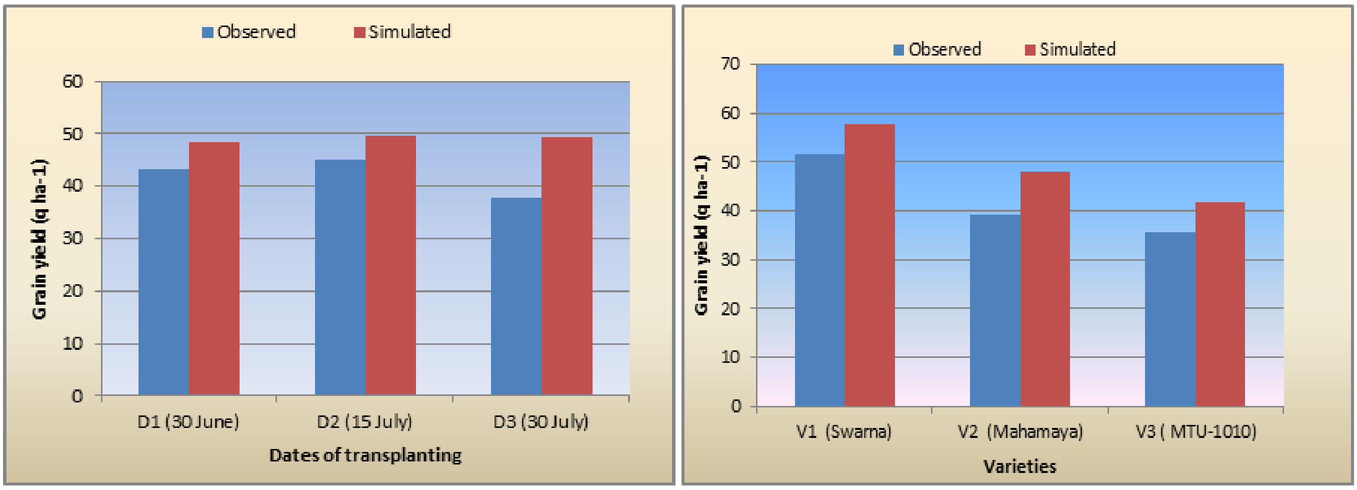

Fig 3: Observed with simulated value for Grain yield (q ha-1) at different dates of transplanting and different varieties.

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