International Journal of Advance Research in Science and Engineering
Volume No.07, Special Issue No.04, March 2018
www.ijarse.com
IJARSE
ISSN: 2319-8354

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ABSTRACT

The present study was conducted by using data from field experiment carried out at Research station Anantnag (Kudwani) Sher-e- Kashmir University of Agricultural Sciences and Technology, during 2011 and 2012. CERES-Rice (ver.4.5.) was used to calibrate and validate the data from field experiment comprises of four cultivars (Jhelum, Shalimar rice-1, SKAU-341 and SKAU-382) and three sowing dates (25 May, 10 and 25 June) . Model performance was satisfactory with regard to parameters phonological events (days to anthesis and maturity), grain yield , top weight at maturity and N-uptake. The per cent variation in simulated duration to anthesis over observed value ranged from -6.5 to 1.9 days. Duration of maturity also varied between transplanting dates and varieties under both simulated and observed values. The per cent variation in simulated duration to maturity over observed value ranged from -7.3 to 2.8 days. The observed values of grain yield of all treatments during both the years ranged from 3241 to 8931 kg ha^{-1}, as compared to simulated data ranging from 3058 to 9221 kg ha^{-1}. predicted total dry matter and N-uptake matched well with observed values.

Key Words: *calibration, CERES-Rice, simulation, sowing date ,and validation.*

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I INTRODUCTION

Rice (*Oryza sativa* L.) is one of the major crops to feed the world's growing population (Shimono *et al*., 2010). It contains a number of energy rich compounds such as carbohydrates, fat, protein and reasonable amount of iron, calcium, thiamine, riboflavin and niacin (Juliano, 1993). Rice crop plays a significant role in livelihood of people of Jammu and Kashmir State, however it is grown only once in a year in Kashmir valley because of extreme climatic conditions. The growth period of rice crop in Kashmir valley is limited by low temperature in spring and autumn. Temperature fluctuation at flowering and grain filling stage results in high spikelet sterility (Kumar, 2002). Temperature cannot be manipulated easily under field conditions but seeding time can be adjusted to meet the specific requirement for physiological stage of crop growth cycle (Suresh *et al.*, 2001). The adverse effect of sowing dates can also be minimized by selecting a suitable cultivar as the magnitude of yield reduction varies with the varieties (Medhi and Baruah, 2001). Crop simulation models can be used as a tool for agricultural risk analysis. They allow researchers to explore potential cropping location and appropriate farm management strategies. The generation of new data through agronomic research methods is insufficient to meet these needs. Conducting experiments at particular points in time and space is time consuming and expensive due to the many years of data collection that are required. In recent years, several dynamic crop growth simulation models have been developed as tools to support decision-making for agronomic research, land-use planning and crop production. These models have been embedded within the Decision Support System for Agrotechnology Transfer (DSSAT) (Hoogenboom *et al.*, 2010). The CERES-Rice model is one such crop model. This model is intended to have global application; therefore, genetic coefficients are an essential model component. Crop performance is terms of genetic coefficients used in the model can be used as a tool in choosing varieties and extend the utility of field experimentation. Once a crop model has been validated, it can be used to match variety and site rather than carry out extend field experiments. Modelling of rice growth and development began more than 30 years ago (Bouman and van Laar, 2006).In the temperate Kashmir valley in India it is noted that the model could be used to estimate crop productivity and optimize management practices.

II MATERIAL AND METHODS

The CERES- rice model was calibrated and validated with the data sets generated during kharif season of 2011 and 2012 through the field experiment carried out at Anantnag Station of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir with the objective to study the growth and yield of different varieties of rice at varying sowing dates. The Kashmir valley has humid temperate characterized by hot summers and severe cold winters. The annual precepetation ranges from 676 to 1193 mm with an average of 944.6 mm. The minimum and maximum temperature range between -8.0 to 33^{O}C, exhibit considerable variation both in summer and winter. The soil of the experimental site was silty clay loam. The treatment consisted of three dates of transplanting *viz.* 25 May, 10 June and 25 June and four cultivars *viz.* Jhelum, Shalimar rice-1, SKAU-341 (SR-2) and SKAU-382 (SR-3). The experiment was laid out in split plot design with four replications, assigning transplanting dates in main plot and cultivars in sub-plots. Treatments were allotted in each experimental plot randomly.

III RESULTS AND DISCUSSION

Calibration of the CERES-RICE MODEL

The CERES-rice model has been calibrated by conducting field experiments during the year 2011 and 2012 for validation of phenology, biometric parameters and yield. The coefficients were estimated by Hunt's (Hunt *et al*;

1993) method. The calibrated genetic coefficients based on field experiment data for rice cultivars (Jhelum, Shalimar rice-1, SKAU-341 and SKAU-382) are mentioned in table 1.

Validation of the CERES-RICE MODEL

To assess the accuracy of the CERES-rice model simulation results were validated against observed data generated from all treatments (four cultivars of rice transplanted on 25 May, 10 June and 25 June) prediction capabilities of the model were tested by judging the performance of crop in terms of grain yield, phenology top weight at maturity and N-uptake.

Phenological observations

The simulated duration to anthesis is shown in Table 2. The per cent variation in simulated duration to anthesis over observed value ranged from -6.5 to 1.9 days. Duration to anthesis varied between sowing dates and varieties under both simulated and observed values. The range was between 73 to 108 days and 77 to 105 days for observed and simulated data, respectively. The RMSE (Root Mean Square Error) obtained between the actual and predicted anthesis was 3.40 days with a MAE (Mean Absolute Error) of 3.0 days .Simulated data showed that 25 May recorded highest number of days to reach anthesis and 25 June transplanting took least number of days to anthesis. Simulated and observed data showed cultivar SKAU-382 transplanted on 25 June recorded least number of days to reach anthesis and cultivars SKAU-341 and Shalimar rice-1 transplanted on 25 May took maximum number of days to anthesis.

Duration of maturity also varied between transplanting dates and varieties under both simulated and observed values. The per cent variation in simulated duration to maturity over observed value ranged from -7.3 to 2.8 days. Duration to maturity varied between sowing dates and varieties under both simulated and observed values (Table 2). The range was between 117 to 150 days and 115 to 149 days for observed and simulated data, respectively. The RMSE (Root Mean Square Error) obtained between the actual and predicted maturity was 4.27 days with a MAE (Mean Absolute Error) of 3.88 days.Simulated data showed that 25 May recorded highest number of days to reach maturity and 25 June transplanting took least number of days to maturity. Cultivars Shalimar rice-1 and SKAU-341 transplanted on25 May recorded maximum number of days to mature for both predicted and observed values whereas cultivar Jhelum and SKAU-382 transplanted on 25 June took least number of days to mature for both simulated and observed values.

Grain yield

Observed and Predicted yield have been presented in Table 2. The observed values of all treatments during both the years ranged from 3241 to 8931 kg ha^{-1}, as compared to simulated data ranging from 3058 to 9221 kg ha^{-1}.

The predicted yield value varied between -12.8 to 15.5 per cent over observed values during both the years of validation. The RMSE for the grain yield was 551.13 kg ha^{-1} with a MAE of 455.58 kg ha^{-1}.The grain yield was maximum for the earliest transplanting (25 May) over the year and decreased progressively with delay in transplanting. Cultivar SKAU-341 recorded lowest observed yield on all transplanting dates where as cultivar Jhelum recorded highest observed grain yield.

Tops weight at maturity

Observed tops weight at maturity ranged from 6017 to 15287 kg ha^{-1}, compared to 5732 to 15616 kg ha^{-1} for simulated yield under different treatments (Table 3). The per cent variation in simulated tops weight at anthesis over observed value ranged from -10.2 to 9.0. The RMSE of tops weight at maturity was 700.78 kg ha^{-1} along with MAE value of 595.63 kg ha^{-1} .For both observed and simulated data 25 May transplanting gave the maximum tops weight at maturity. While lowest tops weight at maturity was recorded on 25 June transplanting. Cultivars SKAU-341 transplanted on all the three dates recorded maximum tops wt at maturity whereas cultivar SKAU-382 recorded least tops wt at maturity except 10 and 25 June during 2011 and 25 June during 2012. Simulated results also showed the maximum tops wt of cultivar SKAU-341 recorded maximum tops weight except 25 June transplanting of both the years whereas SKAU-382 recorded least tops wt at maturity except 25 June transplanting of both the years.

N-uptake

The tops nitrogen uptake ranged from 66 to 165 kg ha^{-1}, compared to 61 to 162 kg ha^{-1} for simulated yield under different treatments (Table 3). The per cent variation in simulated N uptake over observed value ranged from -7.6 to 10.2. The model predicted N uptake reasonably well with RMSE value of 5.81 kg ha^{-1}, MAE value of 5.0 kg ha^{-1} and D-index value of 0.97.For both observed and simulated data 25 May transplanting gave the maximum nitrogen uptake and the lowest was recorded on 25 June transplanting. Cultivars SKAU-341 transplanted on25 May recorded maximum nitrogen uptake for observed values and cultivar Shalimar rice-1 and SKAU-341 recorded maximum nitrogen uptake for simulated values. Cultivar SKAU-382 transplanted on 25 June recorded least nitrogen uptake.

Table 1: Genetic coefficients of cultivars

Genetic parameter	Description*	Jhelum	Shalimar rice-1	SKAU-382	SKAU-341
P1	Time period (GDD) of basic vegetative phase	440.0	510.0	430.0	510.0
P2R	Extent phasic development (GDD)	10.0	10.0	10.0	10.0
P5	Time period (GDD) of grain filling phase	400.0	405.0	400.0	405.0
P20	Critical photo period (hour)	12.0	12.0	12.0	12.0
G1	Potential spikelet number	60.0	59.0	60.0	60.0
G2	Single grain weight	0.240	0.250	0.238	0.250
G3	Tillering coefficient	1.00	1.00	1.01	1.10
G4	Temperature tolerance coefficient	1.00	1.25	1.00	1.00

Table 2: Validation results of rice cultivars for, days to anthesis and maturity and yield (kg ha^{-1}) under different transplanting dates at Anantnag

Obs=observed ; sim=simulated; devi=deviation; RMSE=Root mean square error; MAE=Mean Absolute Error

Treatment	Days to anthesis				Days to maturity				Yield			
	Obs	Sim	Devi	% Devi	Obs	Sim	Devi	% Devi	Obs	Sim	Devi	%Devi
25th May SR-1	99	102	-3	3.03	141	145	-4	2.84	8759	9011	-216	2.46
25th	97	100	-3	3.09	139	141	-2	1.44	8931	9221	-290	3.25

May Jhelum												
25th May SKAU-382	96	100	-4	4.17	138	141	-3	2.17	8612	9221	-609	7.07
25th May SKAU-341	106	103	3	-2.83	149	145	4	-2.68	8217	9049	-832	10.13
10th June SR-1	91	89	2	-2.20	131	128	3	-2.29	7859	8343	-484	6.16
10th June Jhelum	90	87	3	-3.33	129	126	3	-2.33	7926	8923	-997	12.58
10th June SKAU-382	90	87	3	-3.33	129	126	3	-2.33	7754	8923	-1169	15.08
10th June SKAU-341	97	93	4	-4.12	139	131	8	-5.76	7210	8326	-1116	15.48
25th June SR-1	81	79	2	-2.47	122	117	5	-4.10	4205	4384	-179	4.26
25th June Jhelum	81	77	4	-4.94	121	116	5	-4.13	4562	4973	-411	9.01

IJARSE
ISSN: 2319-8354

25th June SKAU-382	83	77	6	-7.23	123	116	7	-5.69	4208	4973	-765	18.18
25th June SKAU-341	88	86	2	-2.27	129	125	4	-3.10	3996	4547	-551	13.79
25th May SR-1	101	104	-3	2.97	142	145	-3	2.11	7563	7240	323	-4.27
25th May Jhelum	98	101	-3	3.06	140	136	4	-2.86	7687	7381	306	-3.98
25th May SKAU-382	99	101	-2	2.02	140	136	4	-2.86	7321	7381	-60	0.82
25th May SKAU-341	107	102	5	-4.67	149	144	5	-3.36	6532	7228	-696	10.66
10th June SR-1	91	95	-4	4.40	132	135	-3	2.27	5679	5077	602	-10.60
10th June Jhelum	90	85	5	-5.56	132	128	4	-3.03	5832	5088	744	-12.76
10th June SKAU-	91	85	6	-6.59	120	128	-8	6.67	5219	5088	131	-2.51

382												
10^{th} June SKAU-341	97	95	2	-2.06	138	133	5	-3.62	4924	5163	-239	4.85
25^{th} June SR-1	83	80	3	-3.61	123	126	-3	2.44	3106	2894	212	-6.83
25^{th} June Jhelum	82	77	5	-6.10	122	117	5	-4.10	3398	3414	-16	0.47
25^{th} June SKAU-382	83	77	6	-7.23	131	117	6	-4.88	3241	3414	-173	5.34
25^{th} June SKAU-341	89	82	7	-7.87	125	125	6	-4.58	2863	3058	-195	6.81
MAE	**3.75**				**4.46**				**47.15**			
RMSE	**4.02**				**4.73**				**574.21**			

Table 3 : Validation results of rice cultivars for tops N (kg ha^{-1}) and tops weight at maturity (kg ha^{-1}) under different transplanting dates at Anantnag

Treatment	**Tops N**				**Tops weight at maturity**			
	Obs	**Sim**	**Devi**	**% Devi**	**Obs**	**Sim**	**Devi**	**% Devi**
25^{th} May SR-1	159	162	-3	1.89	14638	15616	-978	6.68
25^{th} May Jhelum	155	159	-4	2.58	14429	15583	-1154	8.00

25th May SKAU-382	151	159	-8	5.30	13972	15583	-1611	11.53
25th May SKAU-341	165	162	3	-1.82	15287	15496	-209	1.37
10th June SR-1	138	144	-6	4.35	13651	14880	-1229	9.00
10th June Jhelum	137	151	-14	10.22	14062	15315	-1253	8.91
10th June SKAU-382	135	151	-16	11.85	13860	15315	-1455	10.50
10th June SKAU-341	142	144	-2	1.41	15269	15077	192	-1.26
25th June SR-1	86	81	5	-5.81	8017	7902	115	-1.43
25th June Jhelum	89	84	5	-5.62	8865	9029	-164	1.85
25th June SKAU-382	85	84	1	-1.18	8326	9029	-703	8.44
25th June SKAU-341	86	81	5	-5.81	8991	8100	891	-9.91
25th May SR-1	133	137	-4	3.01	14210	13901	309	-2.17
25th May Jhelum	128	125	3	-2.34	14107	13552	555	-3.93
25th May	126	125	1	-0.79	13768	13552	216	-1.57

SKAU-382								
25th May SKAU-341	140	137	3	-2.41	14289	13880	409	-2.86
10th June SR-1	109	104	5	-4.59	11283	10128	1155	-10.24
10th June Jhelum	98	91	7	-7.14	10105	9524	581	-5.57
10th June SKAU-382	95	91	4	-4.21	9865	9524	341	-3.46
10th June SKAU-341	111	104	7	-6.31	11253	10312	941	-8.36
25th June SR-1	70	65	5	-7.14	6017	5732	285	-4.74
25th June Jhelum	68	63	5	-7.35	6218	6526	-308	4.95
25th June SKAU-382	66	63	3	-4.55	6117	6526	-409	6.69
25th June SKAU-341	69	64	5	-7.25	6410	5959	451	-7.04
MAE	**5.17**				**663.02**			
RMSE	**6.20**				**799.15**			

Obs=observed ; sim=simulated; devi=deviation; RMSE=Root mean square error; MAE=Mean Absolute Error

CONCLUSION

Among transplanting dates 25 May transplanting of rice is most suitable in terms of yield under temperate

Kashmir. Cultivar Jhelum out yield all other rice varieties and can be recommended for getting higher productivity in the of Valley.

Crop growth models are very good tools for analyzing the earth-plant-atmospheric system and their interactions. The crop models can provide a frame work for interpreting the output from field experiments and they can be used to explore ways of improving management A rice yield of simulated by the crop model agrees well with the actual yield record. Thus study demonstrates that CERES-Rice can be utilized to predict development (phenological stages), growth, yield and yield attributes at different locations of Kashmir.

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