The Pharma Innovation Journal 2023; 12(1): 2724-2728

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(1): 2724-2728

www.thepharmajournal.com
Received: 10-10-2022
Accepted: 18-12-2022

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Futuristic yield of summer rice under changing climatic scenario using DSSAT model in Khordha district

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Abstract

Rice is the staple food crop of Odisha region, but it is matter of concern that it is below national average in yield. The predominate reason is adverse climate condition. With increasing effect of climate change, Rice production in the region is at stake, that's why it was needed to study impact of climate change on the yield in the future perspective. In this study CERES-RICE model of DSSAT is used to asses climate change impacts in Odisha region. This study aimed to explore the impacts on yield of rice variety (Sahabhagidhan) in summer season under projected climate change for Khordha, Odisha using four global climate change Representative Concentration Pathways (RCP) scenarios 2.6, 4.5, 6.0 and 8.5 for four future years 2040, 2060 and 2080. CMIP5 (Coupled Model Intercomparison Project Phase 5) was employed to generate these climate projections with weather parameters like temperature, rainfall and solar radiation for the study area. The Decision Support System for Agro technology Transfer (DSSAT) software was used to forecast the rice yield under four transplanting dates (15 January, 31 January, 15 February and 28 February) for summer season in 2040, 2060 and 2080. In the present study, Sahabhagidhan recorded higher grain yield in early season transplanting (January 15) whereas late season transplanting (February 28) recorded lower grain yield condition. Under the projected climatic condition for the years 2040, 2060, and 2080, RCP 2.6, 4.5, 6.0 and 8.5 scenarios are found to cause negative impacts on the grain yield of summer rice in. In the Future years namely 2040, 2060, and 2080 there is a reduction in the grain yield of summer rice under the seasonal climatic projection due to the increase in seasonal maximum temperature, minimum temperature and decreasing rainfall condition.

Keywords: Futuristic, summer rice, climatic, DSSAT, Khordha

Introduction

Under India, rice is farmed in a wide range of climatic and altitude conditions. As a result, depending on factors like temperature, rainfall, soil type, water availability, and other meteorological circumstances, the rice growing seasons fluctuate in different parts of the country. Under climate change scenarios, an increase in ambient CO_2 is usually considered beneficial as it results in increased photosynthesis in rice crop while the rising temperature nullifies the positive effect of increased CO_2 concentration on rice yield. Higher temperatures will reduce crop yields due to reduction in the rate of photosynthesis, increase of respiration process and also a shortened vegetative and grain-filling period (Radziah *et al*., 2010) [9]. This may eventually reduce the yield and rate of productivity.

Being the coastal state, climate of Odisha is varying due to various factors like late onset of monsoon and more pre-monsoon rainfall. Reduced post-monsoon and winter rainfall, maximum increase in temperature in post-monsoon followed by summer, more frequent extreme weather events such as hot extremes (maximum temperature above 45 °C) and prolonged heat waves, more intense tropical cyclones with larger peak wind speeds and heavier rainfall and intense storms resulting in loss of the rain water as direct runoff resulting in reduced groundwater recharging potential. It is found that optimum combinations of temperature and rainfall are needed to increase agricultural production of Odisha (Pasupalak, 2009) [7].

In India, crop simulation models (CSMs) are becoming a crucial research tool for quantifying the change in yield potential under various management levels and environmental variability. Technology for efficient crop production is built on making the correct choice at the right time in the right manner. It has also been demonstrated that simulation research can support field research in the area of decision-making (Aggarwal *et al*., 1994) [1].

The best suitable model for a given situation will rely on how it will be used and how well the input data are (Mall *et al*., 2002; Ziaei and Sepaskhah, 2003) [13, 6]. One such model that can accurately predict the growth, development, and yield of rice crop with the help of soil, daily weather, and management inputs data is the Decision Support System for Field research is frequently carried out in little experimental plots, but crop models may quickly and cheaply offer an answer for the entire region before planting the crop under any climatic change. The use of simulation models in field research is crucial for boosting agriculture production while utilizing the fewest resources possible in both rich and developing nations (Jones *et al*., 1994) [4].

Materials and Methods

Location of the experimental site: The field experiment was carried out at the Research and Instructional farm of OUAT, College of Agriculture, Bhubaneswar, Odisha situated at 20.15^0 N latitude and 85.52^0 E longitude and at an altitude of 25.9 m above the mean sea level. It comes under the East and South-East coastal plain of Odisha.

The field experiment was conducted during the summer season of 2021-22 from December- April with two varieties of rice namely Bina-11 (125 Days) & Sahabhagidhan (115 Days) in four different dates of transplanting (15th January, 31st January, 15th February and 28th February). The net plot area was 20m².

Field Observations

The agronomic data of Sahabhagidhan such as plant height (in cm), Number of tillers/m2, observations on phenological stages like tillering, PI, anthesis, maturity and harvesting stages were carefully observed and recorded. The yield data like number of panicles per square meter, total number of grains per panicle, grain yield, Straw yield, biological yield and harvest index were recorded.

Projection of futuristic climatic scenario

The changes in weather parameters like temperature, CO_2 concentration for future years (2040, 2060 and 2080) in Khordha district coming under East and South East Coastal Plain Zone of Odisha were projected under four possible climatic scenarios (RCP 2.6, 4.5, 6.0 and 8.5), which were used in Fifth Assessment Report of IPCC. These projection scenarios (RCP2.6, 4.5, 6.0 and 8.5) for all the three projected years (2040, 2060, and 2080) are used individually to make weather data for simulating in the CERES-Rice model to study the impact of climate change that may affect the Summer-rice 26 production potential. To test the hypothesis an attempt has been made to assess the effect of these parameters on crop growth, yield and physiological vegetation of the rice variety i.e., Sahabhagidhan, which is commonly grown under the East and South Eastern Coastal Plain zone of Odisha.

Representative Concentration Pathway (RCPs)

Representative Concentration Pathway (RCPs) are used to provide time-dependent projections of atmospheric greenhouse gas (GHG) concentrations in future. The pathways are possible depended on the greenhouse gases (GHGs) emissions in future years. The value in each pathway determines radiative forcing value in the year 2100 relative to pre-industrial values, i.e., +2.6, +4.5, +6.0 and +8.5W/m2, respectively.

Results and Discussion

Phenological studies

The number of days required to reach a particular phenophase varied significantly under different varieties and dates of planting which is presented in table 1 below. The rice varieties planted on 15 January took maximum number of days to reach the maturity (113) & harvesting stage (131) and gradually decreased with advancement of date of transplanting with 28th Feb DAT showed minimum (105) days to reach harvesting stage. In case of tillering, PI and harvesting, Sahabhagidhan was significantly different from Bina 11. The interaction effects between date and varieties were significant in all the phenological phases.

Table 1: The number of days required to reach a particular phenophase varied significantly under different varieties and dates of planting which is presented

DATs	Tillering	PI	Anthesis	PM	Harvesting
15-Jan	39.2	71.5	95.2	113.3	131.0
31-Jan	36.8	70.0	85.7	103.5	117.5
15-Feb	35.0	66.0	79.0	98.7	110.2
28-Feb	31.3	59.5	74.8	91.8	105.5
Sem ±	0.17	0.36	0.5	0.5	0.4
CD	0.51	1.08	1.6	1.4	1.3
Bina 11	35.9	68.8	83.9	102.2	117.3
Sahabhagidhan	35.3	64.8	83.4	101.5	114.8
Sem ±	0.12	0.25	0.4	0.3	0.3
CD	0.36	0.77	1.1	1.0	0.9
Interaction					
Sem ±	0.24	0.51	0.7	0.7	0.6
CD	0.71	1.53	2.2	2.0	1.9

Plant height (cm)

The plant height was influenced with different varieties and dates of planting. At 75DAT rice transplanted on 15 January recorded the highest plant height (100.5 cm) which was at par with 31 January planting. Among varieties, Bina 11 recorded highest plant height (92.6 cm) which is at par with Sahabhagidhan at 75DAT. The interaction effects are significant with respect to planting heights at all dates of transplanting.

Number of tillers/m^2

The number of tillers/m^2 was influenced by different varieties and dates of planting. Rice transplanted on 15 January recorded the highest tillers/m^2 (352.8) at 75DAT and the tiller numbers decreased with postponement of transplanting dates. Among varieties, Sahabhagidhan recorded the highest tillers/m^2 (343.4) which is at par with Bina 11 at 75DAT. From the interaction effect we can observe that Sahabhagidhan planted on 28th February recorded maximum tillering as compared to other date & variety combinations.

Harvest data

Tillers/m2 & panicles/m2: From the data presented in the table 2, it indicates that the tillers/m^2 at harvest stage were influenced by different varieties and dates of planting. Rice plant transplanted on 15th of January observed highest tillers/m2 (358.2) which is at par with the transplantation on 31st January (314.3) & and highest panicles/m2 (310.3) which is at per with others. Among varieties Sahabhagidhan recorded both highest number of tillers (343.4) and panicles (292.7) per square meter. The panicle-2 of Sahabhagidhan is at par with Bina 11. The interaction effect resulted in both highest tillers/m2 (400.0) & panicles/m2 (340.7) in Sahabhagidhan 0n 15 January transplanting.

Total grains/panicle & Fertility %: Total grains per panicle and fertility percentage of two rice varieties are displayed in table 2 below. Fertility in rice is mostly an environmental dependent character rather than a vertical character. It was observed that total grains per panicle & fertility percentage decreased with advancement of transplanting date i.e., highest total grains per panicle (96.9) and fertility percentage (82.5) on 15 January. Among varieties Bina 11 observed highest fertility 81.2% which is significantly different from Sahabhagidhan and in Sahabhagidhan highest total grains per panicle were recorded. From the interaction effect were significant in both fertility percentage and total grains/panicle.

Grain yield & Straw yield in (kg/ha)

The grain yield of a rice is a function of total number of panicles, number of grains per panicle and the test weight. It was observed that grain & straw yield decreased with advancement of transplanting date i.e., highest grain yield (3984.2 kg/ha) and highest straw yield (4595.8 kg/ha) was observed on 15 January. Among varieties Sahabhagidhan observed both highest grain yield and straw yield. The interaction effect recorded Sahabhagidhan planted on 15 January recorded both highest grain (3993.3 kg/ha), straw (4616.7 kg/ha) yield which was at par with Bina 11.

Table 2: Data presented in the table 2, it indicates that the tillers/m^2 at harvest stage were influenced by different varieties and dates of planting

DAT	Tillers/m^2	Panicles/m^2	Total Grains/Panicle	Fertility %	Grain Yield (kg/ha)	Straw yield (kg)/ha
15-Jan	358.2	310.3	96.9	82.5	3984.2	4595.8
31-Jan	314.3	269.5	95.9	77.2	3117.2	3520.8
15-Feb	277.3	234.7	91.2	75.9	2716.0	3183.3
28-Feb	295.5	249.5	87.7	61.7	1883.3	3063.3
Sem ±	16.7	32.8	4.0	1.2	150.7	143.7
CD	50.7	99.4	12.1	3.7	456.9	435.7
Varieties						
BINA 11	279.3	236.6	88.3	81.2	3341.7	3585.4
Sahabhagidhan	343.4	292.7	97.6	67.4	3375.0	3596.3
Sem ±	11.8	23.2	4.4	0.9	106.5	101.6
CD	35.9	70.3	13.5	2.6	323.1	308.1
Interaction						
Sem ±	23.71	23.6	5.7	3.0	213.1	203.2
CD	71.8	71.7	17.2	9.0	646.2	616.2

Future scenario of summer rice yield under projected seasonal climate change

Predicted yield of Sahabhagidhan in four transplanting dates D1, D2, D3, D4 under the projected climate RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 scenarios for 2040, 2060 and 2080 are given in table 3 (a-d). It also shows the percent of decrease in yield with respect to the present yield.

For the year 2040, Model simulated the changes in yield of -10.77%, -8.56%, -6.31%, -16.78% for D1 transplanting, -9.33%, -8.05%, -13.63%, -15.50% for D2 transplanting, -8.20%, -3.45%, -9.90%, -15.10% for D3 transplanting, -8.34%, - 13.43%, -20.19%, -21.43% for D4 transplanting under RCP 2.6, 4.5, 6.0 and 8.5 scenarios respectively.

For the year 2060, Model simulated the changes in yield of -7.51%, - 12.02%, -8.26%, -19.3% for D1 transplanting, -7.76%, -11.16%, -11.22%, -15.21% for D2 transplanting, -5.76%, -5.72%, -7.79%, -15.46% for D3 transplanting, -3.55%, -11.80%, -16.00%, -20.09% for D4 transplanting under RCP 2.6, 4.5, 6.0 and 8.5 scenarios respectively.

For the year 2080, Model simulated the changes in yield of -12.27%, - 10.52%, -10.32%, -19.28% for D1 transplanting, -12.13%, -14.59%, -15.33%, -18.46% for D2 transplanting, -7.34%, -6.13%, -14.25%, -18.35% for D3 transplanting, -10.963%, -14.96%, -16.88%, -25.23% for D4 transplanting under RCP 2.6, 4.5, 6.0 and 8.5 scenarios respectively.

Table 3a: Transplanting on Jan 15

Scenario	2040		2060		2080	
	Yield	Change (%)	Yield	Change (%)	Yield	Change (%)
Present	3993		3993		3993	
RCP 2.6	3563	-10.77	3603	-7.51	3503	-12.27
RCP 4.5	3651	-8.56	3513	-12.02	3573	-10.52
RCP 6.0	3743	-6.31	3663	-8.26	3581	-10.32
RCP 8.5	3323	-16.78	3223	-19.3	3128	-19.28

Table 3b: Transplanting on Jan 31

Scenario	2040		2060		2080	
	Yield	Change (%)	Yield	Change (%)	Yield	Change (%)
Present	3234		3234		3234	
RCP 2.6	2932	-9.33	2983	-7.76	2842	-12.13
RCP 4.5	2993	-8.05	2873	-11.16	2762	-14.59
RCP 6.0	2793	-13.63	2817	-11.22	2738	-15.33
RCP 8.5	2733	-15.50	2742	-15.21	2637	-18.46

Table 3c: Transplanting on Feb 15

Scenario	2040		2060		2080	
	Yield	Change (%)	Yield	Change (%)	Yield	Change (%)
Present	2463		2463		2463	
RCP 2.6	2261	-8.20	2321	-5.76	2282	-7.34
RCP 4.5	2378	-3.45	2322	-5.72	2312	-6.13
RCP 6.0	2219	-9.90	2271	-7.79	2112	-14.25
RCP 8.5	2091	-15.10	2082	-15.46	2011	-18.35

Table 3d: Transplanting on Feb 28

Scenario	2040		2060		2080	
	Yield	Change (%)	Yield	Change (%)	Yield	Change (%)
Present	2025		2025		2025	
RCP 2.6	1856	-8.34	1953	-3.55	1803	-10.96
RCP 4.5	1753	-13.43	1786	-11.80	1722	-14.96
RCP 6.0	1616	-20.19	1701	-16.00	1683	-16.88
RCP 8.5	1591	-21.43	1618	-20.09	1514	-25.23

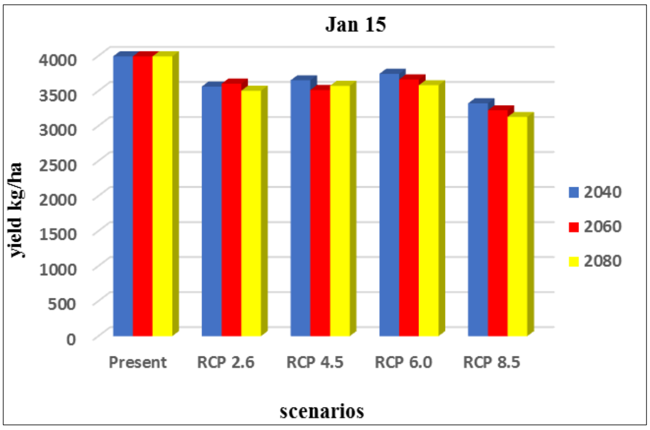

Fig 1a: Transplanting on 15 January

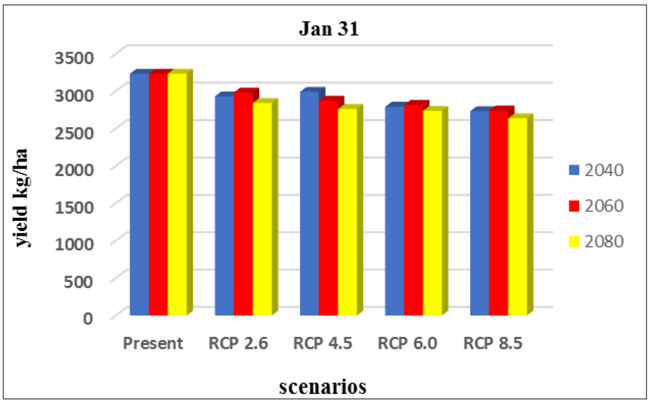

Fig 1b: Transplanting on 31 January

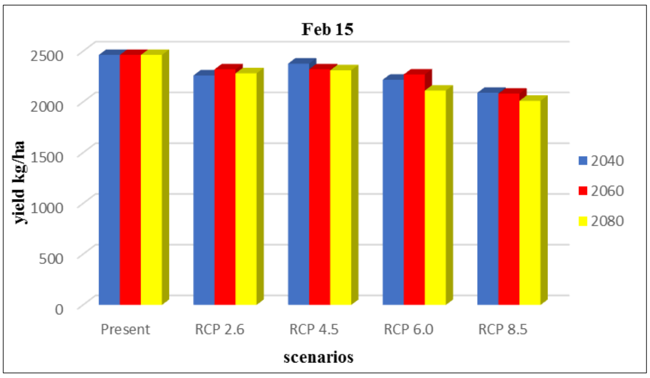

Fig 1c: Transplanting on 15 February

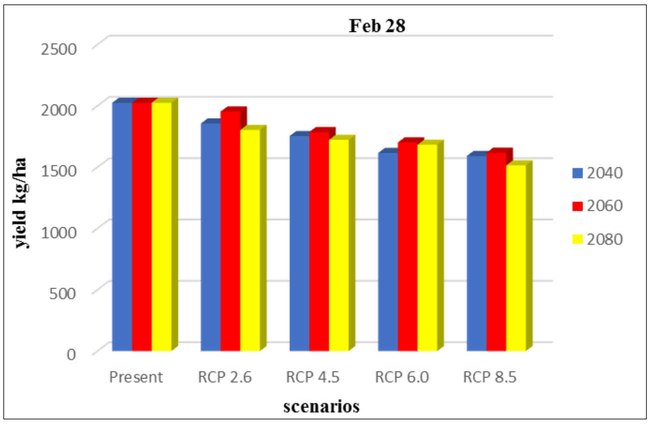

Fig 1d: Transplanting on 28 February

Fig 1a-d: Reveals the future yield trends in four transplanting dates under four scenarios of climate change for 2040, 2060 and 2080.

Conclusion

Different transplanting dates significantly reflected the grain yield and it was reduced with postponement of transplanting. The highest grain yield was recorded when transplanted on 15 January (3984.2 kg/ha) followed by 31 January (3117.2 kg/ha) transplanting and the lowest yield was noted on 28 February (1883.3 kg/ha). The yield on 15 January was significantly different from others. The favorable effect of transplanting during 23rd and 31st January in increasing the yield components of rice ascribed to enhancement of grain yield. These results are in line with findings of Duvvada *et al*. (2020) [3] & Roy *et al*. (2019) [10].

In the present investigation, it has been found that the projected impact under RCP 4.5, RCP 6.0 and RCP 8.5 scenarios is more severe as compared to RCP 2.6 scenario on the grain yield characteristic of rice resulting in decrease of the yield in future for the years 2040, 2060 and 2080. The extent of decrease in yield is mostly because of the fact there is significant increase in projected mean maximum and minimum temperature by the years 2040, 2060 and 2080.

In this study, the crop model is used to assess the impact of climate change on Rice yield in Odisha region. The yield reduction can be explained as increase in temperature, as Rice is heat-stress sensitive, (>35 °C) and flowering stage is most sensitive to such stress (Prasad *et al*. 2006) [8].

There is seen an increase in temperature more than the optimum in the study area with an average of 30-35 °C in

RCP 4.5 and RCP 8.5., As increase in 1 °C will reduce the yield by 6-11% (Saxsena and Kumar 2014) [11], and due to increase in minimum temperature (T_{min}) over the years, the yield is affected as higher minimum temperature would increase respiration rate and thus reduce yield (Mall *et al.* 2019) [12].

References

1. Aggarwal PK, Kalra N. Analyzing the limitations set by climatic factors, genotype, and water and nitrogen availability on productivity of wheat II. Climatically potential yields and management strategies. Field Crops Research. 1994;38(2):93-103.
2. Ahmad S, Ahmad A, Tojo Soler CM, Ali H, Zia-Ul-Haq M, Anothai J. Application of the CSM-CERES-Rice model for evaluation of plant density and nitrogen management of fine transplanted rice for an irrigated semiarid environment. Precision Agriculture. 2012;13:200-218.
3. Duvvada SK, Mishra GC, Maitra S, Patra C. Influence of irrigation regimes and date of transplanting on yield and economics of summer rice (*Oryza sativa*). Crop Research. 2020;55:0970-4884.
4. Jones JW. Input and output files. Decision Support System for Agrotechnology Transfer (DSSAT) Version, G. Y. Tsuji, G. Uehara, and S. Balas, Eds., University of Hawaii. 1994;3(2):1-94.
5. Lamsal A, Amgain LP. Simulation of growth and yield of rice under varied agronomic management and changing climatic scenario by using DSSAT ver. 4.0 crop model in Chitwan, Nepal. Journal of Hill Agriculture. 2010;1:114-123.
6. Mall RK, Gupta BRD. Comparison of evapotranspiration models. Mausam. 2002;53:119-126.
7. Pasupalak S. Climate Change and Agriculture in Orissa. Orissa Review; c2009 April- May, p. 49-52.
8. Prasad PV, Boote KJ, Allen Jr, LH. Adverse high temperature effects on pollen viability, seed-set, seed yield and harvest index of grain-sorghum [*Sorghum bicolor* (L.) Moench] are more severe at elevated carbon dioxide due to higher tissue temperatures. Agricultural and forest meteorology. 2006;139(3-4), 237-251.
9. Radziah ML, Engku Elini EA, Tapsir S, Mohamad Zabawi AG. Food security assessment under climate change scenario in Malaysia. Palawija News. 2010;27:1–5.
10. Roy KT, Paul SK, Sarkar RA. Md. Effect of irrigation and date of transplanting on summer rice 79 Influence of date of transplanting on the growth and yield performance of high yielding varieties of boro rice. J Bang. Agric. University. 2019;17:301-08.
11. Saxena Rani, Naresh Kumar, Soora. Simulating the impact of projected climate change on Rice (*Oryza sativa* L.) yield and adaptation strategies in major Rice growing regions of India. Journal of Agrometeorology. 2014;16:18-25.
12. Sonkar G, Mall RK, Banerjee T, Singh N, Kumar TL, Chand R. Vulnerability of Indian wheat against rising temperature and aerosols. Environmental Pollution. 2019;254:112946.
13. Ziaei AN, Sepaskhah AR. Model for simulation of winter wheat yield under dryland and irrigated conditions. Agricultural Water Management, 2003;58(1):1-17.