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Nitesh Kumar Jaiswal
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

JL Chaudhary
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Anil Patel
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Corresponding Author:
Nitesh Kumar Jaiswal
Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India

Assessment of yield variation in rice varieties under changing climate scenario under RCP 4.5 in Chhattisgarh plain zone

Nitesh Kumar Jaiswal, JL Chaudhary and Anil Patel

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Abstract
Result revealed that Panicle initiation days, anthesis days and the duration of physiological maturity of MTU-1010, Rajeshwari and CG Sugandhit Bhog under RCP 4.5 scenario is projected to decrease from present condition (2021) to future scenario i.e., 2030, 2050 and 2070 under all growing environments at Raipur condition. Highest reduction in error percentage with RMSE is projected in 2070 under all three dates of sowing while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments. In MTU-1010, Rajeshwari and CG Sugandhit Bhog projection observed highest reduction in grain yield with error percentage and RMSE in 2070 followed by 2050 and 2030 in all three growing environments (D_1, D_2 and D_3).

Keywords: RMSE, scenario, RCP

Introduction
Rice (*Oryza sativa* L.) is an important staple food for nearly 50% of the global population (Heinrichs *et al*., 2017) [3]. Amongst the important rice-producing nations in the world, India ranks second to China in terms of area and production.). Out of 782 million tonnes (MT) of global rice production from 167.1 million hectares (M ha), India produced 116.42 million tonnes in 44.5 m ha (rainy season: 102.13 MT from 39.27 M ha) (FAO, 2020; GoI, 2020) [2]. Chhattisgarh, India's newest state, has long been regarded as the country's rice bowl. Millions of rice farmers in India have already been negatively affected by climate. Rice yield can be affected by climate change due to direct effects of temperature and carbon dioxide on crop growth and yield. The last three decades have showed a decline in rice yield, which may be related to the weather gradually changing. Globally, climate change is accelerating rapidly. By 2050, it is predicted that climate change will have a 4.5 to 9 percent negative impact on India's rice production (Munneh *et al.* 2007) [5]. According to Pattanayak and Kumar (2013) [6], India's rice production from 1969 to 2007 would have been 8% higher in the absence of climate change. Kumar *et al.* (2013) [4] stated reduction in irrigated paddy yields about 4, 7 and 10% during the 2020s, 2050s and 2080s scenarios, respectively in India. In the 2020s scenario, rainfed rice yields are expected to decrease by about 6%, but in the 2050s and 2080s, the decline is only expected to be slight (2.5%).

Material Method
The present investigation on "Assessment of yield variation in rice varieties under changing climate scenario under RCP 4.5 in Chhattisgarh plain zone" has been conducted during kharif season, 2021 at Research and Instructional farm of Indira Gandhi Krishi Vishwavidyalaya. Raipur situated in Eastern Central part of Chhattisgarh at $21^0$16' N, longitude 81^0 36' E latitude and an altitude of 289.5 m above mean sea level. The details of materials used and techniques adopted during the course of investigation have been described in this chapter under following heads.

Climate change Scenarios
Projected climate change scenario of RCP was done in MarkSim weather generator.
Impact of climate change on different varieties of rice under Chhattisgarh plain zone was assessed based on RCP scenarios (RCP 4.5).
RCP 4.5 it is a stabilization scenario where total radiative forcing is stabilized before 2100 by employing a range of technologies and strategies for reducing GHG emissions.

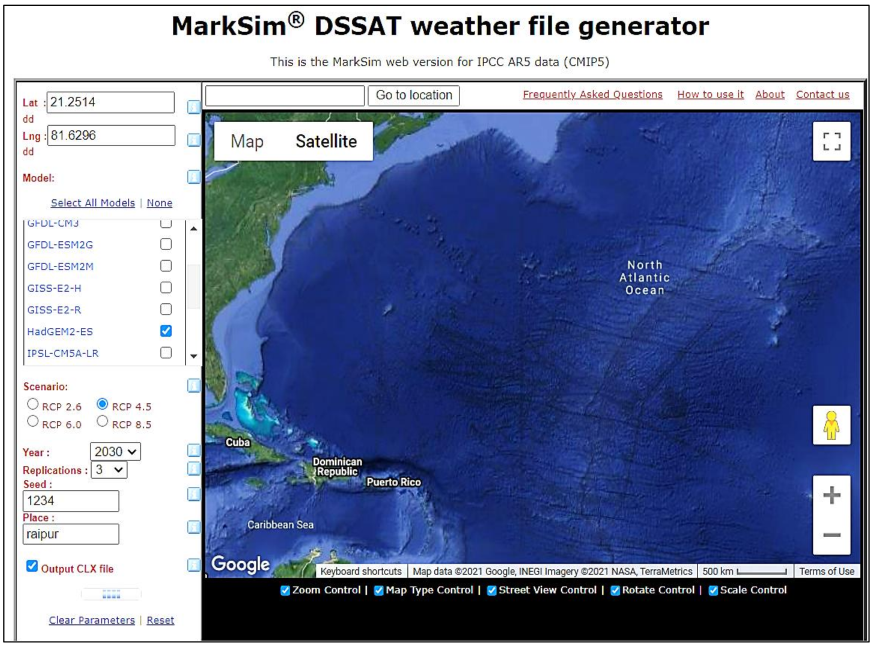

Fig 1: MarkSim DSSAT weather file generator

Climate change impact assessment using crop model

The CERES-Rice model of Decision Support System for Agro-technology Transfer (DSSAT V. 4.5), developed by International Benchmark Sites Network for Agro technology Transfer (IBSNAT) was used to assess the impact of climate change on rice. The CERES-Rice model is a simulation model for rice that describes daily phenological development and growth in response to environmental factors.

Three input files were created to run the DSSAT model using collected data

- **Weather file:** Weatherman program in DSSAT and collect weather data.
- **Soil file:** S-Build program in DSSAT and soil data.
- **Experimental data file:** X-Build program in DSSAT and crop management data.

Weather data file

The weather data file contains a daily weather data of maximum temperature, minimum temperature, rainfall and total solar radiation for the entire crop duration. Daily weather data (*viz*., maximum and minimum temperature, rainfall and bright sunshine hours) of the year 2021 (kharif season) has been collected from the Department of Agrometeorology, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G).

Soil data file:

Soil file was developed using soil characteristics of the experimental site located at the Research Farm of Department of Agrometeorology, Raipur Agricultural College, Raipur. The soil texture of the experimental field was sandy loam. The layer-wise depth of soil was taken as 120 cm.

Cultivar data file

The file contains the cultivar specific coefficients. The cultivars are identified by a specific number. Crop data (crop coefficient value, phenological stages, rooting depth, yield and yield attributes etc.) and crop management data (such as amount of irrigation, irrigation method, fertilizer and harvesting, planting information) were collected from the Department of Agrometeorology, Raipur. Three rice varieties i.e., MTU1010, Rajeshwari and CG Sugandhit Bhog are most commonly grown in study area.

Results and Discussion

Yield variation in rice varieties under changing climate scenario

1. Impact on panicle initiation days

Under the RCP 4.5 scenario, there was a reduction in panicle initiation days for MTU-1010 in D_1 growth environments, with error percentage -1.47 percent and RMSE 0.71 in 2030, -4.55 percent with RMSE 2.12 in 2050 and -7.81 percent with RMSE 3.54 in 2070. Panicle initiation days for MTU-1010 in D_2 growing environment under RCP 4.5 scenario were reduced with error percentage -3.08 percent and RMSE 1.41 in 2030, -4.69 percent with RMSE 2.12 in 2050 and -9.84 percent with RMSE 4.24 in 2070. Panicle initiation days for MTU-1010 in D_3 growing environments under RCP 4.5 scenario are projected to reduce by -1.52% with RMSE 0.71 in 2030, -6.35% with RMSE 2.83 in 2050 and -11.67% with RMSE 4.95 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 4.1 and fig. 4.1.

The reduction in panicle initiation days for Rajeshwari variety in D_1 growing environment under RCP 4.5 scenario was -2.86 with RMSE 1.41 in 2030, error percentage -5.88 percent with RMSE 2.83 in 2050 and error percentage -10.77 percent with RMSE 4.95 in 2070. Panicle initiation days for Rajeshwari variety in D_2 growing environment under RCP 4.5 scenario were reduced by error percentage -1.45 percent with RMSE 0.71 in 2030, error percentage -4.48 percent with RMSE 2.12 in 2050, and error percentage -9.38 percent with RMSE 4.24 in 2070. Panicle initiation days for Rajeshwari variety in D_3 growing environment under RCP 4.5 scenario were projected to reduce by error percentage -3.03% with RMSE 1.41 in 2030, error percentage -4.62%

with RMSE 2.12 in 2050, and error percentage -7.94% with RMSE 3.54 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three dates of sowing while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 4.1 and fig. 4.1.

In D_1 growing environment, the reduction in panicle initiation days for the CG Sugandhit Bhog variety under the RCP 4.5 scenario with error percentage -2.41% and RMSE 1.41 in 2030, -4.94% with RMSE 2.83 in 2050 and -8.57% and RMSE 4.95 in 2070. Panicle initiation days for CG Sugandhit Bhog in D_2 growing environment under RCP 4.5 scenario were reduced by -3.70% with RMSE 2.12 in 2030, -6.33% with RMSE 3.54 in 2050 and -10.53% with RMSE 5.66 in 2070. Panicle initiation days for CG Sugandhit Bhog in D_3 growing environment under RCP 4.5 scenario, were projected to reduce by -2.41% with RMSE 1.41 in 2030, -6.25% with RMSE 3.54 in 2050 and -10.39% with RMSE 5.66 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 1 and fig. 1.

2. Impact on anthesis days

In D1 growing environment, the reduction in anthesis days for the MTU-1010 variety under the RCP 4.5 scenario, error percentage was -2.02% with RMSE 1.41 in 2030, -4.12% with RMSE 2.83 in 2050 and -6.32% with RMSE 4.24 in 2070. Anthesis days for MTU-1010 in D2 growing environment under RCP 4.5 scenario were reduced by -1.05% with RMSE 0.71 in 2030, -3.23% with RMSE 2.12 in 2050 and -6.67% with RMSE 4.24 in 2070. Anthesis days for MTU-1010 in D3 growing environment under RCP 4.5 scenario were projected to reduce by -1.10% with RMSE 0.71 in 2030, -3.37% with RMSE 2.12 in 2050 and -8.24% with RMSE 4.95 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 2 and fig. 2.

The reduction in anthesis days for Rajeshwari variety in D1 growing environment under RCP 4.5 scenario was observed with error percentage -1.00% and RMSE 0.71 in 2030, -3.06% with RMSE 2.12 in 2050 and -6.32% with RMSE 4.24 in 2070. Anthesis days for Rajeshwari variety in D2 growing environment under RCP 4.5 scenario were reduced by -1.04% with RMSE 0.71 in 2030, -3.19% with RMSE 2.12 in 2050 and -6.59% with RMSE 4.24 in 2070. Anthesis days for Rajeshwari variety in D3 growing environment under RCP 4.5 scenario were projected to reduce with error percentage -2.08% and RMSE 1.41 in 2030, -5.38% with RMSE 3.54 in 2050 and -8.89% with RMSE 5.66 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 2 and fig. 2.

Under the RCP 4.5 scenario, the reduction in anthesis days for CG Sugandhit Bhog in D1 growing environment was observed with error percentage -1.77% and RMSE 1.41 in 2030, -4.55% with RMSE 3.54 in 2050 and -8.49% with RMSE 6.36 in 2070. Anthesis days for CG Sugandhit Bhog in D2 growing environment under RCP 4.5 scenario were projected to reduce by -1.79% with RMSE 1.41 in 2030, -4.59 with RMSE 3.54 in 2050 and -7.55% with RMSE 5.66 in 2070. Anthesis days for CG Sugandhit Bhog in D3 growing environment under RCP 4.5 scenario were projected to reduce by -2.78% with RMSE 2.12 in 2030, -4.72% with RMSE 3.54 in 2050 and -9.90% with RMSE 7.07 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 2 and fig. 2.

3. Impact on physiological maturity days

The reduction in physiological maturity days for MTU-1010 in D1 growing environment under RCP 4.5 scenario was observed with error percentage -1.60% and RMSE 1.41 in 2030, error percentage -4.10% with RMSE 3.54 in 2050 and error percentage -9.48% with RMSE 7.78 in 2070. Physiological maturity days for MTU-1010 in D2 growing environment under RCP 4.5 scenario were reduced by -1.63% with RMSE 1.41 in 2030, -5.04% and RMSE 4.24 in 2050 and error percentage -9.65% with RMSE 7.78 in 2070. Physiological maturity days for MTU-1010 variety in D3 growing environment under RCP 4.5 scenario were projected to reduce by -2.48% and RMSE 2.12 in 2030, error percentage -4.20% with RMSE 3.54 in 2050 and error percentage -11.71% with RMSE 9.19 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 3 and fig. 3.

The reduction in physiological maturity days for Rajeshwari in D1 growing environment under RCP 4.5 scenario was observed and error percentage -2.33% with RMSE 2.12 in 2030, error percentage -4.76% with RMSE 4.24 in 2050 and error percentage -9.09% with RMSE 7.78 in 2070. Physiological maturity days for Rajeshwari in D2 growing environment under RCP 4.5 scenario were reduced by error percentage -1.56% with RMSE 1.41 in 2030, error percentage -4.00% with RMSE 3.54 in 2050 and error percentage -10.17% with RMSE 8.49 in 2070. Physiological maturity days for Rajeshwari in D3 growing environment under RCP 4.5 scenario were projected to reduce by error percentage -2.40% with RMSE 2.12 in 2030, error percentage -5.79% with RMSE 4.95 in 2050 and -9.40% error percentage with RMSE 7.78 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 3 and fig. 3.

The reduction in physiological maturity days for CG Sugandhit Bhog in D1 growing environment under RCP 4.5 scenario was observed and error percentage -2.07 percent with RMSE 2.12 in 2030, error percentage -3.50% with RMSE 3.54 in 2050 and error percentage -8.03% with RMSE 7.78 in 2070. Physiological maturity days for CG Sugandhit Bhog in D2 growing environment under RCP 4.5 scenario were projected to reduce by error percentage -1.42% with RMSE 1.41 in 2030, error percentage -2.88% with RMSE 2.83 in 2050 and error percentage -7.52% with RMSE 7.07 in 2070. Physiological maturity days for CG Sugandhit Bhog in D3 growing environment under RCP 4.5

scenario were projected to reduce with error percentage -2.92% and RMSE 2.83 in 2030, error percentage -4.44% with RMSE 4.24 in 2050 and error percentage -9.30% with RMSE 8.49 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three dates of sowing while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 3 and fig. 3.

4. Impact on yield

The reduction in grain yield for MTU-1010 in D1 growing environment under RCP 4.5 scenario was observed and error percentage -2.68 percent with RMSE 67.18 in 2030, error percentage -6.57 percent with RMSE 158.39 in 2050 and error percentage -11.26 percent with RMSE 260.22 in 2070. Yield for MTU 1010 in D2 growing environment under RCP 4.5 scenario were projected to reduce by error percentage -2.57 percent and RMSE 76.37 in 2030, error percentage -6.20 percent with RMSE 178.19 in 2050 and error percentage -8.88 percent with RMSE 248.90 in 2070. Yield for MTU-1010 in D3 growing environment under RCP 4.5 scenario, was projected to reduce by error percentage -3.41% with RMSE 91.92 in 2030, error percentage -6.43% with RMSE 168.29 in 2050 and error percentage -6.69% with RMSE 174.66 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 4 and fig. 4.

The reduction in grain yield for Rajeshwari in D1 growing environment under RCP 4.5 scenario was observed and error percentage -1.85 percent with RMSE 41.72 in 2030, error percentage -7.54 percent with RMSE 161.22 in 2050 and error percentage -10.83 percent with RMSE 260.22 in 2070. Yield for Rajeshwari in D2 growing environment under RCP 4.5 scenario was projected to reduce by error percentage -1.43 percent with RMSE 43.13 in 2030, error percentage -5.31 percent with RMSE 154.15 in 2050 and error percentage -10.70 percent with RMSE 282.84 in 2070. Yield for Rajeshwari in D3 growing environment under RCP 4.5 scenario yield was projected to reduce by error percentage -2.46% with RMSE 68.59 in 2030, error percentage -5.20% with RMSE 141.42 in 2050, and error percentage -10.01% with RMSE 174.66 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 4 and fig. 4.

The reduction in grain yield for CG Sugandhit Bhog in D1 growing environment under RCP 4.5 was observed with error percentage -1.60 percent and RMSE 33.94 in 2030, error percentage -5.78 percent with RMSE 118.09 in 2050 and error percentage -11.24 percent with RMSE 218.50 in 2070. Yield for CG Sugandhit Bhog in D2 growing environment under RCP 4.5 scenario was projected to reduce by error percentage -2.88 percent with RMSE 60.81 in 2030, error percentage -7.27 percent with RMSE 147.08 in 2050 and error percentage -12.91 percent with RMSE 248.19 in 2070. Yield for CG Sugandhit Bhog in D3 growing environment under RCP 4.5 scenario was projected to reduce by error percentage -7.93% with RMSE 162.63 in 2030, error percentage -8.49% with RMSE 173.24 in2050 and error percentage -11.34% with RMSE 225.57 in 2070. Highest reduction in error percentage with RMSE is projected in 2070 under all three growing environments while lowest reduction in error percentage with RMSE is projected in 2030 under all three growing environments as shown in Table 4 and fig.4.

The climate change is going to reduce rice yield due to increase in both maximum and minimum temperature as well as variation in rainfall. Increasing trend of maximum temperature may reduce the crop duration of rice, increased spikelet sterility and reduced grain filling duration. Rice is highly susceptible to high temperature particularly at flowering stage. The rise in night temperature enhanced respiration rate resulting in lower yield and lower quality of rice growth. The duration between anthesis and maturity is also projected to reduce for future periods, which affects the spikelet sterility and hence reduce the final grain yield has been reported by Babel *et al.* (2011) [1]. Sastri (2010) [7] found that an increase in temperature by 1 ºC at reproductive stage could reduce the potential yield of rice from 9.35 t/ha to 8.89 t/ha under irrigated condition and from 8.93 to 8.43 t/ha under rain-fed conditions in Chhattisgarh.

Table 1: Comparison of present simulated and future simulated days required for panicle initiation for different rice cultivars i.e. MTU-1010, Rajeshwari and CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

Panicle initiation (days)														
2021						2030			2050			2070		
Variety		Obs. value	Sim value	Error (%)	RMSE value	Sim value	Error (%)	RMSE value	Sim value	Error (%)	RMSE value	Sim value	Error (%)	RMSE value
MTU-1010	D1	68	69	1.4	0.71	68	-1.47	0.71	66	-4.55	2.12	64	-7.81	3.54
	D2	67	67	0.0	0.00	65	-3.08	1.41	64	-4.69	2.12	61	-9.84	4.24
	D3	66	67	1.5	0.71	66	-1.52	0.71	63	-6.35	2.83	60	-11.67	4.95
Rajeshwari	D1	70	72	1.4	1.41	70	-2.86	1.41	68	-5.88	2.83	65	-10.77	4.95
	D2	69	70	0.0	0.71	69	-1.45	0.71	67	-4.48	2.12	64	-9.38	4.24
	D3	68	68	1.5	0.00	66	-3.03	1.41	65	-4.62	2.12	63	-7.94	3.54
CG Sugandhit Bhog	D1	84	85	1.2	0.71	83	-2.41	1.41	81	-4.94	2.83	78	-8.97	4.95
	D2	82	84	2.4	1.41	81	-3.70	2.12	79	-6.33	3.54	76	-10.53	5.66
	D3	82	85	3.5	2.12	83	-2.41	1.41	80	-6.25	3.54	77	-10.39	5.66

D_1-01/07/2021, D_2-15/07/2021, D_3-30/07/2021 (date of transplanting)

Table 2: Comparison of present simulated and future simulated days required for anthesis for different rice cultivars i.e., MTU-1010, Rajeshwari and CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

Anthesis (days)															
2021						2030			2050			2070			
Variety		**Obs. value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	
MTU-1010	D1	96	101	5.0	3.54	99	-2.02	1.41	97	-4.12	2.83	95	-6.32	4.24	
	D2	92	97	5.2	3.54	95	-1.05	0.71	93	-3.23	2.12	90	-6.67	4.24	
	D3	88	94	6.4	4.24	91	-1.10	0.71	89	-3.37	2.12	85	-8.24	4.95	
Rajeshwari	D1	101	104	2.9	2.12	100	-1.00	0.71	98	-3.06	2.12	95	-6.32	4.24	
	D2	98	101	3.0	2.12	96	-1.04	0.71	94	-3.19	2.12	91	-6.59	4.24	
	D3	97	99	2.0	1.41	96	-2.08	1.41	93	-5.38	3.54	90	-8.89	5.66	
CG Sugandhit Bhog	D1	114	117	2.6	2.12	113	-1.77	1.41	110	-4.55	3.54	106	-8.49	6.36	
	D2	112	114	1.8	1.41	112	-1.79	1.41	109	-4.59	3.54	106	-7.55	5.66	
	D3	106	113	6.2	4.95	108	-2.78	2.12	106	-4.72	3.54	101	-9.90	7.07	

D_1-01/07/2021, D_2-15/07/2021, D_3-30/07/2021 (date of transplanting)

Table 3: Comparison of present simulated and future simulated days required for physiological maturity for different rice cultivars i.e., MTU-1010, Rajeshwari and CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

Physiological Maturity (Days)															
2021						2030			2050			2070			
Variety		**Obs. value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	
MTU-1010	D1	123	127	3.1	2.83	125	-1.60	1.41	122	-4.10	3.54	116	-9.48	7.78	
	D2	120	125	4.0	3.54	123	-1.63	1.41	119	-5.04	4.24	114	-9.65	7.78	
	D3	117	124	5.6	4.95	121	-2.48	2.12	119	-4.20	3.54	111	-11.71	9.19	
Rajeshwari	D1	130	132	1.5	1.41	129	-2.33	2.12	126	-4.76	4.24	121	-9.09	7.78	
	D2	124	130	4.6	4.24	128	-1.56	1.41	125	-4.00	3.54	118	-10.17	8.49	
	D3	119	128	7.0	6.36	125	-2.40	2.12	121	-5.79	4.95	117	-9.40	7.78	
CG Sugandhit Bhog	D1	145	148	2.0	2.12	145	-2.07	2.12	143	-3.50	3.54	137	-8.03	7.78	
	D2	139	143	2.8	2.83	141	-1.42	1.41	139	-2.88	2.83	133	-7.52	7.07	
	D3	134	141	5.0	4.95	137	-2.92	2.83	135	-4.44	4.24	129	-9.30	8.49	

D_1-01/07/2021, D_2-15/07/2021, D_3-30/07/2021 (date of transplanting)

Table 4: Comparison of present simulated and future simulated grain yield (kg/ha.) for different rice cultivars i.e., MTU-1010, Rajeshwari and CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

Grain Yield (kg/ha.)															
2021						2030			2050			2070			
Variety		**Obs. value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	**Sim value**	**Error (%)**	**RMSE value**	
MTU-1010	D1	3573.7	3636	1.71	44.05	3541	-2.68	67.18	3412	-6.57	158.39	3268	-11.26	260.22	
	D2	4199.4	4315	2.68	81.74	4207	-2.57	76.37	4063	-6.20	178.19	3963	-8.88	248.90	
	D3	3827.1	3940	2.87	79.83	3810	-3.41	91.92	3702	-6.43	168.29	3693	-6.69	174.66	
Rajeshwari	D1	3110	3253	4.40	101.12	3194	-1.85	41.72	3025	-7.54	161.22	2935	-10.83	260.22	
	D2	3910.6	4326	9.60	293.73	4265	-1.43	43.13	4108	-5.31	154.15	3908	-10.70	248.90	
	D3	3590.9	4045	11.23	321.10	3948	-2.46	68.59	3845	-5.20	141.42	3677	-10.01	174.66	
CG Sugandhit Bhog	D1	2934.3	3057	4.01	86.76	3009	-1.60	33.94	2890	-5.78	118.09	2748	-11.24	218.50	
	D2	2910.5	3070	5.20	112.78	2984	-2.88	60.81	2862	-7.27	147.08	2719	-12.91	248.19	
	D3	2952	3132	5.75	127.28	2902	-7.93	162.63	2887	-8.49	173.24	2813	-11.34	225.57	

D_1-01/07/2021, D_2-15/07/2021, D_3-30/07/2021 (date of transplanting)

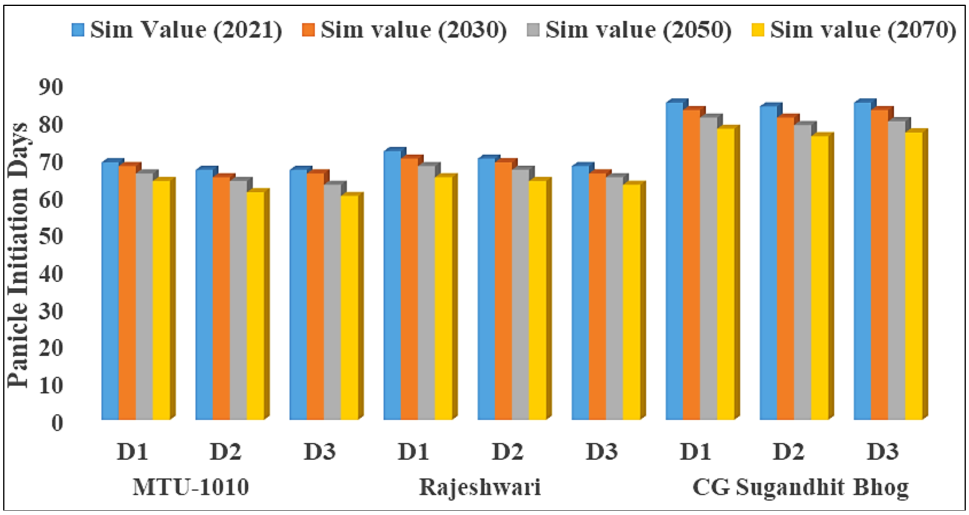

Fig 2: Comparison of future projected and present simulated days required for panicle initiation for different rice cultivars i.e. (a) MTU-1010 (b) Rajeshwari (c) CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

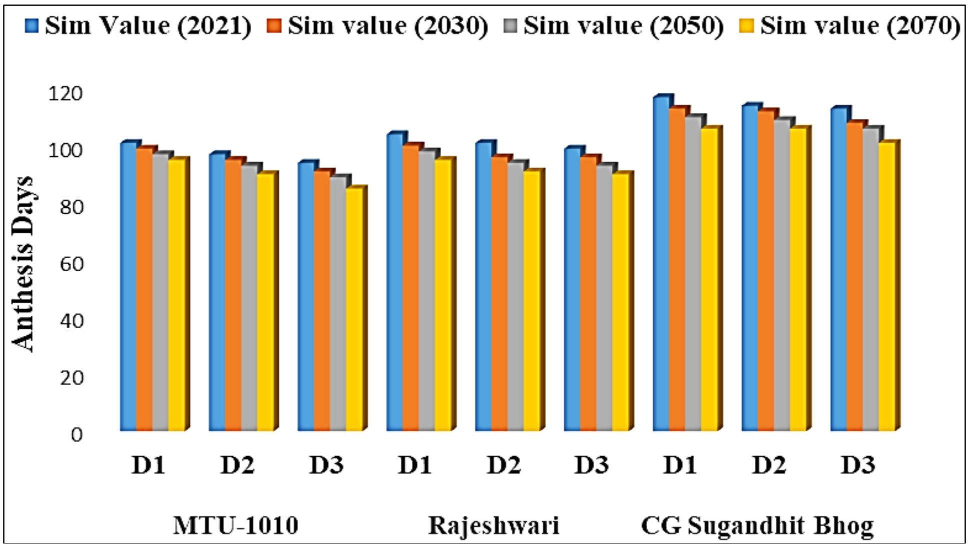

Fig 3: Comparison of future projected and present simulated days required for anthesis for different rice cultivars i.e. (a) MTU-1010 (b) Rajeshwari (c) CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

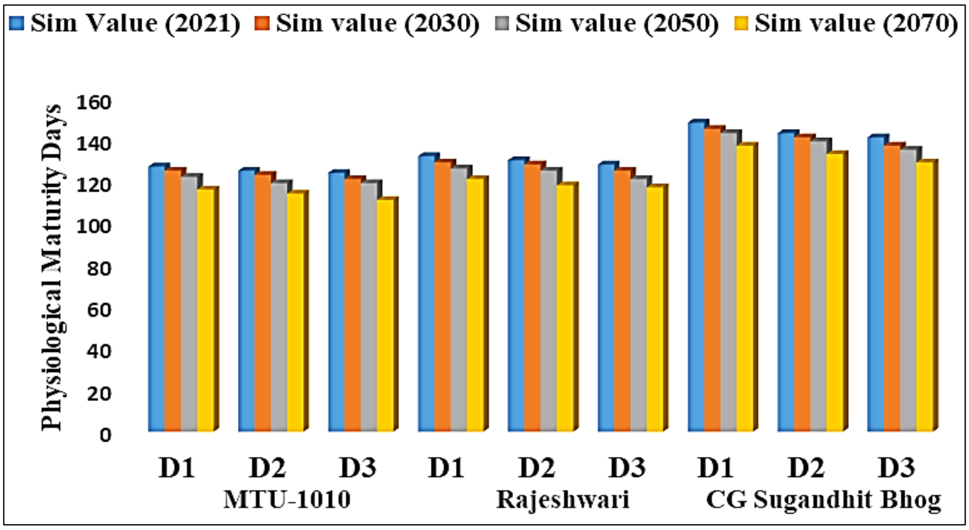

Fig 4: Comparison of future projected and present simulated days required for physiological maturity for different rice cultivars i.e. (a) MTU-1010 (b) Rajeshwari (c) CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

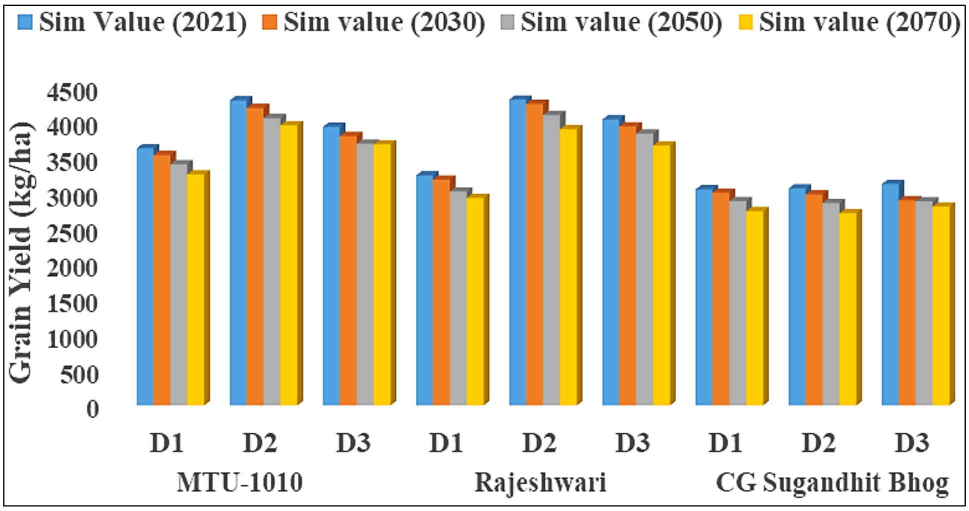

Fig 5: Comparison of future projected and present simulated required for yield (kg/ha) for different rice cultivars i.e. (a) MTU-1010 (b) Rajeshwari (c) CG Sugandhit Bhog under different growing environments in RCP 4.5 scenario

5. Conclusion

For MTU-1010, Rajeshwari and CG Sugandhit Bhog all phenophases (panicle initiation, anthesis, physiological maturity) and grain yield were projected to decrease from present condition (2021) to future scenario (2030, 2050 and 2070) under all growing environments at Raipur condition. Highest reduction in phenophases duration and grain yield is projected in 2070 under all three dates of sowing while lowest reduction in phenophases duration and grain yield is projected in 2030 under all three growing environments. In all growing environments at different level of increase in CO_2 concentration (450, 500 and 550 ppm) showed increase in grain yield.

6. References

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