CLIMATE CHANGE IMPACTS ON RICE IN ANDHRA PRADESH

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ABSTRACT:

Impact of climate change on crop duration grain and biomass yield were studied under different climate change scenarios using CERES-Rice model under Rajendranagar climatic conditions. Evaluated the impact of elevated temperature and carbon dioxide levels and reduced solar radiation (increased cloudiness) using 40 years of long term weather data of Rajendranagar using CERES-Rice model. The elevated temperature by 1^0C and 2^0C increased the number of days to attain anthesis and maturity, and decreased the grain yield by 7.3 and 13.7% under normal planting date respectively. Grain yield has increased when CO_2 increased to 450ppm and 600 ppm. The reduced solar radiation did not show much influence on grain yield of rice.

1. INTRODUCTION

Global food systems are inherently linked to climate in a large number of complex ways. The productivity of food crops is highly dependent on climatic conditions and other environmental factors linked to climate such as atmospheric composition. There is a tradition in agriculture of coping with year to year changes in climate. Climate change and its effects are therefore likely to impact on the production aspects of food security. Climate change is likely to directly impact on food production across the globe. Increase in the mean seasonal temperature can reduce the duration of many crops and hence reduce final yield. In areas where temperatures are already close to the physiological maxima for crops, warming will impact yields more immediately (IPCC, 2007). Drivers of climate change through alterations in atmospheric composition can also influence food production directly particularly by impacts on plant physiology. Increasing concentration of CO_2 in the atmosphere will enhance the productivity of all major food crops. Many hundreds of crop experiments suggest that a doubling of CO_2 from current levels would lead to increase in yield of approximately one third, on average as though recent studies in field conditions indicate that this may an over estimate (IPCC, 2007). Further the state of Andhra Pradesh is frequently prone to cyclones during September to November which is characterized by cloudy weather for 3-5 days causing reduction in availability of solar radiation during flowering and grain filling phase affecting the yield of rice crop. By considering the changes in climate, study was under taken to assess the impact of climate change on rice yield and biomass using CERES – Rice model.

2. MATERIALS AND METHODS

DSSAT V 4.0 (Jones et al, 2003, 2004) was used to assess the impact of climate change scenarios on yield of rice under Rajendranagar climatic conditions using 40 years of long term weather data. Rice is predominately grown in the South Telangana Agroclimatic Zone in clay loam soils was calibrated and validated for CERES-Rice. The popular long duration (150 days) rice cultivar BPT 5204 was used in the study. To evaluate the impact of climate change, different climate change scenarios were identified – S_1 – Normal climatic conditions, S_2- increase in temperature by 1^0C, S_3-increase in temperature by 2^0C, S_4- increase in level of CO_2 to 450 ppm, S_5-increases in level of CO_2 to 600 ppm, S_6-combination of S_2+S_4, S_7-Combination of S_2+S_5, S_8-Combination of S_3+S_4, S_9-combinatoin of S_3+S_6. The elevated temperature and CO_2 levels were considered throughout the growth period. Further the solar radiation was reduced to 1% (considering 99% cloudiness) for the period of 1 week from flowering to beginning of grain filling. Further to evaluate the impact of climate change the model was run for three different dates of planting i.e. D_1-25 July, 10 August and 25 August. The DSSAT V 4.0 software has 'SEASONAL' software that allows analyzing the effects of impact of modified environment over multiple years of weather data.

3. RESULTS AND DISCUSSION

3.1 Effect on Duration of Crop

The difference in the duration for attainment of anthesis and maturity simulated by CERES-Rice model under different climate change scenarios was presented in Table 1. The results revealed that the anthesis was delayed by 4 and 7 days, when temperature was elevated to 1^0C and 2^0C, respectively, and there was no difference when CO_2 levels were elevated to 450 and 600 ppm. The anthesis was delayed by 4 and 7 days even at the elevated temperature and CO_2 when combinedly employed. The maturity was delayed by 7 and 12 days when temperatures were elevated to 1^0C and 2^0C. Where as the elevated CO_2 levels up to 450 and 600 ppm caused one day reduction in maturity date when planting was done on 25 August.

3.2 Effect on Grain Yield

Simulated grain yield under different planting dates and climate change scenarios indicated that the cultivar BPT 5204 has the potential of 11.23 t/ha (Table 2). The potential yield decreased slightly when planting was delayed from 25 July to 25 Aug. The temperature elevation by 1^0C and 2^0C during crop season caused decline in grain yield by 7.3 and 13.7%, respectively when crop was planted on 25 July. However, elevated CO_2 to 450 ppm and 600 ppm enhanced the grain yield of rice to the extent of 31 and 38.2%, respectively. Similar results of increased yield in many crops due to elevated co_2 was reported in IPCC, 2007. Similarly, the combined effects of elevated temperature and CO_2 levels also caused improvement in grain yield of rice over normal weather conditions. The yield levels did not differ largely due to delay in planting times over normal.

3.3 Effect on Biomass

The production of biomass showed the similar trend as that of grain yield under changed climate change scenarios and different planting dates (Table 3).

3.4 Effect of Reduced Solar Radiation in Grain and Biomass Production

The grain yield and biomass yield decreased with the reduced solar radiation during flowering to beginning of grain yield (Table 4). However, the decrease in biomass yield was more compared to grain yield.

Climate Change Scenarios	Anthesis (Days)			Maturity (day)		
	10-Aug	25-Jul	10-Aug	10-Aug	25-Jul	10-Aug
S1 – Normal	-	-	-	-	-	-
S2 - Increase in maximum and minimum temperature by 1^{o}C	4	3	3	7	7	8
S3 - Increase in maximum and minimum temperature by 2^{o}C	7	7	7	12	13	13
S4 - Increase in CO2 level to 450 ppm	0	0	0	0	0	-1
S5 - Increase in CO2 level to 600 ppm	0	0	0	0	0	-1
S6 – S_2+S_4	4	3	3	6	7	7
S7 – S_3+S_4	7	7	7	11	13	13
S8 – S_2+S_5	4	4	3	6	7	7
S9 – S_3+S_5	7	7	7	11	13	13

Table1: Difference in Days in Anthesis and Maturity of rice (BPT 5204) Over Normal as Simulated Using CERES-Rice Model Under Different Climate Change Scenarios

Climate change scenarios	10-Aug		25-Jul		10-Aug	
	Grain Yield (t/ha)	%Dev	Grain Yield (t/ha)	%Dev	Grain Yield (t/ha)	%Dev
S1 – Normal	11.23	-	11.14	-	11.12	-
S2 - Increase in maximum and minimum temperature by 1^{o}C	10.41	-7.3	10.32	-7.4	10.36	-6.8
S3 - Increase in maximum and minimum temperature by 2^{o}C	9.69	-13.7	9.66	-13.3	9.7	-12.8
S4 - Increase in CO2 level to 450 ppm	14.71	31.0	14.62	31.2	14.69	32.1
S5 - Increase in CO2 level to 600 ppm	15.51	38.1	15.41	38.3	15.48	39.2
S6 – S_2+S_4	13.7	22.0	13.55	21.6	13.69	23.1
S7 – S_3+S_4	12.79	13.9	12.7	14.0	12.76	14.7
S8 – S_2+S_5	14.44	28.6	14.29	28.3	14.43	29.8
S9 – S_3+S_5	13.24	17.9	13.39	20.2	13.45	21.0

Table 2: Grain Yield of Rice (BPT 5204) Under Different Climate Change Simulated Using CERES-Rice

Climate Change Scenarios	10-Aug		25-Jul		10-Aug	
	Grain Yield (t/ha)	%Dev	Grain Yield (t/ha)	%Dev	Grain Yield (t/ha)	%Dev
S1 – Normal	21.3	-	21.17	-	22.21	-
S2 - Increase in maximum and minimum temperature by 1^{o}C	19.5	-8.5	19.81	-6.4	20.37	-8.3
S3 - Increase in maximum and minimum temperature by 2^{o}C	17.8	-16.4	18.04	-14.8	18.47	-16.8
S4 - Increase in CO2 level to 450 ppm	28.09	31.9	28.64	35.3	29.41	32.4
S5 - Increase in CO2 level to 600 ppm	29.65	39.2	30.21	42.7	31.04	39.8
S6 – S_2+S_4	25.78	21.0	26.19	23.7	27.01	21.6
S7 – S_3+S_4	23.57	10.7	23.88	12.8	24.49	10.3
S8 – S_2+S_5	27.23	27.8	27.66	30.7	28.51	28.4
S9 – S_3+S_5	24.88	16.8	25.2	19.0	25.86	16.4

Table 3: Biomass of Rice (BPT 5204) Under Different Climate Change Scenarios Simulated using CERES-Rice Model

Date of Planting	Grain Yield (t/ha)			Biomass (t/ha)		
	Normal	Reduced Radiation	%Dev	Normal	Reduced Radiation	%Dev
25-Jul	11.23	11.00	-2.09	21.3	19.77	-7.74
10-Aug	11.14	10.95	-1.74	21.17	20.11	-5.27
25-Aug	11.12	10.97	-1.37	22.21	20.42	-8.77

Table 4: Effect of Reduced Solar Radiation on Simulated Yield and Biomass of rice (BPT 5204) from Flowering to Beginning of Grain Filling

CONCLUSION

From this study, it can be concluded that, with the increase in temperature by 1 and 2^0c the duration of rice crop, grain and biomass yield decreased while increase in grain and biomass yield was observed with increase in co_2 concentrations to 450 and 600 PPM.

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