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Climate change Impact on different rice cultivars at different locations of Kashmir

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Abstract
Agriculture is the major land use across the globe. Agriculture production is highly dependent on climate since crop growth is influenced by solar radiation, temperature and precipitation. To assess the impact of climate change on productivity of rice, a simulation study was carried out using CERES-rice model embedded in DSSAT (V 4.5) to evaluate the potential consequences of climate change on the four different cultivars of rice i.e. Shalimar- rice 1, Jhelum, SKAU-341 and SKAU-382 in terms of yield in different locations (Kokernag, Kupwara, Srinagar, Badgam and Anantnag) of Kashmir valley. The climatic scenario for 2011-2090 under A1B was extracted from a PRECIS run obtained from IITM (Indian Institute of Tropical Meteorology, Pune) which showed that in the year 2040 the maximum temperature will increase by 2 ºC, minimum temperature by 2.3ºC and CO_2 concentration by 80 ppm. Lowest drop in the yield with climate change was observed using weather data of Kokernag per cent decrease ranged between 11.71 to 15.52%, where at other stations i.e. Kupwara, Anantnag, Srinagar and Budgam per cent decrease ranged between 37.46 to 53.67. At Kupwara among different varieties decrease in the yield was recorded between 47.32 to 49.54 corresponding decrease at Anantnag, Srinagar and Budgam ranged between 50.91 to 53.67,37.46 to 41.30 and 45.32 to 47.52 The cultivar SKAU-341 and Shalimar rice-1 were found more sensitive to climate change as compared to Jhelum and SKAU - 382. This is because of the reason that SKAU-341 and Shalimar rice-1 are long duration cultivars compared to Jhelum and SKAU-382. Simulated yield of different varieties ((Shalimar rice-1, Jhelum, SKAU-341 and SKAU-382) tested at different locations indicated that there was an overall decrease in rice yield with regard to different varieties.

Keywords: climate change, CERES-rice model, simulation, cultivars and yield

Introduction
Agriculture is always vulnerable to unfavorable weather events and climate conditions. Despite technological advances such as improved crop varieties and irrigation systems, weather and climate are important factors, which play a significant role to agricultural productivity. Greenhouse gases emissions from human activities are responsible for climate change (IPCC, 2007; Li, *et al.*, 2011) [1]. Climate change leads to increased temperatures, changing rainfall patterns and amounts, and a higher frequency and intensity of extreme climate events such as floods, cyclone, droughts, and heat wave (IPCC 2007; Roudier *et al.*, 2011) [1, 3]. Temperature increases and erratic rainfall patterns affect crop agriculture most directly and adversely (Almaraz *et al.*, 2008) [4]. Changing climate over time affects rice crop production adversely (Behnassi 2011) [5]. Changes in climate generally involve changes in two major climate variables: temperature and rainfall. The increase in temperature shortens the phenological phases of crops (such as planting, flowering and harvesting) (Roudier *et al.*, 2010; Teixeira *et al.*, 2011) [3, 6] and affects plant growth and development. Rainfall extremes, through droughts and floods are very detrimental to rice productivity. While rice production is already under pressure on the demand side due to population growth, the supply side is further exposed to natural pressures through climate change. As a result, overall rice production is forecast to decrease by 17% per annum due to climate change and climatic events. Climate change is expected to significantly impact on global agricultural production. This will occur because agricultural production is highly dependent on climate and is adversely affected by increasing anthropogenic climate change and climate variability. Therefore, weather patterns considerably affect crop production.

Material and Methods
Crop models are assisting tools for assessing the vulnerability and adaptation to climate change. A simulation study was carried out using CERES-rice model embedded in DSSAT (V 4.5) to evaluate the potential consequences of climate change on the four different cultivars of

rice i.e. Shalimar- rice 1, Jhelum, SKAU-341 and SKAU-382 in terms of yield in different locations (Kokernag, Kupwara, Srinagar, Badgam and Anantnag) of Kashmir valley. Base line data for climate change scenario was obtained from a PRECIS run obtained from IITM which showed that in the year 2040 the maximum temperature will increases by 2 ºC, minimum temperature increases by 2.3 ºC and CO_2 concentration will increases by 80 ppm (Table1).

Table 1: Combination of weather parameters selected for climate change scenario

Climatic parameters	Kokernag	Kupwara	Anantnag	Srinagar	Budgam
Normal	Normal	Normal	Normal	Normal	Normal
Maximum temperature (C_1)	+2 ºC	+2 ºC	+2 ºC	+2 ºC	+2 ºC
Minimum temperature (C_2)	+2.3ºC	+2.3ºC	+2.3ºC	+2.3ºC	+2.3ºC
CO_2 (C_3)	+80ppm	+80ppm	+80ppm	+80ppm	+80ppm
ALL	(C_1+C_2+C_3)	(C_1+C_2+C_3)	(C_1+C_2+C_3)	C_1+C_2+C_3)	C_1+C_2+C_3)

Results and Discussion

Simulated yield of different varieties ((Shalimar rice-1, Jhelum, SKAU-341 and SKAU-382) tested at different locations indicated that there was an overall decrease in rice yield with regard to different varieties and locations (Table 2). Lowest drop in the yield with climate change was observed using weather data of Kokernag per cent decrease ranged between 11.71 to 15.52%, where at other stations i.e. Kupwara, Anantnag, Srinagar and Budgam per cent decrease ranged between 37.46 to 53.67. At Kupwara among different varieties decrease in the yield was recorded between 47.32 to 49.54 corresponding decrease at Anantnag, Srinagar and Budgam ranged between 50.91 to 53.67,37.46 to 41.30 and 45.32 to 47.52 respectively. Data indicated that all the four cultivars did not record considerable drop in the yield at Kokernag; however at other locations there was considerable decrease in the yield of all the varieties as a result of climate change. This might be attributed to altitude difference between the locations, Kokernag is high altitude area compared to other locations so the temperature is low compared to other locations, as at higher altitudes evapotranspiration demand is les and irrigation sources are snow melt streams, whereas at lower belts water deficit is observed to decrease the water flow in the streams.

The cultivar SKAU-341 and Shalimar rice-1 were found more sensitive to climate change as compared to Jhelum and SKAU-382. This is because of the reason that SKAU-341 and Shalimar rice-1 are long duration cultivars compared to Jhelum and SKAU-382.

Conclusion

The potential impact of climate change on rice cultivars at various locations was evaluated by simulating under different climatic scenarios in the temperate conditions of Kashmir. Under climate change scenarios, yield of rice cultivars decreased in comparison to current climate conditions at all areas under study.

Table 2: Simulated yield (q ha^{-1}) of rice varieties as a function of climate change (temperature and CO_2)

Variety		Locations									
		Kokernag		Kupwara		Anantnag		Srinagar		Budgam	
		Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)	Decrease (%)
Jehlum	Normal	97.81	11.71	67.81	47.32	77.96	50.91	56.81	37.46	65.69	45.3
	Climate change	86.36		35.72		38.28		35.52		35.93	
Shalimar-Rice 1	Normal	99.32	15.17	67.94	49.54	76.17	52.96	59.52	41.3	67.69	47.52
	Climate change	84.25		34.26		35.83		35.10		35.52	
SKAU-382	Normal	97.81	11.71	67.81	47.32	77.96	50.93	56.81	37.46	65.69	45.3
	Climate change	86.36		35.72		38.28		35.52		35.93	
SKAU-341	Normal	98.65	15.52	68.23	48.52	76.03	53.67	59.84	41.04	68.57	47.06
	Climate change	87.29		35.11		35.23		35.82		36.32	

% relative change in yield is computed in reference to yield from current Scenario or the current atmospheric condition (normal)

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