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Effect of climate change on yield of different varieties of wheat (*Triticum aestivum* L.) in Upper and Trans Indo-Gangetic Plains

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Abstract

Wheat being a temperature sensitive crop, its development and productivity respond significantly to dates of sowing. Result revealed that maximum & minimum temperature and solar radiation will be increased in *rabi* crop growing season in 2030-31, 2050-51 and 2070-71 while rainfall will be decrease during wheat growing season at both Upper and Trans Gangetic plain. Second date of sowing (15 Nov) showed maximum growing yield of HD 3086 at Upper Gangetic plains while first date of sowing showed maximum grain yield of PBW 343 at Trans Gangetic plain region. Based on sensitivity analysis it was observed that taken by emergence, anthesis, physiological maturity and grain yield of HD 3086 will be decrease in the future climatic conditions i.e. 2030-31, 2050-51 and 2070-71, respectively. Highest reduction will be occurred in 2070-71 followed by 2050-51 and 2030-31.

Keywords: Sensitivity analysis, future climate conditions, DSSAT model, wheat crop

Introduction

Wheat serves as a staple food for about one billion people in as many as 43 countries of the world. Soil is the most widely cultivated food crop of the world. Agricultural productivity is sensitive to climate change due to direct effects of changes in temperature, precipitation and carbon dioxide concentration and also due to indirect and direct effect through change in soil moisture and the distribution and frequency of infestation by pests & diseases. In India, wheat crop is cultivated in Rabi season. India is second largest producer of wheat in the world after China. Uttar Pradesh has largest share in area with 9.75 million hectare (32%), followed by Madhya Pradesh (18.75%), Punjab (11.48%), Rajasthan (9.74%), Haryana (8.36%) and Bihar (6.82%). To evaluate the effects of climate change different crop models and scenario have been developed and used across the world. The Decision Support System for Agro Technology Transfer (DSSAT) has been found to be most widely used Decision Support System which included models for cereals, legumes, oilseeds and vegetable crops (Hoogenboom, 2000) [9]. The phenology components of CERES-Rice and CERES-Wheat have been described by Ritchie (1998). Kumar *et al.* (2014) [6] recently looked at the impact of changes in temperature and rainfall in India and also projected a wheat yield reduction, up to 25% by 2080.

Materials and Methods

Two districts were taken for the study which representing the upper & Trans Gangetic Plains Region and the Geographical location are as shown in the following (Table 3.1).

Table 1: Geographical location of selected districts

S. No	District	Agroclimatic Zone	Latitude	Longitude	Altitude
1	Meerut	Upper- IGP	29°04'N	77°46'E	230 mtr
2	Ludhiana	Trans-IGP	30°54'N	75°51'E	262 mtr

Daily weather data, soil data and crop data of Meerut & Punjab districts were collected from IIFSR, Meerut (UP). Those data were used for DSSAT model. The most widely used crop growth models are Decision Support for Agrotechnology Transfer (DSSAT) models, which were designed to stimulate the growth, development, and yield of a crop growing on a uniform

area of land, as well as changes in soil water, carbon, and nitrogen that occur under the cropping system over time. Genetic coefficient of PBW 343 & HD 3086 varieties of wheat crop were used after careful adjustment (Table 3.2).

Table 2: Genetic coefficient used for PBW 343 & HD 3086 varieties in CERES-Wheat model

Districts	Varieties	Genetic coefficients						
		P1V	P1D	P5	G1	G2	G3	PHINT
Meerut	HD 3086	3	35	500	20	45	2.5	95
Ludhiana	PBW 343	2.0	30	400	45	60	2.0	100

Data on climate scenarios (2030-31, 2050-51, 2070-71) to be converted from individual years with the excel file to the DSSAT model simulation to the required input format. In the CERES-Wheat model, all three predicted years (2030-31, 2050-51 and 2070-71) will individually generate weather data for simulation.

Results and Discussion

Current and future climatic conditions during crop growing period at Meerut district

Result revealed that highest maximum temperature 35.8 °C was observed in 15th SMW at upper while lowest minimum temperature was found in 52th SMW (12.9 °C) in 2019-20. Whereas, highest maximum temperature 39.1 °C, 40.1 °C

and 42.8 °C were observed in 17th SMW and lowest maximum temperature 17.1°C, 17.9°C and 19.4°C were recorded in 3rd SMW under future climatic conditions i.e. 2030-31, 2050-51 & 2070-71, respectively. Highest minimum temperature 20.2 C was recorded in 17th SMW in 2019-20 while lowest 4.5 C was observed in 6th SMW in 2019-20. Whereas, 17 SMW highest minimum temperature 23.1 °C, 23.86 °C & 25.14 °C in 2030-31, 2050-51 & 2070-71, respectively while lowest temperature 4.5 °C, 4.84 °C & 5.01 °C was recorded in 2030-31, 2050-51 & 2070-71 in 6th SMW, respectively.

At Meerut, the current year 2019-20, the crops received a total amount 26.9 mm of rainfall with 3 rainy days while, total quantity of rainfall during crop growing season in 2030-31 will be 11.42 mm and in 2050-51 & 2070-71, rainfall will be 4.98 mm & 5.61 mm during crop growing season.

Maximum solar radiation value 23.13 W/m² was recorded in 17th SMW in 2019-20 at Meerut, while lowest solar radiation 5.66 W/m² will be observed in 52th SMW. Whereas maximum solar radiation values 22.89, 23.11 and 25.33 W/m² will be found in 17th SMW in 2030-31, 2050-51 and 2070-71, respectively, while lowest solar radiation values 3.27, 3.14 and 6.33 W/m² will be in 3rd SMW in 2030-31, 2050-51 and 2070-71, respectively.

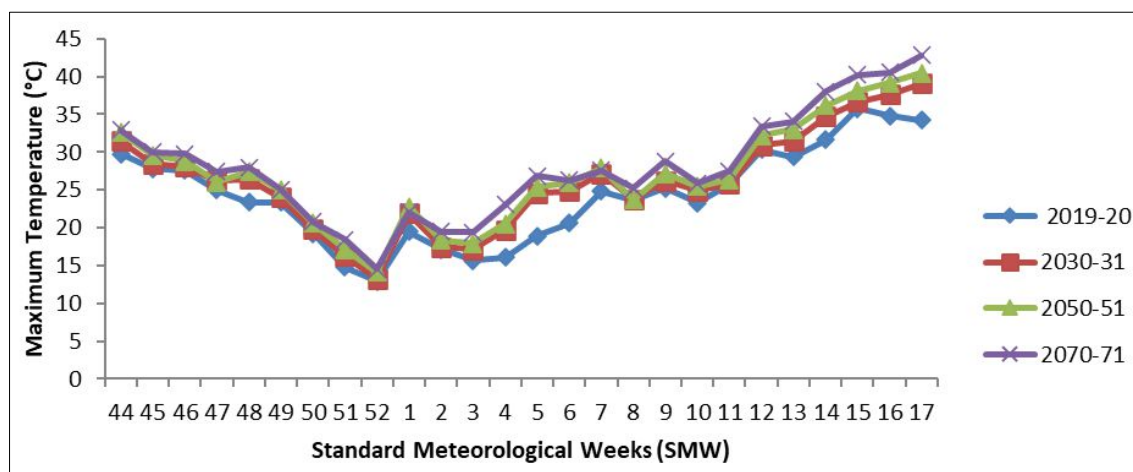


Fig 1: Comparison of maximum temperature patterns between current (2019-2020) and future climatic condition (2030-31, 2050-51 and 2070-71) during crop growth period at Meerut district

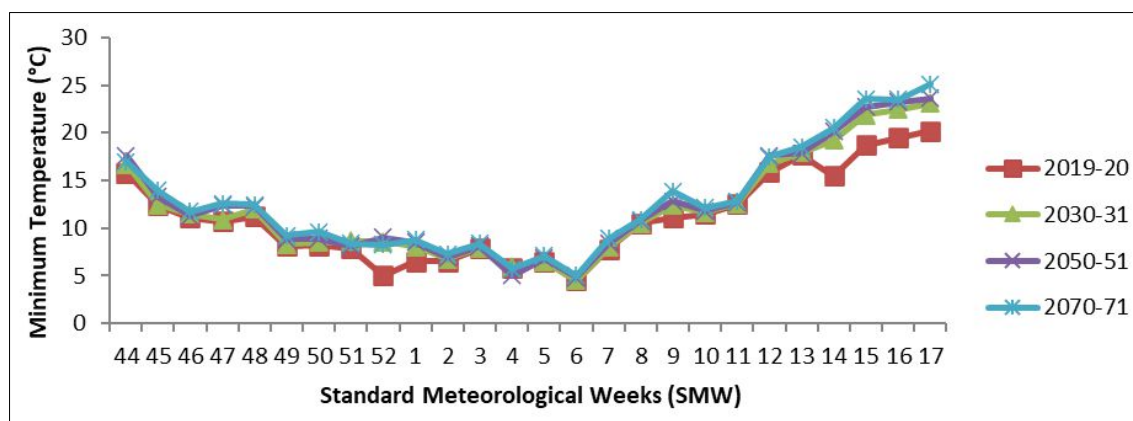


Fig 2: Comparison of minimum temperature patterns between current (2019-2020) and future climatic condition (2030-31, 2050-51 and 2070-71) during crop growth period at Meerut district

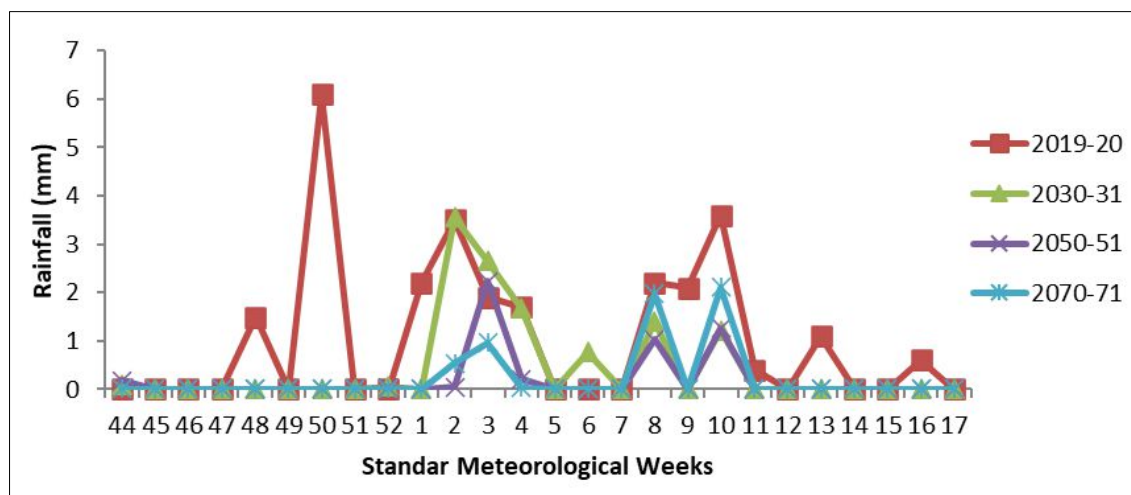


Fig 3: Comparison of rainfall patterns between current (2019-20) and future climatic condition (2030-31, 2050-51 and 2070-71) during crop growth period at Meerut district

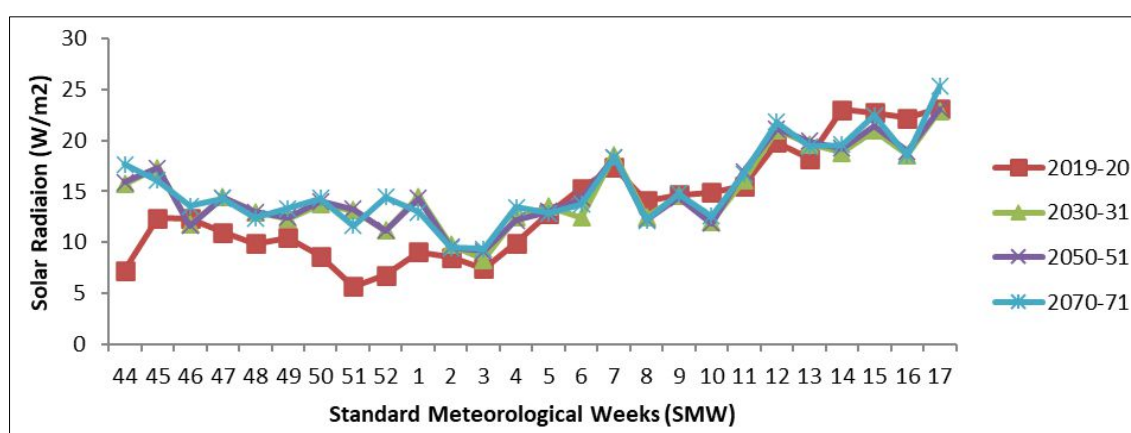


Fig 4: Comparison of solar radiation patterns between current (2019-20) and future climatic condition (2030-31, 2050-51 and 2070-71) during crop growth period at Meerut district

Current and future climatic conditions during crop growing period at Ludhiana district

At Ludhiana, highest maximum temperature 34.0 °C was observed in 15th SMW while lowest maximum temperature was found in 52th SMW (10.4 °C) in 2019-20. Whereas, highest maximum temperature 35.74 °C, 36.99 °C and 37.29 °C were observed in 15th SMW and lowest maximum temperature 11.81 °C, 11.58 °C and 12.9 °C were recorded in 52th SMW under future climatic conditions i.e. 2030-31, 2050-51 & 2070-71, respectively. Highest minimum temperature 19.74 °C was recorded in 16th SMW in 2019-20 while lowest 4.71 °C was observed in 6th SMW in 2019-20. Whereas, highest minimum temperature 22.8 °C & 22.1 °C was found in 17th SMW in 2070-71 & 2050-51, respectively and 21.33 °C in 16th SMW in 2030-31. While lowest temperature 6.14 °C and 5.67 °C was recorded in 3rd SMW in 2050-51 & 2070-71, respectively and 5.03 °C in 1st SMW in 2030-31 at Ludhiana districts.

At Ludhiana, crops received a total of 31.00 mm of rainfall with 5 rainy days. The total quantity of rainfall during crop

growing season in 2030-31 will be 13.53 mm at Ludhiana district. In 2050-51, rainfall will be 9.67 mm while 6.24 mm in 2070-71, total rainfall during crop growing season at Ludhiana district.

At Ludhiana district, maximum solar radiation value 23.66 W/m² will be recorded in 17 SMW in 2019-20 while lowest solar radiation value 5.34 W/m² was recorded in 52th SMW. Maximum solar radiation values 24.44, 25.80 and 26.09 W/m² will be occurred in 17th SMW while lowest solar radiation values 3.27, 3.14 and 6.33 W/m² will be in 3rd SMW in 2030-31, 2050-51 and 2070-71, respectively.

Wardlaw & wringley (1994) [7] reported 3-4% decrease in grain yield for each 1°C rise in ambient temperature above 15 °C during grain filling. Wheat production is estimated to fall 6% for each 1 °C rise in temperature (Asseng *et al.* 2015) [1] whereas in India is was estimated to reduce by 10% in major wheat producing state of Punjab, Haryana and Uttar Pradesh if the winter became warmer by 0.5°C (Khan *et al.* 2009) [5].

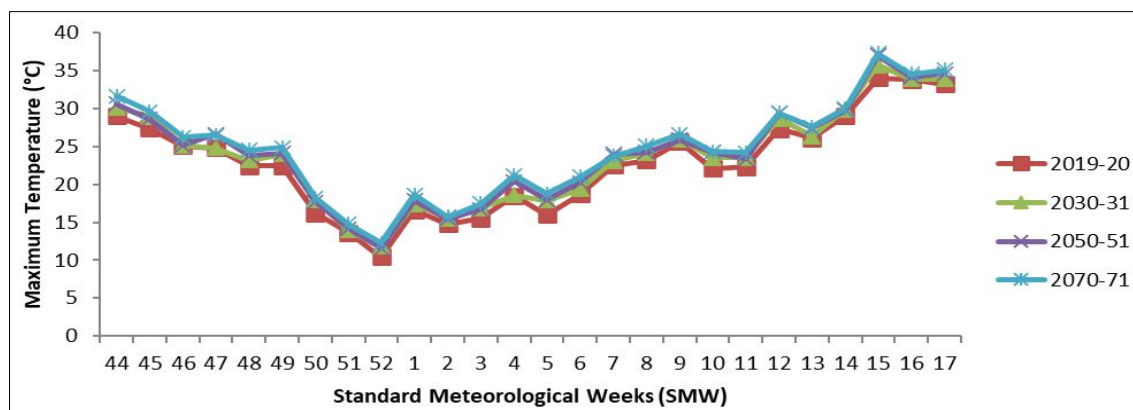


Fig 5: Comparison of maximum temperature patterns between current (2019-2020) and future climatic scenario (2030-31, 2050-51 and 2070-71) during crop growth period at Ludhiana district

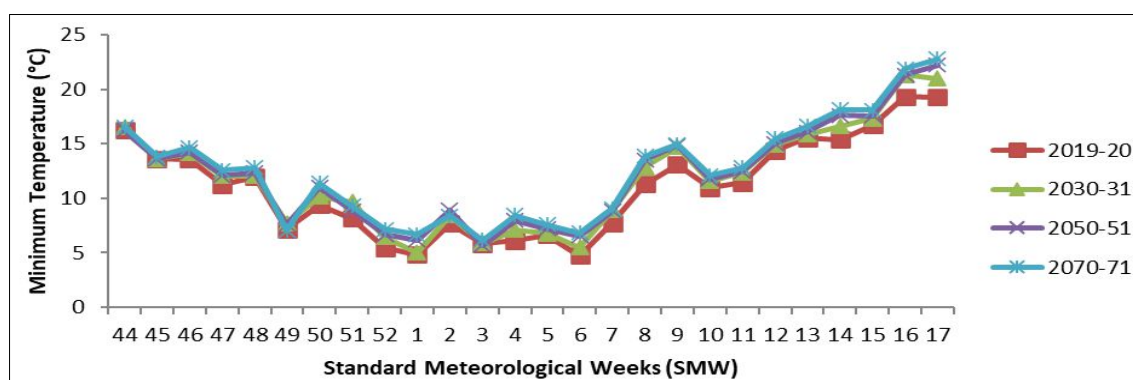


Fig 6: Comparison of minimum temperature patterns between current (2019-2020) and future climatic scenario (2030-31, 2050-51 and 2070-71) during crop growth period at Ludhiana district

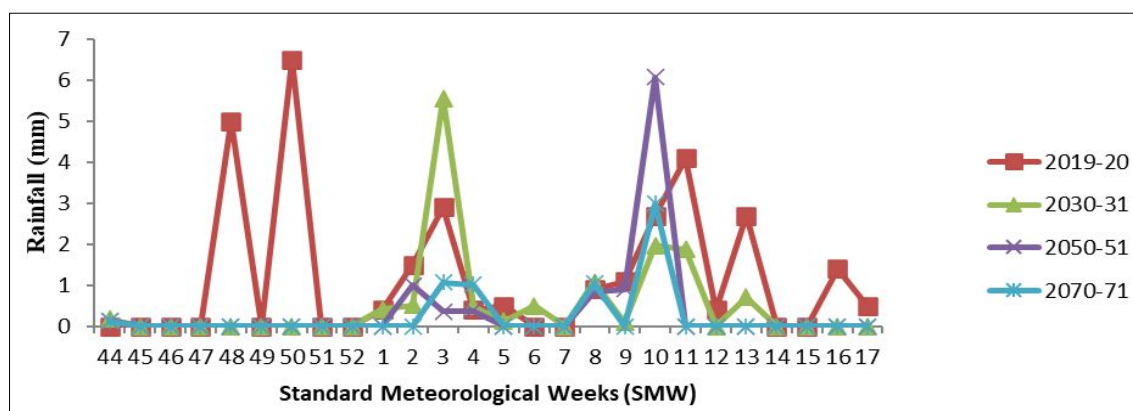


Fig 7: Comparison of rainfall patterns between current (2019-2020) and future climatic scenario (2030-31, 2050-51 and 2070-71) during crop growth period at Ludhiana district

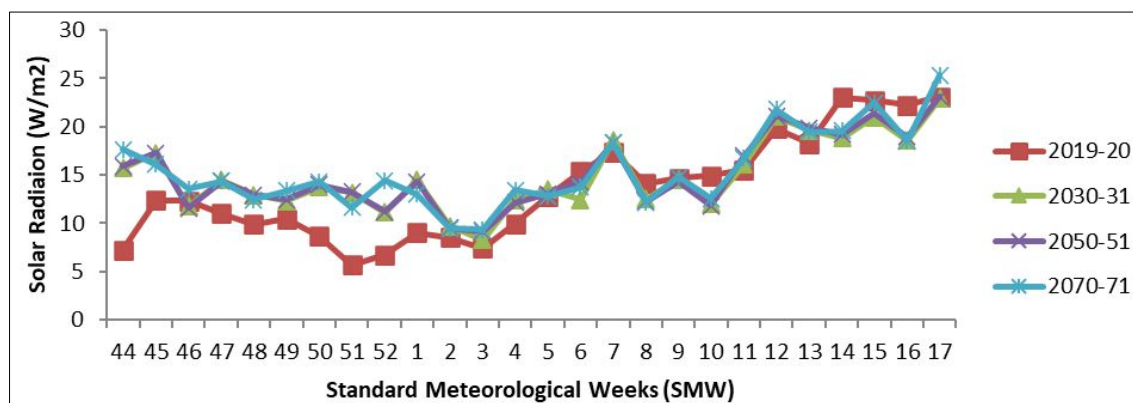


Fig 8: Comparison of solar radiation patterns between current (2019-2020) and future climatic scenario (2030-31, 2050-51 and 2070-71) during crop growth period at Ludhiana district

Sensitivity analysis with projected climate change on wheat crop in Upper and Trans Indo-Gangetic Plains

Result of comparison between current year and future climatic conditions (2030-31, 2050-51 and 2070-71) showed that highest reduction in days will be occurred in 2070-71 followed by 2050-51 and lowest reduction will be occurred in 2030-31 in emergence, anthesis and physiological maturity stages at Upper and Trans Gangetic plains region.

The grain yield of HD 3086 was recorded 44.40 q/ha in present conditions (2019-20) and decrease to 43.19 q/ha (-2.72%), 41.68 q/ha (-6.12%) and 40.37 q/ha (-9.07%) under the projected climate conditions 2030-31, 2050-51 and 2070-71, respectively at D1 (05 Nov). Maximum reduction in grain yield was recorded -11.20% (41.56q/ha) in 2070-71 followed by -9.13% (42.44q/ha) in 2050-51 and -3.76% (45.04q/ha) in 2030-31, respectively in D2 (20 Nov). Similar pattern was observed in D3(05 Dec), maximum reduction -8.09% (39.98q/ha) was found in 2070-71 and minimum -1.19% (42.98q/ha) was recorded in 2030-31, respectively.

D1 (05 Nov) shows maximum reduction -9.72% (40.47

q/ha) in 2070-71 followed by -5.33% (42.44 q/ha) in 2050-51 and -2.14% (43.87 q/ha) in 2030-31, respectively as compare to 2019 in the yield of PBW 343 variety of wheat at Trans Gangetic Plains. In D2 (20 Nov), maximum reduction -8.36% (39.56 q/ha) was found in 2070-71 while lowest was observed in -1.85% (41.77 q/ha) in 2030-31 as compared to present condition (2019-20). Similarly, highest reduction -11.80% (37.54 q/ha) was found in 2070-71 while lowest reduction -1.85% (41.77 q/ha) was observed in 2030-31 in D3 (05 Dec).

Harrison *et al.* (2000) [3] found that rising temperature had a negative effect on wheat yields. High temperature particularly during November sowing accelerates its growth by making the crop to enter into jointing stage too early, thus reducing tillering period. This results in reduced number of tillers, flowering and grain filling stage shortens the duration of grain filling resulting in early maturity, thus reducing the crop yield. Haris *et al.* (2013) [2] reported that an increase in temperature would decrease wheat yield in different part of Bihar. Yang *et al.* (2013) [8] also reported that to decrease wheat yield due to rise temperature.

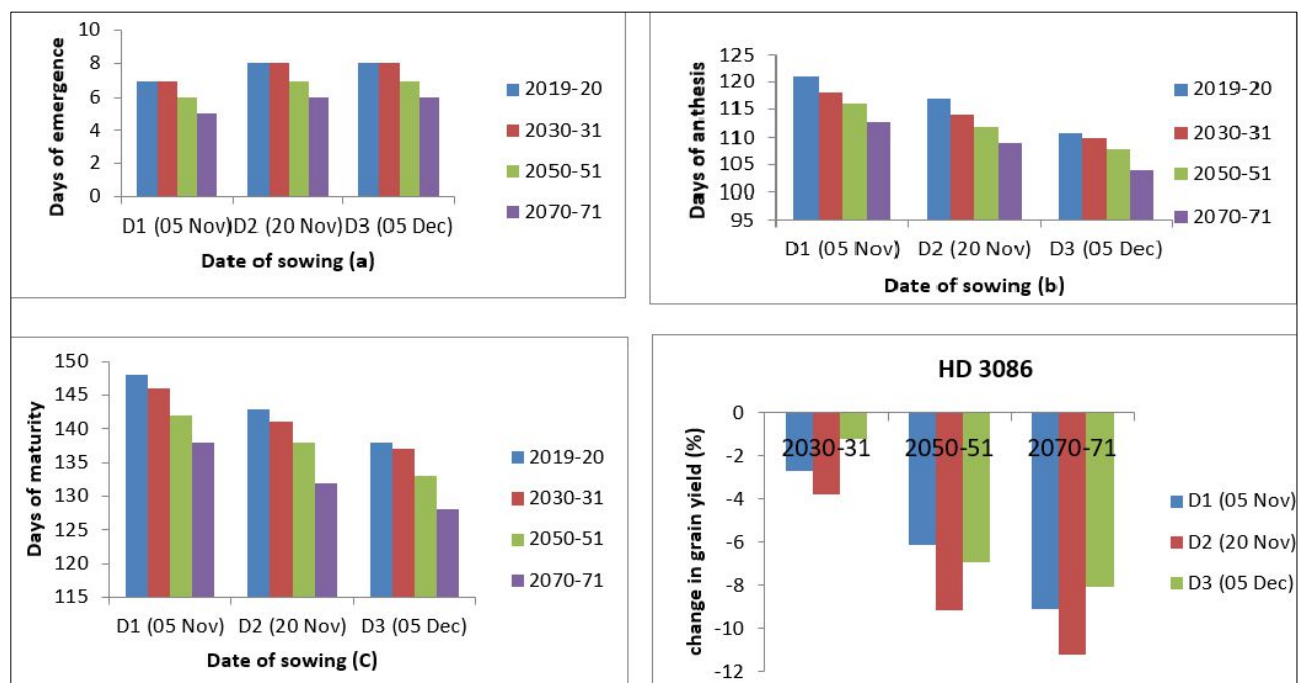
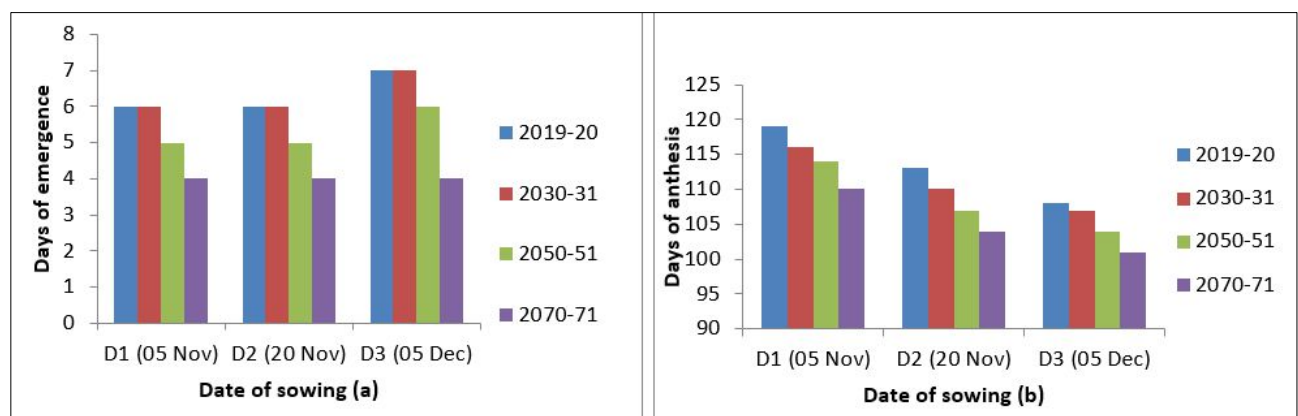


Fig 9: Effect of projected climate scenario on emergence (a), anthesis (b), maturity (c) and yield (d) of wheat cultivars i.e. HD 3086 and PBW 343 under different growing environment at Meerut



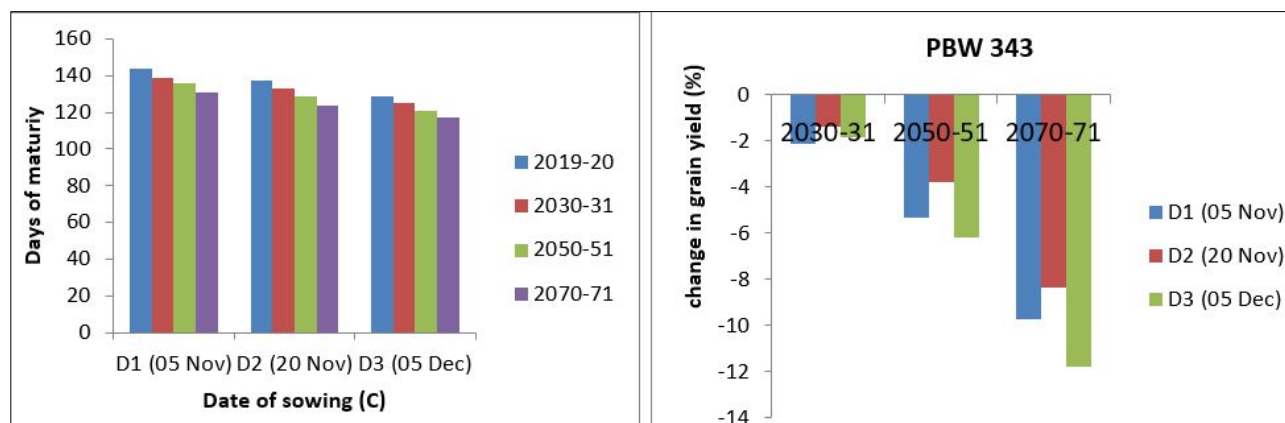


Fig 10: Effect of projected climate scenario on emergence (a), anthesis (b), maturity (c) and yield (d) of wheat cultivars i.e. HD 3086 and PBW 343 under different growing environment at Ludhiana

Conclusion

Maximum and minimum temperature and solar radiation will be increasing in the future due to climate change. While rainfall during rabi crop growing period will be decrease in the future. Maximum reduction was observed in 2070-71 followed by 2050-51 and 2030-31 in both varieties of wheat at Upper and Trans Gangetic Plains region.

References

- Asseng S, Ewert F, Martre P, Rötter RP, Lobell DB, Cammarano D, *et al.* Rising temperatures reduce global wheat production. *Nature climate change*. 2015;5(2):143-147.
- Haris AVA, Biswas S, Chhabra V, Elanchezhian R, Bhatt BP. Impact of climate change on wheat and winter maize over a sub-humid climatic environment. *Current Science*. 2013;25:206-214.
- Harrison PA, Porter JR, Downing TE. 'Scaling-up the AFRC-WHEAT2 model to assess phenological development for wheat in Europe', *Agricultural Forest Meteorology*. 2000;101(2-3):167-186.
- Netshiukhwi ZG. The significance of disadvantaged crop species to improve food systems and security in the changing climate: Learning from Motheo District, South Africa. *International Journal of Agriculture and Nutrition*. 2022;4(1):44-52.
- Khan SA, Kumar S, Hussain MZ, Kalra N. Climate change, climate variability and Indian agriculture: impacts vulnerability and adaptation strategies. In *Climate change and crops*, Springer, Berlin, Heidelberg; 2009, 19-38.
- Kumar SN, Aggarwal PK, Rani DS, Saxena R, Chauhan N, Jain S. Vulnerability of wheat production to climate change in India. *Climate Research*. 2014;59(3):173-187.
- Wardlaw IF, Wrigley CW. Heat tolerance in temperate cereals: An overview. *Functional Plant Biology*. 1994;21(6):695-703.
- Yang X, Liu Z, Chen F. The possible effects of global warming on cropping systems in China I. The possible effects of climate warming on northern limits of cropping systems and crop yields in China. *Sci Agric Sin*. 2010;43(2):329-336.
- Hoogenboom G. Contribution of agrometeorology to the simulation of crop production and its applications. *Agricultural and forest meteorology*. 2000;103(1-2):137-157.
- Gurwaan Singh, Dr. SN Pandey, Rahul Kumar, Subhash Chandra Maurya, Sunil Kumar Prajapati. Effect of weather parameters, date of sowing on performance of wheat varieties (*Triticum aestivum* L.). *Int J Res Agron* 2021;4(2):97-99.