Wheat productivity at various N-levels and future predictions under changing climate

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SUMMARY

OBJECTIVES

- To study the impact of climate change on wheat productivity in irrigated semi-arid conditions
- To find out the appropriate adaptive measures for sustainable nitrogen management under different climate change scenarios

PRELIMINARY FINDINGS

- Result shows that wheat yield potential can be exploit by changing planting dates and by increasing N-level.
- The model results showed that N-levels have not much significant effect on wheat yield under changing climate scenarios RCPs.
- But the change in date of sowing (DOS) showed significant results under these RCPs in irrigated conditions
- The DOS 30th November with 180 kg N ha^{-1} performs better in near, middle and at last of the century than other DOS as predicted by the model

BACKGROUND

- Nitrogen (N) application to agricultural land has increased steeply in recent decades.
- Pakistan was among the top four in terms of N use but had low mean yields, with the lowest NUE and highest N surplus.
- During 1961–2014 in Pakistan, N fertilizer use, and N surplus grew at a much faster pace than mean yields; however, nitrogen use efficiency (NUE) continued to decline.
- The great potential for Pakistan to increase NUE lies in agronomic practices (e.g., change in sowing date) other than increasing N fertilization.
- Wheat (*Triticum aestivum* L.) as a major agronomic crop influences the all-other crops in production and acreage because it is a staple food of people in Pakistan.
- The average yield of wheat is less than the potential yield of wheat due to different factors like application of fertilizer (specifically nitrogen (N) at proper time, which leads towards low wheat yield
- Pakistan is facing brunt of changing climatic conditions like many other countries, as it is in a warm climate region.
- Due to diverse demographic and topographic positions, Pakistan is expected to be more vulnerable to climate change. In Pakistan, under current circumstances temperature changes are expected to be higher (IPCC, 2015).
- Crop modelling technique is an effective tool for improving decision making as it can predict based upon the local conditions, although are not the alternate of field trials. Crop modeling technique is now being used in education, agronomic research and crop management (Hoogenboom et al., 2004).

MATERIALS AND METHODS

EXPERIMENTAL DESIGN

- Field experiments were conducted at Nuclear Institute for Agriculture and Biology (NIAB), Faisalabad (Latitude 31.30 °N, Longitude 73.08 °E and Altitude 184.1 m). Before sowing of the crop, the field were exhausted completely and soil physico-chemical properties were analyzed such as total N %, soil organic carbon etc.
- The experiments were carried out in Randomized Complete Block Design (RCBD), having three replications. Dates of sowing were in the main plots, while in sub plots nitrogen levels was maintained
- CERES-Wheat model was used for calibration and validation of observed and simulated data. DSSAT-4.7 (Decision Support System for Agro-technology Transfer) was used to run the CSM-CERES wheat model because it was widely reported for climate change impact assessment. So that's why it was used in the study.
- MarkSim were used with the help of 17 General circulation models (GCMs) for weather data generation for the year 2030, 2050 and 2090. Weather data including Tmax, Tmin, rainfall and solar radiation were downscaled by using MarkSim (Claessens et al., 2012).
- Intergovernmental panel on climate change (IPCC), representative concentrations pathways (RCPs) were used as changing climate scenario in this study. Each single RCPs is based on an internally consistent set of socio-economic assumptions

STATSTICAL PARAMETERS

- For model accuracy assessment, observed data was compared with simulated data against other treatments. By computing different statistical indexes, simulation performance was checked. There calculation was

$$RMSE = \left[\sum_{i=1}^{n} \frac{(P_i - O_i)^2}{n}\right]^{0.5}$$

$$NRMSE = \frac{RMSE}{O_{i\,max} - O_{i\,min}}$$

$$d = 1 - \left[\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{\sum_{i=1}^{n}\left(\left|P'_i\right| + \left|O'_i\right|\right)^2}\right]$$

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CONTACTS/ACKNOWLEDGEMENT

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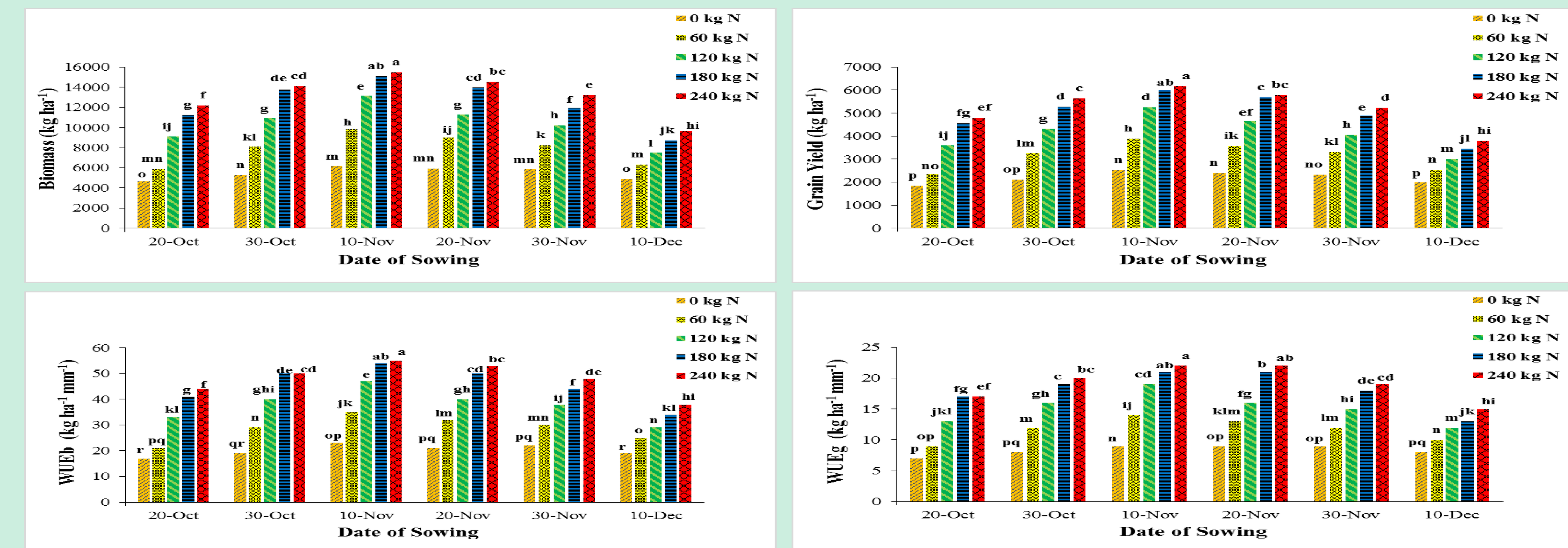
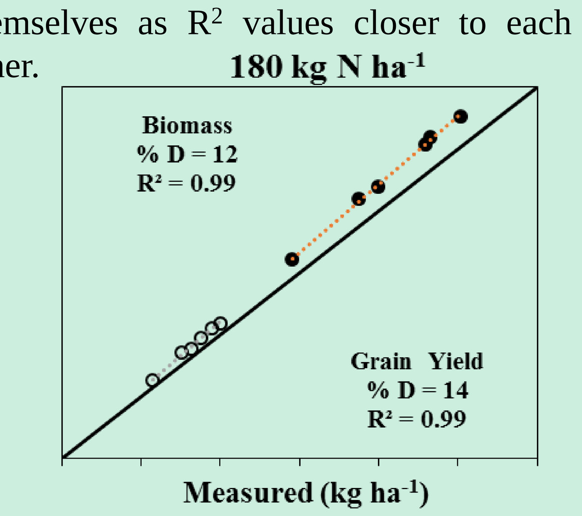
RESULTS

- In this experiment, respective incremental increase in biomass compared to unfertilized (0 kg N ha^{-1}) conditions were 44.72%, 95.03%, 128.74%, and 145.38%. Regarding sowing dates, biomass increased significantly from 20th October to 10th November and then a declining trend was observed up to 10th December. Interactive effect of sowing date and N-levels showed significantly higher biomass of 15500 and 15150 kg ha^{-1} at 180 and 240 kg N ha^{-1} respectively, when crop was sown on 10th of November.
- Incremental increase in grain yield (GY) compared to unfertilized conditions were 43.97%, 89.99%, 127.61 %, and 140.04%. Regarding sowing dates, GY increased significantly from 20th October to 10th November and then a declining trend was observed up to 10th December. Interactive effect of sowing date and N-levels showed significantly higher GY of 5990 and 6160 kg ha^{-1} at 180 and 240 kg N ha^{-1} respectively, when crop was sown on 10th of November.
- WUEb and WUEg increased significantly from 20th October to 10th November and then a declining trend was observed up to 10th December. Statistically significant ($p \geq 0.05$) interaction was observed between DOS and N- levels



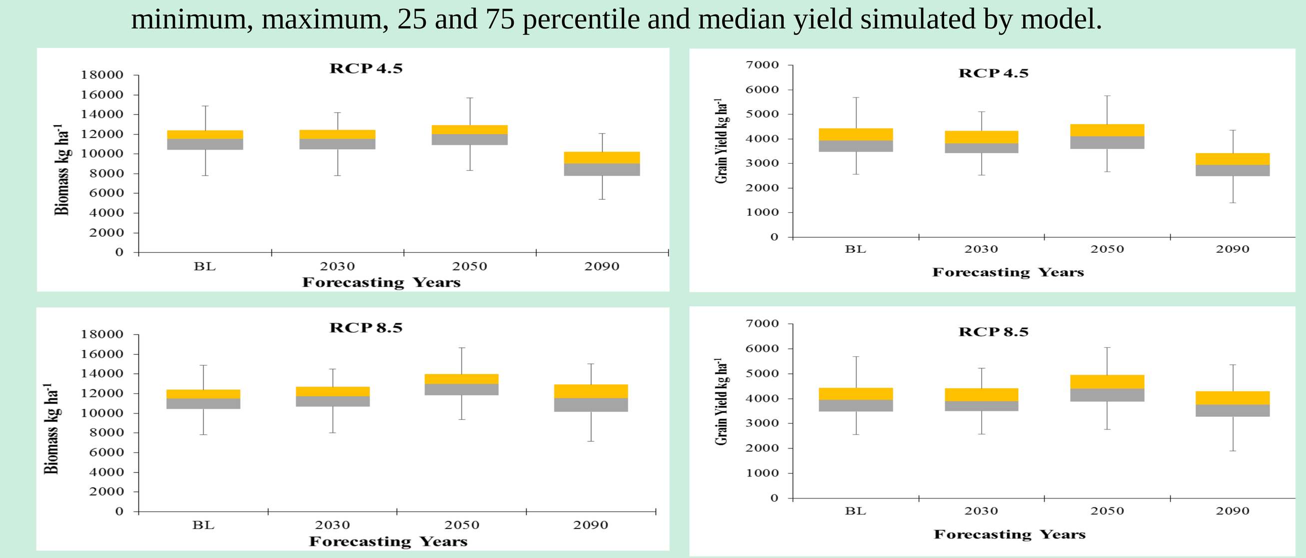
MODELING RESULTS

Maximum yield was observed at 180 kg N ha^{-1} with 30th November as predicted by model. Simulated and observed yield shows strong relationship among themselves as R^2 values closer to each other.



CSM-CERES wheat model was run for climate change impact assessment under different IPCC climate change scenarios (RCP 4.5 and 8.5). Date of sowing and N-levels used as an adaptive measure to cope with these changing climate scenarios for forecasting years 2030, 2050 and 2090.

The box and whisker plot were drawn to check out the range/spread as it indicates minimum, maximum, 25 and 75 percentile and median yield simulated by model.



CONCLUSIONS

- It is concluded from the study that increase in nitrogen level affects all the development processes of crop and date of sowing is also important for higher crop productivity
- However, change in dates of sowing also helps to avoid thermal heat stress and other unfavorable conditions under changing climatic conditions. Result shows that wheat yield potential can be exploit by changing planting dates and by increasing N-level up to 180 kg N ha^{-1}.
- Model predicts that in 2030, 2050 and 2090 the median yield with respect to baseline under different climate change scenarios was non-significantly affected by increase in N-levels, while change in date of sowing show better results as an adaptive measure to cope climate change.
- Increase in NUE and proper application of N with other agronomic practices will sustain our crop production in these changing climatic conditions.