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Impact of Rainfall on Rice Productivity in Terai Region of Uttarakhand

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ABSTRACT: Rainfall pattern and temperature variation are changing due to global warming, affecting crop production. The purpose of this study is to investigate the impact of rainfall on rice production during the rice growth phases over the Terai region of Uttarakhand for the period of 1997–2019. The impact of average growing season rainfall on rice production is analyzed using the statistical techniques. Results revealed that an overall direct positive relationship during the period 1997–2019 between the average seasonal growing rainfall and rice productivity. Correlation coefficient was found to be highest for U S nagar (R^2 = 0.1695) followed by Nainital (R^2 = 0.0488) and Haridwar (R^2 = 0.0263).

Keywords: Global Warming, Impacts, Rice productivity, Terai region and crop production.

INTRODUCTION

Water is essential for the existence of life on the Earth. It is the key element on which various hydro-meteorological processes depend. The small change of rainfall in water cycle has great impact on various processes of the water cycle (Alam *et al.,* 2023). Indian agriculture is predominantly rainfed which encompasses 68% of the total cultivated area (Meshram *et al*., 2017). Climate change is one of the major global challenges to the environment and is currently a critical threat to the agricultural production system. Climate change presents a significant risk to global food security, particularly for agricultural systems that depend on monsoon rainfall, making them especially susceptible to shifts in climate variability (Bowden *et al.,* 2023). The Terai or Tarai is a lowland region in northern India and southern Nepal that lies south of the outer foothills of the Himalayas, the Sivalik Hills, and north of the Indo-Gangetic Plain. Most of India's agricultural activities are concentrated within a few monsoon months. While India typically receives plentiful rainfall during the monsoon season, this abundance can sometimes turn into a disaster, causing severe floods in various parts of the country and ultimately damaging agricultural production (Tarkeshwar and Saini 2023). Climate change poses a significant threat to crop production, making it crucial to analyze the potential impacts of future climate changes by closely examining the current conditions (Pachuau *et al.,* 2022).

MATERIAL AND METHODS

The study was conducted for 3 districts in the Terai region of Uttarakhand *viz.,* Haridwar, Nainital and U S nagar. The Terai or Tarai (meaning "moist land") is a lowland region in northern India and southern Nepal that lies south of the outer foothills of the Himalayas, the Sivalik Hills, and north of the Indo-Gangetic Plain. Daily rainfall data for the period of 1998-2020 (22 years) generated by the India Meteorological Department (IMD) at a grid size of 0.5° latitude × 0.5° longitude (for daily rainfall) (Srivastava *et al.,* 2009) was used for this study. The dataset provided by IMD was developed using quality controlled rainfall data collected from a network of more than 3000 rain gauge stations over India. The details of the gridded data generation are explained in Rajeevan and Bhate (2009). District-level records of annual crop yields of rice and wheat have been taken from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, Government of India, for the period 1999–2020. We restricted our yield analysis part only to those districts that had crop yield data for at least 15 years, between 1998–1999 and 2019–2020.

De-trending crop yield and statistical analysis. Using methods described by Li *et al.* (2019), the difference between the observed and expected yield, divided by the trend yield, is calculated to obtain the percentage yield change, which is a better indicator of the impacts of local climate variability (Fig. 1). Separate analyses were performed for districts and the state to determine the effect of variations in mean annual rainfall on the annual yield of rice for the period 1997– 2019. Linear regression were performed to measure the strength and analyze the trends of the relationship between the crop yield with rainfall anomalies at annual timescale. Yield percent change represents the departure of the observed yield from the long-term trend and better reflects the impacts of inter-annual variability in the local climate.

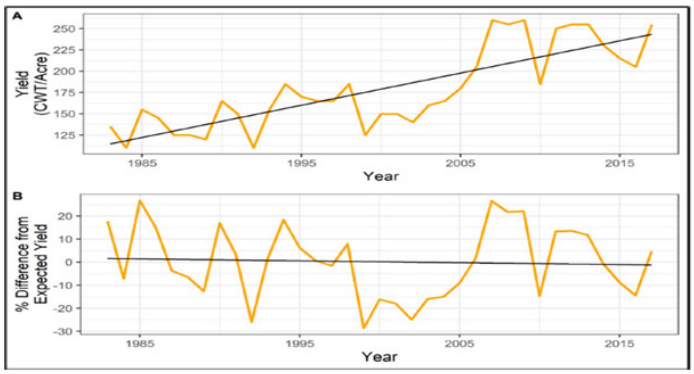

Fig. 1. Example of the transformation between raw crop yield data (A), which exhibits a significant linear trend over time (black line), to the detrended yield variable (B) represented as the percent difference from expected yield each year (Eck *et al.*, 2020).

RESULTS AND DISCUSSION

Rice is a crucial crop in the Terai region of Uttarakhand due to its fertile soil, abundant water supply, and favourable climate. It plays a significant role in food security, providing a staple food source for millions. The linear regression analysis of de-trended rice productivity with mean monthly (growing season months) rainfall are shown in Fig. 2. The results indicated an overall direct positive relationship during the period 1997–2019. Correlation coefficient was found to be highest for US nagar (R^2 = 0.1695) followed by Nainital (R^2 = 0.0488) and Haridwar (R^2 = 0.0263). This means that the rice yield are most correlated with the seasonal rainfall for the US nagar district and least correlated with seasonal for the Haridwar district.

The analysis revealed an increasing trend in rice yield with an increase in rainfall during the period 1997–2019 in all the districts. Previous findings also indicates that an increase in total June–September rainfall has an even larger impact on area than on yield (Kanwar, 2004; Auffhammer *et al.,* 2006). The period and timing of precipitation, as well as the total amount of summer monsoon rainfall, is important for rice cultivation (Gadgil *et al*., 2002). Rahman *et al.* (2017) studied the impacts of temperature and rainfall variation on rice productivity in major ecosystems of Bangladesh regional productiveness of seasonal rice (aus, aman and boro) crops for 1996-2009 also reported a high and significant linear regression. Rainfall at the tillering and stem elongation stages positively impacts the rice plant, resulting in increase in the rate of tillering, which increases the rice production (Jaiswal *et al.,* 2023).

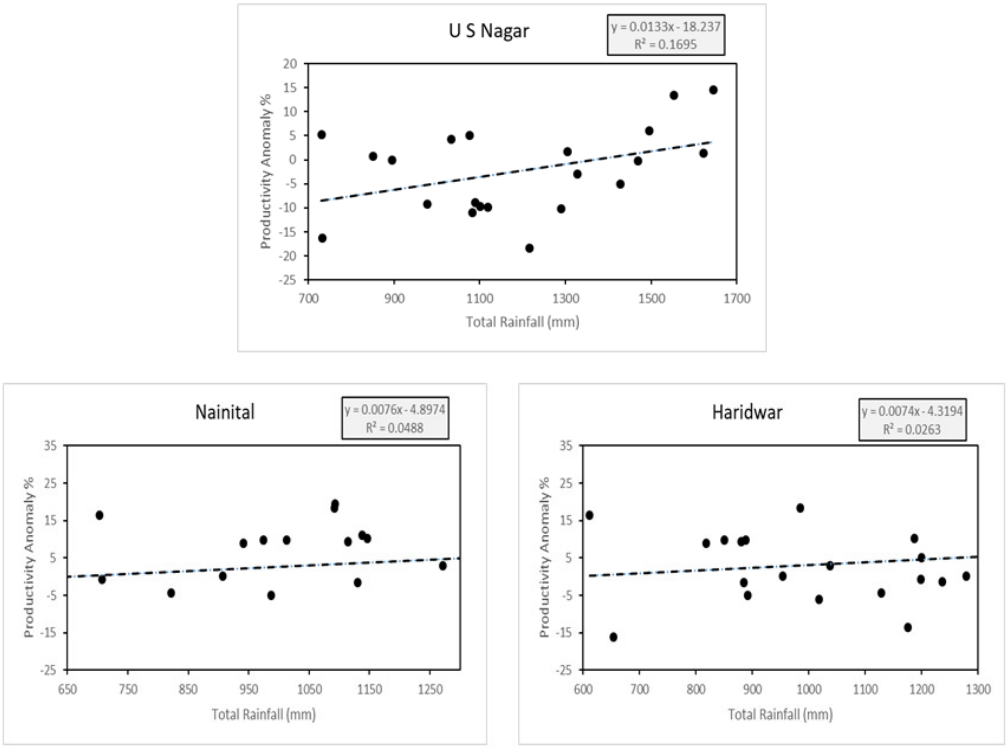

Fig. 2. Impact of Rainfall on Rice Productivity in the Study Region.

CONCLUSIONS

The purpose of present study is to analyze the impact of rainfall on various rice productivity in the study area. The statistical approaches are used to investigate the impact of rainfall on rice crop for the period of 1998–2019. Rice productivity is greatly affected by the local rainfall variability.

FUTURE SCOPE

The consequences of this study show that rice crop response to impact of rainfall has some predictability. It is recommended that breeders should introduce rice varieties that consume less water and are more productive in high temperature.

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