Journal of Science and Technology 22 (December 2024): 105-113
ISSN 1994-0386 (Print), 2959- 3239 (Online)

IMPACT OF CLIMATIC VARIABLES ON THREE MAJOR FIELD CROPS IN CHAR AREAS OF LALMONIRHAT DISTRICT

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DOI: https://www.doi.org/10.59125/JST.22110

ABSTRACT
An agro-climatic study was conducted at the charland areas of Lalmonirhat district considering 25 years of climatic data (i.e., temperature, humidity, rainfall) to observe the climatic variability and their impact on the productivity of three crops such as Boro, Jute and Wheat. Production of all the three crops was found as increasing trend. In Boro season, the production increased by 0.057 ton per hectare per year and the yield trend coefficient was 0.021. Jute production increased by 0.029 ton per hectare and the yield trend coefficient was 0.023 and Wheat production increased by 0.067 ton per hectare and the yield trend coefficient was 0.023 in each year, respectively. The changes of rainfall were lower over the seasons and followed increasing trend. The rainfall in Boro, Jute and Wheat season were increased by 18.62 mm, 13.15 mm and 14 mm in each year, respectively. The average maximum temperature increased by 0.059, 0.074 and 0.064°C in Boro, Jute, Wheat season, respectively. In Boro season, average humidity increased by 21% each year and it increased by 17% in Wheat season in each year. On the other hand, average humidity decreased by 2.1% in Jute season. The influences of climatic variables in the production of the crops are varied. Humidity has influence on seasonal Boro production whereas temperature and rainfall didn’t influence the production. Temperature has influences on both Jute and Wheat production. From correlation analysis, it was revealed that average humidity has considerable influence on seasonal Boro production than all other crops. However, most of the time the production showed increasing trend with some exceptions. The study recommends some essential climate adaptation policy which the government and policy makers may consider to address the challenges that farmers are likely to face as a result of climate change Again, local adaptation practices should be examined, the role of institutional support should be highlighted and national adaptation strategies and resilience should be strengthened.

Keywords: Boro rice, charland, climate change, impact, jute, wheat

INTRODUCTION
The landscape of Bangladesh is primarily composed of deltaic floodplains with a predominantly humid tropical climate. The demography of the country is marked by extremely high population density (1,156.84 people per square kilometer) (BBS 2022). The agricultural sector is a large contributor to economic development of the country contributing to 11.52% of its GDP and employing more than 36.86% of the population (Bangladesh Economic Review 2022). In recent years, extreme weather patterns have resulted in unseasonable biotic and abiotic stresses in agricultural sectors, impacting crop yield potential or resulting in crop failure (Basak 2010). Bangladesh, a country of divergent climatic condition throughout the year, has a complicated influence in economic and social aspects, mainly for its geographic location and physiographic condition. The lofty Himalayas in the North and funnel shaped Bay of Bengal in the South have made Bangladesh a meeting place of the life-giving monsoon rains and the catastrophic devastation of floods, cyclones, storm surges, droughts etc. The Fourth Assessment Report (AR4) of Intergovernmental Panel on Climate Change (IPCC 2020) has reported that the average global surface temperature has increased by 0.62°C during last 100 years. Agriculture is the backbone of the country and is synonymous to the food security of the county It is playing an important role in increasing productivity, ensuring sustainable food security and creating employment opportunities. According to the provisional calculation of BBS 2021, the

contribution of agriculture to the GDP is about 11.50 percent and about 40% of the labor force Agriculture is always susceptible to unfavorable weather conditions and climate events. Climatic factors such as temperature, rainfall, atmospheric carbon dioxide, solar radiation etc. are closely link with agriculture production. Therefore, rice, wheat and jute production would be major concern in recent years due to changing climatic conditions, because there is a significant amount of rice yield may hamper for only fluctuations of those climatic parameters.

Objectives of the research

Research objectives describe concisely what the research is trying to achieve. The overall objective of this research is to evaluate the impact of climatic variables on the production of major field crops.

The specific objectives are as follows:

1. To examine the socioeconomic characteristics and identify the natural calamities faced by the farmers;
2. To observe a long-term trend of climatic variables in the study areas;
3. To estimate the impact of climatic variables on seasonal productivity of major crops;
4. To suggest policy options and recommendations for adoption strategy of the effects of climatic variables.

METHODOLOGY

Necessary data were obtained from the selected area in order to achieve the objectives set for the research. Some char areas of Lalmonirhat district have been considered as the study area. Three char areas have been selected. Selected char areas were a) Char Sendurna, b) Char Karibari and c) Char Nohali. Sampling is the motherboard or core of any research. The following formula was used in determining the sample size

Sample size, $n – N / (1+N^{*}e^{2})$

A total 60 farmers (20 farmers from each area) were selected randomly as the sample for observation and data collection.

The research is based on both primary and secondary sources of data and information. Primary data was collected through field survey during the period of 1 October to 1 November, 2021. Secondary data and information were collected from various governmental organizations. Daily data of different climatic elements such as maximum temperature (C), average humidity (%), total sunshine (hours) and seasonal total rainfall (mm) at Lalmonirhat station for the period of January 1994 to December 2020 (i.e. 25 years) were used in this study. Data were collected from Weather Office, Bangladesh Meteorological Department (BMD), Rangpur; Khamar Bari, Lalmonirhat and Bangladesh Bureau of Statistics (BBS). The yearly crop production data have been obtained from Yearbook of Agricultural Statistics of Bangladesh from 1994 to 2020

Correlation, regression, trend analysis and data visualization between production data and climatic variables was carried using MATLAB (The MathWorks Inc., 2019). First tabulated data of yearly production and climatic variables were arranged according to corresponding year. This data set was imported into MATLAB software as individual column vector. Then the data set is processed, the climatic variable according to crop season was separated and using proper scripts data was analyzed. For correlation coefficient, ′Pearson Correlation Coefficient՝ (according to raw and pair wise) was used. The linear equation (Y = BX+C) was used to analyze climatic data.

Where, Y = Dependent variable such as production;

X = Independent variable such as climatic variables (Temperature, Humidity and Rainfall)

B = Coefficient; and

C = Constant.

RESULTS AND DISCUSSION

Age and Sex Structure of the Respondents

It was seen from the table 1 that, 9 persons (i.e., 5 males, 4 female) belonged to the Group I, 18

Table 1. Distribution of respondents according to their age and sex

Group no.	Age group (years)	Frequency of respondent		Average percentage (%)
		Male	Female	
Group I	10 to 20	5	4	15.45
Group II	21 to 30	10	8	30.90
Group III	31 to 40	11	8	32.25
Group IV	41 to 50	8	3	17.32
Group V	More than 50	3	0	4.05
	Total	37	23	100

Source: Field survey, 2021.

persons (i.e., 10 male, 8 female) belonged to Group II, 19 persons (i.e., 11 male, 8 female) belonged to Group III, 11 person (i.e., 8 male, 3 female) belonged to Group IV, and 3 person (3 male) belonged to the Group V and the percentage of distribution of each group were 15.45, 30.9, 32.25, 17.32 and 4.05 respectively.

Level of Education of the Respondents

This table below indicated that majority of the respondents (55%) had no educational qualification i.e., they were fully illiterate. Only 21.6% respondents had primary education, 13.4% had secondary education, 6.6% had higher secondary education and 3.4 % had more than higher secondary education in the study area.

The literacy rates of the respondents were 44% which was smaller than that of the national level 74.91% (BBS, 2021). Das and Saraf (2007) described in their socio-economic research about 44% people in the char land area are illiterate. It was discussed that these huge illiterate people increase the unemployment status in Bangladesh.

Table 2. Level of education of the respondents

Education level	Frequency of Respondents	Percentage (%)
Illiterate	33	55
Primary	13	21.6
Secondary	8	13.4
Higher secondary	4	6.6
More than higher secondary	2	3.4
Total	60	100

Source: Field survey, 2021

Monthly Income of the respondents

Table 3. Monthly income of the respondents

Income group	Income (Tk)	Frequency of respondents	Percentage (%)
Low	0-2000	7	11.6
Middle	2000-4000	11	18.3
High	4000-6000	27	45
Very high	More than 6000	15	25
	Total	60	100

Source: Field survey, 2021

Data presented in the table revealed that majority (11.6%) of the respondents had a low family income, 45% respondents had medium family income lies between 4000-6000tk. Hutton and Haque (2004) found that the main income sources of the char people were related with river, agricultural land, fishing practices. Most of the families were deprived and they had poor family income. Their low-income capacity made themselves to live below poverty line.

Production Trends of Boro Rice, Jute and Wheat in Lalmonirhat District

All the crops showed an increasing trend of production per hectare. This figure showed that production of all the three crops (Boro rice, Jute and Wheat) were found increasing without following any trend statistically rather the productions were fluctuated. The production of Boro rice was highest in year 2007 of about 4.216 ton per hectare whereas highest production jute was

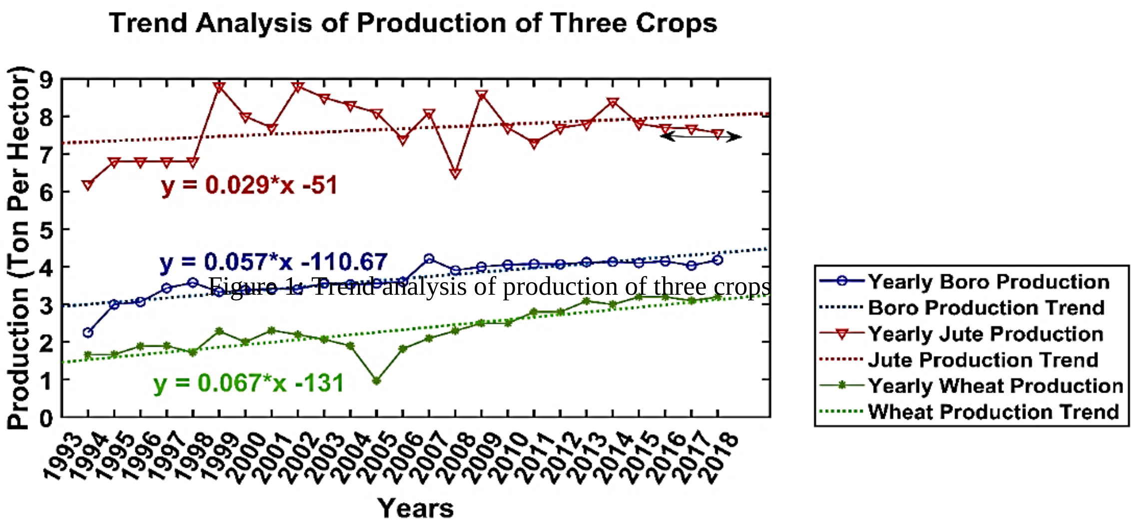

Figure 1: Trend analysis of production of three crops

recorded in 1999 and 2002 about 8.8 ton per hectare. In case of wheat it was 3.2 ton per hectare in 2015, 2016 and 2018 among 25 years from 1994 to 2018.

Total seasonal rainfall: Inter annual variability of Boro rice production with rainfall

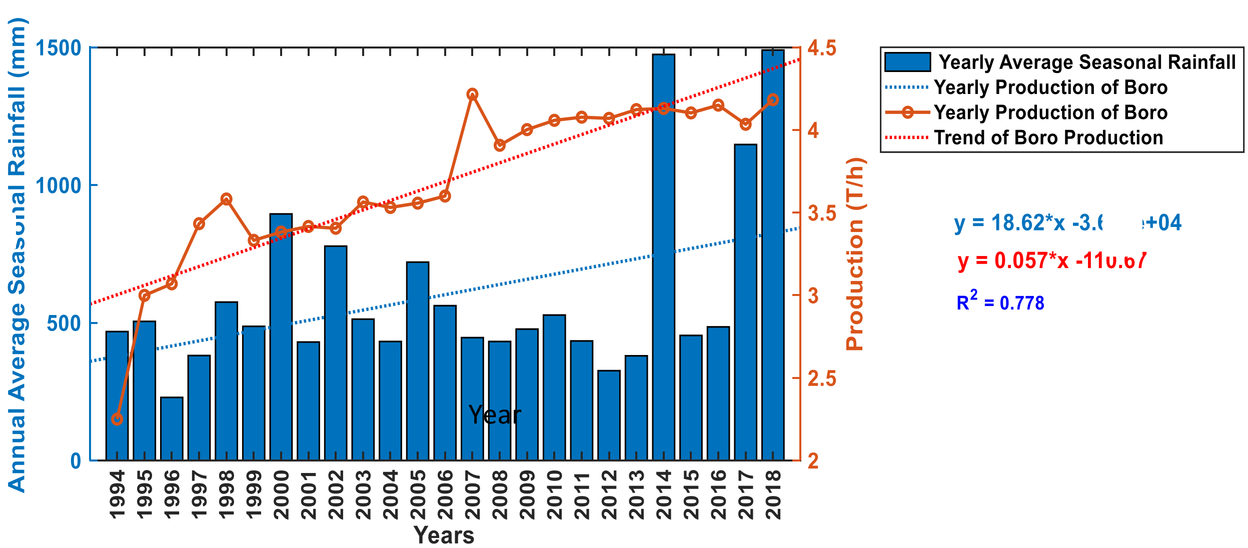

Figure 2: Inter annual variability of Boro rice production with rainfall

This diagram showed the seasonal rainfall followed a positive trend in last 25 years (1994-2018). The coefficient of determination of the yearly seasonal average rainfall was 0.778. Year 2014 and 2018 has a sudden higher amount of rainfall than all the other years.

In this regard Islam *et al.* (2002) found that, rice production mainly depended on rainfall. Deficit rainfall in Bangladesh caused drought in rain fed ecosystem and consequently loss of crop yield and it was many times higher than the damage from flood. Rainfall provides the water that serves as a medium through which nutrients are transported for crop development. In view of this significant role, clearly, inadequate water supply has adverse effects on efficient crop growth, resulting in low productivity.

Again, Quadir *et al*. (2003) showed that the crop production is low for low monsoon rainfall over Bangladesh. The yield increases with the increase of rainfall up to a certain optimum level and further increase of rainfall causes the decrease of the yield. The most important component of weather was the amount of rainfall and its distribution during the life span of a crops which is convenient with our findings as mentioned above.

****Average maximum temperature: Inter annual variability of Boro rice production with maximum temperature**

The figure showed that, both of seasonal maximum average temperature and production of Boro (t ha^{-1}) had a positive/increasing trend from 1994 to 2018. The trend of increasing temperature is

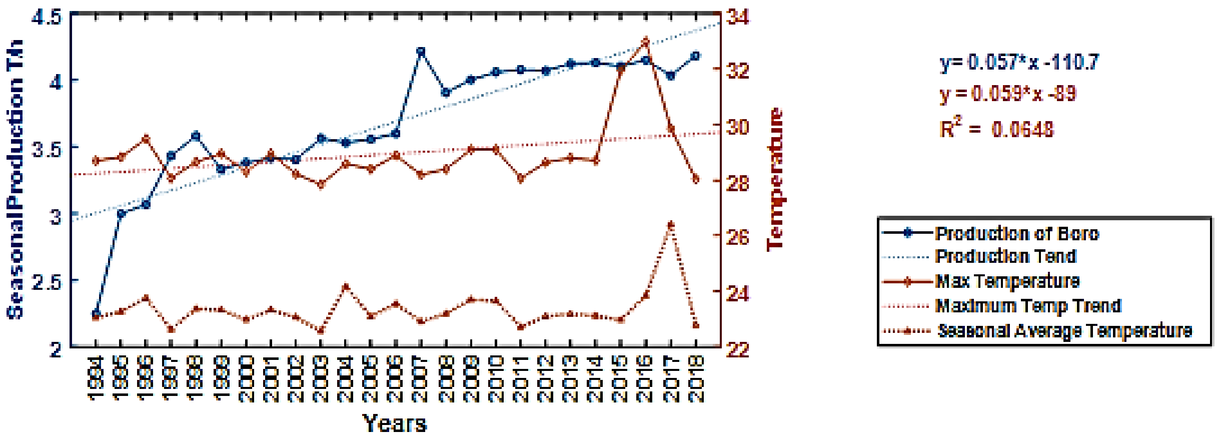

Figure 3. Inter annual variability of Boro rice production with maximum temperature

not significant because of the lower coefficient of determination. Year 2007 had the highest production of Boro and year 2016 had the highest average maximum temperature from 1994 to 2018.

In this esteem Hatfield *et al.* (2008, 2011) found that responses to temperature differ among crop species through out of their life cycle and are primarily the phenological responses, i.e., stages of plant development. For each species, a defined range of maximum and minimum temperatures from the boundaries of observable growth. Vegetative development (node and leaf appearance rate) increases as temperature rise to the species optimum level. For most plant species, vegetative development usually has a higher optimum temperature than reproductive development. Cardinal temperature values for selected annual (non- perennial) crops are given in for different species.

Average humidity: Inter annual variability of Boro rice (t ha^{-1}) production with humidity

Excess humid condition (87%) prevails in the monsoon season (June- September) and then followed by the post monsoon season (October - November) in Bangladesh. Humidity is the least (70%) during the pre-monsoon season (March-May), which coincides with summer in Bangladesh, followed by the dry to winter season (December to February) (Islam *et al*. 2014).

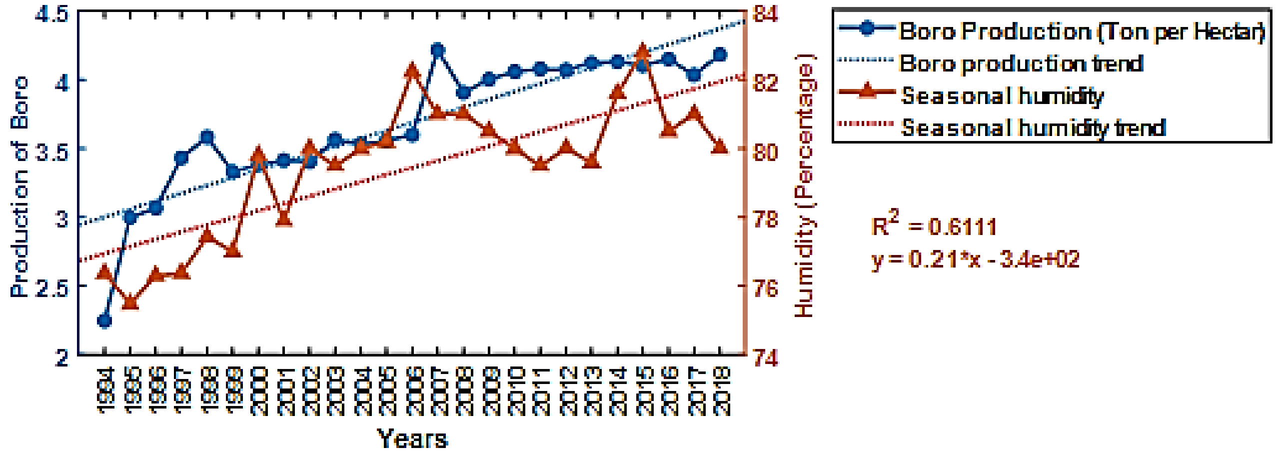

Figure 4. Inter annual variability of Boro rice (t ha^{-1}) production with humidity

According to figure the average seasonal humidity during the Boro season in Lalmonirhat area increased in last 25 years (1994-2018). The increasing trend was moderate (R^2 = 0.61). The trend of production and humidity was similar trend analysis showed that the average humidity was increasing 21% per year.

In accordance to Amin *et al.* (2004) relative humidity may affect grain formation after milk stage, ripening and diseases in rice. High relative humidity favors crop growth through the vegetation stage. During grain formation, low humidity may cause grain to shrink, but high humidity favors disease, particularly in rain fed rice.

Relationship of production of Jute with climate variables: Relationship between seasonal rainfall and Jute production

According to Quadir *et al.* (2001) production of crops depends on different types of weather parameters and phenomenon. Crop failure may sometimes occur due to excess and deficit rainfall conditions or flood or drought of the country comes as a significant strain to its socioeconomic structure.

Seasonal rainfall for the jute season was found having a negative correlation with very low R (0.033) and R^2(0.0011) values. Heavy rainfall causes flood which disturbs the production of jute but, seldom kind phenomenon occurred, that's why the correlation was very poor.

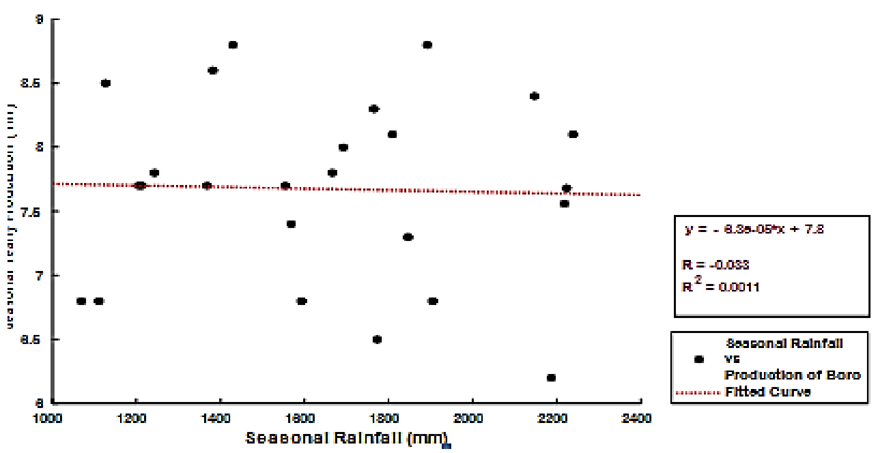

Figure 5. Relationship between seasonal rainfall and Jute production

Relationship between average humidity and production of jute

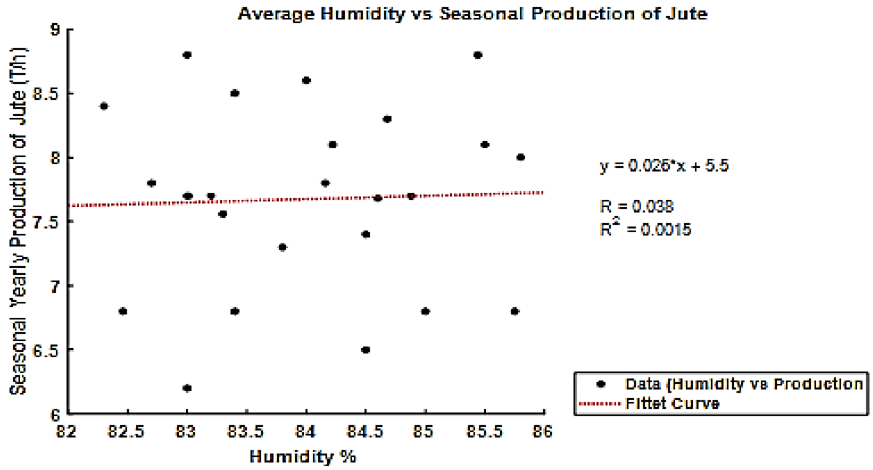

Figure 6. Relationship between average humidity and production of jute

There was no relationship between average humidity and seasonal production of jute. The value of R^2 was nearly zero that implies production can't be predicted by average humidity or there's no influence of average humidity in jute production.

Relationship of production of Wheat with climate variables: Relationship between average temperature and wheat production

Seasonal production of wheat was positively correlated with average maximum temperature with a very weak but statistically significant correlation coefficient. The very low value of coefficient of determination implies that there was not influence of maximum temperature on wheat production.

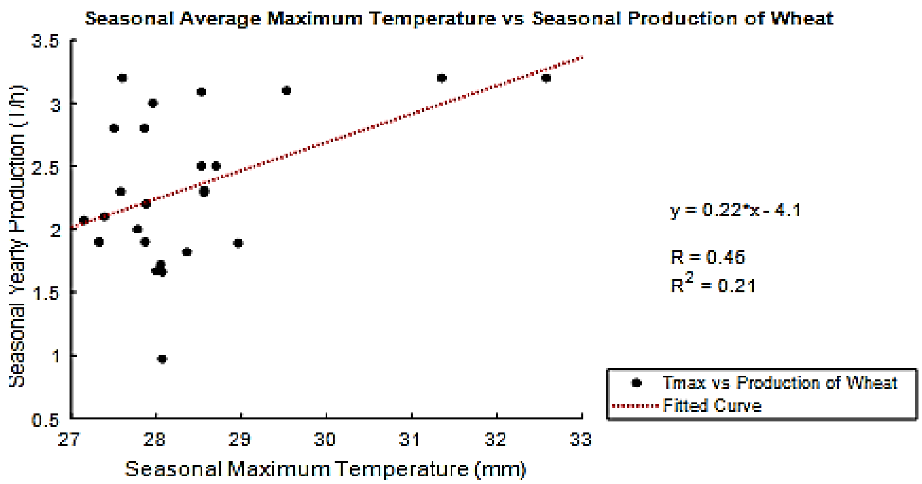

Figure 7. Relationship between average temperature and wheat production

Relationship between humidity and wheat production

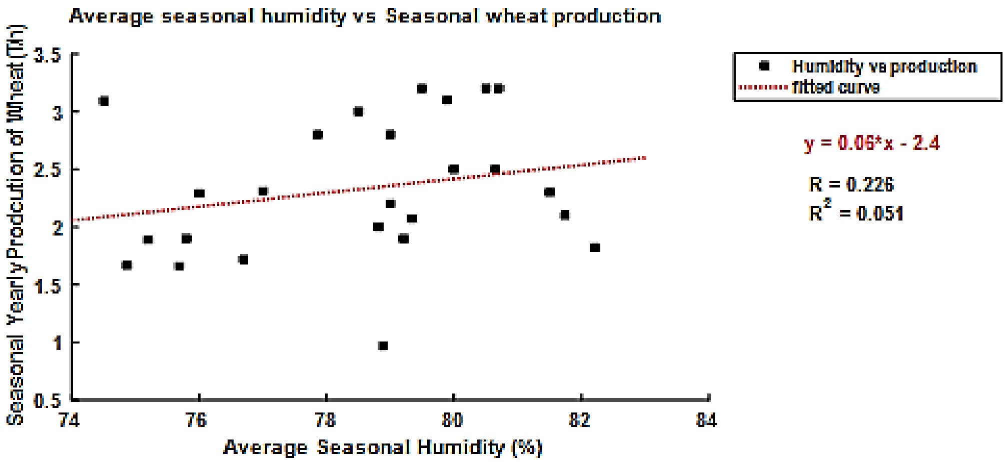

Figure 8. Relationship between humidity and wheat production

Weak positive correlation was observed between average seasonal humidity and wheat production with a statistical non-significance.

CONCLUSION

The influences of climatic variables in the production of the crops are mixed. Humidity has influence on seasonal Boro production whereas temperature and rainfall didn't influence the production. Temperature has influences on both Jute and Wheat production. Other associations are not statistically significant. From correlation analysis it was revealed that average humidity has considerable influence on seasonal Boro production than all other crops. All of three crops had increasing production trend from 1994 to 2020 in Lalmonirhat region. Seasonal productivity of Boro showed an increasing trend in Lalmonirhat region. Temperature, humidity and rainfall showed an increasing trend in this season. Seasonal productivity of Jute also showed an increasing trend. Rainfall and temperature for this season followed increasing trend. Only seasonal humidity showed a decreasing trend in this season. In season of wheat production, the entire climatic variable along with the Wheat production itself showed increasing pattern. The results of our study may guide the government policy makers and rural development practitioners in designing the appropriate adaption strategies in the country. Based on the findings, our study suggests some essential climate adaptation policy recommendations which are as follows

1. Strengthening research capacity for the development of new cultivars and farming techniques with the changes in climate, enhancement of various enterprise diversification activities is necessary to adopt.
2. Adaptation policies should target different climatic zones based on the constraints and potentials of each zone in lieu of recommending uniform interventions.
3. Modern technology and information delivery facilities should be ensured at the Agro-met division to collect more accurate data on crop yields, moisture stress, incidence of pests and diseases, etc.
4. To increase the resilience of crop farming sector of Bangladesh, immediate actions are required taking the current and anticipated climate change impacts into consideration.
5. The agro-met division is recommended to prepare and publish Agro-met advisory bulletin based on major crop seasons for the farmers of different agro-climatic zones.
6. Making provision of crop insurance program and strengthening agricultural extension systems for disseminating up-to-date agricultural adaptation technologies to the farmers is time demanding now.

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