RELATIONSHIP OF CLIMATE VARIABILITY WITH MAJOR CROPS PRODUCTION IN PUNJAB, PAKISTAN

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ABSTRACT

This study investigated crop-climate relationship, using yield statistics for major crops (wheat, rice) and climatic elements (rainfall, temperature) in the Punjab province, Pakistan for the period of 1981-2016. The influences of rainfall and temperature on major crops were more realistic using de trended yield data which ignored the technological effects. This study also examined crop-climate relationship during various phonological stages of wheat and rice crops. Correlation analysis reveals the influence of rainfall and temperatures on crop production. Rainfall and temperature are significantly correlated with wheat production during the stage of germination and early tilling in the month of December. Whereas, a significant negative relationship of temperature and wheat crop detected during flowering and on these stages in the month of March. Further, results indicate that rainfall has significant positive relation with rice production during the plantation stage in the month of June, however temperature has a significant negative relationship with rice crop during the same stage of plantation. This study emphasizing the combined effect of rainfall and temperature and their interactions to annual yield variation were substantial consequences for food related issues across Punjab province of Pakistan. Significant relations illustrate that the productivity of wheat and rice crop is mostly influenced by variability in local climate. This analysis ia a particular argument of the assessment of climate variability and its effect on domestic crop yield with better understanding of crop-climate relationship. The findings of this research are useful to determining the practices to enhance the sustainable crop yield through better agronomic methods.

KEYWORDS: crop-climate relationship, major food crops, plant growth stages, crop yield,

1. INTRODUCTION

Climate change is a global threat to all sectors, specifically the agricultural sector. The effects of changing climate on cereal crops production have received great attention of scientists and policy makers over the last decades. In the race between increasing population and food production, fluctuations of climate elements could lead to a widespread starvation. Growth of crops and their yield are affected by climatic elements, including rainfall and temperature. The climate change problems and its impact on the major cereal crops are important concerns in recent decades in the developed countries (Abbas *et al*., 2018; Attri and Rathore, 2003). However, attention is also given on agro-climate relationship in developing countries after realizing the climate change phenomenon. The agriculture sector is important for rapid economic growth and to enhance food sector for agrarian countries particularly in populous regions. The changing climate is an alarming concern for agriculture productivity on a wider scale in Asian countries in near future (Janjua *et al*., 2014).

On global scale climate acts differently on agriculture across the world, therefore the relationship between regional climate and agriculture is established. A significant number of studies have investigated and measure the crop-climate relationship using statistical procedures and quantifying the association for the entire or/and affected growing period (Mihailovic *et al*., 2015; Yu *et al*., 2014; Fernandez *et al*., 2013; Zhang and Huang 2013; Ravadekar and Preethi 2012; Suzuki *et al*., 2008; Kane *et al*., 1992). Numerous studies reported increasing temperature and changing trends of rainfall have substantia effect on crop yield (Janjua *et al*., 2014; Mahmood *et al*., 2012). The regional potential climate modes such as Indian Summer Monsoon and El Niño Southern Oscillation become increasingly significant predictors for forecasts of crop yields and food monitoring systems (Nageswararao *et al*., 2018; Lizumi *et al* 2014).

Kumar *et al*. (2004) examined an impact of monsoon rainfall on production of the crops in India. Particularly, wheat and rice crops show strong association with Indian summer monsoon rainfall. Ray *et al*., (2012) indicated that temperature has influences on wheat yield variability widely over the northwestern India likewise the agreement of Lobell and Gourdji (2012). Similarly, the productivity of different *Rabi* crops was most likely effected by variation of local temperature changes in the northwestern India (Nageswararao *et al*., 2017) which confirmed findings of Atari and Rathore (2003). Naheed and Mahmood (2009) calculated water requirement for wheat crop in Pakistan and noted a hot and dry climate cover the arid and semi-arid parts of the Pakistan (Hussain and Lee 2015) during milking and dough stage of wheat crop resultant decline in the yield (Sultana *et al*., 2009).

Correspondingly, the strong positive relationship of food-grain crops and rainfall is documented during *Kharif* season over India (Preethi and Revadekar, 2013). Indian agriculture depends on monsoon rainfall and any change in monsoonal rainfall has a drastic impact on food-chain of India (Haris *et al*., 2013; Mahato 20114) predicted a decline of 34% in rice yield by 2080 in the sub-humid climatic environment. Temperature and rainfall effect on the rice crop and the associated changes in rice yield in sub-tropical region were examined (Bhattacharya *et al*., 2013). A study reported that increasing temperature will affect the growth and phenological development of rice crop and ultimately yield of rice likely to drop (Rasul *et al*., 2011). However, it is also reported that rice production was positively affected by the carbon dioxide (Chandia *et al*., 2019).

The Pakistan's economy mainly depends on agriculture which is highly influenced by spatial-temporal variability of rainfall and temperature throughout the country (Ahmed *et al*., 2017). Particularly, the moisture belt is shifting from arid to semi-arid during the Kharif and arid to hyper-arid during Rabi in Pakistan (Hussain and Lee 2009). Temperature is a dominanting factor of arid and semi-arid climatology in the southern half of Pakistan (Ahmed *et al*., 2018). *Rabi* and *Kharif* are the two main cropping seasons, which is the backbone of rural livelihood. The *Rabi* crops are normally grown during the months of November to April and the *Kharif* crops are grown from May to October. These two seasons is critical for an agrarian economy of Pakistan and its performance depends on the climate of the last year. Wheat is the main crop of *Rabi* season and rice is the main crop of *Kharif* season.

Agriculture is the largest and most important sector of Pakistan's economy which employed with more than 50% of total work force and contributes a vital role in the economic prosperity of the country. The direct worth of the agricultural yield, indirect contribution to employment, rural livelihoods and contribution in GDP have widely been determined by the agriculture growth. The sector of agriculture is also the main contributor of raw materials for allied industries in the country. Wheat (rice) accounts for 9.6 (3.0) percent of the value added in agriculture and 1.9 (0.6) percent of Gross Domestic Product (GDP) of Pakistan.

Similarly, it is very significant for the economy of the province of Punjab, Pakistan. Agriculture sector of Punjab already under stress due to changing climate, threats of desertification and increasing demand for food (Ali *et al*., 2017). Rising temperature in Pakistan is the cause of the decline in the yield of wheat and rice crop in the study region (Sultana *et al.*, 2009). Considering the role of agriculture in the economy and its sensitivity to climate, the effects of rainfall and temperature on crops is important to investigate. Therefore, the present study aimed to investigate the impact of climate variables (temperature and rainfall) on major crops production in Punjab, Pakistan. This study also examined crop-climate relationship during various phonological stages of wheat and rice crops.

2. MATERIALS AND METHODS

The Punjab province lies between 27° to 34° north latitude and 69° to 75° east longitudes. The province acquires its names from five flowing rivers, which irrigate the area, signifying a place that is known for its “five rivers”. These five rivers are Jhelum, Chenab, Ravi, Sutlej and Indus flow through the districts and frame the existing line of comprised of a great many people who are one way or the other relies on agriculture in the fertile plains of Punjab. The Punjab province is comprised of leveled fields alongside a few table land areas and hilly regions. It consists of 37 districts and is the largest province of Pakistan in terms of population size (around 110 million people according to 2017 Census of Pakistan).

To study the relationships between climate and agriculture in the Punjab, Pakistan, 11 meteorological stations of the province have been investigated. We used daily rainfall records, monthly mean temperature, and annual productions of wheat and rice crops. All the investigated datasets of climate and crops were taken for a period of 35 years (1981-2016). The reliable climatic data (rainfall and temperature) of selected stations were obtained from Pakistan Meteorological Department. The statistics of crop production and cultivated area (wheat and rice) of the Punjab province were obtained from Pakistan Agriculture Department.

The features of crop production and yield time series reveal strong association and consequent trends. Various studies have attempted to associate these year-to-year association and removing these apparent trends using different forms of smoothing filters and statistical parametric tests (Kumar *et al*. 2004; Parathasarathy *et al*. 1992). Crop production is the total product of cultivated area and yield is the production of per hectare (in metric tons or kilograms). Although climatic conditions influence the seasonal fluctuations of crop yields, it could be related to technological factors/advancement. The annual growth rate of yield increases with the improvement of agricultural technology. The time series using the first difference values of each year and then applied the Pearson’s Correlation, as a parametric test, between detrended crop and detrended climate variables (Kumar *et al.*, 2004). The polynomial variation of paddy yield data could be due to technology trend (Mahato, 2014). So, we detrended the time series of crop yields using the linear fitting to remove the influence of technology (Mohanty *et al*., 2016). In order to detrend the time series of crop yield data, first, all of selected time series were detrended by taking the difference between the present year and the value of the previous year. The detrended datasets were used to examine the relationship of variability in rainfall and mean temperature with wheat and rice crops over the Punjab province of Pakistan.

As a non-parametric test, the pairwise correlations between detrended climate and detrended crop datasets were calculated using the following statistical expression of the Kendall's *tau(τ)*-based correlation:

$$\tau = Nc - Nd/n(n-1)/2 \qquad (2.1)$$

where *N*c is the numbers of concordances, *N*d is the numbers of discordances and the numerator is divided by the number of the possible match ups of data pairs (*xi,yi*) among the *n* observations. The associations of all datasets were computed on the basis of annual and various stages of the both crops. The calculation method was accomplished by considering the association among all likely matching of data pairs same as adopted by (Hussain and Lee, 2016).

The statistical method of standardization is used to the normalization of the climatic and agricultural data over the Punjab province of Pakistan. Numerous scientists have used the standardized method to normalize the data for climatic studies (Usman and Shamseldin 2002; Samba and Nagana, 2012). The technique of data standardization is helpful for removing any oddness or outlier of the dataset. The method was applied by using the following equation:

$$\text{X ij} = Xij - Xi^2/ði \qquad (2.2)$$

where x_{ij} is the annual rainfall or annual mean temperature of station *i* in year j, x*i* is the mean of the annual rainfall or annual mean temperature for station *i*, and ð*i* is the standard deviation of data sets and same for the crop data.

To analyze the pronounced years of enhanced/low yield of wheat and rice, a threshold has set for annual yield of detrended data sets. This threshold of 200kg/ha for wheat and 100kg/ha for rice crops (+1 for positive year and -1 for negative year) is made to identify the pronounced yield years. Further analysis is based on these specific years of wheat and rice yield are studied by comparing the averages of rainfall and mean temperature over the entire study period. To study the crop-climate relationship, various growth stages of wheat and rice such as germination stage, tillering stage, flowering stage and milking stage were selected.

3. RESULTS AND DISCUSSIONS

3.1 Inter-annual variability of climate and crop yield

In regard of the climatology of the study area, the northern half of the Punjab province has wetter with cold weather, whereas the southern part has less rainfall and high temperature. The year-to-year variability of crop yields is explained by year-to-year variability of climate change. This interannual variability of climatic elements and detrended series are constructed in the Figure 1. The trend line of annual rainfall does not show any specific increasing/decreasing trend, however the investigated data span showed some fluctuations, for example, a decrease of rainfall from 1981 to 1987, an increase from 1987 to 1997, a decrease from 1998 to 2001 and then a constant increase until 2016. In case of first difference values, internal variability of rainfall can be noted. The results reveal that in the years of 1988, 1990, 1992, 2003, 2010 and 2013 rainfall has a significant positive amplitude. In adverse case, the annual variability of rainfall in the years of 1984, 1991, 1993, 1998, 1999, 2002, 2004, 2009 and 2016 detected as significant negative rainfall years.

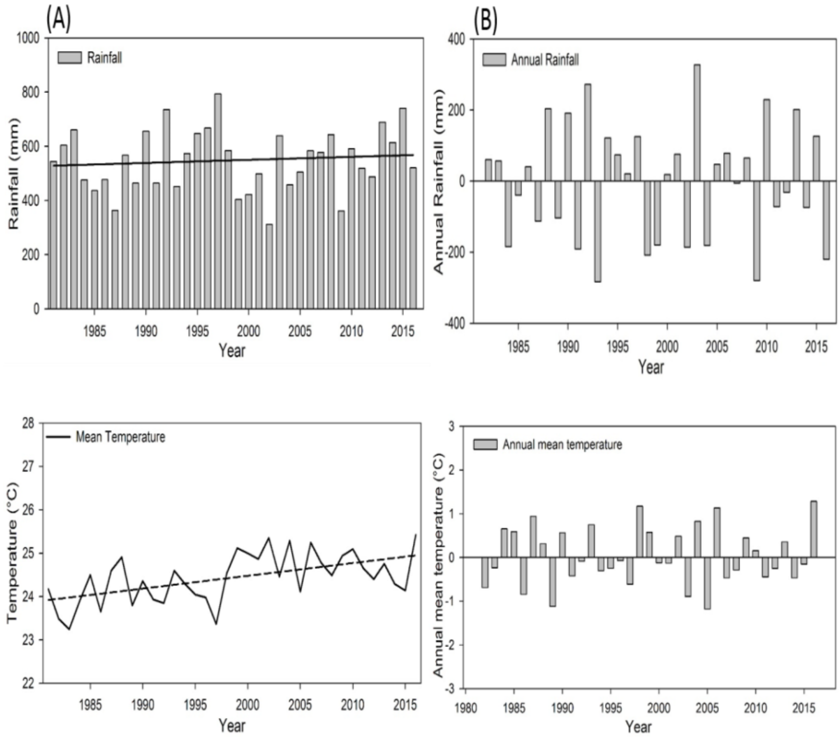

Fig. 1: Panel A (left) is showing annual variability of rainfall (mm) and temperature (°C) and Panel B (right) showing detrended data.

Wheat and rice dominate Punjab's agricultural sector throughout the history. The previous results provide the information about the annual production and cultivated area of wheat and rice crops (Ali *et al*., 2017). The trend lines of the both crops indicate a continues rise in annual production and cultivated area. The investigated datasets duration (1981-2016) in this study is consisted annual growth of average yield started to increase speed, particularly wheat and rice crops. This greater increase is likely due to highly used of fertilizers, new crop varieties, agricultural practices, state policy and changing cropping methods. The trends of annual production of wheat and rice also reflect in cultivated area. While the significant growth of cereal crops is increased, there is also substantial year-to-year variability about the trend is observed.

To see the similarities of interannual variability between climate and crop yield, a detrended time series of temperature and rainfall was established. Figure 2 showed annual crop yield wheat and rice crop (Panel A) and detrended time series of both crop yield variability (Panel B). Some years are selected for analysis by making a threshold for crop yield (See section 2). In the detrended time series of positive wheat yield, the years of 1986, 1995, 2000, 2005, 2007, 2009 and 2011 were selected (Figure 2B upper panel). Similarly, from the detrended time series of negative wheat yield, the years of 1984, 1987, 2001 and 2008 were analyzed. The results revealed that during the years of enhanced yield of wheat (1986, 1995, 2000 and 2005) the annual rainfall is also showing positive behavior during the same years. However, during the years of 2007, 2009 and 2011 when wheat yield was enhanced the rainfall was deficient in the same years. In the case of low wheat yield years, during 1984 and 1987 the rainfall also was deficient while in the year of 2001 and 2008 rainfall was positive. During the enhanced yield of wheat crop, the detrended time series of temperature is negative except the year of 2009. In adverse, during the years of low wheat yield, temperature is positive in 1984 and 1987 and negative in 2001 and 2008.

The trend line of rice yield showed a gradual increase throughout the data series, particularly after 2007 (Figure 2B lower panel). According to the marked threshold in detrended time series, the enhanced yield years of 1996, 2003, 2007, 2008 and 2011 are selected for further analysis. Similarly, from the detrended time series of low rice yield, the years of 1986, 1997, 2002 and 2009 are selected. The results revealed that during the years of enhanced yield of rice (1996, 2003, 2007, 2008 and 2013) the annual rainfall is also showing positive behavior during the same years except the year of 2007. In the case of low rice yield years, during 1986 and 1987 the rainfall was positive while in the year of 2002 and 2009 rainfall was significantly deficient. The results reveal that enhanced and low years of rice yield have some associations with rainfall variations. Figure 2B (lower panel) showed, during all enhanced yield of rice years temperature is negative, except for the year of 2013. In adverse, during low yield years, the temperature is negative in the years of 1996 and 1997 and positive in the years of 2002 and 2009.

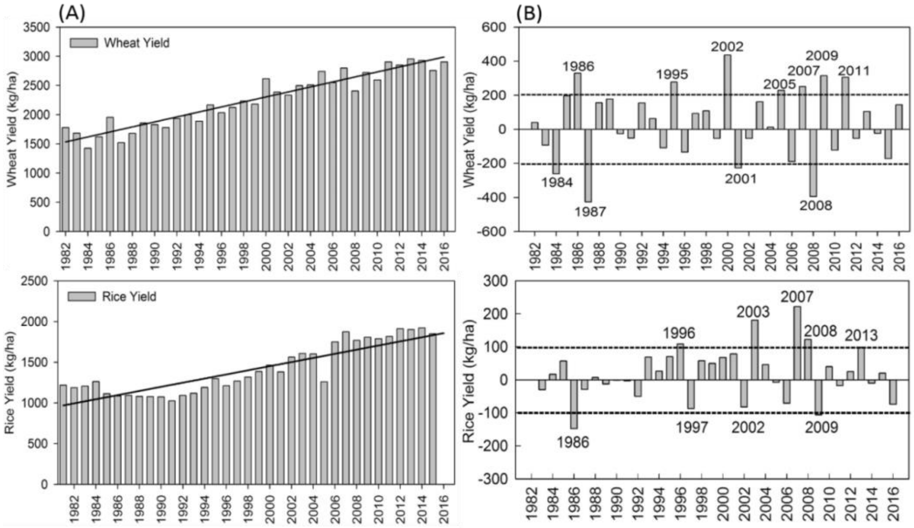

Fig. 2: Panel A (left) is annual yield of wheat and rice crop and panel B (right) is annual detrended data.

3.2 Relationship of climate with wheat yield

The annual total production of wheat crop comes from a single growing season. The ideal planting season of the wheat crop is considered during October-November and harvested during March-April. Thus, sometime wheat cultivation charts fluctuation between October-December to March-May. To study the crop-climate relationship of wheat and rice, four stages namely, germination stage, tillering stage, flowering stage and milking stage are selected. Germination and tillering are the early stages of wheat crop which consists on November-December, while flowering, anthesis and milking stages come in the month of March (Naheed and Mehmood, 2009). These four growth stages of wheat and rice crops are critical and sensitive to rainfall, high temperature, and water deficit (Ali *et al*., 2017). Both numbers of grain and size/weight of grain are sensitive to temperature for wheat crop (Farooq *et al*., 2011). The main wheat growing areas are located in the upper-Indus plain, particularly Faisalabad, Sargodha, Bahawalpur and Bahawalnagar districts. The time series of wheat yield and climatic element showed some distinct results.

To assess the impact of climate variability on wheat crop over Punjab province, the correlation of wheat crop with rainfall and temperature for the germination and milking stages is calculated and illustrated in Figure 3. The rainfall impact on the productivity of wheat crop is varying during all months of the *Rabi* season over the Punjab province. Particularly, the month of December showed a significant positive relationship. This positive relationship of wheat yield and rainfall during germination stage of

Wheat crop in the month of December is established already (Nageswararao *et al*., 2016).

The results from this study also showed that wheat yield has a positive relationship with rainfall in December. In Figure 3A, the plot comprises of rainfall on horizontal (X-axis) axis and the annual wheat yield on vertical pivot (Y-axis). The similar points are firmly grouped around the best fit line and the r value is r = 0.587 which implies that significant positive association of the wheat yield and December rainfall in the data is clarified by the fit line. The selected years of high and low yield of wheat crop and the rainfall of the same years showed similar trends. For example, during the high yields years (1986, 1995, 2005, 2007, 2009 and 2011) rainfall in December also has positive trend, while during the low yield years of 1984 and 2008 December rainfall was deficient. Annual wheat yield and rainfall in December showed dissimilarity in a relationship during the year of 2001. According to investigation, the immense reason of this low yield is heavy rainfall during the second week of April, particularly rain bulk in 16-19 April of 2001. FAO (2001) also indicated the year of 2001 as low yield of wheat crop.

The results revealed that rainfall has a positive impact on wheat crop during germination and early tillering stage in the month of December. Both high and low rainfalls are important for seedling establishment and early tillering for wheat plant. Heavy and above than normal rainfall can reduce annual yield of wheat crop during germination and seedling stages, while less than normal rainfall can negatively impact on wheat yield during early tillering. During the tillering period, the development of roots started and other associated plants from these roots come outside. If rainfall is less than normal, it can negatively impact on roots and new plant blooms of wheat.

The yield of wheat crop and temperature are also showing positive relationship during the germination and early tillering stage (Ali *et al*., 2017). As compared in Figure 3B, r value is r = 0.319. This value seems too low, however the best-fit line still varies fundamentally from zero since it depends on a high random component which shows positive correlation that enhance the yield improvement. The results revealed that the high wheat yield of 1995 and 2011 and temperature of December showed dissimilarity. These both years 1995 and 2011 high yield is linked with rainfall march, particularly end March which is the milking stage of wheat grain. In regard of the low yield years, the year of 1984 has no impact of positive temperature of December. This year, low yield has association with high rainfall in April during the harvesting season of wheat crop.

The flowering, the anthesis and milking stages of wheat crop are very important for yield increase/decrease and sensitive to rainfall and temperature. These three stages of the wheat plant occurred in the month of March. Annual wheat yield and March rainfall showed a significant positive relationship (*p*-value < 0.05). In Figure 3C, the plot comprises of rainfall on horizontal (X) axis and the annual rice yield on vertical pivot. The similar points are firmly grouped around the best fit line and the r value is *r* = 0.566 which implies that a positive association of the wheat yield and March rainfall. The selected years of high and low yield of wheat crop and the rainfall of the same years showed similar trends. The positive relation of wheat yield with March is very obvious, because during these months the grain of wheat gets weight maximum, which make an increase in wheat yield. Heavy and extreme climatic events, particularly rainfall have a negative impact on wheat yield during harvesting season. April is harvesting month, if rainfall come, the prepared crop of wheat can destroy, which leads toward the low yield scenario.

In regard of temperature, wheat yield has a negative relationship during the flowering, anthesis and milking stages. Figure 3D depicted, the correlation of wheat yield and March temperature and the r value is *r* = -0.739 which implies a strong negative association of the wheat yield and March temperature (*p*-value < 0.01). The selected years of high and low yield of wheat crop and the rainfall of the same years showed similar trends. In the context of the above results, March temperature shows the significant negative relationship with annual wheat yield during the flowering and milking stages in the month of March.

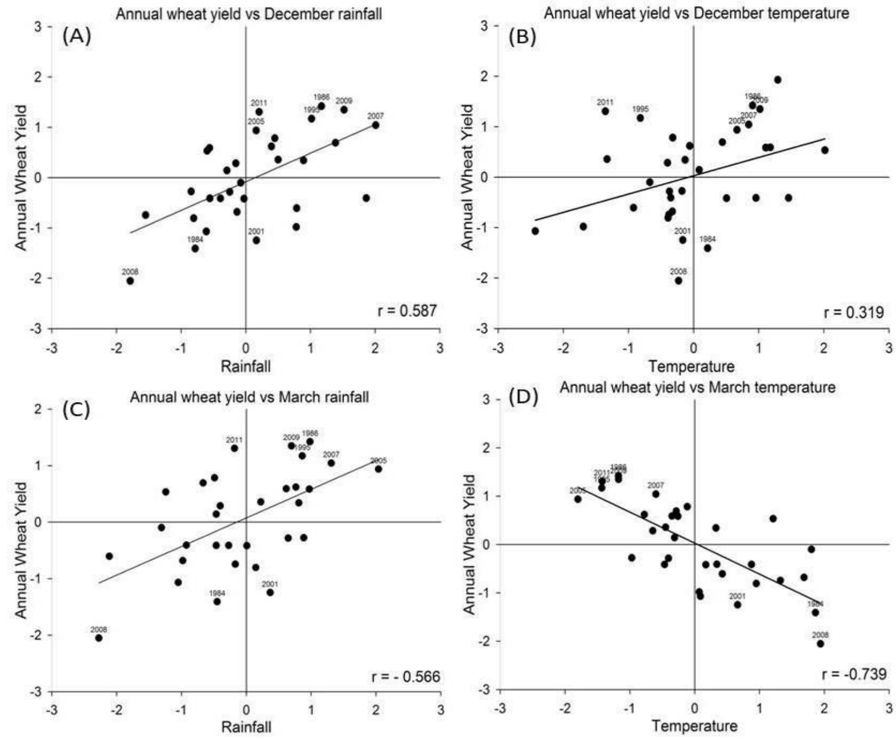

Fig. 3: Relationship of annual wheat yield between rainfall (mm) and temperature (°C), (A) December rainfall, (B) December temperature, (C) March rainfall and (D) March temperature.

The Kendall's *tau*-based slope estimator confirm the regression line in the scatter plots. The rainfall and temperature with wheat yield have the positive τ -value 0.408 and 0.258 respectively in the month of December. However, both climatic factors have a significant positive association with the wheat production in the month of the December. In the month of March, rainfall has positive τ-value 0.236 and temperature has negative τ-value -0.526. So, temperature has a negative impact on the wheat production in the month of the March. During the Rabi season, temperature has the negative association with τ-value -0.248. Whereas rainfall has a positive relationship with wheat production through τ-value 0.173.

Wheat crop being core subject matter, it is found that increasing temperature has significantly negative impact (Shakoor *et al*., 2011) during the stage of flowering and milking. In the perspective of climate change impact on weat production, negative effect of temperature is greater than positive effect of rainfall in the region. Elevated temperature is harmful for grain weight and number of grains, which can lead towards low yield of wheat (Farooq *et al*., 2011). However, the influence of temperature is depends on the growth phase, particularly during flowering and grain-filling stages where wheat yield can reduced by 1 to 30% and 58 to 90 % respectively.

3.3 Relationship of climate with rice yield

Rice is the major crop of *Kharif* season and it's grown in many parts of the Punjab province. The main rice-growing areas are located in northeastern parts of the upper-Indus plain. Particularly, Sialkot, Lahore, Sheikhupura and Gujranwala districts are major rice growing areas and very famous for the best rice variety in the region. Minor rice growing areas are Faisalabad, Multan and Bahawalpur. Rice has one crop during the *Kharif* season (April-October).

The plantation of rice crop starts in the month of June and harvesting during October-November. According to the observations, establishment of rice plant showed a strong positive relationship with rainfall in June. In Figure 4A, the plot comprises of June rainfall on horizontal (x) axis and the annual rice yield on vertical (y) pivot. The points are firmly grouped around the best fit line and the r value (0.571) is near 1. In the context of the above results, rainfall shows the significant positive relationship with annual rice yield during the plantation stage of rice crops in June. Like, during the high yield years (2003, 2008 and 2013) June rainfall also has positive relationship, while during the low yield years of (1997 and 2002) June rainfall was scarce.

In Figure 4B, the plot comprises temperature of June and the annual rice yield. The r value is -0.312 which demonstrates the negative relationship between temperature and rice yield in the long stretch during the plantation stage of rice crops in June. Results indicate that temperature is co-integrated with the annual rice yield for the long run period. Due to long run period, temperature directly impact on the rice production.

Figure 4C shows rainfall in September and the annual rice yield. The r value is -0.271 which demonstrates the negative relationship between rainfall and rice yield in the long stretch during the flowering and an thesis stages of rice crop. Due to this low value, the best-fit line still varies fundamentally from zero since it depends on a high random component. However, high random clouds of rainfall founded in the month of June as compared to September which shows positive correlation that enhance the yield improvement. According to the results, during the years of 1996, 2003, 2008 and 2013, there is positive effect of rainfall in on the annual rice production in September. According to the observations, the high yield of rice crops in the year of 1996 is associated with rainfall of plantation stage in June (last half) and rainfall during the milking of rice crops in October (first half).

Figure 4D shows a weak positive correlation between temperature of September and annual rice yield, where r-value is 0.094 which is implies random cloud of points are low. Low random data clouds of temperature make the non-critical effect on the rice yield. According to the Kendall's tau-based correlation rainfall in the month of June has the positive τ-value of 0.291 but temperature has a negative association to rice production with τ-value of -0.150. In the month of September, rainfall has negative τ-value of -0.194 and temperature has positive τ-value (0.079). So, temperature has a positive impact on the rice production in the month of the September. In October, both rainfall and temperature have a positive association to rice production with τ-value of 0.012 and 0.105, respectively. During the Kharif season, temperature has the negative association with τ-value (-0.077). Whereas rainfall has a positive relationship with rice production through τ-value (0.134).

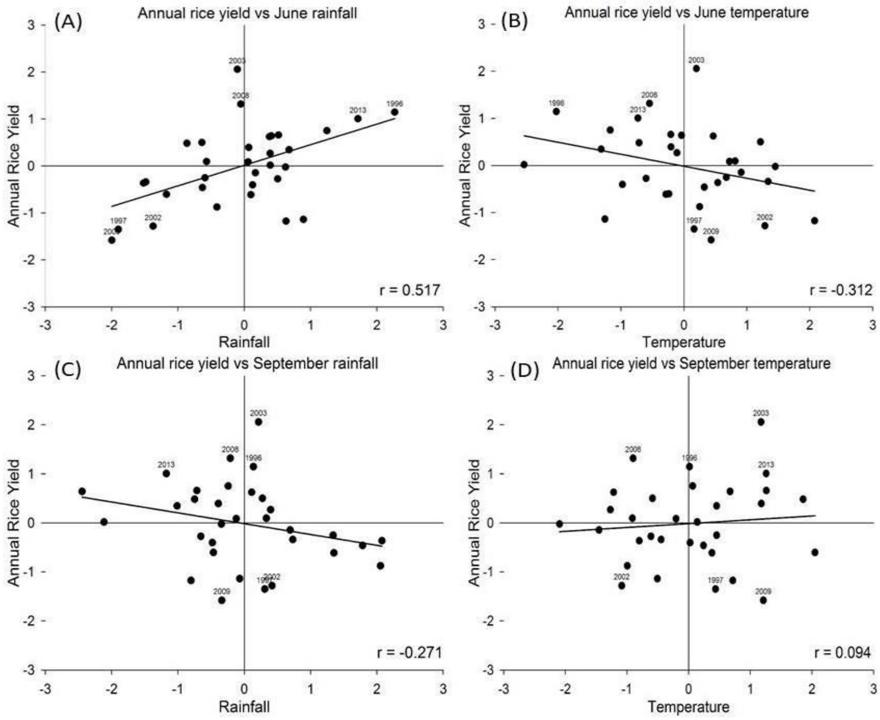

Fig. 4: Relationship of annual rice yield with rainfall (mm) and temperature (°C), (A) June rainfall, (B) June temperature, (C) September rainfall and (D) September temperature.

The influence of climate tends to vary across the each growth stage of rice crop. Temperature (rainfall) has negative (positive) relationship with the rice crop during the plantation stage in Punjab, Pakistan. Rainfall, particularly in June is very essential for rice growth and development during the plantaion stage (Shrestha *et al*., 2017). The availability of sufficient rainfall amount has positive effect on grain size and grain numbers of rice crop during plantation stage (Bhatt *et al*., 2019; Siridevi and Chellamuthu 2015). In adverse, the rainfall in September affects negatively to rice crop during the stage of heading and flowering. In the month of September, rice plant is in the process of anthesis and rainfall pattern could effect the pollen progression (Lawson and Rands 2019), which results in declining of rice yield (Mehmood *et al*., 2012).

In larger context, temperature is significant climatic element for rice crop during all the phenological stages (Hanif *et al*., 2010). At plantation stage, rice plant is very soft and weak, in high temperature particularly mean maximum temperature (Sajjid *et al*., 2017; Siddiqui *et al*., 2012) the rice plant affected and expire resultant low rice yield. The high maximum temperature also reduced the duration of rice crop (Dabi and Khanna 2018) affect the number of tillers and reduced the weight of rice grain (Zhang and Huang 2013).

4. CNCLUSION

In this research, an investigation of the crop-climate relationship is presented over the Punjab province of Pakistan. Climate variability is overall controlling factor (Brown and Funk 2008) for yield variability, and significant temporal variability of climatic factors invariably impacts on year-to-year variations of annual crop yield (Ray *et al*., 2015). Various growth stages of wheat and rice such as germination, tillering, flowering and milking has been observed to investigate the relationship of climate and agriculture.

The results evidently show that climate inducing these two major crops in danger during specific growing stages in Punjab, Pakistan. Temperature of March (milking stage) negatively affects the yield of wheat crop, and rainfall has positive relationship with the yield during the flowering and milking stage. High temperature (rainfall) at milking (harvesting) stage is cause of damage the production of wheat crop, which ultimate leading towards the scenario of food insecurity (Ali *et al*., 2017; Janjua *et al*., 2010). Summer rainfall, particularly rainfall of June has significant positive effect on rice crop during the germination and plantation stage (Ali *et al*., 2017; Ravadekar and Preethi 2012), while high temperature leads to low yield (Preethi and Ravadekar 2013).

This analysis ia a particular argument of the assessment of climate variability and its effect on domestic crop yield with better understanding of crop-climate relationship. The consideration of the relationship between climate and yield may help to monitor crop prediction and to secure food demand (Yu *et al*., 2014) for rapidly growing population of the country near future (Chandia *et al*., 2019). The effect of climate may also have influenced in the length of crop life cycle and various growth phases. To re-measure the length of plant growth stages for wheat and rice crop is required in the future study.

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