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Exploring impact of temperature and rainfall on *Citrus Reticulata Blanco* in tehsil Bhalwal, district Sargodha, Pakistan

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ABSTRACT

The present study investigates the impacts of temperature and rainfall on the production of *Citrus Reticulata Blanco* in Tehsil Bhalwal, District Sargodha. Impacts of temperature and rainfall have been investigated by comparing and contrasting of meteorological parameters with *C Reticulata* production. The monthly averages of these weather phenomena since 2009 to 2015 were used to assess the changes and fluctuations in the weather of an area and the production of *Citrus Reticulata Blanco*. Weather phenomena and *Citrus Reticulata Blanco* production were compared and contrasted in terms of its statistical parameterization. The studied variables were plotted by using interpolation method in ArcGIS to see their spatial trends and patterns across the study area. The analysis revealed that the temperature and rainfall increased from 1986 to 2015. It has been depicted that the rainfall is positively correlated with the production of C Reticulata while temperature is negatively correlated.

Key words: GIS, Interpolation, Monsoon, Rainfall, Temperature, Thunder and dust storms, Western Disturbances.

INTRODUCTION

Climate change is a physical process and no place on the earth is immune from its vulnerable effects (Adams, 1998). The high increase in Green House Gases (GHGs) are noted with the concentration of carbon dioxide (CO_2) 40%, methane (CH_4) 150%, and Nitrous Oxide (N_2O)20% since 1750 (IPCC, 2014). It has been expected that the temperature has been increased in the range of 1.9 to 4.0°C in the end of this century (Agarwal, 2008). The Intergovernmental Panel on climate Change (IPCC) 2007 has projected the rise of 0.5 to 1.2°C in temperature in 2020, 0.88 to 3.16°C in 2050 and 1.56 to 5.44°C in 2080 for the region of Pakistan (South Asia) (Agarwal, 2008). There has also been great variations in the pattern of precipitation in Pakistan. There was a big shift in the rainfall of the upper Indus plain (Faisal and Sadiq, 2011).

The agro-climate of Pakistan, especially the Indus Plain is best suited for fruit production. Citrus is one of the major fruit grown in Pakistan. It is sown between latitude 35°-36° with suitable climate (Mabberley, 2008). The study area, Bhalwal, District Sargodha has continental type, semi-arid climate, with season to season variations (Hayat, 2007; Mukhtar *el al*., 2012). The temperature of the year remained between 5 to 50°C throughout the year (PRRC, 2012) and annual rainfall between 180 to 200 mm (Ahmed *et al*, 2013). The subtropical climate suitable for Kinnow is 10°C to 40°C of temperature, and 100 cm to 150cm of annual rainfall with enough irrigation facilities (Singh, 1989). Approximately, 80 per cent cultivated areas of citrus was under *Citrus Reticulata Blanco* in Sargodha district (Khalil *et al*., 2011) in which Bhalwal (Fig 1) is the major producing centre of *Citrus Reticulata* Blanco (NBP, 2010). The study area (Fig 1) lies between the 31.80°N latitude and 72.80°E longitude. It is situated by River Jehlum. Bhalwal is an agricultural tehsil of district Sargodha with an area of 2115 km^2 and has the population of 3,703,588 (Census, 2017). Bhalwal Tehsil is an agricultural place, famous for the production of "Kinnow" (orange). So, it is also called "California of Pakistan" (GoP, 2000). Its common name is Kinnow and its botanical name is *Citrus Reticulata Blanco* (Naz *et al*., 2014). Kinnow fruit are medium oblate base flattered, and its colour is deep orange yellow and very juicy (Gangwar *et al*., 2005). Its juice content is 44% to 47.5% which is the highest for all easy peelers varieties. The sugar content is 12% – 13% and each 100ml of Kinnow contains 20-25mg of vitamins-C (Memon, 2014). The best harvesting period is mid-January to mid-February, when the fruit attains a TSS/acids ratio of 12:1 to 14:1. The fruit quality reduces in later picking (NBP, 2010). The major processing industries of Kinnow are located at the Bhalwal-Kotmomin road and Sargodha-Bhalwal road. This paper is focused on the impacts of temperature and rainfall on the production of *Citrus Reticulata Blanco*.

MATERIALS AND METHODS

The secondary data were used for analysis. The data of two climatic phenomena (rainfall and temperature) of thirty years (1986-2015) has been received from Pakistan Meteorological Department, Islamabad. Seven surrounding

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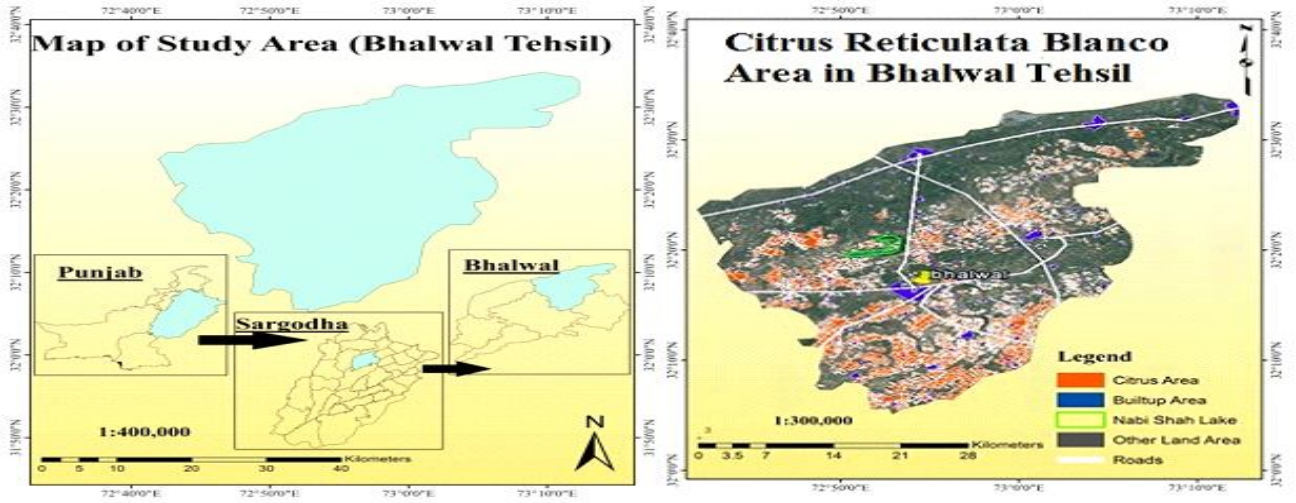

Fig 1: Map of Study Area and Its Area Under *Citrus Reticulata Blanco*.

points (Fig 2) have been selected as sample points to interpolate the climate in the study area. In this current research, the data of thirty years have been divided into three decades (1986-1995, 1996-2005, 2006-2015) for the evaluation of temperature and rainfall trends. The weather data of corresponding years of 2009-15 should be considered for analysis. The data on two citrus phenomena (production and area) were collected from Statistical Department, Sargodha for the period 2009-2015. All districts of Punjab province has been selected as sample points (Fig 2) for the surface generation of *Citrus Reticulata Blanco*. The data of two climatic variables was categorized in different parts. In which rainfall is divided into three categories: monsoon (July, August, and September), rainfall by western disturbances (December, January, February, March) and, rainfall by thunder storms (April, May, June, October, November). The data of temperature was also divided into these three rainfall divisions i.e. temperature of monsoon months, western disturbances months and, the months of thunder and dust storms. Thus, the data of all phenomena was put into ArcGIS to generate the spatial pattern of all of them in the study area. Six years (2009-2015) data of every current research phenomena has been tabulated and were interpolated in ArcGIS year wise to analyse and comprise their spatial trends and effects on each other.

RESULTS AND DISCUSSION

Temperature during monsoon season remained highest in decade-2, and temperature during the season of rainfall by western disturbances and, thunder and dust storms remained highest in decade-3. Monsoon rainfall and rainfall by western disturbances remained highest in first decade,but rainfall by thunder and dust storms remained highest in decade-3.

Decade-1 (1986-1995): The spatial pattern of weather phenomena during decade 1 was depicted in the map (Fig 3). The average rainfall and temperature of this decade were 57.58mm and 24.58°C. During the monsoon season of decade-1, rainfall remained the highest with 120.46 mm than the decade-2 and decade-3, and average temperature of these three months recorded 31.27°C. As we move from east to west, the rainfall increases but the temperature decreases. During the season of rainfall by thunder and dust storms of decade-1, spatial trend of rainfall remained same as monsoon season (increase from east to west) but the temperature has reverse trend. Average recorded rainfall and temperature of this season was 17.44mm and 27.20°C, respectively. The temperature remained low in both eastern and western side and high in central part. The season of rainfall by western disturbances recorded average rainfall of 34.46mm and average temperature of 15.28°C. The trend line of both these phenomena is same as monsoon season.

Decade-2 (1996-2005): The average rainfall of decade-2 has been little decreased than the decade-1. The average rainfall and temperature of this decade were 56.001mm and 24.87°C, respectively (Fig 4). The monsoon season of decade-2 received 114.49 mm rainfall and recorded an average temperature of 31.57°C which is more than the temperature of these months of decade-1. As usual, the spatial trend of rainfall and temperature (Fig 4) remained same

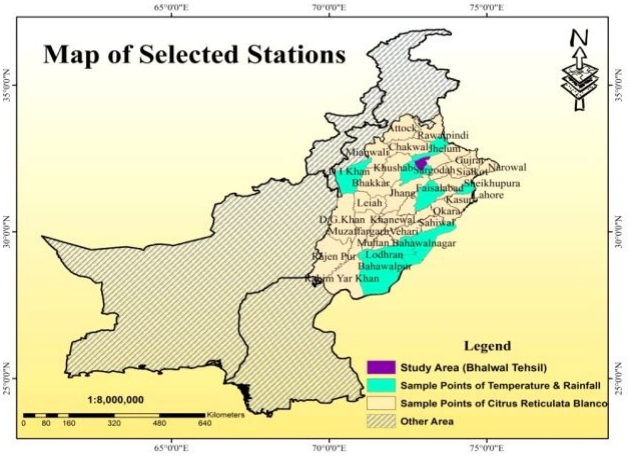

Fig 2: Sample points map.

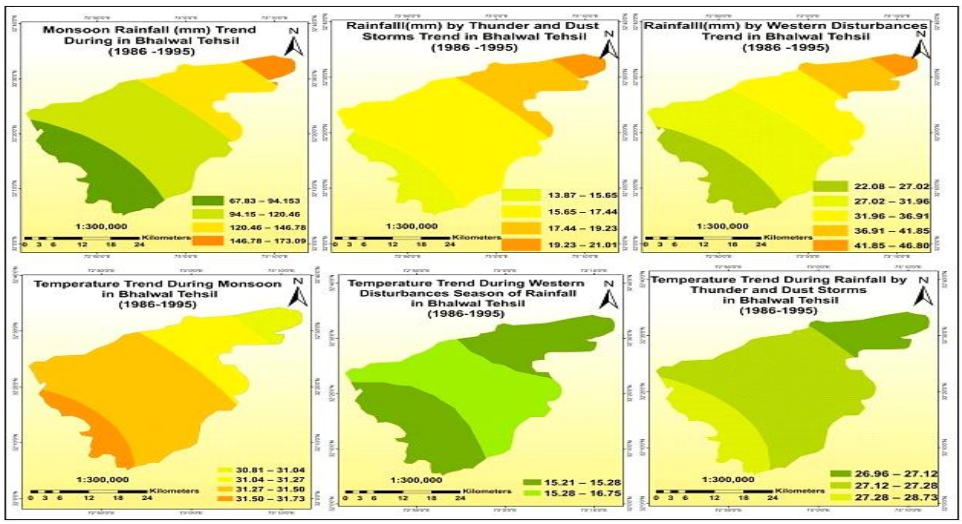

Fig 3: Temperature and rainfall pattern in Bhalwal tehsil during decade-1 (1986-1995).

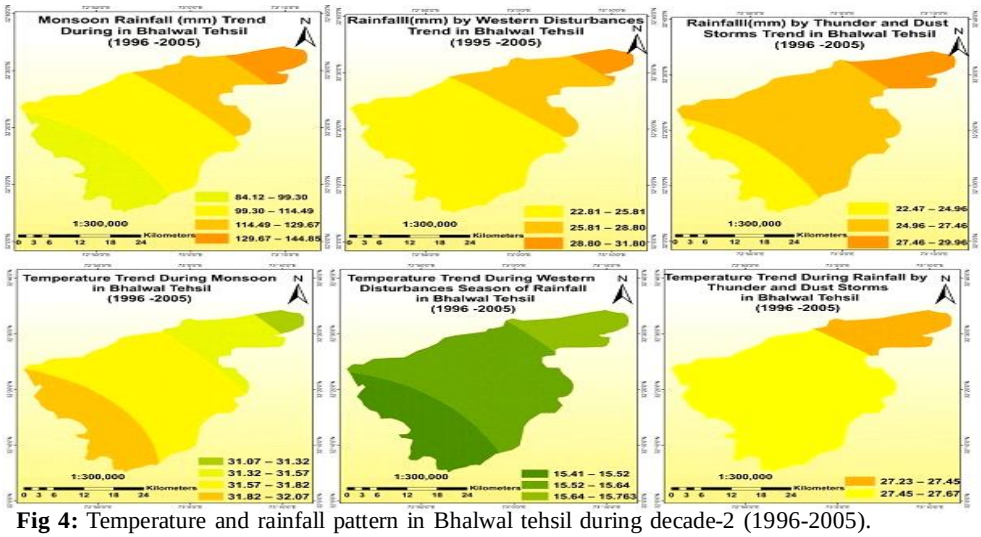

Fig 4: Temperature and rainfall pattern in Bhalwal tehsil during decade-2 (1996-2005).

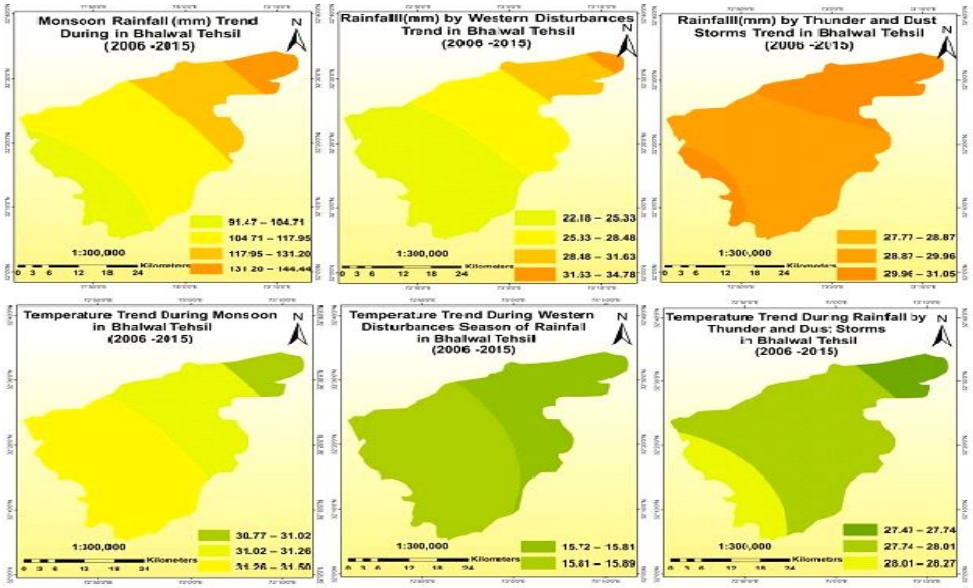

Fig 5: Temperature and rainfall pattern in Bhalwal tehsil during decade-3 (2006-2015).

as in decade-1. During the season of rainfall by western disturbances, the average rainfall recorded was 27.31mm with an average temperature of 15.58°C. The spatial fluctuations of both phenomena remained same as monsoon. The average rainfall of thunder and dust storms was 26.21mm with the temperature of 27.45°C. The spatial fluctuations remained same as monsoon season.

Decade-3 (2006-2015): The maps in (Fig 5) depicted that there was maximum rainfall and temperature during the decade-3. As we move from west to east, the rainfall increased but the temperature decreased in all seasons of decade-3. The average rainfall is recorded 58.61mm with the average temperature of 24.94°C throughout this decade. There was 117.95mm rainfall in monsoon season and the temperature was 31.14°C. During the season of rainfall by western disturbances, the average rainfall was 28.48mm and the temperature remained 15.81°C during decade-3. The thunder and dust storms season of rainfall also reveals the similar pattern of temperature but the trend of rainfall is different. The average amount of rainfall recorded 29.42mm and the temperature was 27.88°C in the study area. The spatial trend of rainfall showed high in western and eastern side and low in the central area but the temperature raised as go from east to west.

Comparisonal studies of temperature, rainfall, *Citrus Reticulata Blanco* production and area (2009-2015) : The average temperature and rainfall recorded in Bhalwal Tehsil and the corresponding yield was recorded during 2009 to 2015.

During 2009-2010(Fig 6), the production of 669,223 tons is gained from 148,309 acres area under the 24.64°C temperature and 41.95mm rainfall in the north eastern side. The 950,994 tons production is gained from 195,767 acres area under the 24.88°C temperature and 37.19mm rainfall in the western and south western side.

During 2010-2011(Fig 7), the 549,597 tons production has been gained from 148,162 acres area under the 24.55°C temperature and 55.27mm rainfall in the north eastern side. The 781,000 tons production is gained from 195573 acres area under the 24.68°C temperature and 53.90mm rainfall in the western side.

During 2011-2012(Fig 8), the 678,246 tons production is gained from 150,368 acres area under the 24.36°C temperature and 49.46mm rainfall in the north eastern side. The 936,620 tons production is gained from 198.485 acres area under the 24.61°C temperature and 45.29mm rainfall in the central and western side.

During 2012-2013(Fig 9), the 599,490 tons production has been gained from 153,375 acres area under the 24.46°C temperature and 46.61mm rainfall in the north eastern side. The 827,862 tons production is gained from 202,414 acres area under the 24.77°C temperature and 35.71mm rainfall in the central and western side.

During 2013-2014 (Fig 10), the 677,993 tons production is gained from 155,127 acres area under the 24.49°C temperature and 53.63mm rainfall in the north

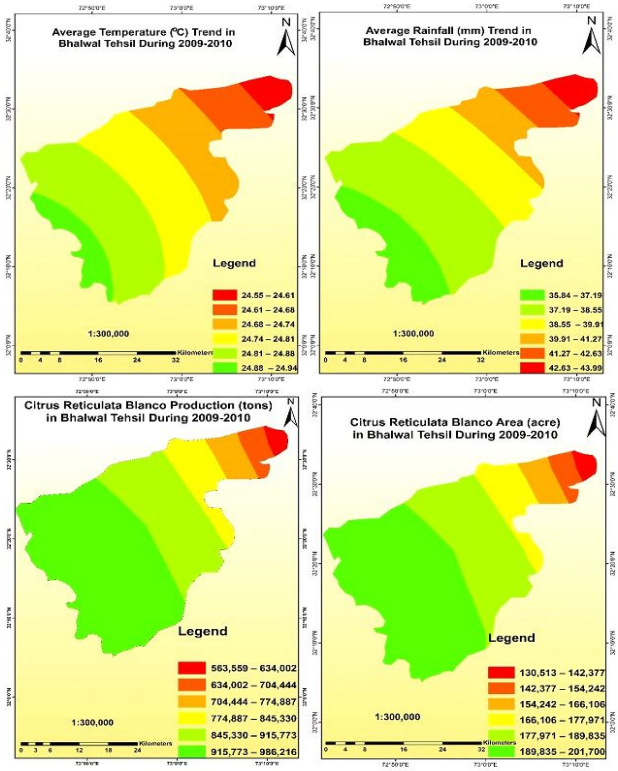

Fig 6: Spatial Pattern of climatic and citrus phenomena in Bhalwal Tehsil during 2009-2010.

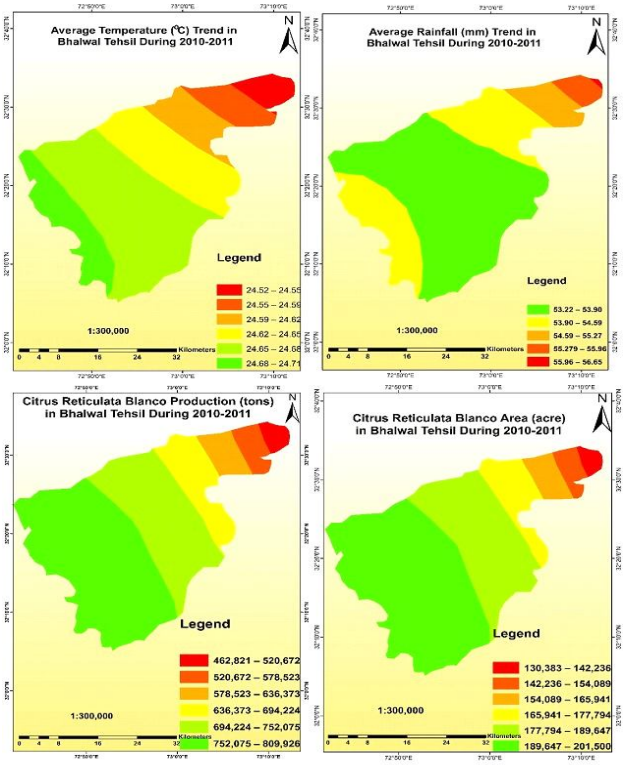

Fig 7: Spatial Pattern of climatic and citrus phenomena in Bhalwal Tehsil during 2010-2011.

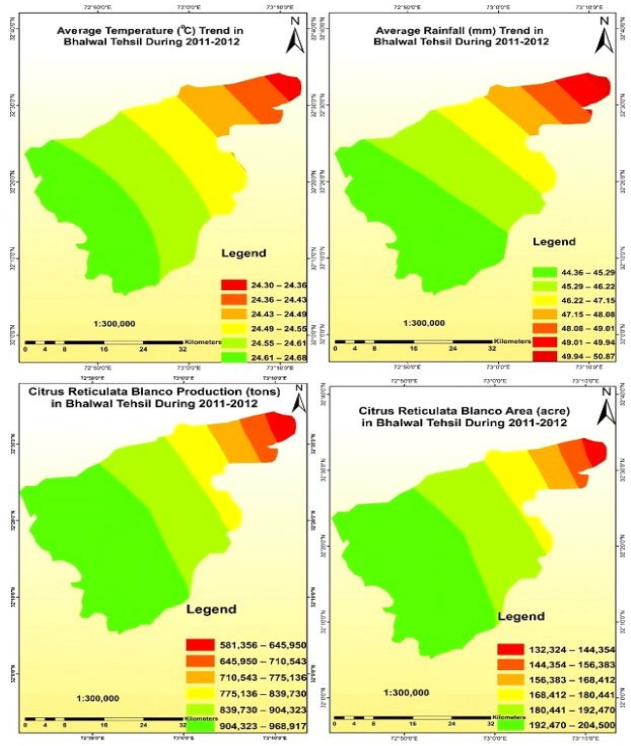

Fig 8: Spatial Pattern of climatic and citrus phenomena in Bhalwal Tehsil during 2011-2012.

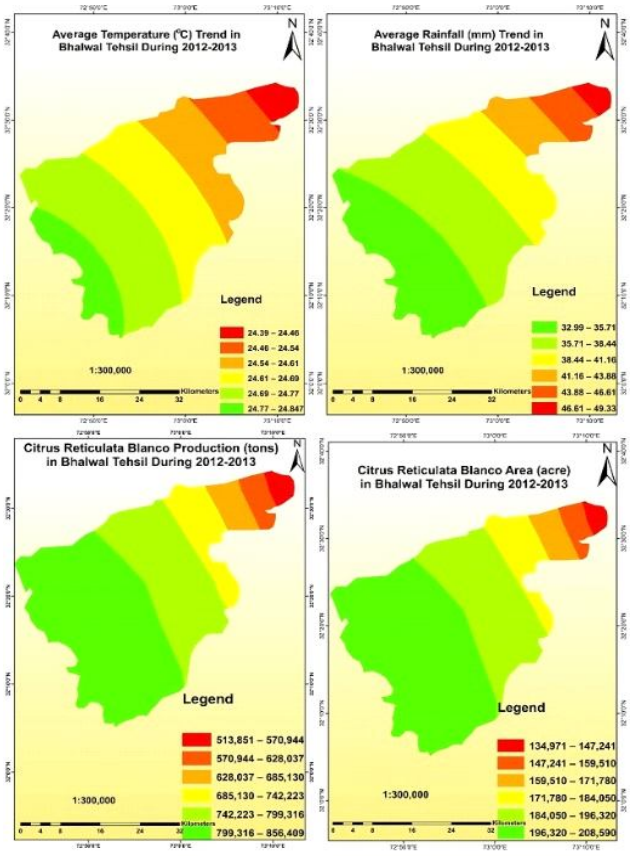

Fig 9: Spatial Pattern of climatic and citrus phenomena in Bhalwal Tehsil during 2012-2013.

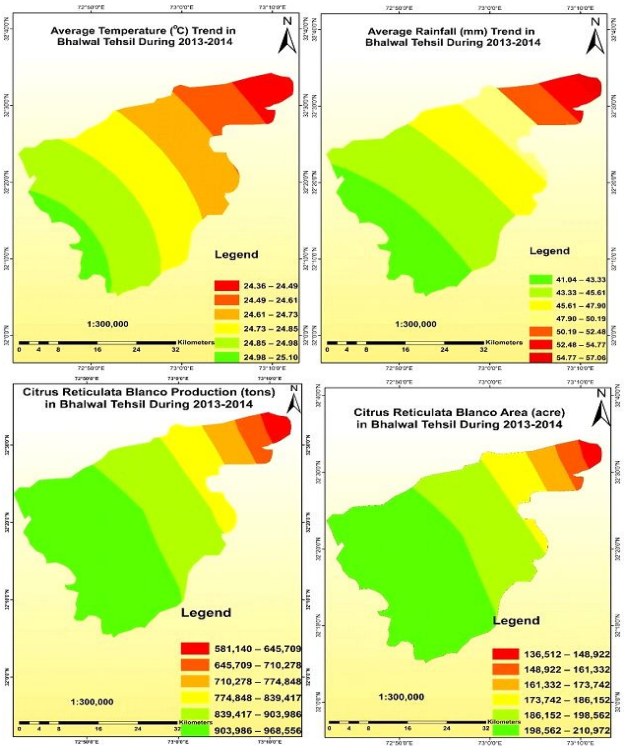

Fig 10: Spatial Pattern of climatic and citrus phenomena in Bhalwal Tehsil during 2013-2014.

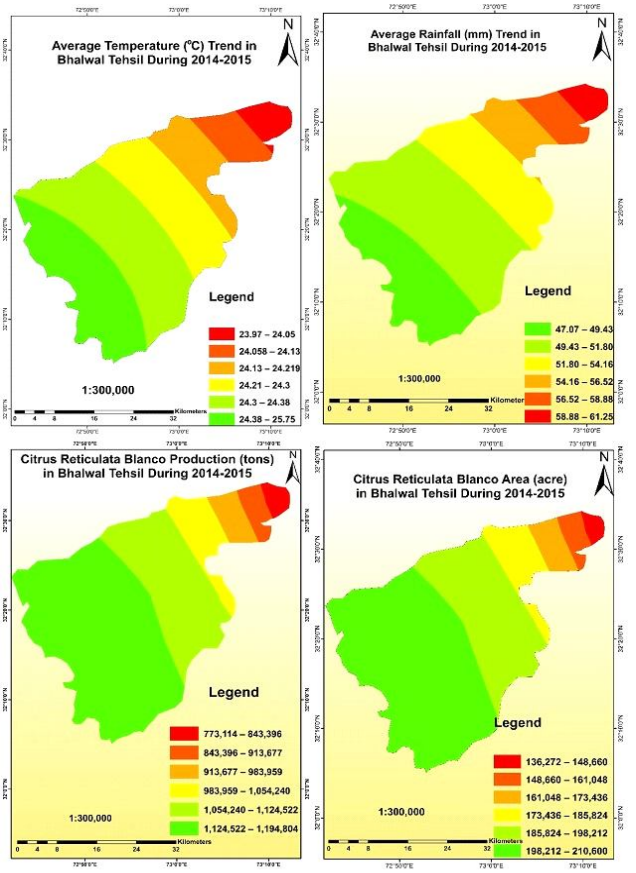

Fig 11: Spatial Pattern of climatic and citrus phenomena in Bhalwal Tehsil during 2014-2015.

Table 1: Average temperature and rainfall with total production and area.

Year	Temperature	Rainfall	Production	Area	Per Acre yield
2009-10	24.74	39.91	774887	166106	4.67
2010-11	24.62	54.93	636373	165941	3.83
2011-12	24.49	47.15	775136	168412	4.6
2012-13	24.61	41.16	685130	171780	3.99
2013-14	24.73	47.90	774848	173742	4.46
2014-15	24.21	54.16	983959	173436	5.67

eastern. The 936,271 tons production is gained from 204,767 acres area under 24.98°C temperature and 43.33mm rainfall in the western side.

During 2014-2015 (Fig 11), the 878,536 tons production has been gained from 154,854 acres area under the 24.05°C temperature and 58.88mm rainfall in the north eastern side of the study area. The 1,159,663 tons production is gained from 204,406 acres under the 24.38°C temperature and 49.43mm rainfall in the western side.

Yield of citrus Reticulata Blanco in Bhalwal Tehsil during 2009-2015: The formula is conducted for the evaluation of yield of Citrus Reticulata Blanco.

$$\textbf{Yield Per Acre} = \frac{\textbf{Total Production of } \textit{Citrus Reticulata Blanco}}{\textbf{Total Area under } \textit{Citrus Reticulata Blanco}}$$

It was indicated that the yield of *Citrus Reticulata Blanco* remained the highest in 2014-2015 and lowest in 2010-2011). The yield of other years remained between these both years.

Correlation of Citrus Reticulata blanco production with temperature and rainfall

The value of R is -0.4419. Although technically a negative correlation, the relationship between your variables is only weak (Table 1) and (Table 2).

The value of R2, the coefficient of determination, is 0.1953

In the present study, the production of *Citrus Reticulata Blanco* has spatial changes due to the change in weather patterns especially temperature and rainfall.

Statistically, the average annual temperature of these thirty years (1986-2015) remained 24.79°C. Fluently, an increase was found during three decades. The temperature of decade-2 increased by 0.29°C than decade-1 and of decade 3 by 0.07°C than decade-2. The temperature of 31.33°C was recorded in monsoon season of these three decades. The monsoon season starts from July and end in September (Khan, 2006). The temperature has been increased by 0.3°C in decade-2 from decade-1 while reduced 0.43OC in decade-3 from decade-2. In the season of rainfall by western disturbances, fluently little increase was recorded during thirty years. The rainfall by western disturbances is from December to March (Khan, 2006). Average temperature of thirty years in this season was 15.56°C. The enhancement of 0.3°C was analysed in decade-2 than decade-1 and 0.23°C in decade-3 than decade-2. During the season of rainfall by thunder and dust storms, the average 27.51°C temperature was found, in which flow with little increase was seen. Rainfall by thunder and dust storms has two periods in a year that are October to November and April to December (Khan, 2006). In decade-2, 0.25°C rise was analysed than decade-1 and 0.43°C in decade-3 than decade-2.

Table 2: Correlation between temperature, rainfall, production and area.

Temperature and Rainfall =	-0.5608
Temperature and Production =	-0.731
Rainfall and Production =	0.73990
Rainfall and Area=	.7989
Temperature and Area =	-0.3730

In the spatial distribution of temperature, isopleths shows low temperature in eastern side and high in western side during three decades (1986-2015) but fluctuations has been found during the thirty years.

Statistically, the average annual rainfall of these thirty years (1986-2015) was remained 57.40mm. In decade-2, rainfall was decrease 1.40mm than decade-1 and 2.61mm enhancement found in decade-3 than decade-2. In monsoon season of these three decades, fluctuations has been analysed in rainfall. Monsoon rainfall enters in Pakistan from eastern side (Khan, 2006). Average rainfall of this season was 117.63mm. These studies in-lines with the studies of Khan (2006) that described less than 250mm rainfall in study area. The decade-1 received peak amount of monsoon. This study in-lines with the studies of Mobeen *et al*. (2017). There was reduction of 5.97mm in rainfall during deacde-2 than decade-1 but the enhancement of 3.46mm was recorded in decade-3 than decade-2. During the season of rainfall by western disturbances, fluctuations was recorded during thirty years. Rainfall by western disturbances or depressions comes from the western side of Pakistan. The study area annually receives 125-250mm rainfall in this season (Khan, 2006). Average rainfall of thirty years in this season was 30.08mm. There was decreased of 7.15mm rainfall during decade-2 than decade-1 and little increase of 1.17mm was found in decade-3 than decade-2. During the season of rainfall by thunder and dust storms, average 24.36mm rainfall was recorded. Rainfall in October and November is remained less than 25mm annually. There, the rainfall is recorded less than 50 mm in the months of April, May and June (Khan, 2006). There was increase of 8.77mm rainfall found in decade-2 than decade-1 and 0.46mm in decade-3 than decade-2.

In the spatial distribution of rainfall in Bhalwal Tehsil, isohyets showed low rainfall in south western side and high in north eastern side in all months on an average. The maximum rainfall was received in the north eastern portion of Bhalwal Tehsil (Hanif *et al*. 2013; Mobeen *et al*, 2017). Many fluctuations are also perceived in three seasons of rainfall during 1986 to 2015.

The statistical and spatial distribution of *Citrus Reticulata Blanco* production and area also shows fluctuations (2009-2015). Statistically, the highest average production was recorded in 2014-2015 and the lowest in 2010-2011. So, the average increase of 85,847 tons in production, 6167 acres in area and 0.4 tons in per acre yield were depicted. The temperature conditions have important effects on citrus growth and production (Reuther, 1973). The high temperature of spring season (March to June) effects the citrus orchards, unfavourably (Jones and Cree, 1965). Spatially, the production and area remained highest in western side and lowest in eastern side with the same trend of temperature but rainfall remained low in western side and high in eastern side of the study area.

CONCLUSION

The study estimated variability in rainfall and temperature for three decades (1986-2015) in the study area. It was found that the rainfall and temperature showed a significance increase in their monthly averages since 1986 to 2015. This rising trend in both variable was compared and contrasted with the production of *Citrus Reticulata Blanco* in the study area. The geo-statistical analysis revealed that the production of *Citrus Reticulata Blanco* also increased in the region. The rainfall of the study area was found higher in the east which reduced its amount in the west. The same east to west declining trend become more pronounced since 1986. The temperature showed the reversed geo-statistical trend as compared to rainfall. The area under cultivation and production of *Citrus Reticulata Blanco* also increased as we move from north-east to south-west. The average temperature of studied years has been decreased but the rainfall and production increased. In this way, production is positively correlated with the rainfall while negatively correlated with temperature.

REFERENCES

Adams, R. M., Hurd, B. H., Lenhart, S., and Leary, N. (1998). Effects of global climate change on agriculture: an interpretative review. *Climate Research*, **11**(1)**:** 19-30.

Aggarwal, P. K. (2008). Global climate change and Indian agriculture: impacts, adaptation and mitigation. *Indian Journal of Agricultural Sciences*, **78**(11)**:** 911.

Ahmad, K., Khan, Z. I., Rizwan, Y., Sher, M., Mukhtar, M. K., Nawaz, R., Mirzaei, F. (2013). Nickel, lead and manganese content of forages irrigated with different sewage water treatments: A case study of a semiarid region (Sargodha) in Pakistan. van der Linden, P. J., and Hanson, C. E. (2007). *Climate change 2007: impacts, adaptation and vulnerability* (Vol. 4). M. Parry, O. Canziani, and J. Palutikof (Eds.). Cambridge: Cambridge University Press.

Faisal, N., and Sadiq, N. (2009). Climatic zonation of Pakistan through precipitation-effectiveness index. *Pakistan journal of Meteorology*, **6**(11).

Gangwar, L. S., Ilyas, S. M., Singh, D., and Kumar, S. (2005). An economic evaluation of kinnow mandarin cultivation in Punjab. *Agricultural Economics Research Review*, ***18***(1)**:** 71-80.

Government of Pakistan, (2000).District Census Report of Sargodha 1998. Islamabad:Population Census Organization, Statistics Division. pp. 1-10.

Hanif, M., Khan, A. H., and Adnan, S. (2013). Latitudinal precipitation characteristics and trends in Pakistan. *Journal of hydrology*, **492:** 266-272.

Hayat, A. (2007). Irrigation sector development in Punjab (Pakistan): Case study of district Sargodha.

Intergovernmental Panel on Climate Change. (2014). *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*. Cambridge University Press.

Jones, W. W., & Cree, C. B. (1965, January). Environmental factors related to fruiting of Washington Navel oranges over a 38-year period. In *Proceedings of the American Society Horticultural Science, Alexandria* (Vol. 86, pp. 267-271).

Khalil, S. A., Sattar, A., & Zamir, R. (2011). Development of sparse-seeded mutant kinnow (Citrus reticulata Blanco) through budwood irradiation. *African Journal of Biotechnology*, **10**(65)**:** 14562.

Khan, F.K., (2006). Pakistan Geography, Economy and people. Karachi, Pakistan: Oxford University Press, 34-40.

Mabberley, D. J. (2008). *Mabberley's plant-book: a portable dictionary of plants, their classifications and uses* (No. Ed. 3). Cambridge University Press.

Memon, A.N. (2014). Market potential for Pakistani Citrus fruit (Kinnow) in world.Exclusive on kinnow.

Mobeen, M., Ahmed, H., Ullah, F., Riaz, M. O., Mustafa, I., Khan, M. R., & Hanif, M. U. (2017). Impact of climate change on the precipitation pattern of district Sargodha, Pakistan. *International Journal of Climate Change Strategies and Management*, **9**(1)**:** 21-35.

Mukhtar, M. K., Khan, S. Y., Jabeen, S., Tahir, H. M., Qadir, A., Ahmad, K. Rarshad, M. (2012). A preliminary checklist of the spider fauna of Sargodha (Punjab),Pakistan. *Pakistan J. Zool*, **44**(5)**:** 1245-1254.

Naz, S., Shahzadi, K., Rashid, S., Saleem, F., Zafarullah, A., & Ahmad, S. (2014). Molecular characterization and phylogenetic relationship of different citrus varieties of Pakistan. *J. Ani. Plant.Sci*, *24*, 315-320.

NBP.(2010). Kinnow Processing Plant. R & D and Training Wing Agriculture Business Division, Lahore: NBP.

PARC (2012). Pakistan Agricultural Research Council, Agro-ecological zones of Punjab.

Reuther, W. (1973). Climate and citrus behavior. *The Citrus Industry*, ***3*****:** 280-337.

Singh, A. (1989). Review article digital change detection techniques using remotely-sensed data. *International Journal of Remote Sensing*, **10**(6)**:** 989-1003.