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Maize and Wheat Suitability Analysis for District Dir Upper by Using Crop Growth Index

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Abstract: This study was conducted at District Dir Upper of Khyber Pakhtunkhwa to find out growing degree days of wheat and maize and their crop growth index by using long term climatic data (1971-2010). The climatic data used for research was acquired from Pakistan Meteorological Department (PMD), Islamabad. The available growing degree days of wheat and maize were classified by subtracting the base temperature from average temperatures. Decade-wise and overall trend of Growing Degree Days were calculated by using simple linear regression analysis. Based on 40 years data an increasing trend was observed for the GDD of wheat and maize at Dir Upper. Based on the crop growth index (I_{cg}) limits District Dir Upper was classified as Moderately Adequate.

Key words: Maize · Wheat · Growing Degree Days · Crop Growth Index · Dir Upper

INTRODUCTION

Pakistan is an agricultural country. The climate of Pakistan is different from region to region in which two-third of the area show arid type of climate. Just a thin belt of sub-hilly regions have humid climate. The greater part of the central and southern areas of Pakistan is greatly arid, whereas the northern part of the country is humid but the severe northern mountains are comparatively dry. The agriculture of Pakistan not only depends on rainfall but also depends on water, which flows from melting of snow and ice. This water is used for irrigation of agricultural lands when it reaches rivers, dams and canals. On the western side of Pakistan, Arabian Sea is located while in northern side there are Himalaya and Karakoram mountains. These mountains are covered with snow and they act like water tanks over the top, which provide water when needed. The low temperatures in the mountainous areas have negative impact on agriculture, which decreases the growing stage for the winter period crops. In the mountainous areas, the winter crops like wheat cannot reach to maturity, the crop is harvested before the time and used as fodder for animals [1].

Pakistan can be divided on the basis of climate into different zones such as arid, semi-arid, sub-humid and humid, in other words from a drier to wetter. The naming of climatic characteristics of a region helps in assessment of agro-climatic potential, the plant and animal variety, which are situated in that area and selection of crop-varieties, which are able to produce more yields. Agro-climatic classification enables us to draw boundaries on the basis of homogeneity.

The impacts of climate change are more critical in South Asia and may result in 50% reduction in wheat yield. Due to climate change, the rainfall decreases and temperature increases. In the World Bank's list, Pakistan is included in 12 extremely exposed countries to climate change. In Pakistan, due to climate change temperature will rise and the severe rains can reduce the production. In the northern region of Pakistan, the rains will increase and the recent floods are due to extreme and uneven rains.

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In Asia the variation in rainfall has increased annually in a few past decades. The declining trends in rainfall patterns along Pakistan's coastal areas and arid plains have been observed [2]. According to Pakistan Meteorological Department, main parts of Pakistan experience dry climate and receive less than 250 mm of rainfall [3].

The Pakistan is a populated country its economy is based on Agriculture and it is highly exposed to natural disaster. Therefore, it is important to find out the trends of rainfall in different climate zones of Pakistan over the last four decades. The Pakistan Meteorological Department reported that in the year 2012 has been a slow but steady change occurred in the position where more rainfalls occurred. In the past, decade's monsoon rains fell intensively over the Punjab, but slowly and gradually the concentration of rainfall has moved to north and west of Khyber Pakhtunkhwa [3].

In Pakistan the climate change is a big challenge for the agrarian economy. Climate changes have disturbed the agriculture production. Arid areas are more at risk to climate change due to increase in temperature and decreased in rainfall production in arid area significantly reduced. The present study was carried out to analyze the agro-climatic condition in the District Dir Upper of Khyber Pakhtunkhwa.

MATERIALS AND METHODS

In Khyber Pakhtunkhwa, there exist all types of climates, which are different from place to place, the northern region has humid while the southern region have dry climate. Due to this changeable climatic condition, it is divided into different agro climatic zones.

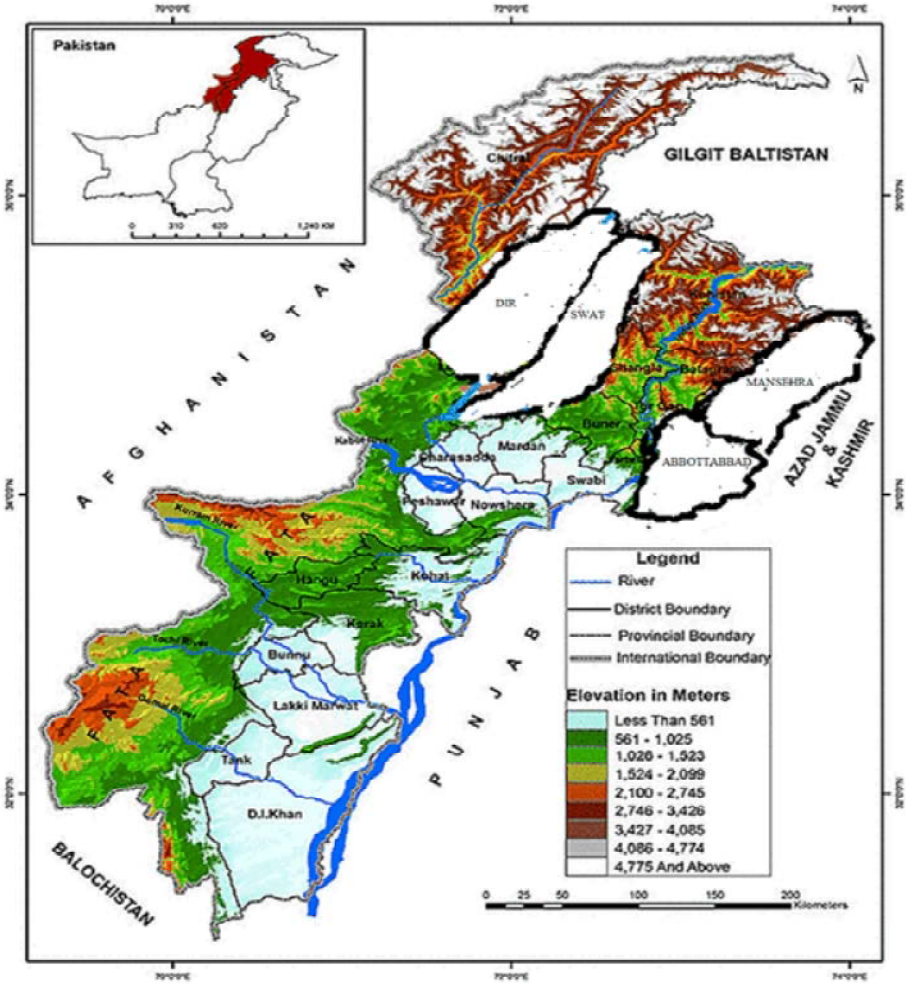

Fig. 1: Map of Khyber Pakhtunkhwa showing selected stations (http://maps.onepakistan.com.pk/khyber-pakhtunkhwa.php)

Table 1: Description of Dir Upper and Crop data

				Wheat			Maize		
Location	Altitude (m)	Latitude (°N)	Longitude (°E)	Planting date	Harvesting date	Growth Period (day)	Planting date	Harvesting date	Growth Period (day)
Upper Dir	1399	35.16	72.04	10 Nov	13 May	185	25-Jun	1-Oct	125

Table 2: Classes of Crop growth Index.

Classes	I_a limits
Deficit	,<0.5
Moderately adequate,	,0.5-1.0
Adequate,	,1.05-1.5
Excess,	,>1.5

Description of the Study Area: Khyber Pakhtunkhwa has a wide range of physical and climatic environment. The present study was carried out at District Dir Upper (Fig. 1).

Dir Upper is situated in northern region of Khyber Pakhtunkhwa, and it has a moist subtropical climate. The average temperature is 18°C, whereas the expected rainfall is 850 mm per year. The main river of Dir Upper is Panchokora. The flows of water in the river are due to the snow fall on the mountain of Kohistan, Brawal, Osheri, Lawari and Wari. The climate is dangerous in the month of July and August due to thunders and land sliding.

Crop Suitability Analysis: For the crop suitability analysis the crop growth index was calculated for both wheat and maize crop. The crop growth index is defined as the ratio between available growing degree days and that of the required. The crop growth index (I_{cg}) is given below

$$I_{cg} = \frac{\text{GDD available}}{\text{GDD required}} \quad (1)$$

The required Growing Degree Days for wheat crop was 1800 while for maize crop was 2700 [4]. According to the classes which were determined by [5] used for the preparation of maps (Table 2)

Growing Degree Days (GDD): GDD is defined, as the amount of heat increase used to predict plant development rates in an area with supposition that plant growth is widely influenced by ambient temperature in the absence of extreme conditions such as drought or disease. GDD can be calculated as:

$$GDD = \frac{T\max + T\min}{2} - Tbase \quad (2)$$

where:

T_{max} = Daily highest temperature

T_{min} = Daily lowest temperature

T_{base} =Temperature below which the crop growth stops.

T_{upper} = Upper temperature

If T min < T base, then T min = T base

If T max > T upper, Then T max =T upper

The base temperature calculated for wheat crop was 0 °C while the base temperature for maize crop was measured 8 °C. For wheat crop the upper temperature was 26°C while it was 30°C for the maize crop [6] decade-wise and long term trend analysis in GDD was calculated by using simple linear regression equation. Considered correlation coefficients (r) were compared with table values at 5% probability to verify its statistical significance [7].

RESULTS AND DISCUSSION

This study was carried out at District Dir Upper of Khyber Pakhtunkhwa to determine the maize and wheat suitability by using crop growth index

Analysis of Growing Degree Days (GDD) of Wheat and Maize

GDD of Wheat in Dir Upper: Table 3 and Fig. 2 describe the variation in GDD of wheat at Dir Upper. There was a decreasing trend during the 1st decade (1971-1980). The maximum GDD (2208) was observed in the year 1971 and minimum (1691) in 1980. Similarly, the declining trend was observed during the second decade (1981-1990). The maximum value of (2028) was observed in the year 1981 and minimum (1682) in 1984. However, the 3rd decade (1991-2000) showed an increasing trend. The maximum value (2038) was noted in the year 1999 and minimum (1744) in 1991. The last decade (2001-2010) showed an increasing trend the maximum value (2198) was observed in the year 2010, while the minimum (1701) in 2005. Based on 40 years data (1971-2010), an increasing trend was observed in GDD. The overall increase in GDD was statistically insignificant. The increase of GDD could be due to the increase in average temperature during the growing season of wheat crop. The main reason of

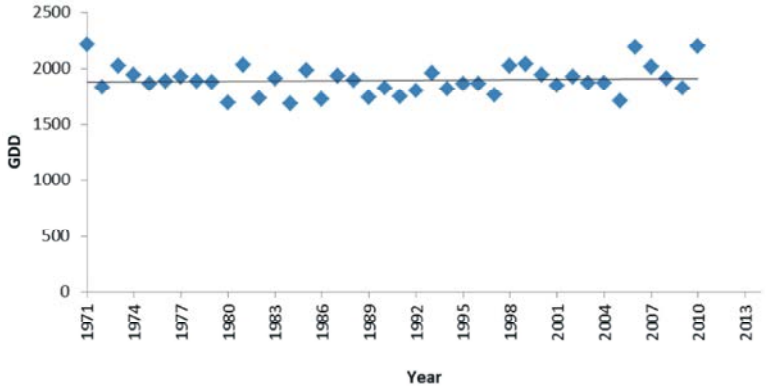

Fig. 2: Long-term (1971-2010) variation in GDD of Wheat in Dir Upper

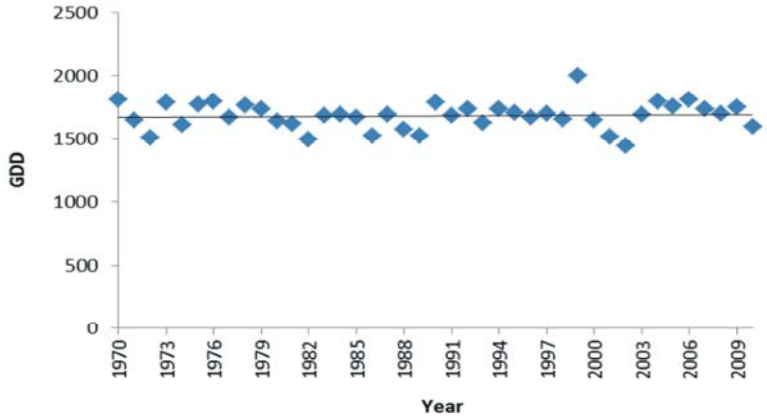

Fig. 3: Long-term (1971-2010) variation in GDD of Maize in Dir Upper

Table 3.GDD of Wheat in Dir Upper

Decade	Min.	Max.	Avg.	Slope	R^2	R	Significance
1971-1980	1691	2208	2924	-25.10	0.42	0.48	ns
1981-1990	1682	2028	1846	-8.33	0.04	0.02	ns
1991-2000	1744	2038	1880	21.83	0.39	0.62	ns
2001-2010	1701	2198	1937	21.40	0.16	0.04	ns
Overall (1971-2010)	1682	2208	1897	0.64	0.003	0.05	ns

Table 4. GDD of Maize in Dir Upper

Decade	Min.	Max.	Avg.	Slope	R^2	R	Significance
1971-1980	1509	1810	1699	2.41	0.007	0.08	Ns
1981-1990	1493	1789	1629	6.45	0.04	0.20	Ns
1991-2000	1624	2002	1733	9.24	0.06	0.24	Ns
2001-2010	1444	1809	1671	16.78	0.17	0.45	Ns
Overall (1971-2010)	1444	2002	1685	0.54	0.00	0.00	Ns

*significant at 0.05 probability level; ns: non-significant

increases of temperature in the past 40 year was due to increase of greenhouse gases such as carbon dioxide, sulfur dioxide and nitrogen dioxide. Due to the increase in temperature, the growth and yield of the wheat crop was decreased. The increase of temperature is the cause of global warming, which was earlier apparent in various parts of the world and also in our country [8].

GDD of Maize in Dir Upper: Table 4 and Fig. 3 present the variation in GDD of maize at Dir Upper. The first decade (1971 -1980) showed an increasing trend. The maximum value (1810) was found in the year 1971 and minimum (1509) in 1972. Similarly, the second decade (1981-1990) also showed an increasing trend. The maximum value (1789) was measured in the year 1990

Table 5: Crop Growth Index (I_{cg}) of wheat and Maize at Dir Upper

Location	Min.	Max.	Avg.	I_{cg} Class
Dir Upper	0.93	1.22	1.05	Adequate
	0.53	0.74	0.62	Moderately Adequate

and lowest (1493) in 1982. There was an increasing trend during the third decade the maximum value (2002) was found in the year 1999 while, the minimum (1624) in 1993. There was an increasing trend during the last decade (2001-2010). The maximum value (1809) was observed in the year 2006 and minimum (1444) in 2002. Based on 40 years data (1971-2010), an increasing trend was observed in GDD. The overall increase in GDD was statistically insignificant. The temperature was increased due to the deforestation and the increase of green-house gases in the atmosphere. The available GDD was less than the required GDD, which is 2700 for maize crop. The increase of temperature is the cause of global warming, which was earlier apparent in various parts of the world and also in Pakistan [8]

Crop Suitability Analysis

Crop Growth Index (I_{cg}) of Wheat: Table 5 presents the (I_{cg}) classes of the selected location. Maximum I_{cg} (1.05) and minimum (0.93) of wheat was calculated for Dir Upper. The lowest CGI was due to the low temperature in the month of January and February. Based on the CGI limits, Dir Upper were classified as adequate. These results are in agreement with [5] who also found that the available GDD in the selected location were adequate. The climate of this location was good for the growth of wheat.

Crop Growth Index (I_{cg}) of Maize: Table 5 presents the classes of the selected location. The maximum I_{cg} (0.62) while minimum (0.53) of maize was calculated for Upper Dir. On the basis of I_{cg} limits District Dir Upper were classified as Moderately Adequate. These results are in conformity with [5] who also determined that the available GDD at Dir Upper were moderately adequate. The temperature was high in the month of June and July. The climate of the selected place was suitable for the growth of maize.

CONCLUSION

- The Growing degree days of wheat and maize crops showed an increasing trend in District Dir Upper.
- Based on the I_{cg} limits District Dir Upper were classified as adequate, for wheat and moderately adequate for maize crop.

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