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Research Article

Impact of Climatic Factors on Wheat Yield in Quetta District

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ABSTRACT

Balochistan is the largest province of Pakistan, rich in mineral resources, livestock, fertile lands and famous for agricultural produce including apple and grapes and wheat. Quetta district is one of the largest districts of Balochistan in terms of population and economic activities. The district agriculture produce has been largely affected by changes in climate and environmental degradation mainly due to increased population and economic activities. The present study aims to analyze the impact of changing climatic parameters i.e. temperature and rainfall on wheat production during three years of Rabi season (2017 – 2020) through descriptive analysis. The results showed less wheat production on cultivable land in the Quetta district due to the changes in rainfall patterns and overall high range of minimum temperature compared to the maximum temperature. The study implies that climatic factors including temperature and rainfall can check the wheat production even if the wheat is cultivated in large areas.

Keywords: Wheat production, Climate change, Rainfall, Temperature, Population.

INTRODUCTION

Wheat production involves the cultivation and harvesting of wheat crop for human consumption and livestock feed (It et al., 2017). Agriculture is the backbone of Pakistan's economy as it contributes 22%-24% to the national GDP (Gross domestic product) and employs 44% of the country's total labor force (Chandio et al., 2016; Naeem et al., 2017). Overall, this sector directly involves 75% of the population and contributes 30% of the country's exports (Chandio et al., 2016; Naeem et al., 2017). Pakistan is among the top wheat-producing countries but far behind China and India (Khan et al., 2002). The country's major wheat demand (80%) is fulfilled by the Punjab province followed by Sindh, KP, and Balochistan. Balochistan contributes about 3-4% of the total wheat production of the country. Balochistan is the largest province of Pakistan with a total area of approximately 347,190 square kilometers (Siddiqui and Siddiqui, 2009). It has a sparse population with diverse climatic conditions, ranging from hyper-arid to semi-arid weather (Khan et al., 2021). Wheat is the major staple crop in Balochistan and therefore increase in its cultivation contributed significantly to the overall wheat output in Balochistan (Bajkani et al., 2014; Baloch et al., 2014; Zulfiqar and Thapa, 2017). In Balochistan, the upper plain is wheat production-oriented (Loralai, Killa Saifullah), and the lower plain is Nasirabad and Jaffarabad (Bajkani et al., 2014). Wheat crop productivity is annually different and is cultivated in the Rabi season planting time (Rana et al., 2021). Planting in late October or early November is essential to gain more productive output (Gadiwala et al., 2014). These varieties include Sassui, TD-1, and Raskoh-2005. They are grown in Balochistan (Baloch et al., 2014). Naseerabad, Jaffarabad, Dera Murad Jamali, Usta Mohammed, and parts of central Balochistan are agricultural areas (Baloch et al., 2014).

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Nasirabad and Jaffarabad are the most fertile districts, yielding high agricultural output (Gadiwala et al., 2014). In general, wheat production depends on factors like timely sowing, seed, age, fertilizer application (DAP, Urea), temperature, and irrigation highly impact wheat yield (Iqbal et al., 2014; Jakperik and Oduro, 2013). Pest control measures and proper fertilization practices are essential for maintaining crop health (Zhang et al., 2022).

Water scarcity is the biggest challenge in the agriculture sector in Balochistan as there is no perennial system (irrigation system guarantees continuous and constant water supply to the crops throughout the crop period as per the requirement of the crop) of irrigation and the area depends on rain, Karezat and tube-wells for irrigation (Rana et al., 2021). The province relies on annual rainfall for wheat cultivation, with most cropping lands under spate irrigation systems (Rasool et al., 2021). According to statistics, wheat cultivated area in Baluchistan increased from 262 thousand hectares during 1981-85 to 384 thousand hectares in 2011-15 (Abid et al., 2018). With the increase in wheat cultivated area, wheat production also increased from 407 thousand tones during 1981-85 to 840 thousand tones in 2011-15 (Abid et al., 2018). Safi et al. (2014) reported the average productivity of wheat in Baluchistan was around 83.7 kg per hectare from 1980-81 to 2008-09. Thus the increase in cultivation area and production of Wheat showed a greater potential of Balochistan to meet the wheat demands of the province and country.

However, the climate change variability in Balochistan due to its arid and semi-arid climates, water scarcity, and extreme temperatures hinders wheat production (Khan et al., 2023). Irregular and insufficient rainfall in drought-prone areas also affects wheat production (Khakwani et al., 2012). Further issues like land ownership, access to resources, high fertilizer prices, seed unavailability, and low adoption of modern practices check wheat productivity (Naeem et al., 2017). Previously, there were fewer studies reported on the impact of temperature and precipitation variation on wheat production in Balochistan. The present study aims to analyse the variability in wheat yield during the Rabi season for three years (2017 – 2020) in response to rainfall and temperature in the Quetta district.

MATERIAL AND METHODS

The meteorological data on temperature and rainfall was obtained from the Pakistan Meteorological Department, Quetta, situated in Western Bypass, Brewery Road Quetta, and the wheat yield data (2011 – 2020) was provided by the Agriculture Department, Government of Balochistan. The data was exported in Microsoft Excel for descriptive analysis in Microsoft excel. The 10-year data on wheat production and cultivation in the Quetta district was analysed through the linear graph. Afterward, variation in temperature and rainfall was evaluated through the bar charts on Phenological stages of wheat growth in the Quetta district.

RESULTS AND DISCUSSION

Wheat production and cultivation from 2011-2020 in Quetta District

Figure 1, Table 1 shows the area under wheat cultivation (ha) and production (tons) for ten years in district Quetta. From 2011-2016, the area under wheat cultivation remained constant, and onward from 2018, the area under wheat cultivation increased. Likewise, the production of wheat remains nearly constant from 2011-2016 and onwards from 2016-2018 first increasing and then decreasing. The largest area under wheat cultivation was reported during 2019-2020, while the highest wheat production rate was reported during 2017-2018. This is contrary to the normal assumption that a large area available for wheat cultivation increases the wheat yield. This result indicated the influence of certain other factors including temperature and precipitation on the annual yield of wheat in Quetta district.

Table 1. Wheat production and area under wheat cultivation in district Quetta (2011-2020).

Years	Area in hectares	Production in tons
2011-2012	388,416	842,734
2012-2013	363,154	768,053
2013-2014	399,456	875,257
2014-2015	384,968	872,078
2015-2016	382,942	871,300
2016-2017	394,064	931,828
2017-2018	394,443	935,375
2018-2019	389,547	865,299
2019-2020	427,862	867,188

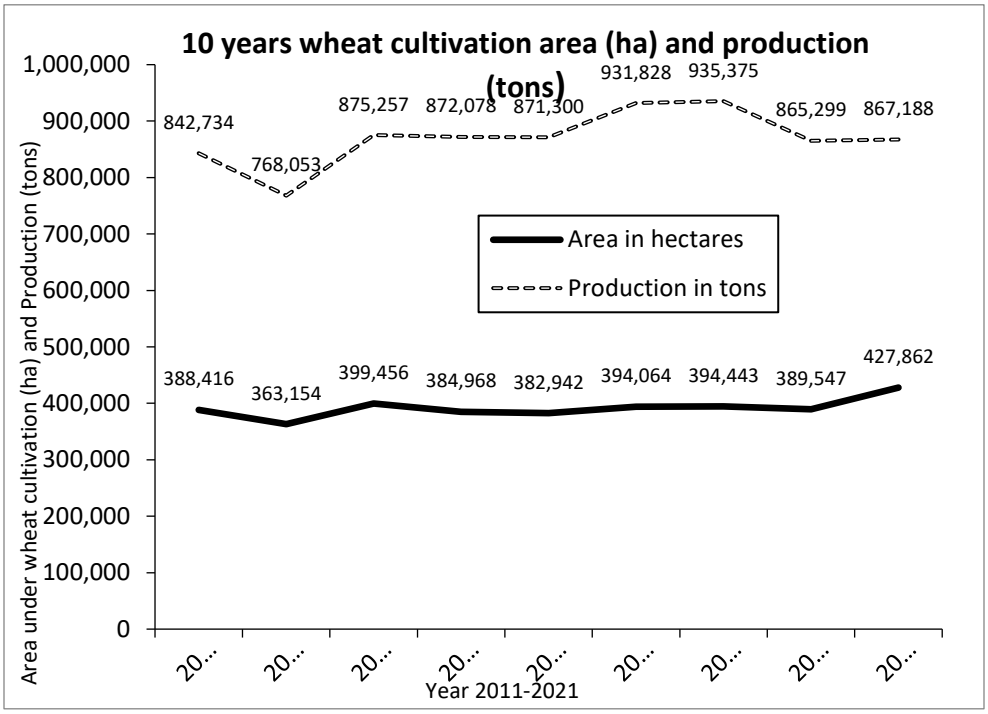

Figure 1. Wheat production and area under wheat cultivation during 10 years (2011-2020)

Effect of Rainfall on wheat yield during three years Rabi season (2017-2020)

Wheat production in Balochistan is mainly influenced by extreme weather, climate change, and varying precipitation levels, with the condition of the land surface strongly dependent on rainfall (Khan et al., 2023; Rana et al., 2021). Rainfall is considered as one of the key factors affecting the annual wheat production (Ahmad et al., 2021). Generally, the rainfall is effective before sowing and shooting to grain formation (Faryal and Ayaz, 2014-2015). In Pakistan, the sowing of wheat takes place from October to December, and harvesting from March to May while in Balochistan sowing months of wheat are November and December (Faryal and Ayaz, 2014-2015). The data in Figure 2, Table 2 shows no rainfall was recorded in Quetta during November and December in 2017 and 2018**.** Likewise, no rainfall was recorded during January and May of 2018, and May of 2019. Further from the data it is also clear that shooting to grain formation months receive rainfall in all three Rabi seasons (Table 2), however, the highest rainfall was recorded during February, March, and April months of the 2018-2019 Rabi season which might have positively impacted the wheat yield in Quetta city. The rainfall can also have a negative impact on wheat after sowing, before germination, and at the time of full maturity. The highest rainfall recorded in January during 2019-2020 might also result in a low yield of wheat even though the wheat was cultivated in large areas compared to the 2017-2018 and 2018-2019 Rabi seasons. Contrary to that January 2018 did not receive any rainfall which might resulted in a higher yield of wheat during the 2017-2018 Rabi season even in lesser cultivated area.

Table 2. Average rainfall during Rabi season (2017-2020) for wheat cultivation

Phenological stages	**Months**	**2017 Nov - 2018 May**	**2018 Nov - 2019 May**	**2019 Nov - 2020 May**
Emergence	November	0	0	0.8
	December	0	0	0.4
Third Leave	January	0	1.4	3.1
Tillering	February	1.2	1.5	0.9
Shooting	March	1.3	1.9	0.5
Heading and Flowering	April	1.7	1.8	0.3
Maturity	May	0	0	0.4

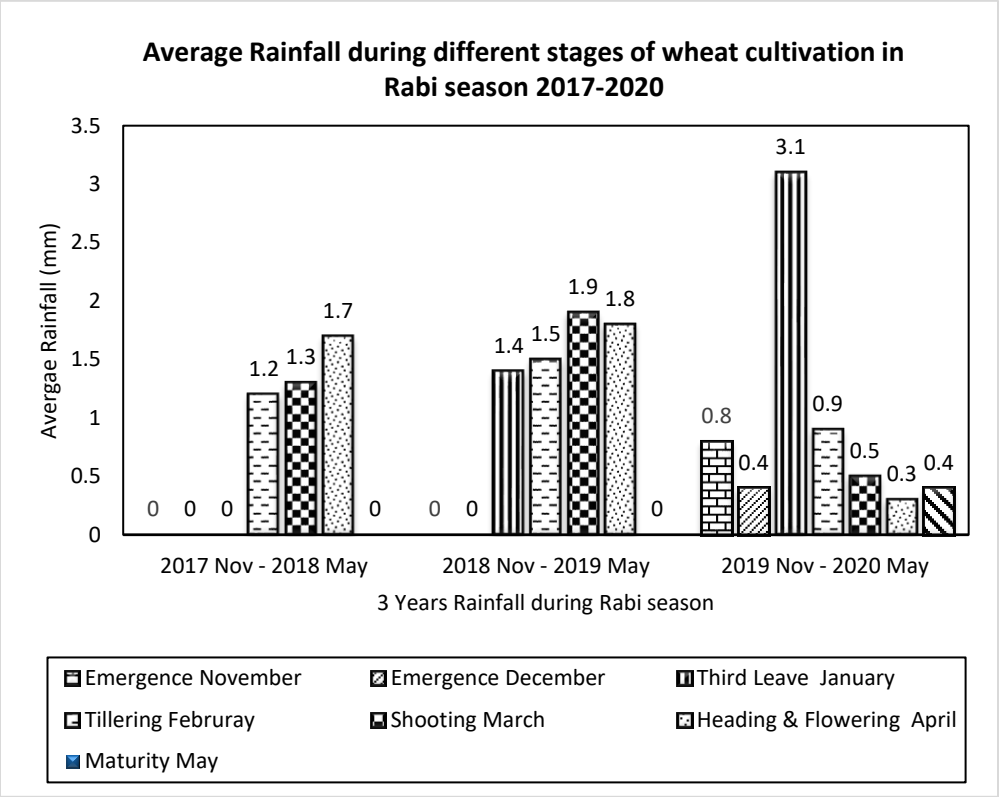

Figure 2. Average rainfall during three years Rabi season (2017-2020)

Effect of Temperature on wheat yield during three years Rabi season (2017-2020)

Temperature fluctuations impact wheat growth, with germination requiring cold temperatures and maturation needing normal temperatures (Gavrilescu, 2021; Hussain et al., 2021; Mahmood et al., 2019). Like other plants air temperature also affects the wheat plant growth. The optimum temperature limit for wheat plant growth is 25°C at which maximum plant growth is achieved (Faryal and Ayaz, 2014-2015).

Figure 3a, Table 2 shows the 3 years (2017-2020) average maximum temperature Tmax °C. The maximum temperature threshold for the wheat plant is 30-32°C above which plant growth disturbs. The highest maximum temperature of 30.7°C was recorded in May 2018 (25°C) and 30.8°C was recorded in May 2020 while the lowest highest temperature was recorded in November 2017. The data shows that the average maximum temperature never exceeds 30˚ C during three Rabia seasons i.e. from 2017-2020. Therefore, it is expected that the wheat growth in Quetta City did not experience high-temperature variability. Like the maximum temperature threshold, the minimum temperature limits of 0°C to 5°C are also reported below which wheat growth hinders. Figure 3b, Table 3 shows three years (2017-2020) average minimum Temperature, Tmin °C during Rabi Season. The lowest minimum temperature was recorded for December 2017 and January 2018 during the 2017-2018 Rabi season while the highest minimum temperature was recorded in December during the 2019-2020 Rabi season. Overall minimum temperature during the 2019-2020 Rabi season was high. Thus the lesser wheat yield during the 2019-2020 Rabi season can be attributed due to the high minimum temperature.

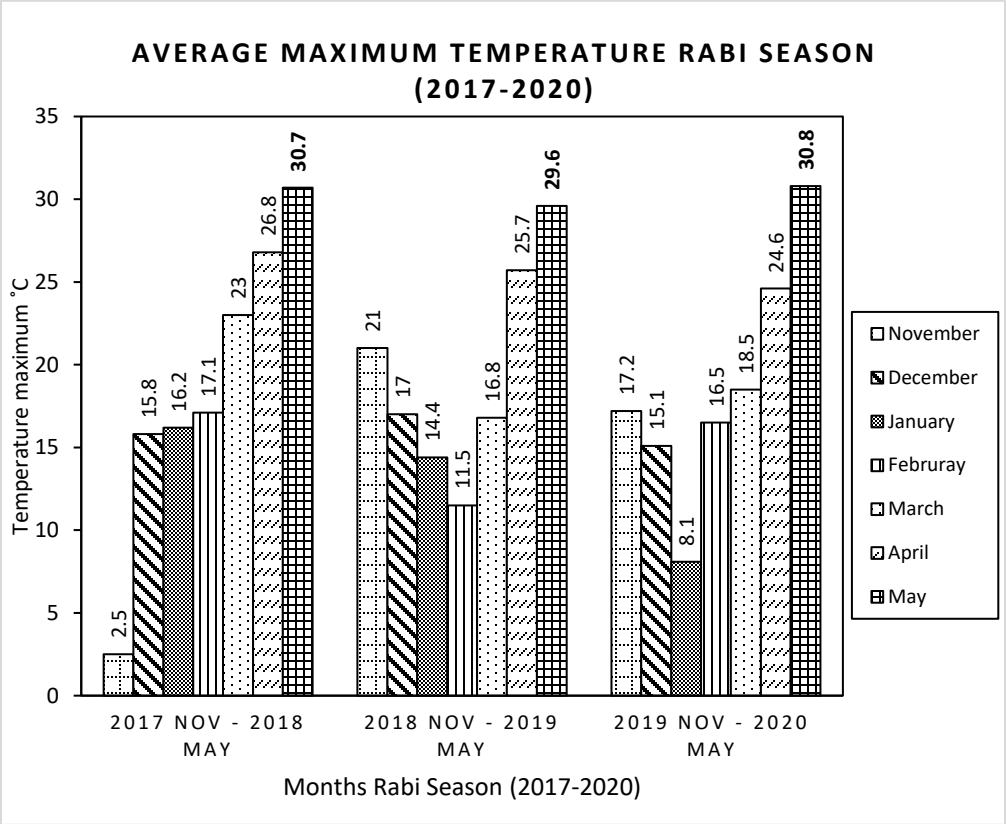

Figure 3. Average maximum temperature T_{max} °C during three years Rabi season (2017-2020).

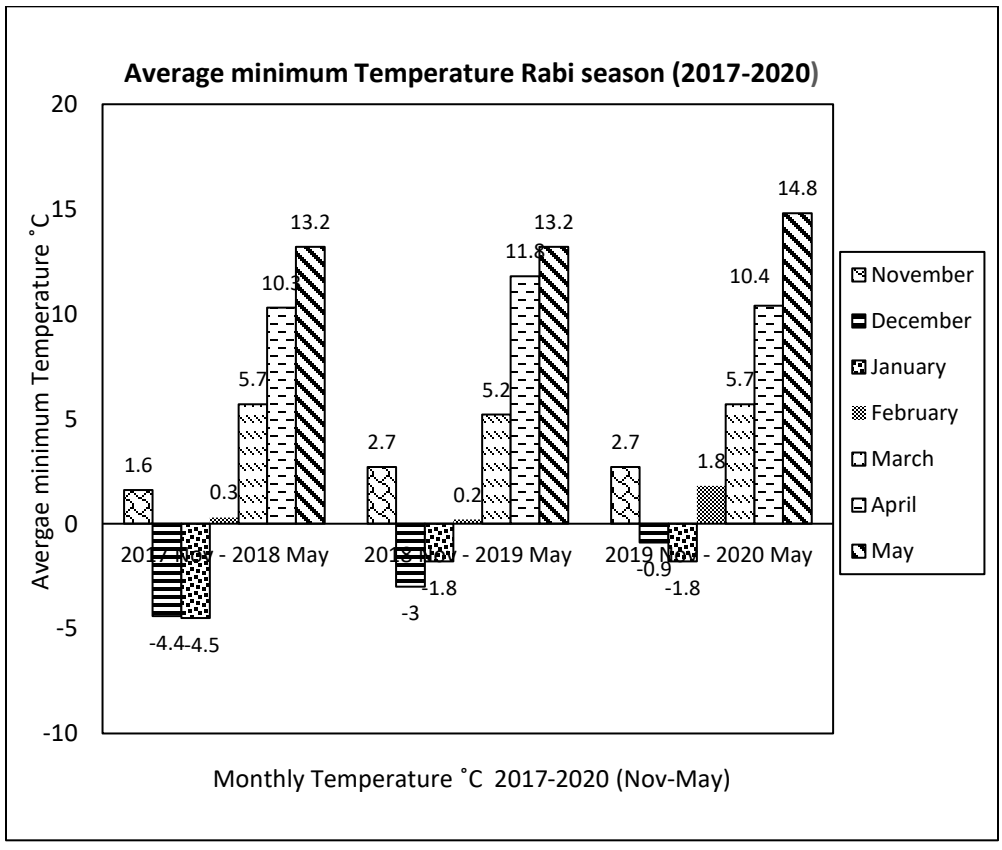

Figure 4. Average minimum Temperature Tmin °C during three years Rabi Season (2017-2020).

Table 3. Average maximum (Tmx) and minimum Temperature (Tmn) °C during three years Rabi Season (2017-2020).

	November		December		January		February		March		April		May	
	Tmx	Tmn	Tmx	Tmn	Tmx	Tmn	Tmx	Tmn	Tmx	Tmn	Tmx	Tmn	Tmx	Tmn
2017 Nov to 2018 May	2.5	1.6	15.8	-4.4	16.2	-4.5	17.1	0.3	23	5.7	26.8	10.3	30.7	13.2
2018 Nov to 2019 May	21	2.7	17	-3	14.4	-1.8	11.5	0.2	16.8	5.2	25.7	11.8	29.6	13.2
2019 Nov to 2020 May	17.2	2.7	15.1	-0.9	8.1	-1.8	16.5	1.8	18.5	5.7	24.6	10.4	30.8	14.8

CONCLUSIONS

The study conclusively shows that the availability of large areas does not necessarily produce the higher yield of wheat in the Quetta district due to the effect of climate parameters i.e. temperature and rainfall**.** The highest rainfall recorded during the shooting to grain formation months of the 2018-2019 Rabi season has positively impacted the wheat yield as reflected in the high wheat yield. Further, the high minimum temperature during the 2019-2020 Rabi season was reported which resulted in a lesser wheat yield during the 2019-2020 Rabi season. The results from the study suggest that the disturbance in climatic factors such as temperature, and rainfall under the direct influence of an increase in population and pollution in Quetta district can check wheat production in the future.

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AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

COMPETING OF INTEREST

The authors declare no competing interest.

REFERENCES

Abid, S., Masood, M.A., Anwar, M.Z., et al 2018. Trends and variability of wheat crop in Pakistan. *AJARD*, 8(2), 153-159.

Ahmad, Q.u.A., Biemans, H., Moors, E., et al 2021. The impacts of climate variability on crop yields and irrigation water demand in South Asia. *Water*, 13(1), 50.

Bajkani, J.K., Ahmed, K., Afzal, M., et al 2014. Factors Affecting Wheat Production in Balochistan Province of Pakistan". *IOSR-JAVS*, 7(12), 73-80.

Baloch, S.U., Li-Jun, L., Kandhroo, M.N., et al 2014. Effect of different irrigation schedules on the growth and yield performance of wheat (triticum aestivum l.) varieties assessment in district awaran (balochistan). *Journal of biology, Agriculture and healthcare,* 4(20), 5-17.

Chandio, A.A., Yuansheng, J., Magsi, H. 2016. Agricultural sub-sectors performance: an analysis of sector-wise share in agriculture GDP of Pakistan. *IJEF*, 8(2), 156-162.

Faryal, K., Ayaz, M. 2014-2015. Weather and Wheat Crop Development in Northwest Baluchistan (Quetta).

Gadiwala, M.S., Safi, G.M., Burke, F., et al 2014. A spatio-temporal analysis of wheat crop diversification and concentration in Baluchistan. *Asia Pac. J. Educ. Arts Sci,* 1(4), 58-65.

Gavrilescu, M. 2021. Water, soil, and plants interactions in a threatened environment. *Water*, 13(19), 2746.

Hussain, J., Khaliq, T., Rahman, M.H.U., et al 2021. Effect of temperature on sowing dates of wheat under arid and semi-arid climatic regions and impact quantification of climate change through mechanistic modeling with evidence from field. *Atmosphere*, 12(7), 927.

Iqbal, M., Fahim, M., Zaman, Q., et al 2014. Effect of various factors on wheat production. Sarhad J. Agric, 30(1), 135-143.

It, O., Mo, O., Sa, A., et al 2017. Economic Appraisal of Inert Atmosphere Silo for Wheat Storage.

Jakperik, D., Oduro, S. 2013. Statistical analysis of factors affecting crop production in Navrongo, Tono irrigation dam a case study. *Albanian J. Agric. Sci.*, 12(1), 33.

Khakwani, A.A., Dennett, M., Munir, M., et al 2012. Growth and yield response of wheat varieties to water stress at booting and anthesis stages of development. *Pak. J. Bot,* 44(3), 879-886.

Khan, I., Ihsanullah, A.J., Taj, F., et al 2002. Effect of sowing dates on yield and yield components of Mash bean. *Asian J. Plant. Sci,* 1, 622-624.

Khan, N., Ma, J., Zhang, H., et al 2023. Rural Farmers' Perceptions for the Impacts of Climate Change and Adaptation Policies on Wheat Productivity: Insights from a Recent Study in Balochistan, Pakistan. *Atmosphere*, 14(8), 1278.

Khan, S., Shahab, S., Fani, M. I., et al 2021. Climate and weather condition of Balochistan province, Pakistan. *IJEEG*, 12(2), 65-71.

Mahmood, N., Arshad, M., Kächele, H., et al 2019. Wheat yield response to input and socioeconomic factors under changing climate: Evidence from rainfed environments of Pakistan. *Sci. Total Environ.*, 688, 1275-1285.

Naeem, M., Shah, S.G., Rasheed, M. 2017. Analyses of cost and revenue of wheat crop production in district Musakhail, Balochistan. *J. Econ. Sustainable Dev*, 8(21), 86-92.

Rana, A.W., Moeen, M.S., Shikoh, S.H., et al 2021. Proposed Balochistan agriculture policy 2021. *Intl Food Policy Res Inst.*

Rasool, G., Ullah, A., Jan, A., et al 2021. 49. Morphological evaluation of wheat genotypes for grain yield under arid environment of Balochistan. *PAB*, 10(4), 1441-1449.

Safi, G.M., Gadiwala, M.S., Burke, F., et al 2014. Agricultural Productivity in Balochistan Province of Pakistan A Geographical Analysis. *J. Basic Appl. Sci.*10, 292-298.

Siddiqui, G.-u., Siddiqui, Z.A. 2009. Balochistan: People and Culture. Al-Burz, 1(1), 38-56.

Zhang, Q., Men, X., Hui, C., et al 2022. Wheat yield losses from pests and pathogens in China. *Agric. Ecosyst. Environ.*, 326, 107821.

Zulfiqar, F., Thapa, G.B. 2017. Agricultural sustainability assessment at provincial level in Pakistan. *Land use policy*, 68, 492-502.