Performance Evaluation of Commercial Wheat Varieties for Yield and Quality Attributes Under Agro-Climatic Conditions of Quetta

Muhammad Saddam[1], Noorullah Kakar[2], Sharif Kakar[3], Naseeruddin[4]*, Manzoor Ahmed[5], Barkat Ali[4], Israr Ahmed[6], Saduddin[7], Faraz Ahmed[8], Muhammad Affan[1], Wasil Khan[9], Hussan Nawaz[1]

[1]Scholar MSc. (Hons) Department of Agronomy Balochistan Agriculture College, Quetta, Balochistan, Pakistan.
[2]Assistant Professor Department of Agronomy, Balochistan Agriculture College, Quetta Balochistan, Pakistan.
[3]Directoriate Agriculture Research Quetta, Balochistan, Pakistan.
[4]Lecturer Department of Agronomy, Balochistan Agriculture College, Quetta Balochistan, Pakistan.
[5]Lecturer Department of Agriculture Extension, Balochistan Agriculture College, Quetta Balochistan, Pakistan.
[6]Lecturer Department of Computer Science, Balochistan Agriculture College, Quetta Balochistan, Pakistan.
[7]Lecturer Department of Soil Science, Balochistan Agriculture College, Quetta Balochistan, Pakistan.
[8]Ph.D. Scholar Sindh Agriculture University, Tandojam Sindh, Pakistan,
[9]MSc. (Hons) Scholar Sindh Agriculture University, Tandojam Sindh, Pakistan,

***Corresponding Author:** Naseeruddin
*Email: Nasir657@gmail.com.

Abstract
Wheat (*Triticum aestivum L.*) is a globally significant cereal crop, providing essential nutrients and serving as a staple food for millions of people. Pakistan, including Balochistan, relies heavily on wheat production, but climatic variability affects yield and quality. This study evaluates the performance of six commercial wheat varieties—Zarghon, Rasco, Umeed Khas, Umeed 2014, Aghaz, and Zardana—under the agro-climatic conditions of Quetta. The field experiment was conducted at the Agriculture Research Institute (ARI), Quetta, using a Randomized Complete Block Design (RCBD) with three replications. Agronomic parameters, such as plant height, number of tillers per square meter, spike length, and yield, as well as quality attributes like protein content and gluten percentage, were measured. The results revealed that Umeed Khas performed best in terms of yield components, while Umeed 2014 exhibited superior biochemical quality, particularly in protein and gluten content. Aghaz performed the weakest in most categories. Based on these findings, Umeed Khas is recommended for high yield, and Umeed 2014 for superior quality traits under the climatic conditions of Quetta.

Keywords: Wheat, Performance Evaluation, Yield, Quality Attributes, Agro-climatic Conditions, Quetta

Introduction

Wheat (*Triticum aestivum L.*) is a staple cereal crop that plays a crucial role in global food security. As one of the most widely grown crops, wheat occupies a significant position in agriculture as it is the most cultivated cereal grain in the world (Kumar et al., 2013; Nawaz et al., 2013). It serves as a primary source of carbohydrates and proteins for millions of people across the globe. Wheat contributes significantly to both human nutrition and agricultural economies, especially in countries like Pakistan, where it constitutes a large part of the daily diet (Shewry & Hey, 2015). In Pakistan, wheat occupies 65% of the total land under food crops and provides around 60% of the country's total caloric intake (Shuaib et al., 2007). However, wheat production faces numerous challenges due to environmental factors, particularly in regions like Balochistan. The agro-climatic conditions of Balochistan are unique, characterized by a dry, semi-arid environment, which can pose significant obstacles to crop productivity (Haider, 2018). To ensure food security and sustainable agriculture, it is essential to identify high-performing wheat varieties that can thrive in these specific conditions. This requires a focus on both yield and quality attributes, including protein content, gluten strength, and grain yield, to meet local nutritional demands and market requirements (Mushtaq et al., 2021).

The development of new wheat varieties and multi-environment trials have been central to improving crop performance. Varieties must be tested under specific environmental conditions to determine their suitability for different regions (Iqbal et al., 2022). In the case of Quetta, a region with distinct agro-climatic conditions, this study aims to evaluate the performance of six commercial wheat varieties to identify those with superior agronomic traits and quality attributes (Rasool et al., 2021).

Materials and Methods

Study Area

The field experiment was conducted at the Agriculture Research Institute (ARI), Quetta, Balochistan, during the 2022-2023 cropping season. The region is characterized by a semi-arid climate with limited rainfall and cold winters, making it essential to evaluate wheat varieties that can adapt to these environmental conditions.

Experimental Design
The study used a Randomized Complete Block Design (RCBD) with three replications. Six commercial wheat varieties—Zarghon, Rasco, Umeed Khas, Umeed 2014, Aghaz, and Zardana—were tested. Each plot consisted of five rows, with a row-to-row distance of 6 cm. The total area of the experimental field was divided into 15 plots, and standard agronomic practices were applied, including weeding and irrigation according to crop requirements.

Agronomic Parameters
Plant Height (cm) was measured from the ground to the tip of the spike at maturity. Number of Tillers per Square Meter (tillers/m²) were counted in each plot using a quadrat method at maturity. Days to Heading were calculated by the number of days from sowing to the full emergence of spikes. Days to Maturity was calculated by the number of days from sowing until 80% of the plants had reached maturity (chlorosis of leaves). Spike Length (cm) was measured from three randomly selected spikes in each plot. Number of Grains per Spike was counted from three randomly selected spikes in each plot. Spikelets per Spike was recorded from three spikes per variety. 1000-Grain Weight (g) was measured using an electronic balance. Biological Yield (kg/ha): The total above-ground dry biomass was recorded after harvesting. Grain Yield (kg/ha): The total grain yield from each plot was calculated and converted to kilograms per hectare. Harvest Index (%): The ratio of grain yield to biological yield, expressed as a percentage.

Quality Parameters
Protein Content (%) was determined using the Kjeldahl method, following the standards of the AACC (American Association of Cereal Chemists). Gluten Content (%) was measured using the wet gluten method, based on AACC guidelines. Ash Content (%) was calculated by burning grain samples in a muffle furnace and weighing the residual ash. Starch Content (%) was determined using the standard AACC method. Moisture Content (%) was measured by oven-drying grain samples at 130°C for 60 minutes and calculating the percentage loss in weight.

Statistical Analysis
All data collected were analyzed using STATISTIX 8.1 software. The Least Significant Difference (LSD) test at a 5% significance level was applied to determine the statistical difference among the wheat varieties for the recorded parameters.

Results

Agronomic Parameters

Plant height: In the tested varieties, there was a significantly difference in plant height ($P<0.05$), according to the analysis of variance. The variety Umeed khas had the tallest plants (102 cm), followed by Umeed (98.67 cm), Rasco (96.33 cm), Zardana (90.76 cm), and Zarghon (88.0 cm), while Aghaz had the shortest plants (86.0 cm). Overall, results showed that the Umeed khas is most promising variety in terms of height (Figure-1).

Days to heading: Days taken by varieties to reach heading were significantly ($P<0.05$) different. The minimum time was taken by Umeed khas (76.67 days), followed by Zardana (78.67 days), Umeed 2014 (84.0 days), Rasco (86.0 days), Zarghon (88.0 days) whereas maximum time was taken by Aghaz (90.0 days) (Figure-2).

Days to maturity: Days taken by varieties to reach maturity were significantly ($P<0.05$) different. The minimum time was taken by Umeed khas (122.67 days), followed by Zardana (125.0 days), Umeed 2014 (129.0 days), Rasco (132.0 days), Zarghon (134.0 days) whereas maximum time was taken by Aghaz (135.0 days) (Figure-3).

Tillers (m^{-2}): The tillers m^{-2} was significantly ($P<0.05$) varied in tested varieties grown in climatic conditions of Quetta. The results showed that the maximum number of tillers was noted in Umeed khas (352.33) followed by Umeed 2014 (348.33), Rasco (345.670), Zardana (331.0), Zarghon (320.0) and minimum was noted in Aghaz (301.33) (Figure-4).

Spike length (cm): The spike length significantly ($P<0.05$) varied in all tested varieties. The highest spike length was noted in Umeed 2014 (13 cm) followed by Umeed khas (12.07 cm), Rasco (11.667 cm), Zardana (11.549 cm), Zarghon (9.23 cm) and minimum was noted in Aghaz (9.30) (Figure-5).

Spikelets per spike: The results showed the significant variation ($P<0.05$) in spikelets per spike in all tested varieties. The maximum spikelets per spike were noted in Umeed khas (19.33) followed by Umeed 2014 (18.33), Rasco (17.33), Zardana (17.33), Zarghon (17.0) and minimum was noted in Aghaz (16.33) (Figure-6).

Grains per spike: The grains per spike was significantly ($P<0.05$) different in tested varieties. The maximum number of grains was noted in Umeed khas (53.33) followed by Umeed 2014 (49.33), Rasco (46.00), Zardana (45.67), Zarghon (43.00) and minimum was noted in Aghaz (41.00) (Figure-7).

1000-Kernel weight: The 1000-Kernel weight was significantly ($P<0.05$) different in tested varieties. The maximum weight was noted in variety Umeed khas (55.33) followed by variety Umeed 2014 (50.72), Rasco (49.76), Zardana (47.6), Zarghon (44.80) whereas lowest was noted in Aghaz (38.93) (Figure-8).

Biological yield (Kg/ha): The Biological yield was significantly (P<0.05) different in tested varieties. The highest biological yield was noted in Umeed khas (13339 kg/ha) followed by variety Umeed 2014 (12819 kg/ha), Rasco (12569 kg/ha), Zardana (12277 kg/ha), Zarghon (11977 kg/ha) whereas lowest was noted in Aghaz (11232 kg/ha) (Figure-9).

Grain yield (Kg/ha): The grain yield was significantly (P<0.05) different in tested varieties. The highest grain yield was noted in Umeed khas (5355 kg/ha) followed by variety Umeed 2014 (5070 kg/ha), Rasco (4907 kg/ha), Zardana (4714 kg/ha), Zarghon (4436 kg/ha) whereas lowest was noted in Aghaz (4228 kg/ha) (Figure-10).

Harvest index: The harvest index was significantly (P<0.05) different in tested varieties. The highest harvest index was noted in Umeed khas (40.123) followed by variety Umeed 2014 (39.54), Rasco (39.03), Zardana (38.39), Aghza (37.64) whereas lowest was noted in Zarghon (37.03) (Figure-11).

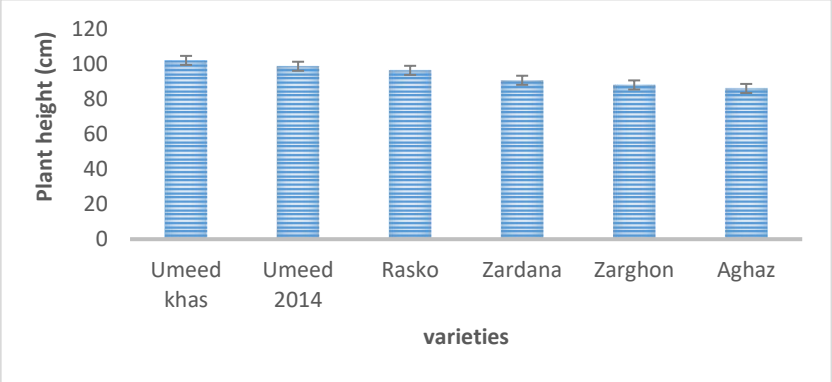

Figure 1: Plant height of different wheat varieties cultivated in climatic conditions of Quetta

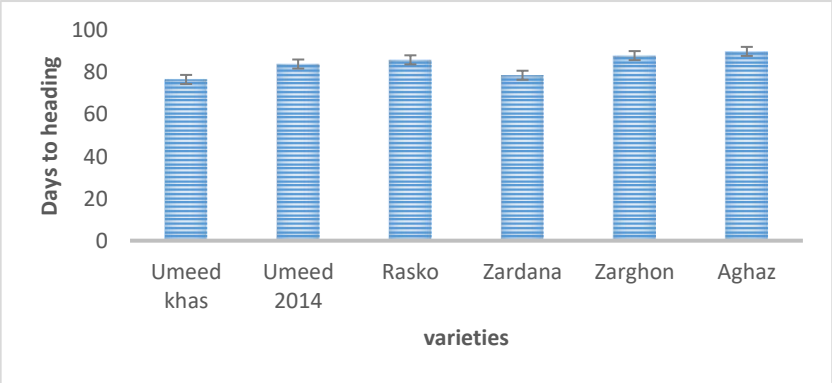

Figure 2: Days taken by different wheat varieties to reach at heading stage, cultivated in climatic conditions of Quetta

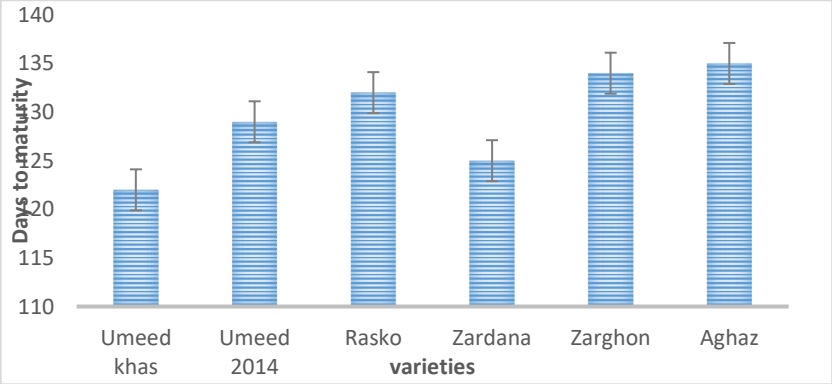

Figure 3: Days taken by different wheat varieties to reach at maturing stage cultivated in climatic conditions of Quetta

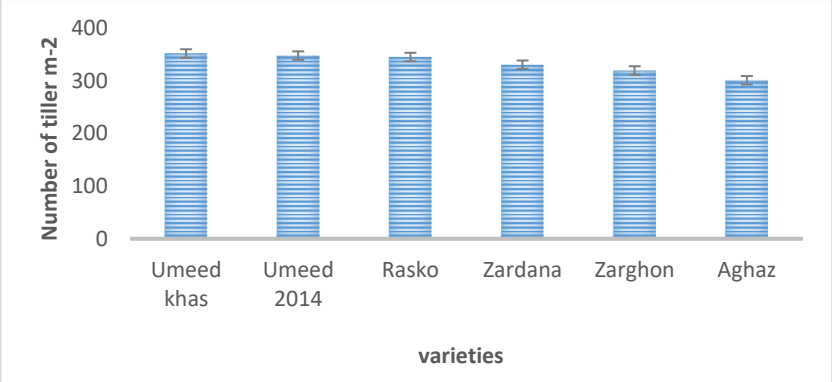

Figure 4: Number of tillers per meter square of different wheat cultivated in climatic conditions of Quetta

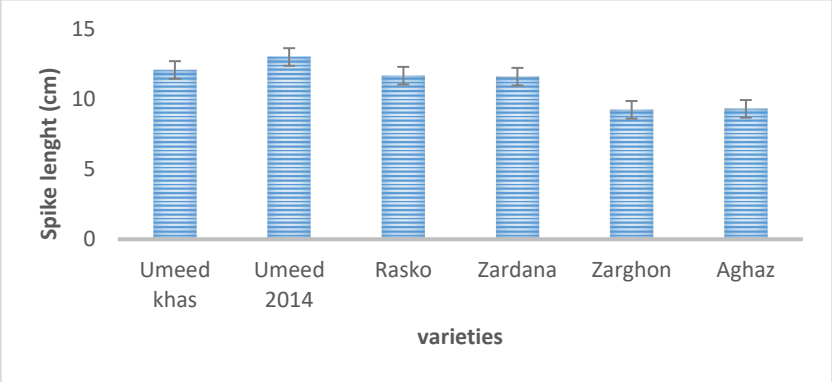

Figure 5: Spike length of several wheat varieties cultivated in climatic conditions of Quetta

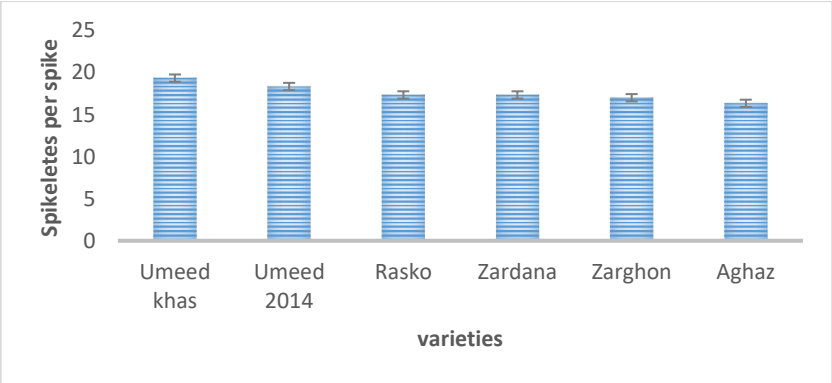

Figure 6: Spikelets per spike of several wheat varieties cultivated in climatic conditions of Quetta

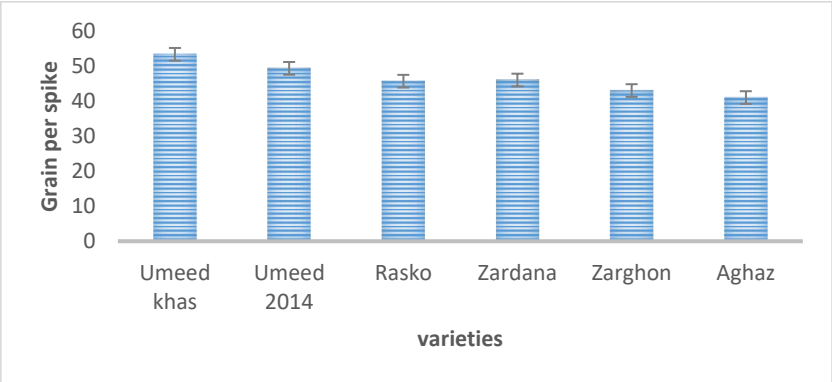

Figure 7: Grains per spike of several wheat varieties cultivated in climatic conditions of Quetta

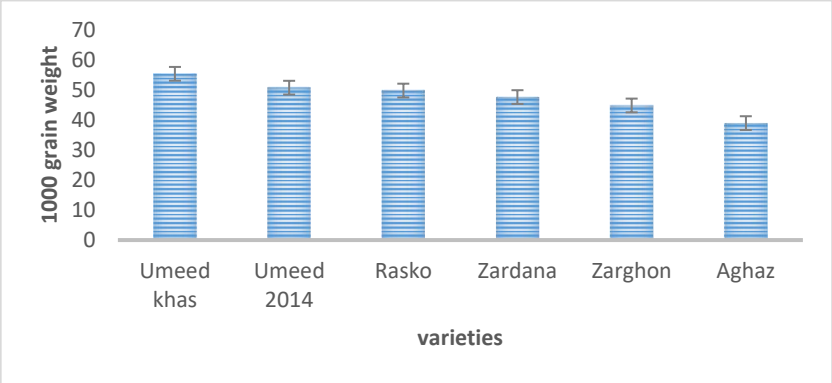

Figure 8: 1000 kernel weight of several wheat varieties cultivated in climatic conditions of Quetta

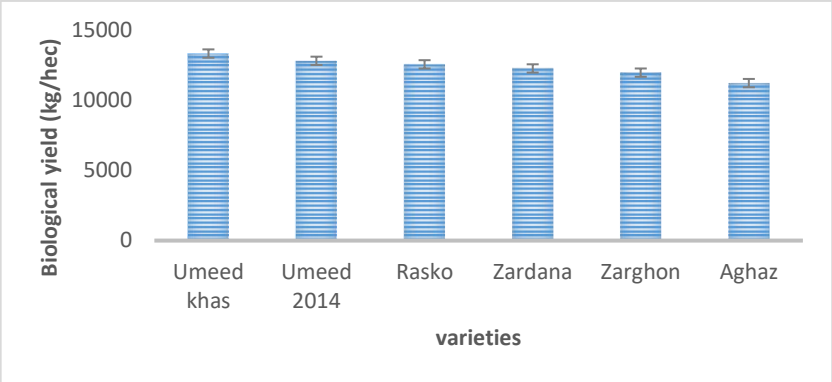

Figure 9: Biological yield of several wheat varieties cultivated in climatic conditions of Quetta

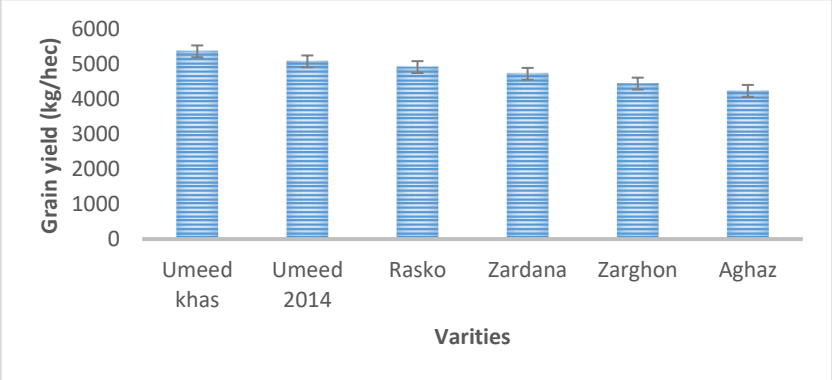

Figure 10: Grain yield of several wheat varieties cultivated in climatic conditions of Quetta

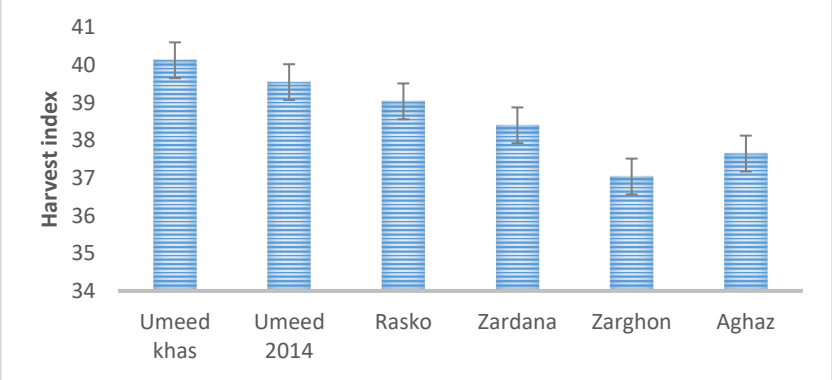

Figure 4.11: Harvest index of several wheat varieties cultivated in climatic conditions of Quetta

2. Quality parameters

Moisture contents: The moisture contents were non-significantly (P>0.05) different in tested varieties. In present study, the moisture contents were not significantly different among different wheat varieties. Moisture contents were noted in range of 9.33 to 9.42 % (Figure-12).

Protein contents (%): The protein contents were significantly (P<0.05) different in tested varieties. The highest protein contents were noted in Umeed 2014 (11.8%), followed by variety Umeed khas (11.03%), Rasco (10.99%), Zardana (10.25%), Zarghon (10.1%) whereas lowest was noted in Aghza (9.85%) (Figure-13).

Ash contents: The ash contents were significantly (P<0.05) different in tested varieties. The highest protein contents were noted in Umeed khas (2.96%) followed by variety Umeed 2014 (2.89%), Rasco (2.69%), Rasco (2.32%), and Zardana (2.07%) whereas lowest was noted in Aghza (1.79%) (Figure-14).

Gluten contents: The gluten contents were significantly (P<0.05) different in tested varieties. The highest contents were noted in Umeed 2014 (9.8%) followed by variety Umeed khas (9.23%), Rasco (8.76%), Zardana (8.2%), Zarghon (8.0%) whereas lowest was noted in Aghza (7.82%) (Figure-15).

Starch contents (%): The starch contents were significantly (P<0.05) different in tested varieties. The highest contents were noted in Zardana (69.29%) followed by variety Zarghon (68.22%), Rasco (62.67%), Umeed khas (61.0 %), Umeed (57.3 %) whereas lowest was noted in Aghza (53.0%) (Figure-16).

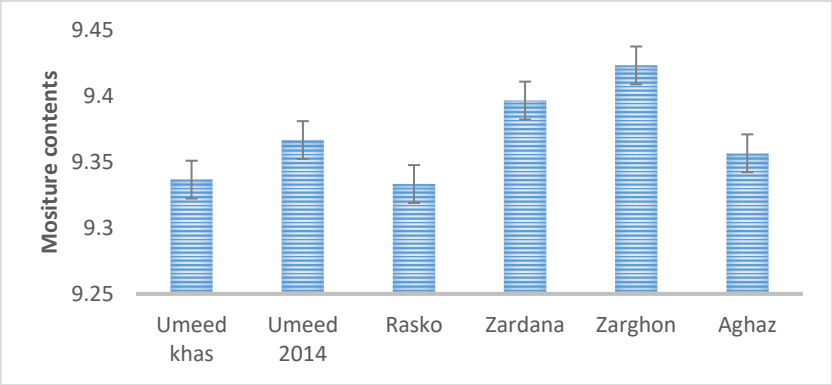

Figure 12: Moisture contents of several wheat varieties cultivated in climatic conditions of Quetta

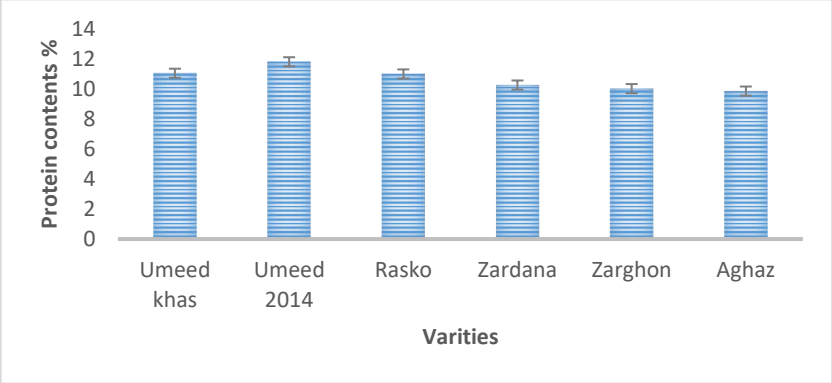

Figure 13: Protein contents of several wheat varieties cultivated in climatic conditions of Quetta

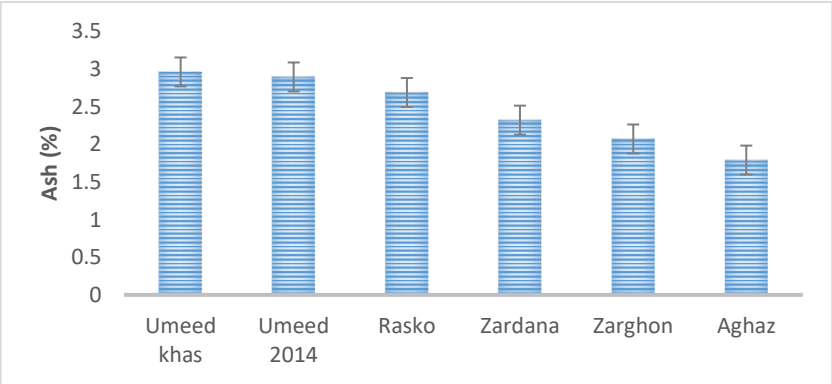

Figure 14: Ash contents of several wheat varieties cultivated in climatic conditions of Quetta

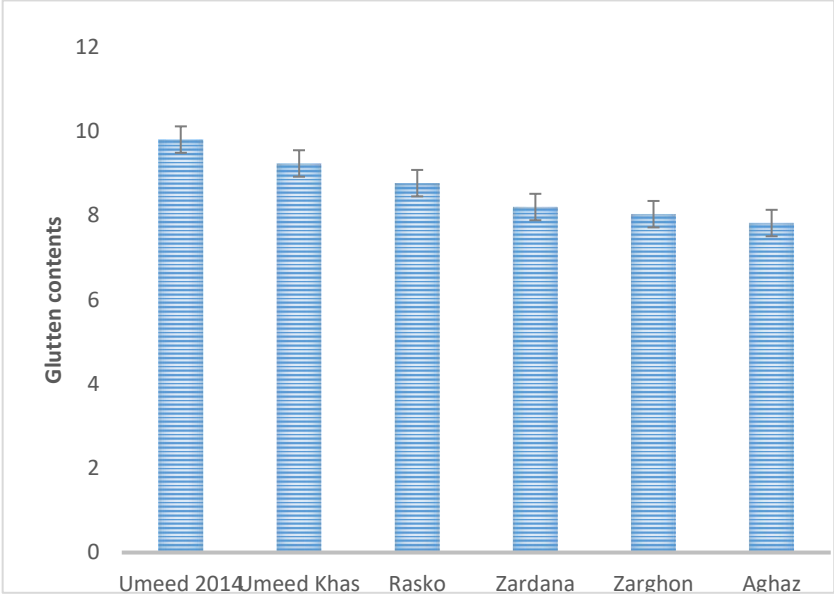

Figure 15. Gluten contents of several wheat varieties cultivated in climatic conditions of Quetta

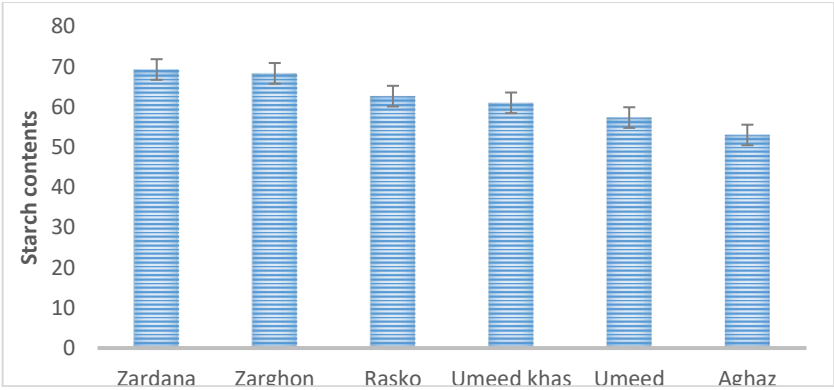

Figure 16: Starch contents of several wheat varieties cultivated in climatic conditions of Quetta

Discussions

Plant height is one of the important agronomic parameters that correlates with yield. Several studies showed that the positive relationship between plant height and yield. Moreover, environmental factors and genetic make of variety affect the height of plant (Shahzad et al., 2007). Results showed that the Umeed khas is most promising variety in terms of height. The results of present study are in line with findings of Truberg & Huhn (2000) who reported the variation in height of wheat varieties. Similarly, study conducted by Wamatu & Thomas (2002) showed that the in different environmental conditions plant performed differently. The research conducted by Longove et al. (2014) showed that the most promising variety was Rasco followed by Zardana. This might be due to variation in environmental factors and environmental factors. Similar results were reported by Naveed et al. (2007).

Days to heading is the time taken to reach maturity is one of the important characteristic traits. The day to reach maturity is highly linked with maturity. As a result, the variety reached at heading stage in a shorter period thus saving time and avoided drought. In present study Umeed khas take less time to reach maturity and escape the drought conditions as compared to the other studied varieties which makes its promising variety of study area. In present study different varieties took varied time to reach heading. This might be due to their genetic variability. Similar results were reported by Rasool et al. (2021) who noted that the different varieties take varied time to reach the heading stage. These findings are supported by Sohail et al. (2013), who reported that early heading wheat genotype might avoid the stress conditions.

In present study different varieties took varied time to reach heading. This might be due to their genetic variability. Similar results were reported by Rasool et al. (2021) who noted that the different varieties take varied time to reach the heading stage. In present study, Umeed khas performed better in climatic conditions of study area. The minimum number of days needed for Umeed khas to mature also reduces cost of production, although late maturing varieties are more vulnerable to drought stress. These results are consistent with earlier observations (Arain et al., 2011).

In present study the highest number of tiller m^{-2} was noted in Umeed khas. Moreover, tillers m^{-2} varied in tested varieties. Truberg & Huhn (2000) revealed that the tillers m^{-2} frequently correlate with the genetic make of the parental material of

various wheat varieties, which provides more credence to these findings. Similar results were reported by Yousif et al., (2015). The highest spike length was noted in Umeed 2014 and minimum was noted in Aghaz. These findings regarding spike length concur with those of Voltas et al. (2005) and Wamatu & Thomas (2002), who noticed that the parent material used to produce wheat cultivars grown under various environmental conditions had a genetic impact on tillering capacity and spike length.

In present study, the spikelets per spike were varied in all tested varieties, this might be due to their genetic makeup. Umeed khas performed better as compared to other varieties due to its adaptability according to climatic conditions of study area. The findings of the present research are further confirmed by Porfiri et al. (2001). The research conducted by Longove et al. (2014) showed the significant variation in spikelets per spike in different tested wheat varieties.

In present study, the grain per spike varied in different tested varieties. This is due to their genetic makeup. These findings were further confirmed by Vaughan & Judd (2003), who noted that cultivars produced under similar environmental circumstances had variable numbers of grains per spikes. The majority of earlier studies that were conducted by various researchers in various locations across the world based on the results of wheat cultivar performance trials have also been verified by the findings of the current research in connection to grains per spike. Similarly, the research conducted by Longove et al. (2014) showed that grains per spike in different varieties varied under similar environmental circumstances due to their genetic diversity and adaptability.

Test weight is frequently used to evaluate a cultivar's performance in challenging circumstances and is regarded as an important indicator for grain values (Misic & Mladenov, 1998). The 1000-Kernel weight was significantly ($P<0.05$) different in tested varieties. The maximum weight was noted in variety Umeed khas (55.33) followed by variety Umeed 2014 (50.72), Rasco (49.76), Zardana (47.6), Zarghon (44.80) whereas lowest was noted in Aghaz (38.93) as showed in table 4.8(b). In the present study, 1000-Kernel weight was significantly different in tested varieties which might be due to their genetic variability. Our results were supported by observations of Truberg & Huhn, (2000) who reported that varieties showed different weight due to their genetic variability The 1000 kernel weight was highest in Umeed khas variety. This might be due to its healthy and high weighty seed production. Similar results were reported by Arif et al., (2009) who noted that the better test weight were obtained for wheat samples having healthier wheat kernels

The highest biological yield was noted in Umeed khas and lowest was noted in Aghaz. These findings are consistent with those made by Dahleen et al. (1991), who observed a range of total biomass for cultivars grown in various areas. Furthermore, the present findings about the biological yield in several wheat varieties have also been verified by Longove et al. (2014).
In present study, the grain yield varied in different tested varieties. Number of viable tillers, number of spikes, and grain weight are all closely related to grain production. These findings are comparable to past research where yield under rainfed environments was shown to be significantly substantial (Farooq et al., 2006). Given that the grain yield varied greatly even under the same soil, climatic, input, and crop management circumstances, another explanation for the high grain yield may be related to the genetic make-up of the parental material of these varieties. These findings are in line with those of Wamatu & Thomas (2002) who noted a notable difference in the grain yield of wheat varieties grown in various ecologies. Porfiri et al. (2001) found that the environmental factors have the greatest influence on the grain yield of wheat varieties. In present study Umeed khas gave highest grain yield. This might be due to its high number of grains, number of tillers and number of spikelets. The grain yield is highly linked with number of tillers (Yousif et al., 2015). Similarly, Khan et al. (2010) and Ashfaq et al. (2003) reported that while tillers per plant tillers and grain weight have a direct impact on grain yield. Similarly, Shoran et al. (2000) reported that the number of grains per spike have positive impact on grain yield. In the present study Umeed khas gave highest yield due to its high number of grains, number of tillers and number of spikelets.

The difference among the potential and actual yield may be measured with the use of the harvest index. It is the proportion of plant yield to grain yield. It serves as an efficiency indicator for each crop. Harvest index is one of the factors helping enhance any crop at a certain level. It specifies the ability of plants to distribute biomass into the developed reproductive parts (Wnuket al., 2014). In present study, Umeed khas showed highest harvest index. This might be due to high grain yield and weight of Umeed khas. Knezevic et al. (2008) reported that harvest index is positively related with grain yield. Peltonen-Sainio et al. (2018) noted that the grain weight has direct link with harvest index.

The quantity of water in each variety of wheat was tested to determine its moisture content, which is crucial for production (Khan & Kulachi, 2002). Thus moisture content appears to affect the grain hardness and is important parameter for meal as well (Gaines & Windham, 1998). In present study, the moisture contents were not significantly different among different wheat varieties. Moisture contents were noted in range of 9.33 to 9.42 %. This might be due to environmental condition of study area. However, our results were in contradiction with findings of Ikhtiar & Alam, (2007) who reported the variation in moisture contents in different varieties.

Protein contents of wheat are important determinants of grain quality. In the present study, the protein contents were different in all studied varieties. This might be due to genetic variability and adaptability of varieties in climatic conditions of study area. Our results were supported by findings of Ikhtiar & Alam, (2007) who reported the variation in protein contents of different varieties. In present study, the protein contents was noted in range of 9.85 to11.8% which is according to findings of Anjum et al. (2005), who reported that the average protein content of Pakistani wheat cultivars ranged from 9.68% to 13.45%. In present study, Umeed variety showed higher protein contents which is the in line with findings of Mushtaq et al. (2021) who noted the high protein in Umeed cultivar. The high protein content of Umeed might be due to its genetic makeup. Giancaspro et al. (2019) who reported that the protein contents in wheat varieties were varied due to their genetic variability.

In the present study, the ash contents were different in all studied varieties. This might be due to genetic variability and adaptability of varieties in climatic conditions of study area. Our results were supported by findings of Ikhtiar & Alam, (2007) who reported the variation in ash contents of different varieties. Ash contents were different in all tested varieties and within range of 1.79 to 2.96 % which is in line with findings of Ali et al. (2013). The highest ash contents were noted in Umeed variety followed by Umeed khas which showed that these are high in nutrition. Amir et al. (2020) reported that the increase in ash contents of wheat enhance its nutritional value.

In the present study, the gluten contents were different in all studied varieties. This might be due to genetic variability and adaptability of varieties in climatic conditions of study area. Our results were supported by findings of Asim et al. (2018) who reported the variation in gluten contents of different wheat varieties due to genetic variability. Similarly, Amir et al. (2020) reported the variation in gluten contents in different wheat cultivars. The gluten contents are varied among different varieties due to genetic makeup (Finlay et al., 2007). Bilgin et al. (2016) reported that wheat genotype is important factor in determining the quality and quantity of gluten. In present study, the high gluten contents were noted in Umeed variety which might be due to its high protein contents. Grain protein and gluten concentration have a significant impact on grain protein. However, according to Simic et al. (2006), the wheat genotype is thought to have the greatest impact on the qualitative properties of gluten. According to Perten et al. (1992), an increase in the total protein level is positively correlated with its gluten content of wheat.

In the present study, the starch contents were different in all studied varieties. This might be due to genetic variability and adaptability of varieties in climatic conditions of study area. Our results were supported by findings of Rhazi et al. (2021) who reported the variation in starch contents of different varieties due to genetics. In present study, the starch contents were noted in range of 52 to 69% which is according to findings of Raziet al. (2021), who reported that the average content of Pakistani wheat cultivars ranged from 54% to 69%. Moreover, Zardana variety showed higher starch contents which is the in line with findings of Mushtaq et al. (2021) who noted the high starch in Zardana cultivar.

Conclusion

The results of present study concluded that Umeed khas performed better in terms of plant height, tillers m^{-2}, spikelets per spike, grains per spike, biological yield, grain yield and harvest index followed by Umeed 2014 variety. Moreover, the biochemical analysis showed that the Umeed 2014 had highest protein and gluten contents followed by Umeed khas whereas Aghza variety showed least promising effects in terms of plant height, tillers m^{-2}, spikelets per spike, grains per spike, biological yield, grain yield and harvest index, protein, gluten, starch and ash contents.

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