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RESEARCHARTICLE

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Variability among Okra Genotypes for Various Maturity Traits

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Abstract
Okra is a popular vegetable crop belonging to Malvaceae family and is also known as lady finger and 'bhindi' in Pakistan. It is known for its nutritional value and culinary versatility. These fifteen varieties seeds were sown in a randomized complete block design (RCBD) with three replications in the experimental field of the Department of Plant Breeding and Genetics, at the University of Agriculture Faisalabad, Pakistan. The row-to-row and plant-to-plant distances were maintained at 75 cm and 30 cm, respectively. Morphological traits such as plant height, young fruit diameter, mature fruit diameter, mature fruit length, number of fruits per plant and fruit diameter were recorded. Analysis of variance showed significant differences among all the genotypes under study. The results revealed that genotypes obtained from Vegetable Research Institute AARI, Faisalabad had the highest mean young fruit diameters among all the genotypes. Genotype collected from Grain Market (Jarawala) had the highest mean mature fruit length among all the genotypes. The genotype obtained from Vegetable Research Institute AARI, Faisalabad also had the highest mean number of fruits per plant and highest mean fruit weight as well. The collected data were statistically analyzed through ANOVA, HSD test, and mean graphs to determine and visualize the significance of genetic variation among genotypes. These findings provide valuable insights for okra breeders in identifying promising genotypes for future breeding programs.

KEYWORDS
Nutrition quality, Fruit diameter, Morphological variability, Fruit weight.

1 |INTRODUCTION

Okra is a popular vegetable crop belonging to Malvaceae family and is also known as lady finger and 'bhindi' in Pakistan (Athira and Jayaraman, 2018). It is known for its nutritional value and culinary versatility (Singh et al*.,* 2018). The quality of seeds used for cultivation plays a crucial role in determining the success and productivity of the crop. The variation in seed sources, including original seeds and adulterated or commercially marketed seeds, can have a profound impact on the growth, development and overall performance of the Okra plant. One of the key factors that influence the successful cultivation of okra is the quality of the seeds used for planting (Joshi et al*.,* 2015). Among the different factors that affect seed quality, the source of the seeds is of particular significance (Liu *et al.,* 2021). The seeds have been utilized as a neurological and digestive aid in addition to having soothing and antispasmodic qualities **(**Das et al*.,* 2019; Qasem, 2020).

Seed source variation refers to the differences in seed characteristics that arise from different geographical locations, seed production practices, or seed lots (Jemal et al., 2022). These variations can affect the morphological attributes of the seeds, their germination behavior and early seedling growth which in turn can impact the overall performance of the crop. Original seeds, obtained from reliable sources such as local farmers or seed banks, hold immense value in preserving genetic diversity (Wambugu et al., 2023). These seeds are often the result of careful selection and preservation by generations of farmers who had developed unique strains adapted to local growing conditions. Original seeds exhibit a wide range of genetic traits, making them valuable resources for breeding programs and crop improvement initiatives (Gramazio et al., 2023).

Adulterated seeds refer to those that are counterfeit, mixed with lower-quality seeds or genetically modified

without proper authorization (Ferreira et al., 2023). These seeds are often produced and sold for their commercial value, focusing primarily on factors such as yield and uniformity. However, the use of such seeds can lead to a loss of genetic diversity, increased vulnerability to diseases and pests and a reduction in overall crop quality.

Okra is propagated mainly by seeds and the quality of the seeds can had a significant impact on the growth and development of the plants (Abd El-Raouf et al., 2023). Seed source variation is a key factor that can affect the morphology, germination and growth of okra seedlings. Despite the wide variety of applications for this species, little information is available about many aspects of it. When determining the capacity of a plant for producing high-quality seeds, environmental variables, in conjunction with genetic and physiological factors play a vital influence. It would indicate that these traits are subject to significant genetic regulation.

Sabaz Pari is the only approve variety that is being sold by various Punjab seed companies mixed with different varieties. However, little is known about the extent of seed source variation in okra, particularly in the "Sabaz Pari" variety. The aim of the current study is to evaluate the variations among the various morphological, germination, and seedling characteristics of Sabaz Pari okra seeds collected from various sources.

The objective of the study is to evaluate the seed source variation in variety Sabaz Pari morphological trait under field condition.

2 METERIAL AND METHOD

The study involved the collection of seeds of 14 varieties of okra marketed as Sabaz Pari, along with the standard variety Sabaz Pari, from Ayub Agriculture Research Institute, Faisalabad, Pakistan (Table 1). These fourteen varieties seeds were sown in a randomized complete block design (RCBD) with three replications in the experimental field of Department of Plant Breeding and Genetics, at the University of Agriculture Faisalabad, Pakistan during the kharif season of 2022. The row-to-row and plant-to-plant distances were maintained at 75 cm and 30 cm, respectively. For each of these traits, 5 plants were selected from each variety and the measurements were taken at the appropriate growth stage. The data collected from each replication were recorded and the mean value for each variety was calculated.

The following morphological traits of each okra plant were recorded:

1. Plant Height (cm)

The height of each plant was measured from the base of the stem to the tip of the main stem using a measuring tape at maturity stage.

Table 1: Okra genotypes used in the experiment

Genotype Code	Area	Seed Source / Company name
G1	Jarawala	Grain market
G2	Jarawala	Grain market
G3	Hafizabad	Farmer seed
G4	Hafizabad	Bandesha seeds
G5	Makhdoom Aali	Durga seed
G6	Vehari	Agri tech
G7	Lodhran	Grain market
G8	Okara	Grain market
G9	Dhnot	Green Gold
G10	Faisalabad	Vegetable Research Institute, AARI, Faisalabad
G11	Dunya Pur	Asia Seed
G12	Bastimalook	Super Seeds
G13	Bastimalook	Reco Seeds
G14	Jhang	Grain market
G15	Dunya pur	Anmol Seeds

2. Young Fruit Diameter

The diameter of each young fruit was measured using a vernier calliper and five plants were selected to record the data in each replication.

3. Mature Fruit Diameter

The diameter of each mature fruit was measured using a vernier calliper and five plants were selected to record the data in each replication.

4. Mature Fruit length

The length of each mature fruit was measured using a calliper and five plants were selected to recorded the data in each replication.

5. Number of Fruits per Plant

The total number of fruits were counted on each plant under observation. Five representative plants were sampled from each genotype. Both ripening and ripened fruits were counted at time of observation. Multiple counts were taken during fruiting season and were taken the average.

6. Weight of Fruit (g)

Ten fruits from different parts of each plant were randomly selected. Each fruit individually weighed using a digital weighing balance. Weight was recorded in grams (g). The average fruit weight was calculated for each plant by taking the total weight divided by number of fruits weighed. Average was taken of 5representative plants per genotype or variety.

Data Analysis

The data collected from the field and laboratory

experiments were analyzed using appropriate statistical tools. To determine the significance of the observed variations, the data was subject to analysis of variance (Steel et al*.,* 1997) using a software package, such as Statistix 12.0. Tukey's test was performed for pairwise comparison of mean of each character.

3 RESULTS & DISCUSSION

The analysis of variance results showed significant differences among the okra genotypes for most of the morphological traits evaluated.

1. Plant Height (cm)

The analysis of variance (Table 2) showed the variability among the 15 different okra genotypes. The analysis showed that the variation in plant height among the different okra genotypes was highly significant ($p<0.01$). This suggested that the different genotypes had a significant impact on plant height under field conditions.

The Table 3 presented the mean values of plant height for different genotypes of okra (Sabaz Pari) obtained from 15 different sources in the market. Additionally, the table provided homogeneous groups based on the Tukey HSD test, which helped to determine whether the mean values were statistically significant or not (Wambugu et al., 2023).

Genotypes obtained from Grain Market (Jarawala) had mean heights of 122.81 and 119.40 respectively, which belonged to homogeneous group AB. This implies that their heights were not significantly different from each other, but they may differ from the genotypes in group A. Genotypes obtained from Framer Seed (Hafizabad), Grain Market (Jarawala), Durga Seed (Hafizabad) had progressively lower mean heights and they belonged to the homogeneous groups ABCDE, BCDE, BCDE respectively. This indicated that their heights were not significantly different within each group but may differ from the genotypes in the previous groups. Genotype obtained from Asia had the lowest mean height (110.74) and was placed in homogeneous group E, suggesting that its height was not significantly different from the other genotypes in the same group, but it may differ from those in the previous groups (Fig. 1).

2. Young Fruit Diameter

The results of the analysis of variance conducted showed the young fruit diameter of 15 okra genotypes under field conditions (Table 2). The analysis showed that the variation in young fruit diameter among the different okra genotypes was highly significant ($p<0.01$). This indicated that the genotypes had a significant impact on the diameter of the young fruits under field conditions (Gramazio et al., 2023).

Table 3 presented the mean values of the young fruit diameter for different genotypes of okra (Sabaz Pari) obtained from fifteen different sources in the market. It also provided homogeneous groups based on the Tukey HSD test which helped determine whether the mean values were statistically significant or not.

Table 2: Analysis of variance of fifteen okra genotypes for morphological traits

Sources of Variance	Plant height	young fruit diameter	mature fruit diameter	mature fruit length	no. of fruits per plant	weight of fruits
Replication	100.331	0.000002	0.034	13.8889	58.289	10138.700
Genotype	68.206	0.06848	0.039	7.6889	27.927	8976.100
Error	6.873	0.01061	0.007	1.8889	0.146	24.000

Table 3: The mean comparison of different okra genotypes using Tukey (HSD) Test

Genotype	Plant height	Young fruit diameter	Mature Fruit Diameter	Mature fruit length	No. of fruits per plant	Weight of fruits per plant
1	119.40 ABCD	1.52 A	1.76D	13.33 ABC	23.00 B	305.02 C
2	118.11 BCDE	1.53 A	1.77 CD	16.00 A	22.00 B	287.20 D
3	118.98 ABCD	1.34 ABC	1.88ABCD	12.67 ABC	26.33 A	368.54 A
4	120.32 ABC	1.46 AB	2.01ABCD	13.67 ABC	19.00 CD	218.68 F
5	117.14 BCDE	1.37 AB	1.95ABCD	11.00 BC	18.33 DE	211.9 F
6	123.31 AB	1.27 ABC	2.05 AB	13.00 ABC	20.00 C	347.1 B
7	122.81 AB	1.03 C	2.05 AB	11.00 BC	23.00 B	316.35 C
8	126.23 A	1.51 A	2.05 AB	11.00 BC	18.33 DE	220.69 F
9	115.67 BCDE	1.35 AB	1.87ABCD	13.33 ABC	20.00 C	247.81 E
10	113.58 CDE	1.55 A	2.06 A	14.67 AB	26.33 A	372.59 A
11	110.74 E	1.27 ABC	2.02 ABC	13.33 ABC	17.33 E	252.9 E
12	113.25 CDE	1.24 ABC	1.80 BCD	10.67 BC	20.00 C	282.54 D
13	111.80 DE	1.44 AB	1.77 CD	12.33 ABC	19.00 CD	277.04 D
14	111.71 DE	1.47 AB	1.93ABCD	13.33 ABC	18.33 DE	281.99 D
15	113.01 CDE	1.17 BC	1.96ABCD	10.33 C	25.33 A	362.65 A

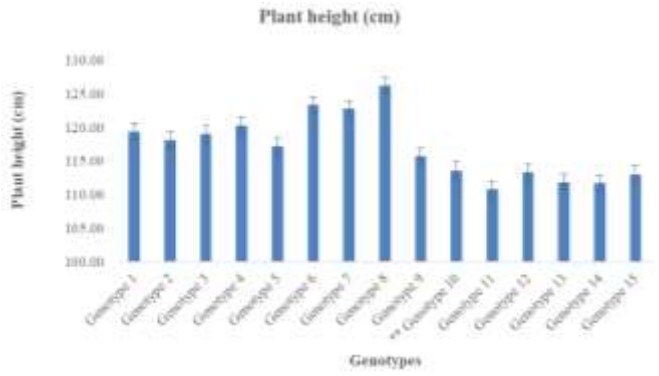

Fig. 2.1: Variation of plant height among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (**)

Genotypes obtained from Vegetable Research Institute AARI, Faisalabad and Grain Market (Jarawala) had the highest mean young fruit diameters among all the genotypes (1.55, 1.53, 1.52 and 1.51, respectively) and belonged to the same homogeneous group “A”. This suggested that their diameters were not significantly different from each other.

Genotypes obtained from Grain Market (Jhang), Bandesha Seeds (Hafizabad), and Reco seed (Bastimalook) had mean diameters of 1.47, 1.46, 1.44, 1.37, 1.35 respectively, which belonged to the homogeneous group “AB”. This implies that their diameters were not significantly different from each other but may differ from the genotypes in group A (Fig. 2).

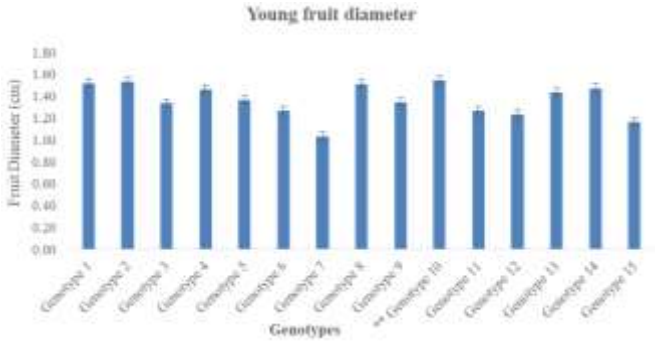

Fig. 2.2: Variation of young fruit diameter among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (**)

3. Mature Fruit Diameter

Table 2 represents the results of a variance analysis conducted on the mature fruit diameter of fifteen okra genotypes under field conditions. The p-value associated with the F-calculated value determined the statistical significance of the genotype factor. This suggested that the genotypes had a significant impact on the diameter of the mature fruits under field conditions (Gramazio et al., 2023).

Table 3 presents the mean values of the mature fruit diameter for different genotypes of okra (Sabaz Pari) obtained from 15 different sources in the market. Genotype obtained from Vegetable Research Institute AARI, Faisalabad had the highest mean mature fruit diameter among all the genotypes (2.06) and was placed in homogeneous group “A”. This suggested that its diameter was not significantly different from the other genotypes in the same group. Genotypes obtained from Grain Market (Okara), Grain Market (Lodhran), and Grain Market (Agri Tech) had mean diameters of 2.05 and belonged to the homogeneous group “AB”.

This indicated that their diameters were not significantly different from each other but may differ from the genotypes in group A. Genotypes obtained from Asia Seed (Dunya pur), Baudesha Seeds (Hafizabad), and Anmol Seed (Dunya pur) had progressively lower mean diameters (2.02, 2.01, 1.96 and 1.95, respectively) and belonged to homogeneous group ABCD. This implies that their diameters were not significantly different within the group but may differ from the genotypes in the previous groups.

Genotypes obtained from Grain Market (Jhang), Famer Seed (Hafizabad), Green Gold (Dhnot), and Super seeds (Bastimalook) had further lower mean diameters and belonged to the homogeneous groups ABCD, ABCD, ABCD, BCD, CD, CD and D, respectively. This indicated that their diameters were not significantly different within each group but may differ from the genotypes in the previous groups. However, there were statistically significant differences in mean diameters between different homogeneous groups (Liu et al., 2021). This information can be useful in comparing the performance of different okra genotypes and selecting those with desirable mature fruit diameters for further cultivation or breeding purposes (Fig. 3).

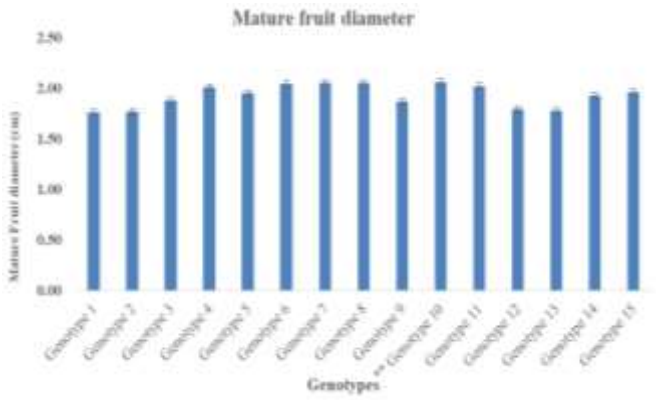

Fig. 2.3: Variation of mature fruit diameter among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (**)

4. Mature Fruit Length

The Table 2 presented the results of a variance analysis conducted on the mature fruit length of 15 okra genotypes under field conditions. P-value suggested that the genotypes had a significant impact on the length of the mature fruits under field conditions.

Mean values of the mature fruit length (Table 3) for different genotypes of okra (Sabaz Pari) were obtained from 15 different sources in the market (Joshi et al., 2015). The genotype obtained from Grain Market (Jarawala) had the highest mean mature fruit length among all the genotypes (16.00) and was placed in homogeneous group A. This suggested that its length was not significantly different from the other genotypes in the same group. Genotypes obtained from Vegetable Research Institute AARI, Faisalabad, Baudesha seeds (Hafizabad) and Agri tech (Vehari) had mean lengths ranging from 14.67 to 13.00 and belonged to homogeneous group ABC. This indicated that their lengths were not significantly different within the group but may differ from the genotypes in the previous groups (Liu et al., 2021).

Genotypes obtained from Farmer seed (Hafizabad) and Reco seed (Bastimalook) had mean lengths of 12.67 and 12.33, respectively, and were placed in homogeneous group ABC. This suggested that their lengths were not significantly different from the genotypes in the same group but may differ from the genotypes in the previous groups. Genotypes obtained from Durga Seeds (Makhdoom Aali), Grain Market (Lodhran) and Grain Marker (Okara) had mean lengths of 11.00 and belonged to homogeneous group BC. This implies that their lengths were not significantly different within the group but may differ from the genotypes in the previous groups.

Genotypes Super Seed (Bastimalook) 12 and Anmol Seeds (Dunya pur) had the lowest mean lengths (10.67 and 10.33, respectively) and were placed in homogeneous groups BC and C, respectively. This indicated that their lengths were not significantly different within each group but may differ from the genotypes in the previous groups. However, there were statistically significant differences in mean lengths between different homogeneous groups. This information can be useful in comparing the performance of different okra genotypes and selecting those with desirable mature fruit lengths for further cultivation or breeding purposes (Fig. 4).

5. Number of fruits per plant

The results of analysis of variance of the number of fruits per plant of 15 okra genotypes under field conditions was given in Table 2. P-value suggested that the genotypes had a significant impact on the number of fruits per plant under field conditions.

The Table 3 presented the results of a Tukey HSD test comparing the mean number of fruits per plant for 15 different okra genotypes collected from various sources in the market. Genotypes obtained from Framer seed (Hafizabad), Vegetable Research Institute AARI 3, 10 and Anmol Seed (Dunya pur) had the highest mean number of fruits per plant, with values of 26.33, 26.33 and 25.33 respectively. They belonged to group A, indicating their means were not significantly different. Genotypes obtained from Grain Market (Jarawala) and Grain Market (Lodhra) formed group B with means ranging from 23.00 to 22.00 fruits per plant. Their means were statistically similar but lower than group A. Genotypes obtained from Agri tech (Vehari), Green Gold (Dhnot) and Super seed (Bastimalook) had means of 20.00 fruits per plant. They were assigned to group C, having similar means amongst each other but lower than groups A and B. Genotypes obtained from Framer seed (Hafizabad) and Vegetable Resaerch Institute AARI both had the highest mean value of 26.33 fruits per plant. Genotype obtained from Anmol Seed (Dunya pur) had the third highest mean of 25.33 fruits per plant. Genotype obtained from Grain Market (Jrawala) had a mean of 23.00 fruits per plant. And genotype obtained from Grain Market (Lodhra) also had a mean of 23.00 fruits per plant. Genotype obtained from Asia Seed (Dunya pur) which had the lowest mean value of 17.33 fruits per plant. Genotype obtained from Grain Market (Jhang) which had a mean of 18.33 fruits per plant (Fig. 5).

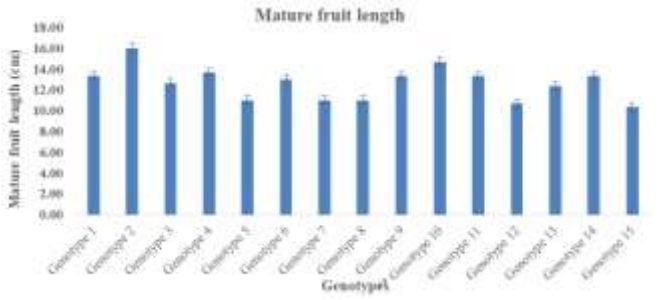

Fig. 2.4: Variation of mature fruit length among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (**)

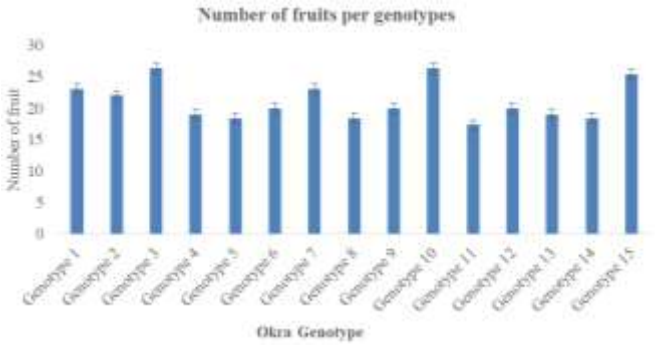

Fig. 2.5: Variation of no. of fruits per plant among fifteen okra genotypes collected from market sold as Sabaz Pari including original variety (**)

6. Weight of Fruit (g)

Table 2 presented the results of a variance analysis conducted on the weight of fruit of 15 okra genotypes under field conditions. P-value suggested that the genotypes had a significant impact on the weight of fruit under field conditions (Ferreira et al., 2023).

Table 3 presented the results of a Tukey HSD test comparing the mean weight of fruits per plant for 15 different okra genotypes. Genotypes obtained from Vegetable Research Institute AARI, Faisalabad, Farmer seed (Hafizabad) and Anmol Seeds (Dunya pur) had the highest mean fruit weights, with values of 372.59g, 368.54g and 362.65g respectively. They belonged to group 'A', indicating their means were statistically similar. Genotype 6 had a slightly lower mean weight of 347.1g and was assigned to group 'B'. The genotype obtained from the Vegetable Research Institute AARI, Faisalabad had the highest mean value of 372.59g (Fig. 2.6). The genotype obtained from Farmer seed (Hafizabad) had the second-highest mean of 368.54 g and the genotype obtained from Anmol seed (Dunya pur) had the third-highest mean of 362.65g. The genotype obtained from Baudesha seed (Hafizabad) had a mean of 218.68 g. The analysis showed significant variation in fruit weight per plant across the genotypes (Singh et al., 2018). Genotypes obtained from Vegetable Research Institute AARI, Faisalabad, Farmer Seed (Hafizabad) and Anmol seeds (Dunya pur) had the heaviest fruits (Fig. 6).

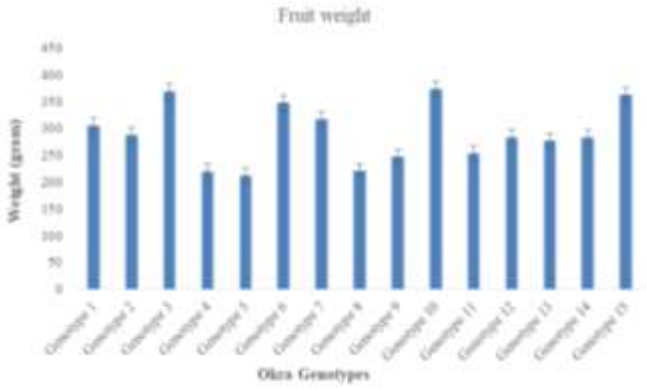

Fig. 6: Variation of weight of fruits per plant among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (Genotype 10)

Conclusion

Okra (*Abelmoschus esculentus*) is an important vegetable crop grown for its nutritious pods. The quality of seeds used for cultivation plays a crucial role in determining the performance and productivity of okra. Seed source variation refers to differences in seed characteristics arising from geographical location, seed production practices, or seed lots. An analysis of variance (ANOVA) was performed on the collected data to ascertain the significance of the genotype-to-genotype differences. There were notable variations between the traits. Genotype collected from Grain Maket (Jarawala) had the highest mean heights and young fruit diameter. Genotype Farmer Seed (Hafizabad) and seed obtained from Vegetable Research Institute AARI, Faisalabad had the highest mean number of fruits per plant and highest mean fruit weights. Overall, the study provided valuable insights into the morphological variability among 15 okra genotypes collected from several sources sold as Sabaz Pari in the market. The findings can contribute to the selection of genotypes with desirable traits for breeding and crop improvement purposes.

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