



# Genetic Variability among Different Okra Genotypes for different Seedling Traits

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## Abstract

Okra belongs to the Malvaceae family and is known by various common names such as lady's finger, gumbo, and bhindi. Okra has been consumed for centuries and is a staple in many culinary traditions, particularly in tropical and subtropical regions. The seed of the only approved variety 'Sabaz Pari' in Pakistan is mixed and distributed among the farmers. To evaluate its characteristics an experiment was carried out in the laboratory of the University of Agriculture, Faisalabad to study genetic variability for different seedling traits of 14 varieties of okra marketed as Sabaz Pari, collected from Ayub Agriculture Research Institute. The same varieties were sown in a completely randomized design (CRD) in a laboratory with three replications, using a sand and soil mixture as the growing media. Seedling traits such as root length, shoot length, leaf width, leaf length, fresh weight of root, dry weight of root, fresh weight of shoot, dry weight of shoot and germination percentage were recorded. Data recording was conducted after 40 days in each replication by randomly selecting three plants. Analysis of variance showed significant difference among all the okra genotypes under study. Results showed Genotypes obtained from different sources showed the significant variations for different traits. These findings help okra breeders to select viable genotypes for future breeding plan

## KEYWORDS

Vegetable crop, Okra genotypes, Germination percentage, Yield.

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## 1 | INTRODUCTION

Okra has been consumed for centuries and is a staple in many culinary traditions, particularly in tropical and subtropical regions (Gemede et al., 2015). The okra in Pakistan is known by the name of "bhindi" and it is represented by a species called *A. esculentus*. It is widely planted throughout the nation's plains, especially within the provinces of Punjab and Sindh and therefore is prized for providing growers with a good source of revenue (Hussain et al., 2019; Elkhalifa et al., 2021). Okra pods that are completely mature and ripe can occasionally have their seeds used as poultry feed. Okra seeds had been used to extract edible oil on a limited scale and as a substitute for coffee.

Understanding the extent and nature of seed source variation in okra is crucial for making informed decisions about seed selection, seed sourcing strategies and crop management practices (Anjum et al., 2017). In recent years, there has been increasing interest in studying the seed source variation in okra, with a focus on specific varieties. One such variety is "Sabaz Pari," which is known for its unique characteristics and has gained popularity among farmers and consumers alike. A wide range of genetic traits are exhibited by the original seeds of Okra that make those seeds a valuable resource for crop improvement through breeding program (Gramazio et al., 2023). They offer the potential for developing Okra varieties that are better adapted to specific environmental conditions, more resistant

to pests and diseases and possess desirable agronomic traits. On the other hand, the use of adulterated or commercially marketed seeds can had detrimental effects on okra cultivation.

Avoiding the use of adulterated seeds is crucial to maintain the integrity of the Okra crop and safeguard the interests of farmers. Adulterated seeds not only compromise the genetic diversity of Okra but also contribute to the erosion of traditional varieties and the loss of valuable agronomic traits. Additionally, the use of unauthorized genetically modified seeds may raise ethical and environmental concerns.

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.

Understanding how genetic variability affects the many characteristics of okra can be a useful tool in enhancing the crop. This will enhance the identification of pertinent genes and their behavior, which is a benefit of the hybridization attempt. *Abelmoschus* species that are raised have a significant genetic diversity (Sun et al., 2023).

Okra germplasm varies more in terms of the number of days until flowering, plant height and various fruit characteristics. Therefore, these characteristics may be crucial for identifying various *A. esculentus* types (Asare et al., 2016). It is anticipated that there would be a large amount of genetic variation in the Sabaz Pari population (Ijaz et al., 2015).

The only approved variety, namely Sabaz Pari is grown in Punjab seed companies are being sold mixed with different varieties to the farmers. However, the information about the extent of seed source variation in okra is very scarce, particularly in the "Sabaz Pari" variety. The goal of the current study is to evaluate the variation in the morphology, germination, and seedling characteristics of Sabaz Pari okra seeds collected from various sources under controlled conditions. The objective of the study was to evaluate the seed source variation in variety Sabaz Pari seedling trait under lab condition.

## 2 MATERIAL 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). The same varieties were sown in a completely randomized design (CRD) in a laboratory with three replications, using a sand and soil mixture as the growing media. Seedling traits such as root length, shoot length, leaf width, leaf length, fresh weight of root, dry weight of root, fresh weight of shoot, dry weight of shoot and germination percentage were recorded. Data recording was conducted after 40 days in each replication by randomly selecting three plants.

### Root Length (cm)

The length of each seedling's root was measured from the tip to the base of the root using a ruler.

**Table 1:** The 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

### Shoot Length (cm)

The length of each seedling's shoot was measured from the base of the stem to the tip of the highest leaf using a ruler.

### **Leaf Width (cm)**

For each seedling, the 3rd leaf from the apex was selected for width measurement. The width was measured at the widest point perpendicular to the midvein using a ruler. Multiple measurements were taken along the leaf and averaged to obtain the final leaf width.

### **Leaf Length (cm)**

The length of each seedling's leaf was measured from the base to the tip of the leaf using a ruler.

### **Fresh weight of root (mg)**

The weight of each seedling's root was measured immediately after removing it from the growing media using a precision balance.

### **Dry weight of root (mg)**

The weight of each seedling's root was measured after drying the root in an oven at 70°C until it reached a constant weight using a precision balance.

### **Fresh weight of shoot (mg)**

The weight of each seedling's shoot was measured immediately after removing it from the growing media using a precision balance.

### **Dry weight of shoot (mg)**

The weight of each seedling's shoot was measured after drying the shoot in an oven at 70°C until it reached a constant weight using a precision balance.

### **Germination Percentage**

The number of seeds that germinated from each variety was counted daily for a specified number of days after sowing. The percentage of seeds that germinated was calculated for each variety.

### **Data Analysis**

The data collected from laboratory experiments were analysed 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 will be performed for pairwise comparison of mean of each character.

## **3 RESULTS &**

### **1. Root length (cm)**

Table 2 presented the results of a variance analysis conducted on the root length of 15 okra genotypes under laboratory conditions. The analysis showed that the variation in root length among the different okra genotypes was highly statistically significant ( $p < 0.01$ ). This suggested that genotypes had a significant impact on the root length under laboratory conditions. The provided Table 3 presented the mean values of the root length for different genotypes of okra (Sabaz Pari) collected from 15 different sources in the market. It also provided homogeneous groups based on the Tukey HSD test which helped to determine whether the mean values were statistically significant or not (Athira and Jayaraman, 2018).

Based on the table, Genotypes 4 and 5 had the highest mean root lengths (Fig. 1) among all the genotypes (9.00 and 8.70, respectively) and were placed in homogeneous group A. This suggested that their lengths were not significantly different from each other. Genotypes obtained from Grain Market (Jarawala) had a mean length of 8.30

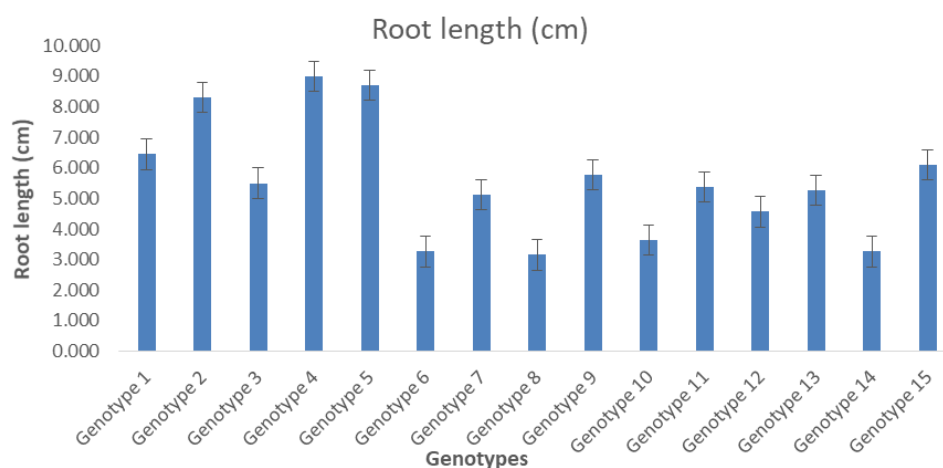
and was placed in homogeneous group AB. Genotypes obtained from Vegetable Research Institute, AARI, Faisalabad, Agri tech (Vehari), Grain Market (Jhang), and Grain Market (Okara) had the lowest mean lengths (ranging from 3.63 to 3.15) and were placed in homogeneous group F. This implies that their lengths were not significantly different within the group but may differ from the genotypes in the previous groups. The Tukey HSD analysis reveals that some genotypes of okra (Sabaz Pari) had similar mean root lengths, as indicated by their assignment to the same homogeneous 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 root lengths for further cultivation or breeding purposes.

**Table 2:** Mean square values for different traits in okra genotypes

Sources of Variance	of root length	Shoot length	leaf width	leaf length	Root weight	Fresh Root weight	dry shoot weight	fresh shoot weight	dry germination percentage
Replication									1.7259
Genotype	11.083	6.96263	0.93987	1.2676	0.00003	0.0000088	0.005403	0.0009	29.3186
Error	1.236	1.36273	0.31206	0.3125	0.00001	0.0000029	0.001076	0.0003	19.5341

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

Genotype	Root length	Shoot length	Leaf width	Leaf length	Root Fresh Weight	Root dry weight	Shoot fresh weight	Shoot dry weight
1	6.45 BC	9.22 DE	2.83 ABCD	3.11 ABCD	0.007 ABCDE	0.0027 BCDEF	0.090 BCD	0.040 BC
2	8.30 AB	11.13 BCD	3.47 A	3.87 A	0.004 DE	0.0023 CDEF	0.186 A	0.072 A
3	5.50 CD	9.68 DE	2.03 CDE	2.23 DE	0.003 DE	0.0020 DEF	0.062 DE	0.040 BCD
4	9.00 A	13.20 A	3.03 AB	3.40 AB	0.008 ABCD	0.0041 ABCDE	0.084 BCDE	0.023 CD
5	8.70 A	13.45 A	2.55 ABCD	3.07 ABCD	0.011 AB	0.0045 ABCD	0.117 BC	0.056 AB
6	3.26 F	11.04 BCD	1.95 DE	2.42 CD	0.004 DE	0.0018 DEF	0.085 BCDE	0.032 BCD
7	5.12 CDE	12.20 AB	2.27 BCDE	2.32 DE	0.004 DE	0.0016 EF	0.126 B	0.055 B
8	3.15 F	13.25 A	2.55 ABCD	2.53 BCD	0.003 E	0.0014 EF	0.042 DE	0.018 CD
9	5.77 CD	11.65 ABC	3.23 A	3.27 ABC	0.007 BCDE	0.0046 ABCD	0.048 DE	0.022 CD
10	3.63 EF	11.14 BCD	2.30 BCDE	2.53 BCD	0.004 CDE	0.0015 EF	0.042 DE	0.025 CD
11	5.38 CDE	8.53 E	2.03 CDE	2.49 BCD	0.004 DE	0.0024 CDEF	0.037 DE	0.019 CD
12	4.57 DEF	10.75 BCD	2.90 ABC	2.85 BCD	0.012 A	0.0065 A	0.063 CDE	0.052 AB
13	5.27 DE	9.81 CDE	1.44 E	1.44 E	0.009 ABC	0.0054 AB	0.031 E	0.013 D
14	3.26 F	11.91 AB	2.14 BCDE	2.43 CD	0.008 ABCD	0.0050 ABC	0.036 DE	0.022 CD
15	6.10 CD	12.69 AB	3.02 AB	3.85 A	0.002 E	0.0012 F	0.071 CDE	0.033 BCD



**Fig. 1:** Variation of root length among fifteen okra genotypes collected from market sold as SabazPari including one original variety (Genotype 10).

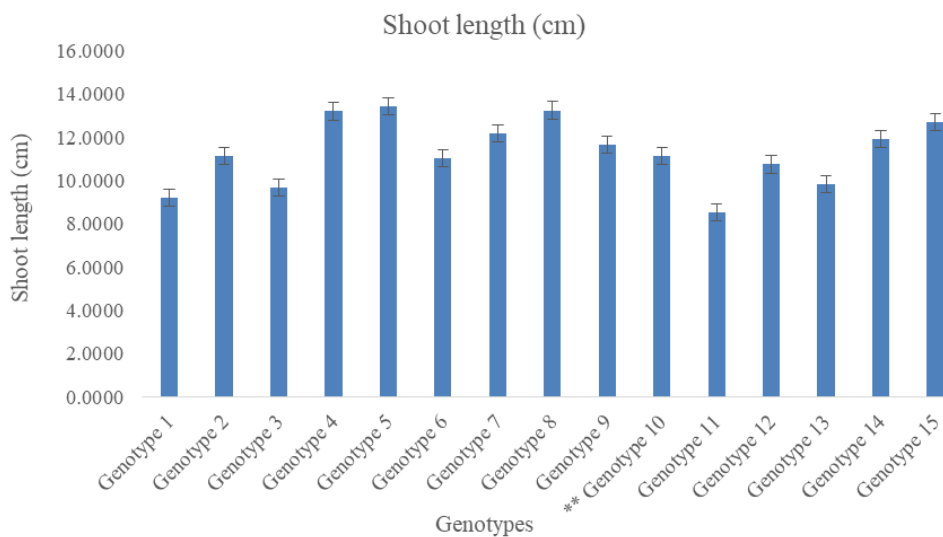
## 2. Shoot Length (cm)

Table 2 presented the results of a variance analysis conducted on the shoot length of fifteen okra genotypes under laboratory conditions. The analysis showed that the variation in shoot length among the different okra genotypes was highly statistically significant ( $p < 0.01$ ). This suggested that the genotypes had a significant impact on the shoot length under laboratory conditions.

The Table 3 presented the mean values of shoot length for different genotypes of okra (Sabaz Pari) collected

from 15 different sources in the market (Table 3). It also provided homogeneous groups based on the Tukey HSD test which helped to determine whether the mean values were statistically significant or not. The table lists the genotypes along with their corresponding mean shoot lengths. For example, genotypes obtained from Durga seed (Makhdoom Aali) had a mean length of 13.45, genotype obtained from had a mean length of 13.25 and so on. The homogeneous groups were indicated by letters (A, B, C, D, E) in the table. Genotypes with mean values that shared the same letter were considered statistically non-significant, meaning their mean lengths were not significantly different from each other.

Genotypes obtained from Durga seed (Makhdoom Aali), Grain Market (Lodhran) and Bandesha seed (Hafizabad) had the highest mean shoot lengths among all the genotypes (13.45, 13.25 and 13.20, respectively) and were placed in homogeneous group A. This suggested that their lengths were not significantly different from each other. Genotypes obtained from Anmol seeds (Dunya pur), Grain Market (Lodhran), and Grain Mraket (Jhang) had mean lengths ranging from 12.69 to 11.91 and belonged to homogeneous group AB. This indicated that their lengths were not significantly different within the group, but they may differ from genotypes in other groups. This suggested that its length was significantly different from the lengths of genotypes in the previous groups (Fig. 2).



**Fig. 2:** Variation of shoot length among fifteen okra genotypes collected from market sold as SabazPari including one original variety (\*\*).

### 3. Leaf Width (cm)

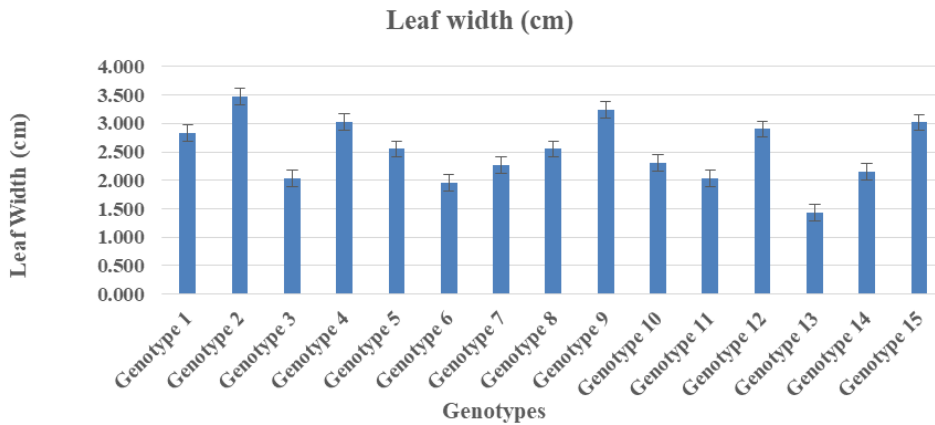
The Table 2 showed the results of a variance analysis conducted on the leaf width of 15 okra genotypes under laboratory conditions. The analysis showed that the variation in leaf width among the different okra genotypes was statistically significant ( $p < 0.05$ ). This suggested that the genotypes had a significant impact on the leaf width under laboratory conditions.

The provided Table 3 presented the results of a mean comparison (Tukey HSD) analysis conducted on the leaf width of okra (Sabaz Pari) genotypes collected from fifteen different sources in the market. Based on the analysis, the genotypes can be divided into several homogeneous groups: Group A: Genotypes obtained from Grain Market (Jarawala) and Green Gold (Dhnot) had the highest mean leaf width values and were not significantly different from each other. Group AB: Genotypes obtained from Bandesha seeds (Hafizabad), Anmol seeds (Dunya pur) and Super seeds (Bastimalook) had similar mean leaf width values and were not significantly different from each other.

The groups with the same letter were not statistically significantly different, indicating that the mean leaf widths of genotypes within each group were similar and likely to occur by chance alone. The analysis revealed the variation in leaf width among the different okra genotypes collected from the market. It identified groups of genotypes with similar mean leaf width values, providing insights into the diversity of leaf width in the studied okra genotypes (Fig. 3).

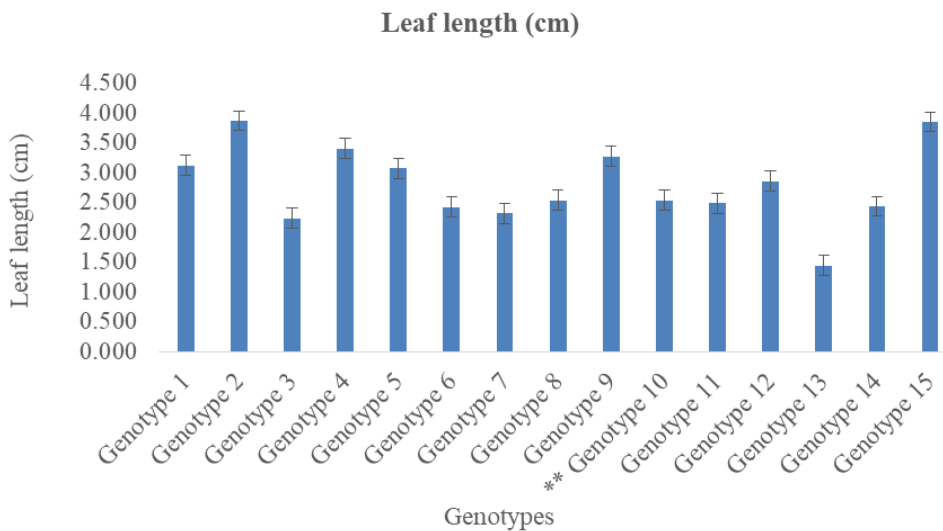
### 4. Leaf Length (cm)

The results of a variance analysis were conducted on the leaf length of 15 okra genotypes under laboratory conditions (Table 2). The analysis showed that the variation in leaf length among the different okra genotypes was statistically significant ( $p < 0.05$ ). This suggested that the genotypes had a significant impact on the leaf length under laboratory conditions.



**Fig. 3:** Variation of leaf width among fifteen okra genotypes collected from market sold as Sabaz Pari including original variety (Genotype 10)

The Table 3 presented the Mean comparison (Tukey HSD) of the leaf length of okra genotypes collected from fifteen different sources in the market. Homogeneous Groups indicated the groups of genotypes that had similar means and were not statistically significantly different from each other. The genotypes within each group showed the same letter. Group A: Genotypes obtained from Grain Market (Jaran wala) and Anmol seeds (Dunya pur) had statistically similar leaf lengths. Group DE: Genotypes obtained from Grain Market (Lodhran) and Farmer seed (Hafizabad) had statistically similar leaf lengths. Group E: Genotype Reco seed (Bastimalook) had a unique leaf length. It was important to note that genotypes within the same homogeneous group do not have statistically significant differences in their leaf lengths (Fig. 4).



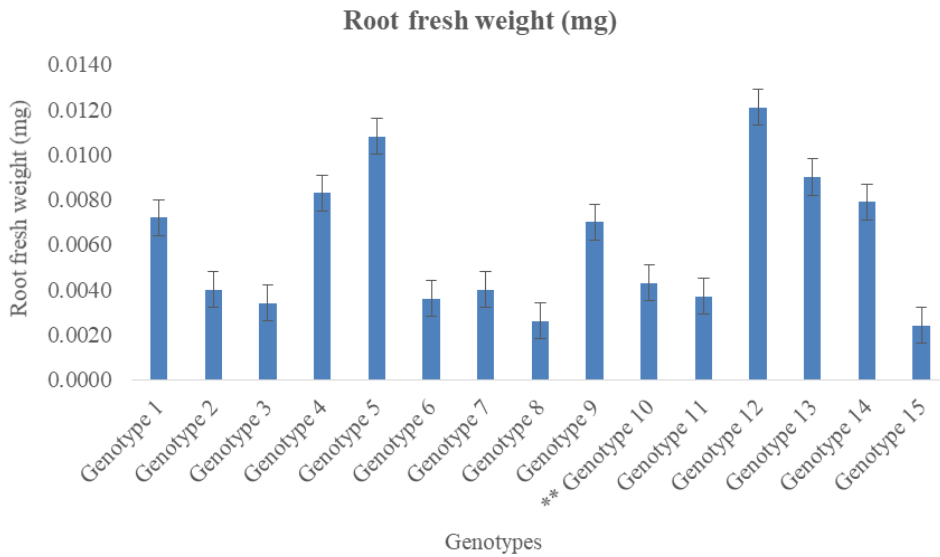
**Fig. 4:** Variation of leaf length among fifteen okra genotypes collected from market sold as SabazPari including one original variety (\*\*)

## 5. Root Fresh Weight (mg)

The results of the variance analysis showed for the root fresh weight of 15 okra genotypes under laboratory conditions. The genotypes significantly contribute to the variability in root fresh weight, as indicated by the significant F-calculated value ( $F = 3.290$ ) and the low p-value ( $p = 0.003$ ). The results suggested that the different genotypes significantly affect the root fresh weight of okra under laboratory conditions (Table 2).

The results of the Mean comparison (Tukey HSD) of the root fresh weight of okra (Sabaz Pari) genotypes collected from fifteen different sources in the market (Table 3). The column "Homogeneous Groups" indicated the groups of genotypes that had similar means and were not statistically different from each other. The genotypes within the same group shared the same letter. Genotypes obtained from Super seed (Bastimalook) had the highest mean (Fig. 2.5) root fresh weight (0.012) and was placed in Group A, indicating that it had the highest weight among all genotypes (Abd El-Raouf et al., 2023).

The results show that there were variations in root fresh weight among the different okra genotypes. Genotype obtained from Super seed (Bastimalook) had the highest weight, while genotypes with lower weights (Fig. 4.16) were distributed across different groups, indicating their lack of statistical significance when comparing their means (Fig. 5).

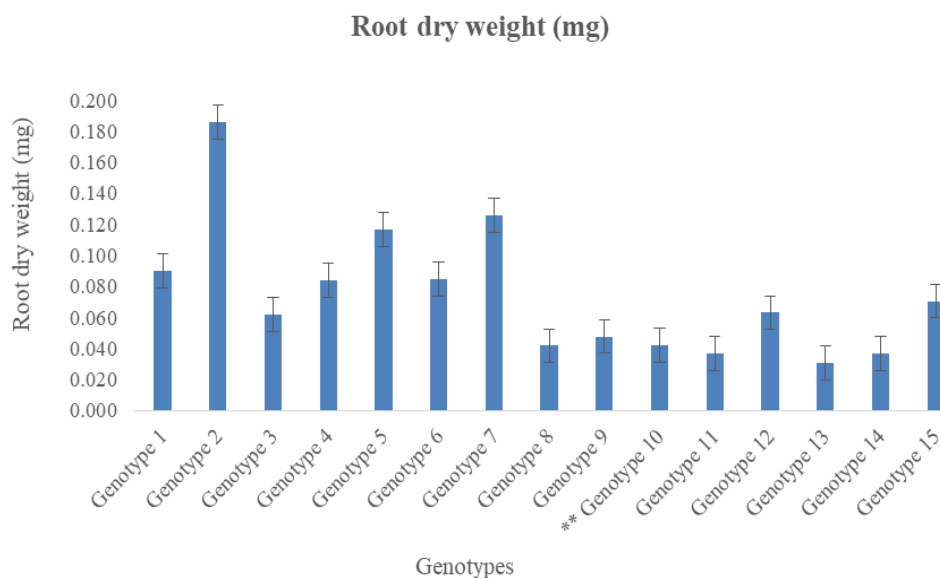


**Fig. 5:** Variation of root fresh weight among fifteen okra genotypes collected from market sold as SabazPari including one original variety (\*\*)

## 6. Root dry weight (mg)

The results of the variance analysis conducted on 15 okra genotypes for root dry weight under lab conditions (Table 2). Based on the results: The genotype factor showed a significant effect on root dry weight, as indicated by the F-calculated value of 2.94 and a corresponding p-value of 0.0065. The analysis demonstrates that the genotypes significantly contribute to the variation observed in root dry weight among the 15 okra genotypes tested under lab conditions.

Table 3 presented the mean comparison (Tukey HSD) results for the root dry weight of okra genotypes (Sabaz Pari) collected from 15 different sources in the market. The genotypes had been grouped into homogeneous groups based on their mean values. Genotypes with the same letter were not significantly different from each other in terms of root dry weight. Genotype obtained from Super seed (Bastimalok) had the highest mean root dry weight (0.0065) and belonged to Group A, indicating it had the highest dry weight compared to other genotypes. This suggested that they had similar root dry weights but were significantly different from the higher-ranked genotype (Group A). The mean comparison analysis reveals the variations in root dry weight among different okra genotypes. The genotypes were grouped based on their similarity in root dry weight and those sharing the same letter designation were not significantly different from each other (Fig. 6).

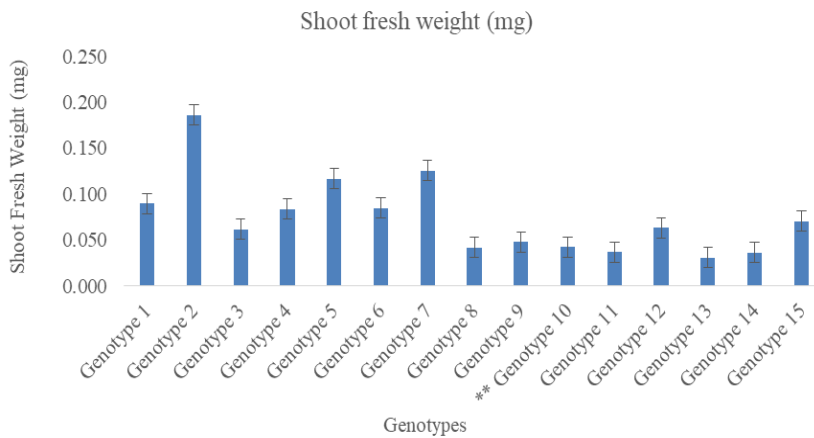


**Fig. 6:** Variation of root dry weight among fifteen okra genotypes collected from market sold as SabazPari including one original variety (\*\*).

## 7. Shoot fresh weight (mg)

The results of the variance analysis conducted on the shoot fresh weight of 15 okra genotypes under laboratory conditions (Table 2). The variance analysis reveals a significant effect of the genotype factor on shoot fresh weight. The calculated F-value of 5.02 was higher than the critical value, indicating that the differences observed in shoot fresh weight among the 15 okra genotypes were unlikely to occur by chance. The p-value of 0.0001 was lower than the significance level of 0.05, indicating that there was a highly significant difference in shoot fresh weight among the genotypes.

The Tukey HSD (Honestly Significant Difference) test was conducted on shoot fresh weight data of different okra genotypes (Table 3). The table provided information about the genotypes, their corresponding means and the homogeneous groups based on statistical significance. Genotypes within the same homogeneous group had shoot fresh weight means that were not significantly different from each other. Genotypes obtained from Grain Market (Jarawala) and Grain Market (Lodhran) had the highest shoot fresh weight means, with values of 0.186, and 0.126 respectively. The genotypes were then sorted in descending order of their means, from highest to lowest (Fig. 7).

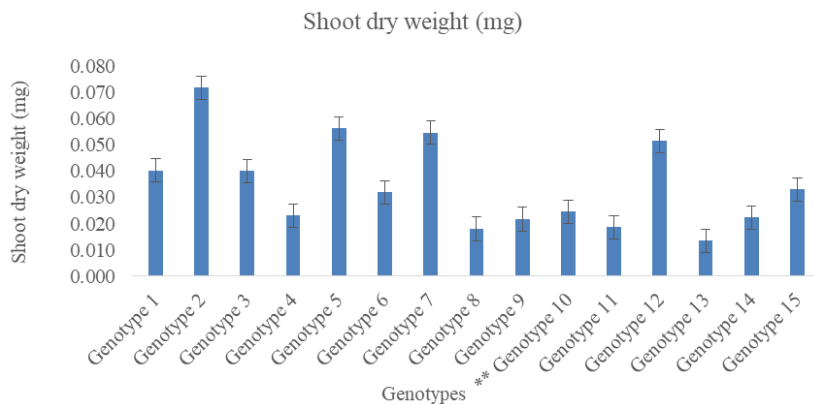


**Fig. 7:** Variation of shoot fresh weight among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (\*\*)

## 8. Shoot dry weight (mg)

The results of the variance analysis for the shoot dry weight of 15 okra genotypes under lab conditions were given in Table 2. The p-value of 0.002 was lower than the significance level of 0.05, indicating a significant difference in shoot dry weight among the genotypes. The results suggest that the okra genotypes exhibit variations in shoot dry weight under the given lab conditions and these differences were statistically significant.

The mean shoots dry weight of different okra genotypes (Sabaz Pari) collected from 15 different sources in the market are given in Table 3. The genotypes were ranked based on their mean values and they were assigned to homogeneous groups. The genotypes labeled with the same letter were considered statistically non-significant, indicating that their shoot dry weights were not significantly different from one another. From the results, genotype obtained from Grain Market (Lodhra) had the highest mean shoot dry weight (0.072 and was assigned to group A. However, it was important to note that the differences between genotypes within the same homogeneous group were not statistically significant (Fig. 8).

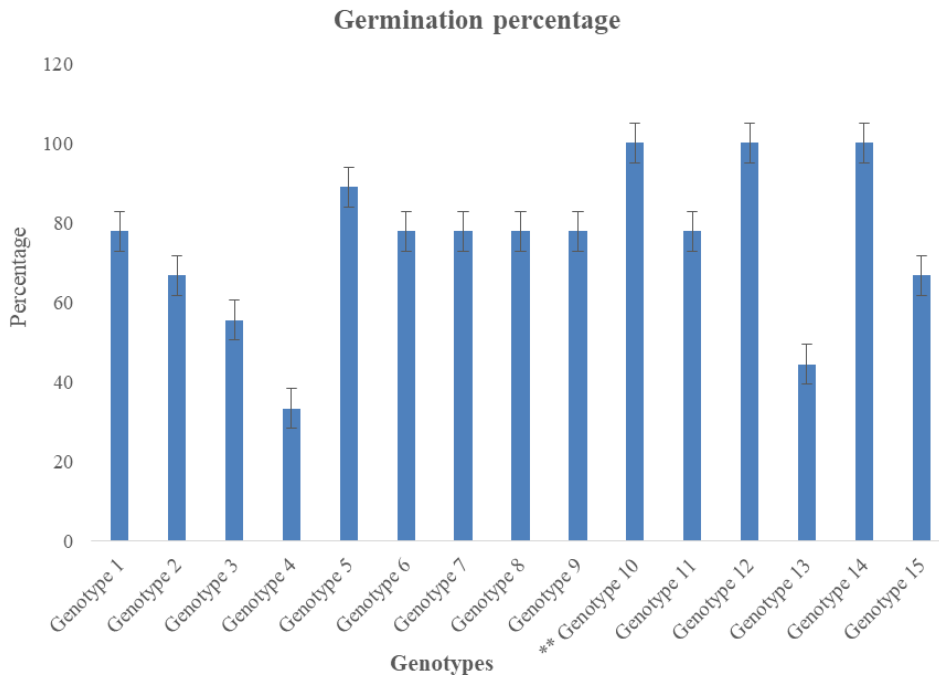


**Fig. 8:** Variation of shoot dry weight among fifteen okra genotypes collected from market sold as Sabaz Pari including one original variety (\*\*)

## 9. Germination Percentage

Table 2 showed the variance analysis of germination percentage for 15 different okra genotypes under lab conditions. The analysis suggested that the variation in germination percentage among the 15 okra genotypes under lab conditions was not statistically significant ( $p > 0.05$ ). This means that the differences observed in germination percentage were more likely due to random variability or other factors not considered in the analysis (Table 3).

The Fig. 9 presented the germination percentages for different genotypes of plants. This figure lists the different genotypes of plants, numbered from genotypes 1 to genotypes 15. Among the genotypes, the seed of genotype collected from Ayub Agriculture Research Institute Faisalabad was the original source of Okra (Sabaz Pari) while other genotypes seed collected from the market sources. The germination percentages range from 33.33% to 100% for the different genotypes. Genotypes obtained from Durga seed (Makhdoom Aali), Vegetable Research Institute, AARI, Faisalabad and Super seeds (Bastimalook) had 100% germination across all four conditions, indicating that all the seeds for these genotypes successfully germinated under each condition.



**Fig. 9:** Variation of germination percentage among fifteen okra genotypes; \*\* = Indicate the original and verified source of Sabaz Pari.

Information was provided about the germination percentages for different genotypes of plants under four different conditions. The data showed the variation in germination rates among the genotypes and provided insights into their germination performance under different environmental conditions.

## 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. Genotypes obtained from Bandesha seeds (Hafizabad) and Durga seed (Makhdoom Aali) had the highest mean root lengths. Genotypes obtained from Durga seed (Makhdoom Aali), Grain Market (Okara) and Bandesha seeds (Hafizabad) had the highest mean shoot lengths among all the genotypes. Genotypes obtained from Durga seed (Makhdoom Aali), and Reco seed (Bastimalook) had slightly lower root fresh weight. Genotype obtained from Super seeds (Bastimalook) had the highest mean root dry weight. Genotypes obtained from Grain Market (Jarawala), Grain Market (Lodhran) and Durga seed (Makhdoom Aali) had the highest shoot fresh weight means. 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.

## DECLARATIONS

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**Data Availability:** The data collected for this article are included in the article.

**Ethics Statement:** No prior study was conducted on live animals/humans; thus, it did not require any ethical approval.

**Author's Contributions:** AB and F designed the experiment and collect the data. TL analyzed the data and wrote the initial draft. Review and editing were performed by AB, F and RNS. All authors approved the final version of the manuscript.

**Generative AI Statements:** The authors declare that no Gen AI/DeepSeek was used in the writing/creation of this manuscript.

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