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Characterization of Turkish Edible Pea (*Pisum sativum* L.) Gene Resources and Their Utilisation in Breeding Programs

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ABSTRACT

Total 70 different genotypes sourced from local edible pea (*Pisum sativum* L.) populations were obtained from the Izmir gene bank and sown in the Eastern Mediterranean Agricultural Research Institute to morphologically characterize the genotypes. This trial was conducted in 2013. Morphological characterization studies were carried out according to the identification list published by IPGRI for peas and the UPOV feature document for peas. The characteristics of the pea plants and their seeds were examined and the differences between these characteristics were determined. It was aimed to determine the vegetative characteristics of the related pea populations, to assist selections of pre-breeding material and start breeding studies for cultivar development.

Plant height, first pod height, number of main branches and number of pods per plant of the examined pea populations were 32-135 cm; 17-85 cm; 1-4; 1-26, respectively. The number of full pods per plant, pod length, number of grains per plant, grain weight per plant and plot yields values were varied between 1-30; 3-9 cm; 2-118; 1-83 g and 50-434 kg/9 m^2, respectively. It was determined that the number of pods, number of full pods, number of grains, plant straw weight and plant grain weight were effective on the first main component. Seed color, pod length, seed color, hilum color and plot yield were found to be effective on the second main component. In the third main component, the effect of plant height and first pod height characteristics was determined. It was concluded that there are promising genotypes in terms of breeding, and selection work should be continued in these genotypes.

Keywords: Pea, genetic resources, morphological characterization

Introduction

Pea (*Pisum sativum* L.) is an important legume vegetable crop which is an essential component of human nutrition (Sapre et al., 2022). Due to the high protein content (23-33%), there is an interest in growing this crop as a source of protein for humans and animals (Renata et al., 2021). There has been an increasing demand for diverse and more functional plant-based protein ingredients for food uses (Shen & Li, 2021). Pea proteins are emerging as a popular alternative to those conventional (deriving from animal and soy) due to their high protein content with interesting functionality, sustainability, availability and affordability (Boukid et al., 2021). Among the legume family, peanuts and soybeans are considered as commonly allergenic and regulations in many countries require special labeling and manufacturing control measures for foods containing peanuts or soybeans or ingredients derived from those two legumes. Peas are also legumes but are not on the lists of priority allergenic foods, so special labeling and manufacturing control measures are not needed for peas or pea-based ingredients. Peas contain comparatively high levels of protein (Taylor et al., 2021).

Pea as a cool-season legume crop grown in more than 85 countries, is the second most important grain legume and one of the major green vegetables in the world. While pea was historically studied as the genetic model leading to the discovery of the laws of

genetics, pea research has lagged behind that of other major legumes in the genomics era, due to its large and complex genome. The evolving climate change and growing population have posed grand challenges to the objective of feeding the world, making it essential to invest research efforts to develop breeding tools to support fast and continuous development of improved pea varieties (Pandey et al., 2021).

Climate change shifts abiotic (high temperature stress, cold stress, frost, wind, drought) and biotic (pathogens, pests) stress factors, and threats agricultural productivity around the world (Shahzad et al., 2015). As biotic stresses, fungal diseases of rust, powdery mildew, root rots, common root rot, wilt and ascochyta blight are the widespread and severe for the pea crop at different growth stages. Among abiotic stresses, heat, drought and frost are frequent which reduce quantity and quality of the product. Genetic improvement for these traits is important and needed. Conventional and molecular breeding approaches may accelerate breeding programmes for improvements (Parihar et al., 2020).

In past, some local and international studies on local pea gene resources in Türkiye, which is very rich in pea gene resources, have been carried out. Continuous examination of these sources with new researches is highly important whose diversity is increasing every year in terms of agronomic and quality characteristics, with the target of utilizing them in breeding programs. There are 34 species of legumes and 7.443 samples in the Aegean Agricultural Research Institute National Gene Bank (Tan, 2010). Conservation and sustainable use of these genetic resources, to ensure production is necessary to reduce the effect of climate change. The loss of these resources will also pose a threat to global food security in the long term (Ferranti, 2016).

In this study, it was aimed to determine the morphological characteristics of these pea populations as pre-breeding materials before starting a breeding study for cultivar development.

Materials and Methods

Total 70 different genotypes sourced from local edible pea (*Pisum sativum* L.) populations were obtained from the National Seed Genebank (İzmir) (Table 1).

Genotypes were sown in the Eastern Mediterranean Agricultural Research Institute (Adana, Türkiye), under typical Mediterranean climatic conditions to morphologically characterize the genotypes. Sowing date was 8th December of 2012. Genotypes were randomly distributed in the plots where plots were including 4 rows each was at 5m length with 0,45 m interrow distance. Sowing was conducted on flat soil (no ridge) and fertilized with 25 kg N ha + 55 kg P_2O_5 in pure form which spread to plots as in DAP (18.46.0) form at pre-sowing stage. No pesticides were applied for pest and weed control. Weed control was done once by hand for weed control. Harvest date was 6th of July 2013. From each plot of 70 different populations, three plants representing the populations were selected and their characteristics were examined. Each parcel was harvested bulk for yield evaluations.

IBGRI (Anonymous, 1993) and UPOV (Anonymous, 2003) identification lists were used for characterization. Morphological characterization of plants during post-emergence stage was carried out according to the identification criteria determined by the International Plant Identification Center (IBGRI). To provide details on different form groups, the samples cropped in augmented design and the observed characters' data was analyzed by using Major Component Analysis (MCA), one of a multivariate analyzes (Tan, 1983), and the differences between the plant quantitative and qualitative characteristics were determined.

Results and Discussion

In terms of qualitative characteristics, the majority of the populations were in white seed color, round seed shape, yellow grain color and colorless hilum color class (Table 2).

In the analysis of sown seed characteristics, it was determined that the pea populations were round (54%), wrinkled (16%) and cornered (3%) in shape. It was observed that the harvested grain color was white (36%), green (24%), brown (23%), black (11%), yellow (3%) and brown-white (3%).

The grain color of the genotypes after sowing was determined to be yellow (35%), dark green (19%), green (17%), light green (7%), brown (2%) and purple (1%). Differences were detected for the ratios of sown seed colour and harvested grain colour. Reason of this change was that the grain color darkening during storage period. The hilum color of the genotypes was found to be colorless (74%) and black (26%).

In the study, agronomic characteristics of genotypes in field conditions were also determined, where the min, max and average values for each trait are given in Table 3.

Plant height, first pod height, number of main branches and number of pods per plant of the examined pea populations were 32-135 cm; 17-85 cm; 1-4; 1-26, respectively. The number of full pods per plant,

pod length, number of grains per plant, grain weight per plant and plot yields values were varied between 1-30; 3-9 cm; 2-118; 1-83 g and 50-434 kg/9 m^2, respectively. It was concluded that there are promising genotypes in terms of breeding and selection work should be continued in these genotypes.

Correlation Values Between Characters

The connection between the characteristics examined in the pea populations was investigated, and determined correlation values are given in Table 4.

According to the correlation analysis between the examined traits, the highest correlation (0.8) were found between plant height and first pod height. It was determined that there was a positive and significant relationships between the number of full pods and the number of empty pods on the number of pods per plant in order to increase the pea yield.

High level of significant correlations were found between plant height-first pod height; number of main branches-number of lateral branches; number of main branches-number of pods; number of lateral branches-number of pods; number of pods-number of grains, and plant seed weight-plot yield (Table 4).

Relationships between characters are important in revealing the feature emphasized in yield studies (Bozoğlu & Sözen, 2007). The most effective feature in determining the effects of the characters with each other is the climatic features (Ülker & Ceyhan, 2008; Mart, 2022a, 2022b, 2022c; Mart, 2023a; Mart et al., 2007a; Tugay Karagül et al., 2024).

The "Eigen Values of Major Components", "Percentage Variances" and "Percentage Cumulative Variance Values" among the investigated characteristics of the studied local pea populations are given in Table 5.

The main component percent variance values of the major three characteristics (plant height, first pod height and number of main branches) of the studied pea populations represent more than 50% of the pea genotypes. These three features were determined as important character traits to be considered in the differentiation of local populations among the features determined for the main component.

Conclusions

In this study, morphological characterization of local pea populations grown in Türkiye in winter in Eastern Mediterranean region was carried out. When the "distribution of pea populations in the main component", "weights in the first three main components" and "additives" were examined, it was determined that the number of pods, number of full pods, number of grains, plant straw weight and plant grain weight were effective on the first main component. Seed color, pod length, seed color, hilum color and plot yield were found to be effective on the second main component. In the third main component, the effect of plant height and first pod height characteristics was determined.

It is concluded that there are promising genotypes in terms of breeding and selection work should be continued in these genotypes.

Table 1. Pea Genotypes and Source Locations in Türkiye.

Record No	Location Province	Record No	Location Province	Record No	Location Province	Record No	Location Province
TR-33233	Çanakkale	TR-40710	Antalya	TR-49601	İzmir	TR-61284	Tekirdağ
TR-33238	Çanakkale	TR-40715	Antalya	TR-53742	Çanakkale	TR-61290	Tekirdağ
TR-33246	Çanakkale	TR-40682	Muğla	TR-53747	Çanakkale	TR-61298	Tekirdağ
TR-33372	Tekirdağ	TR-39061	Aydın	TR-53749	Tekirdağ	TR-61301	Giresun
TR-37374	Çorum	TR-39071	Muğla	TR-54386	Aydın	TR-61305	Denizli
TR-30686	Antalya	TR-43509	İstanbul	TR-54953	Tekirdağ	TR-61307	Tekirdağ
TR-30760	Adana	TR-43619	Sakarya	TR-54954	Tekirdağ	TR-61309	İzmir
TR-77732	Muğla	TR-43647	Sakarya	TR-61266	Tekirdağ	TR-61311	Edirne
TR-77733	Muğla	TR-26306	Muğla	TR-56016	Giresun	TR-32230	Muğla
TR-77735	Denizli	TR-42159	Hatay	TR-5478	Antalya	TR-61246	Kütahya
TR-77736	Muğla	TR-46023	Trabzon	TR-57120	Hatay	TR-61287	Çanakkale
TR-77737	Manisa	TR-44916	Adapazarı	TR-5479	İzmir	TR-67094	Tekirdağ
TR-80188	Aydın	TR-44939	İzmit	TR-58078	İzmir	TR-61431	Tekirdağ
TR-80189	Antalya	TR-46469	Gümüşhane	TR-71699	İzmir	TR-61324	Tekirdağ
TR-80192	Burdur	TR-49596	Antalya	TR-64147	Çanakkale	TR-69399	Tekirdağ
TR-80193	Burdur	TR-49598	Hatay	TR-61253	Çanakkale	TR-70382	Kırklareli
TR-80199	Muğla	TR-49599	İzmir	TR-61277	Tekirdağ		
TR-45933	Artvin	TR-49600	İzmir	TR-61280	Aydın		

Table 2. Characteristics of Qualitative Characters and % Frequency Values.

Characters	Score	Description	Piece	Frequencies (%)
Seed Shape	1	Round	37	54
	2	Cornered	21	3
	3	Wrinkly	11	16
Sown Seed Colour	1	White	25	36
	2	Green	17	24
	3	Yellow	2	3
	4	Black	8	11
	5	Brown	16	23
	6	Brown-white	2	3
	7	Light green	0	0
	8	Dark green	0	0
Harvested Grain Colour	1	Light green	5	7
	2	Green	12	17
	3	Yellow	24	35
	4	Brown	14	2
	5	Dark green	13	19
	6	Purple	1	1
	7	Light Brown	0	0
Hilum Colour	1	Black	18	26
	2	Colorless	51	74

Table 3. Simple Statistics of Quantitative Characters.

Characters	Min.	Max.	Average	Standard Error
Plant Height (cm)	32	135	80,9	24,6
First Pod Height (cm)	17	85	46,7	16,6
Number of Branches (piece)	1	4	1,7	0,83
Number of Lateral Branches (piece)	0	6	0,6	0,98
Pod Number (piece)	1	26	10,0	5,49
Filled Pod Number (piece)	1	30	9,7	5,61
Empty Pod Number (piece)	0	3	0,5	0,76
Pod Length (cm)	3	9	5,6	1,11
Seed Number (piece)	2	118	41,4	23,8
Straw Yield of Plant (g)	3	26	9,1	4,97
Grain Yield of Plant (g)	1	83	8,0	10,05
Parcel Yield (kg/9 m^2)	50	434	215,8	84,6

Table 4. Correlation Analysis of Traits Examined in Pea Populations.

	Plant Height	First Pod Height	Number of Branches	Number of Lateral Branches	Pod Number	Filled Pod Number	Empty Pod Number	Pod Length	Seed Number	Seed Shape	Seed Colour	Grain Colour	Hilum Colour	Straw Yield of Plant	Grain Yield Per Plant	Parcel Yield
Plant Height	1	0,888**	0,023	-0,155	0,106	0,129	-0,185	-0,129	0,02	-0,181	-0,086	0,113	0,410**	0,051	0,164	0,164
First Pod Height		1	0,063	-0,214	0,024	0,057	-0,153	-0,233	-0,047	-0,194	-0,041	0,008	0,397**	0,061	0,010	0,010
Number of branches			1	0,380**	0,634**	0,665**	0,149	-0,198	0,647**	-0,104	0,139	-0,138	0,561**	0,094	0,011	0,011
Number of lateral branches				1	0,393**	0,360**	0,262*	-0,073	0,314**	-0,148	0,028	0,016	0,195	0,035	0,227	0,227
Pod number					1	0,971**	0,495**	-0,054	0,901**	-0,074	-0,091	0,135	0,600**	0,121	0,093	0,093
Filled pod number						1	0,396**	-0,053	0,928**	-0,109	-0,117	0,15	0,645**	0,155	0,095	0,095
Empty pod number							1	-0,038	0,305*	0,098	-0,088	0,082	0,146	0,006	-0,027	-0,027
Pod length								1	-0,006	0,286*	-0,294	0,514**	-0,022	-0,174	0,236	0,236
Seed number									1	0,023	-0,001	0,077	0,558**	0,136	0,045	0,045
Seed shape										1	0,235	0,276*	-0,02	-0,079	-0,199	-0,199
Seed colour											1	-0,392**	-0,032	0,013	-0,293	-0,293
Grain colour												1	0,216	-0,041	0,149	0,149
Hilum colour													1	0,490**	0,010	0,010
Straw yield of plant														1	-0,113	-0,113
Grain yield per plant															1	1,000**
Parcel yield																1

* The correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level.

Table 5. Eigen Values, Variances (%) and Cumulative Variances (%) of Main Components.

No	Examined Features	Eigen Value	Variance (%)	Cumulative Variance (%)
1	Plant height	4,35	27,21	27,21
2	First pod height	2,76	17,27	44,48
3	Number of branches	2,24	13,99	58,46
4	Number of lateral branches	1,47	9,17	67,63
5	Pod number	1,10	6,85	74,48
6	Filled pod number	0,95	5,93	80,41
7	Empty pod number	0,78	4,88	85,28
8	Pod length	0,60	3,77	89,05
9	Seed number	0,42	2,60	91,65
10	Seed shape	0,41	2,54	94,19
11	Seed colour	0,33	2,09	96,28
12	Grain colour	0,30	1,87	98,15
13	Hilum colour	0,14	0,87	99,02
14	Straw yield of plant	0,09	0,54	99,56
15	Grain yield of plant	0,05	0,33	99,89
16	Parcel yield	0,02	0,11	100,00

References

Anonymous, (1993). Descriptors for chickpea (*Cicer arietinum* L.). International board for plant genetic resources, Rome, Italy, 31. http://www.bioversityinternational.org/e-library/publications/detail/descriptors-for-chickpea-cicer-arietinum-l/

Anonymous, (2003). Broad bean *(Vicia faba* L. var. *major Harz)* guidelines for the conduct of tests for distinctness, uniformity and stability. http://www.upov.int/edocs/tgdocs/en/tg206.pdf

Boukid F, Rosell CM & Castellari M, (2021). Pea protein ingredients: A mainstream ingredient to (re)formulate innovative foods and beverages. *Trends in Food Science & Technology, 110, 729-*742. https://doi.org/10.1016/j.tifs.2021.02.040

Bozoğlu H & Sözen Ö, (2007). Some agronomic properties of the local population of common bean (*Phaseolus vulgaris* L.) of Artvin province. Turkish Journal of Agriculture and Forestry, 31, 327–334.

Ferranti P, (2016). Food sustainability, security, and effects of global change. In reference module in food science. Elsevier. https://doi.org/10.1016/B978-0-08-100596-5.03445-4

Mart D, (2023). Characterization and principle component analysis for some characteristics of local spring sown chickpea (*Cicer arietinum* L.) genotypes. Türk Tarım ve Doğa Bilimleri Dergisi, 10(2):420-430. https://doi.org/10.30910/turkjans.1129493

Mart D, (2022a). Investigation of the morphological characteristics of chickpea (*Cicer arietinum* L.) cultivars cultivated under irrigated and non-irrigated conditions sown in winter and early spring. Turkish Journal of Range and Forage Science, 3(2):75-83. https://doi.org/10.51801/turkjrfs.1207788

Mart D, (2022b). Characterization of Turkey local winter sown chickpea (*Cicer arietinum* L.) populations using principle component analysis. ISPEC Tarım Bilimleri Dergisi, 6(2):407-418. https://doi.org/10.46291/ISPECJASvol6iss2id316

Mart D, (2022c). Determination of some characteristics of eding pea (*Pisum sativum* L.) genotypes. MAS Journal of Applied Sciences, *7*(2):506-518. https://doi.org/10.52520/masjaps.v7i2id202

Mart D, Cansaran E, Karaköy T & Şimşek M, (2007).

Çukurova ve Orta Anadolu Bölgesinden toplanan yerel nohut (*Cicer arietinum* L.) populasyonlarının bazı önemli özelliklerinin belirlenmesi, seleksiyonu ve kalitatif karakterlerinin karekterizasyonu. *Tarla Bitkileri Araştırma Enstitüsü Dergisi, 16*(1-2), 61-72 (in Turkish).

Pandey AK, Rubiales D, Wang Y, Fang P, Sun T, Liu N & Xu P, (2021). Omics resources and omics-enabled approaches for achieving high productivity and improved quality in pea (*Pisum sativum* L.). Theoretical and Applied Genetics, 134(3): 755-776. https://doi.org/10.1007/s00122-020-03751-5

Parihar AK, Dixit GP, Bohra A, Gupta DS, Singh AK, Kumar N & Singh NP, (2020). Genetic advancement in dry pea (*Pisum sativum* L.): Retrospect and prospect. In S. S. Gosal & S. H. Wani (Eds.), Accelerated plant breeding (Vol. 3, Food legumes, pp. 283-341). Springer Nature. https://doi.org/10.1007/978-3-030-47306-8_10

Renáta Š, Nicolette V, Monika B, Stanislav K, Eliška G, Veronika M & Ľudmila S, (2021). Enhanced in situ activity of peroxidases and lignification of root tissues after exposure to non-thermal plasma increases the resistance of pea seedlings. Plasma Chemistry and Plasma Processing, 41, 903-922. https://doi.org/10.1007/s11090-021-10160-z

Sapre S, Gontia-Mishra I, & Tiwari S, (2022). Plant growth-promoting rhizobacteria ameliorates salinity stress in pea (*Pisum sativum*). Journal of Plant Growth Regulation, 41(2):647-656. https://doi.org/10.1007/s00344-021-10329-y

Shahzad R, Waqas M, Khan AL, Hamayun M, Kang SM & Lee IJ, (2015). Foliar application of methyl jasmonate induced physio-hormonal changes in *Pisum sativum* under diverse temperature regimes. Plant Physiology and Biochemistry, 96:406-416. https://doi.org/10.1016/j.plaphy.2015.08.020

Shen Y & Li Y, (2021). Acylation modification and/or guar gum conjugation enhanced functional properties of pea protein isolate. Food Hydrocolloids, 117, 106686. https://doi.org/10.1016/j.foodhyd.2021.106686

Tan A, (2010). Türkiye gıda ve tarım bitki genetik kaynaklarının durumu: Gıda ve tarım için bitki kaynaklarının muhafazası ve sürdürülebilir kullanımına ilişkin Türkiye ikinci ülke raporu. ETAE Yayın, 141. Ege Tarımsal Araştırma Enstitüsü, Menemen, İzmir (in Turkish).

Tan A, (1983). Sayısal taksonomik yöntemlerle varyasyonun saptanması. EBZAE, 30. Menemen (in Turkish).

Taylor SL, Marsh JT, Koppelman SJ, Kabourek JL, Johnson PE & Baumert JL, (2021). A perspective on pea allergy and pea allergens. Trends in Food Science & Technology, 116, 186-198. https://doi.org/10.1016/j.tifs.2021.07.017

Tugay Karagül E, Niksarlı İnal F & Kaya E, (2024). Nohut (*Cicer arietinum* L.) yerel çeşitlerinin agro-morfolojik karakterizasyonu. Anadolu Ege Tarımsal Araştırma Enstitüsü Dergisi, 34 (Özel Sayı), 149-159. https://doi.org/10.18615/anadolu.1464905 (in Turkish)

Ülker M & Ceyhan E, (2008). Determination of some agricultural characters of common beans (*Phaseolus vulgaris* L.) genotypes in Central Anatolian ecological condition. Selçuk Üniversitesi Ziraat Fakültesi Dergisi, *22*(46):77-89 (in Turkish).

Research Article

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Effects of Different Nutrient Media on Embryo Induction and Plant Regeneration in Cucumber (*Cucumis sativus* L.) Ovary Cultures

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ABSTRACT

Haploids and doubled haploids play a crucial role in the process of plant breeding. Ovary culture has proven to be an effective method for generating double haploid (DH) plants in cucumbers. The objective of this study was to optimize culture media conditions for gynogenesis induction *in vitro* to broaden morphogenetic possibilities and accelerate the creation of homozygous lines. The effects of seven different induction culture media on embryo and plant development in the ovary culture of Beith Alpha-type and Silor-type cucumber (*Cucumis sativus* L.) were investigated. Ovary culture experiments were conducted during the fall and spring seasons with 26 Beith Alpha-type and 11 Silor-type cucumber genotypes at the F_2 and F_3 generations. The results revealed that the most successful outcomes were obtained from genotypes coded HTB20, HTB24 and HTB25 of the Beith Alpha-type and HTS4 and HTS5 of the Silor-type. The findings also demonstrated that explants cultured in the autumn season showed higher regeneration efficiency compared to those cultured in spring. Overall when compared to Silor types, Beith Alpha types exhibited a more favorable response in terms of plant regeneration and embryo development, depending on genotype.

Keywords: Gynogenesis, medium compositions, haploid, Beith Alpha, Silor-Type

Introduction

Cucumber (*Cucumis sativus* var. *sativus* L.) is an important species with significant economic value within the Cucurbitaceae family. Of the 97 million tons of cucumber produced annually in the world, 80 million tons belong to China. The second country that produces the most cucumber is Türkiye (1.87 million tons). Russia comes in 3rd with a very close value (FAO, 2023). In Türkiye, cucumber is the most produced vegetable after tomatoes and watermelons (Anonymous, 2024). Originating from India, cucumber is among the Asian/Australian group species in the *Cucumis* genus (Renner et al., 2007; Renner and Schaffer 2008). Cucumber is one of the oldest cultivated vegetables. It is thought that cucumber, which completed its evolution process in India, passed from the Himalayas to China from the north, or was carried to China and Europe via the "Silk Road" (Staub et al., 2008). Cucumber was brought to Syria and Anatolia via Iran in the 6th-7th centuries (Paris et al., 2012). Günay (2005) reports that the famous Çengelköy, Langa and Maltepe local cucumber varieties were grown in vegetable gardens in Istanbul from the 1500s until the 1960s. In addition to these monoic varieties, many landraces specific to different regions such as Kilis (Tombul) and Dere have been grown all over Anatolia until recently (Çağlar and Şensoy 2021). Anatolia has a diversity of cucumber genetic resources. However,

improved quality OP varieties are almost nonexistent and old. Hybrid cucumber production has become increasingly widespread globally due to its potential for higher yields, improved disease resistance, and better marketability. The hybrid cucumber market is projected to continue expanding, as growers seek varieties that offer both enhanced productivity and resilience against environmental stresses. Crop productivity can be significantly improved by creating hybrids through the crossing of pure lines with specific characteristics. Consequently, pure lines are crucial for plant breeding programs. However, producing 100% homozygous lines through traditional breeding methods demands considerable time and resources due to multiple cycles of self-pollination and selection. On the other hand, biotechnological alternatives are considerably more efficient and sustainable compared to conventional approaches.

For cucurbits, there are three primary methods frequently employed in modern breeding programs to generate haploids and homozygous doubled haploids (DHLs): in situ haploid parthenogenesis (mainly induced by pollination with irradiated pollen), *in vitro* gynogenesis (occurring during *in vitro* ovule or ovary culture), and *in vitro* androgenesis (taking place during *in vitro* anther or microspore culture) (Dong et al., 2016). Among them, to date, *in vitro* unfertilized ovule/ovary culture remains the most successful and widely used method for haploid induction in cucumber (Gémes-Juhász et al., 2005).

The process of haploid regeneration through unpollinated female gametophytes is commonly referred to as "gynogenesis." Chambonnet and Dumas de Vaulx (1985) were the first to successfully obtain haploid embryos and plants from squash via *in vitro* unfertilized ovule/ovary culture. Since then, gynogenesis is a viable method for haploid production in various cucurbits, including pumpkin (Kwack and Fujieda 1988; Sun et al., 2009; Min et al., 2016), squash (Metwally et al., 1998b), melon (Beharav and Cohen 1995; Ficcadenti et al., 1999), cucumber (Gémesné et al., 1997; Gémes-Juhász et al., 2002; Moqbeli et al., 2013; Özsan et al., 2017; Pınar et al., 2021), and others (Rakha et al., 2012; Dong et al., 2016). Numerous studies have demonstrated that the successful recovery of haploids and doubled haploids in ovule/ovary culture is influenced by several factors, such as the genotype of donor plants, temperature pre-treatment, the developmental stages of the female gametophyte, growth regulators, and other components of the culture media. Specific efforts have been made to optimize these conditions for cucumber (Suprunova and Shmykova 2008; Diao et al., 2009; Li et al., 2013; Moqbeli et al., 2013; Plapung et al., 2014; Tantasawa et al., 2015; Baktemur et al., 2022) and squash (Xie et al., 2006; Shalaby 2007), aiming to maximize the number of haploid plantlets.

This study aimed to investigate the impact of various factors influencing *in vitro* gynogenesis, including the genotypes of donor plants and the induction media, on embryo and plant formation in the unpollinated ovary culture of 26 Beith Alpha-type and 11 Silor-type of cucumber genotypes.

Materials and Methods

Plant Material

26 Beith Alpha-type and 11 Silor-type cucumber genotypes, at the F_2 and F_3 generations, were used as donor plants. The plants were cultivated in greenhouses at Antalya Technopark, Hektaş Seed Co., and maintained using conventional horticultural practices. The study was conducted in three consecutive growing seasons, the spring and autumn seasons of 2023 and the spring season of 2024, each genotype was represented by 40 plants (Table 1). Fertilization included MAP (mono-ammonium phosphate) at a rate of 750 g/da applied throughout the ovary collection period. Irrigation was performed every 4 days via drip system, delivering 750 cc per plant per irrigation event. No pest control treatments were applied in order to preserve embryo quality from donor plants.

In the study, female flowers were harvested from donor plants for about two to three weeks after the emergence of the first female flowers. Unpollinated ovaries were collected early in the morning, six hours before anthesis as described by Gémes-Juhász et al. (2002). Petals, sepals, and styles were removed, and the ovaries were surface sterilized in 70% ethanol solution for 1 min and then soaked in 20% commercial bleach solution supplemented with 1-2 drops Tween20 for 15 min, and finally rinsed with sterile dH_2O three times for 5 min. The peels of the sterilized ovaries were removed and they were cut lengthwise into two halves (Nyirahabimana and Solmaz 2021), which were then placed into seven different culture media. Each ovary explant was placed in a single petri dish with two ovary slices (Table 1).

Unpollinated Ovary Media and Culture Conditions

The induction media used in this study were based on Murashige and Skoog (1962) (MS) medium, with 30 g/L sucrose and 7 g/L agar added to each (Diao et al., 2009). The media were coded from C1 to C7 and consisted of different plant growth regulators as follows: C1: 0,1 mg/L 2,4-D and 1 mg/L kinetin; C2: 0.04 mg/L TDZ, 0.05 mg/L NAA, and 0.2 mg/L BAP;

C3: 0,1 mg/L 2,4-D, 1 mg/L kinetin, 0,05 mg/L NAA and 0.2 mg/L BAP; C4: 0.04 mg/L TDZ; C5: 0,1 mg/L 2,4-D, 1 mg/L kinetin and 0.02 mg/L TDZ; C6: 0.05 mg/L 2,4-D and kinetin, with 0.02 mg/L TDZ; C7: 0.7 mg/L 2,4-D, 1 mg/L kinetin, 0.5 mg/L NAA, 1 mg/L BAP, and 10 mg/L $AgNO_3$.

Ovary pieces were incubated in the dark at 35°C for 2 days, followed by 3 more days at 25°C in the dark. After the induction period, they were transferred to growth chambers with a 16/8 light/dark photoperiod. Cultures were visually monitored daily, and when embryo-like structures first appeared -typically between 2 and 3 weeks- they were transferred to regeneration medium (coded as R), which contained an MS-based medium with 30 g/L sucrose, 0.05 mg/L NAA, and 0.2 mg/L BAP (Gémes-Juhász et al., 2002). For rooting, the plants were rooted in a hormone-free MS medium. For plants that did not root, they were transferred to MS medium containing 0.1 mg/L IAA. Plants showing sufficient root development were then acclimatized to external conditions in pots containing a 1:1:1 mixture of peat:perlite:vermiculite, and their cultivation continued in the greenhouse. The pH of the C, R and rooting medium was adjusted to 5.8 and autoclaved at 121°C for 20 min. and then poured on sterile plastic petri dishes (60 mm in diameter), tubes or jars. The hormones were filter-sterilized and added to the media after autoclaving, once the temperature of the medium had dropped to 40-50°C.

Statistical Analysis

The experiment began in the spring season of 2023 with 11 Beith Alpha-type and 6 Silor-type F_2 cucumber genotypes, using seven different induction media. The results were analyzed, and three prominent C media were selected to establish the experiments for the autumn season of 2023, where 11 Beith Alpha-type and 7 Silor-type genotypes were used. Finally, in the spring season of 2024, only the C1 medium was used for the culture of 14 Beith Alpha-type genotypes at the F_3 stage. After two weeks of culture, embryo observations were carried out for another ten weeks. The plants that developed were then rooted and acclimatized to greenhouse conditions. The culture initiation procedures were carried out over three weeks. A total of 2665 Beith Alpha-type and 863 Silor-type cucumber genotypes' ovaries were cultured. The data on the number of developing embryos and plant regeneration were recorded at the end of 12 weeks following the initiation of the culture process. The embryo development frequency, expressed as the percentage of embryos per ovary, and the plant conversion frequency, defined as the percentage of embryos successfully developing into plants, were calculated.

One-way analysis of variance (ANOVA) was performed to evaluate differences between applications and genotypes. The general linear model procedure of SPSS (Statistics 20) software (IBM Corp., Armonk, NY, USA) was used for data analysis. All main effects were considered fixed effects. Tukey's multiple range post hoc test was employed for multiple comparisons of the genotypes and media and t-test for seasons with an alpha level of 0.05.

Results and Discussion

In the study, embryo structures (ES) began to appear on the surface of ovules approximately 2 to 3 weeks after culture initiation. The experiments were completed in approximately 16 weeks, including the acclimatization of the plantlets. (Figure 1).

The studies carried out in the spring of 2023 with 11 Beith Alpha-type and 6 Silor-type genotypes across seven different induction media showed no statistically significant effect of either genotype or medium on embryo development frequency ($P<0.05$). However, based on observations and mean values of embryo development frequencies, the responses of the C1, C4, and C6 media were found to be more successful compared to the other media. The data from the first phase of the study (2023 Spring), among the 17 genotypes, C1, C4, and C6 induction media proved to be effective in promoting embryo development, with C1 medium standing out as the most promising (Table 2). In contrast, the genotypes did not respond to the C7 medium, which contained $AgNO_3$. Moreover, in this medium, the ovary explants exhibited the development of high-mass callus formations (data not shown).

In the 2023 fall season, the genotypes of the donor plants and the induction media had significant effects on the formation of ES and plant development ($P<0.05$) (Table 3). Differences in embryo structure and plant development were observed depending on the induction medium used. Although no significant differences were observed among the genotypes, an analysis of the mean values indicated that the Beith Alpha type genotypes HTB20, HTB24 and HTB25 and Silor-type genotypes HTS4 and HTS5 exhibited the highest embryo development frequency. According to the calculations of embryo percentage per ovary, these genotypes achieved approximately 167%, 118%, and 125% success in Beith Alpha-type and 18% and 14% in Silor-types, respectively. The influence of these factors on embryo formation and subsequent plant growth highlights the importance of genotype and media selection in the successful induction of gynogenesis in cucumbers. Domblides et al. (2020) reported that unpollinated ovule culture can reliably induce doubled

haploid plants in Cucurbitaceae, highlighting that similar protocols can effectively shorten breeding cycles in cucumber species-our findings also support the efficacy of ovary culture for embryo induction, even if ploidy states were not assessed. When evaluating the frequency of healthy embryo-to-plant conversion, the C4 induction medium exhibited significantly higher success in Beith Alpha-type genotypes, while the conversion frequency was found to be the lowest in the C1 medium (Table 3). Given the high incidence of abnormal embryo development in cucumbers (Li et al., 2013), this result is particularly meaningful. Similarly, Özsan et al. (2017) reported abnormal embryo development in a comparable induction medium in their study. However, other factors such as genotype and pre-treatments should also be considered when assessing embryo-to-plant conversion frequencies.

These findings are consistent with the results reported by Diao et al. (2009) and Moghbeli et al. (2013) in cucumber, Dumas and Chambonnet (1986) and Shalaby (2007) in squash. A recent study evaluated genotype-specific responses and heat shock pretreatment for induction of embryo-like structures, reporting rates of 16-20% across commercial cucumber varieties (Nyirahabimana and Solmaz, 2024). This aligns with our observed high induction frequencies in selected genotypes under C1, C4, and C6 media, reinforcing the importance of both media composition and pre-treatment regimes. These studies have demonstrated the effects of genotype and medium composition on embryogenesis.

This study also investigated the effect of the spring and fall seasons on embryo development. Przyborowski and Nlemirowicz-Szgzytt (1994) reported a significant impact of the growing season on haploid embryo development in cucumbers in their study, where they examined various parametric factors influencing embryo formation. In the present study, based on the embryo development frequencies and embryo-to-plant conversion frequencies of the cultivars subjected to ovary culture in both seasons (Table 4), a statistically significant difference was observed between the two seasons ($P<0.05$).

In the case of *Cucurbita pepo*, the highest number of embryos was obtained from ovaries harvested one day before anthesis (Dumas de Vaulx and Chambonnet, 1986; Metwally et al., 1998a), whereas in cucumber, the maximum number of embryos was observed in ovaries collected 6 hours before to anthesis (Gémes Juhász et al., 2002). Although the timing of donor plant collection in the study was determined based on these results, the effects of ovaries collected at different time intervals before anthesis could be further explored.

As reported by Li et al. (2013), gynogenesis was triggered using unpollinated ovules from Chinese long cucumbers, with the most effective induction treatment involving CBM medium containing 0.03 - 0.07 mg dm^{-3} TDZ. In contrast, in this study, the best hormonal combination for induction was obtained from an MS-based medium containing 2,4-D and kinetin. Çetinkaya (2015) also found these PGR concentration rates and types to be successful for the induction of gynogenesis in cucumber. Nevertheless, the C4 induction medium containing TDZ has yielded successful results in embryo development compared to some other media. To enhance the efficiency of these results, further studies could be conducted on the ovarian developmental stage and pretreatment conditions.

Conclusions

Haploids can be obtained using the ovary as well as other sexual explants. The current study reveals various factors for efficient ovary embryogenesis induction in cucumbers using different culture media. Our findings demonstrated that the rate of embryo production induction varied among genotypes and culture media. Future recommendations include the use of SSR markers, flow cytometry, and other methods to detect spontaneously regenerated plants and integrate them directly into breeding programs. Additionally, identifying the response of genetic resources in the existing gene pool to ovary culture and conducting more productive studies with varieties from this pool will provide valuable insights. Optimization of genotypes and culture media plays a significant role in hybrid production and enhancing genetic diversity. In this context, further detailed studies on additional genotypes and culture conditions will contribute to improving cucumber productivity. Future research is expected to advance with comprehensive genetic analyses and applied techniques, building upon the findings of this study.

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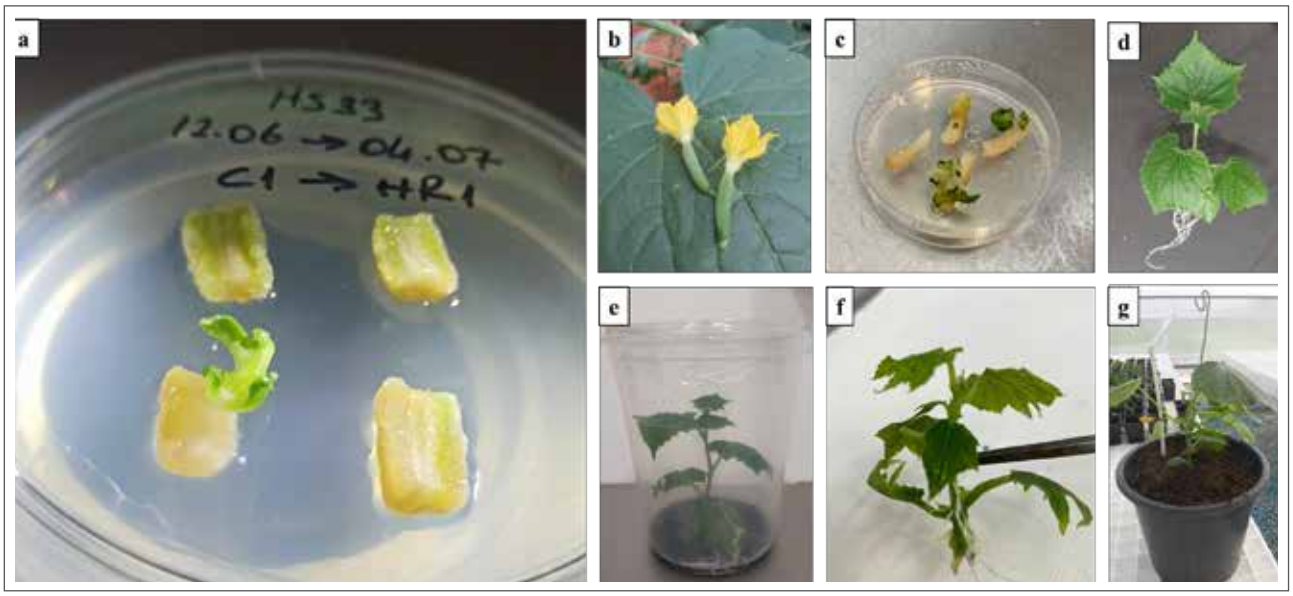

Figure 1. Stages of ovary culture in cucumber. (a) 3 weeks old ovaries in C1 media; (b) flowers collected 6 hours before anthesis; (c) embryos derived on ovaries; (d-e-f) a rooted plant; (g) an acclimatized plant (Original).

Table 1. The number of donor plants grown per genotype and the number of explants cultured in each induction medium.

Type of Cucumber	Genotype Code	Number of Donor Plants	Number of Explants Used						
			Medium Code						
			C1	C2	C3	C4	C5	C6	C7
Beith Alpha-type	HTB1	40	24	23	17	28	20	25	20
	HTB2	40	19	7	5	13	15	27	34
	HTB3	40	25	14	14	18	36	16	32
	HTB4	40	13	17	18	19	34	17	19
	HTB5	40	11	8	13	13	14	15	18
	HTB6	40	12	11	13	2	20	19	19
	HTB7	40	9	10	1	7	6	2	19
	HTB8	40	15	13	1	5	6	6	5
	HTB9	40	12	5	4	2	4	3	7
	HTB10	40	21	15	2	36	6	17	17
	HTB11	40	6	20	15	19	15	21	20
	HTB12	40	15	0	0	2	0	20	0
	HTB13	40	32	0	0	7	0	27	0
	HTB14	40	13	0	0	9	0	24	0
	HTB15	40	49	0	0	30	0	9	0
	HTB16	40	26	0	0	18	0	6	0
	HTB17	40	75	0	0	11	0	3	0
	HTB18	40	83	0	0	7	0	14	0
	HTB19	40	17	0	0	3	0	19	0
	HTB20	40	34	0	0	3	0	14	0
	HTB21	40	47	0	0	17	0	9	0
	HTB22	40	14	0	0	8	0	19	0
	HTB23	40	182	0	0	40	0	4	0
	HTB24	40	308	0	0	24	0	0	0
	HTB25	40	160	2	2	15	10	1	1
	HTB26	40	86	0	0	0	0	5	0
Silor-type	HTS1	40	31	6	5	12	23	6	12
	HTS2	40	14	5	20	6	17	0	14
	HTS3	40	9	13	8	2	0	0	3

Continuing Table 1

Type of Cucumber	Genotype Code	Number of Donor Plants	Number of Explants Used						
			Medium Code						
			C1	C2	C3	C4	C5	C6	C7
Silor-type	HTS4	40	13	10	20	67	25	40	28
	HTS5	40	33	0	23	32	18	1	5
	HTS6	40	22	10	12	29	19	20	12
	HTS7	40	28	0	0	14	0	7	0
	HTS8	40	17	0	0	37	0	5	0
	HTS9	40	5	0	0	35	0	6	0
	HTS10	40	11	0	0	7	0	5	0
	HTS11	40	13	0	0	35	0	5	0

Table 2. Mean values of seven induction media on the frequency of embryo structure (ES) formation and frequency of embryo to plant conversion on the 2023-Spring season.

Induction Media	Frequency of Embryo Structure Formation (%)	Frequency of Embryo to Plant Conversion (%)
C1	7.72±11.67	87.85±23.06
C2	2.40±5.26	100±0
C3	0.85±2.40	100±0
C4	7.51±16.52	88.89±14.59
C5	4.72±8.51	77.08±25.51
C6	6.62±18.70	79.05±21.44
C7	0±0	ND*

* represents “not detected”

Table 3. Effects of different induction media on the frequency of embryo structure (ES) formation and embryo-to-plant conversion on the 2023-Fall season.

Induction Media	Frequency of Embryo Structure Formation (%)		Frequency of Embryo to Plant Conversion (%)	
	Beith Alpha-type	Silor-type	Beith Alpha-type	Silor-type
C1	156.10±176.78a	19.40±24.87a	42.61±32.22b	97.5±5b
C4	11.93±27.23b	6.46±10.25b	95.83±7.22a	100±0a
C6	21.14±30.82b	13.33±32.66b	85.83±14.90ab	75±0ab

*Values are mean and standard error (SE). Means were separated by using Tukey’s multiple range post hoc test. Different letters near the means represent significant differences at $p \leq 0.05$.

Table 4. Embryo development and embryo-to-plant conversion frequencies of selected Beith Alpha-type genotypes across different seasons. All data was taken after 12 weeks of culture.

Genotype	Frequency of Embryo Formation (%)		Frequency of Embryo to Plant Conversion (%)	
	Spring	Fall	Spring	Fall
HTB13	10.00	266.67	0	34.38
HTB14	0	0	ND*	ND
HTB16	5.26	0	100	ND
HTB17	31.88	66.67	86.36	75.00
HTB20	15.38	475.00	100.00	31.58
HTB23	33.73	12.50	60.71	100.00
HTB24	53.56	268.29	60.84	14.55
HTB25	15.17	377.78	54.55	23.53

*ND: Not Detected

References

Anonymous, (2024). Bitkisel üretim istatistikleri. https://biruni.tuik.gov.tr/medas/?locale=tr Access Date: 16.06.2025 (in Turkish)

Baktemur G, Keleş D, Kara E, Yıldız S & Taşkın H, (2022). Effects of genotype and nutrient medium on obtaining haploid plants through ovary culture in cucumber. Molecular Biology Reports, 49:5451-5458. https://doi.org/10.1007/s11033-022-07238-y

Beharav A & Cohen Y, (1995). Effect of kinetin and GA_3 on *in vitro* ovule embryo culture of *Cucumis melo* L. Plant Growth Regulation, 16(3):267-269. https://doi.org/10.1007/BF00024785

Chambonnet D & Vaulx RD, (1985). Obtention of embryos and plants from *in vitro* culture of unfertilized ovules of *Cucurbita pepo*. Cucurbit Genetics Cooperative, 8:66

Çağlar G & Şensoy S, (2021). Hıyar ıslahı. In K. Abak, A. Balkaya, Ş. Ş. Ellialtıoğlu & E. Düzyaman (Eds.), Sebze Islahı. Cilt II: *Cucurbitaceae* (Kabakgiller) (ss. 87-201). BİSAB Yayınları, Gece Kitaplığı Yayınevi (in Turkish)

Çetinkaya E, (2015). Farklı besi ortamı kombinasyonlarının bazı hıyar **(***Cucumis sativus* L.) genotiplerinde gynogenesis yolu ile embriyo ve haploid bitki oluşumu üzerine etkisi [Yüksek lisans tezi, Akdeniz Üniversitesi]. Antalya (in Turkish)

Diao WP, Jia YY, Song H, Zhang XQ, Lou QF & Chen JF, (2009). Efficient embryo induction in cucumber ovary culture and homozygous identification of the regenerants using SSR markers. *Scientia Horticulturae,* 119(3):246-251. https://doi.org/10.1016/j.scienta.2008.08.016

Domblides E, Shmykova N, Khimich G, Korotseva I, Kan L, Domblides A, Pivovarov V & Soldatenko A, (2020). Production of doubled haploid plants of Cucurbitaceae family crops through unpollinated ovule culture *in vitro*. In VI International Symposium on Cucurbits (Vol. 1294, pp. 19-28) https://doi.org/10.17660/ActaHortic.2020.1294.4

Dong YQ, Zhao WX, Li XH, Liu XC, Gao NN, Huang JH, Wang WY, Xu XL & Tang ZH, (2016). Androgenesis, gynogenesis, and parthenogenesis haploids in cucurbit species. Plant Cell Reports, 35, 1991-2019. https://doi.org/10.1007/s00299-016-2018-7

Dumas de Vaulx R & Chambonnet D, (1986). Obtention of embryos and plants from *in vitro* culture of unfertilized ovules of *Cucurbita pepo*. In W. Gruyter (Ed.), Genetic Manipulation in Plant Breeding (pp. 295-297). De Gruyter.

FAOSTAT, (2023). http://www.fao.org/faostat/en/#data/QC (Access Date: 16.06.2025)

Ficcadenti N, Sestili S, Annibali S, Marco MD & Schiavi M, (1999). *In vitro* gynogenesis to induce haploid plants in melon (*Cucumis melo* L.). Journal of Genetics and Breeding, 53(3):255-257.

Gémes Juhász A, Balogh P, Ferenczy A & Kristo´f Z, (2002). Effect of optimal stage of female gametophyte and heat treatment on *in vitro* gynogenesis induction in cucumber (*Cucumis sativus* L.). Plant Cell Reports, 21(2):105-111. https://doi.org/10.1007/s00299-002-0482-8

Gémes Juhász A & Jakše M, (2005). Haploids in the improvement of miscellaneous crop species (Cucurbitaceae, Liliaceae, Asparagaceae, Chenopodiaceae, Araceae and Umbelliferae). In C. E. Don Palmer, W. A. Keller, & K. J. Kasha (Eds.), Biotechnology in Agriculture and Forestry: Haploids in Crop Improvement II (pp. 259-278). Springer

Gémesné Juhász A, Venczel G & Balogh P, (1997). Haploid plant induction in zucchini (*Cucurbita pepo* L. convar. *giromontiina* Duch) and in cucumber (*Cucumis sativus* L.) lines through *in vitro* gynogenesis. Acta Horticulturae*, 447*, 623-625

Günay A, (2005). Sebze Yetiştiriciliği (Cilt II). Meta Basımevi (in Turkish)

Kwack SN & Fujieda K, (1988). Somatic embryogenesis in cultured unfertilized ovules of *Cucurbita moschata*. Journal of the Japanese Society for Horticultural Science, 57(1):34-42. https://doi.org/10.2503/jjshs.57.34

Li JW, Si SW, Cheng JY, Li JX & Liu JQ, (2013). Thidiazuron and silver nitrate enhanced gynogenesis of unfertilized ovule cultures of *Cucumis sativus*. Biologia Plantarum, *57*(1):164-168. https://doi.org/10.1007/s10535-012-0269-x

Metwally EI, Moustafa S A, EI-Sawy BI & Shalaby TA, (1998a). Haploid plantlets derived by anther culture of *Cucurbita pepo*. Plant Cell, Tissue and Organ Culture, 52(3):171-176. https://doi.org/10.1023/A:1005908326663

Metwally EI, Moustafa SA, El-Sawy BI, Haroun SA & Shalaby TA, (1998b). Production of haploid plants from *in vitro* culture of unpollinated ovules of *Cucurbita pepo* L. Plant Cell, Tissue and Organ Culture, 52(3):117-121. https://doi.org/10.1023/A:1005948809825

Min ZY, Li H, Zou T, Tong L, Cheng J & Sun XW, (2016). Studies of *in vitro* culture and plant regeneration of unfertilized ovary of pumpkin.

Chinese Bulletin of Botany, 51(1):74-80. https://doi.org/10.11983/CBB15004

Moqbeli E, Peyvast GH, Hamidoghli Y & Olfati JA, (2013). *In vitro* cucumber haploid line generation in several new cultivars. Asia-Pacific Journal of Molecular Biology and Biotechnology, 21(1): 18-25

Murashige T & Skoog F, (1962). A revised medium for rapid growth and bioassays with tobacco tissue cultures. Physiologia Plantarum, 15(3):473-497

Nyirahabimana F & Solmaz İ, (2021). Haploid plant production technology in cucumber (*Cucumis sativus* L.). In M. Tutuncu (Ed.), Proceedings Book. 10th Int. Mol. Biol. & Biotech. Congress (pp. 28-37). Online

Nyirahabimana F & Solmaz İ, (2024). Haploid induction through ovary culture in cucumber. In Vitro Cellular & Developmental Biology-Plant, 60(1):122-130. https://doi.org/10.1007/s11627-023-10406-9

Özsan T, Gozen V & Onus A, (2017). Cucumber gynogenesis: Effects of 8 different media on embryo and plant formation. International Journal of Agriculture Innovations and Research, 6(2):419-422

Paris HS, Daunay MC & Janick J, (2012). Occidental diffusion of cucumber (*Cucumis sativus*) 500-1300 CE: Two routes to Europe. Annals of Botany, 109(1):117-126. https://doi.org/10.1093/aob/mcr281

Pınar H, Toprak S, Hancı F & Şimsek D, (2021). Effects of genotypic variation and some new protocols on gynogenesis efficiency of cucumber. Fresenius Environmental Bulletin, 30(5):4763-4770

Plapung P, Khamsukdee S, Potapohn N & Smitamana P, (2014). Screening for cucumber mosaic resistant lines from the ovule culture derived double haploid cucumbers. American Journal of Agricultural and Biological Sciences, 9(3):261-269. https://doi.org/10.3844/ajabssp.2014.261.269

Przyborowski J & Nlemirowicz-Szgzytt K, (1994). Main factors affecting cucumber (*Cucumis sativus* L.) haploid embryo development and haploid plant characteristics. Plant Breeding, 112(1):70-75. https://doi.org/10.1111/j.1439-0523.1994.tb01278.x

Rakha MT, Metwally EI, Moustafa SA, Etman AA & Dewir YH, (2012). Evaluation of regenerated strains from six 'Cucurbita' interspecific hybrids obtained through anther and ovule '*in vitro*' cultures. Australian Journal of Crop Science, 6(1):23-30

Renner SS, Schaefer H & Kocyan A, (2007). Phylogenetics of *Cucumis* (Cucurbitaceae): Cucumber (*C. sativus*) belongs in an Asian/Australian clade far from melon (C. *melo*). BMC Evolutionary Biology, *7*(1):58. https://doi.org/10.1186/1471-2148-7-58

Renner SS & Schaefer H, (2008). Phylogenetics of *Cucumis* (Cucurbitaceae) as understood in 2008. In M. Pitrat (Ed.), *Cucurbitaceae* 2008, Proceedings of the IXth EUCARPIA Meeting on Genetics and Breeding of Cucurbitaceae (pp. 53-58). Avignon, France

Shalaby TA, (2007). Factors affecting haploid induction through *in vitro* gynogenesis in summer squash (*Cucurbita pepo* L.). Scientia Horticulturae, 115(1):1-6. https://doi.org/10.1016/j.scienta.2007.07.008

Sun SR, Zhai QH, Hu JB, Chen JF & Zhang P, (2009). Effects of several physiological factors on embryo formation in unpollinated ovary culture of pumpkin (*Cucurbita moschata* Duch. Ex Poiret). Plant Physiology Communications, 45(10):977-980

Suprunova T & Shmykova N, (2008). *In vitro* induction of haploid plants in unpollinated ovules, anther and microspore culture of *Cucumis sativus*. In M. Pitrat (Ed.), Proceedings of the IXth EUCARPIA Meeting on Genetics and Breeding of Cucurbitaceae (pp. 371-374). Avignon, France

Staub JE, Robbins MD & Wehner TC, (2008). Cucumber. In J. Prohens & F. Nuez (Eds.), *Vegetables I:* Asteraceae, Brassicaceae, Chenopodicaceae, and Cucurbitaceae, Handbook of Plant Breeding (Vol. 1, pp. 241-282). Springer

Tantasawat PA, Sorntip A, Poolsawat O, Chaowiset W & Pornbungkerd P, (2015). Evaluation of factors affecting embryo-like structure and callus formation in unpollinated ovary culture of cucumber (*Cucumis sativus*). International Journal of Agriculture and Biology, 17(3):613-618. https://doi.org/10.17957/IJAB.17.3.14.257

Xie M, Qin LY, Pan JS, He HL, Wu AZ & Cai R, (2005). Flower morphogenesis and microspore development versus anther culture of cucumber. Acta Botanica Boreali-Occidentalia Sinica, *25*(6):1096-1100

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Assessment of Ber Germplasm for Fruit Morphological Traits Under Semi-Arid Conditions

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ABSTRACT

A study on fruit morphological parameters of different ber germplasm was carried out at the Experimental Orchard, CCS Haryana Agricultural University, Regional Research Station, Bawal (Rewari), Haryana during 2022-23 and 2023-24. Sixteen selected germplasm of ber planted at 8 m × 8 m in randomized block design (RBD) in three replications were characterized based on fruit morphological traits, including fruit colour, shape, fruit apex and base shape and pulp cavity at styler and stem end. Among different ber germplasm, round fruit shape was noticed in five germplasm viz. Gola, Kakrola Gola, Narendra Ber Sel-1, Narendra Ber Sel-2 and Katha Phal, while oblong fruit shape was observed in 6 germplasm viz. Umran, Kaithali, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2 and Mudia Murhara. The germplasm Chhuhara and Thar Sevika had ovate fruit shape. Further, oval fruit shape was noticed in two germplasm viz. Goma Kriti and Thar Bhubraj, while oblate fruit shape was noticed in only one germplasm i.e. Illaichi. At fruit maturity, Katha Phal exhibited anthocyanin blush on fruit skin while remaining germplasm does not exhibit anthocyanin blush. The round fruit apex was noticed in 10 germplasm, while it was pointed in 4 germplasm and 2 germplasm had flat fruit apex. The varieties were systematically classified into five distinct groups based on stone shape, viz. oblong, spindle, club, oval and falcate. The significant variability observed in morphological traits among the germplasm likely represents the genetic diversity inherited from the ancestral species from which these cultivars originated.

Keywords: Ber (*Ziziphus mauritiana* Lamk.), germplasm, DUS, fruit morphology

Introduction

The Indian ber (*Ziziphus mauritiana* Lamk.) is an ancient and highly significant, yet underutilized, fruit crop native to India. It belongs to the family *Rhamnaceae* and has a chromosome number 2n=48 (Srinivasan, 1952). Ber originated from India to Malaya, includes parts of south-western China (Vavilov, 1951; Hu et al., 2010). Globally, the genus *Ziziphus* has over 170 species of tiny trees and spiny shrubs that grow in warm-temperate and subtropical climates (Islam and Simmons, 2006). It is widely known by various names, including Indian jujube, Chinese fig, Chinese date and poor man's fruit (Kumari et al., 2016). It is also nominated as "King of Arid Fruits" due to the facts that it can be successfully grown in barren land and marginal soil of arid and semi-arid regions.

The ber fruit possesses a distinctive combination of sour and sweet taste, along with significant nutritional benefits. Besides consumed as fresh fruit, it is widely processed into products like dried fruits, candies, powder, pulp, jam and beverages. Nutritionally, the ripe fruit surpasses apples in protein, calcium, phosphorus and vitamin C content (Godi and Joshi, 2016), providing 20.9 kcal per 100 g pulp. It is a nutrient-rich fruit, providing 70–165 mg of ascorbic acid per 100 g of pulp and 70 IU of vitamin A.

Most of the commercially grown cultivars today were developed through selection. Farmers have also selected naturally growing seedlings based on desirable economic traits and subsequently propagated them vegetatively to preserve their genetic identity (Krishna, 2016). In ber breeding, the primary focus has been on clonal selection, especially for early-maturing clones. The majority of common germplasm results from selection practices across various regions.

India exhibits a vast diversity in ber, encompassing a wide range of variations across all key traits, providing significant potential for genetic improvement. Understanding the genetic diversity within germplasm collections is crucial for their effective utilization. While this process is complex, expensive, and time-intensive, it plays a vital role in crop improvement by guiding decisions on breeding methodologies and the management of genetic resources.

Thus, there is an urgent need to give attention to ber improvement by augmenting, characterizing, evaluating germplasm and utilizing it in breeding programme for the enhancement of productivity and development of better fruit quality. The characterization and evaluation of *Ziziphus mauritiana* germplasm are primarily based on morpho-physiological traits. Researchers use morphological descriptors such as growth habit, shoot, leaf, flower and fruit morphology to classify and distinguish different varieties of *Z. mauritiana* (Vashishtha, 2001 and Saran et al*.,* 2006). With this context, the present investigation was conducted to characterize sixteen ber germplasm based on fruit morphological traits and to establish the distinctness of the candidate germplasm from another available germplasm in India.

Materials and Methods

The investigation was conducted at the experimental orchard of Chaudhary Charan Singh Haryana Agricultural University, Regional Research Station, Bawal. The Regional Research Station in Bawal located in the south-west part of Haryana, at an elevation of 266 meters above sea level. Its geographic coordinates are 28° 10' N latitude and 76° 50' E longitude. The region falls within an arid to semi-arid climatic zone marked by hot and dry summers and very cold winters. The experimental orchard was laid out in randomized block design (RBD) with three replications examining 16 ber germplasm (*viz*. Gola, Umran, Kaithali, Chuhhara, Goma Kriti, Thar Sevika, Thar Bhubhraj, Narendra Ber Sel-2, Narendra Ber Sel-1, Bawal Sel-1, Bawal Sel-2, Rohtak Safeda, Kakrola Gola, Mudia Murhara, Katha Phal and Illaichi). The study was comprised of 8 different fruit morphological characters, which were noticed at specified stage of crop growth when a particular character showed its full expression as per Distinctness, Uniformity and Stability (DUS) guidelines (Anonymous, 2016). Observations on the mature fruit and stone were made when the fruit reached the harvesting stage. Observations on anthocyanin blush was observed with naked eyes on immature fruit from all the directions of selected tree and expressed as anthocyanin blush present or anthocyanin blush absent. For assessment of fruit colour, the Royal Horticultural Society (RHS) colour chart shall be used.

Results and Discussion

Significant variation was observed among sixteen selected germplasm for different fruit morphological characters. The frequency distribution of each trait along with representative germplasm examples, is presented in Table 1 & 2. In the current investigation, mature fruit shape varied significantly among different germplasm. The round fruit shape was noticed in 5 germplasm *viz*. Gola, Narendra Ber Sel-1, Narendra Ber Sel-2, Kakrola Gola and Katha Phal while oblong fruit shape was observed in 6 germplasm *viz*. Umran, Kaithali, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2 and Mudia Murhara. The germplasm Chhuhara and Thar Sevika had ovate fruit shape. Further, oval fruit shape was noticed in 2 germplasm *viz*. Goma Kriti and Thar Bhubhraj, while oblate fruit shape was noticed in only one germplasm i.e. Illaichi. Similar results were also reported by Kumar et al. (2021), Yadav et al. (2020), Singh et al. (2019), Godi et al. (2016) and Krishna et al. (2016) among different ber genotypes. The germplasm are typically identified based on their fruit characteristics, such as shape, the form of stylar and basal ends, pulp cavity and colour etc. These prominent characters are often reflected in their nomenclatures, such as Gola, Narma, Tikadi, Illaichi, Banarasi Karaka etc. (Vashishtha, 2001).

In relation to fruit colour, huge variability was noticed among different germplasm. Colour of fruits at maturity was noticed yellowish in Gola, Kaithali and Goma Kriti, greenish yellow in Chuhhara, Thar Bhubraj and Narendra Ber Sel-2, yellowish green in Thar Sevika, Rohtak Safeda, Kakrola Gola and Mudia Murhara and Greenish in Narendra Ber Sel-1, Bawal Sel-1 and Katha Phal. Umran had golden yellow and Bawal Sel-2 has golden green colour at maturity. In Illaichi, matured fruit was of brownish colour at horticultural maturity. Among the evaluated germplasm, only one germplasm *i.e.* Katha Phal, exhibited an anthocyanin blush on immature fruits; while remaining 15 germplasm had no anthocyanin

blush on immature fruit. Results are in accordance with the findings of Kumar et al. (2021), Yadav et al. 2020), Singh et al. (2019) and Krishna et al. (2016) among different ber genotypes. The variations in fruit colour largely depend on climatic conditions and light intensity, light quality etc. Diversity in shape and colour among different germplasm help breeders to choose genotypes according to the type of consumption (Liu et al., 2009).

The round fruit apex was noticed in 10 germplasm *viz*. Gola, Umran, Thar Bhubhraj, Narendra Ber Sel-2, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Mudia Murhara, Katha Phal and Illaichi, while it was pointed in 4 germplasm Kaithali, Chhuhara, Goma Kriti and Thar Sevika. However, Narendra Ber Sel-1 and Kakrola Gola had flat fruit apex. Fruit base was observed round in 9 germplasm *viz*. Gola, Umran, Goma Kriti, Narendra Ber Sel-2, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Katha Phal and Illaichi, while flat in 7 germplasm *viz*. Kaithali, Chhuhara, Thar Sevika, Thar Bhubraj, Narendra Ber Sel-1, Kakrola Gola and Mudia Murhara.

Among different ber germplasm, 11 germplasm *viz*. Gola, Kaithali, Chhuhara, Goma Kirti, Thar Sevika, Thar Bhubraj, Rohtak Safeda, Bawal Sel- 2, Mudia Murhara, Katha Phal and Illaichi had pulp cavity at stylar end, while it was absent in 5 germplasm *viz*. Umran, Narendra Ber Sel-1, Bawal Sel-1, Narendra Ber Sel-2 and Kakrola Gola germplasm. Pulp cavity at stem end was present in Gola, Umran, Kaithali, Chuhhara, Goma Kriti, Thar Sevika, Thar Bhubraj, Narendra Ber Sel-1, Narendra Ber Sel-2, Rohtak Safeda, Bawal Sel-2, Katha Phal, Kakrola Gola, Mudia Murhara and Illaichi germplasm whereas, it was absent in only one germplasm i.e., Bawal Sel-1 (Table 1 & 2). Key fruit characteristics such as apex type, stylar and stem end cavities, and fruit shape are considered the most dependable traits for classification (Bal, 1992; Azam-Ali et al., 2006).

The germplasm were further classified into five groups based on stone shape into five groups *i.e.* spindle, oblong, club, oval and falcate. The club shape stone was noticed in Umran, Chuhhara, Goma Kriti, Thar Bhubraj and Mudia Murhara while most of germplasm exhibited oval stone shape i.e., Gola, Narendra Ber Sel-1, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Kakrola Gola, Katha Phal and Illaichi. The oblong shape stone was found in Kaithali. Further, falcate stone shape was noticed in Thar Sevika and spindle type stone were found in Narendra Ber Sel. 2. Results are in accordance with the findings of Singh et al. (2019) and Krishna et al. (2016) in ber germplasm under different growing conditions.

Cluster Analysis

On the basis of clustering dendrogram (ward D) sixteen ber germplasm are divided into four groups/ cluster (Table 3, Figure 1). Maximum germplasm (10) were grouped into cluster II, whereas minimum genotypes (1) were in group Cluster III and IV. The germplasm in the same group are more less similar to each other. For example, Narendra Ber Sel-1 and Kakrola Gola are clustered together at a lower height compared to Katha Phal. This indicates that the diagram is visualizing how different variables contribute to the principal components (PCs) in a Principal Component Analysis (PCA) (Figure 2). PC1 and PC2 represent 30.2% and 21.8% of the total variance in the data. In correlation metrics fruit shape is negatively correlated with stone shape, pulp cavity stem end, pup cavity styler end, and fruit apex shape (Figure 3). However, pulp cavity stem end is positively correlated with mature fruit shape. Stone shape is positively correlated with pulp cavity (stem and styler end) and fruit apex shape.

The descriptors of ber germplasm plays a vital role in identification of variation in genetic diversity among germplasm, which enable breeders/growers to select the suitable character of economic importance (Bioversity International, 2007).

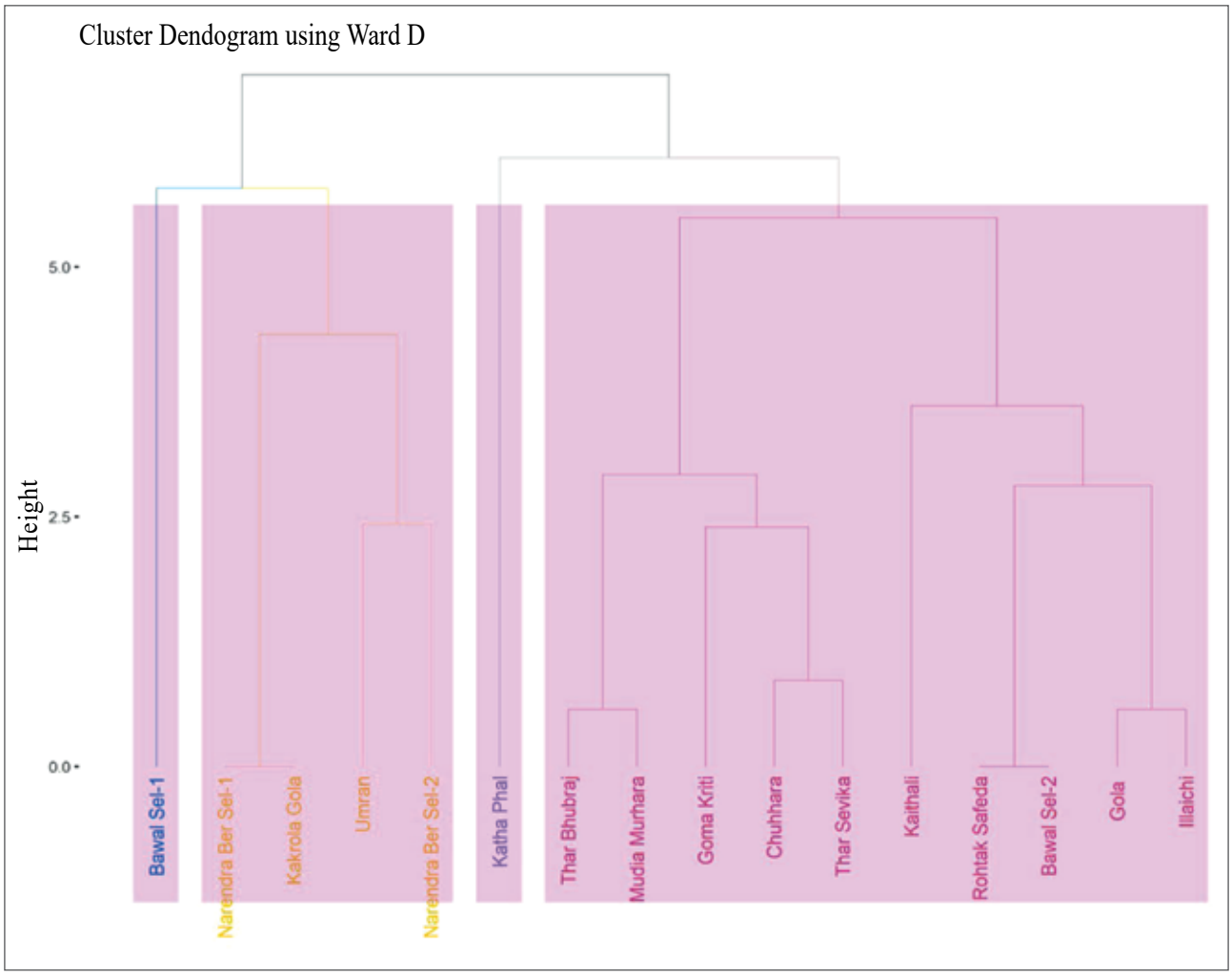

Figure 1. Cluster dendrogram (ward D) representation of ber germplasm.

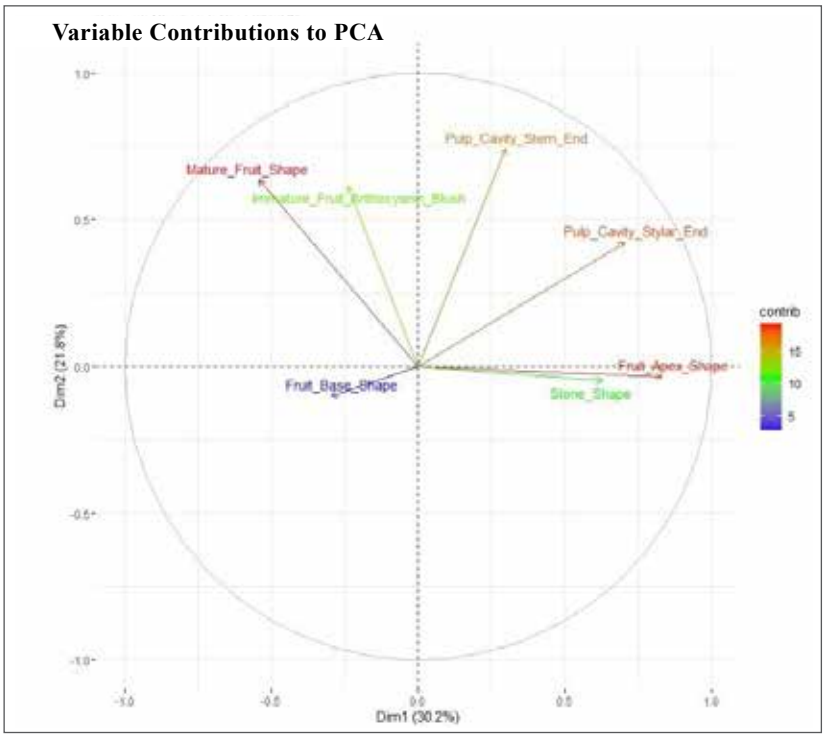

Figure 2. Different variables contribution to the principal components (PCs) in a Principal Component Analysis (PCA).

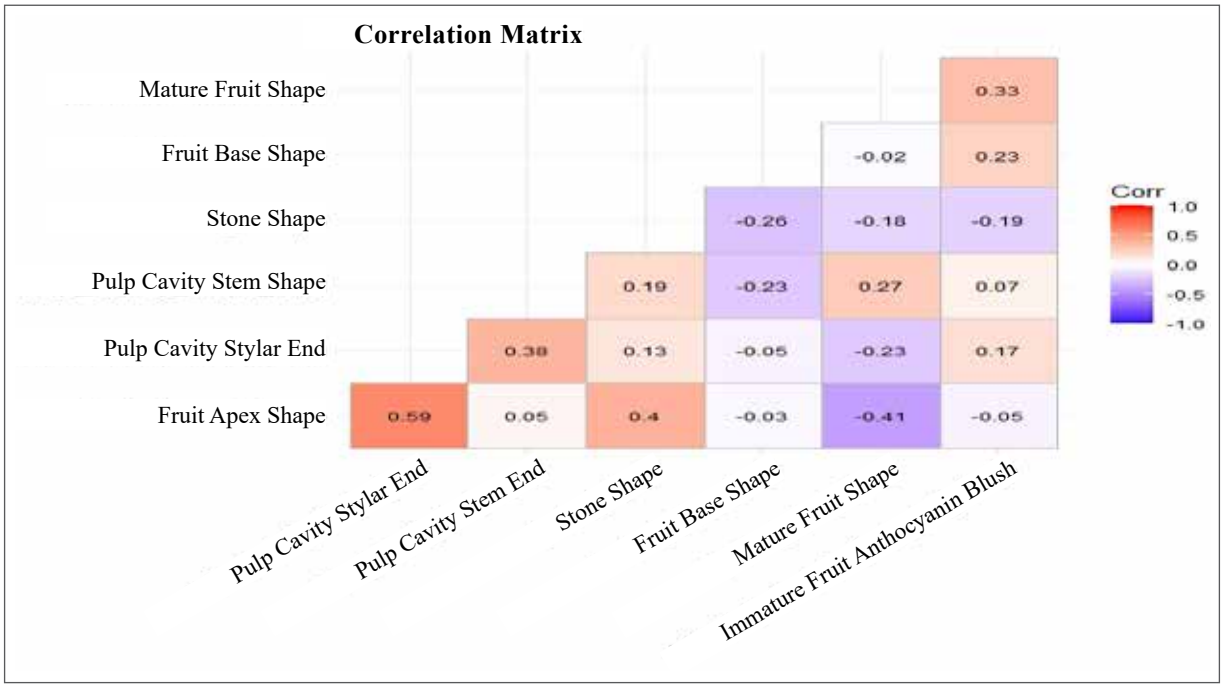

Figure 3. Correlation metrics for different characteristics of ber germplasm.

Table 1. Frequency distribution and example varieties of some important attributes of 16 ber germplasm.

Plant Descriptor	Range in Expression	Number of Genotypes	Germplasm
Mature fruit: Shape	Oblate	1	Illaichi
	Oval	2	Goma Kriti, Thar Bhubhraj
	Ovate	2	Chhuhara, Thar Sevika
	Oblong	6	Umran, Kaithali, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Mudia Murhara.
	Round	5	Gola, Narendra Ber Sel-1, Narendra Ber Sel-2, Kakrola Gola, Katha Phal
	Falcate	0	-
Fruit shape: Apex	Flat	2	Narendra Ber Sel-1, Kakrola Gola
	Round	10	Gola, Umran, Thar Bhubhraj, Narendra Ber Sel-2, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Mudia Murhara, Katha Phal, Illaichi
	Pointed	4	Kaithali, Chhuhara, Goma Kriti, Thar Sevika
Fruit shape: Base	Round	9	Gola, Umran, Goma Kriti, Narendra Ber Sel-2, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Katha Phal, Illaichi,
	Flat	7	Kaithali, Chhuhara, Thar Sevika, Thar Bhubraj, Narendra Ber Sel-1, Kakrola Gola, Mudia Murhara.
Mature fruit: Colour	Yellowish	3	Gola, Kaithali, Goma Kriti
	Greenish yellow	3	Chuhhara, Thar Bhubraj, Narendra Ber Sel-2
	Yellowish green	4	Thar Sevika, Rohtak Safeda, Kakrola Gola, Mudia Murhara
	Greenish	3	Narendra Ber Sel-1, Bawal Sel-1, Katha Phal.
	Golden yellow	1	Umran
	Golden green	1	Bawal Sel-2
	Brownish colour	1	Illaichi
Immature fruit: Anthocyanin Blush	Present	1	Katha Phal
	Absent	15	Gola, Umran, Kaithali, Goma Kirti, Thar Sevika, Thar Bhubharaj, Narendra Ber Sel-1, Rohtak Safeda, Narendra Ber Sel-2, Bawal Sel-1, Bawal Sel- 2, Kakrola Gola, Mudia Murhara, Illaichi
Pulp cavity: Stylar end	Present	11	Gola, Kaithali,Chuhhara, Goma Kirti, Thar Sevika, Thar Bhubraj, Rohtak Safeda, Bawal Sel- 2, Mudia Murhara, Katha Phal, Illaichi
	Absent	5	Umran, Narendra Ber Sel-1, Bawal Sel-1, Narendra Ber Sel-2, Kakrola Gola
Pulp cavity: Stem End	Present	15	Gola, Umran, Kaithali, Chuhhara, Goma Kriti, Thar Sevika, Thar Bhubharaj, Narendra Ber Sel-1, Rohtak Safeda, Bawal Sel-2, Narendra Ber Sel-2, Katha Phal, Kakrola Gola, Mudia Murhara, Illaichi
	Absent	1	Bawal Sel-1
Stone Shape	Oblong	1	Kaithali.
	Oval	8	Gola, Narendra Ber Sel-1, Rohtak Safeda, Bawal Sel-1, Bawal Sel-2, Kakrola Gola, Katha Phal, Illaichi.
	Spindle	1	Narendra Ber Sel. 2.
	Club	5	Umran, Chuhhara, Goma Kriti, Thar Bhubraj, Mudia Murhara
	Falcate	1	Thar Sevika

Table 2. Morphological characterization of ber fruits.

Germplasm	Mature Fruit Shape	Fruit Apex Shape	Fruit Base Shape	Immature Fruit Anthocyanin Blush	Pulp Cavity Stylar End	Pulp Cavity Stem End	Stone Shape
Gola	5	3	3	1	9	9	2
Umran	1	3	3	1	1	9	4
Kaithali	1	5	1	1	9	9	1
Chuhhara	3	5	1	1	9	9	4
Goma Kriti	2	5	3	1	9	9	4
Thar Sevika	3	5	1	1	9	9	5
Thar Bhubraj	2	3	1	1	9	9	4
Narendra Ber Sel-1	5	1	1	1	1	9	2
Narendra Ber Sel-2	5	3	3	1	1	9	3
Rohtak Safeda	1	3	3	1	9	9	2
Bawal Sel-1	1	3	3	1	1	1	2
Bawal Sel-2	1	3	3	1	9	9	2
Kakrola Gola	5	1	1	1	1	9	2
Mudia Murhara	1	3	1	1	9	9	4
Katha Phal	5	3	3	9	9	9	2
Illaichi	4	3	3	1	9	9	2

Table 3. Distribution of 16 germplasm into different clusters.

Clusters	Number of Germplasm	Germplasm
I	10	Gola, Kaithali, Chhuhara, Goma Kriti, Thar Sevika, Thar Bhubhraj, Rohtak Safeda, Bawal Sel-2, Mudia Murhara and Illaichi
II	4	Umran, Narendra Ber Sel-1, Narendra Ber Sel-2, Kakrola Gola
III	1	Bawal Sel-1
IV	1	Katha Phal

References

Anonymous, (2016). Guidelines of PPV&FRA for the conduct of test for distinctiveness, uniformity and stability on Indian jujube (ber) (*Ziziphus mauritiana* Lamk.). Plant Variety Journal of India,10(2).

Azam-Ali S, Bonkoungou E and Bowe C, (2006). Breeding. In: Ber and Other Jujubes, 289. deKock C, Godara A, Williams J T (Eds). International Centre for Underutilized Crops, Southampton, UK.

Bal JS, (1992). Identification of ber (*Ziziphus mauritiana* Lamk.) cultivars through vegetative and fruit characters. Acta Horticulturae, 317: 245–53.

Bioversity International, (2007). Guidelines for the development of crop descriptor lists. Bioversity Technical Bulletin Series, Bioversity International, Rome, Italy, XII 72 p.

Godi NF and Joshi VR, (2016). Studies on biochemical and organoleptic characters of different ber (*Ziziphus mauritiana* Lamk.) genotypes. Advances in Life Sciences, 5(6):2389-2393.

Godi NF, Joshi VR and Supe VS, (2016). Physical fruit characteristics assessment of selected ber (*Ziziphus mauritiana* Lamk.) genotypes. International Journal of Applied Research, 2(2):757-761.

Hu SY, Wen JB, Satar A and Tian CM, (2010). Research progress of quarantine pest *Carpomyia vesuviana*. Scientia Silvae Sinica, 46(7):147-154.

Islam MB and Simmons MP, (2006) A thorny dilemma: testing alternative intrageneric classifications within *Ziziphus* (Rhamnaceae). Systematic Botany, 31(4):826-842.

Krishna H, Bhargava R, Chauhan N and Sharma SK, (2016). Morphological descriptor for DUS testing of Indian jujube (*Ziziphus mauritiana*). Indian Journal of Agricultural Sciences, 86(6):809-814.

Kumar M, Arya RK, Kumar M, Gaur RK and Sharma S, (2021). Evaluation of Aonla varieties under semi-arid conditions of Haryana. Ekin Journal of Crop Breeding and Genetics, 7(2):139-144.

Kumari S, Bhat DJ, Wali VK, Bakshi P and Kumar R, (2016). Studies on vegetative growth and floral biology of *Ziziphus mauritiana* germplasm under rainfed conditions of Jammu, India. Ecology Environment and Conservation, *22(*2):641-646.

Liu P, Liu MJ, Zhao ZH, Liu XY, Wang JR and Yan C, (2009). Investigation on the characteristics of fruiting and seed development in Chinese jujube (*Ziziphus jujuba* Mill.). Acta Horticulturae, 840: 209-214.

Saran PL, Godara AK and Sehrawat SK, (2006). Characterization of ber (*Ziziphus mauritiana* Lamk.) genotypes. Haryana Journal of Horticultural Sciences, 35:215-18.

Singh OV, Singh K, Gowthami R and Shekhawat N, (2019). Morphological characterization of ber germplasm. Indian Journal of Horticulture, 76(2): 219-225.

Srinivasan VK, (1952). Chromosome number in the genus *Ziziphus*. Current Science, 21:224.

Vashishtha BB, (2001). Ber varieties: A monograph. Agrobios (India), Agro House, Behind Nasrani Cinema, Chopasani Road, Jodhpur, Rajasthan, India. p. 97.

Vavilov NI, (1951). The origin, variation, immunity and breeding of cultivated plants. Soil Science, 72(6): 482.

Yadav J, Gaur RK, Kumar Y, Kumari N, Yadav SS, Khan M and Yadav S, (2020). Evaluation of anti xenotic and allelochemical traits of ber (*Ziziphus mauritiana* Lamk.) fruits as a source of host plant resistance against fruit fly (*Carpomyia vesuviana* Costa) (Diptera: Tephritidae) in semi-arid region of India. Phytoparasitica, 48:607-620.

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Determination of Optimum Cold Acclimation Period under Controlled Conditions and Winter Resistance of Some Winter Wheat Genotypes

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ABSTRACT

The fact that climate conditions that will cause winter damage do not occur every year in the locations where wheat breeding studies are carried out poses an obstacle to selection in terms of cold resistance in breeding material. The research was planned and carried out to carry out the selection in question in a short time and clearly. 135 different bread wheat genotypes were acclimated to cold for 0, 21, 35 and 49 days using Hoagland solution under controlled conditions, and at the end of these periods, genotypes with high survival rates were identified by testing them to temperatures of -3, -5, -7, -9, -11 and -13°C. At the same time, the survival rates of the genotypes under the shelter where snow cover was prevented were also determined. It was revealed that the temperatures between -3°C and -13°C and the cold acclimation periods linearly affected the survival rates of the genotypes and the winter hardiness increased as the cold acclimation period increased. In the winter resistance studies to be conducted using Hoagland solution in wheat, it was determined that a 49-day cold acclimation period was appropriate and the maximum test temperature was -13°C. As a result of the study, it was decided to eliminate 97 genotypes from a total of 135 genotypes, which had high yields but low winter hardiness, before they were taken to the next breeding stage. Thus, 60% savings were achieved in terms of labor, time and other costs in the studies.

Keywords: Cold acclimation, hoagland solution, wheat, winter hardiness

Introduction

Cool climate cereals, which are the product group with the largest cultivation area in the world among cereals, constitute approximately 90% of cereal planting areas in Türkiye and 78% in the Eastern Anatolia Region. The average yield from wheat in the region is 3.1 tons-ha, which is around the Turkish average (3.2 tons-ha) (TÜİK, 2023). However, there is more yield potential in the region due to the high total annual rainfall. One of the reasons for this low yield is the spring or freezing planting due to winter damage. It is necessary to develop winter-resistant, high-yielding wheat varieties and expand the planting areas in the region. In Türkiye, as in the world, winter crops have higher grain yields than spring crops in areas with annual rainfall below 600 mm (Kırtok, 1974; Akten, 1985). Fowler and Gusta (1979) and Brule-Babel and Fowler (1989) stated in their studies that if varieties that are not resistant to cold are used in regions with harsh winters, their yield will decrease significantly. Öztürk et al. (1998) emphasized that winter planting is necessary to obtain high yields from wheat in the Eastern Anatolia Region and therefore winter resistance should be emphasized in breeding studies.

In Türkiye, winter resistance selections in cereals have mostly been carried out under field conditions,

but with this study, winter resistance tests in breeding material have begun to be carried out under controlled conditions. Field trials are affected by climate factors that change over the years in natural conditions. With this study, as a result of wheat breeding studies carried out in our institute, the winter hardiness degrees of genotypes brought to advanced breeding stages and varieties adapted to the region have been determined and good selection opportunity has been achieved. In addition, genotypes with determined hardiness are used as parents in crossing studies and are contributed to variety development studies.

Materials and Methods

In the breeding studies carried out by our institute, 128 bread wheat lines brought to advanced breeding stages by crossing, selection and induction methods and 7 bread wheat varieties Bezostaja-1, Yıldırım, Daphan, Karahan-99, Kate A-1, Pehlivan and İntensivnaya) with high adaptation to the region constituted the material of the study. Yıldırım and Daphan varieties were developed for the Eastern Anatolia Region.

The research was carried out with a total of 135 bread wheat genotypes according to the split-split plot experimental design in randomized blocks with three replications (Yıldız and Bircan, 1991).

There were three factors in this study, the first factor was the acclimation periods to cold, the second factor was temperature degrees and the third factor was bread wheat genotypes.

1. For the snow-free environment study, the seeds of the material were planted by hand under the shelter in a 2 m x 1 row (Figures 1 and 2).

2. In determining the degree of winter hardiness, the method applied by Fowler et al. (1995) was used with modification as follows.

Seeds belonging to genotypes were placed in petri dishes, watered and kept at +4°C and in the dark for 2 days against the possibility of dormancy. Then, the petri dishes were kept in the growth chamber at 20-22°C for 2 days. Then, the petri dishes were kept in the climate chamber at 20-22°C for 2 days. The next day, the seeds (5 seeds x 6 degrees x 3 replication=90 seeds) of each genotype that were just beginning to germinate were placed on perforated trays (containing 90 holes) for each cold acclimation periods. These trays were placed on previously prepared pots (40x16x12.5 cm) containing Hoagland solution, and the solution was changed every 2 weeks. The pots were placed in a growth chamber with a temperature of 20°C and a light of approximately 300 m mol m^{-2} s^{-1} (16 000 lux).

16 hours of photoperiod application was made in the growth chamber and the plants were kept in the chamber until they had 3-4 leaves (approximately 2 weeks). When the plants had 3-4 leaves, they were taken to the chamber containing 4±0.2°C temperature and the same light environment for cold acclimation (Figure 3). Cold acclimation periods were applied as 0 (control), 21, 35 and 49 days. At the end of each cold acclimation period, the pots determined for that period were taken out of the growing cabinet, and the plants in the pots were cut 0.5 cm below the root crown and 3-4 cm above the stem (leaf) crown (so as not to damage the roots and growth crown) (Figure 4). This process was applied in one replication from each genotype for each degree (-3, -5, -7, -9, -11, -13°C) with 5 plants. After cutting the roots and stems, the plant parts containing live roots and shoots of each genotype were grouped according to their test degrees and placed separately in aluminum boxes filled with 5 cm moist sand, and 5 cm thick moist sand was added on top. Then, these boxes were closed and placed in the freezer (Figure 5).

The temperature of the freezer was set at -3±0.2°C and the materials were kept in the freezer for 12 hours. This process is necessary to ensure complete freezing of the intercellular substances. At the end of twelve hours, the boxes marked -3°C were taken out, and then the process was continued by decreasing the temperature by 2°C every hour. The containers corresponding to the temperature after each hour (5 plants from each genotype at each temperature) were taken out of the freezer. The containers taken from the freezer were kept in the climate room at +4°C for one day. The next day, they were transferred to pots containing specially prepared humus flower soil and placed in the growth chamber where room temperature and 16 hours of photoperiod were applied. The pots were watered by adding fertilizer containing microelements (1 ml per 1 liter of water as stated in the fertilizer's instructions) and the pot soil was completely saturated and the live plants were regenerated. (Figure 6).

l. After approximately 3 weeks, the regenerating plants were counted and the temperature degree at which at least 3 plants out of 5 survived was determined as the winter resistance degree.

Results and Discussion

Without snow cover studies under the shelter

The material was planted in an environment without snow cover in order to understand whether the winter damage that may occur when snow cover is prevented under natural conditions coincides with the winter damage tests to be carried out under controlled conditions. The study material was planted under the shed in 2 m x 1 rows and it was watered after planting and 4 times with one week for 100% germination before winter.

100% germination was achieved before winter. After winter, the plants were watered for regeneration. However, regeneration occurred in 13 genotypes, while 112 genotypes died completely due to winter damage. This shows that snow cover is a good protector in winter months. In winter wheat, a snow cover must be occur to prevent freezing and increase survival rate. There should be 5 cm of snow cover at -8°C, 7 cm at -10°C, 14 cm at -15°C, 20 cm at -20°C, and 27 cm at -25°C. As the thickness of the snow cover increases, the survival rate of plants will increase (Dilmurodov and Ziyadullaev, 2020; Shakirjanovich and Dilmurodovich, 2021).

The results of the without snow cover could not be evaluated statistically, the germination rates are given in Table 4. Line 32 showed 70%, line 90 45%, line 116 40%, line 5 20%, lines 19, 20, 56, 8 and 50 10%, lines 74, 71, 1 and 15 5% post-winter regeneration rate (Table 4). Although it was observed that the performance of these lines as a result of winter hardiness tests under controlled conditions was parallel to their resistance under shelter, this relationship was weak in other genotypes. No literature was found on this subject.

Winter hardiness studies in controlled conditions

Creating cold-resistant varieties in wheat breeding programs is one of the most difficult tasks because several genes are involved. The main difficulty in creating cold-resistant varieties in breeding is usually the relationship between high cold tolerance and low yield and late ripening. Therefore, the purpose of selection is not to maximize cold tolerance, but to create varieties that can withstand the minimum temperature for a particular area (Dilmurodovich et al., 2021). In order to develop winter-hardiness varieties, studies that can yield results in a short time are needed and the study was conducted for this purpose.

The differences between cold acclimation periods (days), temperature test degrees, and genotypes, as well as the interactions between day x temperature, day x genotype, temperature x genotype, and day x temperature x genotype were found to be statistically significant ($p<0.01$) (Table 1).

The variance analysis showing the effects of different cold acclimation periods and temperature applications on the winter hardiness performances of genotypes is presented in Table 1.

The analysis results of the performances of genotypes against low temperatures with different cold acclimation periods are presented in Table 2.

Winter wheats develop adaptation mechanisms during the cold acclimation process to increase winter resistance (Struthers and Greer, 2001). As shown in Table 2, all plants exposed to low temperatures without cold acclimation died. As the cold acclimation period increased, winter hardiness performance improved, and the highest number of plants was obtained from plants acclimated for 49 days (2,289 plants). While the number of living plants was 1,426 on the day 21, it was 2,065 on the day 35. The effects of different cold acclimation periods on the winter hardiness of genotypes are presented in Figure 7. Galiba et al. (2011) reported that cold hardiness mechanisms are activated during the cold acclimation process.

Plants that were not acclimated to cold could not withstand winter (0.000 units), winter hardiness started to increase in plants acclimated to cold for 35 days. The analysis results of the winter hardiness performances of genotypes with different temperature applications are presented in Table 3.

As the temperature decreased, decreasing hardiness performance was observed in the genotypes. While the maximum number of live plants (2,714) was obtained from the -3°C temperature application, the minimum number of live plants was obtained from the -13°C application (0.018). The temperatures at which the least resistance was obtained were determined as -9°C, -11°C, -13°C. A rapid decrease in resistance was recorded after -9°C. In a study where Homer et al. (2016) researched the winter resistance of local and registered pea genotypes under controlled conditions, they could not determine any genotypes that could withstand -12 and -16°C, while local and registered genotypes that could withstand -8°C were determined.

The effects of different test temperatures on the cold resistance performance abilities of the genotypes are presented in Figure 8.

-3°C, -5°C, -7°C, -9°C temperatures had similar effect whereas -11 and -13°C temperatures gave similar results.

Dendrogram of temperatures applied were presented in Figure 8. The groupings are similar according to both the dendrogram and the variance analysis results. In Figure 10, although the genotypes showed similar reactions at -3°C, -5°C, -7°C, and -9°C, they showed different reactions at -11 and -13°C. Therefore, they were placed in different groups in Figure 9. The fact that the genotype x temperature interaction was statistically very significant supports this result. The hardiness levels shown by the genotypes at -11 and -13°C temperatures formed the basis for the classification of the genotypes. Therefore, the cluster analyses in Figures 9 and 10 show similarity with the variance analysis table (Table 3). The winter hardiness

rates of the genotypes under controlled conditions and their regeneration rates after winter without snow cover are presented in Table 4.

As a result of the applied cold acclimation and low temperature applications, genotypes 90 and 74 were determined to be the hardiest genotypes (2,958 and 2,681 plants, respectively). While genotype 90 showed a 45% regeneration ratio after winter in without snow cover, genotype 74 showed a 5% regeneration ratio. There was no regeneration observed in genotypes 130 and 131 (Table 4). The effects of cold acclimation duration and low temperature applications on the hardiness of genotypes were mostly determined to be linear and quadratic. Among the registered varieties included in the study, the following number of live plants were obtained: 1,236 from Bezostaja-1, 0.625 from Yıldırım, 0.694 from Daphan, 0.806 from Kate A-1, 1,139 from Pehlivan, 1,667 from Karahan-99 and 1,014 from Intensivnaya. No winter survival rate was observed in the rows of these varieties under the shelter. These values were obtained as a result of the combined analysis of data from all temperatures between -3°C and -13°C and four cold acclimation periods. However, each genotype responded differently to each cold acclimation period and applied temperature degrees. In a study conducted by Yıldırım et al. (2003) using 24 wheat and barley genotypes under controlled conditions, it was found that the Kıraç 66 variety was the most sensitive wheat variety to winter (-3.5°C) while Bülbül 89 was the most sensitive barley variety (-2.7°C). As a result of this study, line no. 8 (NGDA146/4/YMH/TOB//MCD/3/LIRA/5/F130L1.12) was registered with the name Ayyildiz, taking into account other agronomic features. As seen from Figure 7, 1, 5, 9, 7, 27, 34, 33, 40, 24, 22, 14, 15, 31, 44, 26, 25, 23, 41, 39, 35, 18, 48, 60, 113, 12, 2, 3, 6, 8, 11, 16, 20, 46, 51, 63, 117, 67, 57, 84, 85, 112, 106, 19, 62, 119, 32, 52 genotypes constituted of same group. The next group had 56, 71, 74, 77, 78, 79 86, 88, 90, 104, 122, 128, 134 genotypes. While 126, 127, 82, 93, 53, 87, 121, 68, 116, 125, 58, 72, 89, 105, 111, 129, 83, 95, 120, 135, 105, 55, 123, 59, 73, 99, 70, 105, 103, 115, 118 genotypes occurred in same group; the last group had 133, 114, 28, 38, 52, 54, 76, 61, 29, 124, 94, 108, 100, 30, 107, 132, 65, 17, 96, 21, 66, 43 64, 109, 69, 97, 102, 80, 98 91, 36, 13, 42, 92, 47, 45, 49, 10, 130, 131 and 37 genotypes.

The orthogonal partitioning table used to determine the effects of cold acclimation period and low temperature applications on the hardiness of genotypes is given in Table 5.

As indicated in Table 5, the effects of cold acclimation period and test degrees applications on the hardiness of genotypes were mostly determined to be linear and quadratic. The effects of cold acclimation period and low temperature applications on the winter resistance performance of genotypes and the effect type in terms of linear and quadratic effects are given in Table 6.

Through modeling calculations, the optimal cold acclimation period for maximum viability of genotypes was determined to be 58 days. In addition, cold acclimation periods after 40 days cause a relatively lower increase in plant vitality.

It has been determined that wheat genotypes acclimated to cold for a longer period can maintain their vitality at lower temperatures. The response to this acclimation period is not linear but quadratic. In other words, in plants acclimated to cold up to (58th day), maximum cold resistance is achieved although it varies according to the genotypic capacity. The winter resistance feature is not linear but quadratic although it varies according to the capacity of the genotypes. The maximum winter hardiness temperature has been identified as -16°C.

As a result, wheat genotypes subjected to a cold acclimation period of at least 40 days can survive winter without snow cover down to -16°C. Therefore, considering these results in applications to be made in breeding studies will increase success. It has been demonstrated that various temperature degrees between -3°C and -13°C and cold acclimation periods linearly affect the survival rates of the genotypes. Both cold acclimation periods and various temperature degrees have similar effects on the survival rates of the genotypes. The survival temperature limit for plants grown in Hoagland solution was determined to be -13°C in this study. Plants hadn't survived below this degree. In plants grown in a soilless environment, the presence of excessive water in plant cells caused more damage due to freeze-thaw cycles, reducing the survival rates of the plants. However, it is predicted that the hardiness levels of plants may decrease if winter hardiness studies are conducted under soil conditions. A method study was carried out by Küçüközdemir (2025) using soil and Hoagland solution media to determine the winter hardiness degrees of wheat under controlled conditions. In this study, stepwise and non-stepwise cold acclimation periods were applied in both media, and it was revealed that performing winter resistance tests in soil media by applying stepwise cold acclimation degrees gave the closest results to reality. For this reason, conducting newly planned winter hardiness test studies in soil conditions will be easier and data much closer to natural conditions will be obtained.

Conclusions

As the cold acclimation period increases, the winter hardiness of plants also increases. The maximum survival rate was determined at the end of the 49-day cold acclimation period. On the other hand, it was found that various temperature degrees between -3°C and -13°C linearly affect the survival rates of the genotypes.

With this study, all genotypes in advanced breeding stages were tested in terms of winter hardiness. From 135 genotypes, 97 genotypes with low winter hardiness levels were eliminated. This resulted in a 60% savings in terms of labor, time, and other expenses. While the breeding process of hardy genotypes continues, they have started to be used as parents in crossing studies.

Acknowledgements

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Figure 1. Genotypes planted in 2 m x 1 rows in a snow-free environment (Original).

Figure 2. Post-winter appearance in an environment without snow cover (Original).

Figure 3. Cold acclimated plants in Hoagland solution (Original).

Figure 4. Cutting of plants after cold acclimation period is completed (Original).

Figure 5. Plant parts placed in sand-filled containers for cold tests and placed in the freezer (Original).

Figure 6. Transferring the plant parts, whose test process has been completed, into soil pots to regeneration (Original).

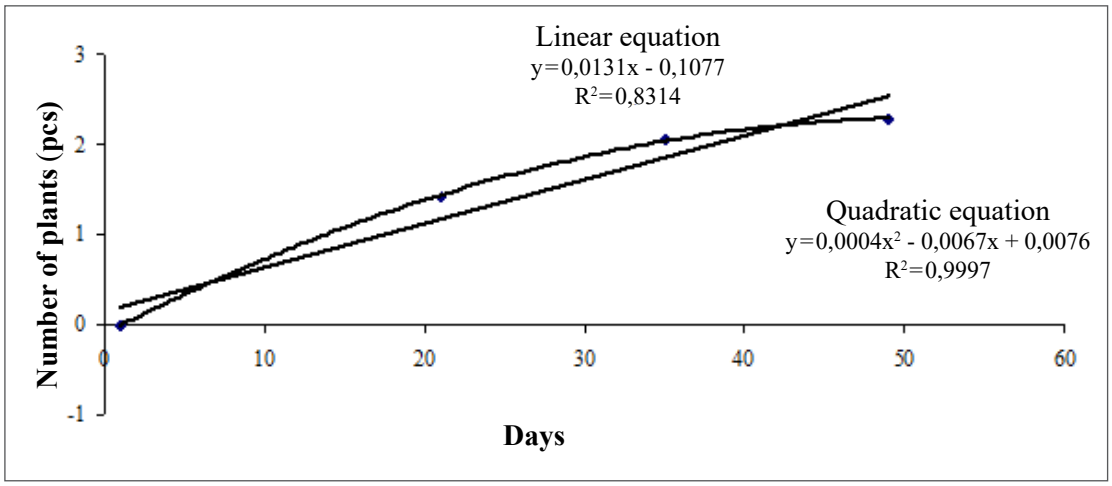

Figure 7. Effects of different cold acclimation periods on the winter hardiness performances of genotypes.

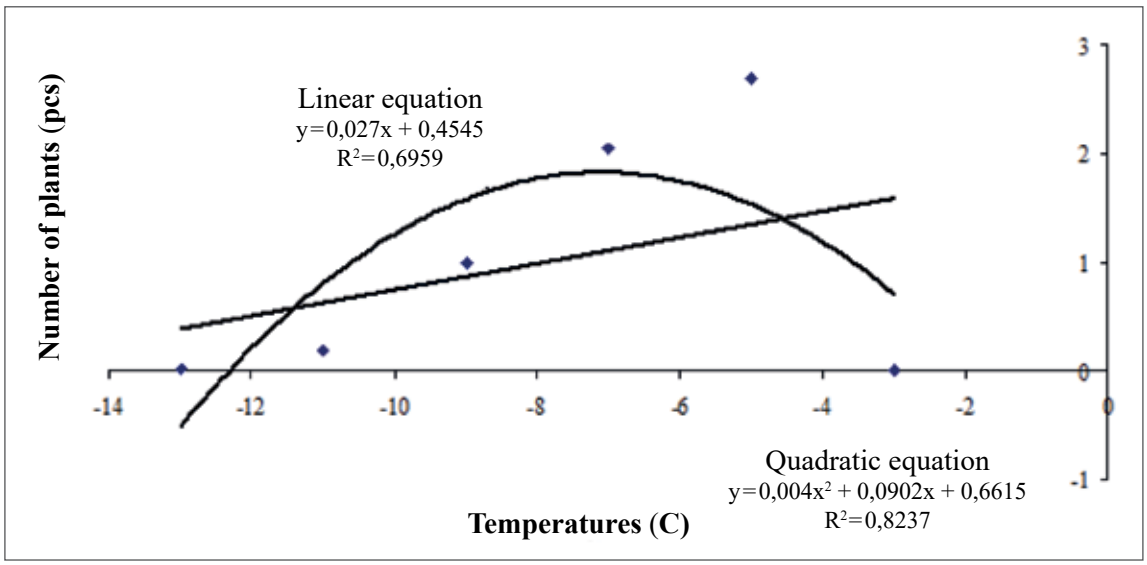

Figure 8. Effects of different temperatures on winter hardiness of genotypes.

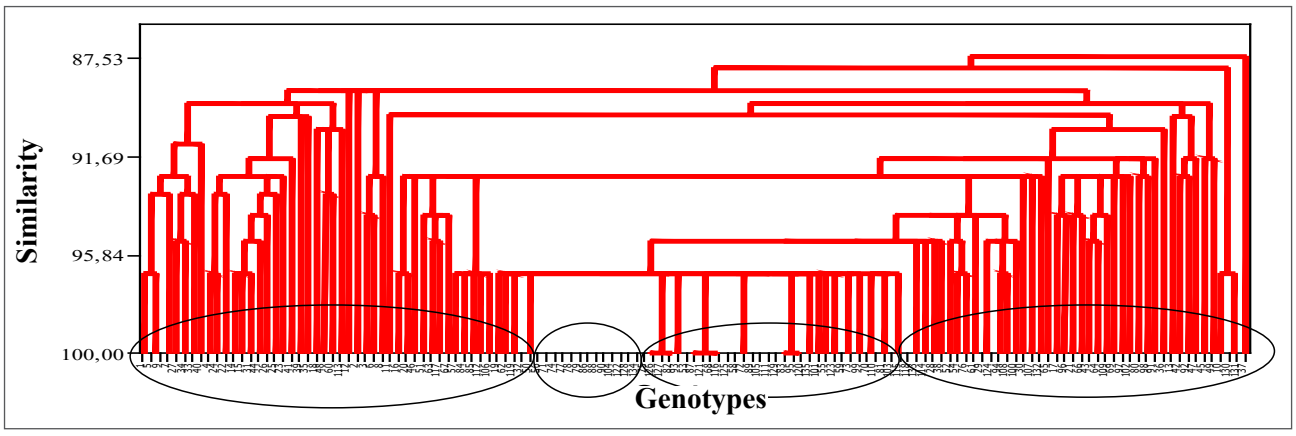

Figure 9. Dendrogram of genotypes.

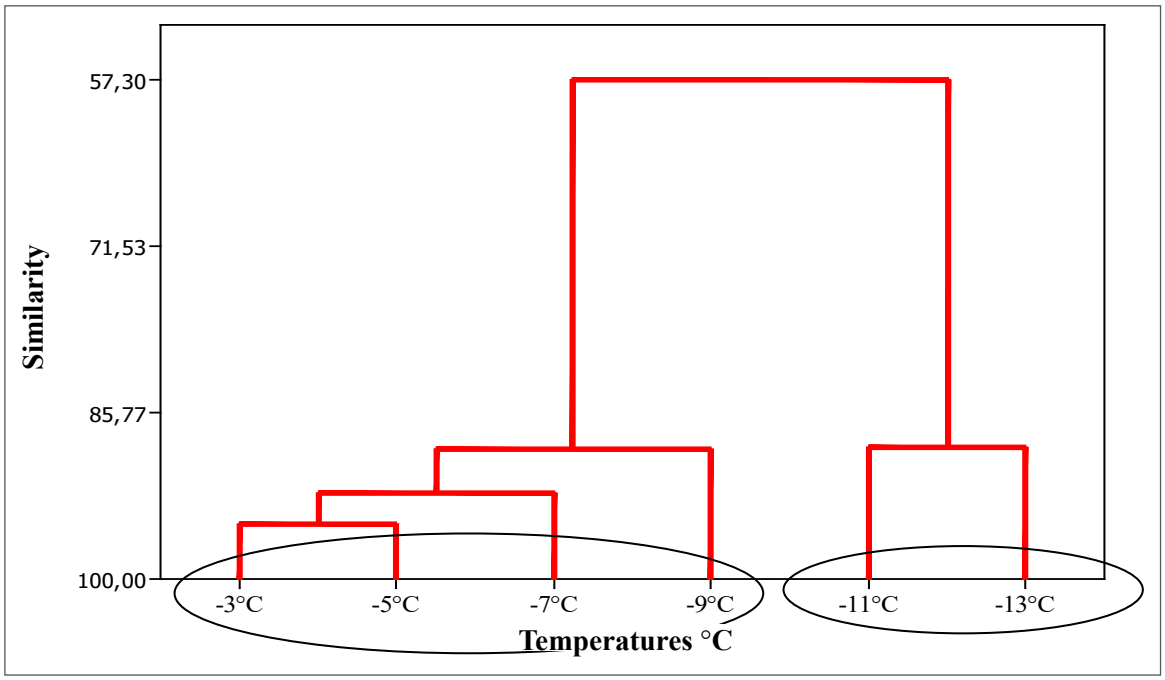

Figure 10. Dendrogram of temperatures applied as a factor.

Table 1. Variance Analysis of Winter Hardiness Performances of Genotypes with Different Cold Acclimation Periods and Temperature Applications.

Source of Variation	Degree of Freedom	Mean Squares	F Value
Replication	2	4.448	2.224*
Cold Acclimation Day	3	2579.019	234.915**
Temperature	5	2391.353	217.821**
Day x Temperature	15	294.571	26.832**
$Error_1$	48	10.978	-
Genotype	134	36.832	73.840**
Day x Genotype	402	6.188	12.405**
Temperature x Genotype	670	4.979	9.981**
Day x Temp x Genotype	2010	1.720	3.449**
$Error_2$	6432	0.499	-
General	9719	4.328	-
C.V. (%): 32.04			

Table 2. Effects of Different Cold Acclimation Periods on Winter Hardiness Performances of Genotypes.

Cold Acclimation Days	Number of Live Plants
Control (0 day)	0.000 C
Day 21	1.426 B
Day 35	2.065 A
Day 49	2.289 A
Mean	1.445
L.S.D. (%): 0.255	

Table 3. Effects of Different Temperature Treatments on Winter Hardiness Performance of Genotypes.

Test degrees	Number of Live Plants
-3°C	2. 714 A
-5°C	2.702 A
-7°C	2.054 B
-9°C	0.992 C
-11°C	0.190 D
-13°C	0.018 D
Mean	1.912
L.S.D. (%): 0.313	

Table 4. Survival Rates of Genotypes After Winter Hardiness Tests and Post-Winter Regeneration Rates in Without Snow Cover under the Shelter.

No	[a]L.P (number)		[b]R (%)	No	[a]L.P (number)		[b]R (%)	No	[a]L.P (number)		[b]R (%)
90	2,96	A	45	36	1,85	I-W	-	18	0,96	`-h	-
74	2,68	AB	5	32	1,82	J-X	70	6	0,93	a-i	-
89	2,46	BC	-	81	1,82	J-X	-	11	0,93	b-j	-
93	2,46	BC	-	106	1,79	K-X	-	5	0,88	b-j	20
77	2,46	BC	-	119	1,78	L-Y	-	91	0,88	c-k	-
112	2,42	B-D	-	95	1,76	M-Y	-	30	0,88	c-k	-
71	2,40	B-E	5	19	1,75	M-Y	10	20	0,86	c-k	10
88	2,39	B-F	-	85	1,72	N-Y	-	64	0,86	c-k	-
116	2,39	B-F	40	84	1,72	N-Y	-	9	0,85	c-k	-
86	2,35	B-G	-	67	1,69	O-Z	-	97	0,83	c-l	-
87	2,35	B-G	-	117	1,69	O-Z	-	44 (Kate A-1)	0,81	c-m	-
72	2,33	B-G	-	115	1,69	O-Z	-	98	0,78	d-m	-
79	2,31	B-H	-	62	1,68	O-[	-	66	0,78	e-n	-
56	2,29	B-H	10	111	1,68	O-[	-	109	0,75	e-n	-
78	2,29	B-H	-	54	1,67	P-\	-	1	0,74	e-o	5
120	2,28	B-I	-	49 (Karahan-99)	1,67	P-\	-	29	0,72	e-o	-
129	2,28	B-I	-	3	1,67	P-\	-	2	0,71	e-o	-
8	2,26	B-I	10	124	1,67	P-\	-	12	0,71	e-p	-
126	2,26	B-I	-	76	1,65	Q-]	-	14	0,69	e-p	-
128	2,25	B-J	-	65	1,64	Q-]	-	40	0,69	f-p	-
134	2,25	B-J	-	99	1,64	Q-]	-	43 (Daphan)	0,69	f-p	-
101	2,24	C-J	-	61	1,61	R-]	-	48	0,64	g-q	-
127	2,24	C-J	-	38	1,61	R-]	-	34	0,63	g-q	-
125	2,22	C-K	-	110	1,61	R-]	-	42 (Yıldırım)	0,63	g-q	-
53	2,21	C-L	-	100	1,60	S-]	-	21	0,60	g-q	-
75	2,18	C-M	-	94	1,58	S-]	-	18	0,57	h-r	-
82	2,15	C-N	-	69	1,58	S-]	-	33	0,56	i-r	-
70	2,15	C-N	-	13	1,58	S-]	-	23	0,51	j-s	-
83	2,14	C-N	-	51	1,57	T-^	-	35	0,50	j-t	-
55	2,11	C-O	-	112	1,57	T-^	-	22	0,49	k-t	-
123	2,11	C-O	-	16	1,54	U-^	-	17	0,46	k-t	-
121	2,10	C-P	-	46	1,49	V-_	-	25	0,42	l-u	-
118	2,07	C-Q	-	102	1,43	W-`	-	96	0,42	l-u	-
59	2,07	C-Q	-	80	1,42	W-`	-	113	0,42	l-u	-
73	2,04	C-R	-	28	1,39	X-a	-	15	0,40	m-u	5
104	2,01	D-S	-	133	1,35	Y-b	-	31	0,36	n-u	-
50	2,01	D-S	10	108	1,26	Z-c	-	41	0,36	n-u	-
135	2,00	D-T	-	60	1,25	[-c	-	24	0,32	o-u	-
52	2,00	D-T	-	37 (Bezostaja-1)	1,24	\-d	-	4	0,28	p-u	-
105	1,97	E-U	-	132	1,22	]-d	-	27	0,24	q-u	-
103	1,97	E-U	-	45 (Pehlivan)	1,14	^-e	-	26	0,14	r-u	-
58	1,96	F-U	-	107	1,10	_-e	-	39	0,11	s-u	-
114	1,94	G-U	-	57	1,01	_-f	-	10	0,07	t-u	-
122	1,94	G-U	-	92 (Intensivnaya)	1,01	`-g	-	131	0,00	u	-
7	1,88	H-V	-	47	1,00	`-g	-	130	0,00	u	-

a: Number of live plants [Number of living plants resulting from the combined analysis of all temperatures (out of 5 plants)]

b: Regeneration (%): Percentage of plants surviving after winter in without snow cover under the shed)

Table 5. Orthogonal Partitioning Table Conducted to Determine the Effects of Cold Acclimation Period and Low Temperature Applications on the Resistance of Genotypes.

Source of Variation	D.F	Cold Acclimation Periods (day)		Test Degrees (°C)	
		Mean Squares	F-value	Mean Squares	F-value
Linear Effect	1	6844.879	13722.334**	11284.899	22623.504**
Quadratic Effect	1	875.400	1754.966**	38.571	77.325**
Cubic Effect	1	16.778	33.636**	628.431	1259.852**
Quadratic Effect	1	-	-	1.259	2.525ns
Error	6432	0.499	-	0.499	

**: Significant at the 1% level; ns: Non-significant.

Table 6. The Effect of Cold Acclimation Period and Low Temperature Applications on the Winter Hardiness Performance of Genotypes and the Effect Form in Terms of Linear and Quadratic Effect.

Effect Type	Cold Acclimation Period (days)		Test Degree (°C)	
	Formula	R^2	Formula	R^2
Linear Effect	y = 0,0131x - 0,1077	0.8314	y = 0.027x + 0.4545	0.6959
Quadratic Effect	$y = 0,0004x^2 - 0,0067x + 0,0076$	0.9997	$y = 0.004x^2 + 0.0902x + 0.6615$	0.8237

References

Akten Ş, (1985). Winter barley cultivation and problems in the Eastern Anatolia Region [Unpublished manuscript]. Atatürk University, Faculty of Agriculture, Department of Field Crops, Erzurum.

Brule-Babel AL & Fowler DB, (1989). Use of controlled environments for winter cereal cold hardiness evaluation: Controlled freeze tests and tissue water content as prediction tests. Canadian Journal of Plant Science, 69(2):355-369.

Dilmurodov EB, (2018). Spectrum and quadratic numerical range of the generalized Friedrichs model. Young Scientist, (11):1-3.

Dilmurodov SD & Ziyadullaev ZF, (2020). Selection of early and productive lines in preliminary yield trial of bread wheat. Innovation Technical and Technology, 1(1):55-59.

Dilmurodovich DS, Usmanovna HS, Ugli JEJ & Vokhidovna SN, (2021). Selection of cold-tolerant varieties and lines of bread wheat. Наука *и* образование сегодня, 4(63):30-33.

Fowler DB & Gusta LV, (1979). Selection for winter hardiness in wheat. I. Identification of genotypic variability. Crop Science, 19(6):769-772.

Fowler DB, Limin AE, Wang SY & Ward RW, (1995). Relationship between low-temperature tolerance and vernalization response in wheat and rye. Canadian Journal of Plant Science, 39:37-42.

Galiba G, Vágújfalvi A, Vashegyi I, Soltész A, Stockinger EJ, Dubcovsky J & Kocsy G, (2011). Interaction between cold acclimation, frost tolerance and flower initiation in wheat. Agrisafe Final Conference (March 21-23), Clımate Change: Challenges and Opportunıtıes in Agriculture, 163-166.

Homer A, Şahin M & Küçüközdemir Ü, (2016). Evaluation of pea (*Pisum sativum* L.) germplasm for winter hardiness in Central Anatolia, Turkey, using field and controlled environment. Czech Journal of Genetics and Plant Breeding, 52(2):55-63.

Kırtok Y, (1974). A research on the effects of fertilization and planting time treatments applied in wet and dry conditions on yield and yield components of some winter barley varieties in Erzurum plain [Unpublished doctoral dissertation]. Atatürk University, Faculty of Agriculture, Department of Field Crops.

Küçüközdemir Ü, (2025). Determination of the most appropriate winter hardiness test method for wheat under controlled conditions. Wheat Studies, 13(2):37-43.

Öztürk A, Çağlar Ö & Akten Ş, (1998). Cereal agriculture in the North East Anatolia Region, productivity problems and solutions. In Proceedings of the Eastern Anatolia Agriculture Congress (pp. 157-169). 14-18 September.

Shakirjanovich KN & Dilmurodovich DS, (2021). Analysis of yield and protein content of drought-resistant chickpea lines for rainfed areas. International Journal of Discourse on Innovation, Integration and Education, 2(1), 108-111.

Struthers D & Greer K, (2001). Basics of cold tolerance and winter survival in winter wheat. In Manitoba Agronomists Conference (pp. 181-189).

TÜİK, (2023). Bitkisel üretim istatistikleri. https://data.tuik.gov.tr/Search/ Search?text=bu%C4%9Fday. Access Date: 01 May 2025.

Yıldırım T, (2003). Determination of cold resistance and vernalization needs in some wheat and barley genotypes grown in Eastern Anatolia Region [Unpublished doctoral dissertation]. Atatürk University, Faculty of Agriculture, Erzurum.

Yıldız N and Bircan H, (1991). Araştırma ve Deneme Metodları. Atatürk Üni. Zir. Fak. Yay. No: 305, Ders Kitapları Serisi No: 57, Erzurum, 277 (in Turkish).

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Determination of Yield and Some Quality Characteristics of Bread Wheat (*Triticum aestivum* L.) Genotypes in Different Environmental Conditions

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ABSTRACT

This study was conducted in 2 regions (Samsun-Bafra and Tokat) in the Central Black Sea Region, depending on rainfall, during the 2021-2022 production period. The trial consists of 21 lines and 4 standard varieties in the regional yield stage within the scope of the bread wheat breeding program conducted by the Black Sea Agricultural Research Institute. The aim of the study is to determine the lines superior to the varieties in terms of grain yield and quality. The trial was conducted in randomized block design in 6 m^2 (5 m x 1.2 m) plots with 4 replications. In the study, yield and some quality traits (thousand grain weight, hectoliter weight, protein ratio, zeleny sedimentation, alveograph energy value, grain hardness and water absorption (Farinograph) value) were examined. According to the obtained results, grain yield was 476.6 - 1125.8 kg/da, thousand grain weight was 31.9 - 54.1 g, hectoliter weight was 68.0 - 80.8 kg/hl, protein content was 10.8 - 15.3%, zeleny sedimentation was 32 - 75 ml, alveograph energy value (W) was 105 -385 Joule, grain hardness (PSI) was 34.4 - 88.6 and water absorption (Farinograph) value was 56.9 - 67.5%. Significant ($p<0.01$) differences were found among the genotypes in terms of grain yield, thousand grain weight and hectoliter weight. The highest grain yield with 1125.8 kg/da was obtained from line 1 in Bafra location, hectoliter weight value with 80.8 kg/hl was obtained from line 12 in Bafra location, thousand grain weight value with 54.1 g was obtained from line 18 in Bafra location and protein value with 15.3% was obtained from line 18 in Bafra location, grain hardness (PSI) value with 88.6 was obtained from line 4 in Tokat location, zeleny sedimentation value with 75 ml was obtained from Altındane standard variety in Bafra location, alveograph energy value with 385 Joule was obtained from line 22 in Tokat location and water absorption (Farinograph) with 67.5% was obtained from line 9 in Bafra location. According to the results obtained from the trial, it was concluded that lines 1, 4, 9, 12, 18 and 22 could be evaluated as variety candidates in the future and therefore should be included in the next breeding program.

Keywords: Bread wheat, line, breeding, quality, region yield

Introduction

Wheat (*Triticum* spp.) has been cultivated and improved by humans for approximately 10,000 years, beginning with the advent of settled agriculture. Today, wheat constitutes a significant portion of the global food supply. More than 720 million people around the world are currently under the threat of hunger, making wheat production and accessibility critically important for global food security (Ibba MI et al., 2022). Wheat is a vital cereal crop with global production exceeding 770 million tons annually (Anonymous, 2022). It is cultivated on more than 217 million hectares worldwide and plays a key role in global food security (Erenstein, 2022).

In Türkiye, wheat was cultivated on 6.8 million hectares with a total production of 20.8 million tons during the 2023-2024 growing season (Anonymous, 2024). Approximately 95% of the wheat grown globally is bread wheat (hexaploid), while the remaining 5% is mostly durum wheat (tetraploid), which is used primarily for pasta production (Shewry, 2009). Wheat provides

about 21% of daily caloric intake, approximately 55% of carbohydrates, and 13% of proteins consumed by humans (Riaz et al., 2021; Ali et al., 2012). The global population is projected to reach around 9 billion by 2050, leading to an expected 60% increase in wheat demand (Anonymous, 2025). One of the most effective ways to increase wheat production is by improving grain yield per unit area. Yield is influenced by the plant's genetic potential, environmental factors, and agronomic practices. Variations in grain yield are largely attributable to the genetic characteristics of wheat varieties (Kırtok et al., 1988; Sharma, 1992; Öztürk & Akkaya, 1996; Ağdağ et al., 1997; Dokuyucu et al., 1997; Anıl, 2000). In addition to yield, bread-making quality is another crucial parameter in wheat production. In particular, both the quantity and quality of protein are among the most important traits affecting bread-making performance. The demand for high-quality flour in the food industry naturally drives producers to seek wheat varieties that are both high-yielding and of superior quality. For an ideal bread wheat variety, the required quality parameters include a minimum protein content of 11.5%, a hectoliter weight of 77-78 kg/hl, a Zeleny sedimentation value of at least 30 ml, and high energy and water absorption values, along with a hard grain texture. Pastry products (such as pasta, biscuits, and buns) require an even higher protein content, preferably 12-12.5%, and a baking strength (alveograph energy value) of 220-300 joules (W), which is higher than that of typical bread dough (Anonymous, 2022).

Climate change may negatively affect wheat production due to temperature increase, water scarcity and extreme weather events. This situation necessitates the development of new wheat varieties and the implementation of sustainable agricultural techniques (Asseng et al., 2015). This study was conducted in 2022 in different regions of Türkiye (Bafra/Samsun and Merkez/Tokat) under rainfed conditions. The aim is to comparatively evaluate the grain yield, yield components and certain quality traits of some advanced bread wheat lines. In this context, it is aimed to determine genotypes with high adaptability and increased yield and quality traits together. It also aims to obtain important data that will contribute to both producers and the food industry for sustainable wheat production. The data obtained will contribute to wheat breeding studies in regions with similar ecological conditions.

Materials and Methods

Materials

This study was conducted under rainfed conditions during the 2021-2022 growing season at two experimental sites: the Black Sea Agricultural Research Institute in Bafra (Samsun) and the Transitional Zone Agricultural Research Institute located in the Central Black Sea Region in Tokat (Figure 1). The experimental material comprised 20 advanced bread wheat lines along with 5 standard check varieties. The check varieties included Altındane, Kirve, and Nevzatbey (registered by the Black Sea Agricultural Research Institute), the SİTAP-14/21 line, and Flamura 85 (registered by TAREKS Inc.) (Table 1). Climatic data for the experimental locations are presented in Table 2, while soil analysis results are provided in Table 3.

Methods

The experiment was conducted using a randomized complete block design (RCBD) with four replications. Sowing was carried out using a plot drill with six rows, with each plot measuring 7.7 m². Sowing dates were November 4, 2021, in Tokat and November 18, 2021, in Bafra. The seeding rate was adjusted to establish a target plant population of 550 plants per square meter. Harvesting was performed using a plot combine harvester on July 4, 2022, in Tokat and July 6, 2022, in Bafra, with a harvested area of 6 m² per plot.

Fertilization at sowing included the application of 6 kg/da of pure nitrogen and 6 kg/da of pure phosphorus at both locations. In Bafra, an additional 10 kg/da of nitrogen was applied at the stem elongation stage, followed by 4 kg/da at the heading stage. In Tokat, only 10 kg/da of nitrogen was applied at the stem elongation stage. Weed control was achieved through the application of a herbicide containing Halauxifen-methyl, 25% Pyroxsulam, and 35.4% Cloquintocet-acid as active ingredients, applied at the recommended doses to control both narrow- and broad-leaved weeds.

The primary traits evaluated included grain yield (kg/da), hectoliter weight (kg/hl), and thousand kernel weight (g). Quality traits assessed were moisture content (%), protein content (%), SDS sedimentation value (ml), grain hardness, Alveograph energy value (W), and water absorption (Farinograph, %). These analyses were conducted at the Quality Laboratory of the Bahri Dağdaş International Agricultural Research Institute. Grain yield was calculated by extrapolating the grain weight obtained from the 6 m² plots to a per-decare (da) basis.

For quality analyses, grain samples were ground using a Perten 3100 mill (Perten Instruments AB, Sweden) with a 0.8 mm sieve. Protein content was determined by multiplying the nitrogen content, measured via the Dumas method using a Leco FP 528 analyzer, by a factor of 5.7, according to AOAC 992.23 (Anonymous, 2000a). Grain hardness was assessed using a Foss DS2500 F NIR instrument, calibrated according to the Single Kernel Characterization System

(SKCS) standard (AACC 55-31) (Anonymous, 2000b). For flour production, 1 kg of cleaned wheat grain was tempered to 14.5% moisture (w/w) and rested for 12 hours before milling with a Yücebaş YM1 laboratory mill (Yücebaş Machinery Analytical Equipment, İzmir, Türkiye), following AACC methods 26-95 and 26-50 (Anonymous, 2000b).

Thousand kernel weight (g/1000 seeds) and hectoliter weight (kg/100 L) were measured according to the method of Williams et al. (1988), and results were reported on a dry matter basis. Zeleny sedimentation was assessed using ICC Standard Method No. 116 (Anonymous, 1981), while grain protein content was also evaluated with the Foss 1241 Infratec Grain Analyzer (NIT) (Anonymous, 2002b). Flour yield was determined following ICC Standard Method No. 137/1 (Anonymous, 2002a).

Statistical analyses were performed using JMP software version 7.0. Differences among treatment means were evaluated using the Least Significant Difference (LSD) test at significance levels of $p \leq 0.01$ and $p \leq 0.05$ (Kalaycı, 2005).

Results and Discussion

The grain yield (Table 4), hectoliter weight (Table 5), thousand kernel weight (Table 6), and selected quality parameters (Tables 7-8) of the genotypes evaluated at the Bafra and Tokat locations are presented. Statistically significant differences among genotypes were observed for grain yield, hectoliter weight, and thousand kernel weight at the $p \leq 0.01$ level.

Grain Yield

When both locations were evaluated together, the overall average grain yield was 830.5 kg/da, with values among genotypes ranging from 476.6 to 1125.8 kg/da. The highest yield was recorded for genotype No. 24 (972.0 kg/da), while the lowest yield was observed in genotype No. 22 (573.4 kg/da).

The average grain yield was higher at the Bafra location (876.5 kg/da) compared to Tokat (784.6 kg/da). However, some genotypes exhibited higher grain yields in Tokat. This discrepancy is primarily attributed to the higher rainfall and humidity levels in Bafra, which, while beneficial for crop growth in general, also create favorable conditions for the development of fungal diseases such as rusts, Fusarium, and powdery mildew, and increase the risk of pre-harvest sprouting. Consequently, certain genotypes (Nos. 11, 20, 22, and 25) experienced yield losses in Bafra due to yellow rust infection.

Aydın et al. (2005) reported that grain yields of genotypes ranged from 165 to 381 kg/da under the conditions of Samsun and Amasya, noting that lower-than-expected yields in Samsun were primarily caused by lodging and disease outbreaks associated with excessive rainfall. Similarly, Mut et al. (2005), in a study involving 25 bread wheat genotypes conducted in the same regions, reported grain yields ranging from 284.4 to 490.6 kg/da and observed statistically significant differences among the genotypes. In another multi-environment trial conducted by Mut et al. (2009) across seven locations in Samsun and Amasya, grain yields ranged between 350.3 and 550.6 kg/da.

Karaman and Aktaş (2020) reported grain yields ranging from 581.1 to 777.3 kg/da under Diyarbakır conditions during the 2011-2012 growing season. Similarly, Erkul (2006), in a trial conducted during the 2004-2005 season at the experimental fields of the Department of Field Crops, Faculty of Agriculture, Adnan Menderes University, reported grain yields ranging from 378.12 to 522.40 kg/da.

Yazar et al. (2013), in a bread wheat breeding study conducted in the Central Anatolia Region during the 2010-2011 growing season, found grain yields ranging from 379 to 551 kg/da. Karaman et al. (2017), in trials carried out under rainfed conditions in Diyarbakır, Ceylanpınar, and Hazro during the 2014-2015 season, observed grain yields ranging from 564 to 678 kg/da. Likewise, Aydoğan and Soylu (2017) reported grain yields between 447.42 and 709.08 kg/da in a study conducted at the Bahri Dağdaş International Agricultural Research Institute in Konya during the 2014-2015 season.

Naneli (2022), in a study conducted at the Kaynarca and Taraklı locations during the 2020-2021 growing season, found that grain yields varied significantly ($p \leq 0.01$), ranging from 481 to 727 kg/da in Kaynarca and from 426 to 791 kg/da in Taraklı. The average yields were 617 kg/da and 595 kg/da for Kaynarca and Taraklı, respectively.

Aktaş and Gökdere (2025), in a regional study conducted across the Aegean, Marmara, Mediterranean, Southeastern Anatolia, and Central Anatolia Regions during the 2016-2017 and 2017-2018 growing seasons, reported grain yields ranging from 4260 to 8137 kg/ha.

Ersöz and Budak Başçiftçi (2024) determined that grain yields ranged between 237.91 and 491.20 kg/da in a trial conducted at the research and trial area of the Faculty of Agriculture, Eskişehir Osmangazi University, during the 2021-2022 growing season. Similarly, Doğan (2024), in a study carried out at the Eskişehir Transitional Zone Agricultural Research Institute during the 2021-2022 production season, reported grain yields ranging from 259 to 506 kg/da. Demir (2024), in a trial conducted at the S.S. Akşehir-

Ilgın Sugar Beet Growers Cooperative field during the 2022–2023 growing season, reported grain yields ranging from 436 to 711 kg/da.

Hectoliter Weight (HLW)

Hectoliter weight is a key physical quality parameter in wheat, providing insights into potential flour yield and widely used by the grain industry. Values of 78 kg/hl and above are generally considered favorable by millers. This trait is influenced by both genetic factors (genotype) and environmental conditions.

The hectoliter weight values of the genotypes included in the trial are presented in Table 5. According to the results, the overall mean across locations was 76.1 kg/hl. At the Bafra location, the highest hectoliter weight was observed in genotype No. 12 (80.8 kg/hl), while the lowest was recorded for genotype No. 22 (68.0 kg/hl). In the Tokat location, the highest value was recorded for the standard variety Nevzatbey (79.5 kg/hl), and the lowest for genotype No. 23 (69.7 kg/hl).

Hectoliter weight is significantly affected by environmental variables such as temperature, humidity, and precipitation. When comparing the locations, it is evident that the hectoliter weight values in Tokat were generally lower than those in Bafra. This difference is attributed to Tokat's lower precipitation and higher temperatures. Regular precipitation, particularly during the grain filling period, and hot, dry conditions can promote grain filling and increase weight. Conversely, excessive heat or stress can negatively impact grain development (Slafer & Andrade, 1991).

In a study conducted under Samsun and Amasya conditions, Aydın et al. (2005) reported an average hectoliter weight of 62 kg/hl in the Samsun location, attributing the low values to lodging and disease outbreaks resulting from excessive rainfall. Similarly, Mut et al. (2005), evaluating 25 bread wheat genotypes in the same regions, reported hectoliter weight values ranging from 68.4 to 74.9 kg/hl. In another study across seven environments in Samsun and Amasya, Mut et al. (2010) found an average hectoliter weight of 71.4 kg/hl.

Karaman and Aktaş (2020) reported hectoliter weight values ranging between 76.5 and 85.4 kg/hl in a study conducted in Diyarbakır during the 2011-2012 growing season. Erkul (2006), in a trial carried out during the 2004–2005 season at the Field Crops Department of the Faculty of Agriculture, Adnan Menderes University, reported hectoliter weight values ranging from 75.87 to 81.40 kg/hl.

Karaman et al. (2017), in a study conducted under rainfed conditions in Diyarbakır, Ceylanpınar, and Hazro during the 2014–2015 season, observed hectoliter weight values between 78.2 and 82.7 kg/hl. Likewise, Aydoğan and Soylu (2017), in a trial conducted at the Bahri Dağdaş International Agricultural Research Institute in Konya during the 2014–2015 growing season, reported hectoliter weight values ranging from 73.32 to 78.35 kg/hl.

Aktaş and Gökdere (2025), in a regional study conducted across the Aegean, Marmara, Mediterranean, Southeastern Anatolia, and Central Anatolia regions during the 2016–2017 and 2017-2018 seasons, reported hectoliter weight values ranging from 77.2 to 79.2 kg/hl. Naneli (2022), in a study carried out in Kaynarca and Taraklı during the 2020–2021 growing season, found that genotype differences in hectoliter weight at both locations were statistically significant at the 1% level. Hectoliter weight ranged between 71 and 81 kg/hl in Kaynarca and between 70 and 81 kg/hl in Taraklı. The mean hectoliter weight was 76.6 kg/hl in Kaynarca and 75.3 kg/hl in Taraklı, with the difference between the two locations also statistically significant at the 1% level.

Aydoğan et al. (2019), in their study at the Bahri Dağdaş International Agricultural Research Institute during the 2013–2014 production year, reported hectoliter weight values for bread wheat varieties ranging from 72.38 to 78.48 kg/hl. Demir (2024), in a study conducted during the 2022–2023 growing season at the trial field of the S.S. Akşehir-Ilgın Sugar Beet Growers Cooperative, found hectoliter weight values ranging from 65.7 to 76.2 kg/hl.

Thousand Kernel Weight (TKW)

Thousand kernel weight is one of the key technological quality parameters in wheat production. In addition to genetic factors, environmental conditions significantly affect thousand kernel weight. High temperature stress during the grain filling period negatively impacts thousand kernel weight by shrinking the grains, while adequate water availability supports grain filling and increases kernel weight. In the present study, the average thousand kernel weight across locations was recorded as 41.7 g. The highest value was obtained from genotype number 18 with 48.2 g, while the lowest was observed in genotype number 7 with 31.1 g. The average thousand kernel weight was 45.7 g at the Bafra location and 37.7 g at the Tokat location.

In a study conducted under rainfed conditions during the 2011-2012 growing season in Diyarbakır, Türkiye, Karaman and Aktaş (2020) reported thousand kernel weight values ranging from 28.3 to 53.5 g while identifying superior wheat lines in terms of yield and quality. Similarly, Yazar et al. (2013), in

a study conducted within the scope of bread wheat breeding programs in Central Anatolia during the 2010-2011 growing season, reported a maximum thousand kernel weight of 38.6 g. Aydın et al. (2005) observed an average thousand kernel weight of 26.1 g under Samsun and Amasya conditions, attributing the low values to lodging and disease epidemics caused by seasonal rainfall.

Aktaş and Gökdere (2025) reported regional thousand kernel weight values ranging between 35.3 and 39.9 g in their study conducted across the Aegean, Marmara, Mediterranean, Southeastern Anatolia, and Central Anatolia regions during the 2016-2018 period. Yıldırım and Deger (2021) found thousand kernel weight values ranging from 35.48 to 42.71 g in commonly cultivated bread wheat varieties in the Mardin region in 2018. Similarly, Aydoğan et al. (2019), in their study conducted during the 2013-2014 production season at the Bahri Dağdaş International Agricultural Research Institute, reported a thousand kernel weight range of 31.10-41.31 g.

Erbaş Köse et al. (2023), in their study conducted under Bilecik ecological conditions in the 2019-2021 seasons, reported an average thousand kernel weight of 42.5 g. Ersöz and Budak Başçiftçi (2024) found thousand kernel weight values ranging from 37.9 to 44.3 g in their 2021–2022 study conducted at Eskişehir Osmangazi University, Faculty of Agriculture. Similarly, Doğan (2024), in a study carried out during the same season at the Eskişehir Transitional Zone Agricultural Research Institute, reported thousand kernel weight values between 36.2 and 51.25 g. Demir (2024) reported thousand kernel weight values ranging from 31.21 to 45.08 g in a study conducted in the 2022-2023 season at the trial field of the S.S. Akşehir-Ilgın Sugar Beet Growers Cooperative.

Mut et al. (2005) evaluated 25 bread wheat genotypes under Samsun and Amasya conditions and reported thousand kernel weight values ranging from 28.4 to 38.9 g. In another study by Mut et al. (2010), which included seven different environments within the same region, the average thousand kernel weight was found to be 48.4 g. Karaman et al. (2017), in their rainfed trials conducted in Diyarbakır, Ceylanpınar, and Hazro during the 2014-2015 season, reported thousand kernel weight values ranging from 30.0 to 41.4 g. Similarly, Aydoğan and Soylu (2017), in their study conducted during the 2014-2015 growing period at the Bahri Dağdaş International Agricultural Research Institute in Konya, reported thousand kernel weight values between 30.90 and 46.46 g.

Protein Content (%)

Protein content is known to be affected by genotype, but primarily by environmental conditions (Baenziger et al., 1985). High temperatures during ripening can reduce starch accumulation and subsequently increase protein content. Similarly, insufficient rainfall or drought conditions may restrict grain development, thereby increasing the relative protein concentration (Rharrabti et al., 2001). In our study, the Tokat location experienced higher temperatures and lower rainfall compared to the Bafra location. Accordingly, the higher protein content observed in the genotypes grown in Tokat supports the findings reported in both aforementioned studies.

In the present study, the highest protein content in the Bafra location was recorded in genotype 18, with a value of 15.3%, while the lowest values were observed in genotypes 1 and 7, both with 10.8%. At the Tokat location, the highest protein content was found in the control cultivar Flamura-85 with 15.2%, whereas the lowest values were recorded in genotypes 8-11 and 16, with 12.6%.

Previous studies have reported comparable results across various regions and environmental conditions in Türkiye. Aydın et al. (2005) reported an average protein content of 10.9% under Samsun conditions. Mut et al. (2005) evaluated 25 bread wheat genotypes in Samsun and Amasya, reporting protein contents ranging from 10.4% to 13.6%. Similarly, Mut et al. (2010) reported an average protein content of 12.4% across seven different environments under Samsun and Amasya conditions. Karaman and Aktaş (2020) found protein content ranged from 12.4% to 15.4% during the 2011–2012 growing season in Diyarbakır. Sevim and Erekul (2020) reported a range of 9.1% to 14.6%. Erkul (2006), in a study at the Adnan Menderes University during the 2004-2005 season, recorded protein content between 10.39% and 13.33%.

Aktaş and Gökdere (2025) determined regional protein contents between 13.4% and 14.7% in the Aegean, Marmara, Mediterranean, Southeastern Anatolia, and Central Anatolia regions during the 2016-2017 and 2017–2018 seasons. Yıldırım and Değer (2021) observed protein content ranging from 11.50% to 13.25% in bread wheat varieties grown in Mardin in 2018. Aydoğan et al. (2019), in a study at the Bahri Dağdaş International Agricultural Research Institute during the 2013-2014 production year, reported average protein values ranging between 14.16% and 16.09%.

Erbaş Köse et al. (2023), under Bilecik ecological conditions in the 2019-2020 and 2020–2021 seasons, found an average protein content of 13.5%. Doğan (2024) reported protein content ranging from 11.33% to 16.29% in a study at the Eskişehir Transitional Zone Agricultural Research Institute during the 2021-2022 growing season.

Demir (2024) recorded protein values between 11.5% and 14.8% in trials conducted in the S.S. Akşehir-Ilgın Sugar Beet Growers Cooperative experimental field during the 2022-2023 season.

Yazar et al. (2013) reported a maximum protein content of 13.4% in their Central Anatolia Region study during the 2010-2011 growing season. Karaman et al. (2017), under rain-fed conditions in Diyarbakır, Ceylanpınar, and Hazro during the 2014-2015 season, reported protein content ranging from 12.1% to 13.9%. Aydoğan and Soylu (2017), at the Konya Bahri Dağdaş International Agricultural Research Institute during the 2014-2015 season, recorded protein content values between 11.93% and 13.44%.

Alveograph Energy Value (W)

At the Bafra location, the highest alveograph energy value was recorded in the control variety Altındane, with a value of 335 Joules, while the lowest value was observed in genotype 23, with 105 Joules. In the Tokat location, the highest energy value was 385 Joules, obtained from genotype 22, whereas the lowest was recorded in genotype 16, with 141 Joules.

Aktaş and Gökdere (2025) reported that alveograph energy values ranged between 191.2 and 276.4 Joules on a regional basis in their study conducted across the Aegean, Marmara, Mediterranean, Southeastern Anatolia, and Central Anatolia regions during the 2016-2017 and 2017-2018 growing seasons.

Similarly, Kılıç et al. (2014) found that, in their study conducted during the 2004-2005 season at the Diyarbakır GAP International Agricultural Research and Training Center and the Ceylanpınar TİGEM trial site, the average alveograph energy values of genotypes ranged from 37 to 233 Joules.

Water Absorption (Farinograph) (%)

At the Bafra location, the highest water absorption value was recorded in genotype 9 at 67.5%, while the lowest value, 56.9%, was observed in both the Flamura 85 control variety and genotype 23. At the Tokat location, the highest water absorption value was found in genotype 13 at 66.0%, and the lowest was recorded in genotype 11, also at 56.9%.

Sevim and Erekul (2020), in their study conducted at the Aegean Agricultural Research Institute's Menemen trial site, reported water absorption values ranging from 57.6% to 66.6%. Similarly, Aydoğan et al. (2019), in their research conducted during the 2013-2014 production year at the Bahri Dağdaş International Agricultural Research Institute, found that the farinograph water absorption of bread wheat varieties ranged from 62.50% to 68.20%.

Grain Hardness (PSI)

At the Bafra location, the highest grain hardness value was recorded in genotype 13 with a value of 80.0, while the lowest was observed in genotype 1 at 34.4. In the Tokat location, genotype 4 showed the highest grain hardness at 88.6, whereas the lowest value, 57.0, was recorded in genotype 11.

Aydoğan and Soylu (2017), in their study conducted during the 2014-2015 growing season at the Konya Bahri Dağdaş International Agricultural Research Institute, reported that grain hardness values (PSI) ranged from 41.27 to 64.82. Similarly, Doğan (2024), in a study conducted at the Eskişehir Transitional Zone Agricultural Research Institute during the 2021-2022 production season, reported grain hardness values for bread wheat ranging from 19.33 to 64.18 PSI.

Zeleny Sedimentation (ml)

According to Elgün et al. (2002), genotypes with Zeleny sedimentation values below 15 ml have very poor gluten quality; values between 16-24 ml indicate poor quality, 25-36 ml reflect good quality, and values above 36 ml represent very good gluten quality. In the present study, the average Zeleny sedimentation value was 51.8 ml at the Bafra location and 54.0 ml at the Tokat location (Tables 7 and 8).

At the Bafra location, the highest Zeleny sedimentation value was recorded in the Altındane standard variety at 75 ml, while the lowest was observed in genotype 12 at 32 ml. In the Tokat location, genotype 22 exhibited the highest value at 69 ml, and genotype 8 had the lowest at 43 ml.

Aydın et al. (2005) reported that under Samsun and Amasya conditions, Zeleny sedimentation values of genotypes ranged from 27.3 to 50.8 ml, with genotype 22 showing the highest value at both locations -this genotype was later registered as Altındane in 2012. These results are in agreement with our findings. Similarly, Mut et al. (2005) found sedimentation values between 25.0 and 50.6 ml in their study involving 25 bread wheat genotypes under the same regional conditions. Mut et al. (2010) reported an average value of 44.7 ml in seven different environments in Samsun and Amasya.

In Diyarbakır, Karaman and Aktaş (2020) recorded Zeleny sedimentation values ranging from 22.0 to 37.0 ml during the 2011-2012 growing season. Sevim and Erekul (2020) found a range of 14 to 45 ml, while Erkul (2006), in a study conducted at Adnan Menderes University during the 2004-2005 growing season, reported values between 16.33 and 24.33 ml.

Aktaş and Gökdere (2025) reported regional Zeleny sedimentation values ranging from 43.2 to 53.3 ml in their study covering the Aegean, Marmara, Mediterranean, Southeastern Anatolia, and Central

Anatolia regions during the 2016-2017 and 2017-2018 production seasons. In Mardin, Yıldırım and Değer (2021) found values between 26.0 and 43.5 ml among commonly cultivated bread wheat varieties.

Erbaş Köse et al. (2023), in a study conducted under Bilecik ecological conditions during the 2019-2020 and 2020-2021 seasons, reported an average sedimentation value of 29.8 ml. Similarly, Doğan (2024) recorded sedimentation values ranging from 10 to 50 ml at the Eskişehir Transitional Zone Agricultural Research Institute during the 2021-2022 production season. Demir (2024) reported values between 35 and 65 ml in a trial conducted in the experimental field of the S.S. Akşehir-Ilgın Sugar Beet Growers Cooperative in the 2022-2023 growing season.

Yazar et al. (2013), in a study on bread wheat breeding in the Central Anatolia Region during the 2010-2011 growing season, found Zeleny sedimentation values between 12.3 and 48.5 ml. Karaman et al. (2017) reported values ranging from 25.8 to 41.5 ml in a study conducted under rain-fed conditions during the 2014-2015 growing season in Diyarbakır, Ceylanpınar, and Hazro. Finally, Aydoğan and Soylu (2017), in their research at the Konya Bahri Dağdaş International Agricultural Research Institute during the 2014-2015 season, reported values ranging from 26.0 to 39.5 ml.

Conclusions

As a result of the study conducted under rainfed conditions during the 2021-2022 production season in the Samsun and Tokat ecological regions, significant differences were observed among the genotypes. In terms of grain yield, genotype 1 at the Bafra location demonstrated superior performance. Regarding protein content, genotype 18 at the Bafra location had the highest value. The highest hectoliter weight was recorded in genotype 12, and the highest thousand-grain weight was also found in genotype 18, both at the Bafra location.

For Zeleny sedimentation value, the highest result was obtained from the standard cultivar Altındane at the Bafra location. In the Tokat location, genotype 22 showed the highest alveograph energy value. The highest water absorption was observed in genotype 9 at the Bafra location, while genotype 4 at the Tokat location had the highest grain hardness value.

These findings indicate that the aforementioned genotypes exhibit promising technological and agronomic characteristics. Therefore, they are considered potential candidates for inclusion in future wheat breeding programs and will be evaluated in the next breeding cycle.

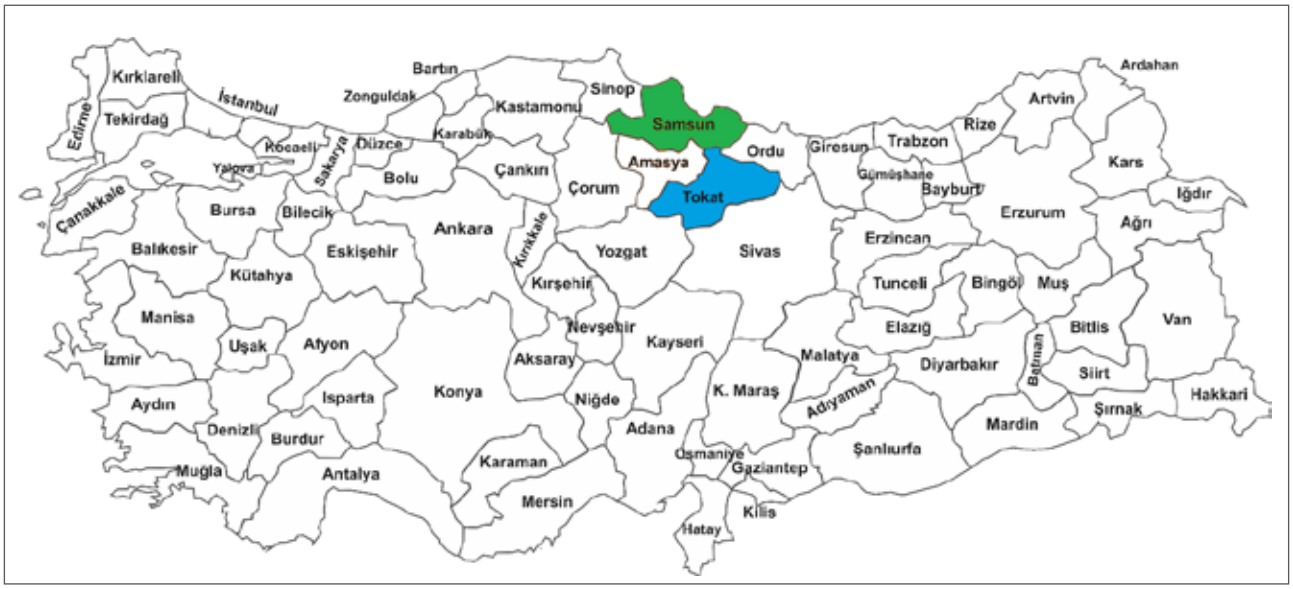

Figure 1. The Location of the Experimental Fields on the Map of Türkiye.

Table 1. Pedigree Information of Bread Wheat Lines and Varieties Used in the Experiment.

Genotype No	Cross/Pedigree	Breeding Instit
1	KS040477K-12/GALLAGHER	CIMMYT
2	KS050255K-6/KANMARK	CIMMYT
3	DONSKAYA YUBILEYNAYA	CIMMYT
4	(ATTILA*2/ESDA//MASON)/(HBK0935-7-4/…	CIMMYT
Altındane	Standard	KTAE
6	KS13DH002722	CIMMYT
7	KS14DH0013-19	CIMMYT
8	CUPRA1/3/CROC1/AE.SQUARROSA(224)//2*…	CIMMYT
9	WEAVER/4/NAC/TH.AC//3*PVN/3/MIRLO/….	CIMMYT
Nevzatbey	Standard	KTAE
11	DH01-29-33*R/3/VORONA/KAUZ//1D13.1/MLT	CIMMYT
12	CNDO/R143//ENTE/MEXI_2/3/AE.SQ.(TAUS)/4/…	CIMMYT
13	53/3/ABL/1113//K92/4/JAG/5/KS89180B/6/RSK/…	CIMMYT
14	CA8055/4/ROMTAST/BON/3/DIBO//SU92/CI13645/…	CIMMYT
Kirve	Standard	KTAE
16	WHEAR//INQALAB 91*2/TUKURU/3/PYN/BAU//…	CIMMYT
17	TACUPETO F2001/BRAMBLING//KIRITATI/3/…	CIMMYT
18	FRANCOLIN#1/BLOUK#1/3/KINGBIRD#1//….	CIMMYT
19	BABAX/LR42//BABAX*2/3/KUKUNA/4/….	CIMMYT
20	WHEAR//INQALAB 91*2/TUKURU/3/PYN/BAU/…	CIMMYT
Flamura 85	Standard	TAREKS
21	ATTILA/3*BCN//BAV92/3/TILHI/4/SUP152/5/…	CIMMYT
22	KMU/KTAE-21/100	KMU
23	KMU/KTAE-21/200	KMU
24	MUTUS*2/MUU/6/ATTILA/3*BCN//BAV92/3/…	CIMMYT
SİTAP-14/21	BABAX/LR42/BABAX*2/3/PAVON....	KTAE

CIMMYT: International Maize and Wheat Improvement Center, TAREKS Inc.: Agricultural Credit Cooperative Seed Company, KTAE : Black Sea Agricultural Research Institute, KMU: Karamanoğlu Mehmetbey University.

Table 2. Precipitation, Temperature, and Relative Humidity Values for the Experimental Locations During the 2021-2022 Growing Season.

Locations	Samsun/Bafra			Tokat		
Month-Year	Precipitation (mm)	Temperature (°C)	Humidity (%)	Precipitation (mm)	Temperature (°C)	Humidity (%)
October	169.2	14.8	81.4	10.5	13.0	65.6
November	75.0	12.6	80.3	0.1	15.2	68.8
December	50.3	10.5	76.7	45.1	3.7	69.1
January	164.2	5.5	70.1	51.3	1.7	71.0
February	61.0	8.1	67.6	35.3	5.4	65.0
March	115.4	5.1	73.0	54.0	3.3	65.1
April	39.8	12.5	70.5	30.2	15.1	51.3
May	44.8	15.1	71.4	34.6	15.3	59.8
June	73.4	20.9	74.9	83.2	20.9	64.2
July	4.6	22.9	68.6	0.1	21.0	59.8
Total	**797.7**			**344.4**		

Table 3. Soil Characteristics of Experimental Fields in 2021.

Location	Soil Texture Class	Total Salt (%)	pH	Lime ($CaCO_3$, %)	Phosphorus (kg/da)	Organic Matter (%)	Field Capacity (%)
Samsun/Bafra	Clay-Loam	0.028	7.13	8.29	6.13	1.73	64
Tokat	Clay-Silty	0.025	7.85	11.0	3.50	1.60	62

Table 4. Mean Grain Yields of Genotypes and Duncan's Multiple Range Grouping (kg/da).

Genotype No	Bafra	Tokat	Average
1	1125.8 a	803.6 a-g	964.7 a
2	974.2 c-f	726.9 f-h	850.5 c-f
3	793.0 h-k	757.1 c-h	775.0 f-i
4	1045.7 a-c	847.0 a-d	946.4 ab
5	757.9 ı-k	740.8 d-h	749.3 g-i
6	924.7 d-g	902.0 a	913.3 a-c
7	1105.2 ab	741.4 d-h	923.3 a-c
8	998.6 b-e	862.9 a-c	930.7 a-c
9	822.8 g-j	797.0 a-g	809.9 d-h
10	882.3 e-h	832.0 a-f	857.2 c-e
11	780.7 h-k	810.3 a-g	795.5 e-h
12	1017.3 a-d	836.2 a-f	926.7 a-c
13	783.3 h-k	762.7 c-h	773.0 f-i
14	1034.6 a-d	800.2 a-g	917.4 a-c
15	776.9 h-k	713.5 gh	745.2 h-j
16	931.3 c-g	793.6 a-g	862.4 c-e
17	675.1 kl	732.1 e-h	703.6 ı-j
18	740.7 jk	764.1 c-h	752.4 g-i
19	977.5 c-f	723.7 f-h	850.6 c-f
20	573.3 lm	761.5 c-h	667.4 j
21	976.1 c-f	778.6 b-h	877.3 b-d
22	476.6 m	670.2 h	573.4 k
23	865.6 f-ı	730.7 f-h	798.1 d-h
24	1099.6 ab	844.4 a-e	972.0 a
25	773.3 h-k	882.5 ab	827.9 d-g
Location Mean	876.5	784.6	830.5
CV (%)	9.6	10.2	9.9
Significance	**	**	**

CV: Coefficient of Variation (%), Significance: Statistical significance level, ** Significant at the 1% level.

Table 5. Mean Hectoliter Weight Values of Genotypes and Duncan Grouping (kg/hl).

Genotype No	Bafra	Tokat	Average
1	76.3 e–g	75.2 d–i	75.8 h–j
2	79.8 a–c	75.3 d–h	77.6 d–f
3	76.8 d–f	76.8 b–e	76.8 fg
4	80.7 a	75.3 d–h	78.0 c–e
5	70.5 i	74.3 f–i	72.4 m
6	80.7 a	77.8 a–c	79.3 ab
7	78.5 b–d	76.5 b–f	77.5 d–f
8	76.3 e–g	73.7 hi	75.0 j–l
9	77.2 de	76.8 b–e	77.0 e–g
10	78.5 b–d	79.5 a	76.0 a–c
11	75.0 f–h	74.3 f–i	74.7 kl
12	80.8 a	78.7 ab	79.8 a
13	73.8 h	74.3 f–i	74.1 l
14	77.8 c–e	74.7 e–i	76.3 g–i
15	78.5 b–d	78.5 ab	78.5 b–d
16	75.0 f–h	74.0 g–i	74.5 kl
17	76.7 d–f	77.2 b–d	76.9 fg
18	78.0 c–e	75.3 d–h	76.7 f–h
19	76.8 d–f	74.7 e–i	75.8 h–j
20	73.3 h	76.0 c–g	74.7 kl
21	77.8 c–e	73.0 i	75.4 i–k
22	68.0 j	74.8 e–i	71.4 m
23	74.3 gh	69.7 j	72.0 m
24	80.3 ab	75.7 c–h	78.0 c–e
25	76.7 d–f	74.3 f–i	75.5 i–k
Location Mean	76.7	75.5	76.1
CV (%)	1.6	1.8	1.4
Significance	**	**	**

CV: Coefficient of Variation (%), Significance: Level of statistical significance, **: Significant at the 1% level.

Table 6. Average Values and Duncan Grouping for Thousand Kernel Weight of Genotypes (g).

Genotype No	Bafra		Tokat		Average	
1	43,7	f-ı	33,8	mn	38,8	f-h
2	42,1	h-j	31,9	n	37,0	hı
3	44,6	e-h	40,4	c-g	42,5	c-e
4	46,0	d-f	36,2	j-m	41,1	c-e
5	41,1	ı-j	36,1	j-m	38,6	gh
6	46,5	d-f	36,6	ı-l	41,5	c-e
7	36,1	k	26,0	o	31,1	j
8	46,7	d-f	35,2	k-m	40,9	d-f
9	45,9	d-f	37,6	h-k	41,7	c-e
10	46,5	d-f	39,4	d-h	43,0	c-d
11	38,7	jk	34,0	l-n	36,4	ı
12	47,2	de	38,7	e-j	42,9	c-d
13	44,4	e-ı	38,9	e-ı	41,6	c-e
14	47,7	c-e	38,3	f-j	43	c-d
15	48,7	b-d	43,6	ab	46,1	ab
16	45,7	d-g	37,5	h-k	41,6	c-e
17	50,9	a-c	44,6	a	47,7	ab
18	54,1	a	42,3	a-c	48,2	a
19	52,8	a	41,1	b-e	46,9	ab
20	44,4	e-ı	42,1	a-d	43,2	c
21	53,6	a	38,0	g-j	45,8	b
22	36,6	k	41,1	b-e	38,8	f-h
23	42,3	g-ı	32,3	n	37,3	hı
24	51,7	ab	40,7	c-f	46,2	a-b
25	45	e-h	36,1	j-m	40,6	e-g
Location Mean	45,7		37,7		41,7	
CV (%)	5,4		5,1		5,3	
Significance			**		**	

CV: Coefficient of Variation (%), Significance: Level of statistical significance, **: Significant at the 1% level.

Table 7. Quality Values of Genotypes in the BVD at the Bafra Location.

Genotype No	Moisture (%)	Protein (%)	Zeleny SDS (ml)	Grain Hardness (PSI)	Alveograph Energy (W)	Water Absorption (%)
1	10.1	10.8	45	34.4	158	57.5
2	9.7	13.4	40	56.9	208	58.1
3	9.7	12.4	47	53.6	261	58.5
4	9.6	12.5	52	59.8	229	60.6
5	10.1	12.9	75	54.3	335	60.0
6	10.5	12.0	65	62.3	260	61.7
7	9.7	10.8	38	74.9	157	60.9
8	9.7	11.6	46	69.2	215	59.6
9	10.1	12.7	51	72.0	203	67.5
10	9.9	12.8	50	61.4	223	62.5
11	9.6	10.9	54	45.9	147	58.1
12	9.9	10.9	32	71.7	142	57.1
13	9.8	14.0	63	80.0	308	59.9
14	9.9	11.3	45	47.0	144	58.2
15	10.2	12.6	55	59.4	167	60.5
16	10.1	11.4	51	59.0	127	62.6
17	9.8	15.1	61	62.4	296	59.8
18	9.8	15.3	59	71.4	311	63.9
19	9.8	12.5	48	70.0	276	60.8
20	10.7	11.4	44	54.0	200	56.9
21	10.5	11.8	52	57.8	175	58.7
22	10.0	11.6	60	49.8	248	58.3
23	9.8	10.8	52	48.9	105	56.9
24	9.7	12.2	57	65.7	195	58.6
25	10.0	12.0	53	59.8	204	59.6

Table 8. Quality Values of Genotypes in the BVD at the Tokat Location.

Genotype No	Moisture (%)	Protein (%)	Zeleny SDS (ml)	Grain Hardness (PSI)	Alveograph Energy (W)	Water Absorption (%)
1	9.5	13.8	48	58.7	204	62.5
2	9.3	14.3	44	60.3	230	59.3
3	9.4	13.6	61	84.9	303	61.4
4	9.1	12.9	55	88.6	368	63.4
5	9.8	14.0	65	72.4	374	62.8
6	9.5	13.4	58	79.9	222	62.4
7	9.3	13.1	49	79.0	288	61.0
8	9.3	12.6	43	81.0	212	63.0
9	9.2	14.1	44	84.6	249	65.2
10	9.4	12.8	52	74.6	266	63.6
11	9.5	12.6	55	57.0	155	56.9
12	9.1	13.0	58	64.9	164	61.2
13	9.6	13.6	55	78.0	356	66.0
14	9.6	13.8	48	73.3	196	61.8
15	10.3	13.9	52	71.7	228	62.1
16	9.2	12.6	50	59.8	141	57.5
17	9.3	13.0	64	64.3	291	59.3
18	9.3	13.2	53	61.8	318	61.9
19	9.2	12.9	46	57.1	210	58.6
20	9.3	15.2	61	66.7	277	62.0
21	9.1	14.1	65	74.3	313	61.9
22	9.2	14.0	69	67.9	385	60.4
23	9.4	14.2	48	67.0	315	62.4
24	10.1	13.6	52	66.2	199	60.1
25	9.1	14.1	55	70.4	262	58.6

References

Aktaş B & Gökdere Hİ, (2025). Evaluation of grain yield, and quality characteristics of some bread wheat cultivars in different agro-ecological regions of Türkiye. Heliyon, 11(1), e41547. https://doi.org/10.1016/j.heliyon.2024.e41547

Ali A, Khaliq T, Ahmad A, Ahmad S, Malik A & Rasul F, (2012). How wheat responds to nitrogen in the field. Crop & Environment, *3*(1-2):71-76.

Anonymous, (1981). ICC standards. International Association for Cereal Chemistry.

Anonymous, (2000a). Official methods of analysis of the Association of Official Analytical Chemists (17th ed., Method 992.23). AOAC.

Anonymous, (2000b). Approved methods of the American Association of Cereal Chemists (10th ed.). AACC.

Anonymous, (2022). Crop prospects and food situation #2, July 2022. https://www.fao.org/3/cc6806en/cc6806en.pdf (Accessed date: January 17, 2025).

Anonymous, (2022). Quick guide to wheat quality, August 4, 2022. https://lidea-seeds.com/news (Accessed date: January 22, 2025).

Anonymous, (2023). https://www.fao.org/faostat/en/#data/QCL (Accessed date: January 17, 2025).

Anonymous, (2024). Bitkisel üretim istatistikleri 2024. https://data.tuik.gov.tr/Bulten/Index?p (Accessed date: January 17, 2025).

Anonymous, (2025). The international wheat yield partnership. https://iwyp.org/global-challenge (Accessed date: January 21, 2025).

Asseng S, Ewert F, Martre P, Rötter RP, Lobell DB, Cammarano D & Zhu Y, (2015). Rising temperatures reduce global wheat production. Nature Climate Change, *5*(2):143-147. https://doi.org/10.1038/nclimate2470

Aydın N, Mut Z, Bayramoğlu HO & Özcan H, (2005). A study on the yield and some quality characteristics of bread wheat (*Triticum aestivum* L.) genotypes in Samsun and Amasya conditions. OMÜ Journal of Agricultural Faculty, *20*(2):45-51.

Aydoğan S & Soylu SS, (2017). Determination of yield, yield components, and some quality traits of bread wheat varieties. Field Crops Central Research Institute Journal, *26*(1):24-30.

Aydoğan S, Şahin M, Gökmen A, Demir B, Hamzaoğlu S & Yakışır E, (2019). Bazı makarnalık ve ekmeklik buğday çeşitlerinin kalite özelliklerinin araştırılması. KSÜ Tarım ve Doğa Dergisi, *22*(Ek Sayı 2):264-271. https://doi.org/10.18016/ksutarimdoga.vi.563954 (in Turkish).

Baenziger PS, Clements RL, McIntosh MS, Yamazaki WT, Starling TM, Sammons DJ & Johnson JW, (1985). Effect of cultivar, environment, and their interaction and stability analyses on milling and baking quality of soft red winter wheat. Crop Science, 25(1):5-8. https://doi.org/10.2135/cropsci1985.0011183X002500010002x

Demir M, (2024). Farklı ekmeklik buğday çeşitlerinin Orta Anadolu sulu koşullarında verim ve kalite özelliklerinin incelenmesi [Yüksek Lisans Tezi, Selçuk Üniversitesi, Fen Bilimleri Enstitüsü] (in Turkish).

Doğan İ, (2024). Bazı yerel buğdayların morfolojik, fizyolojik ve kalite özellikleri bakımından karakterize edilmesi [Yüksek Lisans Tezi, Bursa Uludağ Üniversitesi, Fen Bilimleri Enstitüsü] (in Turkish).

Erbaş Köse ÖD, Mut Z, Kardeş YM & Akay H, (2023). Grain-bran quality parameters and agronomic traits of bread wheat cultivars. Turkish Journal of Field Crops, 28(2):269-278. https://doi.org/10.17557/tjfc.1336316

Erenstein O, Jaleta M, Mottaleb KA, Sonder K, Donovan J & Braun HJ, (2022). Global trends in wheat production, consumption and trade. In M. P. Reynolds & H.-J. Braun (Eds.), Wheat improvement: Food security in a changing climate (pp. 47-66). Springer International Publishing. https://doi.org/10.1007/978-3-030-90673-3

Elgün A, Ertugay Z, Certel M & Kotancılar HG, (2002). Tahıl ve ürünlerinde analitik kalite kontrolü ve laboratuar uygulama kılavuzu (Atatürk Üniversitesi Yayın No: 867, Ziraat Fakültesi Yayın No: 335, Ders Kitapları Serisi No: 82, s. 245). Atatürk Üniversitesi, Ziraat Fakültesi, Erzurum (in Turkish).

Erkul A, (2006). Determination of grain yield and some quality characteristics of advanced bread wheat (*Triticum aestivum* L.) lines under irrigated conditions. Adıyaman University Faculty of Agriculture Journal, 3(1):27-32.

Ersöz İ & Budak Başçiftçi Z, (2024). Bazı ekmeklik buğday (*Triticum aestivum* L.) çeşitlerinin kışlık ekim zamanları ve yazlık ekimde verim ve verim özelliklerinin karşılaştırılması. International

Journal of Applied Biology and Environmental Sciences, 6(2):44-50. https://doi.org/10.5505/ijabes.2024.13007 (in Turkish).

Ibba MI, Gupta OP, Govindan V, Johnson AAT, Brinch-Pedersen H, Nikolic M & Taleon V, (2022). Editorial: Wheat biofortification to alleviate global malnutrition. Frontiers in Nutrition, 9, 1001443. https://doi.org/10.3389/fnut.2022.1001443

Karaman M, Aktaş H, Başaran M, Erdemci İ, Kendal E, Tekdal S, Bayram S, Doğan H & Belgizar Ayana B, (2017). Evaluation of some advanced bread wheat genotypes for yield and quality parameters using biplot analysis. Field Crops Central Research Institute Journal, 26(Special Issue), 45-51.

Karaman M & Aktaş H, (2020). Comparison of advanced bread wheat (*Triticum aestivum* L.) lines and registered varieties for agricultural traits. Euroasia Journal of Mathematics, Engineering, Natural & Medical Sciences, 7(9).

Kılıç H, Kendal E, Aktaş H & Tekdal S, (2014). Evaluation of advanced bread wheat lines in different environments for grain yield and some quality traits. Iğdır University Institute of Science and Technology Journal, 4(4):87-95.

Mut Z, Aydın N, Özcan H & Bayramoğlu HO, (2005). Determination of yield and some quality traits of bread wheat (*Triticum aestivum* L.) genotypes in the Middle Black Sea Region. GOÜ Journal of Agricultural Faculty, 22(2):85-93.

Mut Z, Aydın N, Bayramoğlu HO & Özcan H, (2009). Interpreting genotype × environment interaction in bread wheat (*Triticum aestivum* L.) genotypes using nonparametric measures. Turkish Journal of Agriculture and Forestry, 33(2), Article 4.

Mut Z, Aydın N, Bayramoğlu HO & Özcan H, (2010). Stability of some quality traits in bread wheat (*Triticum aestivum*) genotypes. Journal of Environmental Biology, (31):489-495. http://www.jeb.co.in

Naneli İ, (2022). Determination of the yield and quality of some bread wheat genotypes in different locations. ICONTECH International Journal, 6(3):47-58. https://doi.org/10.46291/ICONTECHvol6iss3pp47-58

Pena RJ, (1990). Sodium dodecyl sulfate (SDS) sedimentation test. Journal of Cereal Science, (12):105-112.

Rharrabti Y, Villegas D, García del Moral LF, Aparicio N, Elhani S & Royo C, (2001). Environmental and genetic determination of protein content and grain yield in durum wheat under Mediterranean conditions. Plant Breeding, 120(5):381-388. https://doi.org/10.1046/j.1439-0523.2001.00628.x

Riaz MW, Yang L, Yousaf MI, Sami A, Mei XD, Shah L, Rehman S, Xue L, Si H & Ma C, (2021). Effects of heat stress on growth, physiology of plants, yield, and grain quality of different spring wheat (*Triticum aestivum* L.) genotypes. Sustainability, 13, 2972. https://doi.org/10.3390/su13052972

Sevim İ & Erekul O, (2020). Farklı buğday genotiplerinde kalite parametrelerinin incelenmesi üzerine bir araştırma. Adnan Menderes Üniversitesi Ziraat Fakültesi Dergisi, 17(2):235-243. https://doi.org/10.25308/aduziraat.741840 (in Turkish).

Shewry PR, (2009). Wheat. Journal of Experimental Botany, 60(6):1537-1553.

Shewry PR, (2018). Do ancient types of wheat have health benefits compared with modern bread wheat? Journal of Cereal Science, (79):469-476.

Slafer GA & Andrade FH, (1991). Changes in physiological attributes of the dry matter economy of bread wheat (*Triticum aestivum*) through genetic improvement of grain yield potential at different regions of the world. Euphytica, (58):37-49. https://doi.org/10.1007/BF00035338

Yazar S, Salantur A, Özdemir B, Alyamaç ME, Evlice KA, Pehlivan A, Akan K & Aydoğan S, (2013). Investigation of some agricultural characteristics in bread wheat breeding studies in the Central Anatolia Region. Field Crops Central Research Institute Journal, *22*(1):32-40.

Yıldırım A & Deger Ö, (2021). Physical, physicochemical (technological) and chemical characteristics of common bread wheat (*Triticum aestivum* L.) varieties grown in Mardin region of Turkey. Harran Tarım ve Gıda Bilimleri Dergisi, 25(2):151-162. https://doi.org/10.29050/harranziraat.892966

Williams P, El-Haramein JF, Nakkoul H & Rihawi S, (1988). Crop quality evaluation methods and guidelines. International Center for Agricultural Research in the Dry Areas (ICARDA).

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DUS Characterization of Phalsa (*Grewia subinaequalis* DC.) Genotypes

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ABSTRACT

Phalsa genotypes were characterized on the basis of DUS guidelines at experimental orchard, RRS Bawal. The genotypes were maintained under similar agronomic practices in randomized block design. The growth parameters were measured in the month of May and fruiting parameters were recorded at the maturity of fruits or at the time of picking. The qualitative data was observed by jury members by matching with the DUS characteristics. On overall basis the genotype was divided into three groups, tall, dwarf and tall plants with globose shaped fruits. The dwarf genotype starts bearing earlier than tall plants and tall plants with globose shaped fruits were late bearers. The yield of tall genotype was higher as compared to dwarf. However, shelf life of dwarf plants (roundish fruit), tall plants (roundish shape) and tall plants with globose shaped fruits was more as compared to fruits of tall plant. Fruits of tall genotypes were slightly infected with fruit fly in the last picking; however other two genotypes (dwarf plants and tall plant with globose shaped fruits) were resistant to fruit fly. None of the genotypes was infected with any disease. The fruit size and fruit weight of globose shaped fruits was more, however the seed size was also more. It is concluded from the four years study that the tall genotype having globose shaped fruits is a new and elite genotype with higher fruit weight, fruit yield and shelf life of fruits.

Keywords: Phalsa (*Grewia subinaequalis* DC.), DUS, genotypes, yield, shelf life, fruit fly

Introduction

Phalsa (*Grewia subinaequalis* DC.) is an important fruit crops of India and Southern Asia. It is hardy and drought tolerant crop, it can be grown on all kind of soils and climate except high altitude. India is said to be the home of phalsa because it is originated in India and South-East Asia. It yields delicious, sour to sweet, pleasant flavored edible quality fruits. Among 140 species of genus *Grewia*, only *subinaequalis* species produce commercially important fruits. It belongs to family Tiliaceae. Phalsa requires least inputs and has less attack of diseases and insect-pests. Under subtropical plants normally shed their leaves during the winter season; however, under tropical conditions, plants remain evergreen. The plant growth was observed optimum at 3°C to 45°C temperature and under light frost conditions. Fruit development, ripening and fruit color development requires a good amount of sunlight. It grows well on low fertile barren lands but well-drained loamy soil with a pH range from 6.1 to 6.5 is found the best for its growth, productivity and quality. The juice content in ripe fruits varied from 50-60, sugars 10-11 per cent and acids 2.0-2.5 per cent and a good source of vitamin A and C. Calories and fat are low in its fruit, while minerals and fibers are high. This is also a fair source of phosphorus 24.2 mg/100gm (Yadav, 1999) and iron 140.8 mg/100gm of fresh fruit weight (Khan et al., 2006). Ripened fruits are perishable so consumed fresh and may be processed in soft drinks *viz*; squash, juice, syrup, etc. Its fruits gave a cooling effect to stomach during summer. *Grewia* species are of high medicinal value due to presence of different metabolites like saponins, coumarins, anthraquinone (Sharma and Patni, 2013).

It is also associated with many health benefits, builds muscle, healthy bones, relieves stomachache, promotes healthy heart, prevents diabetes, lower down cancer risk (Steinmetz and Potter, 1991), cures anemia (Khemiss et al., 2006), heals wounds (Sharma and Patni, 2013), anti-inflammation, anti-microbial, treat respiratory problems and source of antioxidants (Kaur and Kapoor, 2005). The extract of bark (mucilaginous) is used to clarifying sugar and jaggery, and fibre for making rope. The wood of annual pruning are used for support sticks, basket making and fuel. Keeping in view the above benefits, the emphasis has been made to study the adaptability of different genotypes based on growth, yield and quality. The genotypes were evaluated to study the variation among different genotypes using the DUS guidelines. The suitable genotypes can be selected for the semi-arid conditions. This will also help the orchardist in the selection of an appropriate genotype of this neglected crop for large-scale cultivation or to include in breeding programme and to get higher yield of quality fruits. Therefore, this study has been planned to fulfill the gaps, increase adoption, awareness of this crop among farmers and fulfill the gap of productivity. This crop is most suitable for natural farming in hot arid climate because its litter fall increase organic carbon and fertility of the soil.

Materials and Methods

The experiment was conducted on 39 years old phalsa plants planted at 3 m x 3 m spacing in the experimental orchard, CCS Haryana Agricultural University, Regional Research Station, Bawal (Rewari), Haryana situated at an altitude of 266 m above mean sea level with coordinates of 28º 10′ N latitude and 76º 50′ E longitudes in South-West zone of Haryana. It comes under a typical semi-arid climatic zone with hot and dry summer during May and June (45°C and above) and extremely cold winter during December-January (0°C and below). The average rainfall is 456 mm, 80-85 per cent of total annual rainfall is received from the South West monsoon, i.e., from July to September, and a little shower of rainfall is received from December to February. On the basis of visual observations, a total of thirty-nine uniformly grown genotypes were selected randomly in three replications and maintained under uniform conditions of orchard management practices during the study period.

Thirty-five seedling plants of phalsa were selected to study the DUS characteristics. On the basis of plant height, plants were divided into two groups dwarf and tall while tall group was further divided into tall with round fruit and tall with (globose shaped fruit). The growth parameters of phalsa were recorded as per descriptor (Table 1) of NBPGR (Mahajan et al., 2002), and guidelines for DUS testing of PPV and FRA (Anonymous, 2016). Plant height was measured with the help of a graduated measuring pole from ground level to the tip of the highest shoot and the average height was expressed in a meter. Canopy spread was measured in both directions, *i.e.*, north to south and east to west, with the help of a graduated measuring tape. The average plant spread was calculated and expressed in a meter.

Internodal length, space between two nodes was recorded and average of middle internodes of five randomly selected shoots / plant was measured with the help of scale and mean value was worked out and expressed in centimeter. Tree habit was observed visually for depicting the shape of the tree at flowering and fruiting stage as upright, spreading and drooping as per tree shape given in the guidelines for DUS testing of PPV and FRA (Anonymous, 2016). Leaf shape was observed visually from mature leaves and marked as ovate (leaves which are egg-shaped, with the broader end of the leaf nearest the petiole), oblong (leaves almost resembling a rectangle with round corners) and elliptical (leaves are about twice as long as broad, the broadest part is in the middle and the two ends narrow equally). The margin of the leaves was observed visually from mature leaves as serrate, irregular and dentate. The pubescence on the dorsal side of mature leaves was observed with the help of convex lens at leaf maturity stage as sparse, medium and dense. The surface colour on the dorsal side of mature leaves was observed visually at maturity stage and marked as greenish white, light green, green etc. as per standard colour chart at the leaf maturity stage. Ten mature leaves were selected randomly from each direction of a plant. These leaves were used to measure leaf length and width with the help of measuring scale and mean value was calculated and expressed in centimeter. The type of inflorescence was observed visually during flowering as axillary cyme, leaf opposite cyme and axillary clusters based on group or cluster of flowers arranged on the stem. Numbers of flowers were counted manually from five randomly selected inflorescence from each direction of plant and mean value was worked out. Date of the start of flowering was observed at five per cent flower buds opening stage from tagged branches.

The date of the end of flowering was noted when 85-90 per cent flower buds opened on the tagged branches. The duration/ variation in the end of flowering in different plants was mentioned in a range. The petal colour was observed visually during flowering as yellow, dull yellow and others as per

standard colour chart. Uniformly ripened healthy fruits free from any injury or disease were harvested from each direction of tagged branches for the estimation of physio-chemical characteristics. The date of 50 per cent fruits maturity was noted when at least 50 per cent fruits attained maturity on the tagged branches. The variation in 50 per cent fruits maturity in different replications was mentioned in a range/period. The ripened fruits were picked and number of pickings were counted. Fruit length was recorded as average of 50 fruits per plant plucked randomly and their length from distal to proximal end and fruit breadth was measured with the help of digital vernier calipers and the average value was calculated and expressed in millimeter. These fruits were weighed on digital electronic balance and average fruit weight was calculated and expressed in gram. The shape of fruits was observed visually as round, globose and others based on curvature at the distal end of the fruit. Visual interpretation of fruit skin colour was carried out by considering the outer surface colour of the ripe fruits and marked as red, dark red, purple, deep purple and others as per standard colour chart. Fruit lobe was also observed visually as present or absent.

Ripened fruits collected from different directions of the plant were used to extract the juice and the quantity of juice extracted per 100 g fruit was expressed as low, medium and high. Ripened fruits were smashed to extract seeds and counted the number of seeds per fruit and average number of seeds per fruit was worked out. These seeds were used for 100 seed weight and average weight was expressed in gram. Seed edible quality was tested organoleptically by jury of 10 members. The weight of harvested fruits after each picking was recorded for final yield per plant and expressed as low (5 kg/plant), medium (7.5 kg/plant) and high (10 kg/ plant). Freshly harvested fruits were kept in perforated paper bags at room temperature to study shelf life. Loss in fruit weight was recorded at 6 hours interval and calculated as percent loss. Fruits were considered as spoiled when they start shriveling and become soft, and start oozing out liquid from stalk end of the fruit. When fruits decayed above 50 percent were considered as the end of shelf life. The ERMA made Hand Refractometer of 0 to 32 was used to determined TSS at 20°C. The refractometer was calibrated with distilled water after every sample and the unit value of TSS was expressed in degree Brix (°B).

Results and Discussion

On the basis of plant height, plants were divided into two groups tall and dwarf. The qualitative characters of different genotypes such as plant height ranged from 1.01 m to 2.91 m (Table 3a), tree spread 1.58 m - 3.69 m (Table 3b), internodal length 5.98 cm to 7.82 cm (Table 3c), leaf length 12.10 cm - 16.84 cm (Table 3d), leaf width 10.02 to 15.72 cm. The lowest tree spread was observed in dwarf plants. Genetic constitution/ variation in individual genotype or their acclimatization to varied agro-climatic conditions might be the reasons for variations in different characters (Singh et al., 2014). The observed differences in the growth of genotypes under different agro-climatic conditions might be due to their genetic makeup, prevailing climatic conditions and/or the interaction effect of genotype with the environment. The selection of cultivar must be based on the performance of genotype/ variety under particular condition because the same cultivars behave differently with a change in agro-climatic conditions. The variability in growth characters of plants might be due to specific characters of germplasm/ cultivar (Kumar et al., 2021). Similar type of variation was also observed in plant habit of Aonla under different agro-climatic conditions (Pathak et al., 2004; Singh et al., 2015; Kumar et al., 2016). The morphological variation in genotypes may be due to inherent genetic characteristics of genotypes (Kumar et al., 2024a)

Leaf shape was observed as cordate and leaf margin was serrate in all the genotypes. Pubescence on the dorsal side were observed as dense in double seeded trees, medium in tall and sparse in dwarf trees (Table 2). Leaf margin of all the genotypes was observed as serrated. The variability in phalsa leaf margin was observed similar by Haq et al. (2013). The similarity in the leaf margin of different genotypes might be due to the close relation in the genetic makeup of plant.

Leaf colour on dorsal side of the leaf was observed greenish white in dwarf trees, however, green in tall and double seeded trees. These types of variation in colour on the dorsal side of phalsa leaves were also found by Dhawan et al. (1993) and Mishra et al. (2018). Leaf size was observed (length and breadth) less in dwarf trees than tall and double seeded trees. The leaf size of the plant under humid conditions may be slightly more as compared to arid conditions. However, the variation in leaf size under similar conditions may be due to its genetic variability. These types of variation in leaf length and width of phalsa were also observed by Mishra et al. (2018) under the arid condition of CAZRI, Jodhpur.

Inflorescence type in all the genotypes was observed as auxiliary cluster, and the petals are dull yellow. This variation in inflorescence type and the number of inflorescences might be due to the genetic makeup of genotypes. However, such variations in a number of flowers per cyme in different ber cultivars were also observed by Gupta (2001) in Haryana.

Number of flower clusters per leaf were observed highest in dwarf trees, however, number of flowers per inflorescence were observed highest in tall and double seeded trees (Table 4-7). Start of flowering, end of flowering and fruit maturity were observed earliest in dwarf trees; however, these were observed late in tall double-seeded trees, and the number of fruit pickings was observed to be lowest. In case of dwarf and tall trees number of pickings varied from 6-8. This may be due to the requirement of environmental / physiological conditions of the particular genotype during this period. Such type of variation in fruit maturity was also found by Dhaliwal et al. (2012), Aulakh et al. (2013), Bakshi et al. (2015) in different Aonla cultivars.

Fruit length, fruit width and fruit weight were observed to be highest in double-seeded trees; however, these were observed to be observed lowest in dwarf trees (Table 4-7). Fruits of dwarf and tall trees were observed round in shape with bright purple colour whereas fruits of double seeded were lobbed with globose shaped and are dull purple in colour. Fruit lobe was present in all tall double seeded genotype, whereas it was absent in tall single seeded and dwarf genotypes. The variation in the present or absent of lob may be due to the number of seeds per fruit and it clear from the results that the fruits had two lobs were double seeded and without lob were single seeded or seeds are adjoining to each other. Moreover, extensive genetic variations in genotypes are significant for breeders to develop high-yielding varieties, premium quality fruits, and resistant or tolerant to various biotic/abiotic stresses (Kumar et al., 2024b).

Fruits from double seeded trees have highest TSS, however, fruits of dwarf and tall trees have less TSS (Table 4-7). Juice content was less in fruits from double seeded trees (Table 2). These variations in juice content of some genotypes might be due to more uptake of water, nutrients and also due to the translocation of photosynthates from source to sink. However, Muhammad et al. (2013) observed increase in juice yield in the tall type. Ray and Bala (2016) studied the shelf life and reported that the shelf life of phalsa varies between 24-48 h at ambient storage conditions. Mishra et al. (2018) observed 14 °B TSS in tall type phalsa genotype whereas 18-20 °B in dwarf type phalsa genotypes.

Seeds of double seeded were hard and comparatively large in size having more 100 seeds weight, whereas dwarf trees have smallest seeds (Table 4-7). Seeds of double seeded fruits were non-edible. Productivity and shelf life of the double seeded fruits was observed more as compared to other genotype. The lowest shelf life was observed in fruits of tall seedlings.

Infestation of fruit fly was observed in the last harvest of tall trees. The fruits from double seeded and dwarf trees were free from infestation of fruit fly. No disease incidence was observed in genotypes.

Off season flowering: The off-season flowering in phalsa might be due to global warming/variation in rainfall/ stress conditions or changes in tree physiology resulted in missing of particular phase after fruit harvest. The partial flowering occurs in plant it may exhaust plant and disturb the routine growth of plant. The fruit were not developed properly and drop subsequently. Similarly, these types of variation in off-season flowering and fruiting characteristics of phalsa were also found by Rai et al. (2002) in Aonla and Mishra et al. (2016) in different tropical and sub-tropical fruits.

Table 1. Descriptors of Phalsa.

Type of Planting Material	**Code**	**Tree Habit**	**Code**	**Leaf Shape**	**Code**
Seedling	1	Upright	3	Ovate	1
Cutting	2	Spreading	5	Oblong	2
Others	99	Drooping	7	Cordate	3
Leaf margin	**Code**	**Leaf pubescence on dorsal side**	**Code**	Elliptic	4
Serrate	1	Sparse	3	Oblong lanceolate	5
Irregular toothed	2	Medium	5	Other	99
Dentate	3	Dense	7	**Leaf surface colour on dorsal side**	**Code**
Inflorescence type	**Code**	**Patl colour**	**Code**	Greenish white	1
Axillary	1	Yellow	1	Light green	2
Leaf opposed cyme	2	Dull yellow	2	Green	3
Axillary cluster	3	Others	99	Other	99
Fruit skin colour	**Code**	**Fruit lobe**	**Code**	**Fruit shape**	**Code**
Red	1	Absent	0	Round	1
Dark Red	2	Present	1	Globose	2
Purple	3	**Productivity status**	**Code**	Others	99
Deep purple	4	Low (< 5 kg/ plant)	3	**Biotic stress susceptibility categories**	**Rating**
Others	99	Medium (5 to 10 kg/ plant)	5	Very low or no visible sign of susceptibility	0-5%
Juiciness	**Code**	High (> 10kg/ plant)	7	Low	5-10%
Low	3	**Seed edible quality**	**Code**	Intermediate	10-20%
Medium	5	Non edible	0	High	20-40%
High	7	Edible	1	Very High	>40%

Table 2. Evaluation of phalsa genotypes as per DUS guidelines 2019-22

S. No.	**Characters**	**Type of Phalsa Genotypes**		
		Dwarf	**Tall**	**Double Seeded (tall)**
1	Type of planting material	1	1	1
2	Tree habit	7	5	5
3	Leaf shape	3	3	3
4	Leaf Margin	1	1	1
5	Leaf pubescence on dorsal side	3	5	7
6	Leaf surface colour on dorsal side	1	3	3
7	Inflorescence type	3	3	3
8	Petal colour*	2	2	2
9	Fruit shape	1	1	2
10	Fruit skin colour	4	4	3
11	Fruit lobe	0	0	1
12	Juiciness	7	7	5
13	Seed edible quality	1	1	0
14	Productivity status	5	7	7
15	Biotic stress susceptibility (insect pest)	1**	2**	1**

*Light pink at maturity

** The infestation of fruit fly was (*Bactrocera dorsalis*) was noticed as 3.0% in dwarf and 6.0% in tall during the month of June.

Table 3a. Plant height (m) of phalsa genotypes (2019-22).

Germplasm	Plant Height (m)			
	2019	2020	2021	2022
Dwarf	1.01±0.10	1.09±0.10	1.12±0.11	1.12±0.11
Tall	2.81±0.04	2.72±0.05	2.78±0.04	2.81±0.01
Double seeded (tall)	2.88±0.05	2.83±0.05	2.91±0.05	2.85±0.06
Range	1.01-2.88	1.09-2.83	1.12-2.91	1.12-2.85
CD (p=0.05)	0.22	0.18	0.18	0.21

Table 3b. Tree spread (m) of phalsa genotypes (2019-22).

Germplasm	Tree Spread (m)			
	2019	2020	2021	2022
Dwarf	1.62±0.04	1.58±0.05	1.58±0.05	1.58±0.05
Tall	2.52±0.35	3.07±0.05	2.87±0.19	2.95±0.12
Double seeded (tall)	3.54±0.17	3.67±0.19	3.65±0.19	3.69±0.19
Range	1.62-3.54	1.58-3.67	1.58-3.65	1.58-3.69
CD (p=0.05)	0.76	0.33	0.42	0.42

Table 3c. Internodal length (cm) of phalsa genotypes (2019-22).

Germplasm	Internode Length (cm)			
	2019	2020	2021	2022
Dwarf	6.14±0.08	6.04±0.09	6.02±0.11	5.98±0.18
Tall	6.10±0.07	7.53±0.24	7.50±0.25	7.54±0.34
Double seeded (tall)	7.76±0.20	7.64±0.20	7.70±0.19	7.82±0.17
Range	6.10-7.76	6.04-7.64	6.02-7.70	5.98-7.82
CD (p=0.05)	0.40	0.42	0.42	0.90

Table 3d. Leaf length (cm) of phalsa genotypes (2019-22).

Germplasm	Leaf Length (cm)			
	2019	2020	2021	2022
Dwarf	12.24±0.23	12.10±0.24	12.12±0.23	12.16±0.19
Tall	16.54±0.15	16.74±0.16	16.76±0.19	16.84±0.21
Double seeded (tall)	16.48±0.42	16.42±0.39	16.52±0.39	16.76±0.43
Range	12.24-16.54	12.10-16.74	12.12-16.76	12.16-16.84
CD (p=0.05)	0.93	0.44	0.51	0.48

Table 3e. Leaf width (cm) of phalsa genotypes (2019-22).

Germplasm	Leaf Width (cm)			
	2019	2020	2021	2022
Dwarf	10.02±0.09	10.06±0.11	10.16±0.09	10.02±0.16
Tall	15.64±0.19	15.60±0.18	15.70±0.18	15.70±0.21
Double seeded (tall)	15.42±0.13	15.50±0.15	15.72±0.17	15.68±0.21
Range	10.02-15.64	10.06-15.60	10.16-15.72	10.02-15.70
CD (p=0.05)	0.48	0.23	0.26	0.60

Table 4. Evaluation of phalsa genotypes for quality parameters as per DUS guidelines 2019.

S. No.	Characters	Type of Phalsa Genotypes		
		Dwarf	Tall	Double Seeded (tall)
1	Number of clusters per leaf axil	10-12	8-10	7-10
2	Number of flowers per inflorescence	2-5	3-4	3-4
3	Date of starting of flowering (at 5% buds opened)	22-26 March	25-31 March	1-6 April
4	Date of end of flowering (at 85 to 90% flowers bud opened)	25-30 April	1-8 May	15-22 May
5	Date of 50% fruit maturity (> 50% fruits attain maturity)	20-25 May	22-28 May	1-7 June
6	Number of fruit pickings	6-8	6-8	3-4
7	Fruit length (mm)	11.8-12.8	12.1-14.1	13.7-15.6
8	Fruit width (mm)	9.1-10.2	9.8-11.3	10.6-11.3
9	Fruit weight (g)	0.8-1.1	0.9-1.2	1.2-1.5
10	TSS (ºB)	18.1-19.2	18.9-20.8	21.4-22.8
11	Number of seeds per fruit	1-2	1-2	2
12	100 seed weight (g)	5.6-6.2	6.1-6.6	6.8-7.8
13	Shelf life	24 hr	24 hr	48 hr

Table 5. Evaluation of Phalsa genotypes for plant and fruit attributes as per DUS guidelines 2020.

S. No.	Characters	Type of Phalsa Genotypes		
		Dwarf	Tall	Double Seeded (tall)
1	Number of clusters per leaf axil	10-12	8-10	7-10
2	Number of flowers per inflorescence	2-5	3-4	3-4
3	Date of starting of flowering (at 5% buds opened)	22-27 March	25-2 April	1-7 April
4	Date of end of flowering (at 85 to 90% flowers bud opened)	25-2 April	1-9 May	14-22 May
5	Date of 50% fruit maturity (> 50% fruits attain maturity)	20-26 May	22-29 May	29 May-7 June
6	Number of fruit pickings	6-8	6-8	3-4
7	Fruit length (mm)	11.8-12.8	12.1-14.1	13.7-15.6
8	Fruit width (mm)	9.1-10.1	9.8-11.2	10.6-11.2
9	Fruit weight (g)	0.8-1.1	0.9-1.2	1.2-1.6
10	TSS (ºB)	18.2-19.2	18.8-20.8	21.2-22.8
11	Number of seeds per fruit	1-2	1-2	2
12	100 seed weight (g)	5.6-6.2	6.1-6.6	6.8-7.8
13	Shelf life	24 hr	24 hr	48 hr

Table 6. Evaluation of Phalsa genotypes for quality parameters as per DUS guidelines 2021.

S. No.	Characters	Type of Phalsa Genotypes		
		Dwarf	Tall	Double Seeded (tall)
1	Number of clusters per leaf axil	10-12	8-10	7-10
2	Number of flowers per inflorescence	2-5	3-4	3-4
3	Date of starting of flowering (at 5% buds opened)	23-29 March	26 March -3 April	2-9 April
4	Date of end of flowering (at 85 to 90% flowers bud opened)	26 April -3 May	1-8 May	15-23 May
5	Date of 50% fruit maturity (> 50% fruits attain maturity)	22-28 May	24-31 May	31 May-9 June
6	Number of fruit pickings	6-8	6-8	3-4
7	Fruit length (mm)	11.6-12.7	12.2-14.0	13.6-15.7
8	Fruit width (mm)	9.2-10.1	9.9-11.3	10.7-11.3
9	Fruit weight (g)	0.80-1.15	0.90-1.25	1.20-1.65
10	TSS (ºB)	18.1-19.3	18.7-20.9	21.3-22.9
11	Number of seeds per fruit	1-2	1-2	2
12	100 seed weight (g)	5.6-6.2	6.1-6.6	6.8-7.8
13	Shelf life	24 hr	24 hr	48 hr

Table 7. Evaluation of Phalsa genotypes for quality parameters as per DUS guidelines 2022.

S. No.	Characters	Type of Phalsa Genotypes		
		Dwarf	Tall	Double Seeded (tall)
1	Number of clusters per leaf axil	10-12	8-10	7-10
2	Number of flowers per inflorescence	2-5	3-4	3-4
3	Date of starting of flowering (at 5% buds opened)	22-31 March	24 March -5 April	4-12 April
4	Date of end of flowering (at 85 to 90% flowers bud opened)	25 April -5 May	2-10 May	17-25 May
5	Date of 50% fruit maturity (> 50% fruits attain maturity)	23-30 May	25-31 May	29 May-10 June
6	Number of fruit pickings	6-8	6-8	3-4
7	Fruit length (mm)	11.7-12.8	12.3-14.1	13.5-15.9
8	Fruit width (mm)	9.3-10.2	9.9-11.2	10.8-11.4
9	Fruit weight (g)	0.81-1.12	0.92-1.27	1.22-1.70
10	TSS (ºB)	18.2-19.4	18.6-20.9	21.1-22.9
11	Number of seeds per fruit	1-2	1-2	2
12	100 seed weight (g)	5.76-6.3	6.0-6.7	6.7-7.9
13	Shelf life	24 hr	24 hr	48 hr

References

Anonymous (2016). Guidelines of PPV&FRA for the conduct of test for distinctiveness, uniformity and stability on Indian gooseberry (*Emblica officinalis* Gaertn.). Plant Variety Journal of India, 10(2).

Aulakh PS, Kaur A, Singh J & Thakur A, (2013). Performance of Aonla (*Emblica officinalis* Gaertn.) cultivars in Punjab. Journal of Research Punjab Agricultural University, 50(3):110-113.

Bakshi P, Wali VK, Jasrotia A, Sharma A & Iqbal M, (2015). Evaluation of different Aonla (*Emblica officinalis*) cultivars under rainfed conditions of lower Shivalik foothills of Himalayas. Indian Journal of Agricultural Sciences, 85(8):1012-1016. https://doi.org/10.56093/ijas.v85i8.50817

Mor R, Kumar M, Kumar S, Kumari S and Jat ML, (2022). Decipheration of flowering and fruiting characters in phalsa (*Grewia subinaequalis*) germplasm under semi-arid conditions of Haryana. Current Horticulture, 10(2):62-65. https://doi.org/10.48165/

Dhawan K, Malhotra S, Dhawan SS, Singh D & Dhindsa KS, (1993). Nutrient composition and electrophoretic pattern of protein in two distinct types of Phalsa (*Grewia subinaequalis* DC). Plant Foods for Human Nutrition, 44(3):255-260. https://doi.org/10.1007/bf01088320

Gupta RB, (2001). Cyto-morphological studies in wild and cultivated species of ber [Master's thesis, CCS Haryana Agricultural University]. Hisar.

Haq MZ, Stankovic MS, Rizwan K & De Feo V, (2013). Phalsa (*Grewia asiatica* L.) food plant with multiple uses. Molecules, 18, 2663-2682. https://doi.org/10.3390/molecules18032663

Kaur C & Kapoor HC, (2005). Antioxidant activity of some fruits in Indian diet. In ISHS Acta Horticulturae. VII International Symposium on Temperate Zone Fruits in the Tropics and Subtropics, Part II (Vol. 696, pp. 563-565).

Khan AS, Hussain A & Khan F, (2006). Nutritional importance of micronutrients in some edible wild and unconventional fruits. Journal of Chemical Society of Pakistan*, (28)*:576-582.

Khemiss F, Ghoul-Mazgar, S, Moshtaghie AA & Saidane D, (2006). Study of the effect of aqueous extract of *Grewia tenax* fruit on iron absorption by everted gut sac. Journal of Ethnopharmacology, 103(1):90-98. https://doi.org/10.1016/j.jep.2005.07.017

Kumar M, Arya R, Kumar M, Gaur RK & Sharma S, (2021). Evaluation of Aonla varieties under semi-arid conditions of Haryana. EKIN Journal of Crop Breeding and Genetics, 7(2):139-144.

Kumar S, Sharma JR, Kumar M, Singh N & Kumar N, (2024). Evaluation of ber genotypes grown under semi-arid condition. Indian Journal of Horticulture, 81(4):359-365. https://doi.org/10.58993/ijh/2024.81.4.4

Kumar R, Khadda BS, Jadav JK, Rai AK, Khajuria S & Lata K, (2016). Evaluation of aonla (*Emblica officinalis*) varieties under hot semi-arid conditions of Western India. Current Horticulture, 4(2):39-43.

Kumar S, Sharma JR, Kumar M, Bishnoi M, Reetika & Gavri A, (2024a). Evaluation of ber (*Ziziphus mauritiana*) genotypes under semi-arid region of Haryana. Indian Journal of Agricultural Sciences, 94(8):881-889. DOI: 10.56093/ijas.v94i8.147830

Mahajan RK, Gangopadhyay KK, Kumar G, Dobhal VK, Srivastava U, Gupta PN & Pareek SK, (2002). Minimal descriptors agri-horticultural crops: Fruit crops. NBPGR, 3, 168-171.

Mishra DS, Tripathi A & Nimbolkar PK, (2016). Review on physiological disorders of tropical and subtropical fruits: Causes and management approach. International Journal of Agriculture Environment and Biotechnology, 9(6):925. 10.5958/2230-732X.2016.00120.0

Mishra D, Kumar R & Singh A, (2018). Phalsa (*Grewia subinaequalis* DC.). In S. N. Ghosh (Ed.), Breeding of Underutilized Fruit Crops (1st ed., pp. 405-410). Narendra Publishing House.

Muhammad Z, Milan SS, Komal R & Vincenzo DF, (2013). *Grewia asiatica* L., a food plant with multiple uses. Molecules*,* 18(3):2663-2682. doi: 10.3390/molecules18032663

Pathak RK, Singh S & Saroj PL, (2004). Aonla. In P. L. Saroj & O. P. Awasthi (Eds.), Advances in Arid Horticulture (Vol. 2, pp. 1-20). IBDC Publishers.

Rai M, Nath V, Singh HS, Dwivedi R & Gangopadhaya KK, (2002). Overcoming off season flowering in aonla. Indian Horticulture, 47(3):12-13.

Ray A & Bala K, (2016). Effects of storage conditions on sensory attributes of phalsa fruit (*Grewia asiatica*) of variety Sharbati. International Journal of Advanced Research in Science and Engineering, 5(8):720-725.

Sharma N & Patni V, (2013). *In vivo* and *in vitro* qualitative phytochemical screening of *Grewia* species. International Journal of Bio. Pharm Research, 4(9):634-639.

Singh AK, Singh S & Makwana P, (2015). Characterization of aonla (*Emblica officinalis*) varieties under zero irrigation semi-arid conditions. Indian Journal of Agricultural Sciences, 85(10):1365-1369. https://doi.org/10.56093/ijas.v85i10.52308

Singh RS, Bhargava R, Pal G & Sharma BD, (2014). Effect of spacing on growth and biomass production in bael (*Aegle marmelos* Correa) under hot arid conditions. Progressive Horticulture, 46(1):58-60.

Steinmetz K & Potter J, (1991). Vegetables, fruit and cancer epidemiology. Cancer Causes & Control, 2(5):325-357.

Yadav AK, (1999). Phalsa: A potential new small fruit for Georgia. In J. Janick (Ed.), Perspectives on New Crops and New Uses (pp. 348-352). ASHS.

Variety Registration

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A New Kabuli Chickpea (*Cicer arietinum* L.) Variety "Nuribey 01" for Cultivation in Türkiye

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ABSTRACT

It was developed and submitted for registration as a result of chickpea breeding studies carried out at the Eastern Mediterranean Agricultural Research Institute Directorate, Adana location; and it was registered in 2024 with the name "Nuribey 01" as a result of yield, ascochyta blight tolerance and quality values in registration trials. As a result of chickpea registration yield trials established in different regions of Türkiye, the average yield of Nuribey 01 chickpea variety was 240.3 kg/da^{-1} and the highest yield value was 364.8 kg/da. According to the results of the experiment, the flowering period of the varieties was 66-156 days, plant height was 39-65 cm and hundred grain weight was 30.7-45.6 g. In terms of technological characteristics, protein ratio was determined in the range of 23,1-27,0%. The gradual seed production of our Nuribey 01 edible chickpea variety, which was registered in 2024, will be planted as of 2025 and will be offered to the service of our farmers.

Keywords: Chickpea, yield, quality

Introduction

Türkiye has a rich plant diversity with different ecological regions. Within this biodiversity, wild relatives of chickpea *(Cicer arietinum L.)* are also found in Türkiye. Chickpea is the second most resistant to drought and low temperature among edible grain legumes after lentils. It is not very selective in terms of soil requirements. It is drought resistant thanks to its small vegetative parts, short development period and taproot system. The importance of chickpea plant in crop rotation increases the importance of its ability to utilize the free nitrogen of the air with Rhizobium bacteria in its roots. At the same time, in addition to these, the contribution of protein richness in eliminating the nutritional deficit makes the chickpea plant indispensable. It is inevitable to supply the food deficit in the world and in our country from different sources. Chickpea is a protein and vitamin-rich edible legume plant that contains 18-31% protein in its grain, as well as important essential amino acids such as leucine, alanine, lysine, isoleucine, methionine, tryptophan, valine, which are the basic building blocks of the human body, elements such as K, P, Ca, Mg, S, Fe, Mn and vitamins such as A, B and C respectively.

The data for chickpea in Türkiye for 2022 show a cultivation area of 456,480 ha, a production of 580,000 tons, and a grain yield of 1270,6 kg/ha per unit area (FAO, 2024). Chickpea is grown as a winter crop in the Mediterranean and Southeastern Anatolia regions. Chickpea plants to be grown as winter crops should be tolerant/resistant to ascochyta blight disease. The most important biotic factor limiting the winter cultivation and yield of chickpea is *Ascochyta rabiei* (Pass) Labr, which causes ascochyta blight. Anthracnose is a fungal disease. The development and rate of the disease varies according to climatic conditions; it occurs mostly in rainy, hot weather with high relative humidity. Especially rain is an important factor in the spread of the disease. For this reason, it is very important that the varieties are tolerant/resistant to diseases and pests in breeding.

Our aim in breeding studies is to identify chickpea varieties with high yield, high market value, good quality values and tolerant/resistant to Ascochyta blight. Nuribey 01 chickpea variety is an edible grain legume chickpea variety registered for this purpose.

Materials and Methods

Our material sources in our edible grain legume breeding studies; We obtain our materials from material sharing within the scope of the national project, ICARDA material exchange programs, new variations created from our own crossbreeding programs or local varieties.

Our Nuribey 01 chickpea variety is also a variety developed with the national hybridization method. Nuribey 01 Chickpea *(Cicer arietinum* L.*)* variety was registered by the Eastern Mediterranean Agricultural Research Institute in 2024, suitable for winter cultivation in the Mediterranean, Aegean and Southeastern Regions and summer cultivation in other regions. Nuribey 01 edible chickpea variety is of national material origin and was developed by single plant selection (ENA 144-10) from F_4 populations of material opened from hybridization studies, using hybridization and selection breeding method from breeding methods; It was bred in 2021 and registered in 2024 with the variety name "Nuribey 01" and offered to the service of farmers.

Findings and Discussion

Grain yield is the most important breeding objective in edible grain legumes as in other cultivated plants; in addition, grain size is also a highly demanded trait in chickpea breeding. However, due to the negative correlation between grain yield and grain size and between grain size and ascochyta blight, the optimum grain size should be determined very carefully according to the regional conditions.

The findings obtained with "Nuribey 01" chickpea variety as a result of the two-year multi-location registration trials carried out were determined by the Seed Registration Office. Biological characteristics of Nuribey 01 chickpea variety vary between 66-156 days of flowering and 119-198 days of physiological maturity. The cultivation method is suitable for winter cultivation. Morphological Characteristics; plant height 39-65 cm, first pod height 22-33 cm, plant growth form semi-erect; it is a variety suitable for machine harvesting. Plant Grain Characteristics 100 grain weight 30,7-45,6 g; grain color beige, grain shape angular round. Technological Characteristics of Nuribey 01 chickpea variety: water absorption capacity 0,40-0,49 g/grain; swelling capacity 0,37-0,481 ml/grain; water absorption index 1,08-1,18%; swelling index 2,41-2,48%; sieve values 9,3-39,1% for 9 mm sieve; 23,2-48,0% for 8 mm sieve; protein ratio 23,1-27,0% (SRCCD,2024).

Grain yield value of Nuribey 01 chickpea variety was 240.3 kg/da on average, the highest yield value was 364.8 kg/da and it was determined that it was tolerant to ascochyta blight. Cooking time for cooking showed a cooking value between 37-41 minutes (SRCCD, 2024), (Mart et al., 2020a, 2020b; Mart et al., 2023a, 2023b).

Conclusions

Improving chickpea agriculture in our country through chickpea breeding studies, increasing cultivation areas, narrowing fallow areas by introducing chickpea into fallow areas, supporting sustainable agriculture by introducing it into crop rotation are important for the country's agriculture and our future.

The introduction of new registered varieties such as Nuribey 01 and chickpea varieties suitable for winter and summer cultivation, high yielding, suitable for machine harvesting, high quality, tolerant/resistant to diseases and pests, with high market value, will carry chickpea agriculture forward.

Figure 1. Plant (a) and grain shape (b) of Nuribey 01 chickpea variety (Original).

Nuribey 01
CHICKPEA (*Cicer arietinum* L.)

Registration year	2024	
Place and year of breeding	Adana - 2021	
The organization that owns the variety	The Eastern Mediterranean Agricultural Research Institute Directorate Adana/Türkiye	
Breeding organization	Eastern Mediterranean Agricultural Research Institute Directorate	
Breeding method	Hybridisation and selection breeding	
Biological properties	Number of days to flowering Number of days to Physiological death	66-156 days 119-198 days
Morphological features	Plant height (cm) First pod height (cm) Plant growth form Cultivation method	39-65 22-33 Semi erect Winter sowing
Grain properties	Hundred seed weight(g) Grain color Grain shape	30,7-45,6 Beige Round corner
Technological features	Water absorption capacity (g/grain) Swelling capacity (ml/grain) Water absorption index (%) Swelling index (%) Cooking time (min.) Protein rate (%) Sieve values (%)	0,40-0,49 0,37-0,48 1,08-1,18 2,41-2,48 37-41 23,1-27,0 9 mm---- 9,3-39,1 8 mm---- 23,2-48,0
Agricultural properties	In registration trials; Average yield (kg/da) Highest yield (kg/da)	 240,3 kg/da 364,8 kg/da
Places where registration trials are carried out	Diyarbakır, Adana, Manisa, Şanlıurfa, Kahramanmaraş	

References

FAO, (2024). FAO. https://www.fao.org/faostat/ (Access Date: 15.06.2025)

Mart D, Öktem G, Akın R, Türkeri M, Atmaca E, Mart S, Çankaya N, Dumlu SE, Yücel D & Karaköy T, (2023). Evaluation of yield, morphological and quality characteristics of some registered chickpea (*Cicer arietinum* L.) varieties in Şanlıurfa. Turkish Journal of Agriculture and Natural Sciences, 10(1):152-160. https://doi.org/10.30910/turkjans.1208010

Mart D, Türkeri M, Öktem G, Akın R, Atmaca E, Mart S, Çankaya N, Dumlu SE, Yücel D & Karaköy T, (2023). Investigation of yield and quality values of some registered chickpea (*Cicer arietinum* L.) varieties. Turkish Journal of Agriculture - Food Science and Technology, 11(4):420-430.

Mart D, Türkeri M & Yücel D, (2020). Registration of "Sezgin" chickpea (*Cicer arietinum* L.) variety. Ekin Journal of Crop Breeding and Genetics, 6(2):118.

Mart D, Türkeri M & Yücel D, (2020). Registration of "Caner" chickpea (*Cicer arietinum* L.) variety. Ekin Journal of Crop Breeding and Genetics, 6(2):119.

SRCCC, (2024). Seed Registration and Certification Center Directorate chickpea report, 2024, Ankara.

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Ekin, Journal of Crop Breeding and Genetics, is an international journal owned and edited by the Plant Breeders Sub-Union of Turkey (BISAB). Ekin is aimed at keeping information among plant breeders about new advances in the plant breeding and genetics as well as genetic diversity of plant species. Ekin publishes research papers and critical reviews on all aspects of plant breeding, genetics and plant registrations cover; old and new cultivars, local populations and introduction materials, germplasm, resistance sources for biotic and abiotic stresses, parental lines, genetic stocks, breeding materials, mapping populations. All manuscripts submitted for publication are reviewed by at least two referees and accepted for publication by editors based on advice from referees.

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In Turkey, wheat was produced 10 million tons in 1923 (Gokgol 1939).

This result was in agreement with result of Sahin and Yildirim (2004).

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Journal article:

Toker C (1998). Adaptation of kabuli chickpeas (*Cicer arietinum* L.) to the low and high lands in the West Mediterranean region of Turkey. Turk J Field Crop 3:10-15.

Toker C and Canci H (2003). Selection of chickpea (*Cicer arietinum* L.) genotypes for resistance to ascochyta blight [*Ascochyta rabie*i (Pass.) Labr.], yield and yield criteria. Turk J Agric For27: 277-283.

Toker C, Canci H and Ceylan FO (2006). Estimation of outcrossing rate in chickpea (*Cicer arietinum* L.) sown in autumn.Euphytica 151: 201-205.

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Yasar M, Ceylan FO, Ikten C and Toker C (2013). Comparison of expressivity and penetrance of the double podding trait and yield components based on reciprocal crosses of kabuli and desi chickpeas (*Cicer arietinum* L.). Euphyticadoi:10.1007/s001090000086

Book:

Toker C (2014). Yemeklik Baklagiller. BISAB, Ankara.

Book chapter:

Toker C, Lluch C, Tejera NA, Serraj R and Siddique KHM (2007). Abiotic stresses. In: Chickpea Breeding and Management,Yadav SS, Redden B, Chen W and Sharma B (eds.),CAB Int. Wallingford, pp: 474-496.

Online document:

FAOSTAT J (2013) http://faostat.fao.org/site/567/default.aspx# anchor. Accessed 15 May 2013.

Dissertation (Thesis):

Yasar M (2012). Penetrance and expressivity of double podding characteristic in chickpea (*Cicer arietinum* L.). Dissertation, Akdeniz University, Antalya.

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Abbreviations

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