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Research Article

Evaluation of Morphological Diversity of Jujube (*Ziziphus jujuba* Mill.) Genotypes

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Abstract

Biodiversity is an achievement that has been formed since the existence of living things in the world and that we human beings are obliged to protect. Maintaining the balance of changes in living species and numbers in the face of biotic and abiotic stress factors and natural events will only be possible by preserving biological diversity. Considering that almost 50% of the global economy is related to biological products and their consumption processes, the importance of this issue will be understood more. Jujube is also a specie of fruit that is still popular in Türkiye and is considered one of the elements of biodiversity. This study was carried out to evaluate the morphological and pomological diversity of 18 different jujube ecotypes that seed-propagated in Dinar District of Afyonkarahisar Province. For pomological measurements, jujube fruits were harvested when the peel color was less than 50% brown-red and healthy leaf samples were taken for morphological measurement in the same period. According to the results of the research, leaf length, leaf width, fruit length, fruit width, fruit weight, endocarp length, endocarp width and endocarp weight values of the studied genotypes are found to be 29.47-50.66 mm, 13.35-28.70 mm, 14.72-38.93 mm, 14.79-35.72 mm, 1.51-17.54 g, 7.42-23.87 mm, 5.12-11.00 mm, 0.20-1.55 g, respectively. The fact that the morphological and pomological diversity of the jujube genetic resources in the region was carried out was very high, indicates the richness of a valuable treasure for jujube variety breeding.

Key Words: Jujube, Ziziphus, morphology, pomology, genetic sources

Hünnap (*Ziziphus jujuba* mill.) Genotiplerinin Morfolojik Çeşitliliğinin Değerlendirilmesi

Öz

Biyoçeşitlilik dünyada canlıların var olmasından bu yana oluşan ve biz insanoğlunun korumakla yükümlü olduğu bir kazanımdır. Biyotik ve abiyotik stres faktörleri ve doğa olayları karşısında canlı tür ve sayısında meydan gelen değişimlerin dengesinin korunması ancak biyolojik çeşitliliği korumakla mümkün olacaktır. Küresel ekonominin neredeyse %50'si biyolojik ürünler ve bunların tüketim süreçleriyle alakalı olduğu düşünülürse konun önemi daha fazla anlaşılacaktır. Hünnap da Türkiye'de henüz popüler olan ve biyolojik çeşitliliğin unsurlarından biri olarak kabul edilen bir meyve türüdür. Bu çalışma Afyonkarahisar İli Dinar İlçesinde sınır ağacı olan ya da hobi amaçlı yetiştirilen 18 farklı hünnap genotipinin morfolojik ve pomolojik çeşitliliğinin değerlendirilmesi amacıyla yürütülmüştür. Pomolojik ölçümler için hünnap meyveleri meyve kabuk renginin % 50'den daha az kahverengi-kırmızı renkli olduğu dönemde hasat edilmiş ve aynı dönemde morfolojik ölçüm için sağlıklı yaprak numuneleri alınmıştır. Araştırma sonuçlarına göre çalışılan genotiplerin yaprak boyu değerleri 29,47-50,66 mm, yaprak eni 13,35-28,70 mm, meyve boyu 14,72-38,93 mm, meyve eni 14,79-35,72 mm, meyve ağırlığı 1,51-17,54 g, endokarp boyu 7,42-23,87 mm, endokarp eni 5,12-11,00 mm ve endokarp ağırlığı 0,20-1,55 g aralığında bulunmuştur. Çalışmanın yürütüldüğü bölgedeki hünnap genetik kaynaklarının morfolojik ve pomolojik çeşitliliğin çok yüksek çıkmış olması, çeşit ıslahı için kıymetli bir hazinenin zenginliğini göstermektedir.

Anahtar Kelimeler: Hünnap, Ziziphus, morfoloji, pomoloji, genetik kaynaklar

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1. Introduction

Biodiversity or biological diversity is the whole of the ecosystems, ecological events and genes in a region in which all species survive. In other words, the concept of biological diversity (biodiversity), which includes all species of plants, animals and microorganisms living in a region, consists of three parts from top to bottom: 1) Ecosystem diversity, 2) Species diversity, 3) Genetic diversity [1]. Türkiye is in a position that can be considered very rich in terms of plant species diversity. There are 12,140 recorded vascular plant species in Türkiye. 7,603 (63%) of these species are non-endemic, 3,955 (33%) are endemic and 582 (4%) are locally endemic [2]. The fact that the rate of endemism is so high has made Türkiye a center of attraction in terms of flowering plants. From this point of view, there is no other country on the European Continent that is as rich in plant species as Türkiye [3]. Jujube is one of the most economically valuable fruit species that contributes to Türkiye's plant biodiversity.

Jujube (*Ziziphus jujuba* Mill) is a perennial and thorny fruit specie that grows naturally in tropical and subtropical regions of Asia, North Africa, America, Europe and Australia. The specie belongs to the genus *Ziziphus* (*Rhamnaceae* family), and is highly tolerant to some environmental stresses such as water scarcity and salinity, as well as some diseases and pests [4-6]. It is a fact known by many scientists that the homeland of jujube is China, Afghanistan, Australia, Malaysia, and that jujube has existed for 4000 years, especially in China [7-9]. 25 different jujube species belonging to *Hovenia, Rhamnus, Colletia, Frangula, Ziziphus* and *Paliurus* genera, which are taxonomically in the same family, are naturally distributed in Türkiye [10]. Although the specie generally exists as seed-propagated in Türkiye, the provinces producing the highest amount of jujube are Amasya (522 tons), Manisa (252 tons), Denizli (233 tons), Balıkesir (187 tons) and Çanakkale (170 tons) according to TUIK (Turkish Statistical Institute) 2022 data. Türkiye's jujube production amount is 2248 tons [11]. Jujube is a specie of fruit that has local names such as Hinnabi, İnnap, Hinnap, Çiğde, Ünnap and Kuran İğdesi. It is not also well known in Türkiye [12].

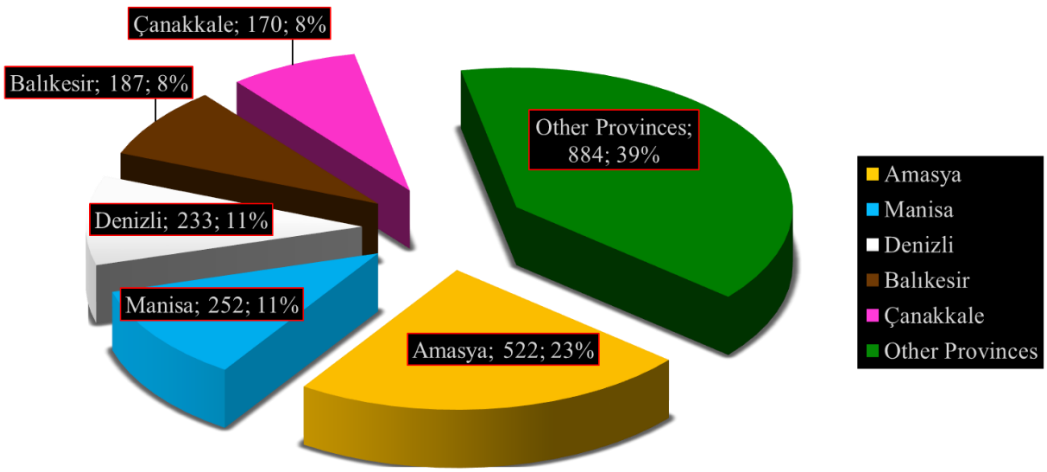

Figure 1. Provinces with the highest amount of jujube production in Türkiye and their production amounts (tons) [11]

According to the United Nations Food and Agriculture Organization (FAO) data, jujube is not considered as a different fruit species. Its production data is shared under the title of dates, and is called "Chinese Date" [6]. In addition to dried and fresh consumption, there are more than 800 varieties of jujube cultivated for confectionery and ornamental plants in China. It has been stated that the fruits of more than 700 of 800 varieties are suitable for drying jujube [13]. Jujube is classified worldwide as the group of small fruit and large fruit. According to Ikinci et al. [14], the ones with large fruits are cultural jujube and they are consumed as table food. The ones with small fruits are wild jujube and they are consumed as dried fruits. Jujube is not only consumed as fresh and dried fruit in China, but also it is widely used as an edible-medical fruit. Compared to standard herbal drug, extracts from jujube are safer and healthier [15]. Herbal medicines are widely used in developing countries. It has been reported that around 70% of people worldwide prefer traditional medical methods [16]. In addition, there are many advantages of obtaining drugs from plants compared to synthetic drugs. Some of these are that herbal medicines are more economical, have less side effects and have a faster effect [17]. In many scientific studies conducted in recent years, the antibacterial and antifungal effect of jujube; evaluation as fish feed; It has been proven to have a protective effect from harmful ultraviolet rays from the sun. In recent years, a lot of research has been conducted on the different usage areas of jujube. Some of these areas are the evaluation of jujube as a fish feed, the protective effect of jujube from harmful ultraviolet rays that can come from the sun, and the antifungal and antibacterial effect of jujube [18].

Morphological markers are the most common agricultural markers that create phenotypic characters in the taxonomic classification of plants. Being economical and directly applicable, they have been indispensable markers in plant breeding studies since the past. However, the fact that the morphological features depend on the environmental conditions and the results can vary from person to person during the evaluation stage showed that the use of morphological markers alone is not sufficient. With the effect of technological developments, plant breeding studies have gained a different dimension and biotechnological studies have accelerated the breeding processes [19]. However, characterization based on molecular markers alone is never sufficient to get results. The importance of this subject has been demonstrated by conducting many scientific studies based on pomological and morphological markers [20-22].

It has been observed that the number of scientific studies in the field of describing the herbal characteristics of jujube, which is not widely cultivated in Türkiye, is also low. This research was carried out to evaluate the pomological and morphological diversity of jujube genotypes inner Aegean region, which were observed to have differences in plant and fruit structure.

2. Material and Method

In the research, 18 jujube genotypes aged 5-15 years, which are seed-propagated and can be easily distinguished from each other in terms of morphological differences, were used as plant material in Dinar District of Afyonkarahisar Province. Jujube genotypes are named from G1 to G18, and the sampling map of the genotypes used in the study is presented in Figure 1.

The jujube genotypes used in the study were obtained from seeds. These plants are offered for sale in the nurseries in the region without grafting. Irrigation, fertilization, harvesting, disease and pest control processes of the studied genotypes are carried out regularly. The most important criteria in the selection of jujube genotypes: The genotypes should be high yielding, free from diseases and pests, and at full yield period. Jujube fruits were harvested when the peel color of the fruit was less than 50% brown-red. Harvest was done by hand on 25.09.2022 with 20 randomly selected fruits from each genotype. 10 intact leaves samples of the genotypes were collected from 4 different directions of the tree at harvest time. The image of the tree and shoot structure of the G15 genotype is presented in Figure 2. In determining the parameters to be examined in the study, first of all, the UPOV (The International Union for the Protection of New Varieties of Plants) criteria were examined and it was seen that there were no evaluation criteria for jujube on the relevant web page. For this reason, it was found appropriate to examine the criteria of leaf length, leaf width, fruit length, fruit width, endocarp length, endocarp width, endocarp weight and fruit weight in the jujube species that did not provide standardization on the basis of cultivar, making use of previous studies on jujube.

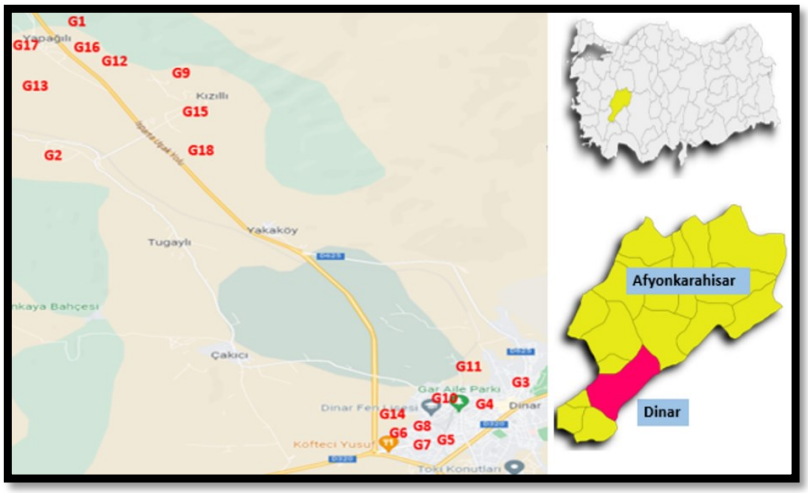

Figure 2. Sampling map of *Ziziphus jujuba* Mill genotypes used in the study

Figure 3. The image of the tree and shoot structure of the G15 genotype

Leaf length, leaf width, fruit length, fruit width, endocarp length and endocarp width were measured with a digital caliper sensitive to 0.01 mm. The measurement of endocarp weight and

fruit weights was carried out in the laboratories of the Department of Horticulture of Atatürk University with a balance with a sensitivity of 0.001 g [23]. Statistical analysis was performed to determine whether there were significant differences between the obtained data. In the analysis, one-way analysis of variance (ANOVA) and Duncan multiple comparison tests were applied using the SPSS-20 package program [24].

3. Results and Discussion

The average measurement values of the *Ziziphus jujuba* Mill genotypes are presented in Table 1. It was determined that there were statistically significant differences at the level of 5% between the genotypes examined. Leaf lengths of the studied genotypes are ranged from 29.47 mm (G8) to 50.66 mm (G13). The leaf widths are ranged from 13.35 mm (G8) to 28.70 mm (G13). The fruit lengths are varied from 14.72 mm (G6) to 38.93 mm (G14) and, the fruit widths are varied from 14.79 mm (G15) to 35.72 mm (G13). The endocarp lengths are ranged from 7.42 mm (G6) to 23.87 mm (G14), and the endocarp widths are ranged from 5.12 mm (G6) to 11.00 mm (G13). The fruit weights are varied from 1.51 g (G12) to 17.54 g (G13), and the endocarp weights are varied from 0.20 g (G6) to 1.55 g (G13). The leaf length was found to be 32.90-50.90 mm, leaf width was 13.10-26.50 mm, fruit length was 21.77-39.47 mm, fruit width was 18.62-37.23 mm and fruit weight was 2.78-20.28 g in jujube genotypes named as wild and cultured in Şanlıurfa province [14]. In a study carried out on 3 different jujube genotypes aged 10 in Aydın province, leaf length of the genotypes ranged from 32.79 mm to 47.20 mm, leaf width ranged from 17.46 mm to 27.05 mm, fruit length ranged from 29.47 mm to 43.73 mm, fruit width ranged from 24.02 mm to 37.35 mm, fruit weight ranged from 8.21 g to 28.85 g, endocarp length ranged from 15.99 mm to 25.38 mm, endocarp width ranged from 7.92 mm to 9.62 mm and endocarp weight ranged from 0.58 g to 1.16 g [10]. According to the results of a study conducted to determine the morphological diversity of 140 jujube genotypes wild-growing in Iran, the leaf length of jujube genotypes was 26.33-84.05 mm, leaf width was 11.02-32.87 mm, fruit length was 9.43-49.47 mm, fruit width was 8.38-30.17 mm and fruit weight was 0.36-3.83 g [25]. The average leaf length of 24 jujube genotypes (12 plants from the desert and 12 plants from the irrigated area) was 74.00 mm, the average leaf width was 42.00 mm, the average fruit length was 39.00 mm, the average fruit width was 38.00 mm, the average endocarp length was 20.00 mm and the average endocarp width was 14.00 mm in the Cholistan Desert, which has a dry and hot climate in Pakistan [26]. Pomological characterization study was carried out on 131 jujube genotypes in full yield age obtained by crossing from six different jujube cultivars in Macedonia (Skopje). According to the results of the research, it was determined that the genotype of the "Kitajski 2A cultivar" have been the heaviest fruit in all the genotypes with a fruit weight of 13.1 g. The genotype of the "Da Baj Chafifzao cultivar" have been the lightest fruit in all the genotypes with a fruit weight of 6.3 g [27]. A study was conducted to evaluate the morphological diversity of 10 different jujube ecotypes in the Golestan region of Iran. According to results of the research, leaf length is varied from 25.0 mm to 56.0 mm, leaf width is varied from 13.0 mm to 22.0 mm, fruit length is varied from 15.30 mm to 21.60 mm, fruit width is varied from 14.60 mm to 21.30 mm, fruit weight is varied from 0.79 g to 4.8 g, endocarp length is varied from 3.80 mm to 7.90 mm, endocarp width is varied from 10.20 mm to 13.50 mm and endocarp weight is varied from 0.26 g to 1.93 g [28].

A research was conducted by Tatari et al. [5] to determine the pomological and morphological diversity of jujube genotypes collected from different regions of Isfahan (Iran). According to the results, leaf lengths, leaf widths, fruit lengths, fruit widths, fruit weights is ranged of 44.00-51.00 mm, 18.00-28.00 mm, 10.00-22.00 mm, 6.00-17.00 mm and 18.4-42.0 g, respectively.

The results of this morphological and pomological characterization studies of the jujube genotypes show similarities with the results of some researchers, and differences with the results of some researchers. It has been stated that various factors such as the studied plant species, genotype, agronomic practices, maturity level of the fruit at harvest time, post-harvest storage conditions, extreme climatic conditions to which the plant is exposed, geographical location cause diversity in the morphological and biochemical content of horticultural crops [29].

Table 1. Measurement values of *Ziziphus jujuba* Mill genotypes

Genotype Name	Leaf Length (mm)	Leaf Width (mm)	Fruit Length (mm)	Fruit Width (mm)	Fruit Weight (g)	Endocarp Length (mm)	Endocarp Width (mm)	Endocarp Weight (g)
G1	34.69 ef	17.09 fgh	20.81 ef	21.42 efg	4.16 cde	12.15 h	7.33 j	0.35 i
G2	32.88 fg	14.47 hi	18.13 efg	19.42 fgh	2.88 de	10.23 l	7.03 k	0.40 i
G3	49.89 ab	18.93 ef	23.07 de	17.46 gh	3.25 de	15.68 f	7.75 h	0.52 g
G4	38.31 de	17.78 efg	20.37 ef	17.71 gh	3.58 de	10.37 k	6.89 l	0.39 i
G5	34.06 efg	15.36 ghi	19.65 efg	18.81 fgh	3.55 de	10.18 l	7.49 i	0.46 h
G6	40.29 d	17.82 efg	14.72 g	17.03 gh	1.80 e	7.42 o	5.12 o	0.20 k
G7	41.76 cd	24.66 b	33.66 b	29.70 cd	9.22 b	18.56 d	10.14 c	0.98 c
G8	29.47 g	13.35 i	20.44 ef	21.43 efg	4.86 cd	11.92 i	7.77 h	0.52 g
G9	41.43 cd	20.11 de	28.69 c	22.79 ef	6.52 b	18.29 e	8.13 g	0.60 f
G10	49.26 ab	25.26 b	37.67 ab	31.08 bc	15.08 a	19.30 c	8.41 e	0.67 e
G11	50.21 ab	21.94 cd	21.38 ef	17.05 gh	2.71 de	11.59 j	8.22 f	0.46 h
G12	32.68 fg	14.56 hi	16.31 fg	16.99 gh	1.51 e	10.45 k	7.54 i	0.38 i
G13	50.66 a	28.70 a	35.83 ab	35.72 a	17.54 a	19.93 b	11.00 a	1.55 a
G14	45.37 bc	23.95 ab	38.93 a	34.26 ab	17.15 a	23.87 a	10.89 b	1.47 b
G15	30.36 fg	14.97 hi	16.99 fg	14.79 h	1.92 e	9.43 m	6.53 m	0.28 j
G16	41.50 cd	16.33 fgh	26.54 cd	25.89 de	6.79 ab	11.66 j	8.46 e	0.52 g
G17	38.36 de	14.89 hi	19.95 ef	20.64 fg	5.16 cd	12.54 g	9.51 d	0.85 d
G18	46.37 abc	17.13 fgh	18.20 efg	17.95 gh	3.48 de	8.65 n	5.62 n	0.22 k
Mean	40.42	18.74	23.96	22.23	6.18	13.46	7.99	0.60
F Value	19.77	29.20	25.39	19.87	36.12	12875.77	3106.36	410.29

The same letters in the same column indicate statistically significant differences ($p< 0.05$) between genotypes.

4. Conclusion

The differences between the results obtained from the studies may vary depending on environmental and genetic factors. Differences in fruit cultivars that are not found in geographically distant regions are mostly the result of genetic diversity. However, the morphological and pomological diversity of jujube genotypes found in different agro-ecological regions may vary depending on both environmental and genetic factors. The

morphological and pomological diversity of the genotypes used in this study was very high. This situation is an indication of how rich the plant germplasm we have is.

In general, the first breeding purposes in fruit growing are to obtain high-yielding and large-fruited varieties. It has been stated that jujube genotypes with high fruit weight can be obtained from larger seeds [27]. The use of the superior genotypes of this research (G13 and G14) in a breeding study to be carried out for table consumption in jujube species may be a good choice to achieve the desired results.

Jujube has been a fruit specie that is consumed lovingly in Türkiye and cultivated in low quantities in certain regions, but has not yet found the necessary value. However, it has been cultivated since ancient times and its use has become widespread in its homeland (China). In addition to being a table fruit specie, consuming jujube in the form of dried fruit provides an advantage for farmers who produce jujube. Jujube is consumed only as table and dried fruit in Türkiye. But in foreign countries, confectionery obtained from jujube is consumed as a value-added food product. Also, according to the results of the researches, jujube can be used for many different purposes (the using of jujube as an ornamental plant, the producing of medicine and sunscreen from jujube extracts, its usage as fish feed, etc.), and this is another proof of how valuable jujube is.

Ethics in Publishing

There are no ethical issues regarding the publication of this study.

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