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Araştırma
(Research)

Clonal Selection in the Local 'Trabzon Sivrisi' Hazelnut Population Grown in Some Districts of Trabzon*

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Abstract

Purpose: The purpose of this study was to determine the clones with superior characteristics in the 'Trabzon Sivrisi' hazelnut population.

Materials and Method: The study was carried out in hazelnut orchards in the Araklı, Arsin and Yomra districts of Trabzon (Türkiye) in 2016 and 2017. The study was planned as selecting 3 different ocaks from each hazelnut orchard followed by the selection of a plant (branch) with the highest yield among these ocaks. Nut per cluster, yield (g), kernel weight (g), kernel ratio (%), shell thickness (mm), kernel cavity (mm), good kernel (%) and defective kernel belonging to the selected hazelnut clones in the study were examined and recorded. In addition, the protein (%), and fat ratio (%) were determined.

Results: Out of 207 clones observed and examined in the research area, 8 are promising and recommended for further research. Clones numbered TY42-3 and TA42-2 with a total score above 400 were selected according to the modified weighted grading method carried out at the end of the study. In the examination made according to nut characteristics the following clones were evaluated as promising: TAK20-2 in terms of nut per cluster, TA39-1 in yield, TY35-3 in kernel weight, TY15-1 in shell thickness, TY1-3 in kernel percentage, good kernel, and defective kernel rate and TY28-1 in terms of kernel cavity.

Conclusion: In this study, 8 clones were evaluated as hopeful. The fact that cultural practices such as irrigation, pruning and fertilization were not carried out in the orchards where the study was carried out both increases the value of the data obtained and reveals the importance of our country regarding the gene center. It is important for our country to continue the study and put the clones determined as promising under trial in controlled conditions, to follow the process and to take them to the registration process.

Keywords: *Corylus avellana* L., Clone, Population, Selection, 'Trabzon Sivrisi', Yield

Trabzon'un Bazı İlçelerinde Yetiştirilen Yerel 'Trabzon Sivrisi' Fındık Popülasyonunda Klon Seleksiyonu

Öz

Amaç: Bu çalışmada 'Trabzon Sivrisi' fındık popülasyonunda üstün özelliklere sahip klonların tespit edilmesi hedeflenmiştir.

Materyal ve Yöntem: Çalışma 2016 ve 2017 yıllarında Trabzon'un Araklı, Arsin ve Yomra ilçelerinde yürütülmüştür. Çalışma, her fındık bahçesinden 3 farklı ocak ve bu ocaklar arasından verimi en yüksek olan bir bitkinin (dal) seçilmesi şeklinde planlanmıştır. Araştırmada seçilen fındık klonlarına ait çotanaktaki meyve sayısı, verim (g), iç ağırlığı (g), iç oranı (%), kabuk kalınlığı (mm), göbek boşluğu (mm), dolgun meyve oranı (%) ve kusurlu meyve oranı (%) gibi özellikler bakımından incelenerek kaydedilmiştir. Ayrıca protein (%) ve yağ oranları (%) da belirlenmiştir.

Araştırma Bulguları: Araştırma alanında gözlenen ve incelenen 207 klon arasından 8'i ümitvar olarak ileri araştırmalar için önerilmektedir. Çalışma sonucunda yapılan değiştirilmiş tartılı

derecelendirme metoduna göre toplam puanı 400'ün üzerinde olan TY42-3 ve TA42-2 numaralı klonlar seçilmiştir. Meyve özelliklerine göre yapılan incelemede TAK20-2 klonu çotanaktaki meyve sayısı, TA39-1 klonu verim, TY35-3 klonu iç ağırlığı, TY15-1 klonu kabuk kalınlığı, TY1-3 klonu iç oranı, dolgun meyve oranı, kusurlu meyve oranı ve TY28-1 klonu ise göbek boşluğu yönüyle ümitvar olarak değerlendirilmiştir.

Sonuç: Bu araştırmada 8 birey ümitvar olarak değerlendirilmiştir. Çalışmanın yürütüldüğü bahçelerde sulama, budama, gübreleme gibi kültürel işlemlerin yapılmamış olması elde edilen verilerin hem değerini artırmakta hem de ülkemizin gen merkezi konusundaki önemini ortaya koymaktadır. Çalışmanın devam ettirilmesi, ümitvar olarak belirlenen bireylerin kontrollü koşullarda denemeye alınıp, sürecin takip edilerek tescil işlemine kadar götürülmesi ülkemiz için önemlidir.

Anahtar Kelimeler: *Corylus avellana* L., Klon, Popülasyon, Seleksiyon, 'Trabzon Sivrisi', Verim

Introduction

Since our country is the homeland of hazelnut and the place where it was first cultivated, wide variations are seen in the production regions (İslam, 2021). This variation has enabled the emergence of many important varieties, both through the selection studies carried out by the producers and the hybridization studies carried out with natural methods (İslam, 2019).

After selection and hybridization; Tombul, Çakıldak, Palaz, Mincane, Foşa, Sivri and varieties of Sivri which are of commercial importance stand out compared to others in terms of yield and quality characteristics (Pelvan et al., 2012). Mutations and natural hybridizations occurring between plants cause a wide variation within the same variety.

The newly formed variations may be economically worse than the original variety, but the good ones are noticed and maintained. Therefore, the selection of clones with the desired characteristics within the variations is very important for breeders. For this purpose, methods such as 'mass selection, single selection, clone selection' are used in horticultural crops. The selection of the types that are superior to the main variety in terms of economic value among the variations in a variety is called 'clone selection' (Şeniz, 1990).

Numerous clone selection studies have been carried out in hazelnut production regions from the past to the present (İslam, 2000; Medel, 2004; Turan, 2007; De Salvador et al., 2009; Turan and Beyhan, 2009; Petriccione et al., 2010; Sathuvalli and Mehlenbacher, 2012; Balık and Beyhan, 2014; Mehlenbacher, 2014; Balık et al., 2018; İslam and Çayan, 2019; Şahin, 2019; Karadeniz et al., 2020; Karakaya, 2021; Turan, 2021; Uzun, 2021; Rovira et al., 2022; Sali, 2022). Most of the selection studies in our country have been carried out on standard cultivars. However, there has been no study carried out on the 'Trabzon Sivrisi' until today. Therefore, studies on these genotypes are of great importance. The study was carried out in order to determine the clones that stand out in terms of some characteristics among the local 'Trabzon Sivri' clones in the Araklı, Arsin and Yomra districts of the Trabzon province. This local variety attracts attention with its late leafing feature. Since the data to be obtained from the study is the first, it is thought that clones which stand out in terms of their late leafing feature will contribute to the literature on the one hand and to the hazelnut sector on the other.

Materials and Method

This study was carried out on clones of the 'Trabzon Sivrisi' hazelnut population grown in the Araklı, Arsin and Yomra districts of Trabzon (Türkiye) in 2016 and 2017 (Figure 1).

In the study, the productive branches of the orchards belonging to the densely populated areas were determined and the clones were collected (Table 1). By entering the orchards where the study was carried out, the most productive branches of 3 different ocaks, which were determined to be productive as a result of the observations made, were marked and harvested. In the first year (2016), 106 orchards were determined, and in the second year (2017), the same orchards were visited again, the number of orchards was reduced to 69 after a process of elimination, and a total of 207 clones were studied for two years. The planning and conduct of the experiment and pomological measurements were based on the methods stated by Çetiner (1976), Ayfer et al. (1986), İslam (2000), Köksal (2002) and Turan (2007).The selected specimens were manually separated from their clusters and dried in the shade. Properties such as yield, nut per cluster, kernel weight, kernel percentage, shell thickness, kernel cavity, good kernel and defective kernel were investigated in dried nut clones. In addition, fat and protein ratio were

determined in the clones that were determined as promising.

Yield (g/plant): It was determined by weighing all dried nuts harvested from a plant (branch).

Nut per cluster: Total number of nuts in the cluster.

Kernel Weight (g): 30 nuts were weighed and their average taken.

Shell Thickness (mm): 30 nuts were measured with a digital caliper and their average taken.

Kernel Cavity (mm): 30 nuts were measured with a digital caliper and their average taken.

Kernel Percentage (%): Calculated as the ratio of the kernel weight to the weight of the shelled nut ([Kernel weight / Nut weight] x 100).

Good Kernel (%): Calculated by dividing the number of completely filled, non-defective kernels to the total number of nuts ([Number of good kernels / Total number of kernels]) x 100

Defective Kernel (%): Found by dividing the number of kernels other than good and defective kernels (abortive, wrinkled, black-tipped, moldy, rotten, wormy, missing, etc.) to the total number of kernels ([Defective kernel / Total number of kernels)] x 100)

Oil ratio (%): Soxhlet method used. The clones were subjected to immersion, washing and recovery processes in the soxhlet device and the amount of oil was calculated (James, 1995).

Protein ratio (%): The Kjeldahl method was used to determine the protein percentage. % Protein: % Nitrogen x 6.25 (James, 1995).

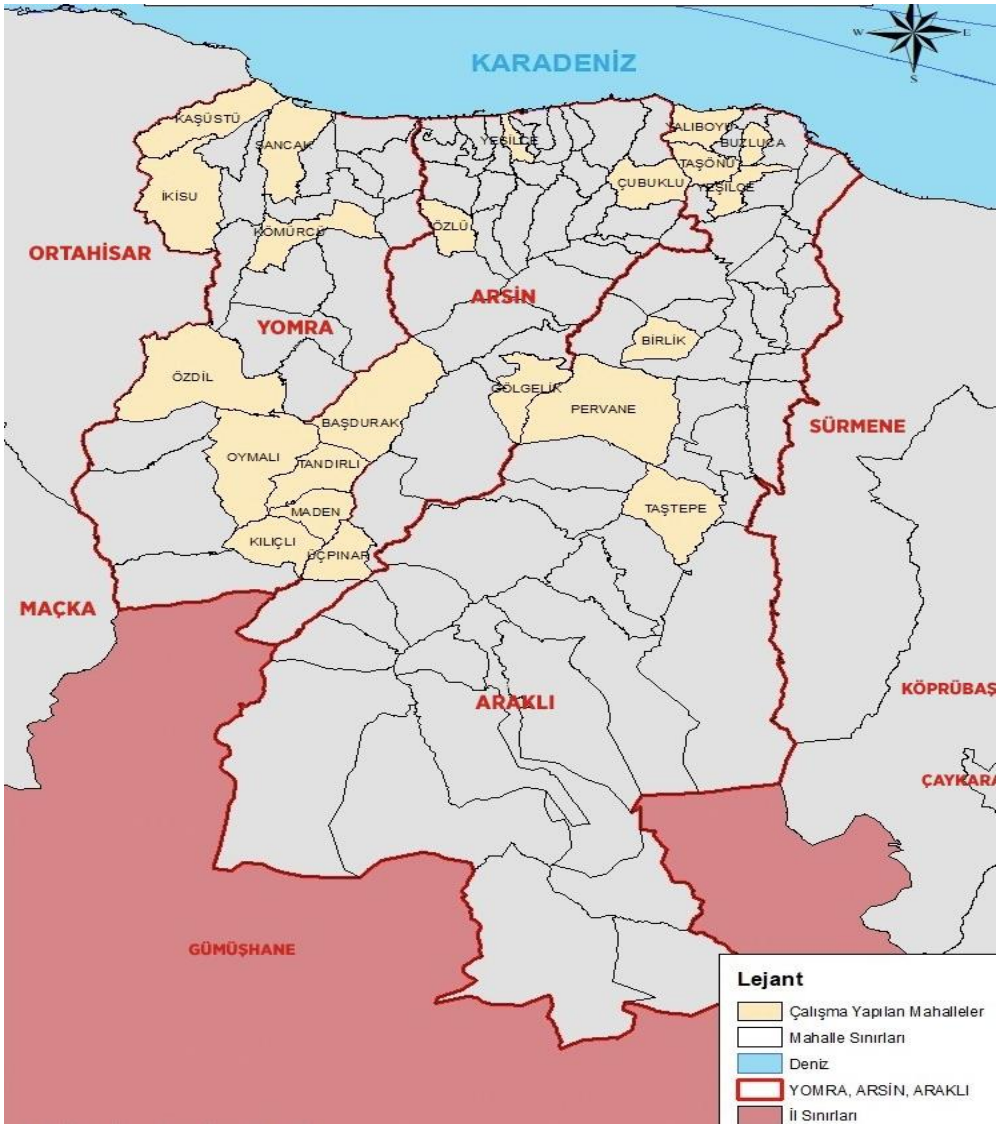

Figure 1. Districts and neighborhoods where research materials were collected

Table 1. Information on the places where the study was carried out and the hazelnut clones taken

District	Neighbourhood	Altitude (m)
Yomra	İkisu	410-440
	Kaşüstü	350-400
	Kılıçlı	910-970
	Kömürcü	450-500
	Maden	750
	Oymalıtepe	770-800
	Özdil	600- 620
	Sancak	150-180
	Tandırlı	820-900
Arsin	Başdurak	800-850
	Çubuklu	270-310
	Gölgelik	610-720
	Özlü	340-375
	Üçpınar	900-950
	Yeşilce	120-170
	Birlik	350
Araklı	Buzluca	130
	Pervane	500-550
	Taşönü	190
	Taştepe	400-450
	Yalıboyu	70-100
	Yeşilce	150

Weighted rating method

As a result of the selection studies carried out between 2016 and 2017, the "Modified Weighted Rating Method" was used for the selection of clones (Michelson et al., 1958). In addition, when the importance levels are evaluated, parameters such as nut per cluster, yield (total nut weight), shell thickness, kernel weight, kernel percentage, good kernel, defective kernel and kernel cavity were taken into account (Table 2). In scoring, the difference between the values obtained from the population was divided by 5 and the maximum and minimum values were determined.

Table 2. Features, importance levels, class intervals and score table of the modified weighted grading method used in the study

Traits	Importance Level (%)	Class Interval	Score
Yield (g)	25	498.5-02.4	5
		394.6-98.5	4
		290.7-94.6	3
		186.7-90.6	2
		82.8-186.7	1
Kernel Percentage (%)	20	53.0-54.8	5
		51.2-53.0	4
		49.4-51.2	3
		47.6-49.4	2
		45.8-47.5	1
Good Kernel (%)	15	64.4-76.4	5
		52.4-64.4	4
		40.4-52.4	3
		28.4-40.4	2
		16.3-28.3	1
Defective Kernel (%)	15	13.7-27.6	5
		27.6-41.4	4
		41.4-55.2	3
		55.2-69.0	2
		69.0-82.8	1
Shell Thickness (mm)	10	0.8-0.9	5
		0.9-1.0	4
		1.0-1.1	3
		1.1-1.2	2
		1.2-1.3	1

Table 2. Features, importance levels, class intervals and score table of the modified weighted grading method used in the study (continued)

Traits	Importance Level (%)	Class Interval	Score
Kernel Weight (g)	5	1.1-1.2	5
		1.0-1.1	4
		0.9-1.0	3
		0.8-0.9	2
		0.7-0.8	1
Nut per Cluster (number)	5	4.3-4.7	5
		3.9-4.3	4
		3.4-3.8	3
		3.0-3.4	2
		2.5-3.0	1
Kernel Cavity (mm)	5	1.1-1.4	5
		1.5-1.8	4
		1.9-2.2	3
		2.3-2.6	2
		2.7-3.1	1

The maximum value started from 5 points and continued by decreasing to 1. In the study, 8 clones stood out and 2 of these clones were selected.

Results and Discussion

The properties of the clones are given in Tables 3 and 4. When the charts are examined, it is understood that there is a large variation among the clones. In the selected clones, it was observed that the nut per cluster was between 1.9 and 5.0 (Tables 3 and 4).

When the previous studies on the number of nuts in the cluster were examined it was seen that the difference in the number of nuts per cluster ranged as follows; İslam (2000) 3.50-4.39, İslam (2003) 3.55-5.37, İslam et al. (2004) 2.8-2.9, Schepers (2005) 2-4, Turan (2007) 3.51-4.64, Kalkışım and Balık (2012) 2.15-4.38, Güler (2017) 1.91-4.47, Bostan (2019) 2.2-3.9, İslam and Çayan (2019) 1.41-4.90, Şahin (2019) 1.7-4.7, Karakaya (2021) 1.90-2.72, Uzun (2021) 2.44-3.93. It has been observed that the values found by the researchers on the number of nuts in the cluster and the values in our study are similar. In addition, Thompson et al. (1996), who carried out studies on heritability, determined the heritability of nuts per cluster to be 0.70, Yao and Mehlenbacher (2000), and Mehlenbacher (2018) determined it to be 0.67.

Table 3. Nut characteristics of 'Trabzon Sivri' clones

Traits	Lowest	Highest	Average
Yield (g/plant)	55	810	316
Nut per Cluster	1.9	5.0	3.5
Husk Height (cm)	3.2	4.5	3.9
Nut Weight (g)	1.13	2.61	1.96
Kernel Weight (g)	0.70	1.25	0.98
Kernel Percentage (%)	44.21	55.42	50.34
Nut Width (mm)	14.55	19.50	17.24
Nut Height (mm)	16.42	22.08	20.17
Nut Thickness (mm)	12.17	17.43	15.19
Kernel Width (mm)	9.56	13.97	12.48
Kernel Height (mm)	13.39	17.97	15.68
Kernel Thickness (mm)	7.99	12.85	10.88
Shell Thickness (mm)	0.72	1.38	1.06
Kernel Cavity (mm)	0.79	3.41	2.09
Good Kernel (%)	10.29	91.10	53.94
Defective Kernel (%)	7.20	88.65	42.44

Climatic factors are one of the main factors limiting nut production. Late spring frosts cause fluctuations in yield by significantly reducing yield in hazelnuts as in many nuts. When the yield values of both periods are examined in the study, they have been noted to vary between 82.8 g (TAK2-2) and 602.4 g (TA39-1). When the previous studies on yield (shelled nut weight) were examined, it was stated by the following

researchers that it varied in the following way; Çalış (2010) 335.80-527.41 g, Güler (2017) 45.89-775.9 g, Çalışkan (2018) 244.6-595.4 g, İslam and Çayan (2019) 44-349 g, Pekdemir (2019) 400.4-587.9 g, Şahin (2019) 45.13-694.83 g, Karakaya (2021) 95-934 g, Uzun (2021) 134-737 g. The results obtained differ with the findings of other researchers. Especially the difference between varieties changes nut characteristics.

When the kernel weight values were examined, it was observed that they varied between 0.65 and 1.31 g. When the previous studies on kernel weight are examined, it is seen that the following researchers put these values forward; Adrienko (1997) 1.9-2.3 g, Bostan et al. (1997) 0.85-1.40 g, Solar and Stampar (1997) 1.1-1.5 g, İslam (2003) 0.98-1.44 g, İslam et al. (2004) 1.15-1.18 g, Turan (2007) 0.65-1.18 g, Kalkışım and Balık (2012) 0.89-1.19 g, Semiz (2016) 0.79-1.46 g, Güler (2017) 0.36-1.30 g, İslam and Çayan (2019) 0.59-1.28 g, Karakaya (2021) 0.88-1.30 g. It was determined that the findings we obtained as a result of the analyzes were lower than the results of Adrienko (1997) and were similar to the findings of other researchers. Yao and Mehlenbacher (2000), who carried out studies to determine the heritability of kernel weight in hazelnuts, determined in a study they conducted that the heritability of kernel weight was 0.67.

Table 4. Detailed data of selected and promising clones

Traits	TY1-3	TY15-1	TY28-1	TY35-3	TY42-3	TA39-1	TA42-2	TAK20-2
Yield (g/planti)	196	299	307	361	422	602	584	376
Nut per Cluster	3.5	3.6	4.0	3.6	3.8	3.8	3.8	4.7
Nut Weight (g)	1.89	1.90	1.83	2.37	1.95	2.03	2.03	1.97
Kernel Weight (g)	0.99	0.94	0.90	1.17	1.01	1.03	1.04	0.98
Kernel Percentage (%)	53.2	49.5	49.4	49.5	51.8	50.50	51.40	49.82
Nut Width (mm)	15.9	17.2	16.8	18.6	17.5	17.79	17.59	17.21
Nut Height (mm)	18.6	20.1	20.1	20.4	19.9	20.85	20.37	20.94
Nut Thickness (mm)	15.6	14.8	14.6	16.1	15.0	15.83	15.03	15.18
Kernel Width (mm)	12.0	11.9	12.4	13.3	12.8	13.09	12.86	12.40
Kernel Height (mm)	14.9	15.4	15.5	15.4	15.8	16.11	15.90	16.65
Kernel Thickness (mm)	10.1	10.1	10.4	11.3	10.8	11.79	11.27	10.61
Shell Thickness (mm)	1.00	0.90	1.02	1.16	1.03	1.12	1.09	1.09
Kernel Cavity (mm)	1.9	2.8	1.06	2.6	2.2	2.84	2.42	2.03
Good Kernel (%)	76.4	34.1	53.2	70.3	70.4	54.04	66.44	51.27
Defective Kernel (%)	14.1	62.4	43.1	25.7	26,1	42.17	28.82	43.75
Oil ratio (%)	69.0	61.0	00.0	63.3	00.0	61.75	65.00	64.75
Protein ratio (%)	12.69	12.10	00.0	14.22	00.0	13.70	14.28	15.32

When the values of the kernel percentage were examined, it was determined that it varied between 44.21% and 54.86%. Considering the studies carried out on the kernel percentage the following researchers determined that it varied between the given values; Mehlenbacher et al. (1991) kernel percentage 44%, Adrienko (1997) 49-51%, Bostan et al. (1997) 48.53-56.34%, Solar and Stampar (1997) 39.3-45.4%, İslam (2000) 53.48-56.65%, Mirotadze (2005) 47-59%, Balta et al. (2006) 32.26-46.11%, Turan (2007) 47.12-58.70%, Yılmaz (2009) 31.25-64.34%, Kırca (2010) 46.66-55.09%, Şahin (2019) 47.16-62.92%, Karakaya (2021) 51.59-57.31%. It was observed that the results we obtained were higher than those found by Mehlenbacher et al., (1991) and Solar and Stampar (1997) and were similar to the results of other studies. We can state that the reason for this is due to the lack of water and nutrients. As a result of the studies carried out, the heritability of the kernel percentage was determined as 0.87 (Yao and Mehlenbacher, 2000; Mehlenbacher, 2018).

The examination of kernel cavity values determined that the difference was between 0.96-3.11 mm. When the studies on kernel cavity were examined, the following researchers determined that it varied between the given values; Islam (2000) 0.76-3.25 mm, Turan (2007) 0.73-2.99 mm, İslam and Çayan (2019) 1.57-3.42 mm, Şahin (2019) 0.39-2.80 mm, Karadeniz et al. (2020) 0.55-3.28 mm, Karakaya (2021) 0.94-4.29 mm, Sali (2022) 1.87-3.70 mm. Our findings are similar to the literature. Variety and ecology change kernel cavity values.

When the values of the shell thickness were examined, it was determined that they vary between 0.89-1.34 mm. When the studies on shell thickness were examined, it was seen that the following researchers determined that it varied between the given values; Balta et al. (1997) 0.82-0.97 mm, Bostan et al. (1997) 0.66-1.04 mm, Solar and Stampar (1997)

0.80-1.10 mm, Karadeniz et al. (1997) 0.78-1.47 mm, İslam (2000) 0.88-1.14 mm, İslam (2003) 0.75-0.93 mm, Turan (2007) 0.67-1.23 mm, Öztürk et al. (2017) 0.7-1.7 mm, İslam and Çayan (2019) 0.60-1.24 mm, Uzun (2021) 0.71-1.42 mm. The results obtained are similar to other studies.

It was determined that the good kernel ranged between 11.35-91.53%. When the studies on good kernel were examined, it was seen that the following researchers determined that it varied between the given values; İslam (2000) 80.75-94.33%, İslam (2003) 69.90-92.15%, Turan (2007) 32-98%, Semiz (2016) 98-100%, Güler (2017) 53-98%, Pekdemir (2019) 57-59%, Karakaya (2021) 73.7-90.7%, Aydemir et al. (2023) 53-95%. The results obtained were lower than the results of İslam (2003), but higher than the other results.

It was determined that the values of the defective kernel varied between 7.20-88.65%.

When the studies on defective kernel were examined, it was seen that the following researchers determined that it varied between the given values; Turan (2007) 3.99-83.34%, Güler (2017) 2-43%, İslam and Çayan (2019) 0-62.39%, Şahin (2019) 0.28-49.70%, Karakaya (2021) 5.7-20.0%, Uzun (2021) 1.8-20.0%, Aydemir et al. (2023) 2-38%. The results obtained are similar to other studies.

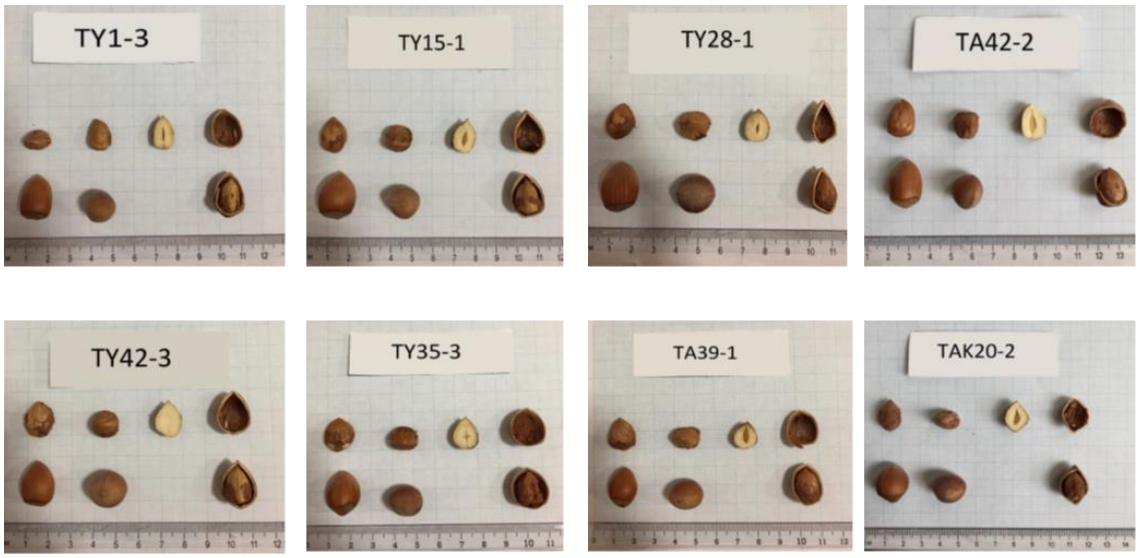

Figure 2. Selected and promising 'Trabzon Sivrisi' clones

In the study, it was determined that the oil percentage in the clones selected as promising ranged between 61% (TY15-1) and 69% (TY1-3). It was stated by the following researchers the the oil percentage varied as follows; Baş et al. (1986) 59.85-64.77%, Calişkan (1995) 63.82%, Adrienko (1997) 66%, Rovira et al. (1996) 59.3-63.0%, İslam (2000) 58.41- 64.85%, Mirotadze (2005) 60.69%, Kırca (2010) 46.56-64.44%, Şahin (2019) 48.87-64.62%, İslam and Çayan (2019) 50.5-60.9%, Karakaya (2021) 52.50-65.33%, Sali (2022) 50.25-63.75%. The results obtained are consistent with the findings of other researchers.

It was determined that the protein percentage of the clones determined as hopeful differed between 12.10% (TY15-1) and 15.32% (TAK20-2) (Figure 2). It was stated by the following researchers the the protein percentage varied as follows; Caliskan (1995) 16.92%, İslam (2003) 15.61-18.53%, Balta et al. (2006) 15.7-19.2%, Kırca (2010), 15.15-17.07%, İslam and Çayan (2019) 15.3-19.5%, Karakaya (2021) 13.12-15.70%, Uzun (2021) 13.57-16.06%, Sali (2022) 15.48-20.64%. It has been observed that the results found by other researchers are higher than our values. The reason for this is thought to be due to the variety of species.

Conclusion

This research is the first clone selection study in the literature conducted on hazelnut populations locally known as 'Trabzon Sivrisi' in the Araklı, Arsin and Yomra districts of the Trabzon province. It was observed that there were variations among clones in the region where the study was conducted. Among the 207 clones evaluated in the region, 8 are regarded as promising and recommended for further research. At the end of the study, clones TY42-3 and TA42-2 with a total score of 400 and above were selected according to the modified weighted grading method which was used. In the examination made according

to nut characteristics the following clones were evaluated as promising in terms of the given features: TAK20-2 clone (nut per cluster), TA39-1 clone (yield), TY35-3 clone (kernel weight), TY15-1 clone (shell thickness), TY1-3 clone (kernel percentage, good kernel and defective kernel), and TY28-1 clone (kernel cavity). It was determined that the maximum nut per cluster was 4.74 in the TAK20-2 clone.

When the results of the 'Trabzon Sivrisi' hazelnut population were evaluated within the scope of this study, it was determined that the yield at high altitudes (500 m and above) was higher than at low altitudes (250 m and below).

As a result of the pomological analyzes, the highest yield was found in clone TA39-1 with 602.4 g, the highest kernel weight in clone TY35-3 with 1.17 g, the highest kernel percentage in clone TY1-3 with 54.81%, the lowest defective kernel rate in clone TY1-3 with 13.75% and the highest good kernel in clone TY1-3 with 76.44%. The fact that cultural processes such as irrigation, pruning and fertilization were not carried out in the orchards where the clones constituting the material of this study were collected, increases the value of our results. In addition, it also proves that our country is in an important position when the determined data is considered on the basis of the gene center. In the further stages of this study, it is evaluated that the clones that emerge by testing the clones with superior characteristics under controlled conditions can be registered. In addition, it is important to examine the phenological characteristics of the selected clones and different physiological issues such as rest, bud burst, and resistance to low temperatures in detail.

Conflict of Interests

There is no conflict of interest between the authors.

Authors' statement of contribution

Aİ: Contributed to the planning and conduct of the research, the evaluation of the data, and the writing of the article.

EK: Contributed to the collection of clones, conducting studies, laboratory analysis and writing of the article.

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