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Yaygın Kavun Hatlarında Toprak Üstü ve Altı Gelişiminin Genetik Varyasyonu

Genetic Variation of Above and Below Ground Growth in Common Melon Lines

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Özet

Kavun (*Cucumis melo* L.), Türkiye ve dünya için önemli bir sebzedir. Kavun geniş bir genetik çeşitliliğe sahiptir ve mevcut çeşitliliğin çoğu yeterli düzeyde tanımlanmamıştır. Temel kök özellikleri üzerindeki çeşitlilik düzeyi bilgisinin hala araştırılması gerekmektedir. Bu çalışmada beş farklı kavun hattı ve bir yabani kavun genotipinin gövde ve kök morfolojik özellikleri araştırılmıştır. Çalışmada Ananas, Ankara, Beji12-2, Kışlık, Turuncu ve Yabani genotipleri kontrollü saksı ortamında incelenmiş, gövde aksamları ayrıldıktan sonra kökler yıkanarak ölçümler yapılmıştır. Sonuçlarımıza göre altı farklı kavun genotipi önemli morfolojik çeşitlilik göstermiştir. Kışlık hat'ı, toprak üstü ve altı morfolojik özelliklerinin çoğunda en yüksek büyüme oranını ve en yüksek ortalama değerleri göstermiştir. Öte yandan, Yabani hat bu özellikler için en düşük değerleri göstermiştir. Ancak Yabani'nin hayatta kalmak için başka avantajlı özellikleri de olabilir ve bundan sonraki çalışmalarda değerlendirilmesi gerekmektedir. Kavun türlerinde stres tolerans seviyeleri, fotosentez kapasiteleri ve toprak altı büyüme ve gelişme hakkında hala çok az bilgi bulunmaktadır. Bu çalışmanın bu türle ilgili daha ileri çalışmalara olanak sağlayacağına inanıyoruz.

Anahtar Kelimeler: Kavun, kök gelişimi, gövde gelişimi, yabani kavun

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Abstract

Melon (*Cucumis melo* L.) is an important crop for Turkey and the world. Melon has a wide range of genetic diversity and most of the available diversity is not well characterized. The knowledge of diversity level on basic root traits still needs to be investigated. In this study, we investigated five different melon lines and one wild melon genotype for their shoot and root morphological traits. In the study, Ananas, Ankara, Beji12-2, Kışlık, Turuncu, and Yabani genotypes were examined in a controlled pot experiment, and measurements were made by washing the roots after the stem parts were separated. According to our results, six different melon genotypes showed significant morphological diversity. Line Kışlık demonstrated the highest growth rate and the highest mean values in most of the above and below-ground morphological traits. On the other hand, Yabani showed the lowest values for those traits. However, yabani may have other advantageous traits for surviving and it needs to be evaluated in further studies. There is still very little knowledge of stress tolerance levels, photosynthetic capacities, and below-ground growth and development in melon species. We believe that this study may enable further studies on this species.

Keywords: Melon, root development, shoot development, wild melon

1. Introduction

Melon (*Cucumis melo L.*) is commonly grown in countries with temperate climates in Europe, Asia, and Africa, and is also found in arid regions. Melon is a well-known crop with its drought tolerance capabilities and ability to be grown at high temperatures and in arid and semi-arid regions. Even in regions where it is very difficult to grow other crops, melons can be grown by adjusting the sowing time according to the rain season (seed sowing time) without giving any supplemental irrigation. It is grown and consumed in more than 130 countries (1). Wild melons can be found in countries such as Angola, Cape Verde, China, India, Japan, Nepal, Indonesia, and Australia (2, 3). Since melon is grown in very diverse ecogeographic regions all over the world, it has a wide genetic diversity. The melon genus has about 750 species. There are two subspecies of the melon, *C. melo* ssp *agrestis* (originated from India) and *C. melo* ssp *melo* (originated from Africa). Pitrat et al. (4) and Robinson and Decker-Walters (5) classified melon subspecies into six groups. Turkey is one of the countries where cucurbits are grown intensively and even Anatolia is the secondary gene center of melon.

Melon can be divided into 15 genetic groups, *cantalupensis, reticulatus, adana, chandalak, ameri, inodorus, chate, flexuosus, dudaim* and *tibish* (subsp melo), *momordica*, *conomon*, *chinensis*, *makuwa*, and *acidulus* (subsp *agrestis*) (6). Stepansky et al. (7) determined that the *Cucumis melo* L. (melon) genotypes have a wide variation in terms of morphology and biochemistry. There is a significant variation in the morphology of its fruits, such as size, shape, color, texture, and flavor, and therefore the melon is considered one of the most diverse species in the genus Cucumis (8).

Melon is considered one of the functional foods. Because not only the fruit but also the seed and the peel are the parts rich in nutrients. Currently, in many countries, melon seeds are dried and consumed as a snack. Outer parts of melon are used as animal feed, especially for cattle. Melon by-products contain phytochemical compounds with nutritional and functional potential (9).

Even though there is a vast number of melon genotypes and cultivated varieties, most of the morphological traits and differences are not well documented. Therefore, in this preliminary study, we aimed to evaluate and compare above and below-ground morphological characteristics of five different cultivated and one wild melon accession. The study also aimed to identify the best performing genotype(s) in terms of biomass accumulation on above and below-ground traits.

2. Material and Methods

2.1. Plant Material

Five different common melon (*Cucumis melo* L.) lines and a wild genotype were selected for the evaluation of the genetic diversity in above and below-ground developmental traits. Selected lines were; Ananas, Ankara, Beji12-2, Kışlık, Turuncu, and Yabani. Seeds were obtained from the gene pool of the Department of Horticulture at Siirt University. From each line, 6 seeds were surface sterilized with 5% NaOCl, followed by 70% ethanol for 5 minutes. Surface sterilized seeds were washed with distilled water three times and dried with filter papers.

2.2. Experimental Procedure and Growth Conditions

To compare the growth and development of the melon lines, a pot experiment was conducted under controlled conditions. 0.8-liter pots filled with peat were used for the study. Pot experimental procedure was done following Waines and Ehdaie (10) and Bektas and Waines (11). Pots were first filled with excessive water to reach above the field capacity, after excessive water was drained, one seed was sown per pot. Plants were irrigated weekly with tap water. All plants were watered with fertilizer solution if needed. Experiments were conducted in the growth room of the Department of Agricultural Biotechnology, Faculty of Agriculture, Siirt University, Siirt Turkey. The mean temperature and relative humidity of the growth room ranged between 26-28 degrees Celcius and 50-65%, respectively. Experiments were designed according to randomized complete blocks design (RCBD) with six replications and one plant per replication.

2.3. Evaluated Traits

Eight different above and below-ground traits were evaluated. Stem diameter was measured with a digital caliper at the end of the experiment from each pot. Plant height was measured two times to understand the plant growth rate. The first measurement (PH1) was conducted in the midtime of the experiment and the second measurement (PH2) was obtained at the end of the experiment. Plant heights were measured with a ruler. Root and shoots were separated at the end of the experiment and fresh weights were obtained using an analytical scale (Weight Lab Instruments). Root and shoot dry weights were obtained using an analytical scale (Schimatzu Instruments) after drying samples at 70 degrees Celcius for 48 hours. Fresh root volume was obtained using a measure following the overflow technique. Root/shoot dry weight ratios were calculated using the mean values of each replication.

2.4. Statistical Analyses

Analysis of variance (ANOVA) was performed for each trait using the mean values of each replication (12). The normality of distribution was tested by normal probability plots (Data not shown) using the specific function of the Statistics software. Statistical analyses were done using Statistix software V10 (Analytical Software; Tallahassee, FL, USA). Pearson's simple correlation analysis was followed for the relationships between pairs of traits.

3. Results and Discussion

Melon species are one of the widest grown and most consumed crops worldwide (13). They are mostly consumed as human food and sometimes as animal food. Melons can be consumed at early stages (Kelek), as pickled, and as fresh fruit at maturity. Melon (*Cucumis melo* L.) is grown all around the world and has a significant genetic diversity. The taste, aroma, and sugar content of the melon significantly change based on the region and climate variables. It is a relatively drought tolerant species, even though drought significantly reduces the yield and quality of the crop (14). Genetic diversity in the growth and development of the melon genotypes commonly grown around Turkey is not utilized with an emphasis on root development. Here, we aimed to evaluate five common melon lines and a wild accession to make a side-by-side comparison under controlled growth conditions. The results of the study revealed significant genetic diversity in all evaluated traits (Table 1 and Figure 1). However, most of the diversity was observed in the below-ground traits. The highest mean values for the stem diameter were obtained in the Kışlık (3.11) followed by the Ananas (2.39), on the other hand, the lowest values in the stem diameter were obtained in Yabani (1.15) and Ankara (1.99) lines (Figure 1A). Plant height at the seedling stage was sorted from the tallest to the shortest as, Kışlık, Turuncu, Ananas, Beji12-2, Ankara, and Yabani. The seedling plant height of the Yabani was about ten times smaller compared to Kışlık (Figure 1B). The mean values for the plant height at the mid-growth stage were ordered from, Turuncu, Kışlık, Beji12-2, Ananas, Ankara, and Yabani (Figure 1C). The highest values (Max) in plant height were obtained in Turuncu with 25 cm height per plant. When we evaluated root fresh weight, we found similar results with the above developmental traits. The highest mean root fresh weight was obtained in kışlık with 1.14 g, which is followed by Ankara with 0.69 g root per plant. Root fresh weight was the lowest in Yabani with 0.11 g, followed by the Ananas with 0.45 g per plant (Figure 1D). Maximum root fresh weight was also obtained in Kışlık. The highest root volume value was obtained in Kışlık with 2.2 cm^3, while the lowest was in Yabani with 0.75 cm^3 per plant (Figure 1E). Shoot dry weight was measured to compare biomass allocation patterns between the lines and the highest value was obtained in Kışlık, and the lowest was in the Yabani with 0.01 g per plant (Figure 1F). Root dry weight was similar to root fresh weight values obtained. Accordingly, the highest root dry weight was in Kışlık with 0.05 g, while the lowest was in Yabani with 0.005 g per plant (Figure 1G). And finally, root dry weight/shoot dry weight was calculated to observe biomass allocation ratios between the lines. The results revealed that the highest ratio in root and shoot dry weights was in Ankara (0.32), followed by Yabani (0.30). Contrastingly, Turuncu and Ananas had the lowest values in root and shoot dry weight ratio (Table 1H). When we evaluated the literature for the morphological characterization studies in Turkish melon lines, we found several studies with or without a stress application. Of these, Kuşvuran et al. (15) evaluated 30 melon lines and a commercial cultivar under drought-stressed conditions. According to their results, there was significant diversity in shoot and root biomass as well as a wide level of stress tolerance in evaluated lines. In another study, Kuşvuran et al. (16) compared 36 different melon genotypes in terms of morphological diversity and salt tolerance levels. They reported a significant level of diversity in melon genotypes. According to their results, Midyat, Besni, and Şemame were the salt stress tolerant genotypes, while Ananas and Yuva were the most sensitive ones. Similarly, we also evaluated Ananas under non-stressed conditions and we found Ananas as one of the less developed genotypes, especially when compared to Kışlık. In a similar study, Dal et al. (17) evaluated germplasm accessions and reported a significant level of genetic diversity. Since most of the studies do not evaluate root development, they did not have a comparative result with our root biomass and volume observations. In an in-depth morphological and pomological evaluation study, Ermiş and Aras (18) compared 54 hybrid cultivars and 10 open-pollinated cultivars of *Cucumis melo* var. *inodorus, Cucumis melo* var. *reticulatus*, ve *Cucumis melo* var. *cantalupensis* for seventy different traits. The result revealed a wide level of diversity and three different main groups for trait relatedness levels.

Table 1. Descriptive statistics for melon lines

Variable	Line/ Genotype	Mean	SD	SE Mean	C.V.	Minimum	Maximum
Stem Diameter (mm)	Ananas	2.39	0.0902	0.0451	3.7734	2.26	2.46
	Ankara	1.99	0.3899	0.1592	19.626	1.23	2.32
	Beji12-2	2.32	0.2971	0.1213	12.807	2.13	2.90
	Kışlık	3.11	0.2815	0.1259	9.0519	2.80	3.53
	Turuncu	1.89	0.4197	0.1713	22.282	1.42	2.47
	Yabani	1.15	0.3493	0.1747	30.509	0.82	1.60
Plant Height Seedling (cm)	Ananas	1.25	0.1500	0.075	11.989	1.06	1.43
	Ankara	1.02	0.4372	0.1785	43.049	0.61	1.62
	Beji12-2	1.15	0.3278	0.1338	28.392	0.60	1.49
	Kışlık	2.38	0.7079	0.3166	29.743	1.18	2.97
	Turuncu	1.28	0.5609	0.229	43.755	0.57	1.95
	Yabani	0.2	0.0416	0.0208	20.781	0.17	0.26
Plant Height Mid-growth (cm)	Ananas	14.13	6.0544	3.0272	42.863	6.30	19.70
	Ankara	8.23	1.3411	0.5475	16.289	6.10	9.60
	Beji12-2	14.73	2.5461	1.0394	17.281	10.00	16.80
	Kışlık	15.14	4.1144	1.8400	27.175	9.10	20.30
	Turuncu	18.53	5.7389	2.3429	30.965	11.00	25.00
	Yabani	6.93	1.2945	0.6473	18.694	5.00	7.80
Root Fresh Weight (g)	Ananas	0.45	0.2184	0.1092	48.023	0.30	0.78
	Ankara	0.69	0.1427	0.0582	20.637	0.50	0.91
	Beji12-2	0.63	0.3096	0.1264	48.823	0.18	1.01
	Kışlık	1.14	0.4264	0.1907	37.354	0.53	1.55
	Turuncu	0.51	0.3336	0.1362	65.441	0.18	0.99
	Yabani	0.12	0.0911	0.0455	78.364	0.02	0.21
Root Volume (cm^3)	Ananas	1.00	0	0	0	1.0	1.00
	Ankara	1.13	0.542	0.2213	48.177	0.50	2.00
	Beji12-2	1.08	0.6646	0.2713	61.346	0.50	2.00
	Kışlık	2.20	0.8367	0.3742	38.03	1.00	3.00
	Turuncu	1.10	0.5831	0.238	53.009	0.50	2.00
	Yabani	0.75	0.2041	0.1021	27.217	0.50	1.00
Shoot Dry Weight (g)	Ananas	0.12	0.0128	6.41E-03	10.818	0.107	0.13
	Ankara	0.09	0.0204	8.33E-03	22.556	0.066	0.12
	Beji12-2	0.13	0.0508	0.0207	38.459	0.04	0.18
	Kışlık	0.24	0.0667	0.0298	27.942	0.127	0.29
	Turuncu	0.12	0.0478	0.0195	42.07	0.044	0.16
	Yabani	0.01	6.38E-03	3.19E-03	45.55	0.003	0.02
Root Dry Weight (g)	Ananas	0.02	7.79E-03	3.89E-03	38.944	0.01	0.03
	Ankara	0.028	6.19E-03	2.53E-03	21.833	0.02	0.03
	Beji12-2	0.025	0.0144	5.90E-03	57.021	0.003	0.04
	Kışlık	0.05	0.0108	4.83E-03	24.113	0.03	0.06
	Turuncu	0.02	7.26E-03	2.96E-03	43.997	0.003	0.03
	Yabani	0.005	4.11E-03	2.06E-03	86.589	0.003	0.01
Root Dry Weight /Shoot Dry Weight	Ananas	0.17	0.0781	0.039	45.124	0.08	0.27
	Ankara	0.32	0.0983	0.0401	30.384	0.23	0.52
	Beji12-2	0.18	0.0709	0.029	39.738	0.10	0.27
	Kışlık	0.19	0.0276	0.0124	14.392	0.17	0.24
	Turuncu	0.15	0.0459	0.0188	29.697	0.10	0.22
	Yabani	0.30	0.1916	0.0958	63.142	0.13	0.50

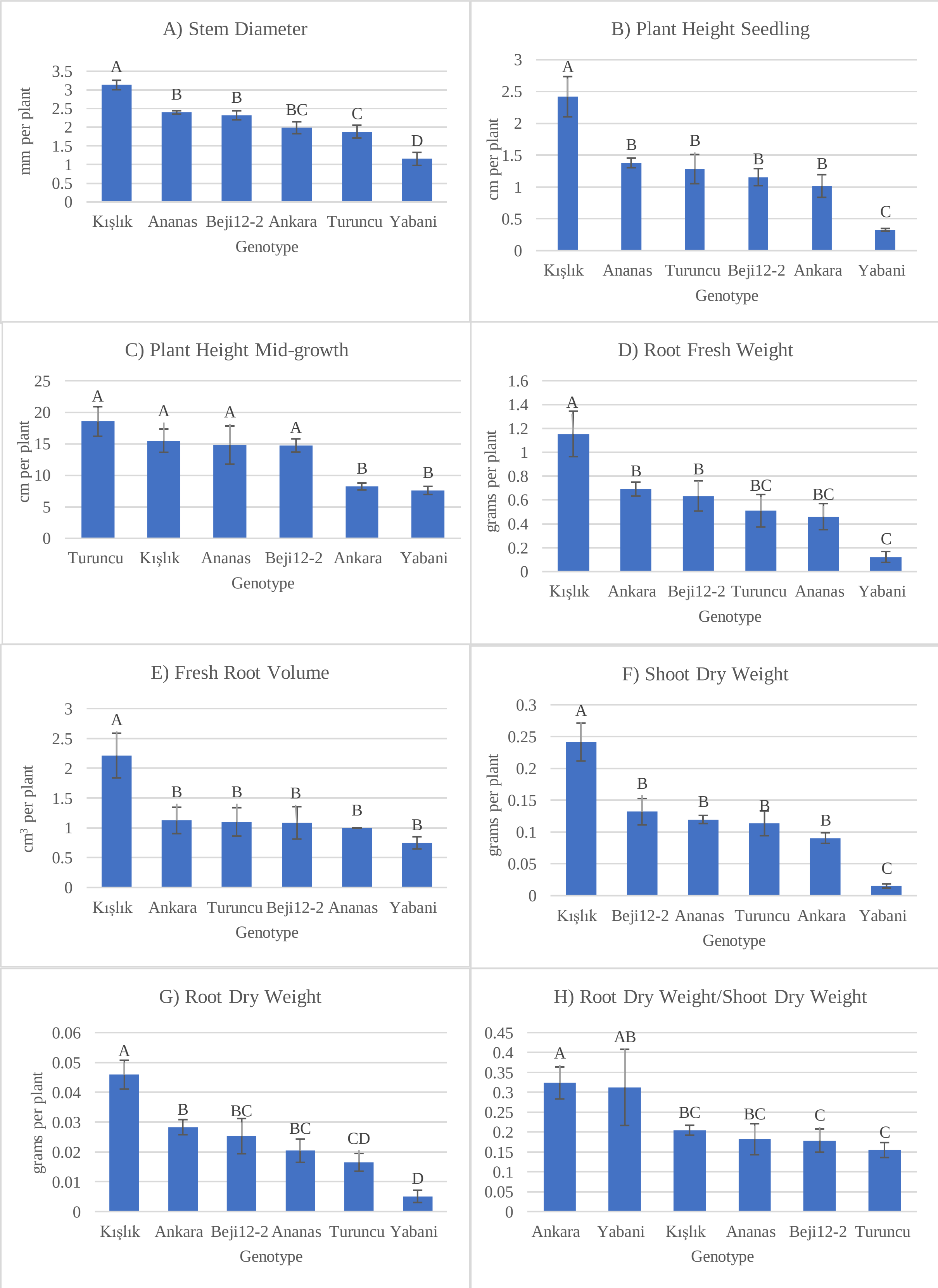

Figure 1. Above and below-ground growth parameters of melon lines under controlled growth conditions. A) Stem diameter, B) plant height seedling, C) plant height mid-growth, D) root fresh weight, E) fresh root volume, F) shoot dry weight, G) root dry weight, H) root dry weight/shoot dry weight ratio. Means followed by a different letter in each figure are significantly different at $p<0.05$ level according to the LSD multiple comparison test.

We aimed to see the relationships between above and below-ground traits by making a Pearsons' simple correlation analysis. The result revealed significant positive interactions between most of the above and below-ground traits (Table 2). The strongest correlation coefficients were between, stem diameter and; plant height seedling, root and shoot fresh and dry weights, and root volume. Plant height at seedling had significant positive correlations with plant height mid-growth (0.64), root fresh weight (0.71), root volume (0.63), shoot dry weight (0.92), and root dry weight (0.75). Plant height mid-growth had positive correlations with shoot dry weight (0.60) and a significant negative correlation with root dry weight/shoot dry weight ratio (-0.55). Root dry weight/shoot dry weight ratio had negative or nonsignificant correlations with most of the other traits. Root volume also had a positive correlation with biomass and height-related morphological traits (Table 2). Plant above and below ground development generally follows a parallel trend. Since photosynthetic assimilation capacity is dependent on traits like leaf size, chlorophyll pigment content, and water and mineral content, above and below-ground development support each other to reach optimum growth and development rate. Here, even only on six different genotypes, we observed this strong correlation. This positive interaction is well known in cereal crops, but, it is not characterized in most vegetable crops. There is a need for understanding plant biomass allocation patterns and source-sink interactions in melon and other vegetable crops. This may enable more economical resource management and help in identifying genotypes with minimal input requirements under stressed and non-stressed conditions.

Table 2. Pearson correlation coefficients between evaluated above and below-ground traits. The significance threshold was set to $p<0.05$.

	STEM	PHS	PHM	FRW	RVol	SDW	RDW
STEM							
p-value	0						
PHS	**0.7556**						
	0	0					
PHM	**0.3925**	**0.641**					
	0.029	0.0001	0				
RFW	**0.7151**	**0.7104**	**0.2344**				
	0	0	0.2044	0			
RVol	**0.6186**	**0.6329**	**0.2092**	**0.8909**			
	0.0002	0.0001	0.2587	0	0		
SDW	**0.8402**	**0.9158**	**0.5967**	**0.793**	**0.6933**		
	0	0	0.0004	0	0	0	
RDW	**0.7914**	**0.7538**	0.2442	**0.9109**	**0.7822**	**0.8397**	
	0	0	0.1856	0	0	0	0
R/S	**-0.2512**	**-0.2948**	**-0.5534**	**0.0554**	**0.0008**	**-0.3174**	**0.1386**
	0.1729	0.1074	0.0012	0.7674	0.9964	0.0819	0.4573

STEM: Stem diameter, PHS: plant height seedling, PHM: plant height mid-growth, RFW: root fresh weight, RVol: fresh root volüme, SDW: shoot dry weight, RDW: root dry weight.

4. Conclusion

Melon is one of the most consumed fruits in Turkey and some other parts of the World. It has a wide genetic diversity and most of the available diversity is not well characterized. Also, there is not much knowledge about the diversity level in even the most basic root traits. Here, we evaluated five different melon lines and a wild accession (*Cucumis melo* var. *agrestis*). According to our results, Kışlık had the highest growth rate and as a result, it had the highest mean values in most of the above and below-ground morphological traits. Yabani did not have a competitive growth speed and biomass allocation capacity. However, there may be other advantageous traits that Yabani may have, which are worth further in-depth evaluations. This study revealed significant morphological diversity between six different melon genotypes. There is still very little knowledge of stress tolerance levels, photosynthetic capacities, and below-ground growth and development in melon species. We believe this study may enable further studies on this species.

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