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A Comparison of Phenotypic Root Characteristics in Local Eggplant Genotypes (*Solanum melongena* L.) Infected and Non-Infected with *Fusarium oxysporum* f. sp. *melongenae*

Tolga ÖZGEN[1] **Ahmet BALKAYA**[1*] **İsmail ERPER**[2,3] **Şenay MURAT DOĞRU**[4]

[1] Department of Horticulture, Faculty of Agriculture, Ondokuz Mayıs University, Samsun, Turkey
[2] Department of Plant Protection, Faculty of Agriculture, Ondokuz Mayıs University, Samsun, Turkey
[3] Department of Plant Protection, Faculty of Agriculture, Kyrgyz-Turkish Manas University, Bishkek, Kyrgyz Republic
[4] The Black Sea Agricultural Research Institute, Samsun, Turkey

Corresponding author e-mail: abalkaya@omu.edu.tr

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ABSTRACT

The eggplant (*Solanum melongena* L.) is an important vegetable species cultivated under openfield and greenhouse conditions in Turkey. In recent years, due to fungal disease in eggplant growing areas, yield quantity and fruit quality problems have been encountered. One of the most effective precautions against disease is to determine the genetic materials that are resistant or tolerant to disease and evaluate them in the plant breeding programs. The number of breeding studies for forming a strong root system in varieties of eggplants is very limited in Turkey. The most important criteria that affect the performance in varieties of eggplant are the root structure and the ability of development under stress conditions. This study investigated 66 local eggplant genotypes against infection by *Fusarium oxysporum* f. sp. *melongenae*. Plants inoculated with *Fusarium oxysporum* f. sp. *melongenae* and non-inoculated (control) plants were subjected to a separate statistical analysis. The Karabey F_1 was used as the positive control variety. The root system architectures parameters (total root length, the root surface area, the root volume, and the root diameter) were determined using the WinRHIZO program. The total root length ranged from 14.57 cm (G43-3) to 787.09 cm (G91), the root surface area ranged from 5.20 cm^2 (G42) to 457.53 cm^2 (G91), the root volume ranged from 0.10 cm^3 (G42) to 26.22 cm^3 (G128), and the root dimeter changed 0.60 mm (G144) to 5.87 mm (G152). When all the characteristics that constituted the root canopy were evaluated together, the root traits of genotype G91 and genotype G113 were found to be stronger and superior compared to the other local eggplant genotypes.

Keywords: Eggplant, *Fusarium* wilt, root system architecture, resistance, Turkey

Introduction

There are approximately 2300 species in the *Solanaceae* family. Half of these species are classified in the genus *Solanum*. This family consists of many cultured species that differ morphologically from each other (Sekara *et al*. 2007). The origin of eggplant is in the Southeast Asia (India and Burma countries). It was first brought to the Mediterranean basin by the Arabs. The first records about eggplants in Europe were found in the 15th century (Kalloo 1993; Çakır *et al*. 2017). The transition of eggplants to the new world was carried out by the Spanish. It was spread to Europe through the Balkan countries by Turks. It is reported that eggplants reached Anatolia in the late 16th century and early 17th century (Vural *et al*. 2000; Çakır *et al*. 2017).

Local genetic resources are very important resources for plant breeders in the development of new varieties with high yield and superior qualities in agricultural production (Balkaya and Yanmaz 2001; Karaağaç and Balkaya 2017; Çakır *et al*. 2019).They have an irreplaceable value and importance for plant breeding studies because they include both cultivated plants and their wild relatives (Engels *et al*. 1995). Local genetic resources are unique sources for a variety of breeding programs due to their adaptability to different ecologies, their resistance to diseases and pests, and the demanded fruit quality characteristics. Genetic diversity has occurred over time and landraces with different qualities have developed in the major eggplant produce countries (Çakır 2018; Çakır *et al*. 2019).

Diseases and pests are the major problems encountered in eggplant cultivation. Breeding purposes for the developing new qualified varieties can generally be listed as featuring high yield, fruit quality, earliness, and resistance to biotic and abiotic stress factors in eggplant cultivation. Diseases such as *Fusarium* wilt, *Verticillium* wilt and root knot nematode pest affect the eggplant cultivation economically. In eggplant cultivation, approximately 50% of the yield values were occurred in areas contaminated with *Fusarium oxysporum* f. sp. *melongenae* (FOMG) that causes *Fusarium* wilt in Turkey (Altınok 2005). To combat *Fusarium* wilt, it is important to use disease resistant varieties and to cultivate in soil that is not infected with the disease. Studies conducted in the fight against *Fusairum* wilt have reported that developing resistant varieties will provide quality products and significantly reduce yield losses (Miller *et al*. 1996; Rizza *et al*. 2002). The number of eggplant varieties resistant to *Fusarium* wilt are almost available in Turkey (Kandemir *et al*. 2016).

Tolerance to edaphic stress has been linked to root system morphology (Suchoff *et al*. 2017). The most important criteria affecting variety performance are root canopy and rooting ability under stress conditions. The ability of rooting to directly take in water and plant nutrients affects the performance of the parts above ground. Root structures need to be examined closer and should be selected for a variety of breeding programs (Schiefeibein and Benfey 1991; Koevoets *et al*. 2016). However, it is quite difficult to examine the root structure, which is inherently underground, compared to the organs above ground. So, the number of selection breeding studies carried out according to the phenotypic features of the root is very limited (Schwarz *et al*. 2010; Suchoff *et al*. 2017; Sarıbaş *et al*. 2019). In recent years, detailed investigations about root structures have been made possible using digital imaging systems (Peaz-Garcia *et al*. 2015, Suchoff *et al*. 2017; Sarıbaş, 2019; Karaağaç *et al*. 2020). Phenotypic root selection study is a new and topical subject in Turkey. In this study, the aim was to investigate the phenotypic root structures of local eggplant genetic resources that have different fruit characteristics and to compare the factors that compose rooting architectures in plants infected with *F. oxysporum* f. sp. *melongenae* and in non-infected plants.

Materials and Methods

Materials: In this study, a total of 66 eggplant genotypes were collected from different regions of Turkey and were used as genetic materials. Also, the Karabey F_1 eggplant variety was used as a positive control in disease testing trials. FOM-10 isolate from *F. oxysporum* f. sp. *melongenae* used in this study was obtained from Dr. H. Handan Altınok.

Growth Condition: This study was carried out in the Samsun province in 2017. The seeds of all eggplant genotypes were sown in different stages on 26 March 2016, 19 August 2016 and 03 March 2017 in the greenhouse belonging to the Ondokuz Mayıs University, Faculty of Agriculture. The growing medium was prepared as a peat: per lite mixture in a 3:1 ratio. Forty seedlings for each eggplant genotypes were grown at the 4 to 5 true leaf stage (approximately 40 days) in the greenhouse.

Determination of root characteristics in eggplant genotypes infected and non-infected with *Fusarium oxysporum* f. sp. *melongenae*: The reactions against *F. oxysporum* f. sp. *melongenae* of the 66 eggplant genotypes and the Karabey F_1 variety, which is known to be sensitive to Fusarium wilt (positive control), were determined *in vivo*. For disease testing, the root dipping method was applied to the eggplant seedlings at the 4 to 5 true leaf stage (Biles and Martyn 1989). Firstly, the roots of the eggplant seedlings were washed in tap water, and then any apparent scar tissue was opened by gently shaving off the root tips with clean scissors. After that, the roots were immersed in the prepared conidia suspension (1×10^6 conidia mL^{-1}) and kept for ten minutes (Altınok 2005). The control plants were also kept in sterile distilled water for the same period. After inoculation, the eggplant seedlings were planted in plastic pots (18 × 16 cm diameter) containing a mixture of peat: perlite (3: 1, v/v) with one seedling per pot. The experiment on rooting levels in eggplant genotypes was carried out using three replicates with ten plants per replicate in the randomized block design. Then, the eggplants were grown at 25 ± 1°C for 4 weeks in controlled growth chambers.

The WinRHIZO root analysis program (Regent Instrument Inc. Canada) was used to examine the root system architectures of the eggplants. In this study, plants were gently excavated from the growing medium at the end of the 30th day. Then the root system was freed. All roots were carefully washed and dried with a paper. Roots were placed in the tray and gently positioned with no overlapping roots to allow for more uniform scanning. Scans were done in gray scale at 800 dots per inch to increase resolution of fine roots (Suchoff *et al*. 2017). All data were transferred to the computer in 3D. As a result of the roots canning performed using the WinRHIZO program, the following root parameters, which reveal the root system architectures, were determined according to Suchoff *et al*. (2017) and Sarıbaş *et al*. (2019).

The total lengths of all roots (cm), including hairy roots in capillary form, were measured. All roots were classified as hairy (1 mm>), medium (1 mm≤D≤2 mm) and thick (2 mm<) roots and length per diameter class were calculated proportionally. Average root diameter (mm) was calculated by examining all root extensions individually. In addition, root surface area (cm^2) and root volume (cm^3) values were determined using the WinRHIZO program. Following scanning, roots were dried at 70°C for 48 hours; it was continued until the samples reached a constant value. Then, the dry weight of the root was determined by weighing on a precision scale (0.001 g) (Karaağaç 2013).

Data Analysis: The results of the study were first tested for normality to determine their conformity to a normal distribution. Variance analysis was carried out using the SAS-JMP 5.01 statistical package program to determine the statistical significance of the investigated root system criteria and differences among eggplant genotypes. Further, Arcsin transformation was applied to the value obtained. Moreover, correlation analysis was used to determine whether there was a statistical relationship between the investigated root characteristics.

Results and Discussion

Total root lengths, particularly in the deeper soil profile, can improve water acquisition (Comas *et al*. 2013; Suchoff *et al*. 2017). The total root length values of eggplant genotypes infected with *F. oxysporum* f. sp. *melongenae* were varied from 14.57 cm (G43-3) to 787.09 cm (G91). Among all the genotypes, the genotypes G91 (787.09 cm), and G113 (647.20 cm) determined the highest root length values (Table 1). The root length of the Karabey F_1 variety was measured to be 116.02 cm. The highest root length value was determined to be 1048.18 cm (G4-1) and the lowest root length value was determined to be 159.40 cm (G49) in the control treatment. The difference in root length values between treatments was at least 2.98 cm (G113), 16.24 cm (G91) and 66.74 cm (G128). The difference in this overlap in the genotypes that are prominent in the disease experiment supported the accuracy of the study results (Table 1). Sarıbaş (2019) determined that total root values were ranged from 1299 to 4322 cm among eggplant rootstock hybrids (*S. melongena x S.aethiopicum*). In the other study, the root characteristics of the *C. baccatum* and *C. chinense* species were found to be stronger and superior than the C. *annuum* species. *C. chinense* in terms of root length and root surface area and *C. baccatum* in terms of root volume and dry weight were more prominent (Karaağaç *et al*. 2020).

The ratio of roots with a diameter of less than 1 mm to total root lengths in plants is an important selection criterion in the resistant variety of breeding programs (Sarıbaş *et al*. 2019). In this study, it has been determined that there are statistically significant differences between the root rate values less than 1 mm in eggplant genotypes. Pereira-Dias *et al*. (2018) reported that nutrient intake in roots smaller than 1 mm in grafted pepper plants was 4 to 5 times more than roots larger than 1 mm. Most of the root length proportional diameter values of eggplant genotypes (more than 70%) infected with FOM-10 isolate consisted of roots less than 1 mm in diameter (Table 2). Further, it was determined that the root length and proportional diameter values of the eggplant genotypes were mostly in those genotypes ranging from 1 to 2 mm in the 10 to 15% ratios for control treatment (Table 3). Among eggplant genotypes, the rates of genotypes with root diameter values greater than 2 mm were found to be from 5 to 10% (Table 4). Sarıbaş *et al*. (2019) were determined that proportional diameter values of the eggplant genotypes consisted of roots less than 1 mm in diameter changed from 64% to 82%.

The average root diameter value is another important indicator of the hairy root tendency. A low average root diameter increases the effects of the absorption ability of the root (Sarıbaş, 2019; Karaağaç *et al*. 2020). Significantly differences were found between the average root diameter values in eggplant genotypes treated with *F.oxysporum* f. sp. *melongenae* according to this study finding. The highest average root diameter value was measured 2.17 mm (G177) among the infected genotypes. The lowest average root diameter value was determined 0.60 mm (G144). When the average root diameter values were examined in the control plants, the highest value was determined 5.87 mm (G152), and the lowest value was measured 1.2 mm (G8) (Table 5). A reduction in root diameter has been also observed in response to low P concentrations and salinity (Zobel *et al*. 2007; Lovelli *et al*. 2012; Suchoff *et al*. 2017). Sarıbaş *et al*. (2019) determined that the root diameter value in the eggplant rootstock hybrids. Researchers found a distribution ranging from 1.1 mm to 3.2 mm for root diameter trait. Besides, root diameter vary according to plant species. Suchoff *et al*. (2017) informed that HN-1088' tomato rootstock had the widest average root diameter (0.37 mm) compared with all other cultivars. The difference in terms of root volume with this literature was caused by the genotype effect. Karaağaç *et al*. (2020) determined the average root diameter of *C. annuum* as 2.45 mm, *C. baccatum* as 3.18 mm and *C. chinense* as 2.80 mm. For tomato rootstock root systems, two commercial rootstocks ('Beaufort' and 'Heman') indicated differences in root density but not of average root diameter (Oztekin *et al*. 2009).

Excessive root surface area is an important factor that increases the water and nutrient uptake capacity of the roots (Sarıbaş, 2019). It has been determined that there are very important differences between infected plants and control plants in terms of root surface area values. When the root surface areas of the eggplant genotypes infected with *Fusarium oxysporum* f. sp. *melongenae* were examined, the highest value was determined in the G91 genotype at 457.53 cm^2. The lowest value was found in the G42 genotype at 5.20 cm^2 (Table 6). Genotypes with the highest root surface area were also determined to exhibit a high resistance to disease. The root surface areas of G113 genotype, which was determined to be highly resistant, and G128 which was determined to be tolerant, were measured at 415.72 and 367.50 cm^2, respectively. When non-infected genotypes were evaluated, the highest value was 1142.59 cm^2 (G152) and the lowest value was 164.23 cm^2 (G2) (Table 6). Kakita . (2015) reported on tomatoes and Bertucci *et al*. (2018) mentioned on watermelons in their respective studies tha trootstocks have higher root surface areas and this increased rate varies according to the rootstock used.

One of the important criteria in terms of root system canopy parameters is the root volume (Karaağaç *et al*. 2020). This criterion is an important factor on the level of resistance to diseases. In this study, root volumes of disease-infected eggplant genotypes were determined at their lowest to be 0.10 cm^3 (G42) and at their highest 26.22 cm^3 (G128). It was also determined that there were statistically significant differences between treatments and genotypes in terms of root volume values.When the root volumes of plants not infected (control) treatment were examined, the lowest root volume was 7.41 cm^3 (genotype G8) and the highest was 66.71 cm^3 (genotype G152). The root volumes of the control plants of promising tolerant eggplant genotypes G91, G113 and G128 were determined 24.17, 41.21 and 40.93 cm^3, respectively (Table 7). Sarıbaş *et al.* (2019) found that the root volume of eggplant rootstocks varied from 40.5 to 96.8 cm^3 in their study. They also reported that the root volume was directly related to the root diameter. When the percentage change rates in the root volumes of eggplant genotypes resistant to the disease were examined, the least affected genotypes were determined G177-1 (26.59%), G128 (34.80%), G91 (41.29%) and G113 (47.94%). The rate of change in the Karabey F_1 variety used as the positive control in the study was found to be 96.88%. The difference between the promising resistant genotypes and the root volumes of the control variety (70.29%) was an important finding that showed efficient of virulent the FOM-10 isolate used in the study.

When the dry weight values of the roots of the genotypes infected with *F. oxysporum* f. sp. *melongenae* were analyzed, it was found that they showed statistically significant differences. When Table 8 was examined, the highest dry root weight value was found to be 0.79 g (genotype G177-1) among the infected plants. The lowest dry weight value for the roots was determined to be 0.01 g (genotype G69). When the dry weights for the roots of the genotypes that were prominent in terms of the disease test were examined, they were determined to be 0.33 g (genotype G91), 0.39 g (genotype G113) and 0.35 g (genotype G128) (Table 8). In the control treatment, the highest value was found to be 1.08 g (genotype G69), and the lowest root dry weight value was determined to be 0.11 g (genotype G33). When the percentage changes in the dry weights of the roots of the eggplant genotypes were examined, the highest ratio was determined to be 98.46% (genotype G69) (Table 9). Sarıbaş *et al*. (2019) determined that dry weight values in eggplant genotypes varied between 10.03 g and 15.13 g. In this study, the fact that the changes in the root dry weights are low in genotypes determined to be resistant showed that the plant can maintain normal photosynthesis activities despite the disease affect.

A correlation analysis was carried out to statistically reveal the relationship between the root system traits of eggplant genotypes and resistance against *Fusarium* wilt disease in this work. It was determined that there was a negative relationship between disease severity and root system characteristics ($P>0.01$). When the diseases severity increased, total root length, root surface area, mean root diameter and total root volume values decreased (Table 10). This result showed that the root length, root surface area, and root volume values are the most important root characteristics on the resistance level for *Fusarium* wilt disease. It was determined that there was a positive relationship between the root characteristics of the infected plants. As the root length values increased, root surface area, root volumes and root percentage changes similarly increased. No significant statistical relationship was found between the diameter class values of root lengths and other parameters. However, a significant relationship was found between the root dry weights of the eggplant genotypes and the root weight percent changes. In accordance with these findings, it was determined that root length, root surface area and root volume values should be evaluated as important criteria in eggplant genotypes in the disease breeding programs.

Conclusions

In recent years, important problems have been encountered in terms of the annual production amount and fruit quality properties in the eggplant growing areas in Turkey due to fungal factors. *F. oxysporum* f. sp. *melongenae*, one of the soil-borne fungi plant pathogens, causes loss of yield values in eggplants, blockages in vascular bundles and wilt disease. The most effective precaution that can be taken against the diseases is to identify the genetic materials from genetic resources that have resistant or tolerant traits and evaluate them in a variety of breeding programs. Resistance eggplant varieties offer growers the ability to manage soil borne diseases in the production. This research indicates that quantifiable morphological differences exist between locale eggplant roots systems. In this study, we determined that the tolerance to *F. oxysporum* f. sp. *melongenae* disease stress has been linked to root system morphology. Some of the root system differences observed may explain the improved disease stress tolerance provided by promising egglant genotypes. Additionally, these differences may help to explain the improved growth and eggplant production associated with qualified resistant varieties of eggplant.

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Table 1. Total root length values (cm) of eggplant genotypes infected and non-infected (control) plants by *F. oxysporum* f. sp. *melongenae*.

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	144.88 d-g	530.22 b-n	G56	70.67 f-g	776.77 a-i
G2	658.62 a-b	268.96 j-n	G58	59.82 f-g	860.87 a-f
G4-1	57.42 f-g	1048.18 a	G61	58.78 f-g	503.83 b-n
G4-2	67.44 f-g	987.54 a-b	G63	68.44 f-g	319.35 h-n
G5	21.61 g	602.81 a-n	G64	97.51 d-g	881.05 a-e
G7-1	17.86 g	195.70 n	G66	135.37 d-g	664.94 a-n
G7-2	36.59 f-g	577.49 a-n	G68	93.63 d-g	710.66 a-l
G8	56.65 f-g	623.94 a-n	G69	91.72 d-g	832.87 a-g
G11-2	68.21 f-g	359.62 g-n	G73	73.91 e-g	614.40 a-n
G12	60.08 f-g	629.41 a-n	G80	83.94 d-g	535.15 b-n
G15	56.65 f-g	309.10 h-n	G88	98.29 d-g	909.40 a-d
G16	71.24 f-g	550.80 a-n	G 91	787.09 a	803.33 a-h
G20	29.85 f-g	447.87 c-n	G98	62.63 f-g	390.62 e-n
G21	112.46 d-g	911.33 a-d	G109	187.92 d-g	234.03 j-n
G22-1	56.99 f-g	771.72 a-i	G113	647.20 a-c	650.18 a-n
G22-2	99.72 d-g	717.42 a-k	G114	148.56 d-g	846.43 a-g
G23	138.03 d-g	576.27 a-n	G119	16.40 g	256.58 j-n
G33	118.40 d-g	924.00 a-d	G122	17.96 g	259.48 f-n
G35-1	533.02 a-d	873.33 a-e	G125	194.27 c-g	931.72 a-c
G36	365.84 a-g	733.64 a-j	G127	218.48 b-g	680.29 a-n
G39	75.45 d-g	523.16 b-n	G128	709.66 a	777.40 a-i
G40-1	112.45 d-g	513.52 b-n	G134	68.40 f-g	367.97 f-n
G40-2	480.24 a-f	603.20 a-n	G138	65.12 f-g	687.39 a-n
G42	21.36 g	540.06 b-n	G144	56.95 f-g	365.42 f-n
G43-1	23.43 f-g	195.70 m-n	G146	101.53 d-g	918.53 a-d
G43-2	40.42 f-g	293.71 i-n	G147	68.57 f-g	707.56 a-m
G43-3	14.57 g	278.53 i-n	G148	72.03 e-g	712.11 a-l
G45-1	41.22 f-g	282.92 i-n	G152	69.75 f-g	641.72 a-n
G45-2	31.27 f-g	216.55 l-n	G154	64.04 f-g	616.44 a-n
G47	245.93 b-g	607.46 a-n	G161	441.74 a-g	889.53 a-e
G49	27.94 f-g	159.40 k-n	G173	140.75 d-g	359.87 g-n
G53	80.59 d-g	496.69 b-n	G177-1	529.69 a-e	427.91 d-n
G55	58.52 f-g	662.65 a-n	G179	84.49 d-g	456.90 c-n
			Karabey	116.02 d-g	540.12 b-n

P>0.01

Table 2. The ratio of root length per diameter class values (D>1 mm) of eggplant genotypes infected with *F. oxysporum* f. sp. *melongenae* and non-infected (control) plants (%).

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	87.15 a-e	85.46 a-j	G56	78.57 d-m	83.90 a-j
G2	77.09 e-n	70.02 i-j	G58	75.25 f-o	88.11 a-h
G4-1	78.55 d-m	92.98 a-e	G61	80.99 b-k	83.43 a-j
G4-2	77.61 e-n	78.54 c-j	G63	76.99 e-n	92.47 a-f
G5	80.35 b-l	92.22 a-f	G64	76.76 e-n	94.74 a-c
G7-1	66.26 n-p	80.02 b-j	G66	72.52 h-p	81.84 b-j
G7-2	71.35 j-p	82.85 a-j	G68	76.47 e-o	91.27 a-g
G8	80.44 b-l	84.83 a-j	G69	73.17 h-p	74.27 g-j
G11-2	73.72 g-o	75.34 f-j	G73	79.26 b-m	94.16 a-d
G12	76.18 e-o	88.84 a-h	G80	79.88 b-l	83.12 a-j
G15	72.95 h-p	86.08 a-j	G88	71.82 j-p	79.34 c-j
G16	71.52 j-p	87.83 a-h	G 91	93.69 a	88.78 a-h
G20	67.79 m-p	88.24 a-h	G98	82.09 a-k	89.09 a-h
G21	84.13 a-h	85.25 a-j	G109	75.24 f-o	84.31 a-j
G22-1	72.08 j-p	81.12 b-j	G113	80.19 b-l	77.37 c-j
G22-2	85.21 a-g	94.72 a-c	G114	71.03 j-p	96.96 a-b
G23	75.74 e-o	75.25 f-j	G119	70.43 k-p	84.35 a-j
G33	74.54 f-o	77.47 c-j	G122	81.82 b-k	76.90 d-j
G35-1	82.34 a-j	85.83 a-j	G125	75.35 f-o	78.21 c-j
G36	79.29 b-m	79.82 b-j	G127	72.27 i-p	69.07 j
G39	77.39 e-n	77.91 c-j	G128	83.94 a-i	78.88 c-j
G40-1	67.87 m-p	82.94 a-j	G134	86.24 a-f	75.64 e-j
G40-2	79.41 b-m	74.37 g-j	G138	81.43 b-k	85.31 a-j
G42	75.52 e-o	78.69 c-j	G144	87.15 a-d	84.77 a-j
G43-1	73.71 g-o	84.44 a-j	G146	80.58 b-l	87.12 a-i
G43-2	64.92 o-p	82.68 a-j	G147	79.13 c-m	89.07 a-h
G43-3	45.89 q	70.05 i-j	G148	79.41 b-m	92.01 a-f
G45-1	73.59 g-o	85.59 a-j	G152	80.32 b-l	100.00 a
G45-2	61.86 o-p	71.98 h-j	G154	72.55 h-p	88.87 a-h
G47	77.92 e-n	77.88 c-j	G161	90.84 a-b	87.01 a-i
G49	69.15 l-p	80.49 a-j	G173	80.05 b-l	88.00 a-h
G53	80.05 b-l	86.94 a-i	G177-1	80.28 b-l	84.59 a-j
G55	73.57 g-o	85.55 a-j	G179	74.40 g-o	82.86 a-j
			Karabey	90.84 a-c	94.42 a-d

P>0.01

Table 3. The ratio of root length per diameter class values (1 mm≤D≤ 2 mm) of eggplant genotypes infected with *F. oxysporum* f. sp. *melongenae* and non-infected (control) plants (%).

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	6.68 p-t	10.42 a-f	G56	8.64 j-t	10.27 a-f
G2	11.13 d-r	16.09 a-b	G58	9.85 d-s	7.13 b-g
G4-1	7.19 o-t	4.41 e-g	G61	7.76 k-t	9.15 a-g
G4-2	13.60 a-k	10.85 a-f	G63	10.04 d-r	3.35 f-g
G5	8.94 h-t	5.93 c-g	G64	12.52 a-p	2.40 f-g
G7-1	14.33 a-j	14.44 a-c	G66	12.25 b-q	9.22 a-g
G7-2	7.51 k-t	8.27 a-g	G68	9.76 d-s	7.32 b-g
G8	8.64 i-t	10.30 a-f	G69	14.97 a-h	14.14 a-d
G11-2	13.21 a-o	13.55a-e	G73	9.94 d-r	5.81 c-g
G12	12.01 c-q	9.47 a-g	G80	12.19 b-q	13.61 a-e
G15	11.99 c-q	6.98 b-g	G88	18.43 a	12.96 a-e
G16	15.69 a-d	6.75 b-g	G 91	9.42 f-s	18.17 a-b
G20	12.79 a-o	7.44 b-g	G98	8.73 i-t	10.90 a-f
G21	9.33 f-s	8.34 a-g	G109	13.31 a-n	10.75 a-f
G22-1	14.06 a-j	8.83 a-g	G113	9.49 e-s	10.09 a-f
G22-2	7.46 l-t	4.87 d-g	G114	14.94 a-h	3.03 f-g
G23	15.59 a-e	13.49 a-e	G119	10.35 d-r	14.73 a-c
G33	14.89 a-h	11.19 a-f	G122	9.76 d-s	15.70 a-b
G35-1	7.40 m-t	9..15 a-g	G125	13.48 a-m	10.15 a-f
G36	13.53 a-l	9.00 a-g	G127	15.02 a-g	14.72 a-c
G39	8.94 g-t	10.87 a-f	G128	9.13 g-t	13.39 a-e
G40-1	4.57 e-g	11.54 a-f	G134	6.36 q-t	12.98 a-e
G40-2	3.13 t	11.76 a-f	G138	9.21 f-t	8.50 a-g
G42	17.66 a-c	14.43 a-c	G144	3.82 s-t	9.77 a-f
G43-1	12.57 a-p	13.33 a-e	G146	10.58 d-r	6.63 b-g
G43-2	14.73 a-i	10.95 a-f	G147	7.26 n-t	8.11 a-g
G43-3	8.68 i-t	15.78 a-b	G148	8.30 j-t	7.81 b-g
G45-1	14.03 a-j	8.25 a-g	G152	7.59 k-t	0.00 g
G45-2	15.31 a-f	17.54 a	G154	10.85 d-r	6.06 c-g
G47	12.82 a-o	10.27 a-f	G161	5.57 r-t	9.26 a-g
G49	11.24 d-r	12.43 a-f	G173	10.65 d-r	10.01 a-f
G53	7.89 k-t	7.58 b-g	G177-1	11.20 d-r	9.19 a-g
G55	10.29 d-r	6.98 b-g	G179	11.16 d-r	8.19 a-g
			Karabey	5.38 r-t	2.72 f-g
		P>0.01			

Table 4. The ratio of root length per diameter class values(D>2 mm) of eggplant genotypes infected with *F. oxysporum* f. sp. *melongenae* and non-infected (control) plants (%).

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	6.16 i-l	4.11 b-j	G56	13.02 c-k	5.82 a-j
G2	11.76 c-l	13.88 a-c	G58	14.89 b-i	4.75 b-j
G4-1	14.25 b-i	2.60 d-j	G61	11.23 d-l	7.40 a-j
G4-2	8.77 g-l	10.60 a-h	G63	12.96 c-k	4.16 b-j
G5	10.74 d-l	1.84 e-f	G64	10.71 d-l	2.85 d-j
G7-1	19.39 b-e	5.52 b-j	G66	15.21 b-i	8.93 a-j
G7-2	21.13 b-c	8.86 a-j	G68	13.76 b-j	1.40 f-j
G8	10.91 d-l	4.85 b-j	G69	11.85 c-l	11.57 a-f
G11-2	13.05 c-k	11.10 a-g	G73	10.78 d-l	0.01 j
G12	11.79 c-l	1.68 e-j	G80	7.91 g-l	3.25 d-j
G15	15.05 b-i	6.92 a-j	G88	9.73 f-l	7.69 a-j
G16	12.78 c-l	5.41 b-j	G 91	13.95 b-i	6.63 a-j
G20	19.40 b-e	4.30 b-j	G98	9.17 g-l	0.00 j
G21	6.53 h-l	6.39 a-j	G109	11.44 d-l	4.93 b-j
G22-1	13.85 b-j	10.04 a-j	G113	10.31 e-l	12.52 a-d
G22-2	7.32 g-l	0.39 h-j	G114	14.01 b-i	0.00 j
G23	8.65 g-l	11.24 a-g	G119	19.20 b-f	0.90 g-j
G33	10.55 e-l	11.32 a-g	G122	8.41 g-l	7.38 a-j
G35-1	10.25 e-l	5.00 b-j	G125	11.15 d-l	11.62 a-f
G36	7.16 g-l	11.16 a-g	G127	12.69 c-l	16.20 a
G39	13.65 b-j	11.20 a-g	G128	6.91 h-l	7.72 a-j
G40-1	11.16 d-l	5.50 b-j	G134	7.39 g-l	11.37 a-f
G40-2	3.16 l	13.86 a-c	G138	9.34 g-l	6.18 a-j
G42	6.80 h-l	6.87 a-j	G144	6.09 i-l	5.45 b-j
G43-1	13.70 b-j	2.22 d-j	G146	8.82 g-l	6.24 a-j
G43-2	20.34 b-d	6.35 a-j	G147	13.60 b-j	2.80 d-j
G43-3	45.42 a	14.15 a-b	G148	12.28 c-l	0.17 i-j
G45-1	12.36 c-l	6.14 a-j	G152	12.08 c-l	0.00 j
G45-2	22.82 b	10.47 a-i	G154	16.58 b-g	5.05 b-j
G47	9.25 g-l	11.83 a-e	G161	3.57 k-l	3.71 c-j
G49	19.59 b-e	7.06 a-j	G173	9.28 g-l	1.97 e-j
G53	12.05 c-l	5.46 b-j	G177-1	8.51 g-l	6.20 a-j
G55	16.12 b-h	7.46 a-j	G179	14.43 b-i	8.94 a-j
			Karabey	4.23 j-l	2.84 d-j

P>0.01

Table 5. Average root diameter values (mm) of eggplant genotypes infected and non-infected (control) plants by *F. oxysporum* f. sp. *melongenae.*

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	0.83 b-d	2.20 b-h	G56	1.47 a-d	1.70 c-h
G2	1.82 a-d	2.00 c-h	G58	1.54 a-d	1.82 c-h
G4-1	1.44 a-d	1.53 f-h	G61	1.48 a-d	1.46 g-h
G4-2	1.18 a-d	1.74 c-h	G63	1.45 a-d	4.34 a-b
G5	0.80 b-d	1.87 c-h	G64	1.35 a-d	2.10 b-h
G7-1	1.12 a-d	3.95 a-c	G66	1.67 a-d	1.98 c-h
G7-2	2.06 a-b	1.29 h	G68	1.29 a-d	2.25 b-h
G8	1.38 a-d	1.27 h	G69	1.80 a-d	1.57 e-h
G11-2	1.24 a-d	1.67 d-h	G73	1.48 a-d	2.99 b-h
G12	1.10 a-d	2.27 b-h	G80	0.98 a-d	3.19 b-h
G15	1.63 a-d	3.31 b-h	G88	1.29 a-d	2.32 b-h
G16	1.31 a-d	2.20 b-h	G 91	1.44 a-d	2.42 b-h
G20	1.22 a-d	2.54 b-h	G98	0.96 a-d	3.02 b-h
G21	1.09 a-d	1.50 f-h	G109	1.50 a-d	3.66 a-g
G22-1	1.80 a-d	1.60 d-h	G113	2.05 a-b	2.39 b-h
G22-2	0.89 b-d	2.04 c-h	G114	1.21 a-d	2.37 b-h
G23	1.26 a-d	1.44 g-h	G119	1.29 a-d	2.54 b-h
G33	1.31 a-d	2.11 b-h	G122	0.84 b-d	3.55 b-g
G35-1	1.86 a-c	2.21 b-h	G125	1.17 a-d	1.67 d-h
G36	1.08 a-d	1.49 f-h	G127	1.46 a-d	2.05 c-h
G39	1.58 a-d	1.54 f-h	G128	1.49 a-d	1.88 c-h
G40-1	1.87 a-c	2.87 b-h	G134	0.89 b-d	2.38 b-h
G40-2	1.79 a-d	2.19 b-h	G138	0.85 b-d	1.86 c-h
G42	0.76 c-d	2.00 c-h	G144	0.60 d	1.99 c-h
G43-1	1.50 a-d	3.10 b-h	G146	1.07 a-d	2.58 b-h
G43-2	1.31 a-d	2.27 b-h	G147	1.11 a-d	2.07 c-h
G43-3	1.85 a-d	2.55 b-h	G148	1.02 a-d	2.61 b-h
G45-1	1.24 a-d	3.82 a-d	G152	1.09 a-d	5.87 a
G45-2	1.39 a-d	2.93 b-h	G154	1.37 a-d	3.72 a-f
G47	1.07 a-d	1.88 c-h	G161	1.66 a-d	1.99 c-h
G49	1.27 a-d	4.06 a-e	G177-1	2.17 a	2.40 b-h
G53	1..64 a-d	1.62 d-h	G179	1.25 a-d	1.84 c-h
G55	1.82 a-d	2.50 b-h	G173	1.15 a-d	2.47 b-h
			Karabey	0.86 b-d	2.85 b-h
		P>0.01			

Table 6. Root surface area values (cm^2) of eggplant genotypes infected and non-infected (control) plants by *F. oxysporum* f. sp. *melongenae*.

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	38.36 f-g	367.72 b-h	G56	32.66 f-g	403.31 b-h
G2	389.89 a-c	164.23 h	G58	28.91 f-g	499.92 b-h
G4-1	25.39 f-g	556.88 b-h	G61	24.27 f-g	210.07 e-h
G4-2	25.62 f-g	548.21 b-h	G63	29.31 f-g	468.15 b-h
G5	5.50 g	351.50 b-h	G64	38.55 f.g	620.33 b-f
G7-1	6.17 g	237.41 d-h	G66	73.11 d-g	444.40 b-h
G7-2	21.92 f-g	233.48 d-h	G68	38.32 f-g	497.17 b-h
G8	24.96 f-g	239.69 c-h	G69	36.68 f-g	407.49 b-h
G11-2	28.24 f-g	188.26 g-h	G73	32.17 f-g	577.40 b-h
G12	20.82 f-g	447.62 b-h	G80	26.47 f-g	537.56 b-h
G15	28.66 f-g	322.29 b-h	G88	41.76 f-g	639.60 b-d
G16	27.99 f-g	410.81 b-h	G 91	457.53a	641.84 b-d
G20	10.99 g	379.93 b-h	G98	18.86 f-g	371.06 b-h
G21	37.97 f-g	431.34 b-h	G109	90.48 d-g	268.42 c-h
G22-1	31.63 f-g	399.52 b-h	G113	415.72 ab	455.18 b-h
G22-2	26.94 f-g	461.80 b-h	G114	58.54 f-g	630.25 b-e
G23	54.85 f-g	264.13 c-h	G119	6.71 g	207.21 e-h
G33	48.30 f-g	616.93 b-f	G122	5.24 g	235.47 d-h
G35-1	307.02 a-f	610.25 b-g	G125	70.75 e-g	475.96 b-h
G36	136.67 b-g	348.63 b-h	G127	99.85 c-g	421.69 b-h
G39	36.90 f-g	255.22 c-h	G128	367.50 a-d	446.91 b-h
G40-1	54.56 f-g	431.97 b-h	G134	21.21 f-g	275.20 c-h
G40-2	291.79 a-g	379.09 b-h	G138	17.56 f-g	390.83 b-h
G42	5.20 g	329.95 b-h	G144	11.08 g	228.11 d-h
G43-1	12.07 f-g	201.65 f-h	G146	34.16 f-g	743.79 a-b
G43-2	16.43 f-g	209.91 e-h	G147	23.52 f-g	461.58 b-h
G43-3	6.79 g	219.76 d-h	G148	24.25 f-g	572.43 b-h
G45-1	16.59 f-g	361.21 b-h	G152	24.15 f-g	1142.59 a
G45-2	13.70 f-g	196.45 f-h	G154	26.33 f-g	664.75 b-c
G47	82.94 d-g	354.78 b-h	G161	288.40 a-g	556.88 b-h
G49	11-31 g	212.83 c-h	G173	51.16 f-g	276.50 c-h
G53	39.14 f-g	253.57 c-h	G177-1	357.97 a-e	371.51 b-h
G55	33.70 f-g	501.61 b-h	G179	33.56 f-g	267.37 c-h
			Karabey	31.62 f-g	498.40 b-h

P>0.01

Table 7. Total root volume values (cm³) of eggplant genotypes infected and non-infected (control) plants by *F. oxysporum* f. sp. *melongenae*.

Genotype	Infected Plant	Control	Root Change (%)	Genotype	Infected Plant	Control	Root Change (%)
G1	0.80 f-i	20.27 m-u	96.01 a-e	G56	1.21e-i	28.79 g-n	94.64 a-f
G2	1.94 e-i	8.14 u-v	75.29 k	G58	1.19 e-i	23.19 k-s	93.57 a-h
G4-1	0.91 f-i	44.04 c-f	97.92 a-e	G61	0.89 f-i	7.71 u-v	88.55 c-j
G4-2	0.80 f-i	24.78 j-r	96.85 a-e	G63	1.04 e-i	44.05 c-f	97.63 a-e
G5	0.11 i	26.97 i-q	99.58 a	G64	1.22 e-i	37.07 e-j	95.87 a-e
G7-1	0.17 i	23.57 k-s	99.23 a	G66	3.25 e-g	41.06 d-g	92.06 a-i
G7-2	1.12 e-i	7.50 v	84.78 g-k	G68	1.24 e-i	27.86 h-p	95.53 a-e
G8	0.89 f-i	7.41 v	88.36 d-j	G69	1.38 e-i	15.90 o-v	91.68 a-i
G11-2	0.93 f-i	7.86 u-v	88.22 e-j	G73	1.16 e-i	43.18 c-f	97.30 a-e
G12	0.61 g-i	24.05 k-s	97.56 a-e	G80	0.66 g-i	42.97 c-f	98.42 a-b
G15	1.16 e-i	59.79 a-b	98.05 a-d	G88	1.46 e-i	37.95 e-i	95.85 a-e
G16	0.91 f-i	42.57 c-f	97.84 a-e	G 91	14.27 d	24.17 k-s	41.29 l-m
G20	0.32 h-i	26.62 i-q	98.06 a-d	G98	0.45 h-i	28.04 h-o	98.37 a-b
G21	1.03 e-i	16.24 n-v	93.07 a-h	G109	3.48 e-f	24.83 j-r	85.52 f-j
G22-1	1.41 e-i	23.70 k-s	94.33 a-g	G113	21.45 b	41.21 d-g	47.94 l
G22-2	1.05 e-i	42.10 d-f	97.56 a-e	G114	0.17 i	37.38 e-j	95.08 a-f
G23	1.73 e-i	9.64 t-v	81.00 j-k	G119	0.22 i	13.39 r-v	98.31 a-b
G33	1.42 e-i	15.97 o-v	90.15 a-j	G122	0.12 i	21.28 l-t	99.25 a
G35-1	1.57 e-i	34.11 f-k	95.49 a-e	G125	2.08 e-i	19.67 m-v	89.31 b-j
G36	1.21 e-1	12.11 r-v	90.68 a-j	G127	3.66 e	23.19 k-s	84.13 h-k
G39	1.50 e-i	9.91 t-v	83.31 i-k	G128	26.22 a	40.93 d-g	34.80 m-n
G40-1	1.41 e-i	31.66 f-m	95.13 a-f	G134	0.59 g-i	16.37 n-v	96.34 a-e
G40-2	2.04 e-i	55.49 b-d	96.01 a-e	G138	0.38 h-i	15.17 p-v	97.48 a-e
G42	0.10 i	16.38 n-v	99.37 a	G144	0.17 i	10.35 t-v	98.52 a-b
G43-1	0.51 h-i	16.01 o-v	96.08 a-e	G146	0.92 f-i	40.32 e-h	97.12 a-e
G43-2	0.56 g-i	11.43 s-v	94.74 a-f	G147	0.66 g-i	23.98 k-s	97.24 a-e
G43-3	0.27 h-1	14.24 q-v	98.00 a-d	G148	0.67 g-i	37.06 e-j	98.16 a-c
G45-1	0.59 g-i	9.10 t-v	93.46 a-h	G152	0.66 g-i	66.71 a	98.78 a-b
G45-2	0.47 h-i	14.66 q-v	96.46 a-e	G154	0.87 f-i	47.41 b-e	98.08 a-c
G47	0.61 g-i	16.60 n-v	96.04 a-e	G161	2.94 e-h	34.08 f-k	90.88 a-i
G49	0.38 h-i	15.81 o-v	97.56 a-e	G173	1.16 e-i	14.43 q-v	26.59 n
G53	1.55 e-i	10.35 t-v	84.74 g-k	G177-1	17.12 c	23.30 k-s	91.154 a-i
G55	1.57 e-i	33.36 f-l	94.55 a-f	G179	1.06 e-i	14.32 q-v	92.69 a-i
				Karabey	1.71 e-i	55.14 a-c	96.88 a-e

P>0.01

Table 8. Root dry weight values (g) of eggplant genotypes infected and non-infected (control) plants by *F. oxysporum* f. sp. *melongenae*.

Genotype	Infected Plant	Control	Genotype	Infected Plant	Control
G1	0.06 d-h	0.68 c-k	G56	0.06 d-h	0.37 r-x
G2	0.03 d-h	0.35 s-x	G58	0.05 d-h	0.95 a-b
G4-1	0.07 d-h	0.24 u-y	G61	0.06 d-h	0.61 v-y
G4-2	0.05 d-h	0.76 c-g	G63	0.06 d-h	0.21 w-y
G5	0.09 c-d	0.35 s-x	G64	0.05 d-h	0.32 t-x
G7-1	0.03 d-h	0.51 k-s	G66	0.05 d-h	0.20 x-y
G7-2	0.06 d-h	0.21 w-y	G68	0.05 d-h	0.54 i-r
G8	0.05 d-h	0.23 u-y	G69	0.01 f-h	1.08 a
G11-2	0.04 d-h	0.40 o-u	G73	0.05 d-h	0.62 d-m
G12	0.05 d-h	0.61 d-m	G80	0.03 d-h	0.70 c-i
G15	0.03 d-h	0.58 g-n	G88	0.03 d-h	0.59 f-n
G16	0.04 d-h	0.45 m-t	G 91	0.33 b	0.29 t-x
G20	0.06 d-h	0.35 s-x	G98	0.05 d-h	0.96 a-b
G21	0.04 d-h	0.24 u-y	G109	0.14 c	0.82 b-c
G22-1	0.03 d-h	0.32 t-x	G113	0.39 b	0.69 c-j
G22-2	0.06 d-h	0.55 i-q	G114	0.06 d-h	0.68 c-l
G23	0.05 d-h	0.24 u-y	G119	0.01 g-h	0.74 c-h
G33	0.05 d-h	0.11 y	G122	0.04 d-h	0.44 m-t
G35-1	0.06 d-h	0.38 q-w	G125	0.07 d-f	0.32 t-x
G36	0.06 d-h	0.35 s-x	G127	0.08 c-e	0.44 m-t
G39	0.05 d-h	0.23 u-y	G128	0.35 b	0.61 d-n
G40-1	0.07 d-h	0.10 y	G134	0.04 d-h	0.77 c-f
G40-2	0.08 d-f	0.32 t-x	G138	0.04 d-h	0.57 h-p
G42	0.07 d-h	0.77 c-f	G144	0.01 h	0.74 c-h
G43-1	0.02 e-h	0.78 b-e	G146	0.03 d-h	0.50 l-s
G43-2	0.02 e-h	0.51 k-s	G147	0.05 d-h	0.31 t-x
G43-3	0.02 e-h	0.40 p-v	G148	0.08 d-e	0.52 j-s
G45-1	0.06 d-h	0.58 h-o	G152	0.07 d-g	0.35 s-x
G45-2	0.04 d-h	0.54 i-r	G154	0.03 d-h	0.46 m-t
G47	0.02 e-h	0.30 t-x	G161	0.08 d-e	0.80 b-c
G49	0.01 g-h	0.74 c-h	G177-1	0.79 a	0.79 b-d
G53	0.06 d-h	0.23 u-y	G179	0.05 d-h	0.61 e-n
G55	0.04 d-h	0.32 t-x	G173	0.06 d-h	0.30 t-x
			Karabey	0.07 d-h	0.53 i-r

P>0.01

Table 9. Root dry weight changes values (%) of eggplant genotypes infected and non-infected (control) plants by *F. oxysporum* f. sp. *melongenae.*

Genotype	Root dry weight changes (%)	Genotype	Root dry weight changes (%)
G1	89.51 a-g	G56	81.08 d-l
G2	89.47 a-g	G58	94.45 a-d
G4-1	71.00 l	G61	73.30 i-l
G4-2	92.54 a-d	G63	71.40 k-l
G5	73.33 i-l	G64	81.00 d-l
G7-1	92.54 a-d	G66	71.12 k-l
G7-2	71.51 k-l	G68	90.91 a-e
G8	76.60 f-l	G69	98.46 a
G11-2	88.20 a-h	G73	85.25 a-k
G12	91.77 a-d	G80	95.69 a-c
G15	93.94 a-d	G88	94.45 a-d
G16	91.11 a-e	G 91	13.27 o
G20	82.89 b-l	G98	94.79 a-d
G21	83.59 b-l	G109	82.13 c-l
G22-1	88.62 a-h	G113	43.83 m-n
G22-2	89.06 a-g	G114	90.19 a-f
G23	77.14 e-l	G119	98.20 a
G33	49.84 m	G122	90.23 a-f
G35-1	82.01 c-l	G125	75.88 g-l
G36	82.60 c-l	G127	81.25 d-l
G39	73.41 i-l	G128	41.43 m-n
G40-1	32.70 n	G134	94.37 a-d
G40-2	74.75 h-l	G138	92.33 a-d
G42	90.47 a-f	G144	98.62 a
G43-1	96.89 a-b	G146	92.43 a-d
G43-2	96.00 a-c	G147	82.07 c-l
G43-3	95.03 a-d	G148	83.95 b-l
G45-1	89.65 a-g	G152	76.90 e-l
G45-2	92.14 a-d	G154	91.61 a-d
G47	91.44 a-d	G161	89.46 a-g
G49	98.19 a	G177-1	69.94 l
G53	71.63 j-l	G179	2 .86 o
G55	85.81 a-j	G173	89.85 a-g
		Karabey	86.98 a-i
	P>0.01		

Table 10.Correlation relationship between root structures and disease severity of eggplant genotypes.

	Root length (cm)	**Root surface area (cm^2)**	**Average diameter (mm)**	**Root volume**	**U< 0- 1mm**	U: 1-2 mm	2 mm>U	Dry weight	Root dry weight % changes	Weight % variation
Disease severity	-0.49**	-0.49**	-0.20	-0.53**	-0.20	0.11	0.18	-0.38	0.38	0.25
Root length (cm)		0.97**	0.35	0.58**	0.35	-0.22	-0.30	0.49**	-0.54**	-0.42**
Root surface area (cm^2)			0.47**	0.59**	0.33	-0.25	-0.26	0.52**	-0.55**	-0.45**
Average root diameter (mm)				0.32	-0.35	0.05	0.39	0.29	-0.37	-0.33
Root volume(cm^3)					0.13	-0.05	-0.13	0.77**	-0.91**	-0.65**
U< 0-1						-0.59**	-0.88**	0.14	-0.10	-0.11
U: 1-2							0.12**	-0.06	0.01	0.03
2 mm>U								-0.14	0.11	0.11
Dry weight									-0.79**	-0.79**
Root dry weight % changes										0.72**

**P>0.01

References

Altınok HH (2005). First report of *Fusarium* wilt of egg plant caused by *Fusarium oxysporum* f. sp. *melongenae* in Turkey. Plant Pathology, 54:4, 577.

Balkaya A ve Yanmaz R (2001). Bitki genetik kaynaklarının muhafaza imkanları ve tohum gen bankalarının çalışma sistemleri. Ekoloji Çevre Dergisi, 10:39, 25-30.(In Turkish).

Bertucci MB, Suchoff DH, Jennings KM, Monks DW, Gunter CC, Schultheis JR and Louws FJ (2018). Comparison of root system morphology of cucurbit rootstocks for use in watermelon grafting. HortTechnology, 28(5): 629-636.

Biles CL and Martyn RD (1989). Local and systemic resistance induced in watermelons by form a especiales of *Fusarium oxysporum*. Phytopathology, 79:8, 856-860.

Çakır Z, Balkaya A, Saribas S and Kandemir D (2017). The morphological diversity and fruit characterization of Turkish eggplant (*Solanum melongena* L.) populations. Ekin Journal of Crop Breeding and Genetics, 3(2): 34-44.

Çakır Z (2018). Patlıcanda (*Solanum melongena* L.) yerel genetik kaynakların karakterizasyonu ve seleksiyon ıslahı ile çeşit ıslah programlarında değerlendirilmesi. Ondokuz Mayıs Üniversitesi Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı, Yüksek Lisans Tezi, 92 s. (In Turkish).

Çakır Z, Balkaya A, Kandemir D and Saribas S (2019). Determination of superior Turkish eggplant (*Solanum melongena* L.) genotypes by pedigree selection method. Ekin Journal of Crop Breeding and Genetics, 5(1): 56-67.

Comas LH, Becker SR,Von Mark VC, Byrne PF and Dierig DA (2013). Root traits contributing to plant productivity under drought. Front. Plant Sci., 4:442.

Engels JMM, Arora RK and Guarino L (1995). An introduction to plant germplasm exploration and collecting: planning, methods and procedures, follow-up. Collecting plant genetic diversity. Technical guidelines. CAB International, Wallingford, United Kingdom, 31-63.

Kakita T, Abe A and Ikeda T (2015). Differences in root growth and permeability in the grafted combinations of Dutch tomato cultivars (Starbuck and Maxifort) and Japanese cultivars (Reiyo, Receive and Magnet). American Journal of Plant Sciences, 6: 2640.

Kalloo G (1993). Eggplant: *Solanum melongena* L. Genetic improvement of vegetable crops,587-604.

Karaağaç (2013). Karadeniz bölgesinden toplanan kestane kabağı (*C. maxima* Duchesne) ve bal kabağı (*C. moschata* Duchesne) genotiplerinin karpuza anaçlık potansiyellerinin belirlenmesi Ondokuz Mayıs Üniversitesi Fen Bilimleri Enstitüsü, Bahçe Bitkileri Anabilim Dalı, Yüksek Lisans Tezi, 258 s. (In Turkish).

Karaağaç O ve Balkaya A (2017). Türkiye'de yerel sebze çeşitlerinin mevcut durumu ve ıslah programlarında değerlendirilmesi. TÜRKTOB Dergisi, 23:6, 8-15. (In Turkish).

Karaağaç O, Taş K, Özgen R, Kanal A ve Balkaya A (2020). *Capsicum* türlerinin kök yapılarının incelenmesi ve kök özellikleri yönünden karşılaştırılması. Yüzüncü Yıl Üniversitesi Tarım Bilimleri Dergisi, Cilt 30, Sayı 2:266-279. (In Turkish).

Kandemir D, Sarıbaş HŞ ve Balkaya A (2016). Aşılı patlıcan üretiminde kullanılan anaçların verim ve kalite üzerine etkileri. Tarım Gündem Dergisi, 6(33): 24-28. (In Turkish).

Koevoets IT, Venema JH, Elzenga JT and Testerink C (2016). Roots with standing their environment: exploiting root system architecture responses to abiotic stress to improve crop tolerance. Frontiers in Plant Science, 1335: 1-19.

Lovelli S, Perniola M, Di Tommaso T, Bochicchio R and Amato M (2012). Specific root length and diameter of hydroponically-grown tomato plants under salinity. J. Agronomy, 11:101-106.

Miller AS, Rowe CR and Riedel MR (1996). *Fusarium* and *Verticillium* wilts of tomato, potato, pepper and eggplant. The Ohio State University Extension Plant Pathology, Hgy-3122- 96. 2021 Cofey Road. Columbus, oh 432101087.

Oztekin GB, Giuffrida F, Tuzel Y and Leonardi C (2009). Is the vigour of grafted tomato plants related to root characteristics? J. Food Agr. Environ. 7:364-368.

Paez-Garcia A, Motes C, Scheible WR, Chen R, Blancaflor E and Monteros M (2015). Root traits and phenotyping strategies for plant improvement. Plants, 4:2, 334-355.

Pereira-Dias L, Lopez-Serrano L, Castell-Zeising V, Lopez-Galarza S, San Bautista A, Calatayud Á and Fita A (2018). Different root morphological responses to phosphorus supplies in grafted pepper. Bulletin UASVM Horticulture, 75, 1: 59-61.

Rızza F, Mennela G, Collonıer C, Sıhachakr D, Kashyap V, Rajam MV, Prestera M and Rotıno LG (2002). Androgenic dihaploids from somatic hybrids between *Solanum melongena* and *Solanum aethiopicum* group gilo as a source of resistance to *Fusarium oxysporum* f. sp. *melongenae*. Genetic Transformation and Hybridization. Plant Cell Reports, 20: 1022-1032.

Sarıbaş Ş (2019). Aşılı patlıcan üretiminde genetik kaynakların anaç ıslah programlarında değerlendirilmesi ve yerli hibrit anaçlarının geliştirilmesi. Ondokuz Mayıs Üniversitesi, Fen Bilimleri Enstitüsü, Bahçe Bitkileri Ana Bilim Dalı, Doktora Tezi, Samsun. (In Turkish).

Sarıbaş Ş, Balkaya A, Kandemir D and Karaağaç O (2019). Yerli patlıcan anaçlarının (*Solanum melongena* x *Solanum aethiopicum*) köklenme potansiyeli ve fenotipik kök mimarisi. Black Sea Journal of Agriculture, 2:3,137-145. (In Turkish).

Sekara A, Cebula S and Kunicki E (2007). Cultivated eggplants-origin, breeding objectives and genetic resources, a review. Folia Horticulturae, 19:1, 97-114.

Schiefelbein JW and Benfey PN (1991). The development of plant roots: new approaches to underground problems. The Plant Cell, 3, 11: 1147.

Schwarz D, Rouphael Y, Colla G andVenema JH (2010). Grafting as a tool to improve tolerance of vegetables to abiotic stresses: thermal stress, water stress and organic pollutants, Scientia Horticulturae, 127: 162-171.

Suchoff D, Gunter C and Louws J (2017).Comparative analysis of root system morphology in tomato rootstocks. Hort Technology, 27(3):319-324.

Vural H, Eşiyok D ve Duman İ (2000). Kültür Sebzeleri: Sebze Yetiştirme. Ege Üniversitesi Bornova, Izmir.

Zobel RW, Baligar VC and Kinraid TB, (2007). Fine root diameters can change in response to changes in nutrient concentrations. Plant Soil, 297:243-254.