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Effects of Different Pre-sized Rooting Blocks and IBA Concentrations on the Rooting of Ramsey Grapevine Rootstock Cuttings

Farklı Ön Boyutlandırılmış Köklendirme Blokları ve IBA Konsantrasyonlarının Ramsey Asma Anacı Çeliklerinin Köklenmesi Üzerine Etkileri

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Key Words:

Rooting, Ramsey, IBA, paper pot, phenolic foam

ABSTRACT

Objective: Ramsey *(Vitis champinii)* is a grapevine rootstock that preferred sandy soils and it has high resistance to phylloxera and nematodes. But rooting of one year-old wood cuttings of this rootstock is quite low. In this study, determination of the effects of two different pre-sized rooting blocks (paper pot and phenolic foam) injected with different IBA concentrations on rooting of Ramsey rootstock cuttings were aimed.

Material and Methods: In this study, for supporting the exogenous auxin treatment, IBA in different concentrations (0-50 ppm) was applied to two different pre-sized rooting media blocks (paper pot and phenolic foam) in which Ramsey cuttings be rooted. IBA solutions were injected into rooting blocks before planting. Cuttings were also pretreated with 2000 ppm IBA as quick dip. Cuttings were evaluated after 45 days in relation with root and shoot quality parameters.

Results: The effects of rooting blocks on root number, root length, shoot length and dry root weight were found statistically significant. Apart from rooting percentage, other quality parameters of cuttings that planted in paper pots were higher than that planted in phenolic foam. The highest rooting percentage (43.2 %) was obtained from cuttings that planted in phenolic foam, injected in 30 ppm IBA.

Conclusion: In this study, it was revealed that paper pot could be a proper medium choice in grapevine nursery tree propagation.

Anahtar Sözcükler:

Köklenme, Ramsey, IBA, kağıt saksı, fenolik köpük

ÖZ

Amaç: Ramsey *(Vitis champinii)* kumlu toprakları tercih eden bir asma anacı olup, floksera ve nematodlara karşı yüksek dayanıklılığa sahiptir. Ancak bu anacın bir yıllık odun çeliklerinin köklenmesi oldukça düşük düzeydedir. Bu çalışmada, farklı ön boyutlandırılmış köklendirme bloklarına (kağıt saksı ve fenolik köpük) enjekte edilen farklı konsantrasyonlardaki IBA'nın Ramsey asma anacı çeliklerinin köklenmesi üzerine etkilerinin belirlenmesi amaçlanmıştır.

Materyal ve Metot: Bu çalışmada, Ramsey çeliklerinin köklendirileceği iki farklı ön boyutlandırılmış köklendirme ortam bloğuna (kağıt saksı ve fenolik köpük) dışarıdan uygulanan oksini desteklemek amacıyla, farklı konsantrasyonlarda (0-50 ppm) IBA uygulanmıştır. IBA çözeltileri dikimden önce köklendirme bloklarına enjekte edilmiştir. Çeliklere ayrıca hızlı daldırma yöntemiyle 2000 ppm IBA uygulanmıştır. Çelikler 45 gün sonra kök ve sürgün kalite parametreleri açısından değerlendirilmiştir.

Bulgular: Köklendirme bloklarının ortalama kök sayısı, kök uzunluğu, sürgün uzunluğu ve kök kuru ağırlığı üzerine etkisi istatistiki açıdan önemli bulunmuştur. Köklenme oranı dışındaki diğer kalite parametreleri, kağıt saksıya dikilen çeliklerde fenolik köpüğe dikilenlere kıyasla daha yüksek olmuştur. En yüksek köklenme oranı (% 43.2), 30 ppm IBA enjekte edilen fenolik köpük ortamına dikilen çeliklerden elde edilmiştir.

Sonuç: Bu çalışmada, kağıt saksının asma fidanı üretiminde uygun bir ortam seçeneği olabileceği ortaya konulmuştur.

INTRODUCTION

Turkey is one of the oldest grape-growing countries and has high grapevine genetic diversity. Today, Turkey that ranks 6th with 4.2 million tons grape production on the acreage of 467.093 ha in the world (Anonymous, 2017). In grape growing, *Vitis vinifera* cultivars grown on their own roots constitutes a major risk for new areas due to the low tolerance to phylloxera, nematodes and soil-born stresses such as lime, salinity and drought. For these reasons, rootstocks should be used in new areas where the new vineyards will be planted (Rieger, 2006). This obligation has brought many problems. Grafted and own-rooted vine nursery tree production is insufficient due to the changing rooting ability among the different rootstocks that affects the quality and yield in grapevine production (Howell, 1987; Hartmann et al., 2002). Ramsey *(Vitis champinii)* has long been known as resistant to root knot nematodes and limestone soils, but recalcitrant to root (Howell, 1987; Hartmann et al., 2002; Ahmed and Mokhtar, 2011). But some vine rootstocks are not easily rooted. For this reason, in some studies, quick-dip up to 4000 ppm or slow dip (25 ppm) IBA solutions increased the most rooting parameters in vine rootstocks cuttings that hard to root. Furthermore, rooting success was also increased with slow dip to IBA and NAA mixtures (Alley, 1979; Chapman and Hussey, 1980; Garande et al., 2002; Sucu and Yağcı, 2017). In particular, rooting and nursery tree yield have been changed due to the rootstock/variety combination and they generally remain at low percentages when the difficult to root rootstocks used. Rooting percentage was found to be 40 % in a study in which the Ramsey cuttings were rooted (Ahmed and Mokhtar, 2011). In grapevine rootstock propagation, the studies have been made in many aspects such as cutting collection time (Çelik and Eriş, 1984), cutting diameter an internode number (Encev, 1970; Garande et al., 2002), effects of rooting media (Geczi, 1974; Çelik and Eriş, 1984; Kelen and Demirtaş, 2001; Sengel et al., 2012) effects of plant growth regulators (Alley, 1979; Chapman and Hussey, 1980; Kelen ve Demirtaş, 2001), aiming on to increase rooting parameters. Rooting ability of vine cuttings was found to be correlated with auxin metabolism (Kracke et al., 1981; Epstein and Lavee, 1984; Kelen and Özkan, 2003; Ahmed and Mokthar, 2011), phenolic metabolism (Bartolini et al., 1991; Çoban, 2007; Satisha et al., 2008; Köse et al., 2010) and nutrient status of cuttings (Ahmed and Mokhtar, 2011). Using radioactive IBA, hardwood cuttings of grapevine metabolized the synthetic auxin (IBA) to the natural one (IAA) and IBA remains at the base of the cutting and releases free IAA which is needed for the rooting process (Epstein and Lavee, 1984). Rooting ability depends on the formation of IAA from IBA and a certain ratio of both auxins must be maintained. So the rooting depends on the free hormone levels during a critical phase of rooting (Epstein and Müller, 1993; De Klerk et al., 1999). From this point of view, supporting the exogenously applied IBA by its slow releasing form, at low concentrations by injecting to the rooting medium might be useful particularly for difficult to root cuttings. Rooting media should be considered an integral part of the propagation system (Loach, 1988). Apart from organic and inorganic substrates, pre-sized rooting blocks (e.g. rockwool, phenolic foam) have been widely used in cutting propagation (Hartmann et al., 2002). They also gave very high rooting scores among the twenty five media assessed in leafy olive cuttings (İsfendiyaroğlu et al., 2009). Cocopeat based paper pot is recently used in large quantities particularly in olive nursery industry. Rockwool and phenolic foam gave the highest values of most rooting parameters in wood cuttings of different grapevine rootstocks (Sengel et al., 2012).

In this study, the effects of two different pre-sized rooting blocks (paper pot and phenolic foam) injected with different IBA concentrations on rooting of Ramsey rootstock cuttings were investigated.

MATERIAL and METHODS

This experiment was carried out at the Department of Horticulture, Faculty of Agriculture, Ege University in İzmir, Turkey in 2015. Cuttings of Ramsey *(Vitis champinii)* rootstock that hard to root were used. Paper pots (Van der Knaap-Antalya Substrat/Turkey) that contained (45 % cocopeat+ 45 % peat+ 10 % perlite- pH: 6.0) and phenolic foam (oasis) (17 kg/m^3; pH: 6.2) were used as rooting blocks. Dimensions of rooting blocks are 4.5 cm in diameter and 7 cm in length. Cuttings from one year-old wood were prepared 7 mm in diameter and 20 cm in length with 2-3 nodes. Distal ends (approx. 2 cm.) of cuttings were dipped into paraffin wax which melted at 60-65°C before planting. Six different IBA concentrations (0, 10, 20, 30, 40, 50 ppm) were injected into the rooting blocks at the day before planting. Injection solutions were prepared by dissolving the necessary amount of IBA in 5 ml isopropyl alcohol. After then, alcoholic solutions were completed to final volumes by water. 60 ml of solution was injected to each rooting block and they were kept at room temperature to allow the complete evaporation of alcohol (Özeker and İsfendiyaroğlu, 2007). Cuttings were treated with 2000 ppm IBA as quick dip before insertion. Cuttings were planted at the beginning of April. Then they have rooted in bench-type low tunnels placed in a greenhouse under the conditions of 25 °C and 80% mean ambient temperature and humidity. Cuttings pulled out 45 days after planting and were evaluated for rooting percentage (%), root number, root length (cm), shoot length (cm), leaf number, root fresh and dry weights (g), shoot fresh and dry weights (g). A completely randomized simple factorial design with three replications (15 cuttings per each) was used. The data were subjected to analysis of variance by SPSS (SSPS Inc. 19.0 v., USA) software, and differences between means were determined by Fischer's Least Significant Difference (LSD) test.

RESULTS

Rooting Percentage

Rooting blocks and IBA applications were not found statistically significant in terms of rooting percentage of cuttings. But the interaction of Block x IBA was found statistically significant ($P<0.05$). The highest rooting percentage (43.2 %) was obtained from phenolic foam injected with 30 ppm IBA (Table 1).

Root Number

Simple effect of rooting blocks was found statistically significant ($P<0.05$). Mean root number of cuttings that planted in paper pots was 46 % higher than cuttings rooted in phenolic foam. IBA concentrations and Block x IBA interaction were found to be non-significant (Table 2).

Root Length

Different rooting blocks had significantly affected the root length of cuttings as in root numbers ($P<0.05$). Cuttings rooted in paper pots produced longer roots than those in phenolic foam (Table 3). There is no significant difference found between IBA concentrations and Block x IBA interactions.

Shoot Length

Shoot lengths of cuttings that planted in paper pot were found higher than that planted in phenolic foam ($P<0.05$). As for the IBA concentrations, there is no significant difference with regard to shoot length. Paper pot gave rise to more than 50 % increase in mean length of shoots compared to phenolic foam. There is no statistically significant difference in terms of interaction between block and IBA (Table 4).

Leaf Number

Effects of rooting blocks, IBA concentrations and Block x IBA interaction were found statistically non-significant. Interaction of block and IBA was also found non-significant. Leaf number per cutting ranged between 0.50 and 1.43 (Table 5).

Root Fresh and Dry Weights

Effects of rooting blocks and IBA concentrations were found to be non-significant. However, mean root fresh weight in paper pot was markedly higher than foam. Non-significant interactions found between blocks and IBA concentrations. Root fresh weights were changed between 0.11 and 1.08 (Table 6).

Different rooting blocks did significantly ($P<0.05$) affect mean root dry weights. Dry weight in paper pot was quite higher than in foam. IBA concentrations did not significantly affect the root dry weights. Non-significant interactions found between blocks and IBA concentrations as well (Table 7).

Table 1. Effects of rooting blocks and IBA concentrations on rooting percentage.
Çizelge 1. *Köklendirme blokları ve IBA konsantrasyonlarının köklenme oranına etkileri.*

IBA Concentrations	Rooting Percentage (%)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	25.9 bc	32.2 ab	**28.9**
10 ppm	33.2 ab	26.4 bc	**29.7**
20 ppm	29.4 abc	20.0 c	**24.5**
30 ppm	23.7 bc	43.2 a	**32.4**
40 ppm	26.4 bc	23.1 bc	**24.7**
50 ppm	20.0 c	23.1 bc	**21.5**
Rooting Block Means	**26.2**	**27.5**	
$LSD_{0.05}$ Rooting block = ns			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = 1.380^*			

*is significant at $P<0.05$, ns: not significant

Table 2. Effects of rooting blocks and IBA concentrations on root number.
Çizelge 2. *Köklendirme blokları ve IBA konsantrasyonlarının kök sayısına etkileri.*

IBA Concentrations	Root Number		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	1.27	1.67	**1.47**
10 ppm	2.97	1.13	**2.05**
20 ppm	1.13	0.87	**1.00**
30 ppm	1.61	1.73	**1.67**
40 ppm	1.86	0.70	**1.28**
50 ppm	1.59	1.07	**1.33**
Rooting Block Means	**1.74 A**	**1.19 B**	
$LSD_{0.05}$ Rooting Blocks = 0.356^*			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

*is significant at $P<0.05$, ns: not significant

Table 3. Effects of rooting blocks and IBA concentrations on root length.
Çizelge 3. *Köklendirme blokları ve IBA konsantrasyonlarının kök uzunluğuna etkileri.*

IBA Concentrations	Root Length (cm)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	5.11	7.51	**6.31**
10 ppm	10.06	4.37	**7.21**
20 ppm	4.17	3.16	**3.67**
30 ppm	6.16	6.44	**6.30**
40 ppm	9.22	2.46	**5.84**
50 ppm	5.52	4.71	**5.12**
Rooting Block Means	**6.71 A**	**4.77 B**	
$LSD_{0.05}$ Rooting blocks = 1.322^*			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

*is significant at $P<0.05$, ns: not significant

Table 4. Effects of rooting blocks and IBA concentrations on shoot length.
Çizelge 4. *Köklendirme blokları ve IBA konsantrasyonlarının sürgün uzunluğuna etkileri.*

IBA Concentrations	Shoot Length (cm)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	1.16	1.60	**1.38**
10 ppm	2.21	1.15	**1.68**
20 ppm	1.50	0.76	**1.13**
30 ppm	1.85	1.73	**1.79**
40 ppm	2.33	0.71	**1.52**
50 ppm	1.08	0.86	**0.97**
Rooting Block Means	**1.69 A**	**1.13 B**	
$LSD_{0.05}$ Rooting blocks = 0.432^*			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

*is significant at $P<0.05$, ns: not significant

Table 5. Effects of rooting blocks and IBA concentrations on leaf number.
Çizelge 5. *Köklendirme blokları ve IBA konsantrasyonlarının yaprak sayısına etkileri.*

IBA Concentrations	Leaf Number		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	0.83	1.00	**0.91**
10 ppm	1.43	0.96	**1.20**
20 ppm	0.86	0.56	**0.71**
30 ppm	1.12	1.40	**1.26**
40 ppm	1.28	0.50	**0.89**
50 ppm	0.71	0.70	**0.70**
Rooting Block Means	**1.04**	**0.85**	
$LSD_{0.05}$ Rooting block = ns			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

ns: not significant

Table 6. Effects of rooting blocks and IBA concentrations on root fresh weight.
Çizelge 6. *Köklendirme blokları ve IBA konsantrasyonlarının kök yaş ağırlığına etkileri.*

IBA Concentrations	Root Fresh Weight (g)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	0.77	1.04	**0.91**
10 ppm	0.81	0.67	**0.74**
20 ppm	0.61	0.59	**0.60**
30 ppm	0.91	1.00	**0.96**
40 ppm	1.08	0.11	**0.59**
50 ppm	0.80	0.53	**0.66**
Rooting Block Means	**0.83**	**0.66**	
$LSD_{0.05}$ Rooting block = ns			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA= ns			

ns: not significant

Table 7. Effects of rooting blocks and IBA concentrations on root dry weight.
Çizelge 7. *Köklendirme blokları ve IBA konsantrasyonlarının kök kuru ağırlığına etkileri.*

IBA Concentrations	Root Dry Weight (g)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	0.07	0.07	**0.07**
10 ppm	0.06	0.04	**0.05**
20 ppm	0.04	0.04	**0.04**
30 ppm	0.06	0.07	**0.07**
40 ppm	0.08	0.02	**0.05**
50 ppm	0.05	0.04	**0.05**
Rooting Block Means	**0.06 A**	**0.05 B**	
$LSD_{0.05}$ Rooting block = 0.008*			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

*is significant at $P<0.05$, ns: not significant

Shoot Fresh and Dry Weights

The effects of rooting blocks and IBA concentrations on mean shoot fresh and dry weights were determined as non-significant. Mean shoot fresh weights were found markedly higher than phenolic foam. IBA applications did not significantly affect the mean shoot fresh weights of grape cuttings (Table 8).

Shoot dry weights had parallel results with the values observed in fresh weights. Cuttings had higher mean dry weight figure in paper pot as in fresh weight. As for the IBA concentrations, 30 ppm gave the highest shoot dry weight as observed in fresh weight.

Despite the insignificant interactions, highest shoot dry weight was obtained from paper pot with 10 ppm IBA injection as in fresh shoots (Table 9).

DISCUSSION

Rooting Block x IBA interaction was found statistically significant on rooting percentage. Cuttings that treated 30 ppm IBA and planted in phenolic foam had the highest rooting percentage (43.2 %) (Table 1). In terms of root number, cuttings that stuck in paper pots produced higher number of roots than cuttings in phenolic foam. In difficult to root 140R cuttings, phenolic foam also gave the highest rooting percentage followed by rock wool and pure perlite (Sengel et al., 2012). Despite the significant year differences, in intermediate to root 'Ayvalık' olive cuttings, the highest rooting (100 %) was obtained with phenolic foam among the 25 different media assessed (İsfendiyaroğlu et al., 2009). On the other hand, mean root number and length of Ramsey cuttings had significantly higher values in paper pots (Table 2, 3). Both parameters are also quite important for the rooting success. Cuttings rooted in paper pots gave remarkably higher values of mean shoot length, leaf number, fresh and dry weights of both roots and shoots (Table 4, 5, 6, 7 and 8). Sengel et al. (2012), also obtained the highest values of root/shoot fresh/dry weights in hydrophonic system, from pre-sized rooting blocks like phenolic foam and rockwool in 140R rootstock. In this work, supplementary IBA injections to rooting blocks seem to give relatively low values in terms of rooting parameters examined. Previous works showed that in grafted or non-grafted Ramsey cuttings, rooting percentages ranged between 6-40 %, mean root numbers were 1.7-6.3 and root fresh/dry weights were 1.1/1.0 g in various media mixes without IBA treatments (Sivritepe and Türkben, 2001; Ahmet and Mokhtar, 2011; Sucu and Yağcı, 2017). However, in Salt Creek (Ramsey) cuttings root lengths and numbers significantly augmented with increasing IBA concentrations (up to 2500 ppm) and internode numbers (up to 5) (Garande et al., 2002). Another work showed that IBA treatments up to 4000 ppm in two consecutive years slightly increased the rooting of Ramsey hardwood cuttings (Sağlam et al., 2005). In this study, relatively low numbers root/cutting in despite of the initial IBA application (2000 ppm), probably derived from using relatively short (20 cm) cuttings and/or short duration (45 d) of the experiment. On the other hand, supplementary IBA injections to rooting blocks gave inconsistent figures in terms of rooting parameters examined. However, in intermediate to root 'Ayvalık' olive cuttings, 50 ppm IBA injection to phenolic foam significantly increased the entire rooting figures compared to control (Özeker and İsfendiyaroğlu, 2007). So increases in cutting length and concentrations of exogenously applied IBA together with higher levels of (up to100 ppm) medium injections could be useful for Ramsey cuttings that rooted in blocks.

CONCLUSION

In conclusion, paper pot was found better than phenolic foam on most rooting parameters assessed. Paper pot was found to be available in grapevine production in this study. This material may provide some benefits to grapevine nursery sector was thought. For example, better adaptation of grapevine nursery tree to the soil, obtaining the grapevine nursery trees that have standard and healthy root features, reducing the costs of potted vine and availability to automation are enumerable among those benefits.

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Table 8. Effects of rooting blocks and IBA concentrations on shoot fresh weight.

***Çizelge 8.** Köklendirme blokları ve IBA konsantrasyonlarının sürgün yaş ağırlığına etkileri.*

IBA Concentrations	Shoot Fresh Weight (g)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	1.59	2.02	**1.80**
10 ppm	2.43	1.41	**1.92**
20 ppm	1.41	0.87	**1.14**
30 ppm	2.35	2.33	**2.34**
40 ppm	2.39	0.81	**1.60**
50 ppm	1.22	1.13	**1.17**
Rooting Block Means	**1.90**	**1.43**	
$LSD_{0.05}$ Rooting block = ns			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

ns: not significant

Table 9. Effects of rooting blocks and IBA concentrations on shoot dry weight.

***Çizelge 9.** Köklendirme blokları ve IBA konsantrasyonlarının sürgün kuru ağırlığına etkileri.*

IBA Concentrations	Shoot Dry Weight (g)		
	PAPER POT	PHENOLIC FOAM	IBA Means
0 ppm	0.25	0.35	**0.30**
10 ppm	0.41	0.24	**0.32**
20 ppm	0.22	0.14	**0.18**
30 ppm	0.39	0.40	**0.39**
40 ppm	0.39	0.14	**0.27**
50 ppm	0.19	0.20	**0.20**
Rooting Block Means	**0.31**	**0.25**	
$LSD_{0.05}$ Rooting block = ns			
$LSD_{0.05}$ IBA = ns			
$LSD_{0.05}$ Block x IBA = ns			

ns: not significant

REFERENCES

Ahmed, M.K. and M. Mokhtar. 2011. Why some grapevine cultivars are hard to root? Australian Journal of Basic and Applied Sciences, 5(2): 110-116.

Alley, C. J. 1979. Grapevine propagation. XI. Rooting of cuttings: Effect of indolebutyric acid (IBA) and refrigeration on rooting. American. Journal of Enology and Viticulture, 30(1): 28-32.

Anonymous. 2014. FAOSTAT. http://www.fao.org/faostat/en/#compare. Access date: December, 2017.

Bartolini, G., M.A. Toponi and L. Santini. 1991. Propagation by cuttings of two Vitis rootstocks: Diffusion of endogenous phenolic compounds into the dipping waters, Phyton, 52(1): 9-15.

Chapman, A.P. and E.E. Hussey. 1980. The value of plant growth regulators in the propagation of *Vitis champinii* rootstocks, American. Journal of Enology and Viticulture, 31(3): 250-253.

Çelik, H. and A. Eriş. 1983. Influence of substrates and collection time of cutting on budburst and rooting of some rootstock cuttings. Ankara Üniversitesi Ziraat Fakültesi Yıllığı, Cilt: 33, 149-154.

Çoban, H. 2007. Determination of polyphenol oxidase activity during rooting in cutting of some grape varieties (*Vitis vinifera* L.). Asian Journal of Chemistry, 19(5): 4020-4024.

De Klerk, G. J., W. Van Der Krieken and J. C. De Jong. 1999. Review – The formation of adventitious roots: new concepts, new possibilities. In vitro Cellular and Devolopmental Biology-Plant, 35:189-199.

Encev, H. 1970. The effect of rootstock diameter on the development of vines and the percentage production of standard first-class transplant. Gradinarska i Lozarska Nauka, 7(5): 121-125.

Epstein, E. and S. Lavee. 1984. Conversion of indole-3-butyric acid to indole-3-acetic acid by cuttings of grapevine (*Vitis vinifera*) and Olive (*Olea europaea*). Plant Cell Physiology, 25 (5): 697-703.

Epstein, E. and L. J. Müller. 1993. Indole-3-butyric acid in plants: Occurrence, synthesis, metabolism and transport, Minireview, Physiologia Plantarum, 88: 382-389.

Garande, V.K., M.H. Gawade, R.T. Sapkal and S.B. Gurav. 2002. Effect of IBA and number of internodes on rooting of stem cuttings of grape rootstocks. Agricultural Science Digest, 22(3): 176-178.

Geczi, L. 1974. Perlite is a suitable rooting medium for grapevine. Kerteszetes Szoleszet, 23 (9).

Hartmann, H.T., D.E. Kester, F.T. Davies and R.L. Geneve. 2002. Plant Propagation, Principles and Practices, 7th Ed., Prentice Hall Inc., New Jersey, p.880.

Howell, G.S. 1987. Vitis rootstocs. In: Rootstocs for Fruit Crops. (Eds: R.C. Rom and R.F. Carlson), John Wiley & Sons, Inc. USA, pp. 451-472.

İsfendiyaroğlu, M., E. Özeker and S. Başer. 2009. Rooting of 'Ayvalik' olive cuttings in different media, Spanish Journal of Agricultural Research, 7 (1): 165-172.

Loach, K. 1988. Controlling environmental conditions to improve adventitious rooting. In: Adventitious Root Formation in Cuttings. (Eds: T.D., Davis, B.E. Haissig and N. Sankla), Dioscorides Press, Portland, Oregon, pp. 248-279.

Kelen, M. and İ. Demirtaş. 2001. 5 BB ve 420 A Amerikan asma anaçlarının köklenme oranları ve kök kaliteleri üzerine farklı köklendirme ortamları ile IBA dozlarının etkileri. Ankara Üniversitesi Tarım Bilimleri Dergisi, 7(1):142- 146. (in Turkish)

Kelen, M. and G. Özkan. 2003. Relationships between rooting ability and changes of endogenous IAA and ABA during the rooting of hardwood cuttings of some grapevine rootstocks. European Journal of Horticultural Science, 68: 8-13.

Köse, C., S. Erdal, Ö. Kaya and Ö. Atıcı. 2011. Comparative evaluation of oxidative enzyme activities during adventitious rooting in the cuttings of grapevine rootstocks. Journal of the Science of Food and Agriculture, 91(4): 738-741.

Kracke, H., G. Cristoferi and B. Marangoni. 1981. Hormonal changes during the rooting of hardwood cuttings of grapevine rootstocks. American Journal of Enology and Viticulture, 32:135-137.

Özeker, E. and M. İsfendiyaroğlu. 2007. 'Ayvalık Yağlık' zeytin çeliklerinin oksin enjekte edilmiş fenol formaldehit köpükte köklenmesi Türkiye V. Ulusal Bahçe Bitkileri Kongresi, 4-7 Eylül 2007, Erzurum, Cilt 1: 15-19. (in Turkish)

Rieger. M. 2006. Introduction to Fruit Crops, Haworth Press Inc., Binghamton, NY, p. 462.

Sağlam, H., A. Yağcı and Ö.Ç. Sağlam. 2005. Bazı Amerikan asma anaçlarında IBA kullanımın fidan kalite ve randımanına etkileri üzerine bir araştırma. Türkiye 6. Bağcılık Sempozyumu (19-23 Eylül 2005, Tekirdağ) Bildiri Kitabı, Cilt 1:554-560. (in Turkish)

Satisha, J., P. Raveendran and N.D. Rokade. 2008. Changes in polyphenol oxidase activity during rooting of hardwood cuttings in three grape rootstocks under indian conditions. South African Journal of Enology and Viticulture, 29 (2): 94-97.

Sengel, E., B. İşçi and A. Altındişli. 2012. Effects of different culture media on rooting in grafted grapevine. Ege Üniversitesi Ziraat Fakültesi Dergisi, 49 (2): 143-148.

Sivritepe, N.and C. Türkben.2001. Müşküle üzüm çeşidinde farklı anaçların aşıda başarı ve fidan randımanı üzerine etkileri. Uludağ Üniversitesi Ziraat Fakültesi Dergisi, 15: 47-58. (in Turkish)

SPSS Inc.; (1999). SPSS Base 19.0 for Windows User's Guide. SPSS Inc., Chicago IL.

Sucu, S. and A. Yağcı. 2017. Bazı Asma Anaçları ve Bu Anaçlar Üzerine Aşılı Sultani Çekirdeksiz Çeşidinde Fidan Randımanı ve Kalite Özelliklerinin Belirlenmesi. Ege Üniv. Ziraat Fak. Derg., 54 (1): 53-59. (in Turkish)