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Effects of IBA and Cutting Dates on the Rooting Ability of Semi-Hardwood Kiwifruit (*Actinidia deliciosa* A.Chev.) Cuttings

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Abstract: The effects of 1 H-indole-3-butyric acid (IBA) and cutting date on the rooting of semi-hardwood cuttings from the kiwifruit (*Actinidia deliciosa* A.Chev.) were investigated. In rooting experiments 0, 4, 6 and 8 gl^{-1} concentrations of the IBA were used and the cuttings were taken on July 23 and August 22, 1999. The results of the study revealed that cuttings taken in July had better rooting ability in terms of main root numbers, the mean length of the longest 5 roots and rooting area. On the other hand, 6 and 8 gl^{-1} IBA concentrations did not significantly affect rooting ability. Split wounding at the base of the cuttings and dipping them into IBA for 5 and 15 sec did not improve the rooting ability of the cuttings. The rooting levels were between 76.6% and 100% for the first group of cuttings taken on July 23, 1999 and between 26% and 63.3% for the cuttings taken on August 22, 1999. The highest rooting level was obtained from the first group of cuttings which were treated with 8 gl^{-1} of IBA for 15 sec and not wounded. These yielded the highest rooting percentage of 100%. It can be concluded that cutting date significantly affected rooting ability.

Key Words: Kiwifruit, *Actinidia deliciosa*, semi-hardwood cuttings, rooting, IBA

Kivi (*Actinidia deliciosa* A. Chev.)'de Yarı Odunsu Çeliklerin Köklenmesi Üzerine IBA ve Çelik Alım Zamanının Etkisi

Özet: Bu çalışmada farklı IBA dozlarının ve çelik alma zamanının Kivi (*Actinidia deliciosa* A. Chev.) yarı odunsu çeliklerinin köklenmesi üzerindeki etkileri araştırılmıştır. Köklendirme denemelerinde 0, 4, 6 ve 8 gl^{-1} dozunda IBA hormonu kullanılmış, çelikler 23 Temmuz 1999 ve 22 Ağustos 1999 olmak üzere iki farklı zamanda alınmıştır. Yapılan çalışma sonucunda, Temmuz ayında alınan çeliklerde köklenmenin ana kök sayısı, en uzun beş kök uzunluğu ve köklenme alanı gibi incelenen özellikler yönünden, daha iyi gerçekleştiği belirlenmiştir. Öte yandan 6 ve 8 gl^{-1} IBA dozlarının ise işlemler bakımından köklenmeye anlamlı etki yapmadıkları anlaşılmıştır. Çeliklerin taban kısmının zedelenmesinin ve 5 ve 15 saniye süre ile hormona daldırılmasının da, köklenmeyi etkilemediği görülmüştür. 23 Temmuz 1999 tarihinde alınan ilk grup çeliklerde köklenme oranları % 76.6 ile % 100 arasında gerçekleşirken, 22 Ağustos 1999'da alınan ikinci grup çeliklerde köklenme oranı % 26 ile % 63.3 arasında bulunmuştur. En yüksek köklenme oranı % 100 ile 8 gl^{-1} IBA dozuna 15 saniye süreyle batırılmış normal çeliklerde gözlenmiştir. Bu sonuçlardan çelik alım zamanının köklenmeyi önemli oranda etkilediği anlaşılmaktadır.

Anahtar Sözcükler: Kivi, *Actinidia deliciosa* , yarı odunsu çelik, köklenme, IBA

Introduction

Due to the existence of suitable ecological conditions in the Eastern Black Sea Region, kiwifruit, which is new to most Turkish people, is widely cultivated in this region. Therefore, there is an increase in demand by farmers for seedlings. Imports have sometimes been used to meet this demand. However, this led to nematode related diseases and other diseases which are not seen in kiwifruit gardens nowadays, but be seen in the future (Warrington and Weston, 1990; Ağı et al., 1998).

Eastern Black Sea region is unsuitable for cultivating various kinds of agricultural products because of its geographical conditions. Opportunities related to agricultural production are very limited (Turna, 1992)

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and so it is important to choose products which can best be adapted to the Black Sea environment to obtain maximum income per unit area.

In kiwifruit adaptation studies, successful results have been achieved in the Eastern Black Sea region. It was thought that in agroforestry, the kiwifruit could be just as useful as such products as alder, hazelnut and tea which are economically important crops in the region today.

On the other hand, low seed germination capacity, seedling loses due to damping off, root infections and low levels of root formation in winter cuttings lead to propagation problems in kiwifruit (Warrington and Weston, 1990).

In this study, in order to increase the production of kiwifruit seedlings we investigated the effects of different IBA concentrations and cutting times on the rooting ability of semi-hardwood cuttings from kiwifruit.

Materials and Methods

Materials

This study was carried out at the Karadeniz Technical University, Faculty of Forestry greenhouse in 1999. Semi-hardwood kiwifruit cuttings used in this study were taken in July and August, 1999. While taking the sprouts, it is necessary to take the cuttings from the parts of the sprouts that will form the fruit branches and from the parts of the shoots which are removed during pruning and have long pruning needs (15 buds). Shoots originating from branches with fruit were not taken as cutting since the presence of fruit buds on cuttings prevents rooting (Hartman et al., 1990).

Methods

Perlite was used as a rooting substrate. The rooting media were 90 cm wide, 25 cm deep and 90 cm above the ground. Morini and Isoleri (1986) indicated in their study that the most suitable rooting substrate for kiwifruit was perlite. IBA was used as a rooting hormone. Cuttings were taken in 2 periods and 2 treatments (normal and split wounded) were formed depending on whether split wounding at the base of the cuttings was used or not. Additional information about the treatments is provided in Table 1.

Cuttings were prepared after discarding the non-hardened upper parts and the lower parts of shoots bearing 4-5 buds. From the remaining parts, from below the bud, cuttings 15-20 cm in size were obtained. Both the lower and upper parts of the cuttings were cut

Table 1. Treatments applied to the cuttings during the course of the experiment

			Cutting Time	
			Group 1 Cuttings (23.07.1999)	Group 2 Cuttings (22.08.1999)
Hormone Concentration	Time	Treatment	Sample Size	Sample Size
IBA 4 gl^{-1}	5 sec	Split wounded	30	30
		Normal	30	30
	15 sec	Split wounded	30	30
		Normal	30	30
IBA 6 gl^{-1}	5 sec	Split wounded	30	30
		Normal	30	30
	15 sec	Split wounded	30	30
		Normal	30	30
IBA 8 gl^{-1}	5 sec	Split wounded	30	30
		Normal	30	30
	15 sec	Split wounded	30	30
		Normal	30	30
Control		Split wounded	30	30
		Normal	30	30

smoothly and one leaf was left on the top of the each cutting. In order to reduce the transpiration, the leaf area was reduced by 50-80 % with cloth scissors. Treatments applied to the cuttings during the course of the experiment are given in Table 1.

Cuttings were planted into the rooting media at 5 x 5 cm spacings after they were treated with different concentration of IBA. During the rooting period, misting was established and a digital time counter was used in order to obtain regular misting. For temperature and moisture measurements, a mechanical thermograph was used.

During the rooting period, in the first group of cuttings (those taken on July 23, 1999) the mean temperature was registered as 27.5 °C and the mean moisture was registered as 69.0% in the greenhouse. In the second group of the cuttings (cuttings taken on August 22, 1999), the mean temperature and moisture were registered as 25 °C and 68.0%, respectively.

To evaluate the rooting of the cuttings in whole experiments, an 8 weeks period was taken as a basis. After 8 weeks, root counting and measurements were performed after removing the cuttings from the rooting environment. In the measurements, main root numbers, the mean length of the longest 5 roots (cm) and the rooting area on millimetric paper separated into 16 equal-sized circles were recorded.

The collected data were evaluated with the statistical program SPSS for Windows (Erdoğan, 1998). Multivariate analysis was used to test the treatment effects on rooting. Differences between the treatment effects were tested by the Student-Newman Keuls test. The Chi-square test was used to test rooting levels according to treatments and cutting dates.

Results and Discussion

Root formations were observed after putting the cuttings into a rooting environment. At the end of the 10th day, callus formation started and at the end of the 20th day adventitious root formation was observed. In order to observe adventitious rooting of the cuttings, it was sufficient to keep the cuttings in the rooting environment for 6-7 weeks.

After the statistical assessment (Table 2) made to determine the effect of the cutting date on the assessed parameters, it was determined that the cutting date had a significant effect on main root numbers, the average root length of the longest 5 roots and the rooting areas.

Between the split wounded and the normal cuttings, there was no significant difference in main root numbers, the mean length of the longest 5 roots and rooting area (Table 2). These findings suggest that split wounding at the base of the cuttings does not have any significant

Table 2. Treatment means for rooting parameters (Treatment means followed by the with same letters are not statistically significant at $P < 0.05$).

Treatments	Applications	Main root number	Mean of the longest 5 roots (cm)	Rooting area (unit)
Cutting	23.07.1999	10.97 b	5.39 b	7.39 b
time	22.08.1999	1.28 a	3.38 a	1.57 a
Treatments applied	Split wounded	6.22a	4.37a	4.61a
to cuttings	Normal	5.93a	4.38a	4.29a
	4 gl^{-1}	5.03 b	4.46 b	4.10 b
Hormone	6 gl^{-1}	7.52 c	5.49 c	5.37 c
concentration	8 gl^{-1}	8.320 c	5.00 b c	5.73 c
	Control	0.64 a	0.73 a	0.66 a
Dipping time	5 sec	6.49 b	5.35 c	5.13 b
into hormone solution	15 sec	7.46 b	4.64 b	5.04 b
	Control	0.64 a	0.73 a	0.66 a

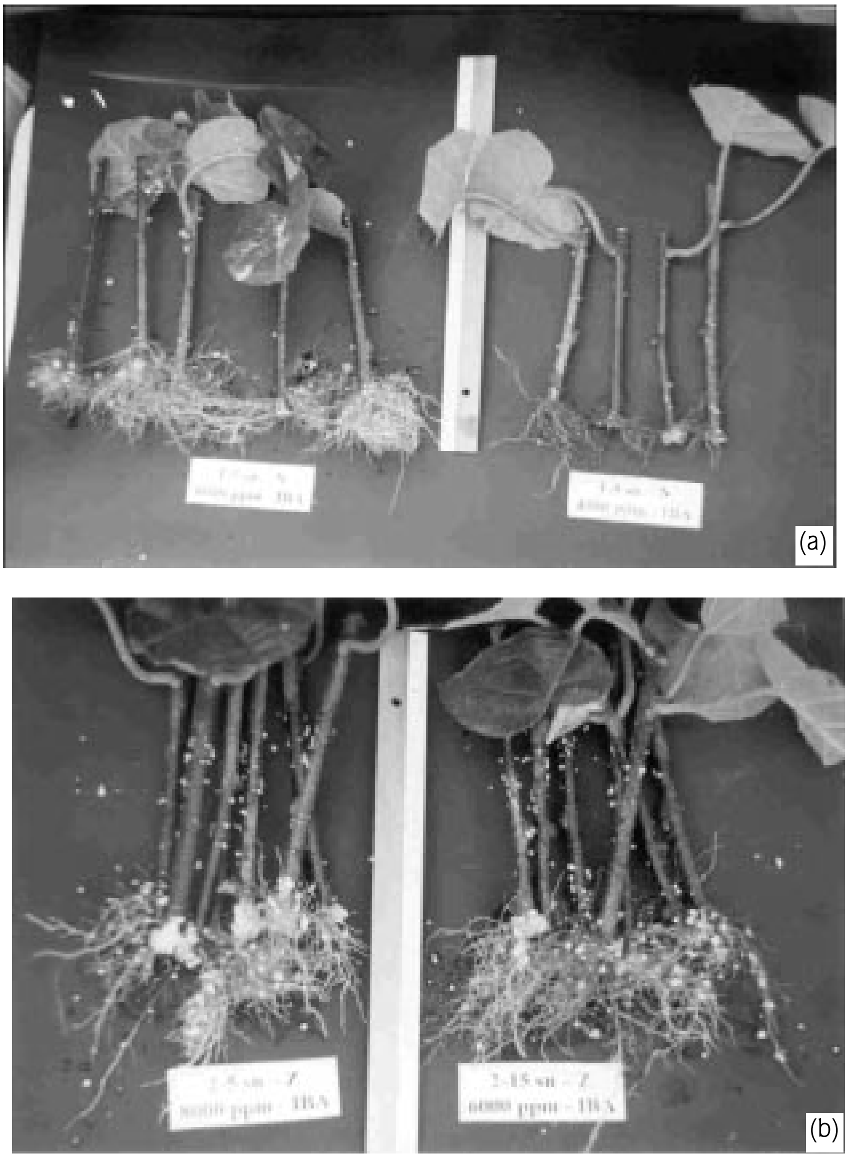

Figure. Rooting status of the normal cuttings at the end of 8 weeks. Cuttings treated with 8 gl^{-1} of IBA for 5 sec are on the top left and 4 gl^{-1} of IBA are on the top right. Rooting status of the split wounded cuttings at the end of 8 weeks. Cuttings treated with 8 gl^{-1} of IBA for 15 sec on bottom left and those treated with 6 gl^{-1} of IBA on bottom right

effect on the rooting ability of semi-hardwood cuttings in kiwifruit. Although it had a significant effect on callus formation, it had none on rooting. However, it is known that wounding at the base of the cuttings has a positive effect on rooting (Hartman et al., 1990). From the results obtained in the present study, split wounding was not a significant factor in the rooting of semi-hardwood kiwifruit cuttings (Table 2).

In the treatments for determining the effects of hormone concentration on the main root numbers, the root length and the rooting area, 8 gl^{-1} IBA concentrations produced the highest effect on the main root numbers and the rooting area (Table 2). However, 6 gl^{-1} and 8 gl^{-1} IBA doses had similar effects on the rooting characteristics of cuttings. Baraldi's study (1988) supported our findings in determining the effects of hormone concentrations on the rooting ability of kiwifruit. Both Baraldi (1988) and Samancı (1990) reported that the most effective IBA concentration range was between 4 and 6 gl^{-1}.

The effect of the hormone concentrations on the rooting area was the same with both 6 gl^{-1} and 8 gl^{-1} of IBA (Table 2). With regard to the mean length of the longest 5 roots, 6 and 8 gl^{-1} IBA concentrations had similar effects. No statistical difference was determined between them. According to these results, it seems that using 6 gl^{-1} of IBA is best to induce rooting.

It was determined that although treatment of cuttings with IBA for 5 and 15 sec had an effect on the mean of the longest 5 roots, it had no effect on the main root numbers and the rooting area. Treatment of cuttings with IBA for 5 and 15 sec had no significant effects on rooting (Table 2). Hartman et al. (1990) reported that treating cuttings with concentrated hormone solution for 3-5 sec could be adequate. Also these findings bear some similarities to those of Biasi et al. (1990), who collected cuttings every 15 days from mid-May to September. On each date cuttings were dipped for 5 s in IBA solutions of 500, 1000, 2000, 4000 and 6000 ppm. The highest rooting was obtained from cuttings collected in July-August and treated with 2000, 4000 and 6000 ppm IBA solutions.

The rooting levels were between 76.6% and 100% in the first group of cuttings, taken on July 23, 1999. The highest rooting level (100%) was obtained from the first group of cuttings treated with 8 gl^{-1} of IBA for 15 sec and not wounded. The lowest rooting level (76.6%) was obtained from cuttings treated with 4 gl^{-1} of IBA for 5 sec. The highest rooting level (between 90 and 100%) was obtained from cuttings treated with 8 gl^{-1} of IBA. A rooting level of between 86 and 96.6% was obtained when cuttings were treated with 6 gl^{-1} of IBA. Rooting levels between split wounded and normal cuttings subjected to the same treatments and cutting date were not statistically significant (Table 3). In terms of rooting levels, the first group of cuttings which were wounded and dipped into 8 gl^{-1} of IBA solution for 5 sec were statistically different from the wounded cuttings dipped into 4 gl^{-1} of IBA solution. In addition, the rooting levels

Table 3. Cutting dates and rooting levels (%).

			Cutting Time			
			Group 1 Cuttings (23.07.1999)		Group 2 Cuttings (22.08.1999)	
Hormone Concentration	Time	Treatment	Root %	Chi-Square	Root %	Chi-Square
IBA 4 gl^{-1}	5 sec	Split wounded	80	0.098 ns	63.3	0.617 ns
		Normal	76.6		53.3	
	15 sec	Split wounded	93.3	0.218 ns	30	0.082 ns
		Normal	90.0		26.6	
IBA 6 gl^{-1}	5 sec	Split wounded	86.6	0.162 ns	43.3	0.268 ns
		Normal	90.0		50.0	
	15 sec	Split wounded	96.6	1.964 ns	63.3	0.278 ns
		Normal	86.6		56.6	
IBA 8 gl^{-1}	5 sec	Split wounded	96.6	1.071 ns	60	1.071 ns
		Normal	90.0		46.6	
	15 sec	Split wounded	93.3	2.069 ns	40	0.287 ns
		Normal	100		33.3	
Control		Split wounded	30	0.341 ns	6	0.218 ns
		Normal	23.3		10	

ns: not significant at $p>0.05$

of normal cuttings dipped into 8 gl^{-1} of IBA solution for 15 sec were significantly higher than those of the cuttings dipped into 6 gl^{-1} of IBA solution for 15 sec. There was no statistical difference among the other treatments (Table 4).

In the control cuttings, the rooting level was 30% in split wounded cuttings and 23.3% in normal cuttings (Table 3). The rooting levels of the second group of cuttings were lower than those of the first group of cuttings in all treatments (The rooting levels were between 26.6 and 63.3%). There was no statistical difference in the second group of cuttings when the 6 and 8 gl^{-1} of IBA concentrations were compared (Table 4). The decrease in the rooting level of the second group of cuttings might be explained by the loss of semi-hardwood characteristic by August 22, 1999.

There are similarities between the results of the studies by Baraldi (1988) and Samancı (1990) and the results obtained in this study. Baraldi (1988) determined that the rooting level was 100% in cuttings taken in July, but only 88% in cuttings taken in September and subjected to the same treatments. On the other hand, Samancı (1990) emphasised that semi-hardwood cuttings taken in July and August yielded average rootings of 70-90%. Ferri et al. (1996) reported that after treating semi-hardwood kiwifruit cuttings collected in November with 0, 2000, 4000, 6000, 8000 ppm of IBA, the highest rate of rooted cuttings was 75.59% achieve on cuttings treated in a 6000 ppm of IBA concentration.

In a study by Mattiuz and Fachinello (1996), the best rooting level was 56.62% for the Tomuri cultivar and 47.35% for the Bruno cultivar with an 8000 ppm IBA concentration in kiwifruit cuttings collected during January and April. According to a study by Cangi et al. (2001), hardwood cuttings of the Hayward kiwi cultivar taken in February yielded the highest rooting percentage (52.22% in cuttings treated with 6000 ppm IBA). There are therefore some differences between these results and the results of Baraldi (1988), Samancı (1990) and this study. Semi-hardwood cuttings taken in July, August and September have better rooting ability than hardwood kiwifruit cuttings taken in January and April.

Based on the results of the present study, the following suggestions can be made; 1) 6 gl^{-1} of IBA and 8 gl^{-1} of IBA had similar effects on rooting and so 6 gl^{-1} of IBA can be used in rooting kiwifruit cuttings. 2) Since there is no difference in root formation between cuttings treated with IBA for 5 and 15 sec, it will be useful to treat

Table 4. Chi-square values for rooting levels according to hormone concentrations.

		Chi-square values			
		Group 1 Cuttings Hormone Concentration		Group 2 Cuttings Hormone Concentration	
Hormone concentration	Treatment	6 gl^{-1}	8 gl^{-1}	6 gl^{-1}	8 gl^{-1}
4 gl^{-1}	Split wounded (5 sec)	0.480 ns	4.043 *	2.411 ns	0.071 ns
	Normal (5 sec)	1.920 ns	1.920 ns	0.067 ns	0.267 ns
	Split wounded (15 sec)	0.351 ns	0.000 ns	6.696 **	0.659 ns
	Normal (15 sec)	0.162 ns	3.158 ns	5.554 *	0.317 ns
6 gl^{-1}	Split wounded (5 sec)		1.964 ns		1.669 ns
	Normal (5 sec)		0.000 ns		0.067 ns
	Split wounded (15 sec)		0.351 ns		3.270 ns
	Normal (15 sec)		4.286 *		3.300 ns

**: $p \leq 0.01$, * : $p \leq 0.05$, ns: not significant at $p > 0.05$

with IBA for 5 sec to save time and labour. 3) Cutting date seems to be important in root formation. It is therefore recommended that cuttings be taken at the end of the July to form roots from semi-hardwood kiwifruit cuttings in the Eastern Black Sea region of Turkey.

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