Black Sea Journal of Agriculture
Open Access Journal
e-ISSN: 2618 - 6578

BSPublishers

Research Article
Volume 1 - Issue 3: 76-82 / Jully 2018
(Cilt 1 - Sayı 3: 76-82 / Temmuz 2018)

THE EFFECT OF IBA AND PH ON ROOTING OF TEA CUTTINGS

Abdulkadir YAVAŞİ[1], Muharrem ÖZCAN[2]*

[1]*Çaykur General Directorate, 53080, Rize, Turkey*

[2]*Ondokuz Mayis University, Faculty of Agriculture, Department of Horticulture, 5513, Samsun, Turkey*

Submission: *March 05, 2018;* ***Published:*** *July 01, 2018*
*(**Gönderi:** 05 Mart 2018; **Yayınlanma:** 01 Temmuz 2018)*

Abstract

This study was conducted to investigate the effects of rooting medium pH and IBA treatments in rooting of tea cuttings. In the study, 10 tea genotypes with 'Tuğlalı' are used as materials and perlite is used as the rooting medium. In the experiment, the effects of three different pH levels (7.0, 5.5, and 3.5) and 3 different applications of IBA (0, 4000, and 6000 ppm) on rooting tea cuttings and growth of tea sprouts were investigated. According to the findings of the study, the best results in the tea plants are taken from 6000 ppm IBA and 5.5 pH applications. In 6000 ppm IBA, rooting rate is 65.26 %, the most advanced root length is 4.90 cm, the root number is 4.97 units and the root quality is defined as 1.33. In cases where the rate of rooting medium pH is 5.5, rooting rate is 69.69 %, the most advanced root length is 9.41 cm, root number is 8.70 units and root quality is seen as 1.70. As the growth rate of tea cuttings, 3.5 pH (79.28 %); in terms of the ratio of growth length, 6000 ppm IBA (7.96 cm) and 3.5 pH (9.20 cm) have given the best results. When all the results are evaluated together, 6000 ppm IBA treatment at 5.5 pH level is recommended for rooting and quality sapling production.

Keywords: Tea, Cutting, IBA, pH, Rooting

***Corresponding author:** Ondokuz Mayis University, Faculty of Agriculture, Department of Horticulture, 5513, Samsun, Turkey
E mail: muozcan@omu.edu.tr (M. ÖZCAN)

1. Introduction

Although the production of tea is done in a limited area in the Eastern Black Sea, Turkey, in terms of both the growing area and the amount of dry tea, it has the potential to meet all demands of domestic market.

The tea cultivation in Turkey has started with tea seeds brought from Georgia since 1937 and with 3788 Tea Act issued in 1940, the support of tea cultivation and tea manufacturer have been secured (Kazma, 1985).

The most convenient and widely used method of propagation the tea plant is a propagation of cuttings. In the propagation of cuttings, upon rooting of cuttings, cultural practices such as fertilization, irrigation, cuttings-(taking) making time, leaves and eye condition on cuttings, rooting medium, temperature, humidity, pH media, growth regulators environmental factors with a number of internal factors such as genetic structure, storage materials, inherent hormones are effective (Kaşka and Yılmaz, 1974; Hartmann et al., 1990). To increase the effectiveness of these factors listed above in a positive way, various researches are maintained in various topics such as cutting cropping time, cutting type, growth regulators and amount of them, rooting environment in tea production as it is in other fruits.

The first studies on the production of tea from tea cuttings started in India in 1928. However, studies on this issue in our country were started by Özbek and his friends with cooperation Rize Tea Research Institute in 1958. The rapid development of tea cultivation in our country is only possible with the use of saplings obtained from cuttings in the brood gardens built with high quality clones selected with clones selection (Çelik and Çelik, 1986).

Materials such as perlite or torf and environments such as mixture are used in rooting of cuttings. The greatest advantages of using perlite as a rooting medium are drainage and ventilation improvements, holding water and plant nutrients on the roots of plants that they can benefit all the time, affecting plant growth in a positive way due to being neutral, not allowing excessive variations in soil temperature, not transporting weed seeds and diseases, similarity of its chemical composition to the mineral component of soil, being clean, odourless and lightweight and being used for many years due to not loosing its property. Perlite which can be used as the rooting medium, needs to be super coarse thickness (Anonymous, 2003).

The pH level of the medium influences significantly on rooting. Although rooting of cuttings of fruit types in the acid and base environments are different, cuttings of most of the fruit types are better rooted in neutral environments (Yılmaz, 1994).

Since tea is a plant that does not like lime, it needs soil with acid. Generally it grows well in soils with pH 4.5 to 6.0. Except these bounds, if the soil pH goes in the direction towards acid or alkaline, the expected development of the tea plant cannot be seen (Kacar, 1986). In order to root tea cuttings, it is declared that pH media should be 4.0-4.5 and soils with pH level less than 6.0 should not be used for rooting (Eden, 1976).

The most widely used growth regulators in the rooting of cuttings is indole butyric acid (IBA) from the auxin group. IBA whose effect is fast and huge in promoting rooting is used very intense (1000-8000 ppm) and diluted (10-250 ppm) as a solution. Naphthalene Acetic Acid (NAA) is also used for rooting. NAA is more toxic, according to IBA (Weawer, 1972). The growth regulators applied to tea cuttings were found to have a positive influence on rooting compared to other regulators of IBA.

It has been observed that Naftalenaset amide (NAD) and Indolbutiric acid (IBA) from hormones used in reproduction of tea with cuttings have positive effects on rooting of tea cuttings (Çelik and Çelik, 1986).

In this conducted study, it has been aimed to determine the effects of different doses of IBA to be applied to tea cuttings and different pH levels in addition to the perlite used as a rooting media so that tea genotypes can help in rooting of cuttings.

2. Material and Method

In the study, as the plant material, Tuğlalı-10 clone which is one of the seven types determined in the region within "Development and Breeding of Tea Agriculture" Project between the years 1967-1971 in the Tea Research Institute has been used. The experiment has been conducted in an unheated glasshouse and it has been shaded with shading material made of porous dark green polyethylene whose light transmission is 50 %. Relative humidity in the greenhouse is set to be 70-90 % (Mist Line System). The temperature inside the greenhouse is at 20 °C and when relative humidity drops below 60 %, 15 minutes misting units were made every 1 hour. Misting unit has been closed between the hours of 17oo-08oo on cloudy and rainy days.

Extended super coarse perlite is used as a rooting environment. Perlites are pure silica small spheres which are formed by expanding power of the water in their body in the 900-1100 degrees after crushing, cleaning and sieving (Anonymous, 2003). It has been sought to be sterile perlite used in the experiment and new perlite is used each year. Rooting medium was thoroughly soaked before and after cuttings were planted.

Levels of pH are set one week before when the cuttings were not cropped and rooting medium was not prepared. Since the pH value of the perlite which is used as the rooting medium is 7.0, the pH was taken to 7.0 as control and in other repetitions; the pH was reduced to be pH 3.5 and pH 5.5 by adding Aluminium Sulfate (Al_2SO_4) to perlite. 3 grams Al_2SO_4 was stirred with 0.5 litres of distilled water and 32 grams of perlite in a polyethylene bag was added. After 3 hours, pH measurement was carried by inserting an electronic pH meter into perlite in polyethylene bags and as a result of measurement, pH is 3.8; in the measurement taken on the following day, it was 3.7 and the one taken after two days was 3.56. This process was repeated in the same way in the parcels, which will be planted at 3.5 pH.

To reduce pH value of perlite into 5.5, 1 gram Al_2SO_4 was mixed with 1 litre of distilled water and pH measurement was made by inserting pH meter into the 32 grams perlite in a polyethylene bag after 3 hours. In the measurements made, pH level was 5.70, the measurements made on the second day was 5.59 and in the measurements made on third day, pH level increased to 5.56. This rate was based on pH 5.5 and was applied all polyethylene planting bags in addressed parcels in the same way.

The cuttings which will be planted were taken from the garden on August 1. The taken cuttings were cut in a way which will be a leaf and a node on them and also just over the eye and at an angle of 45 against the eye and the height would be 7-10 cm and placed in a container filled with water.

On prepared cuttings, Indole Butyric Acid in the pure chemical structure is applied extensively as fresh for each use according to the intense solution method 0, 4000 and 6000 ppm. As a control solution, 100 ml mixture made with 50 % ethanol and 50 % distilled water solution was prepared. After the cuttings from the bottom of 1-1.5 cm were held in IBA solution for 8-10 seconds, they were planted in the rooting medium.

On conducted 2 years study, the cuttings were evaluated by removing them after 103 days in the first year and 90 days in the second year. In cuttings, rooting rate (%), vitality rate (%), the most advanced stem length (cm), the most advanced stem diameter (mm), root number (number), root quality (0-4 points; 0: No rooting, 1: Poor rooting, 2: Moderate rooting, 3: Good rooting, 4: Very good rooting), the proportion of the cuttings that do sprouts (%), sprout length (cm) data were collected. Experiment random parcels were prepared as 3 frequencies and 15 cuttings in every frequencies based on the experiment patterns. Data analysis was performed according to factorial designs in randomized parcels. Although this experiment took 2 years, in this article, the average results of two years are given.

3. Results and Discussion

3.1. Rotting rate

It has been observed that the effects of IBA and pH are significant on rooting percentage and the effects of interactions IBA x pH are found to be insignificant. The highest rooting rate according to different pH levels was at pH 5.5 (69.69 %). It was observed that this ratio decreased at pH 3.5 and 7.0. However, on IBA level, the highest level of rooting was taken in dose of 6000 ppm (65.26 %), while the lowest was taken from 4000 ppm (51.04 %) (Table 1). In this study, the presence of the best rates in rooting pH level of 5.5 shows similarity with the results that Yılmaz (1994) with Hamid et al. (2006)'s earned the best rooting for tea cuttings were 5.5 and 6.2 pH level.

Table 1. Effect of practices on rooting rate (%)

IBA	pH			
	7.0	5.5	3.5	Average
0	46.61±24.11	71.17±6.90	46.56±5.72	54.78^{ab*}
4000 ppm	46.50±3.50	65.56±3.70	41.05±19.56	51.04^{b}
6000 ppm	73.45±6.59	72.35±3.98	50.00±3.42	65.26^{a}
Average	55.52^{b*}	69.69^{a}	45.87^{b}	

*Significant at $P<0.05$

3.2. Vitality rate

It has been observed that the effect of pH on the vitality of cuttings are to be statistically significant, IBA and the interaction effect was found to be trivial. The highest vitality rate was seen at pH 7 (91.46 %), while the lowest rate was observed at pH 3.5 (80.00 %) (Table 2). According to the experiment results, IBA applications did not have statistically significant impact on the viability ratio. This result shows difference with the results reported by Weaver (1972) with Şeker et al. (2010) while it has some similarity with the results of the study conducted by Kalyoncu and Özer (2007) in Gilaburu. It was also defined that pH affects the ratio of vital cuttings rates.

Table 2. The effects of the applications on the viability ratio (%)

IBA	pH			
	7.0	5.5	3.5	Average
0	90.00±10.00	91.11±6.90	73.28±3.16	84.80
4000 ppm	89.00±6.90	83.45±3.25	82.11±8.46	84.82
6000 ppm	95.50±5.08	82.22±7.00	84.56±12.58	87.43
Average	91.46^{a*}	85.60^{ab}	80.00^{b}	

*Significant at $P<0.05$

3.3. The most advanced stem length

When the effects of applications on the most advanced stem length were investigated, it has been found that IBA applications and interaction show statistically significant differences. On pH level, the most advanced root length was obtained at pH 5.5 (9.41 cm), the lowest pH was obtained at 3.5 (1.90 cm). In IBA applications, the highest one was obtained (4.90 cm) from 6000 ppm application, the lowest one was obtained (2.98 cm) from the control application. In interaction level, the most advanced stem length was obtained (7.46 cm) from 6000 ppm x 5.5 pH interaction, the lowest value was at control (0 ppm IBA) x 3.5 pH (1.70 cm) (Table 3).

Table 3. The effect of applications on the most advanced root length (cm)

IBA	pH 7.0	5.5	3.5	Average
0	1.91±1.10[de]*	5.35±0.81[bc]	1.70±0.87[de]	2.98[c]*
4000 ppm	3.05±0.54[cd]	6.00±1.34[b]	2.12±0.74[cde]	3.72[b]
6000 ppm	5.35±0.93[b]	7.46±1.50[a]	1.83±0.40[ce]	4.90[a]
Average	3.44[b]*	9.41[a]	1.90[c]	

*Significant at $P<0.05$

The fact that on IBA applications level, the most advanced stem length was obtained from 6000 ppm and following this from 4000 ppm coincides with the results of the rooting study conducted in Kocayemiş by Şeker et al. (2010) and the best stem length results of rooting study conducted on the woody and semi-woody cuttings of Hayward and Matua kiwifruit types by Zenginbal and Özcan (2013) obtained in 4000 ppm and 6000 ppm. Obtaining good results from pH 5.5 application coincides with the best result at pH 6.2 from the results found among the conducted studies on cherry cuttings by Aka Kacar et al. (2001).

3.4. The most advanced stem diameter

It has been found the effects of applications on stem diameter not significant statistically and the highest root diameter has been taken from 4000 ppm IBA and 3.5 pH applications (Table 4). The fact that pH and IBA applications affect in the increasing of stem diameter coincides with the results which were done on kiwifruit types and the most advanced stem diameter in 4000 and 6000 ppm IBA application by Özcan (1993) and the results taken from hormone applications in the rooting of tea cuttings by Çelik and Çelik (1986).

Table 4. The effects of the application on the most advanced stem diameter (mm)

IBA	pH 7.0	5.5	3.5	Average
0	0.25±0.09	0.56±0.05	0.33±0.08	0.38
4000 ppm	0.36±0.06	0.60±0.09	1.13±0.95	0.70
6000 ppm	0.54±0.02	0.59±0.06	0.34±0.02	0.50
Average	0.39	0.59	0.60	

3.5. Root number (number)

Applications and interaction on root number were found statistically significant. The highest root number in pH applications was found as (6.07 units) in pH 5.5 level while the lowest root number was observed at controlling pH (pH 7). However, in IBA application, the highest root number was obtained as (4.97) in 6000 ppm and the lowest number was obtained in control application. When interaction was analysed, the highest root number was detected as (8.70 units) in 6000 ppm IBA x pH 5.5 while the lowest root number was seen as (1.35 units) in control IBA x control pH interaction (Table 5).

Table 5. The effect of applications on the root number (units)

IBA	pH 7.0	5.5	3.5	Average
0	1.35±0.55[e]*	4.08±1.00[bc]	2.24±0.89[de]	2.56[c]*
4000 ppm	1.85±0.60[de]	5.43±1.00[b]	3.38±1.40[cd]	3.56[b]
6000 ppm	3.55±0.54[cd]	8.70±1.24[a]	2.66±0.90[cde]	4.97[a]
Average	2.25[b]*	6.07[a]	2.76[b]	

*Significant at $P<0.05$

Obtaining the highest root number from IBA and pH applications and on the basis of interaction, obtaining the best root number achieved from 6000 ppm IBA x pH 5.5, reporting that 4000-6000 ppm IBA applications on kiwifruit cuttings give good results in terms of root number by Özcan (1993). It shows closely similarity with the results that Zenginbal and Özcan (2013). They have obtained highest root number from 6000 ppm IBA application in the rooting of the kiwi cuttings and to obtain the 6000 ppm IBA application and the results reported by Weaver (1972) which says that growth regulators affect produced root number and change the types of roots and IBA encourages a strong root formation. The formation of the maximum root number at pH 5.5 level shows similarity with 6.2 pH level in which Hamid et al. (2006) obtained the best results as a result of different pH applications in the rooting of tea cuttings. Rising of root number to the highest value with the application of IBA x pH overlaps exactly with previous studies aforementioned.

3.6. Root quality

It has been observed that the effects of application on root quality made significant differences while the effects of the interaction were found not significant. In practice of pH, the best root quality was obtained from pH 5.5 (1.70) while the lowest root quality level was found to be in pH 3.5 (0.69). In IBA application, the best root quality (1.33) at 6000 ppm, the lowest (0.78) in the control IBA were observed (Table 6).

Table 6. The effect of the applications on the quality of the root (0-4 points)

	pH			
IBA	7.0	5.5	3.5	Average
0	0.34±0.15	1.48±0.19	0.52±0.27	0.78[b]*
4000 ppm	0.53±0.18	1.64±0.26	0.84±0.53	1.00[b]
6000 ppm	1.30±0.08	2.00±0.26	0.71±0.22	1.33[a]
Average	0.73[b]*	1.70[a]	0.69[b]	

*Significant at $P<0.05$

Obtaining the best root quality on average from 6000 ppm application in IBA application coincides with the results that 4000-6000 ppm application increases the root quality by Caldwell et al. (1988). It also shows similarity with the results of Dumanoglu et al. (1999) that low dose of the IBA application in pear has negative effect on rooting while higher doses IBA application significantly increases rooting and root quality. The obtained results are in agreement with the results of Gabrichidze (1975) and Couvillo (1992).

3.7. The proportion of the cuttings that do sprouts

When the effects of applications on the rate of sprouts in the cuttings studied, pH shows statistically significant differences, but effects of application and the interaction of IBA were found to be insignificant. The highest proportion was taken at pH 3.5 to in pH application (79.28 %) (Table 7).

Table 7. The effect of the applications on the proportion of cuttings that do sprouts (%)

	pH			
IBA	7.0	5.5	3.5	Average
0	58.85±5.07	41.06±1.98	77.71±5.28	59.21
4000 ppm	52.33±10.25	52.21±20.41	75.56±8.29	60.04
6000 ppm	48.45±20.78	57.66±15.43	63.56±21.12	63.56
Average	53.21[b]*	50.31[b]	79.28[a]	

*Significant at $P<0.05$

It has been observed that reducing the pH level in the rooting medium increases the percentage of doing sprouts in the cuttings and was found the highest sprouts at pH 3.5. Finding the ratio of the cuttings that do sprouts at 3.5 pH shows similarity with the results in the case of reducing the medium pH to 5.0, sprouts growth increases compared to high pH in the study conducted by Hammatt and Grant (1993) in the cherry. The results that the best bulb formation is in the pH 5.0 level and bulb formation at especially pH 6.0 are negatively affected reported by Tıpırdamaz et al. (1999) in the study in snowdrops at different pH levels (6.0, 5.5, 5.0) are similar to our results.

3.8. The effects of applications on sprout length

When the effects on the sprout length were analysed, applications are significant statistically while the interaction have little impact. The best sprout length in pH application has been observed at pH 3.5 (9.20 cm), while the lowest sprout length (5.02 cm) has been observed at control pH. However, in IBA application, the best sprout length was obtained 7.96 cm in 6000 ppm while the lowest sprout length (5.97 cm) was observed at 4000 ppm (Table 8).

Finding the highest sprout length value in 6000 ppm IBA application closely overlaps with the result reported by Polat et al. (2000), sprout length prolonged more in the cuttings IBA application made compared to those not made and the results of Zenginbal and Özcan (2013), the best sprout length were obtained from the cuttings that were IBA application made in kiwifruit woody cuttings. On the basis of pH values, emergence of the highest shoot length at 3.5 pH shows similarity with the result that Hammatt and Grant (1993) has obtained with the study in the cherry, in case of reducing the medium pH into 5.0, sprout growth increases compared to the high pH and with the result that surplus nitrogen in the rooting medium causes excessive length development in the saplings; as opposed to this, phosphorus and potassium in the medium do not create height in the saplings in a study conducted by Ayan et al. (2002) on paulownia plants for the production of seedlings. It also shows some similarity with the results of Bozkurt et al. (2002) that using same amount of nitrogen affects positively sprout growth, but using phosphorus is statistically insignificant on the growth of sprouts. Giving the best results of applications and interaction is consistent with the declared results of the researches above.

Table 8. The effect of the applications on sprout length (cm)

IBA	pH			
	7.0	5.5	3.5	Average
0	5.86±0.59	4.46±1.35	9.93±2.10	6.75 ab*
4000 ppm	3.69±1.13	7.11±1.69	7.12±1.14	5.97 b
6000 ppm	5.53±2.50	7.80±1.59	10.54±1.30	7.96 a
Average	5.02b*	6.46b	9.20a	

*Significant at P<0.05

4. Conclusion

When the obtained findings are evaluated together, we can say that IBA concentrations and pH level on rooting medium have positive effects on rooting in the rooting of tea cuttings in different mediums. According to the results we obtained in this study, especially pH 5.5 level and 6000 ppm IBA application affects positively root structure of tea cuttings. It can also be said that IBA applications are effective on sprout growth and especially 6000 ppm IBA application has particular effect in a positive way. However, in order to obtain more precise results in terms of rooting performance of tea cuttings, we are in the opinion that it would be effective to evaluate it within a wider frame by doing similar studies composed of different medium and applications.

References

Aka Kacar Y, Yılmaz N, Yalçın Mendi Y, Küden A, Çetiner S. 2001. İn vitro besi ortamında kullanılan değişik katılaştırıcı maddelerin ve farklı pH düzeylerinin bazı kiraz anaçlarının çoğaltılması üzerine etkileri. I. Sert Çekirdekli Meyveler Sempozyumu, 24-28 Eylül 2001, Yalova, Türkiye, 161-166 (in Turkish).

Anonymous. 2003. Etibank Perlit İşletmesi Kayıtları, İzmir.

Ayan S, Gerçek V, Şahin A. 2002. Performation of nursery stage of paulownia sieb.&zucc. species and origins. Turk J Forest, 2: 41-56 (in Turkish).

Bozkurt MA, Cimrin KM, Gülser F. 2002. Elma ağaçlarında azotlu ve fosforlu gübrelemenin yaprak mineral kompozisyonuna ve gelişmeye etkisi. Tar Bilim Derg, 6(2): 30-34 (in Turkish).

Caldwell JD, Coston DC, Brock KH. 1988. Rooting of semi-hardwood "Hayward" kiwifruit cuttings. Amer Soc Horticul Sci, 29(4): 714-717.

Çelik H, Çelik M. 1986. Ülkemizde çelikten çay fidanı üretiminde sağlanan gelişmeler. Çaykur 2(4): 14-16 (in Turkish).

Couvillon GA. 1992. Rooting responses to different treatments. Acta Horticultural, 227: 187-196.

Dumanoğlu H, Aygün A, Alay A, Güneş NT, Özkaya MT. 1999. Ahlat'ın (Pyruselaegrifolia Pall.) yeşil çeliklerinde köklenme ve sürme üzerine çelik alma zamanı, IBA ve putrescine'in Etkileri. Türk Tarım ve Orman Dergisi, 23: 559-565 (in Turkish).

Eden T. 1976. Tea. Tropical Agriculture Series, Longman Group Limited, London, 237.

Gabrichidze Z. 1975. Improving The Technique of Striking Tea Cutting Under Mist. Horticulltural Abstract, 45(1):707.

Hamid FS, Ahmet T, Khan BM, Wahed A, Ahmet N. 2006. Effect of soil pH in rooting and growth of tea cuttings (C. sinensis L.) at nursery level. Pak J Bot, 38(2): 293-300.

Hammatt N, Grant JN. 1993. Apparent rejuvenation of mature Wild Chery (Prunusavium L.) during micropropagation. J Plant Physiol, 141: 341-346.

Hartmann HT, Kester DE, Davies FT. 1990. Plant propagation principles and practices. Prentice-Hall, Inc. Fifth Edition, New Jersey, 256-304 p.

Kacar B.1986. Çay topraklarımızda asitlilik giderek artıyor. Çaykur Derg, 2(4), 13.

Kalyoncu İH, Özer E. 2007. Gilaburu (Viburnusopulus L.)'nun yeşil çelikle çoğaltma imkanlarının araştırılması. Selçuk Üniversitesi Zir Fak Derg, 21(43): 46-52 (in Turkish).

Kaşka N, Yılmaz M. 1974. Bahçe bitkileri yetiştirme tekniği. Çukurova Üniversitesi Ziraat Fak Yayınları, Adana, 601p (in Turkish).

Kazma K. 1985. Kanunlarla dünden bugüne çay. Çaykur Derg, 1: 14-16 (in Turkish).

Özcan M. 1993. Effects of IBA doses and different cutting taking time on the rooting rate of Hardwood Cuttings of "Hayward" and "Matua" Kiwi Cultivars. Bahçe, 22(1-2): 85-90 (in Turkish).

Polat, A. A., Durgaç, C., Kamiloğlu, Ö., 2000. The effects of ındole butyric acid (IBA) on rooting of fig cuttings. Mustafa Kemal Üniv Ziraat Fak Derg, 5(1-2): 1-6.

Şeker M, Akçal A, Sakaldaş M, Gündoğdu AM. 2010. Effects of different periods and auxins concentrations on rooting ability of Strawberry Tree (Arbutus unedo L.) Cuttings Journal of Agricultural Faculty of Uludag University, 24(1): 99-108 (in Turkish).

Tıpırdamaz R, Ellialtıoğlu Ş, Çakırlar H. 1999. The Micropropagation of Snowdrop (Galanthus ikariae Baker.): Effects of different explant types, carbonhydrat sources and doses and ph changes in the medium on the bulblet formation. Turk J Agri Forest, 23(4): 823-830 (in Turkish).

Weawer RJ. 1972. Plant growth substance in agriculture. W.H. Freeman and Company. San Fransisco, 594 p.

Yılmaz M. 1994. Bahçe Bitkileri Yetiştirme Tekniği. Çukurova Üniversitesi Basımevi, Adana. 95-129 pp (in Turkish).

Zenginbal H, Özcan M. 2013. The effects of different treatments on propagation by hardwood cuttings in Hayward and Matua Kiwifruit cultivars. Anad J Agri Sci, 28(3): 115-125.