The Effect of Different Treatments on Semi-Hardwood Cutting Propagated Tea (*Camelia sinensis* L.) Clone

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Abstract- This study was carried out to determine the suitable time for preparation of cuttings, type of cuttings, and various IBA concentrations to root semi-hardwood cuttings of Turkish tea clone cultivars in Rize (Turkey), during 2010 and 2011. The cuttings were collected on 15 July and 1 August. After pre-treating with 0, 2000, 4000 and 6000 ppm IBA, the cuttings with full leaf and half leaf cuttings were rooted in perlite medium at the unheated but mist propagated glasshouse. Semi- hardwood cuttings were exposed to the rooting media for 60 days, and then, they all were removed from media to determine the survival rate, rooting rate, root number, root length, root diameter and root quality. In 2010, the survival rates were between 66.7 – 91.7 %; the rooting rates were between 38.3 – 85.0 %; the root numbers were between 3.2 – 6.4 units; the root lengths were between 8.5 – 14.8 cm; the root diameters were between 0.68 – 1.27 mm and the root qualities were between 1.91 – 3.52. In 2011, the survival rates were between 65. – 91.7 %; the rooting rates were between 51.7 – 85.0 %; the root numbers were between 3.1 – 8.5 units; the root lengths were between 8.3 – 16.6 cm; the root diameters were between 0.81 – 1.23 mm and the root qualities were between 2.33 – 3.65. The highest rooting and rooting quality were from semi hardwood cuttings prepared with full leaf cuttings on 1 August. All the cuttings were treated with 4000 and 6000 ppm IBA. The lowest rooting and rooting quality were from control (0 ppm) treatment.

Index Terms- Cutting type, IBA, collection time, rooting, *Camelia sinensis* L.

I. INTRODUCTION

The first tea cultivation in Turkey started with seeds, brought from Georgia after 1924. Today, tea has been cultivated in 75.889 hectares of total area by 201.957 farmers (PMTSI, 2012). In tea gardens of the country, mostly the genetic purity of seeds has not existed because of seed replicated plant seedlings. Generally Chinese varieties have dominated in the gardens and, in addition, many of other types occurred with different forms of morphology, physiology, quality, and yield. Continuing tea production by seed would unavoidably result in new low yielding and quality types (Ayfer et al., 1987a,b; Altındal and Balta, 2002). For these reasons today, tea has been farmed by vegetative propagation.

Vegetative propagation is a clonal method, where hybrid characters and/or genetically different off springs have not occurred. This propagation method applies grafting, cutting, tissue culture methods, and most commonly cutting. Propagation with cutting, a quicker sapling production, could overcome some difficulties, observed in grafting (Hartmann et al., 2002).

In 1928, the first experiments on cutting propagation of tea started in India, where types and varieties had important differences for rooting capabilities. Subsequent research revealed that cuttings of *Sinensis* varieties and its hybrids were rooted easily, but those of *Assamica* had some difficulties (Kinez, 1967). In Turkey, the first study on tea propagation by cutting was performed by Özbek et al. (1961), reporting auxin applications stimulated the rooting significantly. Similar results were also reported for auxin in a subsequent study on Fener tea clone (Kinez, 1967). The existence of leaf on cuttings was reported to have a positive effect generally on root formation (Hartmann et al., 2002).

To reach the desired level for tea cultivation in Turkey, it is compulsory that clonal cuttings should be produced from high yielding and quality tea types and tea plantations should be established by these cuttings. As literature revealed, no study was performed on tea production by semi hardwood cuttings in Turkey in the last decade. In the present study, the aim was to determine the effects of different cutting times, the type of cuttings, and the effect of plant growth regulators (IBA) on rooting percentage and quality of a hardly rooting tea clone, Pazar-20.

II. MATERIALS AND METHODS

The research was performed in tea garden and greenhouse of the Rize Atatürk Tea Research Institute of during 2010 – 2011. In this study, the tea plant material Pazar-20 clones were used. The garden providing the cuttings was established on a flat field (North: 41° 01 ', East: 40° 30', Altitude: 106). Soil structure was sandy – loamy. Soil analyses on soil taken in 20 cm below of soil surface were the following:

- pH: 4.65 - 5.35
- Organic matter : 0.14 - 3.96 %
- Total nitrogen content: 0.14 – 0.24
- Available P_2O_5: 13 -30 ppm
- Exchangeable K_2O: 80-370 ppm

The 20-year-old stud plants for cuttings were pruned in December and cuttings were taken from newly emerged shoots in two different times on 15 July, and 1 August respectively. Well-developed disease free cuttings with full-leaf and half-leaf shoots, 3.5 to 4 cm in length were prepared and disinfected by a fungicide (Benlate) against fungus infections. Cuttings, after treated by IBA doses of 0 (control), 2000, 4000, and 6000 ppm were transferred to rooting medium including perlite for 60 days.

Rooting was performed in unheated glasshouse and the upper part rooting media was shaded by using of porous polyethylene with 70% light transmittance. For rooting, time-dependent automatic mist-propagation system was set at 70-90% level. Accordingly, fogging period and intervals were adjusted based on the glasshouse interior temperature and relative humidity. When relative humidity increased and temperature decreased the fogging range was extended to 15 seconds in 1 hour. Fogging units are turned off in cloudy days, between the hours of 08:30 to 18:00. On rainy days, it was completely turned off.

At the end of rooting period, survival rate (%), rooting rate (%), root number (quantity), root length (cm), root diameter (mm) and root quality were determined. Experimental design was a randomized complete block design in a split plot arrangement with three replications, each having 20 cuttings. Data expressed as percentage (rooting rate and survival rate) were transformed using the arc-sin$\sqrt{x}$ transformation, and statistical analyses of transformed data were done by MSTAT-C pocket program (Russell D. Freed, Crop and Soil Sciences Department, Michigan State University). Duncan's Multiple Range Test was used to indicate the differences between the averages. The differences between the level of significance in evaluating the results were explained at 5% as important and 1% as very important.

III. RESULT AND DISCUSSION

Experiment carried out in the glasshouse where relative humidity (%) and mean temperature (^oC) were recorded during July 15 to October 1 in both years (Figure. 1 and 2). As shown in Figure 1, 2 mean daily temperatures varied from 18.6 ^oC to 29.9 ^oC in 2010 and from 12.9 ^oC to 28.6 ^oC in 2011. Mean daily relative humidity varied from 61.3 % to 88.3% in 2010 and from 62.3 % to 89.3% in 2011. These temperature and relative humidity values were compatible with those reported previously (TSMS, 2013).

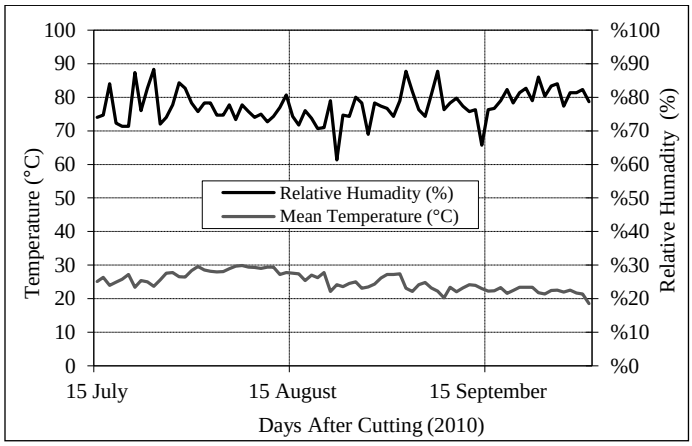

Figure. 1. Changing of mean temperature and relative humidity during the days after cutting (2010)

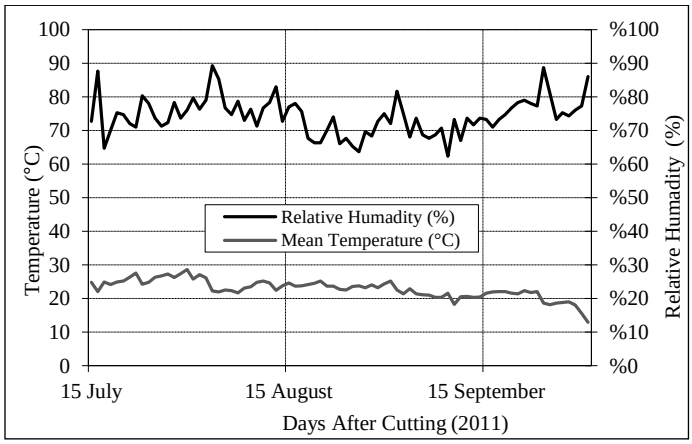

Figure. 2. Changing of mean temperature and relative humidity during the days after cutting (2011)

Survival ratio (%), rooting ratio (%), and root numbers were given in Table 1. According to these data tea cuttings had a significance effect (5%) on the survival rate in 2010, cutting time and a triple interaction. The cutting times and IBA applications had a significance (1%) effect in 2011. Other applications had insignificant effect. The survival rate varied from 66.7% to 91.7 % in 2010 and from 65.0% to 91.7% in 2011. The best results for cutting time were once in every two years (82.3%, 81.3% respectively), on July 15; for type of cuttings full leaf cuttings in 2010 (79.6%), half leaf cuttings in 2011 (79.4%); 6000 ppm IBA applications for the first year (85.1%), second year in a 4000 ppm (87.5%). The rooting rate was very significant applications of IBA (every two years), cutting time and cutting time x IBA applications (in 2011) important effect. Rooting rate varied from 85.0% to 38.3% in 2010 and from 51.7% and 85.0% in 2011. The best results were obtained for the cuttings on 15 July on the full leaf leaved 4000-6000 ppm IBA treatment. The control group had the lowest results for cuttings. When looked at the impact on the root number of applications in 2010, cutting time, type of cutting, and IBA applications had a significant effect. In 2011, the IBA applications and cutting time had a significant effect. The number of root varied from 3.2 to 6.4 units in 2010 and from 3.1 to 8.5 units in 2011. The best results in 2010 and 2011 (6.4 units and 8.5 units, respectively) taken on August 1 and 6000 ppm IBA treatment based on the full leaf cuttings were prepared.

The results of the most improved root length (cm), the diameter (mm) and the root quality (0-4 points) were in Table 2. Based on these results over, the improved root length in 2010, IBA applications significant, type of cutting was very significant; in 2011, the cutting time is significant, cutting type and doses of IBA were very significant impacts. The root lengths varied from 8.5 to 14.8 cm in 2010 and from 8.3 to 16.6 cm in 2011. The best results (14.8 cm and 16.6 cm respectively) were taken from the full leaf cuttings prepared on August 1, in 2010 4000 ppm, in 2011 6000 ppm IBA application. On the root diameter in 2010, cutting time, the cutting type and IBA applications were very important; in 2011, only application of IBA was very significant. The root diameters varied from 0.81 mm to 1.27 mm in 2010 and from 0.81 mm to 1.23 mm in 2011. The best results (1.27 mm and 1.23 mm respectively), taken on August 1 prepared the full leaf cuttings; in 2010 0 ppm (control), in 2011 4000 ppm IBA has been application. Analyzed data on the root quality in 2010, the cutting type and cutting time x cutting type x IBA application is important, IBA application is very important; in 2011, the IBA application was very significant, cutting time x cutting type x IBA application was significant. The quality of the root varied from 1.91 to 3.52 in 2010; from 2.33 to 3.65 in 2011. Every two years, the best result (3.52 and 3.65) was prepared on August 1 and 6000 ppm IBA treatment on the full leaf cutting has been made.

As a result of all these findings, among all parameters the best cutting type was full leaf cutting, 4000 and 6000 ppm IBA was the most appropriate dose. Survival and rooting rate parameters on July 15 was the most suitable time for cutting time, for the other parameters August 1 was determined. As a result, applications of IBA increased rooting. Indeed, Weaver (1972) stated that growth regulators changed the number and the type of root and IBA was a manufacturer of the strong fringe root. Khan

et al. (1991) and Gyana (2006) also reported that treating cuttings with auxins (IBA) increased the percentage of rooting, root initiation, root number and as well as uniformity of roots in *Camelia sinensis*. Researchers, who studied the cutting reproduction of tea (Özbek et al., 1961; Ayfer et al., 1987a) obtained similar results. In terms of cutting time, rooting was better on 1 August. Kinez (1967), in a tea propagation study by cutting in Rize, cuttings taken in the beginning and in the middle of August resulted in higher results. Eliadze et al. (1978), tea cuttings taken during June to October, and vitality and rooting rate of cuttings increased from June to August, and then decreased. Also Gabrichidze et al. (1976) in their study cutting taken in April, August and October. The cuttings taken in August compared with April, October due to the low N and high sugar levels in August described as were the best cutting time in terms of rooting and root number. In terms of type of cutting to the full-leaf cutting had better results than a half-leaf cuttings. In cutting the leaves and buds, prepared had a positive effect on the number of root and root formation, Hartmann et al. (2002), the presence of leaf cuttings physiological and morphological report of activities carried out more quickly.

This study was conducted with for standard varieties, which is an important step to increase the yield and quality in this study for the production of seedlings, propagated the possibilities of usage tea cutting; cutting time, cutting type and different applications of growth regulators effects on rooting percentage and root quality were determined. As a result of this study, rooting of Pazar-20 Turkish tea clones cuttings for rooting in order to ensure a successful, good selection of cuttings and appropriate conditions must necessary. Therefore misting and shading systems unit cutting should be rooting under system with. In addition, tea cuttings on August 1, as a single full leaf should be prepared and 4000 - 6000 ppm IBA should be applied. Perlite is used then as the rooting medium.

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Table 1. Effect of tea cutting of different collection time, type of cutting and IBA dozes cutting survival rate (%), rooting rate (%) and root number (unit/cutting)

Year	Collection Time	Type of Cutting	Survival Rate (%)					Rooting Rate (%)					Root Number (unit / cutting)				
			IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)				
			0	2000	4000	6000	Ortalama	0	2000	4000	6000	Ortalama	0	2000	4000	6000	Ortalama
2010	15 July	Half – Leaf	91.7 a	66.7 b	86.7 ab	80.0 ab	81.3	70.0	45.0	80.0	70.0	66.3	3.5	3.9	4.0	3.5	3.7
		Full – Leaf	81.7 ab	86.7 a	73.3 ab	91.7 a	83.4	48.3	71.7	61.7	85.0	66.7	3.2	5.0	5.8	6.1	5.0
		Mean	86.7	76.7	80.0	85.9	82.3 a*	59.2	58.4	70.9	77.5	66.5	3.4	4.5	4.9	4.8	4.4 b**
	1 August	Half – Leaf	66.7 b	70.0 ab	70.0 ab	91.7 a	74.6	40.0	50.0	63.3	83.3	59.2	4.2	3.4	4.8	5.1	4.4
		Full – Leaf	73.3 ab	73.3 ab	80.0 ab	76.7 ab	75.8	38.3	58.3	76.7	76.7	62.5	5.0	5.4	5.9	6.4	5.7
		Mean	70.0	71.7	75.0	84.2	75.2 b*	39.2	54.2	70.0	80.0	60.9	4.6	4.4	5.4	5.8	5.1 a**
	Overall Mean Half – Leaf		79.2	68.4	78.4	85.9	78.0	55.0	47.5	71.7	76.7	62.7	3.9 c	3.6 c	4.4 c	4.4 c	4.1 b**
	Overall Mean Full – Leaf		77.5	80.0	76.7	84.2	79.6	43.3	65.0	69.2	80.9	64.6	4.1 c	5.2 b	5.9 ab	6.2 a	5.3 a**
	Overall Mean IBA		78.4	74.2	77.6	85.1	78.8	49.2 c	56.3 bc	70.5 ab	78.8 a	63.7	3.9 c	4.4 bc	5.2 ab	5.3 a	4.7
			$LSD_{5\%}$ (Collection time x Type of Cutting x IBA): 14.57					$LSD_{1\%}$ (IBA): 10.27					$LSD_{1\%}$ (IBA): 0.73, $LSD_{5\%}$ (Type of Cutting x IBA): 0.76				
2011	15 July	Half – Leaf	71.7	76.7	91.7	86.7	81.7	56.7	68.3	85.0	81.7	72.9	3.1	5.8	7.7	8.1	6.2
		Full – Leaf	68.3	75.0	90.0	90.0	80.8	51.7	70.0	83.3	85.0	72.5	3.3	6.2	7.9	8.2	6.4
		Mean	70.0	75.9	90.9	88.4	81.3 a**	54.2 d	69.2 c	84.2 a	83.4 a	72.7 a*	3.2	6.0	7.8	8.1	6.3 a*
	1 August	Half – Leaf	65.0	71.7	85.0	86.7	77.1	53.3	63.3	76.7	78.3	67.9	3.3	6.0	7.6	7.9	6.2
		Full – Leaf	66.7	70.0	83.3	85.0	76.3	51.7	70.0	78.3	75.0	68.8	3.4	6.2	8.4	8.5	6.5
		Mean	65.9	70.9	84.2	85.9	76.7 b**	52.5 d	66.7 c	77.5 b	76.7 b	68.3 b*	3.4	6.1	7.8	8.2	6.4 b*
	Overall Mean Half – Leaf		68.4	74.2	88.4	86.7	79.4	55.0	65.8	80.8	80.0	70.4	3.2	5.8	7.6	8.0	6.2
	Overall Mean Full – Leaf		67.5	72.5	86.7	87.5	78.6	51.7	70.0	80.8	80.0	70.6	3.3	6.2	8.0	8.3	6.5
	Overall Mean IBA		68.0 c	73.4 b	87.5 a	87.1 a	79.0	53.4 c	67.9 b	80.8 a	80.0 a	70.5	3.3 c	6.0 b	7.8 a	8.2 a	6.4
			$LSD_{1\%}$ (IBA): 1.66					$LSD_{1\%}$ (IBA): 2.31, $LSD_{5\%}$ (Collection time x IBA): 3.43					$LSD_{1\%}$ (IBA): 0.46				

* Values not associated with the same letter are significantly different (P<.005) ** Values not associated with the same letter are significantly different (P<.001)

Table 2. Effect of tea cutting of different collection time, type of cutting and IBA dozes the root length (cm), diameter (mm) and root quality (0-4 poin)

Year	Collection Time	Type of Cutting	Root Length (cm)					Root Diameter (mm)					Root Quality (0-4 points)				
			IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)					IBA Hormone Doses (ppm)				
			0	2000	4000	6000	Mean	0	2000	4000	6000	Mean	0	2000	4000	6000	Mean
2010	15 July	Half – Leaf	10.0	12.1	13.3	9.2	11.2	0.81	0.84	0.83	0.68	0.79	2.83 ac	3.14 ac	2.95 ac	2.80 ac	2.93
		Full – Leaf	8.5	12.2	13.7	12.8	11.8	0.95	0.85	0.83	0.80	0.86	2.32 cd	2.95 ac	3.20 ab	3.49 a	2.99
		Mean	9.3	12.2	13.5	11.0	11.5	0.88	0.85	0.83	0.74	0.82 b**	2.58	3.05	3.08	3.15	2.96
	1 August	Half – Leaf	9.9	9.8	12.0	11.0	10.7	1.20	1.03	0.99	0.92	1.04	2.47 bd	1.91 d	2.81 ac	3.33 a	2.63
		Full – Leaf	13.0	14.1	14.5	14.8	14.1	1.27	1.21	1.03	1.05	1.14	3.01 ac	3.01 ac	2.90 ac	3.52 a	3.11
		Mean	11.5	12.0	13.3	12.9	12.4	1.24	1.12	1.01	0.99	1.09 a**	2.74	2.46	2.86	3.43	2.87
	Overall Mean Half – Leaf		10.0	11.0	12.7	10.1	11.0 b**	1.01	0.94	0.91	0.80	0.91 b**	2.65	2.53	2.88	3.07	2.78 b*
	Overall Mean Full – Leaf		10.8	13.2	14.1	13.8	13.0 a**	1.11	1.03	0.93	0.92	1.00 a**	2.67	2.98	3.05	3.51	3.05 a*
	Overall Mean IBA		10.4 b	12.1 ab	13.4 a	12.0 ab	12.0	1.06 a	0.98 ab	0.92 bc	0.86 c	0.96	2.66 b	2.75 b	2.97 ab	3.29 a	2.92
				$LSD_{5\%}$ (IBA): 1.97					$LSD_{1\%}$ (IBA): 0.09					$LSD_{1\%}$ (IBA): 0.49 $LSD_{5\%}$ (Collection time x Type of Cutting x IBA): 0.73			
2011	15 July	Half – Leaf	8.3	13.4	15.1	15.1	13.0	0.81	0.86	1.04	1.09	0.95	2.33 d	2.64 bd	3.47 a	3.53 a	2.99
		Full – Leaf	8.4	14.7	15.9	15.7	13.7	0.81	0.93	1.09	1.10	0.98	2.40 cd	2.77 bc	3.56 a	3.63 a	3.09
		Mean	8.4	14.1	15.5	15.4	13.3 b*	0.81	0.89	1.07	1.09	0.97	2.37	2.71	3.52	3.58	3.04
	1 August	Half – Leaf	8.5	13.8	15.4	15.6	13.3	0.83	0.89	1.01	1.04	0.94	2.36 d	2.87 b	3.51 a	3.57 a	3.08
		Full – Leaf	8.6	15.1	16.6	16.1	14.1	0.87	0.89	1.23	1.09	1.02	2.39 cd	2.97 b	3.57 a	3.65 a	3.15
		Mean	8.6	14.5	16.0	15.8	13.7 a*	0.85	0.89	1.12	1.07	0.98	2.37	2.92	3.54	3.61	3.11
	Overall Mean Half - Leaf		8.4	13.6	15.3	15.4	13.2 b**	0.82	1.02	0.84	1.16	0.95	2.34	2.76	3.49	3.55	3.04
	Overall Mean Full - Leaf		8.5	14.9	16.3	15.9	13.9 a**	0.88	1.06	0.91	1.10	1.00	2.40	2.87	3.57	3.64	3.12
	Overall Mean IBA		8.5 c	14.3 b	15.8 a	15.6 a	13.5	0.83 b	0.89 b	1.09 a	1.08 a	0.99	2.37 c	2.82 b	3.53 a	3.60 a	3.08
				$LSD_{1\%}$ (IBA): 0.64					$LSD_{1\%}$ (IBA): 0.11					$LSD_{1\%}$ (IBA): 0.24 $LSD_{5\%}$ (Collection time x Type of Cutting x IBA): 0.35			

* Values not associated with the same letter are significantly different (P<.005) ** Values not associated with the same letter are significantly different (P<.001)