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Effects of Thickness of Hardwood Black Mulberry Cuttings on Rooting and Sapling Performance

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Abstract: The study examined the effect of wood cutting thickness on rooting and sapling performance in black mulberry. The wood cuttings taken in December, classified into three groups according to their diameter, immersed in a 5000 ppm IBA solution for five seconds, and then planted in a sub-heated perlite condition with three replicates. Rooting ratio, number of roots and root length were measured in cuttings which were kept in perlite for 90 days. Relationship between cutting diameter and cutting weight with rooting data was examined by regression analysis. When vegetative growth was stopped; the effects of initial cutting diameter, cutting weight and root characteristics on the sapling quality expressed as plant diameter, weight and height, root length and number were evaluated by multiple regression analysis. In the study, while rooting rate in all cuttings was found to be 47.11%, the percentage of rooting was determined in thin cuttings as 28.18%, in middle thick cuttings as 63.70 and 100% in thick cuttings. Simple and multiple regression analyzes showed that there were also low relationships between the initial data like cutting diameter, cutting weight, root number and root length of rooted cuttings with sapling quality expressed as plant diameter, weight, height, root length.

Keywords: *Morus nigra* L., rooting ratio, callusing ratio, root number, Root length

Karadut Odun Çeliklerinde Çelik Kalınlığının Köklenme ve Fidan Performansı Üzerine Etkisi

Öz: Çalışmada karadut odun çeliklerinde çelik kalınlığının köklenme ve fidan performansı üzerine etkisi incelemiştir. Kasım döneminde alınan odun çelikleri çap kalınlığına göre üç gruba ayrılmıştır. Çeliklere 5000 ppm IBA uygulaması yapılarak köklendirme ortamına üç tekerrürlü olarak dikilmiştir. Köklendirme ortamında 90 gün bekletilen çeliklerde köklenme yüzdesi, kök sayısı ve kök uzunluğu ölçülerek; çelik çapı ve çelik ağırlığı ile köklenme verileri arasındaki ilişki regresyon analizi ile incelenmiştir. Köklenen çeliklerin başlangıç verileri kaydedilerek vejetatif büyümenin durduğu dönemde fidan performansı olarak değerlendirilen; toprak seviyesindeki çap, bitki boyu, toplam sürgün uzunluğu, yan sürgün sayısı, toplam yaprak sayısı ve fidan ağırlıkları belirlenmiştir. Fidan kalitesi üzerine başlangıçtaki çelik çapı ve çelik ağırlığı, çelik başına kök sayısı ve kök uzunluğunun etki payları çoklu regresyonla değerlendirilmiştir. Çalışmada ince (6-10 mm) çeliklerde köklenme yüzdesi %28.18, orta (10-15 mm) kalınlıktaki çeliklerde köklenme yüzdesi %63.70 ve kalın (15-20 mm) çeliklerde de %100 olarak belirlenirken, çelik çapı dikkate alınmadığında tüm çeliklerde köklenme oranı %47.11 olarak tespit edilmiştir. Fidan performansı; fidan ağırlığı, fidan kök sayısı, fidan kök uzunluğu, fidan kök çapı, fidan sürgün uzunluğu, fidan sürgün çapı, fidan boğum sayısı ve fidan yaprak sayısı ile çeliklerde ölçülen çelik çapı, çelik ağırlığı, çelik kök sayısı, çelik kök uzunluğu arasındaki ikili ve çoklu regresyonlarda düşük ilişkiler saptanmıştır.

Anahtar Kelimeler: *Morus nigra* L., köklenme oranı, kallüslenme oranı, kök sayısı, kök uzunluğu

1. Introduction

Mulberry varieties have quite a high adaptation capability, therefore, are grown in every region throughout the world. Mulberry leaves are rich in protein and commonly used in nutrition of silkworms in silk-farming. On the other hand, mulberry have recently become prominent in Turkey. Mulberry fruits are generally consumed as fresh or dried. They are also processed into molasses, churchkhela, fruit juice concentrate, wine and liquor, vinegar, ice-cream and ethyl alcohol. In recent years, black mulberry fruits, rich in antioxidants and phytochemicals, have become even more prominent (Huo, 2002; Machii et al., 2002; Megep, 2007).

Most fruit species are not propagated by seeds due to their heterozygous nature and vegetative propagation methods are applied in these species. Layering and tissue culture propagation techniques have been practiced, but plant propagation by cuttings is easier and more practical, thus more commonly used today.

Grafting success is reduced, even inhibited in mulberry tree propagation by grafting since a milk-like secretion is formed at grafting and there is a hallow section beneath the bud eye (Unal et al. 1992). Studies about mulberry propagation by layering are scarcely any (Saracoglu et al. 2016). Majority of berry fruits could easily be propagated by cuttings. However, some problems and difficulties are encountered in propagation of black mulberry by cuttings and different outcomes were reported in black mulberry propagation studies (Ozkan and Arslan, 1996; Koyuncu et al., 2003). Low rooting levels were reported in majority of previous studies (Unal et al. 1992; Karadeniz and Sisman, 2003; Koyuncu and Senel, 2003), but sufficient rooting levels were also reported in some studies (Yildiz and Koyuncu, 1999; Erdogan and Aygun, 2006).

Just because of difficulties encountered in propagation of black mulberry (Yildiz et al. 2009), black mulberry saplings are insufficient in put on the demands of growers and thus saplings are sold at high prices (Saracoglu et al. 2016).

Previous studies mostly focused on cutting-taking periods and hormone doses and the number of studies about cutting quality is quite limited. On the other hand, majority of the previous studies sustained at rooting success of the cuttings and studies about final take ratios and conversion into sapling ratios of rooted cutting, sapling performance and similar parameters directly toward cater to the sapling needs of growers are still scarcely any. Despite high number of studies, still problems encountered in sufficient sapling supply.

In present study, a single dose, as recommended by several researchers (Ozkan and Arslan, 1996; Yildiz et al. 2009), was experimented on hardwood cuttings of black mulberry and effects of cutting diameter and cutting weight on rooting success were investigated. Besides, effects of these parameters on sapling performance of initial cutting and rooting data-recorded cuttings at the end of one-year vegetation period were also focused on. In this sense, pairwise and multiple correlations in outcomes obtained with the initial data on both rooting success and sapling performance were assessed. From this point of view, objective of the present study is directly toward to focus on the sapling limiting problem encountered for mulberry growers.

2. Material and Method

In the study, hardwood cuttings taken from a local black mulberry genotype with larger fruits and high yielding, in Tokat province in December were used. Bottom buds of the cuttings were blunted and 20-25 cm long cuttings were prepared. Cutting diameters were measured from 5 cm above the bottom of the cutting and cuttings were grouped as: thin (6-10 mm), medium (10-15 mm) and thick (15-20 mm). Prepared cuttings were subjected to fungicide (3% Benlate) treatments and kept for 10 minutes. Cutting were then treated with 5000 ppm IBA. Cuttings were planted into perlite-filled trays with bottom heat (18-24 °C) at the have 2/3 of the cutting into the perlite in randomized block design with 3 replications and 10 cuttings in each replicate. Following 90 days in rooting media, callusing and rooting rates was assessed through Duncan’s analysis.

After taking the cuttings from rooting media, post-rooting characteristics of the cuttings (cutting diameter, cutting weight, number of roots and root length) were also recorded and cuttings were planted in 10 liter pots (1:1:1; peat:perlite:soil) with initial data labeled and cultural practices were performed throughout the vegetation period.

At the end of the vegetation period data of some sapling properties (sapling weight, sapling diameter, shoot diameter, root diameter, shoot length, root length, number of roots), measured for each sapling after removed from the soil were evaluated and correlated with the cutting properties. Sapling performances were also recorded by using the ratio of marketable saplings to the cuttings used at the beginning of experiment.

Multiple regression analysis was also conducted with the cutting diameter, cutting weight, number of roots per cutting and root lengths as independent variables to determine the effects of these parameters on number of shoots and shoot length four months after planting and on sapling weight, sapling number of roots, sapling number of nodes, shoot diameter, shoot length and number of leaves at the end of vegetation season.

3. Results

Callus formation ratios, rooting ratios, number of roots and root length values of present cuttings separated into three different thickness groups were compared. Remarkable increases were observed in callusing and rooting ratios with increasing cutting thicknesses. While 32.88% callusing was observed in thin cuttings and 71.11% in medium-thick cuttings, thick cuttings all developed callus. A similar case was also seen in rooting. Rooting was seen only 28.18% of thin cuttings and rooting success reached to 63.7% in medium-thick cuttings. On the other hand, 100% rooting was achieved in thick (15-20 mm) cuttings. Average number of roots per cutting was 9.97 in medium-thick cuttings, 5.79 in thin cuttings and 5.81 in thick cuttings. However, differences in number of roots per cutting of different thickness groups were not found to be significant. In terms of root lengths, thick cuttings had longer roots than thin cuttings (Table 1).

In terms of sapling performance (transformation into sapling), 9.39% of thin cuttings turned into sapling, 30.37% of medium-thick and 63.63% of thick cuttings tuned into sapling. Considering the entire cuttings regardless of cutting thickness, overall sapling performance was measured as 34.45% (Table 1).

Table 1. Callusing, rooting, number of roots, root length and sapling performance values of black mulberry cuttings
Çizelge 1. *Karadut çeliklerinin kalluslenme oranı, köklenme oranı, kök sayısı, kök uzunluğu ve fidan performansı ortalama değerleri*

Type of Cutting	Callusing Ratio (%)	Rooting Ratio (%)	Number of Roots	Root Length (mm)	Sapling Performance (%)
Thin Cuttings (6-10 mm)	32.88 C	28.18 C	5.79 A	30.50 B	9.39
Medium-thick Cuttings (10-15 mm)	71.11 B	63.70 B	9.97 A	31.62 AB	30.37
Thick Cuttings (15-20 mm)	100.00 A	100.00 A	5.81 A	38.17 A	63.63
Average	52.88	47.11	8.40	31.80	34.45

*The means indicated with the same letters in the same columns are not significantly different and the means with different letters are significantly different

Before the planting, diameter and weight of each cutting were determined and relationships of these values with root lengths were investigated with the use of regression analysis. Root lengths did not have a linear relationship with cutting diameter and cutting weight (Figure 1).

Effects of some parameters measured before planting and after rooting on sapling performance were also investigated. A linear relationship was observed between cutting diameter and cutting weight measured before planting and sapling diameter measured after growing season. There was a linear relationship between sapling diameter and cutting diameter with a coefficient of determination of 0.63 (Figure 2a) and between sapling diameter and cutting weight with a coefficient determination of 0.61 (Figure 2b). Such findings indicated that more than 60% of the change in sapling diameter could be explained with the change in cutting diameter or cutting weight.

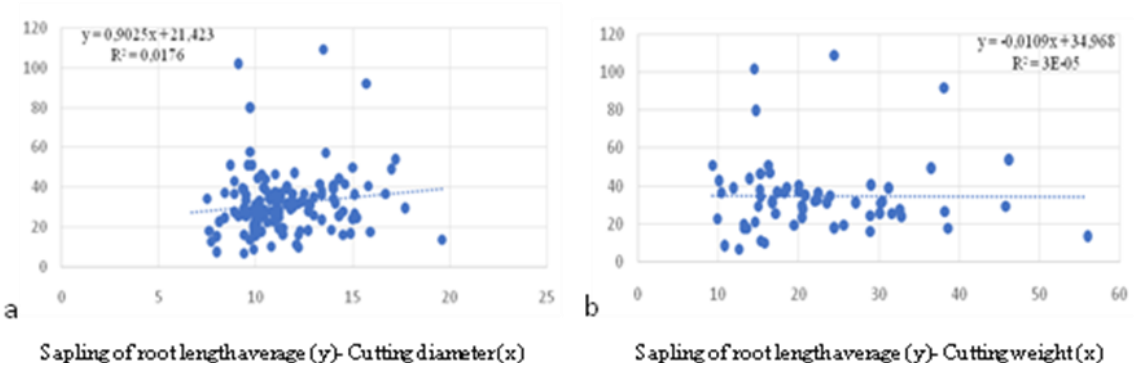

Figure 1. Relationships of root length (y) with cutting diameter (x) (a); number of roots (y) and cutting weight (x) (b)

Şekil 1. *Kök uzunluğu ortalaması (y) ile çelik çapı (x) (a); kök sayısı (y) ile çelik ağırlığı (x) (b) arasındaki regresyon ilişkisi*

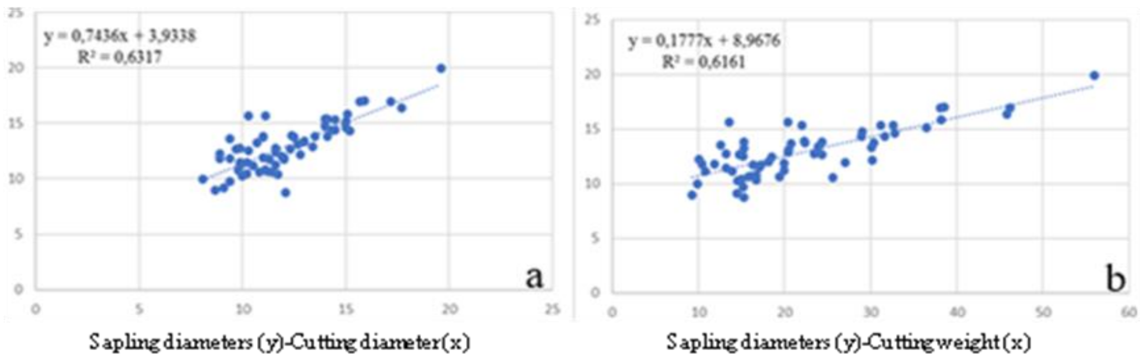

Figure 2. Relationships of black mulberry sapling diameters with initial cutting diameter (a), cutting weight (b)

Şekil 2. *Karadut fidan çaplarının başlangıçtaki çelik çapı (a), çelik ağırlığı (b), çelik kök sayısı (c) ve çelik kök uzunluğu (d) değerleriyle ikili ilişkisi*

Regression analysis was conducted to determine the effects of cutting diameter and cutting weight on sapling number of roots measured at the end of vegetation period and a linear relationship was observed between cutting diameter-weight and sapling number of roots (Figure 3a and 3b). A linear relationship was observed in regression analysis conducted to determine if the sapling number of roots changed with cutting number of roots and root length (Figure 3c and 3d).

Following equations were also obtained at the end of the stepwise regression analysis conducted to determine the best model.

Number of shoots = 1.34203 + 0.00777 x (Cutting number of roots) + 0.00724 x (Average of cutting root length), (R^2=0.057).

Average shoot length = 24.12275 -0.22274 x (Cutting weight) + 0.87393 x (Cutting number of roots) + 0.05249 x (Average of cutting root length), (R^2=0.1475).

Sapling weight = 40.52901 + 0.98028 x (Cutting weight) + 1.95294 x (Cutting number of roots) + 0.55440 x (Average of cutting root length), R^2=0.1401.

Sapling number of roots = 14.17980 - 0.23268 x (Cutting diameter) + 0.52818 x (Cutting number of roots) + 0.00271 x (Average of cutting root length), (R^2=0.2562).

Sapling root diameter = 3.59084 -0.03292 x

(Cutting number of roots) + 0.01159 x (Cutting root length), (R^2=0.09).

Sapling root length = 30.26176 + 3.43963 x (Cutting diameter) – 0.97091 x (Cutting weight) + 0.02360 x (Average of cutting root length), (R^2=0.06).

Sapling shoot diameter = 7.24183 + 0.06789 x (Cutting number of roots) + 0.02460 x (Average of cutting root length), (R^2=0.05).

Sapling shoot length = 39.54561 – 0.00190 x (Cutting diameter) + 0.78824 x (Cutting number of roots) + 0.19684 x (Average of cutting root length), (R^2=0.058).

As can be inferred from the above-given linear equations, determination coefficients (R^2) were quite low. Such a case indicate that a significant linear relationship was not achieved between dependent and independent variables.

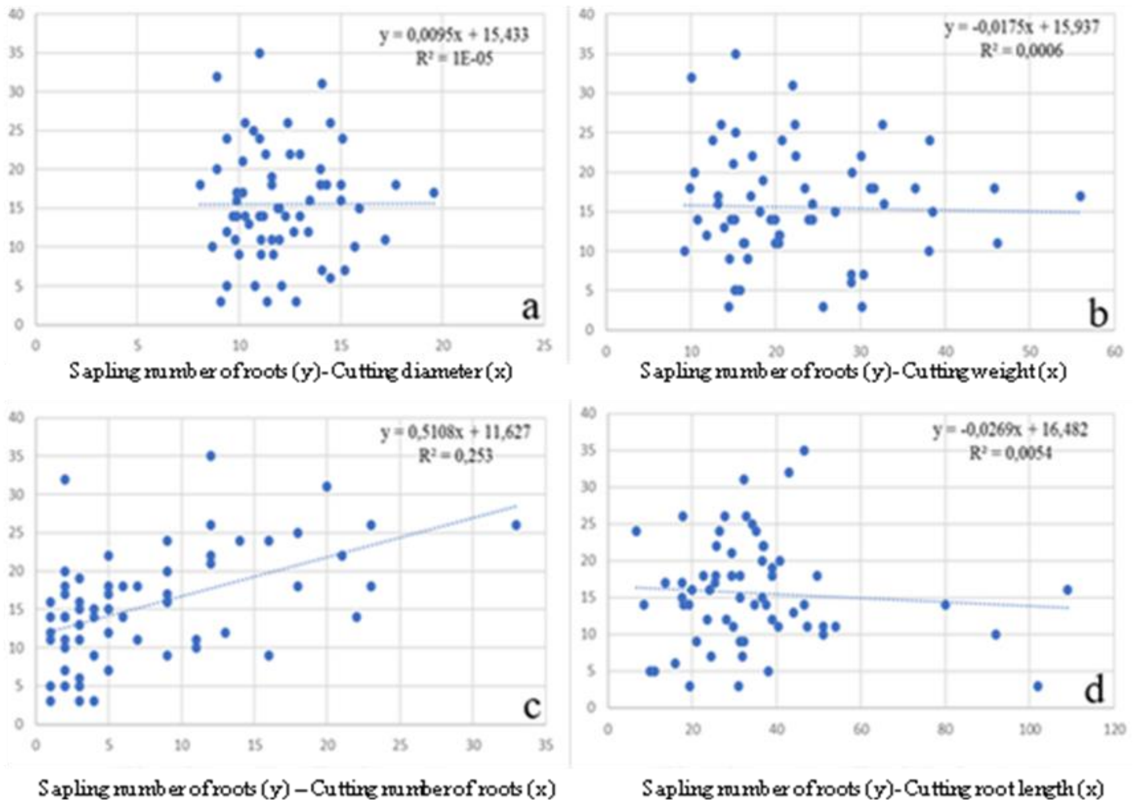

Figure 3. Relationships of mulberry sapling number of roots with initial cutting diameter (a), cutting weight (b), cutting number of roots (c) and cutting root length (d) values

Şekil 3. *Karadut fidan kök sayısının başlangıçtaki çelik çapı (a), çelik ağırlığı (b), çelik kök sayısı (c) ve çelik kök uzunluğu (d) değerleriyle ikili ilişkisi*

4. Discussion and Conclusion

Although 100% rooting was achieved in thick cuttings, overall rooting ratio was 47.11% and sapling performance was 34.45%. It is hard to get cuttings always at the same thickness, therefore, there is a need for further studies to improve rooting ratios and sapling performance in mulberries.

It was observed in present study that cutting thickness significantly influenced rooting success and increasing rooting ratios were observed with increasing cutting thickness. Similar findings were also reported by Sezgin (2009) indicating greater rooting success for mulberry hardwood cuttings taken from bottom sections of the shoots than for the cuttings taken from tip sections of the shoots. In present study, since thick cuttings were taken from bottom sections of the shoots, high rooting ratios were achieved in thick cuttings. Such a high rooting success in thick cuttings of Sezgin (2009) and present study taken from bottom sections of the shoots were mostly attributed to carbohydrate accumulation. Thusly, it was indicated in Megep (2007) that carbohydrate accumulation had positive effects on rooting success and a general idea could be achieved on carbohydrate content by examination of the hardness of the shoot from which cuttings are to be taken. Present rooting percentages expressed based on cutting thicknesses may offer practical information to growers who are to use cuttings for propagation of mulberry trees.

Besides the effects of cutting diameter on rooting ratios, it had also a linear relationship with sapling diameter at the end of vegetation and initial cutting diameter. Such a case indicated that cutting diameter influenced not only the rooting, but also the sapling quality.

There was a linear relationship between cutting number of roots and sapling number of roots at the end of vegetation. Thusly, well-rooted cuttings could be indicator of quality saplings.

Multiple regression analysis revealed that cutting diameter, cutting number of roots and root lengths had significant effects on sapling number of roots and sampling quality.

Present study is the first one about the relationships between cutting rooting and sapling performance in black mulberry with pairwise and multiple regressions, therefore, number of studies to be discussed with is highly limited.

In present study, besides the effects of cutting diameter, number of roots and root length-like initial parameters on sapling take ratios and sapling performance, effects of temperature, lighting and irrigation-like parameters of the rooting ambient of cuttings were also observed. Therefore, in further studies, such environmental and climate data could also be recorded and effects of these parameters on sapling performance could be investigated.

Although high rooting ratios were reported for rooting of black mulberry cuttings in several studies, sapling quality and performance were not assessed in majority of these studies. Although the problems encountered in proportion of black mulberry trees by cuttings seemed to be solved theoretically, previous findings revealed that there were some other issues to be solved in practice. Although present outcomes solved existing problems to some extent, there is still a need for further studies to improve sapling performance and quality.

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