Science, Technology and Development 37 (1): 36-41, 2018
ISSN 0254-6418 / DOI: 10.3923/std.2018.36.41

Rooting Response of Olive Cultivars to Various Cutting Types

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Abstract: Rooting response of olive cultivars to various cutting types was evaluated at Olive Model Farm Sangbhatti, Mardan, Pakistan (Latitude: 34°16′ 21.32″ N; Longitude: 72°18′ 06.33″ and Altitude: 375 m) during the year 2014. The experiment was laid out using Randomized Complete Block Design (RCBD) with two factors factorial arrangement. Semi-hardwood, hardwood and tip cuttings were taken from plants of Frontoio, Manzanilla, Ottobratica, Pendolino and Picual. The cultivars and cutting types significantly affected the studied attributes, while the interaction effects were non-significant at $P \leq 0.05$. More number of shoots (4.33) leaves (140.44) and maximum shoot length (36.67 cm) was recorded in the cuttings of cultivar Frontoio, while less number of shoots (2.44) and leaves (66.89) were noted in the saplings of Ottobratica, while shorter shoots (14.67 cm) were generated by the cuttings of Pendolino. The highest number (10.56) of 6.61 cm lengthy roots were produced by the saplings of Frontoio, followed by Manzanilla, which generated 8.17 number of roots with 6.06 cm length, while less number of roots (5.50) was produced by Pendolino. Ottobratica attained 23.64% survival, followed by Manzanilla (19.48%) and Frontoio (15.75%), while the least survival (9.73%) was recorded in plants of Pendolino. Semi-hardwood cuttings proved to be the root generative type in olive cultivars and produced more (8.97) and lengthy (6.20 cm) roots, also attained a high survival percentage (18.33%), as compared to tip (15.67%) and hardwood (14.47%) cuttings. It is concluded that olive cultivar Ottobratica was found as easy-to-root cultivar, followed by Manzanilla, Frontoio and Picual, while Pendolino was observed as hard-to-root cultivar under the agro climatic conditions of Sangbhatti, Mardan.

Key words: Olive cultivars, Cutting types, Rooting, Plant survival.

INTRODUCTION

None of the cultivated olive cultivars is recommended to be propagated by seed because they revert to the juvenile stage and small-fruited type. Commercially olives are propagated from stem cutting, which favours the speedy nursery production and the new plants can bear fruits after four years, however like other woody plants, olives face variability in rooting efficiency that ranges from easy-to-root to difficult-to-root cultivars (Rugini and Fedeli, 1990; Sarmintor *et al.*, 1990; Ozkayam and Celik, 1999), as great differences exist in olive genotypes to regenerate root formation (Hartmann *et al.*, 2002). Adventitious root induction and initiation as well as the physiology of root development are very complex processes which proceed under multiple changes in plant metabolism as demonstrated by several biochemical and molecular factors involved (Davist and Haissig, 1994; Altmana and Waisely, 1997). The most effective asexual reproduction method is cutting (Fabbri *et al.*, 2004) taken from fruitful, pathogen free mother stock with suitable irrigation and nutrition that eventually lead to healthy plants (Di Giovacchino, 2000). The cuttings are required to be taken from the middle or the bottom part of one or two years old branches with 15-17 cm length and 0.5-1.5 cm thickness (just like pencil) having 4-6 leaves at the upper part (Leifert *et al.*, 1992). The best time for cutting propagation in the spring is before the trees blossom and in the fall before the commencement of dormancy in trees (Mousa, 2003). Cutting is simple and rapid method of propagation to maintain genetic uniformity and the saplings come into bearing earlier than those produced from seeds. Hence, yield is uniform and stable in vegetative propagated plants, therefore, olives are propagated by semi-hardwood or hardwood cuttings (Hartmann *et al.*, 2002; Fabbri *et al.*, 2004), but the propagation response of various olive cultivars is complex, depending on different variables, including status of mother stock and type of cutting taken at particular phase of development. Keeping in view the significance of cutting types (semi-hardwood, hardwood and tip cuttings) in olive

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propagation, the present study was designed to investigate the propagation of different olive cultivars under local conditions of Sangbhatti, Mardan, Pakistan, to determine the response of olive cultivars to various cutting types for propagation and to find out appropriate cutting types for olive propagation.

MATERIALS AND METHODS

The study was conducted during 2014 at Olive Model Farm Sangbhatti, Mardan, Khyber Pakhtunkhwa-Pakistan (Altitude: 375 m; Latitude: 34°16′ 21.32″ N; Longitude: 72°18′ 06.33″). The region has an average annual rainfall of around 600 mm. Precipitation mainly occurs in July-August and the dry season lasts from May-June. The annual rainfall during 2014 was 550 mm. Mean minimal temperature ranged from 2 °C in the coldest month (December-January) to 25 °C in the hottest month (June-July), while the mean maximum temperatures for the same months varied from 18-38°C (Meteorological Department of Pakistan).

The experiment was laid out; using Randomized Complete Block Design (RCBD) with two factors, factorial arrangement replicated three times and had 45 treatments. Statistical software Statistix 8.1 was used for the analysis of the data. Fifty cuttings of each semi-hardwood, hardwood and tip cuttings of about 16-18 cm in length with 4-5 leaves, retained on the upper portion, were taken from the healthy and productive trees of Frontoio, Manzanilla, Ottobratica and Picual, before the commencement of new growth in spring (early March) for each treatment. The cuttings were planted in polythene tubes, pre-filled with the mixture of silt, garden soil and compost in equal proportion and arranged in shaded plastic tunnel (SPT) for further management.

RESULTS AND DISCUSSION

Sprouting percentage: Olive cultivars and cutting types significantly influenced the sprouting percentage of olive while their interaction was non-significant. The cuttings of Ottobratica had the highest sprouting (80.33%), followed by Manzanilla (70.78%), while the lowest value (49.33%) was observed in the cuttings of cultivar Pendolino. Regarding cutting types the maximum sprouting (69.73%) was noted in semi-hardwood cuttings, followed by tip cuttings with 64.13% sprouting, while less sprouting (60.27%) was noted in hardwood cuttings of olive (Table 1).

Physiological conditions of the mother plant and nutritional status of the cuttings can exert a great influence on the sprouting of cuttings. Sprouting is favoured by the store food material (mainly carbohydrates) in the cuttings, that provide sufficient nutrition for bud sprouting at particular stage and also dependent on the efficiency of cultivars. Ottobratica showed better sprouting, as compared to other cultivars, might be due to the efficient utilization of stored food materials in the cuttings and activities of the endogenous hormones that triggered sprouting of the effective buds present in the cuttings. The food material in the cuttings may be utilized as source for new growth because at this stage they had no root for uptake of the nutrients.

Table 1: Sprouting percentage, number of shoots, shoot length (cm) and number of leaves of olive cultivars as affected by various cutting types.

Olive cultivars (Cv)	Parameters			
	Sprouting (%)	**Number of shoots**	**Shoot length (cm)**	**Number of leaves**
Frontoio	66.11 b	4.33 a	36.67 a	140.44 a
Manzanilla	70.78 b	3.67 ab	23.00 b	104.67 b
Ottobratica	80.33 a	2.44 c	18.06 c	66.89 c
Pendolino	49.33 d	2.72 c	14.67 d	72.17 c
Picual	57.00 c	3.61 b	21.61 b	108.44 b
LSD (α = 0.05)	5.05	0.69	2.33	18.77
Cutting types (S)				
Semi-hard wood	69.73 a	3.90 a	27.87 a	124.73 a
Hardwood	60.27 b	2.73 b	17.93 c	71.17 c
Tip	64.13 b	3.43 a	22.60 b	99.67 b
LSD (α = 0.05)	3.91	0.54	1.805	14.54
Interaction (Cv × S)				
Significance levels	NS	NS	NS	NS

Mean followed by similar letter(s) in column do not differ significantly from one another and NS = Non-significant at $P \leq 0.05$.

Number of shoots plant^{-1}: There were significant variations regarding number of shoots produced by olive cultivars, propagated through various cutting types, while the interaction effect between olive cultivars and cutting types was non-significant. The mean values for number of shoot of olive cultivars showed that Frontoio, Manzanilla and Picual produced 4.33, 3.67 and 3.61 number of shoots respectively, which were at par with each other, while few (2.44) shoots were generated by Ottobratica. The differences among the mean values for number of shoots of cutting types were statistically significant. More number of shoots (3.90) was counted in saplings produced through semi hardwood cuttings, followed by number of shoots (3.43) recorded in plants of tip cutting, while less number of shoots (2.73) was noted in saplings of hardwood cuttings (Table 1).

Vegetative growth in plants, propagated through cuttings, mainly depends on rooting, nutrient status and environmental conditions. Enhanced root growth and development in Frontoio induced more number of shoots and growth, which is dependent on the availability of the nutrients and carbohydrates present in the cuttings. The cuttings of Frontoio made efficient utilization of the available nutrients and explored environmental conditions, which led to more sprouting of the buds and hence produced more number of shoot cutting^{-1}. The semi-hardwood cuttings developed more shoots because of the efficient utilization of carbohydrate reserve in the metabolic processes. The low biomass production of hardwood cuttings might be due to conversion of available food materials into lignifications processes, resulted in over lignified stem and then caused lower rooting and shoot development (Santoso and Parwata, 2014). Internal factors of the stock plant, such as, auxin level, root co-factors and carbohydrates, also influenced the root, shoot growth and development (Sharma and Srivastav, 2004).

Shoot length (cm): The olive cultivars and various cutting types had significant variations regarding shoot length, while non-significant variations were recorded for interaction of olive cultivars and cutting types. Shoot length is associated with the varietal tissue potency and the influential factors for growth and development. The cultivar Frontoio produced significantly long shoots (36.67cm), followed by Manzanilla and Picual, which generated 23.00 and 21.61 cm lengthy shoots, respectively, and the differences between their means were statistically non-significant, while the Pendolino produced minimum shoot length (14.67 cm). The sprouting and shoot elongation tendency of the cuttings, dependent on the age and stored food material, was present endogenously and also linked with the rooting potential of the cutting type and genotype. Semi-hardwood cuttings produced significantly lengthy shoots (27.87 cm), followed by shoot length (22.60 cm) produced by tip cuttings, while the minimum shoot length (17.93 cm) recorded in plants propagated through hardwood cuttings (Table 1).

Shoot length was significantly different for the studied cultivars of olive. Frontoio showed pronounced response and produced lengthy shoots. This might be due to the genetic make-up and better utilization of the environmental conditions that favoured better growth in terms of shoot length. The lengthy shoots produced by the semi-hardwood cuttings might be due to the high rooting potency and better utilization of the accumulated carbohydrates and growth promoting substances. Capacity of rooting and shoot development of the cuttings depended on the type of branch taken, usually the cuttings taken from the lateral shoots rather than the terminal ones performed well (Sharma and Srivastav, 2004). The present results are in close conformity with Shah *et al.* (2006), who reported that soft wood cuttings produced better rooting, sprouting, number of shoots and leaves and better shoot and leaf growth in ficus.

Number of leaves plant^{-1}: Number of leaves was significantly affected by the cultivars and cutting types of olive but their interaction effect was non-significant. Leaves are the photosynthetic organ necessary for the growth and development of plants and the number of leaves is closely linked with number and length of shoots. The cultivar Frontoio produced significantly maximum numbers of leaves (140.44), followed by Picual and Manzanilla, which generated 108.44 and 104.67 leaves, respectively, and did not differ significantly from each other. The lowest mean value (66.89) for number of leaves was observed in the plants of cultivar Ottobratica. Regarding cutting types, more leaves (124.73) were recorded in plants of semi-hardwood cutting, followed by number of leaves (99.67) in plants of tip cuttings, while the lowest number of leaves (71.17) was observed in plants of hardwood cuttings (Table 1).

Production of more leaves by Frontoio might be associated with more number and lengthy shoots produced by this cultivar. The rooting co-factors from the leaves are balanced with auxin for the induction of rooting. The co-factors, which regulate rooting, are produced in the leaves and each cultivar requires a specific optimal leaf number or area for the maximal rooting (Hess, 1965). The cultivar Frontoio generated more roots, which might be linked with the requirement of more leaves. The leaves and buds present on the cuttings produced necessary cofactors for rooting and production of other organs which are necessary for the production of complete plant (Hartmann and Kester, 1994).

Number of roots plant^{-1}: Olive cultivars and cutting types had significantly affected the number of roots in olive, whereas, the interactive effect of cultivars and cutting types was found non-significant. Rooting success depends on the genetic potential of various cultivars and the endogenous hormonal and nutritional balance of the cuttings. The mean data in Table 2 showed that significantly more number of roots (10.56) was produced by survived plants of cultivar Frontoio, followed by number of roots (8.17) recorded in plants of cultivar Manzanilla, however, less number of roots plant^{-1} (5.50) was noted in cuttings of Pendolino.

The role of mother trees is of great importance for successful production of nursery plants, using various types of cuttings. The semi-hardwood cutting of olive produced significantly a high number of roots (8.97), followed by number of roots plant^{-1} (6.90) in saplings of tip cuttings, while less number of roots (6.20) was observed in plants of hardwood cuttings (Table 2). The results are in accordance with Hartmann *et al.* (2002), who stated that reduced rooting potential of hardwood cutting is due to the presence of less phenolic substances. The difference in number of roots in olive cultivars might be due the genetic make-up of the varieties as stem cuttings behaviour varies with age, genotypes, and physiological status of mother plant (Henning, 2003). The rooting ability of cutting is in accordance with the cutting type (Wilson, 1993; Hartmann *et al.*, 2002), due to variation in carbohydrates and other stored materials (Leakey, 1999; Hartmann *et al.*, 2002). Poor rooting ability among plant species has been attributed to the presence of growth inhibitors (Barlow *et al.*, 1961; Ooyama, 1962), lack or imbalance of hormones or rooting co-factors (Hess, 1961; Raviv *et al.*, 1986) and the presence of physical barriers (Beakbane, 1961; Edwards and Thomas, 1980). Several anatomical studies have suggested a correlation between difficulty in rooting and the presence of continuous pericyclic sclerenchyma layer that might act as a physiological barrier to adventitious root initiation or a mechanical barrier to root emergence (Ciampi and Gellini, 1958; Beakbane, 1961; Beakbane, 1969; Goodin, 1965; Edwards and Thomas, 1980).

Table 2: Number of roots, root length (cm), root weight (g) and survival percentage of olive cultivars as affected by different cutting types

Olive cultivars (Cv)	Parameters			
	Number of roots	**Root length (cm)**	**Root weight (g)**	**Survival (%)**
Frontoio	10.56 a	6.61 a	3.70 a	15.75 c
Manzanilla	8.17 b	6.06 b	2.97 b	19.48 b
Ottobratica	5.89 c	4.22 d	1.34 d	23.64 a
Pendolino	5.50 c	3.24 e	1.13 d	9.73 d
Picual	6.67 bc	5.11 c	2.35 c	12.18 d
LSD (α = 0.05)	1.85	0.44	0.47	2.47
Cutting types (S)				
Semi-hardwood	8.97 a	6.20 a	2.80 a	18.77 a
Hardwood	6.20 b	4.11 c	1.85 b	14.47 b
Tip	6.90 b	4.84 b	2.24 b	15.23 b
LSD (α = 0.05)	1.44	0.34	0.36	1.90
Interaction (Cv × S)				
Significance levels	NS	NS	NS	NS

Mean followed by similar letter(s) in column do not differ significantly from one another and NS = Non-significant at $P \leq 0.05$.

Root length (cm): The olive cultivars and various cutting types significantly affected the root length of olive cuttings, while non-significant variation was recorded for interaction of olive cultivars and cutting types. The mean data showed that lengthy roots (6.61 cm) were produced by the saplings of cultivar Frontoio and is significantly higher from the rest of cultivars, followed by the root length (6.06 cm) noted in plants of Manzanilla, while, the lowest mean value of root length (3.24 cm) was observed in plants of Pendolino. According to the means of cutting types, the highest root length (6.20 cm) was observed in plants of semi-hardwood cutting followed by the root length (4.84 cm), generated by saplings of tip cuttings. However, short root length (4.11 cm) was recorded in the plants of hardwood cuttings (Table 2).

The difference in adventitious roots developed from different olive cultivars might be due the genetic makeup of the mother stock as cultivars have significant effects on root growth and development of olive (Ullah *et al.*, 2012). The cuttings detached from the mother plants should have food reserves to keep the tissues functioning until the roots and shoots are produced. Carbohydrates content with optimum level of endogenous hormones present in the cuttings of particular cultivars favour better rooting; also certain enzymes are responsible for rooting in cuttings and are probably polyphenol oxidase present in the phloem or cambium. The formation of rhizocaline from these specific enzymes facilitates reactions involved in the process of root initiation (Sharma and Srivastav, 2004). Different anatomical changes viz. dedifferentiation of specific cells and afterwards the formation of root initials are involved in root formation of stem cutting. Once the roots are initiated then the climate, soil condition and food reserves present in the stem cuttings trigger the production of lengthier roots. The nutritional status of the mother plants also played a vital role in root initiation process of the cuttings and among the nutrients carbohydrates and nitrogen in optimal ratio are of prime importance. High carbohydrates and low nitrogen levels enhance rooting of olive and should be maintained in the stock plant before taking cutting (Rahman *et al.*, 2004). The highest rooting percentage, maximum root growth and development was achieved from the semi-hardwood cuttings of olive (Khattak *et al*., 1981).

Root weight (g): There were significant differences in root weight of saplings of olive cultivars produced from different types of cuttings, while their interaction (Olive cultivars × cutting types) had non-significant response. The genotypes played a vital role in accumulation of biomass in different parts of Plant body. Significantly heavier and healthy root weight (3.70 g) was attained in the plants of cultivar Frontoio, followed by the root weight (2.97 g) produced by the saplings of Manzanilla. However, light root weight (1.13 g) was recorded in the plants of Pendolino. The root weight is associated with the concentration of minerals and accumulation of assimilates in the plant parts, particularly, in roots. The plants generated from the semi-hardwood cuttings of olive produced significantly heavy root weight (2.80 g), followed by the root weight (2.24 g) attained by the plants of tip cuttings, while minimum root weight (1.85 g) was recorded in the plants produced from hardwood cuttings of olive (Table 2).

Large differences occur in growth parameters of different cuttings due to status of mother plants (Thomson, 1982) and clones (Lee and Palzkill, 1984). The heavy roots generated by the plants of Frontoio might be due to a high rooting percentage, more and lengthy roots produced by the same cultivar, which ultimately amplified the root biomass of olive. The heavy root weight attained by the plants of semi-hardwood cuttings might be due to the efficient utilization of the nutrients and carbohydrates present in the cutting favoured by optimum environmental condition. The callus initiated at the base of cuttings that resulted into the development of root initials intact with stem became active in semi-hardwood cuttings rapidly and led to the increase in root number, length and weight (Sharma and Srivastav, 2004).

Survival percentage: The olive cultivars and different types of cutting significantly affected the survival percentage of olive plants while the interaction effect was non-significant. The cuttings taken from the cultivars, having the capability of rapid cell division and formation of callus by the active tissues of cambium generate quick rooting that led to plant survival. The survival in the plants of Ottobratica cultivar was significantly higher (23.64%), followed by 19.48% survival recorded in the saplings of Manzanilla, while, the lowest mean value of survival percentage (9.73%) was observed in the plants of cultivar Pendolino. The rooting tendency of the cuttings was linked with the condition and type of the cuttings because of the presence and activity of endogenous auxins and stored food materials. The highest survival percentage (18.77%) was observed in the plants generated from semi-hardwood cutting, followed by 15.23% survival in the plants of tip cuttings; however, less survival percentage (14.47%) was recorded in the saplings produced from hardwood cutting (Table 2).

Ottobratica responded well to the prevailing environmental conditions and efficient utilization of the available nutrients (photosynthates) for survival. Partially matured cuttings showed better survivability as compared to soft and hardwood cuttings because the accumulation of the food reserves in semi-hardwood cuttings is efficiently utilized for rooting and survivability rate as compared to soft and hardwood cuttings (Sharma and Srivastav, 2004). Also the rooting response and survival percentage of the cuttings are related to age, nutritional status and levels of endogenous regulatory substances present in cuttings (Kachecheba, 1976). Hartmann *et al*. (2002) stated that the age of plant from which stem cutting is taken as well as the stem position on plant determined rooting and shoot growth and survival percentage. The high survivability was recorded in the semi-hardwood cutting of *Ficus hawaii* (Siddiqui and Hussain, 2007).

CONCLUSION

Based upon the findings of present research work, semi hardwood cuttings are suggested for olive propagation under the local conditions of Sangbhatti, Mardan. The natural potency of Ottobratica, Manzanilla, Frontoio and Picual cuttings can be utilized for olive propagation, while Pendolino is hard-to-root olive cultivar.

ACKNOWLEDGEMENT

The principal author feels pleasure to extend his thanks to members of the supervisory committee: Prof. Dr. Abdur Rab, Department of Horticulture and Prof. Dr. Muhammad Jamal Khan Khattak, Department of Soil and Environmental Sciences, for their cooperation, excellent supervision, guidance and valuable suggestions. The cooperation and help of Prof. Dr. Noor-Ul-Amin, Chairman, Department of Horticulture and Prof. Dr. Muhammad Jamal Khan, Dean, Faculty of Crop Production Sciences/Director Advance Studies and Research is also highly acknowledged.

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