INTERNATIONAL JOURNAL OF AGRICULTURE & BIOLOGY
1560–8530/2007/09–1–147–151
http://www.fspublishers.org

Effect of Various Potting Media on Growth of Rooted Jojoba (*Simmondsia chinensis*) Cuttings

MUHAMMAD AZHAR BASHIR[1], MUSHTAQ AHMAD AND MUHAMMAD AKBAR ANJUM†
Horticultural Research Station, Bahawalpur - 63100 (Pakistan)
†*University College of Agriculture, Bahauddin Zakariya University, Multan (Present address: Pakistan Council for Science and Technology, Shahrah-e-Jamhuriat, G-5/2, Islamabad – 44000 (Pakistan)*
[1]Corresponding author's e-mail: mabashirbzu@yahoo.com

ABSTRACT

Growth response of rooted cuttings from six promising strains of jojoba to eight different potting media was studied from April to September of year 2003 and 2004. The potting media consist of field soil (control) and its combinations with either each of FYM, leaf mold and sewage sludge (1:1 by weight) or with the combination of two of these three except the last that consisted of the combination of these three only excluding field soil (1:1:1 by weight). The pooled analysis of two years data revealed that the growth of rooted cuttings was affected significantly by potting media and the strains, but the interaction between potting media and the strains for all the parameters studied was found statistically non-significant. The combination of field soil + FYM + leaf mold gave the maximum survival percentage (76.80), maximum number of shoots (3.72), the highest shoot length (7.70 cm) and the maximum number of leaves per shoot (12.60). The minimum values of these parameters were recorded when the cuttings were planted in field soil (control). The combinations consisting of field soil and the material having organic matter in form of leaf mold or FYM are better for good survival and growth of rooted cuttings than the media consisting of field soil alone or the media containing only organic matter. Regarding the strains, the cuttings of PKJ-3 survived the best (77.08%), produced maximum number of shoots (3.61), attained the longest shoot length (8.38 cm) and carried the maximum number of leaves per shoot (12.99). The cuttings of PKJ-2 got the minimum values for the same growth parameters.

Key Words: Cuttings; Genotypes; Growth; Jojoba; Potting media; *Simmondsia chinensis;* Strains

INTRODUCTION

Jojoba (*Simmondsia chinensis*, family: *Simmondsiaceae*) is a dioecious, long-lived perennial evergreen shrub that grows wild in the semi-arid region of the Sonoran desert in Northern Mexico and Southwestern USA. The plants have exceptionally deep tap root system that help to survive in drought conditions. Hence, it can be successfully grown in arid and semi-arid areas of Pakistan. Its natural life span appears to be between 100 and 200 years. The product, which is traded, is called jojoba oil potential world production of this product is currently around 3,500 metric tonnes per year. The cosmetic industry appears to be the principal market for jojoba oil products, around 2,000 tonnes per year are thought to be utilized by this industry, this equates to almost 80% of the total market share. The other major industry using jojoba oil is the pharmaceutical sector. Lubricant applications provide a market for around 100 tonnes of jojoba oil annually. Jojoba oil is a high quality substitute for sperm oil (from the sperm whale); availability of this product is limited now due to the restrictions placed on whaling. Plantations are established by using seeds, seedlings, rooted cuttings, or plantlets produced from tissue culture. Plant vigor, more number of shoots and leaves are important features for good survival and growth of the plant. The growth of aerial plant parts exclusively depends upon the subterranean plant parts. So for normal growth and development of aerial plant parts, proper and suitable environment must be provided to the root system (Wazir *et al*., 2004).

John (1981) observed that incorporation of organic wastes improved the root zone environment. Thomson (1982) used vermiculite as a medium for jojoba cuttings. Feldman *et al*. (1983) reported that incorporating Osmocote into the potting media consisting of mixture of perlite and vermiculite (1:1) had an advantage for jojoba cuttings. Correlatioins between tissue nutrient levels showed significant relationships between % nitrogen in shoot and node number per cutting. Shoot potassium levels were highly significantly correlated with node number per cutting. Lee and Palzkill (1984) found that jojoba cuttings rooted significantly more in mixture of perlite: vermiculite (1:1) than in Oasis Root Cubes. They also transplanted rooted cuttings into a commercial peat: vermiculite potting mix and grown for 3 months in a shade house (50% shade) during summer months. The cuttings grew into normal appearing plants. Howard *et al*. (1984) raised jojoba cuttings in peat: perlite medium. Mixture of perlite and vermiculite as potting medium for jojoba cuttings is also reported by National Research Council of USA (1985). Feldman and Palzkill (1986) successfully rooted jojoba cuttings in perlite: vermiculite (1:1) medium under mist with bottom heat.

Harsh and Muthana (1985) used coarse river sand, sandy soil, or a mixture of the two for stem cuttings of jojoba. Palzkill (1988) after trying many different media settled on a mixture of perlite and vermiculite (1:1) for sticking the jojoba cuttings in flats and a mixture of peat, perlite and vermiculite (1:1:1) for sticking the cuttings in individual containers. Palzkill and Feldman (1993) compared three rooting media perlite: vermiculite (1:1); peat: perlite: vermiculite (1:1:1) and peat: perlite (1:1) by volume for jojoba cuttings. The peat-perlite medium resulted in significantly less rooting than did the other two media. However, rooting occurred 74% for perlite-vermiculite, 78% for peat-perlite-vermiculite and 64% for peat-perlite. Ishtiaq *et al*. (1995a) recommended a mixture of sand + clay + farmyard manure (1:1:1) for the cuttings of *Ficus* species. Ishtiaq *et al*. (1995b) noted that sand media and *Ficus* species have significant effect on number of leaves and number of branches of the cuttings. Different plants perform differently in different medium. The response of the varieties is also different even to the same medium. Both the chemical and physical characteristics of the medium are of the utmost importance for normal plant growth and development (Ahmad *et al*., 1996). Propagation medium is composed of an organic component (peat, sorghum moss, sawdust or hardwood & softwood barks) and a coarse mineral component. Organic matter has a profound effect on biological, chemical and physical properties of the medium. Through the decomposition of organic matter, chemical elements become available to the crop plants. Organic matter provides food and energy for soil organisms, which help in building good soil structure. The coarse mineral component (coarse sand or grit etc.) is used to increase the proportion of large air-filled pores and drainage. Rarely mineral soil is used as a propagation medium component, except in field propagation of hardwood cuttings. Most propagators use a combination of organic and mineral component i.e., peat-bark-sand, peat-rockwool etc. Prat *et al.* (1998) studied the rooting of semi-hardwood cuttings of 5 jojoba clones in 5 substrates and noted significant differences in rooting among clones but no effect of substrate. Wassner and Ravetta (2000) planted the hormone (IBA) treated cuttings of *G. chiloensis* into speedlings filled with peat, vermiculite and sand (1:1:1, v/v/v). They found that the position of the cutting, the IBA concentration and the mother plant affected rooting success. Accessions differed with regard to rooting success. Transplanting survival varied between 25 and 100% depending on the clone. Bashir *et al.* (2001) raised IBA treated jojoba cuttings in sand and silt media. Ahmad and Qasim (2003) studied the effect of various potting media to determine growth response and nutrient uptake efficiency of *Scindapsus aureus* using FYM, leaf mold, poultry manure as main source by making different combinations with sand, silt and saw dust. Potting media in different combinations were better than sole factor of soil itself as different combinations of potting media presented more growth and vigor of the plants along with improving total available nitrogen and phosphorus. Wazir *et al.* (2003) studied the effect of different soil media on the growth of *Dracaena dermensis* var. Janet Craige cuttings. Direct cuttings of Dracaena were planted in 15 cm clay pots containing different soil mixture such as silt, saw dust, leaf mold and garden soil. They found that soil media of silt + garden soil + leaf mold + saw dust gave maximum number of leaves and silt + garden soil gave maximum stem length.

A comprehensive literature is available on the use of rooting media for direct planting of jojoba cuttings into these media, but very little literature is available on the use of soil media for the planting of rooted cuttings during transitional period before planting of these cuttings into field conditions. Direct planting of rooted cuttings into the field conditions may cause death of cuttings, because of stress due to high temperature and low humidity during hot summer months or frost injury during winter months in arid and semi-arid regions (Harsh *et al*., 1987). Jojoba is a slow growing plant. In the hardening process of rooted cuttings, the cuttings should be shifted to such a soil medium that may enhance its growth and vigor before going to the field plantation. The current study has been conducted with this idea and the efforts have been focused on the choice of the best medium from the available cheap resources of organic matter and on the response of selected clones to these soil media in terms of growth and survival.

MATERIALS AND METHODS

The study was conducted at Jojoba Research Station, Bahawalpur during 2003 - 2004. The plant material for this experiment was the rooted cuttings, which had been rooted previously by the application of auxins to semi-hardwood cuttings from fifteen-years-old female plants of promising jojoba strains i.e., PKJ-1, PKJ-2, PKJ-3, PKJ-4, PKJ-5 and PKJ-6, as characterized in Table I. These rooted cuttings were taken out from polyethylene bags, which had been kept under polyethylene sheet tunnel at the end of March, 2003 and before transplanting in the field, were transferred to 25 cm clay pots filled with different potting mixtures in various combinations. Prior to mixing of FYM and leaf mold in different combinations, these two were decomposed for a period of three months in large pits by applying urea @ 1 kg per 100 kg of FYM/leaf mold, then thorough watering and covering with a thin layer of soil under shade. Decomposed FYM and leaf mold were taken out, sewage sludge was obtained and these three were dried in shade before thorough mixing with field soil in combinations as listed below.

i.	Field soil (control)	
ii.	Field soil + FYM	(1:1 by weight)
iii.	Field soil + leaf mold	(“ “ “)
iv.	Field soil + sewage sludge	(“ “ “)
v.	Field soil + FYM + leaf mold	(1:1:1 “ “)

vi. Field soil + FYM + sewage sludge (" " ")
vii. Field soil + leaf mold + sewage sludge (" " ")
viii. FYM + leaf mold + sewage sludge (" " ").

The clay pots were arranged in Randomized Complete Block Design (RCBD) with two factors i.e., soil media and strains with three replications, each replication containing 192 clay pots. The clay pots were sprinkled at weekly interval for about 6 months depending upon the prevailing temperature and humidity till the end of September. Topsin-M @ 1 g 1^{-1} water was sprayed and Chlorpyrifos @ 1 mL l^{-1} solution was applied to the soil media to control termite at fortnightly interval. The experiment was repeated with the rooted cuttings obtained after the end of March, 2004.

Four rooted cuttings of each strain were planted in a potting medium in each replication. One rooted cutting was planted in each clay pot. Each year 576 rooted cuttings were planted and total 1152 rooted cuttings of six strains were planted in two years. The data of both years were combined and analyzed for pooled analysis by using Analysis of Variance technique. The means obtained from the analysis were compared by Duncan's Multiple Range test at $\alpha = 5\%$ (Steele & Torrie, 1984). During the experiment, data were recorded on the following traits.

(a) Survival percentage, (b) Number of shoots per cutting, (c) Shoot length and (d) Number of leaves per shoot.

RESULTS AND DISCUSSION

The results regarding survival percentage and shoot growth parameters of rooted cuttings are presented in Table II.

Survival percentage. The data revealed that the survival percentage was affected significantly by potting media and the strains. The combination of field soil + FYM + leaf mold gave the maximum survival (76.80%), followed by that of field soil + leaf mold (75.00%), both were statistically at par with each other. High survival of rooted cuttings in these soil media reflected the fact that these combinations might have provided favorable physical conditions and sufficient nutrients to the cuttings needed for activating enzymatic and biochemical processes (Wazir *et al*., 2003). Field soil (control) gave the minimum survival (43.33%), which statistically stood at par with the combination of FYM + leaf mold + sewage sludge (47.92% survival). It indicates that the combinations consisting of field soil and the material having organic matter in form of leaf mold or FYM are better for good survival and growth of rooted cuttings than the media consisting of field soil alone or the media containing only organic matter in form of leaf mold, FYM and sewage sludge. As the strains are concerned, the cuttings of PKJ-3 survived the best (77.08%), followed by those of PKJ-6 (71.25%). The cuttings of PKJ-2 survived the least (43.02%). Wassner and Ravetta (2000) have already reported that transplanting survival varies between 25 and 100% depending on the clone. The interaction between potting media and the strains was non-significant due to the similar trend of each strain in each media as was noted by their average performance.

Table I. Source origin, oil contents and yield of six promising jojoba strains

Jojoba Strains	Source origin	Seed oil content (%)	Seed yield per plant (4 years avg.) (kg)	Potential yield per plant (kg)
PKJ-1	California	47.2	3.12	4.00
PKJ-2	Arizona	50.4	2.83	3.10
PKJ-3	Arizona	49.4	2.71	3.10
PKJ-4	Arizona Upland	42.7	2.42	2.80
PKJ-5	California	49.4	2.20	3.10
PKJ-6	California	44.5	2.15	2.65

Source: A report from Jojoba Research Station, Bahawalpur (2000)

Table II. Survival and shoot growth of rooted cuttings from six jojoba strains as affected by potting media

Potting Media	Survival percentage	No. of shoots per cutting	Shoot length (cm)	No. of leaves per shoot
Field Soil (Control)	43.33 e	2.67 e	5.34 c	7.61 e
FS + FYM (1:1 by wt)	62.92 c	2.93 d	6.37 b	10.14 c
FS + Leaf Mold (1:1 " ")	75.00 ab	3.21 c	7.62 a	11.79 b
FS + Sewage Sludge(1:1)	54.30 d	2.85 d	6.70 b	9.50 cd
FS + FYM + LM (1:1:1)	76.80 a	3.72 a	7.70 a	12.60 a
FS + FYM + SS (1:1:1)	59.44 c	3.18 c	6.42 b	9.77 c
FS + LM + SS (1:1:1)	70.28 b	3.50 b	7.37 a	11.70 b
FYM + LM + SS (1:1:1)	47.28 e	2.88 d	6.48 b	8.86 d
Standard Error	1.79	0.06	0.16	0.24
Jojoba Strains				
PKJ-1	61.56 c	3.10 c	6.54 b	10.19 c
PKJ-2	43.02 e	2.71 d	5.41 d	7.81 d
PKJ-3	77.08 a	3.61 a	8.38 a	12.99 a
PKJ-4	63.33 c	3.10 c	6.53 b	10.43 c
PKJ-5	51.25 d	2.82 d	5.90 c	8.34 d
PKJ-6	71.25 b	3.36 b	7.73 b	11.71 b
Standard Error	1.55	0.05	0.14	0.21

Means sharing similar letters in a group are non-significant at $\alpha = 5\%$ (DMR test).

Number of shoots per cutting. The data exhibited that potting media and the strains affected this parameter significantly. The maximum number of shoots (3.72) was obtained by the combination of field soil + FYM + leaf mold, followed by that of field soil + leaf mold + sewage sludge (3.50). It might be due to the rich nutritional status and better physical conditions of this mixture. The minimum number of shoots (2.67) was obtained by field soil (control). It might be due to the poor nutritional status and compacting of field soil. The results partially support the findings of Ahmad and Qasim (2003), who reported that the maximum buds of young rooted plants of *Scindapsus aureus*, sprouted in the media containing organic matter components and the minimum ones in normal soil. As regard the strains, the rooted cuttings of PKJ-3 produced the maximum number of shoots (3.61), followed by those of PKJ-6 (3.36). The cuttings of PKJ-2 gave the minimum number of shoots (2.71) that was statistically at par with that of PKJ-5 (2.82). The interaction between potting media and the strains was non-significant, because of same pattern of performance in each media as indicated by their average performance.

Shoot length. The parameter under study was significantly affected by the potting media and the strains. The maximum shoot length (7.70 cm) was attained by the combination of field soil + FYM + leaf mold, followed by that of field soil + leaf mold (7.62 cm) and that of field soil + leaf mold + sewage sludge (7.37 cm). These three media were statistically at par with each other for this parameter. It may be attributed to nutritionally better mixtures, high water and nutrient holding capacity, good drainage and high porosity, which helped in the development of excellent root system. Such media enhance apical meristematic activities and also trigger cambial division. Decomposed organic matter improves pore spaces, water holding capacity and microbial activity that result in maximum shoot growth (Wazir *et al*., 2004). The lowest shoot length (5.34 cm) was attained by field soil (control). The findings are in line with that of Ahmad and Qasim (2003), who noted the maximum stem length in media containing poultry manure, followed by that of with leaf mold and FYM as main source. They also noted the minimum stem length in normal soil for young rooted plants of *Scindapsus aureus*. Among strains, PKJ-3 attained the longest shoot (8.38 cm), followed by PKJ-6 (7.73 cm), while PKJ-2 attained the shortest shoot (5.41 cm). These differences in shoot length could be due to genetic make up of the strains. Similar results were reported by Ziaullah *et al*. (1999) for Cordyline species to five growth media having organic matter components. No significant interaction was found for this parameter between potting media and strains as every strain performed on same pattern in each medium.

Number of leaves per shoot. The data showed that potting media and the strains affected this parameter significantly. The maximum number of leaves (12.60) was gained by the combination of field soil + FYM + leaf mold, followed by that of field soil + leaf mold (11.79), these two treatments differed significantly from each other. However, the latter stood statistically at par with field soil + leaf mold + sewage sludge (11.70). The minimum number of leaves (7.61) was gained by field soil (control). This shows that nutrients and other factors required for development were readily available to the rooted cuttings in these combinations containing leaf mold. In addition, that the shoot length was maximum in combination of field soil + FYM + leaf mold, which may help the shoot in carrying maximum number of leaves. Wazir *et al.* (2003) found that soil media of silt + garden soil + leaf mold + saw dust gave maximum number of leaves. Regarding the strains, the maximum number of leaves (12.99) was produced in the rooted cuttings of PKJ-3, followed by PKJ-6 (11.71), while the minimum number of leaves (7.81) was produced by PKJ-2 that remained at par with that of PKJ-5 (8.34). These variations among the strains may be due to genetic differences. Ziaullah *et al*. (1999) also found significant genotypic response of Cordyline species to all five growth media tested for number of leaves. The interaction between two factors had no significance on number of leaves due to same reasons as explained under previous section.

The best performance of the rooted cuttings in the medium containing FYM and leaf mold may be due to nutritionally better medium, containing organic material that resulted in maximum survival, number of shoots per cutting, length of shoot and the number of leaves per cutting. Incorporation of organic wastes improved the root zone environment that increased the growth of aerial parts of the plant. The greater shoot length is also attributed to more number of leaves and number of shoots per cuttings that the plants attained in this medium, which greatly increased the photosynthetic rate of the plant, which increased the plant stored material, thereby increasing plant survival and growth. Mathad and Nalwadi (1989) reported that decomposed organic material improve soil fertility by increasing soil aeration, water holding capacity and water infiltration and lower surface crusting. Similarly the poorest performance of rooted cuttings in field soil (control) may be due to nutritionally poor medium, lacking in organic material that resulted in minimum survival, number of shoots per cutting, length of shoot and the number of leaves per cutting, thereby reducing the plant survival and growth. Ahmad and Qasim (2003) found that potting media containing FYM, leaf mold, poultry manure as main source of organic matter with sand, silt and saw dust were better than sole factor of soil itself as these combinations presented more growth and vigor of the plants improving total available nitrogen and phosphorus. The lesser growth in field soil (control) may also be due to minimum number of leaves and shoots that reduced the rate of photosynthesis, thereby reducing plant growth and survival. Similar findings have been reported previously by Rahman and Ishtiaq (1996).

Acknowledgements. The authors would like to thank Mian Abdul Majeed Iqbal, Jojoba Botanist, Jojoba Research Station, Bahawalpur and his staff for facilitating this experiment.

REFERENCES

Ahmad, I. and M. Qasim, 2003. Influence of various potting media on growth and nutrient uptake efficiency of *Scindapsus aureus*. *Int. J. Agric. Biol*., 5: 594–7

Ahmad, M., S. Rahman and M. Ishtiaq, 1996. Studies on aerial and subterranean plant parts of *Ficus elastica* as affected by different soil media. *Sarhad J. Agric*., 12: 633–6

Bashir, M.A., A.M. Iqbal, M.N. Asad, M.Y. Rana and S.F.H. Shah, 2001. Propagation of jojoba through cuttings. *J. Anim. Pl. Sci*., 11: 24–9

Feldman, W.R., D.A. Palzkill and L. Hogan, 1983. Nutrition and growth of vegetatively propagated Jojoba. *Proceedings of the 5th International Conference on Jojoba and its Uses*, Pp: 181–95. October 11–15, 1982, Tucson, Arizona (U.S.A.)

Feldman, W.R. and D.A. Palzkill, 1986. Effects of mode of transport and time of excision on rooting and early growth of jojoba cuttings. *Pl. Propagator*, 32: 4–6

Harsh, L.N. and K.D. Muthana, 1985. Rooting media for vegetative propagation of *Acacia albida*. *J. Tropic. For*., 1: 275–6

Harsh, L.N., J.C. Tewari, D.S. Patwal and G.L. Meena, 1987. *Package of Practices for Cultivation of Jojoba (Simmondsia chinensis) in Arid Zone*, Pp: 1–19. CAZRI, Jodhpur (India)

Howard, B.H., T. Banko and D.C. Milbocker, 1984. Rooting response of jojoba cuttings to stem-wounding, nodal preparation, and IBA treatment. *Pl. Propagator*, 30: 12–4

John, P.M., 1981. *The Rooting Medium and Soil pH, Plant Propagation*, P: 201. John Willy and Sons Inc. London

Ishtiaq, M., J. Khan and A. Rab, 1995a. Effect of different media on different rubber plant species cuttings. *Sarhad J. Agric*., 9: 463–6

Ishtiaq, M., J. Khan and A. Rab, 1995b. Peformance of different species of rubber plant stem cuttings under the agro-climatic conditions of Peshawar. *Sarhad J. Agric.*, 11: 455–7

Lee, C.W. and D.A. Palzkill, 1984. Propagation of jojoba by single node cuttings. *Hort. Sci.*, 19: 841–2

Mathad, M.L. and Nalwadi, 1989. Rooting ability of some important ornamental climbers. *South India Hort*., 37: 307–8

National Research Council (USA), 1985. *Jojoba: New Crop for Arid Lands, New Raw Material for Industry*. National Academic Press (Washington), U.S.A

Palzkill, D.A., 1988. Propagation of jojoba by stem cuttings. *Proceedings of the 7th International Conference on Jojoba and its Uses*, Pp: 86–101. January 17–22, 1988, Phoenix, Arizona (U.S.A.)

Palzkill, D.A. and W.R. Feldman, 1993. Optimizing rooting of jojoba stem cuttings: effects of basal wounding, rooting medium and depth of insertion in medium. *J. American Oil Chem. Soc*., 70: 1221–4

Prat, L., C. Botti and D. Palzkill, 1998. Rooting of jojoba cuttings: the effect of clone, substrate composition and temperature. *Indust. Crops Prod*., 9: 47–52

Rahman, S. and M. Ishtiaq, 1996. Response of *Jasminum sambac* cuttings to different soil media. *Sarhad J. Agric*., 12: 409–15

Thomson, P.H., 1982. *Jojoba Handbook*, (3rd ed.), Pp: 57–162. Bonsall Publications, Bonsall, California, U.S.A

Steele, R.G.D. and J.H. Torrie, 1984. *Principles and Procedures of Statistics: A Biometrical Approach*, McGraw Hill Book Int. Co., Singapore

Wassner, D. and D. Ravetta, 2000. Vegetative propagation of *Grindelia chiloensis* (Asteraceae). *Indust. Crops Prod.*, 11: 7–10

Wazir, M.G., N.U. Amin, M. Ishtiaq, A. Aziz and I.A. Khan, 2003. Effects of different soil media on the growth of *Dracaena dermensis* var. Janet Craige cuttings. *Sarhad J. Agric.*, 19: 31–4

Wazir, M.G., N.U. Amin and M. Ishtiaq, 2003. Effects of different potting mixtures and nitrogen source on the performance of Brassaia seedlings-I. *Sarhad J. Agric.*, 19: 463–8

Wazir, M.G., N.U. Amin, I. Khan and M.I. Khan, 2004. Effects of different potting mixtures and nitrogen source on the performance of Brassaia seedlings-II. *Sarhad J. Agric*., 20: 25–31

Ziaullah, N. Ali, S. Asghar, N.U. Amin and M. Arshad, 1999. Genotypic variation in two Cordyline species and their performance in different growth media. *Sarhad J. Agric*., 15: 177–9

(Received 31 July 2006; Accepted 04 December 2006)