"Science Stays True Here"
Biological and Chemical Research, Volume 2015, 268-275 | Science Signpost Publishing

Propagation of *Simmondsia Chinensis* (Link) Schneider by Stem Cuttings

Ahmed M. Eed[1], Adam H. Burgoyne[2]

1. Department of Plant Production, College of Agriculture and Veterinary Medicine, Ibb University, Yemen.

2. JojobaNaturals Corporation, Montevideo, Uruguay.

Received: November 14, 2014 / Accepted: December 12, 2014 / Published: August 25, 2015

Abstract: Jojoba (*Simmondsia chinensis* (Link) Schneider) is a desert shrub which tolerates saline, alkyle soils and drought. The seeds contain a characteristic liquid wax of economic importance in industry as a machine lubricant and cosmetics. A major problem in seed propagation is that jojoba is a dioecious plant whose its sex is not easily determined prior to flowering (3-4 years from germination). To overcome this phenomenon, asexual propagation using vegetative methods such as cutting can be used. This research was conducted to find out the effect of different plant growth regulators (PGRs) and rooting media on jojoba rhizogenesis. An experiment was carried out in a factorial completely randomized block design (FCRBD) with three replications, each with sixty cuttings per replication in fiberglass house of Jojoba Naturals Corporation at Yemen.

The different rooting media used were peat moss + perlite + vermiculite (1:1:1), peat moss + perlite (1:1), and peat moss + sand (1:1). Plant materials used were semi-hard wood cuttings of jojoba plants with length of 15 cm. The cuttings were collected in the month of June during 2012 and 2013 from the sub-terminal growth of the mother plants of Amman farm and introduced to Yemen. They were wounded, treated with Indole butyric acid (IBA), α-naphthalene acetic acid (NAA), or Indole-3-acetic acid (IAA), all at 4000 ppm (part per million) and cultured on different rooting media under intermittent mist propagation conditions. IBA gave significantly higher percentage of rooting (66.23%) compared to NAA and IAA in all media used. However, the lowest percentage of rooting (5.33%) was recorded with IAA in the medium consisting of peat moss and sand (1:1). No significant difference was observed at all types of PGRs used with rooting media in respect of root length. Maximum number of roots was noticed in medium consisting of peat moss, perlite, and vermiculite (1:1:1); peat moss and perlite (1:1), and peat moss and sand (1:1) using IBA, NAA, and IBA respectively. The interaction among rooting media was statistically significant with respect to rooting percentage character. Similarly, the interaction among PGRs was significant in terms of rooting percentage and also root length characters. The results demonstrated suitability of propagation of jojoba plants by semi-hard wood cuttings.

Keywords: Cutting, IBA, jojoba, propagation, rooting.

1. Introduction

Jojoba (*Simmodsia chinensis* (Link) Schneider) is a perennial woody shrub native to the semiarid regions of southern Arizona, southern California, and northwestern Mexico. Jojoba is being cultivated to provide a

Ahmed. M. Eed is with the Department of Plant Production, College of Agriculture and Veterinary Medicine, Ibb University, Yemen. Also he is now an agricultural expert with Jojoba naturals in Yemen. Phone: 00967-772876682; Fax: 00967-1-447 305; E-mail: ahmede@jojobanaturals.com.

Adam H. Burgoyne is with JojobaNaturals Corporation, Montevideo, Uruguay. E-mail: adam@jojobanaturals.com.

renewable source of a unique high-quality oil. Jojoba seed contains a light-gold colored liquid wax ester which is the primary storage lipid of the plant [1]. This is unlike conventional oilseed crops, such as soybean, corn, olive, or peanut which produce oils as the primary storage lipid. Jojoba liquid wax makes up 50% or more of the seed's dry weight. The physical properties of jojoba oil are high viscosity, high flash and fire point, high dielectric constant, high stability, and low volatility. Its composition is little affected by temperatures up to 300°C. The extracted oil is relatively pure, non-toxic, biodegradable, and resistant to rancidity. Jojoba is propagated by sexual and vegetative methods. In plant populations derived by sexual propagation, it is difficult to determine sex type in early stages of growth i.e., 3-4 years from germination, and plants are genetically variable, which affects growth uniformity, physiological characteristics, yield and early bearing [2-3]. Further, jojoba is biased towards male (5:1; male: female ratio) [4]. On the other hand, vegetative propagation methods provide genetically, uniform plant material with early fruiting. Successful rooting of jojoba cuttings can be achieved by the use of different auxins such as indole butyric acid (IBA), α-naphthalene acetic acid (NAA), and indole-3-acetic acid (IAA). The rooting ratio of semi-hardwood cuttings was increased by IBA at 1000 $mg \cdot l^{-1}$ and the rooting ratio of young individuals was higher than the mature ones [5]. Clonal differences for rooting capability of semi-hardwood cuttings treated with 2000 $mg \cdot l^{-1}$ IBA under intermittent mist were evident among 12 clones of jojoba [6]. Reference [7] reported 30 to 70% rooting in terminal cuttings treated with 4000 $mg \cdot l^{-1}$ IBA using intermittent mist in a partially shaded greenhouse. Reference [8] rooted the cuttings of 20 different male jojoba plants by treating with 4000 $mg \cdot l^{-1}$ IBA for fifteen “s,” (second) misting intermittently for eight “s,” every four minutes. Creating an atmosphere of 100% humidity at the leaf surface of jojoba stem cuttings, without saturating the rooting medium, had contributed to a high degree of rooting [9]. Reference [10] recorded rooting of jojoba cuttings within 3 to 5 weeks in a greenhouse with substrate temperature of 30ºC and mist applied for 10 “s,” every 8-10 minutes. Reference [11] recorded 61% rooting in semi-hardwood cuttings of jojoba just dipped in 4000 $mg \cdot l^{-1}$ IBA solution under partially shaded polyethylene sheet tunnel having 90 to 95% humidity with mean temperature of 15 - 30º C.

Jojoba plants were introduced to Yemen as one of ten Arab countries during late 1986 via Food and Agriculture Organization (FAO) [12]. However, almost all cultivated plants were lost due to no care and attention by farmers after plants cultivation. Currently another attempt has been done for propagating jojoba plants with semi-hard wood cuttings by Jojoba Naturals Corporation in some regions in Yemen. The aim of the present study was to evaluate the effect of different plant growth regulators and rooting media on rhizogenesis of jojoba semi-hard wood cuttings for propagating jojoba plants vegetatively in commercial quantities by the use of intermittent mist propagation system, ultimately to multiply true-to-type uniform, desirable selections to establish jojoba plantations in Yemen.

2. Materials and Methods

A. Collection of Plant Material

The 7-9 year-old female and male plants were derived from seed plants and were attempted to be propagated through stem cuttings. Semi-hardwood cuttings were introduced to Yemen via air freight and used for propagating jojoba plants. These cuttings (about 1-year-old with green to brownish bark) 20-30 cm long and 0.25-0.50 cm in diameter having 4-6 pairs of leaves were collected from the plants in the month of June from a mother farm in Amman, Jordan.

B. Preparation of Cuttings

The leaves from two basal nodes of the cuttings were trimmed off. The basal portion with no leaves of the cuttings was wounded with a sterile and sharp razor and then dipped for ten "s," in IBA and IAA or NAA solution with a fixed concentration for all i.e., 4000 ppm (part per million). The treated cuttings were inoculated in the rooting media composed of peat moss, perlite and vermiculite (1:1:1), peat moss and perlite (1:1), and peat moss and sand and kept under intermittent propagation conditions in the fiberglass house. Propagation trays with a size of 75 x 50 x 10 cm were irrigated weekly. They also were punctured on all sides for facilitating excessive water drainage and getting an oxygen gas. Fog irrigation system (Ausama Hallas Co., Amman, Jordan) was used for providing cuttings the suitable humidity (20 "s," with 5 minutes intervals) a day. Humidity range was between 80-90% and temperature was not more than 35 ºC. The temperature and humidity were measured with Hygro-Thermometer device (Jumbo Display Hygro-Thermometer, USA). The cuttings were kept for 60-75 days from first of July to mid of September. They were sprayed with mixed solution of Aromile plus at 1.5 $g \cdot l^{-1}$ (Fungicide) (Mopedco, Jordan) and Bio 20 at 1.5 $ml \cdot l^{-1}$ (liquid macro nutrient fertilizer) (Omex, Agrifluids, Lmt., England) after one week of culturing of cuttings.

C. Statistical Analysis

The experiment was conducted in a factorial completely randomized block design (FCRBD) with three replications each with 100 cuttings per replication. Percentage data was square root transformed before analyzing data according to [13-14]. Different rooting parameters studied were evaluated. ANOVA values were obtained with Opstat1 software (O.P. Sheron, Programmer, Computer Section, CCS HAU, Hisar, India) and means were separated with least significant difference (LSD) at P =0.05.

3. Results and Discussion

The effect of different plant growth regulators and rooting media used on rhizogenesis of jojoba semi-hard wood cuttings in the fiberglass house under intermittent propagation conditions were studied (Table 1, 2). Among different rooting media and PGRs, IBA at 4000 ppm recorded markedly the highest percentage of rooting (66.23%) in the rooting medium composed of peat moss, perlite and vermiculite (1:1:1). This was followed by IBA at the same concentration but by using peat moss and perlite rooting medium and NAA also at the same concentration in the rooting media consisted of peat moss, perlite, and vermiculite (1:1:1), and peat moss and perlite (1:1); the values were 39%, 37.33% and 33.66% respectively with no significant difference. However, the least percentage of rooting (5.33%) was observed with IAA in the rooting medium comprised of peat moss and sand (1:1). On the other hand, IBA was superior to NAA and IAA as well as the rooting medium composed of peat moss, perlite and vermiculite (1:1:1) was also superior to the rooting medium consisted of peat moss and perlite (1:1) and the rooting medium contained peat moss and sand (1:1). The interaction between PGRs used and rooting media applied was significant. The greatest number of roots per cutting (14.66) was recorded with IBA in the rooting medium comprised peat moss, perlite and vermiculite whereas the lowest number of roots (6.66) was observed with IAA but in the same rooting medium. No significant difference was observed between the interaction of PGRs and rooting media with respect to root length. However, the interaction among different PGRs was significant irrespective of PGR kind used. Generally, the PGR (IBA) and the rooting medium (peat moss, perlite and vermiculite with same ratio) were almost the best for inducing roots, number of roots, and root length from the cuttings compared to the other PGRs and rooting media. This superiority of IBA compared to the other PGRs at all parameters studied referred to that IAA in plant tissue is the principal native auxin. IBA is a synthetic auxin which is chemically similar to IAA with similar physiological activity. NAA is also a synthetic auxin which is not chemically similar to IAA, but still similar in physiological activity. The auxin having indole group generally produces a more fibrous root system than the naphthalene group. That is why IBA is preferred to NAA for rooting of cuttings (15). The findings are partially in line with (16) who found that IBA induced more root formation than NAA in jojoba cuttings. However, in our work, we found that NAA superior to IAA in root formation. This result is in line with the findings of (17) who reported that the best root formation in jojoba cuttings was with IBA first then with NAA and finally with IAA. In this experiment, ideal concentration of PGRs used was 4000 ppm which previously used by [7-18].

Table 1

Effect of Rooting Media and Plant Growth Regulators on the Rooting of Jojoba Plant Cuttings

Media	PGRs @ 4000 ppm	No. of cuttings used	% Rooting (Mean ± SD)[3]	No. of roots (Mean ± SD)[3]	Root length (cm) (Mean)
Peat moss + perlite + vermiculite (1:1:1)	IBA	300	66.23±5.02a[1] (54.49)[2]	14.66 ± 2.51 a[1]	11.66 a[1]
	NAA	300	37.3 ±1.15 b (37.64)	11.33 ± 1.52 abc	9.00 a
	IAA	300	25.00 ± 2.88 c (29.91)	9.00 ± 1.00 bc	9.00 a
Peat moss+ perlite (1:1)	IBA	300	39.00 ± 3.46 b (38.61)	6.66 ± 1.52 c	10.00 a
	NAA	300	33.66 ± 4.04 b (35.43)	14.00 ± 1.00 a	6.66 a
	IAA	300	18.33 ± 0.57 d (25.33)	12.33 ± 2.57 ab	8.00 a
Peat moss + sand (1:1)	IBA	300	20.66 ± 0.57 cd (27.01)	13.33 ± 7.52 ab	12.33 a
	NAA	300	20.00 ± 1.15 cd (26.49)	11.66 ± 1.52 ab	8.33 a
	IAA	300	5.33 ± 0.57 e (13.26)	9.00 ± 1.00 bc	7.66 a

[1]Means followed by the same letter are not significantly different according to the LSD test at $p = 0.05$.

[2]Data inside the brackets are Angular transformed values.

[3]Values represent mean ± Standard Deviation (SD).

PGRs plant growth regulators

Table 2

Effect of Rooting Media and Plant Growth Regulators on the Rooting of Jojoba Plant Cuttings

Rooting media (RM)	Rooting (%) (Mean)	No. of roots (Mean)	Root length (cm) (Mean)
Peat moss + Perlite + Vermiculite (1:1:1)	42.85 a[1] (40.68)2	11.66 a[1]	9.88 a[1]
Peat moss+ Perlite (1:1)	30.33 b (33.12)	11.00 a	8.22 a
Peat moss + Sand (1:1)	15.33 c (22.25)	11.33 a	9.44 a
PGRs @ 4000 ppm			
IBA	41.96 a (40.03)	11.55 a	11.33 a
NAA	30.33 b (33.19)	12.33 a	8.00 b
IAA	16.22 c (22.83)	10.11 a	8.22 b

[1] Means followed by the same letter are not significantly different according to the LSD test at $p = 0.05$, comparisons are made in each column within PGRs and RM.

[2] Data inside the brackets are Angular transformed values.

PGRs plant growth regulators

Although the modern infrastructure was used in this experiment including intermittent mist system, cooling system and ideal mixture of rooting media i.e., peat moss, perlite and vermiculite all in fiberglass house but the highest result of rooting percentage was 66.28% which considered low ratio compared with infrastructures used. This might be due to some reasons including no availability of moisture as a film on the surface of jojoba leaves a day because of moving the fans (cooling system) which carried the mist to outside, insufficient wholes on the propagation trays resulted in low drainage water which caused reduction in oxygen ratio and increase in root rot. Furthermore, increase of relative humidity upto saturation level in the ambient condition of cuttings might be caused spreading of fungal diseases such as Alternaria spot. Additional to that, the source of cuttings was from seed plants in which wide genetic variability caused different responses in the rooting. Therefore, the major

factors for the highest rooting percentage of jojoba cuttings are by providing a required humidity inside and around the rooting medium and using high response strains of jojoba plants for rooting character.

4. Conclusion

The present investigation proved that IBA at 4000 ppm concentration was the best PGR for obtaining the highest percentage of rooting in semi-hard wood cuttings of jojoba plants in the rooting medium comprising peat moss, perlite and vermiculite with the same volume under intermittent mist propagation system.

Acknowledgments

We express our great thanks to Jojoba Naturals Company for the cooperation and providing necessary facilities to carry out this experiment in their polyhouses at Yemen.

References

[1]. J. Sardana, and A. Batra, In vitro regeneration of jojoba (Simmondsia chinensis): a plant of high potential, Adv. in Plant Sci., vol. 11, pp. 143-46, 1998.

[2]. H. A. A. Mohasseb, M. K. El-Bahr, Z. M. Adam, H. A. Moursy, and M. E. Solliman, In vitro clonal propagation (Simmondsia chinensis (Link) Schn), Aust. J. of Basic & Appl. Sci., vol 3, pp. 3128-3136, 2009.

[3]. P. A. Roussos, A. Toila-Marioli, C. A. Pontikis, and D. Kotsias, Rapid multiplication of jojoba seedlings by vitro culture, Plant Cell, Tiss. and Organ Cult., vol. 57, pp. 133-137, 1999.

[4]. J. R. Al-Obaidi, B. K. Suliman, and N. K. Al-Ani, Molecular-based marker for sex differentiation of jojoba in vivo and in vitro Iraqi cultivars using RAPD-PCR technique, Sci. Res. and Essays, vol. 7, pp. 522-527, 2012.

[5]. B. Cao, and H. D. Gao, Technology of cutting propagation of Simmondsia chinensis (Link)Schneider, (in Chinese), J. Nanjing Forest. Univ., vol. 27, pp. 62-66, 2003.

[6]. C. W. Lee, and D.A. Palzkill, Propagation of jojoba by single node cuttings, HortSci., vol. 19, pp. 84-42, 1984.

[7]. P. H. Thomson, Jojoba Handbook (3rd ed.), Bonsall Publications, Bonsall, California, U.S.A., 1982, pp. 57-162.

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

[9]. J. H. Brown, and A. M. Campbell, Practical and scientific aspects of vegetative propagation of jojoba cuttings using fog, in: Proc. 6th Int. Conf. on Jojoba and its Uses. Beer-Sheva, Israel. Ben Gurion University of the Negev, 1984, pp. 253-260.

[10]. A. Benzioni, Jojoba Institute for Applied Research, Ben Gurion University of the Negev, Israel, 1997, pp. 1-6.

[11]. M. A. Bashir, A. M. Iqbal, M. N. Asad, M. Y. Ranam, and S.F.H. Shah, Propagation of jojoba through cuttings, J. Animal & Plant Sci., vol. 11, pp. 24-29, 2001.

[12]. G. Blaak, Jojoba development in ten Arab states in north Africa and near east, in: Proc. 7th Int. Conf. on Jojoba and its Uses. Washington, USA., 1988, pp. 451-453.

[13]. K. A. Gomez, Gomez A. A, Statistical procedures for agricultural research, John Wiley & Sons, New York, 1983, pp. 298-308.

[14]. E. V. D. Sastry, Essentials of Agricultural Statistics, Pointer Publishers, Jaipur (India), 2007, pp 260-266.

[15]. D. K. Singh, "Hi-Tech Horticulture, Geeta Somani Agrotech Publishing Academy, Udaipur, India., 2004.

[16]. P. Arce, and M. Jordan, Evaluation of regenerative responses in explants of jojoba (Simmondsia chinensis Link.) cultured In vitro using cuttings, Simiente, 58, 40, 1988.

[17]. Y. Zhou, "A preliminary study on propagation by cutting of Simmondsia chinensis, Plant Physiol. Communic, 38, 564-566, 2002.

[18]. W. R. Feldman, D. A. Palzkill, and L. Hogan, "Nutrition and growth of vegetatively propagated Jojoba, In: Proc 5th Int. Conf. on Jojoba and its Uses. October11-15, 1982, Tucson, Arizona, USA, 1983, pp. 181-195.