Optimizing Rooting of Jojoba Stem Cuttings: Effects of Basal Wounding, Rooting Medium and Depth of Insertion in Medium

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Seedling populations of jojoba are extremely heterogeneous; about 50% of the plants are nonproducing males, and many of the females are low-yielding or are otherwise undesirable. Asexual propagation methods allow the increase and use of only desirable plants. Rooting of stem cuttings is the most commonly used asexual method; however, unsatisfactory results sometimes still occur when using this method, so it requires further refinement. In this study, three factors suspected to play an important role were studied: rooting medium, basal wounding and depth of insertion in the medium. Three media [perlite/vermiculite, 1:1 (vol/vol); peat/perlite/vermiculite, 1:1:1 and peat/perlite, 1:1], wounding *vs.* not wounding, and insertion of one or two nodes below the surface of the medium were compared. The base (2.5 cm) of each cutting was treated with potassium salt of indole butyric acid, 1000 ppm prior to insertion into the medium, and cuttings were rooted on a heated propagation bench under intermittent mist. The experimental design was a 3 × 2 × 2 factorial and was replicated five times. Sixteen cuttings were used per experimental unit. The study was repeated. Rooting percentage was significantly affected only in the first repetition and then only by media. The peat/perlite medium resulted in significantly less rooting than did the other two media. However, averaged over both repetitions, rooting averaged 74% for perlite/vermiculite, 78% for peat/perlite/vermiculite and 64% for peat/perlite. Depth of insertion and wounding did not affect rooting percent in either repetition of the study. Both deeper insertion and wounding resulted in roots emerging from along a greater length of the stem at the basal end of the cuttings. Cuttings with two nodes inserted into the medium averaged root emergence along a 54% greater length of the stem than those with only one node inserted. With wounding, roots emerged along 17.3 mm of the stem, while without wounding, emergence occurred only along 7.0 mm of the stem. The better root system resulting from wounding and deeper insertion into the medium would likely result in better performance of the cutting when transplanted to a field.

KEY WORDS: Agronomic practices, asexual propagation, clonal propagation, cuttings, nursery practices, planting stock, rooting medium, wounding.

Seed of jojoba [*Simmondsia chinensis* (Link) Schneider] contain a liquid wax, which is used in cosmetics and lubricants (1). Early plantings of jojoba were started from seed; however, use of stem cuttings is rapidly becoming the preferred method for propagating jojoba. Seedling populations of jojoba are extremely heterogeneous; about 50% of the plants are nonproducing males, and many of the females are low-yielding or are otherwise undesirable. Asexual propagation methods allow the increase and use of only desirable plants. Asexual methods that have been successfully tried include stem cuttings (2,3), air-layering (4), grafting (5) and tissue culture (6–8). For a variety of reasons, cutting propagation has become the most widely adopted of these asexual methods.

While cutting propagation is widely used, specific methods used vary considerably, along with degree of success. In this paper, we will report on a study, conducted to optimize rooting, in which wounding, media and depth of insertion were studied.

For rooting jojoba cuttings, a medium consisting of a mixture of perlite and vermiculite (1:1) has been commonly used when rooting cuttings in common flats, followed by potting up into individual containers in a peat-based mix. For labor efficiency and better performance of cuttings, most cuttings are now started directly in small, individual biodegradable containers. Following rooting and hardening, plants are transplanted directly to the field from these containers or shifted into larger nursery containers. Media based only on perlite and vermiculite do not hold together well during transplanting, so an alternative is desired. In this study we compared a perlite/vermiculite medium with two others, which had peat incorporated to increase the integrity of the media.

In two reports on rooting of jojoba cuttings, wounding increased both rooting percent and number of roots (5,6). These studies found, respectively, increases of 60 and 62% in rooting percent for cuttings that were wounded and treated with indole butyric acid (IBA) compared to cuttings that were not wounded but treated with IBA. No studies have been reported on effects of depth of insertion on rooting of jojoba cuttings.

The objectives of this study were to determine (i) whether peat-based media would perform as well as perlite/vermiculite; (ii) whether depth of insertion influenced rooting; and (iii) whether slicing a 1-cm long segment of bark from the proximal end of the cuttings prior to treatment with IBA would improve rooting.

MATERIALS AND METHODS

Stem tip cuttings with six nodes were collected from 4-yr old plants of five jojoba clones growing at The University of Arizona, Casa Grande Overpass Farm located in Tucson, Arizona. Cuttings were collected on June 22 and July 5, 1983, for two complete repetitions of the study. Cuttings were placed in insulated coolers and transported to the propagation house.

The effects of medium, basal wounding and depth of insertion was evaluated in a 3 × 2 × 2 factorial experiment replicated on five clones. Within each replicate, sixteen cuttings were used for each clone × treatment combination. Data were analyzed by the analysis of variance for a randomized complete block design. Means were separated by the Student-Newman Keul procedure.

Media evaluation were (i) perlite and vermiculite 1:1 (vol/vol); (ii) peat, perlite and vermiculite 1:1:1 (vol/vol/vol); and (iii) peat and perlite 1:1 (vol/vol). Media (i) and (iii) were selected because they had been commonly used for jojoba

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in the past. Medium (ii) was selected because it was judged to have desirable characteristics for both rooting and maintaining integrity during transplanting.

To determine the effect of basal wounding, wounded cuttings were compared to nonwounded. After cuttings arrived at the greenhouse, they were re-cut about 1 cm below the 4th node with pruning shears, cutting at right angles to the stem. For the basal wounding treatment, a single-edged razor blade was used to slice away a segment of bark on both sides of the base of the cutting for a length of about 1.5 cm.

To determine the effect of depth of insertion, cuttings were either inserted to cover the basal node (from which leaves were removed), or cuttings were inserted to cover the two most basal nodes (from which leaves were removed). For the cuttings that had two nodes inserted into the medium, we started with an extra node, so we ended up with the same number of pairs of leaves remaining on all cuttings during rooting.

The basal ends of all cuttings were dipped in a 1000-ppm solution of K-IBA for about 5 s prior to inserting them into the appropriate medium. During rooting, cuttings were maintained on a bench in a greenhouse with bottom heat maintained at 25–30°C, and intermittent mist was applied during daylight hours (typically 8 s once every 8 to 16 min).

Cuttings were removed from the mist propagation bench after two months and maintained in a shade house (50% of full sun) for an additional four months. They were then evaluated for rooting and growth. Percent rooting and length of stem with adventitious roots were determined and are given in Table 1. Fresh weight of the root and shoot, and the number of nodes were determined and are given in Table 2.

RESULTS AND DISCUSSION

Rooting percent was variable; however, it was significantly effected in only the first repetition of this study and then only by media. The medium containing peat and perlite resulted in significantly less rooting than the other two media. Depth of insertion and wounding did not affect rooting percent in either study (Table 1).

TABLE 1

Effects of Media, Depth of Insertion and Wounding on Rooting of Jojoba Stem Cuttings[a]

	Rooting parameter					
	Percent rooting			Length of stem with roots (mm)		
Treatment	Exp. A	Exp. B	Ave.	Exp. A	Exp. B	Ave.
Media						
P/V	74.8	73.2	74.0	9.4	16.1	12.8
P/P/V	69.6	86.3	78.0	8.1	16.2	12.2
P/P	49.8*	78.8	64.3	7.1	15.9	11.5
Nodes inserted						
1	70.4	82.9	76.7	6.6*	12.4*	9.5
2	59.1	75.9	67.5	9.9	19.7	14.8
Wounding						
No	66.5	78.6	72.6	6.3*	7.7*	7.0
Yes	63.0	80.2	71.6	10.2	24.4	17.3

[a]P/V, perlite and vermiculite; P/P/V, peat, perlite and vermiculite; P/P, peat and perlite. Exp., experiment; Ave., average. Significantly different (noted by an asterisk) from other values within the same column and treatment factor ($P = 0.05$).

TABLE 2

Effects of Media, Depth of Insertion and Wounding on Shoot and Root Growth of Rooted Jojoba Cuttings[a]

	Rooting parameter								
	FWR (g)			FWS (g)			NN		
Treatment	Exp. A	Exp. B	Ave.	Exp. A	Exp. B	Ave.	Exp. A	Exp. B	Ave.
Media									
P/V	1.2	1.2	1.2	2.1	2.0	2.1	6.8	6.7	6.8
P/P/V	1.1	0.9	1.0	2.0	2.2*	2.1	6.1	7.2	6.7
P/P	0.6*	1.2	0.9	1.4*	1.9	1.7	5.1*	6.3	5.7
Nodes inserted									
1	0.9	1.1	1.0	1.9	2.1	2.0	6.2*	6.6	6.4
2	1.0	1.0	1.0	1.8	2.1	2.0	5.8	6.9	6.3
Wounding									
No	1.0	0.9*	1.0	1.9*	2.0	2.0	6.0	6.4	6.2
Yes	0.9	1.2	1.1	1.8	2.1	2.0	6.0	7.1	6.6

[a]FWR, fresh weight of roots; FWS, fresh weight of shoot; NN, number of nodes on shoot. See Table 1 for other abbreviations. Significantly different (noted by asterisk) from other values within the same column and treatment factor ($P = 0.05$).

The length of the stem from which roots emerged, a measure of rooting quality, was significantly affected in both repetitions of this experiment, and the differences were consistent. Cuttings with two nodes inserted below the surface produced roots along an average length of 14.8 mm of the stem, while cuttings with only one node inserted produced roots along an average length of only 9.5 mm (Table 1).

Wounding had a larger effect on the length of stem from which roots emerged. In the first repetition, on nonwounded cuttings, roots emerged over a mean length of 6.3 mm, while on wounded cuttings, roots emerged along the entire wounded portion of the stem (10.2 mm). In the second repetition, the differences were even greater. On nonwounded cuttings, roots emerged along a mean length of 7.7 mm, while on the wounded cuttings, roots emerged along a length of 24.4 mm. The reason for apparent stimulation of root emergence above the wounded region is unknown (Table 1).

Subsequent growth was little affected by any of the treatments, even though differences were significant in some cases. In the first repetition, as was the case for effects on rooting, cuttings in the medium formulated from peat and perlite grew less than those in other media. The fresh weight of roots and shoots, as well as the number of nodes, were significantly less for cuttings in this medium (Table 2). Depth of insertion and wounding caused small significant differences in growth in several instances; however, the differences were not of practical importance.

The results clearly show that both increasing the depth of insertion and wounding the base of the cuttings will result in rooting along a longer length of the stem. Presumably, the larger number of roots and emergence from a longer length of stem will result in a stronger root system, and, so, these practices are recommended. Unlike other investigators (9,10), we did not find wounding to increase rooting percent of jojoba cuttings.

Significant interactions occurred among certain factors for several of the responses measured, although results were not consistent between repetitions of the study (Table 3). Most interactions occurred for the length of stem with roots (LRA), especially in the second repetition of the study. In the second repetition, both percent rooting and LRA were greater than in the first repetition (Table 1), and this overall greater rooting response likely allowed interactions to be magnified. Significant interactions among factors did not occur for percent rooting.

Although not studied in this experiment, effects of wounding will likely be most pronounced when IBA is used. In earlier studies, little effect of wounding was noticed when IBA was not used. However, in combination with IBA treatment, wounding caused significant increases in rooting (9,10). This suggests that wounding improves the response to IBA.

Overall, the three media tested had no effect on rooting percent or root quality. For direct sticking into open-bottomed biodegradable containers, the peat/perlite/vermiculite medium would be the best of the three media tested because it holds together well after several weeks under mist, even with relatively poorly developed root systems. The other two media have a greater tendency to fall apart at transplanting, resulting in damage to the root system.

TABLE 3

Interactions Between Media, Depth of Insertion (node), Wounding and Cloning on Rooting and Growth of Jojoba Stem Cuttings[a]

Interaction	Exp.	% Rooting	LRA	FWR	FWS	NN
Two-way						
Media × node	A	.21	.58	.88	.09	.35
	B	.94	.15	.38	.64	.84
Media × wound	A	.67	.53	.87	.25	.98
	B	.89	.02*	.73	.24	.39
Media × clone	A	.26	.29	.10	.05*	.21
	B	.32	.07	.02*	.66	.18
Node × wound	A	.93	.82	.85	.11	.88
	B	.44	.001**	.40	.08	.71
Node × clone	A	.77	.03*	.99	.22	.08
	B	.45	.001**	.08	.37	.44
Wound × clone	A	.72	.16	.93	.07	.18
	B	.32	.001**	.25	.92	.75
Three-way						
Media × node × wound	A	.88	.53	.77	.01**	.03*
	B	.32	.22	.53	.68	.31
Media × node × clone	A	.39	.49	.76	.06	.40
	B	.91	.04*	.76	.23	.44
Media × wound × clone	A	.93	.26	.70	.03*	.64
	B	.54	.14	.51	.05*	.67
Node × wound × clone	A	.83	.03*	.80	.09	.07
	B	.37	.02*	.18	.82	.39

[a]Abbreviations: LRA, length of rooted portion of stem; see Table 2 for other abbreviations. Significant ($P = 0.05$) (noted by single asterisk) and highly significant ($P = 0.01$) (noted by double asterisk) interactions.

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