Propagation of *Pistacia chinensis* by Mound Layering[1]

Diane E. Dunn and Janet C. Cole[2]
Department of Horticulture and Landscape Architecture
Oklahoma State University, Stillwater, OK 74078

Abstract

Chinese pistache (*Pistacia chinensis*, Bunge.) is a commonly recommended landscape shade tree in the nursery and landscape industry. Currently, Chinese pistache trees are propagated commercially from seed, which results in highly variable branch habit and fall color. Mature Chinese pistache, like other *Pistacia* have proven difficult to root, graft, or bud successfully. This study was initiated to investigate the potential of mound layering as an alternative vegetative propagation method for producing genetically identical clones of superior mature Chinese pistache trees. Results from a greenhouse pre-trial in which trees were cut at two different heights and at three different morphological stages showed that significantly more shoots were produced when stock plants were cut 5 cm (2 in) above the soil line compared to 1 cm (0.4 in), and when trees completely broke dormancy before cutting. Field trials during two consecutive years evaluated four treatments consisting of 1) wound; 2) 17,500 ppm IBA; 3) wound and 17,500 ppm IBA 4) no wound, no IBA. In 1993, 77% and in 1994, 75% of wounded shoots treated with IBA produced roots.

Index words: stooling, Chinese pistache, indolebutyric acid.

Species used in this study: Chinese pistache (*Pistacia chinensis*, Bunge.).

Significance to the Nursery Industry

Vegetative propagation of Chinese pistache would offer many benefits including establishment of cultivars for marketing in the nursery industry. These cultivars would be propagated from superior, mature trees that have been evaluated for vigor, consistent fall color, disease and insect resistance, and branch habit. Establishment of cultivars based on fruit bearing would also be beneficial where the presence of fruit would be a problem. Mound layering is an efficient, mechanized, economical propagation system that is commonly used to propagate many fruit and landscape trees. This study showed mound layering to be a feasible alternative to cutting propagation of Chinese pistache.

Introduction

Brought to America from China in the late 1800s, Chinese pistache is hardy in USDA hardiness zones 6 through 9, flourishes in full sun, and reaches a mature height of 9 to 12 m (30 to 40 ft) with a 4.2 to 9 m (20 to 30 ft) spread (21). It develops an oval, umbrella-like crown providing generally light-textured shade throughout the growing season. Chinese pistache is native to well drained alkaline soils, but tolerates most soil conditions (11). In California, it is recommended for its xerophilous qualities and salt tolerance (5, 20). It endures extreme heat and drying winds (3, 5, 18), and survives winter temperatures to –26C (–14.8F) (10). As a street tree, Chinese pistache continues healthy growth even when planted on narrow spacings (13). Fall color is variable, ranging from dark red to yellowish-green, and extreme diversity can exist even within the same tree (16). Foliage stays lush throughout the season since it is not prone to insect or disease problems (4, 21).

Mature cuttings of Chinese pistache have proven difficult to root (8); however, some rooting success has been experienced with cuttings from seedlings (12, 18). This is typical of the difficult-to-root *Pistacia* genus. Attempts to root pistachio (*Pistacia vera*) cuttings from mature trees have been unsuccessful (9) or limited, with very high concentrations of IBA (1, 2). Adult growth in Chinese pistache seems to be reached after two years (8, 18), making asexual propagation more difficult. Mound layering offers a method of manipulating stock plants to regain the high rooting potential of juvenile trees. Mound layering, or stooling involves the establishment of a parent stock plant which is then cut back to a very short stub—the stool (15). The process of stooling involves the initiation and development of roots on a stem before that stem is removed from its parent plant. Severe pruning and the induction of adventitious shoots, produce plants which are juvenile-like in appearance and vigorous in growth (7). Propagation of cashew (*Anacardium occidentale*) is accomplished by cutting back the whole plant and mound layering vigorous juvenile shoots (17). Mound layering today is an efficient, mechanized, economical propagation system (14). The purpose of this study was to determine whether mound layering is an effective propagation method for Chinese pistache.

Materials and Methods

Greenhouse cutting time and height pre-trial. This experiment utilized 457 ten-month-old seedlings established in 7 × 7 × 14 cm (2.75 × 2.75 × 5.5 in) deep bottomless waxed cardboard boxes (705 ml, 1–1/2 pint) containing peat:perlite (1:1 by vol) amended with 2.3 kg/m^3 (4 lb/yd^3) 17N-3P-10K (17-7-12) slow release fertilizer (Osmocote, Grace-Sierra, Milpitas, CA) and 0.6 kg/m^3 (1 lb/yd^3) micronutrients (Micromax, Grace Sierra). Trees were in a shade house until October 26, 1992, where the maximum temperature reached 32C (90F) and the maximum photosynthetic photon flux (PPF) was 945 µmol/sq m/sec. Trees were then placed in a cooler at 5C (41F) until January 4, 1993. Upon removal, trees were placed in a polyethylene covered greenhouse at the Oklahoma State University Nursery Research Station, Stillwater. They were exposed to average day/night temperatures of 26/20C (78/68F) with maximum/minimum air temperature of 37/18C (99/64F) and PPF of 815

[1] Received for publication December 6, 1994; in revised form March 6, 1995. Approved for publication by the Director, Oklahoma Agricultural Experiment Station. This research was supported under project H-2436. The authors wish to thank Roger Dunn for his technical assistance.

[2] Graduate Research Assistant and Associate Professor, respectively.

μmol/sq m/sec under natural photoperiod. Trees were fertilized with 20N-4.3P-16.6K (20-10-20) water soluble fertilizer (Peter's Peat Light Formula, Grace-Sierra) at 22.5 ppm N and micronutrients (STEM, Grace Sierra) at 60 ppm at two week intervals until the experiment concluded.

Seedlings were cut 1 or 5 cm (0.4 or 2 in) above the soil line on January 4, January 25, and February 17, 1993. These dates corresponded to dormancy (buds not open), majority of buds broken, and leaves unfurled, respectively. Plants cut January 4 were evaluated after 59 days, while those cut January 25 and February 17 were evaluated after 38 days. Evaluations were done when most shoots were at least 10 cm (3.9 in) long. All shoots were counted regardless of length, and treatments were evaluated for number of shoots produced. Trees were randomized in a split plot design with cutting height as the main plot and cutting time as the subplot. Forty replications with one to four trees per replication were used for a total of 457 subsamples. Analysis of variance procedures were performed on the data, and the differences between the treatment means were further determined with the protected least significant difference (LSD) test.

Field study 1993. On October 1, 1992, 56 ten-month-old trees where removed from 3.7 liter (#1) pots and field planted with 2.5 m (9 ft) between rows and 2.5 m (9 ft) between trees within rows at the Oklahoma State University Nursery Research Station. Half of the trees were cut to one trunk per stool at that time. The soil type was a Norge loam (fine silty, mixed, thermic Udic Paleustolls) with a pH ranging from 4.9 to 5.2 throughout the field. Calcium carbonate was applied at 428 kg/ha (393 lb/A) on April 1. Maximum PPF was 1,780 μmol/sq m/sec. On May 14, 1993, all trees were actively growing (leaves unfurled) and were cut 18 cm (7.1 in) above the soil line and new shoots were allowed to develop. Shoots grew horizontally for approximately 10 mm (0.4 in), then parallel to the stool. Treatments consisted of a 2 by 2 factorial arrangement of wounding vs. no wounding and 17,500 ppm liquid IBA application vs. no IBA. The IBA concentration was determined in a preliminary greenhouse auxin trial (6). Wounding consisted of slicing into the phloem and cambial tissue approximately 1 mm (0.04 in) deep and 8 mm (0.3 in) long on top of the horizontal section of the shoots. The 17,500 ppm IBA solution was applied by lightly rubbing it into this horizontal area. The morphological condition of the shoots was green softwood with the basal 2 cm (0.8 in) beginning to lignify. Treatments were applied when shoots were 12 cm (4.8 in) in length. Sawdust was mounded around treated shoots to a depth of 8 cm (3.1 in). As new shoots developed above treated shoots they received the same treatment and the sawdust depth was increased. Trees received drip irrigation as necessary, sawdust was overhead irrigated every two days. On April 1, 1994, sawdust was removed and each treated shoot was evaluated for primary root number, length of three longest primary roots, circumference of three largest primary roots, and number of secondary roots on the three longest primary roots. Shoot height was measured from its point of emergence from the stool to the tip of the terminal.

Table 1. Influence of stock plant cutting heights of 1 and 5 cm, and three morphological times of cutting on Chinese pistache shoot production.

Cutting date	Stock plant morphology	Stock plant height (cm)	Number of shoots
January 4	Dormant	1	0.9[z]
January 4	Dormant	5	2.8
January 25	Budbreak	1	0.8
January 25	Budbreak	5	3.3
February 17	Shoots and leaves out	1	0.7
February 17	Shoots and leaves out	5	4.8
Significance $LSD_{0.05}$			
Date treatment for same height			0.9
Date treatment for different height			0.7
Height			***[y]
Date			*
Height × Date			**

[z]Mean of 40 replications.

[y]*,**,*** Significant at $P \leq 0.05$, 0.01, and 0.001, respectively.

Field Study 1994. The same trees used in 1993, and 24 other trees that had been planted at the same time were treated as described in the 1993 field study except that all trees were cut to 10 cm (3.9 in) in height on April 15, 1994. Thirteen blocks were used, with a total of 52 trees. Trees were evaluated after 12 weeks for rooting response.

A randomized complete block design was used both years with seven and thirteen replications for 1993 and 1994, respectively. Data were subjected to analysis of variance (GLM), and mean separations were performed with a protected least significant difference (LSD) at $P \leq 0.05$ using SAS (SAS Institute, Cary, NC).

Results and Discussion

Greenhouse cutting time and height pre-trial. The interaction between cutting height and morphological condition of the seedlings was significant at $P \leq 0.01$ (Table 1). Cutting the stock plants to 5 cm (2 in) on February 17, after emergence of shoots and leaves, produced the largest number of shoots. Regardless of whether the trees were dormant, had broken bud, or had unfurled leaves, the 5 cm (2 in) height produced significantly more shoots than the 1 cm (0.4 in) cutting height.

Field Study 1993. Mean primary root number, root length, root circumference, and secondary root number for the wound + 17,500 ppm IBA combination treatment were significantly greater than for the other three treatments (Table 2). There were no significant differences in shoot height, regardless of treatment.

Field Study 1994. Wounding followed by 17,500 ppm IBA resulted in significantly more primary roots than the other three treatments (Table 3). Since no primary roots formed on non-wounded plants, no root lengths, root circumferences, or secondary root numbers were available. There was no signficant difference in mean root length, root circumference, or secondary root number regardless of IBA treatment in wounded stools. Shoots receiving the no wound/no IBA, or no wound/IBA treatment, were taller than wound/IBA treated shoots.

The greenhouse pretrial established that cutting after shoot and leaf emergence and using taller stock plants produce more shoots for Chinese pistache field layering. These results were used in the field trials, except that height was increased to provide more potential shoots. Stock plant height

Table 2. **Number, length and circumference of primary roots, number of secondary roots and shoot height 40 weeks after wounding and application of 17,500 ppm IBA to 18-month-old Chinese pistache seedlings in 1993.**

Treatments Wound	IBA	Primary root number[z]	Root length[y] (cm)	Root circumference[x] (mm)	Secondary root number[w]	Shoot height (cm)
Yes	Yes	7a[v]	26.5a	9.1a	19a	48.9a
Yes	No	1b	2.8b	0.5b	1b	51.8a
No	Yes	1b	5.6b	0.9b	4b	45.5a
No	No	0b	0.6b	0.2b	2b	59.0a

[z]Mean number of primary roots per treated shoot.
[y]Mean length of three longest primary roots.
[x]Mean circumference of three largest primary roots.
[w]Mean number of secondary roots on 3 longest primary roots.
[v]Mean separation within columns by LSD at $P \leq 0.05$.

the second year was decreased (from 18 to 10 cm, 7.1 to 3.9 in) to eliminate any influence due to treatments during the previous year and to encourage shoots to be produced at the same time on the base. The 10 cm (3.9 in) height accomplished these goals and would be recommended for future field studies.

The first year stock plants produced an average of 2 to 3 treatable shoots. The second year, many stock plants produced 8 to 12 shoots, so the number of shoots per tree was reduced during 1994 to the six largest to maintain uniformity across treatments. Commercially, the use of multiple leaders, multiple shoots, and close tree spacings would result in large numbers of marketable sized Chinese pistache clones. In 1993, 77% of the wounded, IBA-treated shoots rooted, compared to 75% rooting in the same treatment in 1994. Comparably, M.9 apple rootstocks, with an average rooting of 70%, and planted at standard 0.3 m × 1.8 m (1 ft × 6 ft) spacing yield 30,000 rooted shoots per acre (14). A similar number of rooted shoots might be expected from mound layered Chinese pistache.

A close relationship between treatment and primary root number, length, circumference, secondary roots, and shoot height occurred both years. Wounding the shoots is usually necessary for root production in Chinese pistache but must be combined with the auxin treatment for high rooting percentages. Wounding removes the hardened periderm that may restrict root emergence. Wounding also allows the IBA to be placed directly on the cambium. Use of auxin is not a traditional procedure in mound layering but has been shown to be important in air layering of many species such as pecan (*Carya illinoinensis*) (19), and cashew (*Anacardium occidentale*) (17). Application of IBA was necessary for rooting of Chinese pistache, but was only effective when a wound was also present.

In conclusion, wounding combined with 17,500 ppm IBA produced 75 to 77% rooted shoots. Due to low rooting percentages of adult Chinese pistache cuttings, mound layering offers a feasible alternative to produce well rooted cuttings of a new cultivar. While adult Chinese pistache cuttings have proven difficult to root, recent research has shown that it can be done (6). A Chinese pistache tree with exemplary characteristics could be chosen, multiple cuttings taken, rooted in a greenhouse, then planted in a field and mound layered indefinitely. Mound layering could also be used in conjunction with budding and grafting. Trees could be budded or grafted at ground level, then layered as described.

Literature Cited

1. Al Barazi, Z. and W.W. Schwabe. 1984. The possible involvement of polyphenol-oxidase and the auxin-oxidase system in root formation and development in cuttings of *Pistacia vera*. J. Hort. Sci. 59:453–461.

2. Al Barazi, Z. and W.W. Schwabe. 1985. Studies on possible internal factors involved in determining ease of rooting in cuttings of *Pistacia vera* and *Prunus avium* cvs. 'Colt' and 'F12/1'. J. Hort. Sci. 60:439–445.

3. Behboudian, M.H., R.R. Walker, and E. Torokfalvy. 1986. Effects of water stress and salinity on photosynthesis of pistachio. Scientia Hort. 29:251–261.

4. Crockett, J.U. 1972. Trees. An encyclopedia of deciduous trees. Vol. 10. Time-Life, New York, NY.

Table 3. **Number, length and circumference of primary roots, number of secondary roots and shoot height 12 weeks after wounding and application of 17,500 ppm IBA to 18-month-old Chinese pistache seedlings in 1994.**

Treatments Wound	IBA	Primary root number[z]	Root length[y] (cm)	Root circumference[x] (mm)	Secondary root number[w]	Shoot height (cm)
Yes	Yes	11a[v]	75.1a	1.6a	22a	63.0c
Yes	No	3b	15.2a	1.2a	3a	80.8bc
No	Yes	0b	—	—	—	91.8ab
No	No	0b	—	—	—	106.8a

[z]Mean number of primary roots per treated shoot.
[y]Mean length of three longest primary roots.
[x]Mean circumference of three largest primary roots.
[w]Mean number of secondary roots on 3 longest primary roots.
[v]Mean separation within columns by LSD at $P \leq 0.05$.

5. Dewers, R.S. 1981. Evaluation of native and exotic woody plants under severe environmental stress. J. Arboriculture 7:299–302.

6. Dunn, D.E. 1995. Vegetative propagation of Chinese pistache. MS Thesis., Oklahoma State Univ., Stillwater.

7. Howard, B.H., R.S. Harrison-Murray, J.Vesek, and O.P. Jones. 1988. Techniques to enhance rooting potential before cutting collection. Acta Hort. 227:176–186.

8. Joley, L.E., 1960. Experiences with propagation of the genus *Pistacia*. Proc. Intern. Plant Prop. Soc. 10:287–292.

9. Joley, L.E. and K.W. Opitz. 1971. Further experience with propagation of *Pistacia*. Proc. Intern. Plant Prop. Soc. 21:67–76.

10. Koller, G. 1978. New trees for urban landscapes. Arnoldia. 38:157–172.

11. Lee, C.L., J.L. Paul, and W.P. Hackett. 1976a. Effect of Ca saturation and air filled porosity of sphagnum peat on the root regeneration of *Pistacia chinensis* Bunge. and *Liquidambar styraciflua* L. J. Amer. Soc. Hort. Sci. 101:233–236.

12. Lee, C.L., J.L. Paul, and W.P. Hackett. 1976b. Root promotion on stem cuttings of several ornamental plants by acid or base pre-treatment. Proc. Intern. Plant Prop. Soc. 26:95–99.

13. Long, D. 1960. Budding and growing *Pistacia chinensis* for street trees. Proc. Intern. Plant Prop. Soc. 10:294–296.

14. McDonald, B. 1988. Practical woody plant propagation for nursery growers. Timber Press, Portland, OR.

15. Macmillian Browse, P.D. 1980. Stooling nursery stock. Grower Guide No. 19. Grower Books, London, U.K.

16. Macmillian Browse, P.D. 1988. Autumn glory. Knowing and growing the versatile Chinese pistache. Amer. Nurseryman 167(1):115–120.

17. Ohler, J.G. 1979. Cashew. Department of Agricultural Research. Koninklijk Instituut voor de Tropen. Amsterdam, Holland.

18. Pair, J.C. and H. Khatamian. 1982. Propagation and growing of the Chinese pistache. Proc. Intern. Plant. Prop. Soc. 32:497–502.

19. Sparks, D., and J.W. Chapman. 1970. The effect of indole-3-butyric acid on rooting and survival of air-layered branches of the pecan, *Carya illinoensis* Koch, cv. "Stuart". HortScience 5: 445–446.

20. Spiegal-Roy, P., D. Mazigh and M. Evenari. 1977. Response of pistachio to low soil moisture conditions. J. Amer. Soc. Hort. Sci. 102:470–473.

21. Whitcomb, C.E. 1985. Know It and Grow It. 2nd. ed. Lacebark Publications, Stillwater, OK.