

Research note

Experiments in rooting bishop pine (*Pinus muricata* D. Don) cuttings

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Application. Bishop pine is valued in regions where Monterey pine (*Pinus radiata* D. Don) is planted, making information on propagation of bishop pine needed. Detached shoots from bishop pine rooted well when 8-10 cm cuttings were taken from seedlings and juvenile (1-4 year-old) hedged plants and stuck in nursery containers. To get the highest rooting success, take cuttings during late winter and early spring from hedges maintained at 0.2-0.3 m. Heritable differences among clones indicate that rapidly rooting clones could be selected.

Abstract. Presented here are results of rooting studies using hedges established from juvenile seedlings of "blue" and "green" foliated bishop pine (*Pinus muricata* D. Don) from Mendocino and Sonoma Counties, California. Rootability, averaged over all clones and all setting dates, was 88%. The average time for 50% of the cuttings to root was 6 months. In general, cuttings began to root rapidly in late winter/early spring. The time of year when cuttings were set determined how soon they began a phase of rapid rooting, with cuttings set in winter and early spring beginning faster than other setting dates. The period of rapid rooting lasted 2-3 months until mid/late summer, beyond which time, rooting was slow. Population and family differences in rooting were not significant; differences in rooting among clones, however, were large and significant. Analyses of clones in two experiments indicated that rooting was heritable.

Introduction

Bishop pine (*Pinus muricata* D. Don) is a small timber tree native to coastal western North America. Although not as widely planted as its relative Monterey pine (*P. radiata* D. Don), certain provenances of bishop pine have attributes that make the species competitive on sites that are marginal for Monterey pine. Northern sources of bishop pine, including "blue" and "green" races of *P. muricata* var. *borealis* (Duffield 1951; Axelrod 1983) from Humboldt, Mendocino, and Sonoma Counties, California (Griffin & Critchfield 1976) survive and outgrow Monterey pine at high elevations, on cold sites, and on low fertility soils (Fielding 1961; Doran 1974; Shelbourne 1974; Burdon 1980; Shelbourne et al. 1982). Northern sources also appear

more resistant to infection of *Dothistroma pini*, which causes red band needle blight, than Monterey pine (Cobb & Libby 1968; Shelbourne 1974). These attributes, combined with good growth and form, and wood quality comparable to Douglas-fir (*Pseudotsuga menziesii* Franc.) (Schniewind & Gammon 1980), have led foresters to plant and test bishop pine both near its native range in USA (Smith 1983; R. Dresser, pers. comm.) and in several other countries, including Australia (Fielding 1961; Doran 1974), New Zealand (Shelbourne 1974; Shelbourne et al. 1982), Britain (Everard & Fourt 1974), Ecuador (F. Montenegro, D. Desmond, pers. comm.), France (H. Chaperon, pers. comm.) and S. Africa (R. Poynton, pers. comm.).

If the northern populations of bishop pine are to be used more commonly, information will be needed on nursery practices for the species. Nursery characteristics relating to seedling establishment resemble those for Monterey pine, except that bishop pine has 3½ times as many seeds per kg (Schopmeyer 1974) and its seedlings usually grow slower than those of Monterey pine in the first few years (Shelbourne 1974). The techniques of vegetative propagation for bishop pine, however, are not well developed. Many of the same reasons that make clonal propagation useful for Monterey pine forestry (Fielding 1964; 1970; Thulin & Faulds 1968; Libby et al. 1972) apply to bishop pine and create a demand for practical knowledge on rooting techniques in this species. Reported in this note are results from experiments in rooting bishop pine cuttings.

Materials and methods

Open-pollinated seeds were collected in 1978 from native bishop pine populations in Sonoma and Mendocino Counties including:

- the green race in central Sonoma Co. (40 trees)
- the blue race in northern Sonoma and Mendocino Counties (40 trees)
- transitional stands where the two races overlap (20 trees)

Seeds were germinated in summer 1979 and grown in 25cm³ plastic containers filled with a light potting soil in a Berkeley greenhouse. In February 1980, 20 seedlings, each from a different tree and collection area (total 60 seedlings), were transplanted into the same soil mixture in 15-cm clay pots, fertilized biweekly (10N-8P-7K plus micronutrients), and grown in a lathhouse. These seedlings were to be hedged at 0.2-0.3 m and kept as cutting donors for rooting studies.

In April 1980, the first cuttings were taken from the terminal and firstorder branches of these seedlings to begin hedging. These and subsequent cuttings were treated according to procedures that have been successful for other pines (Libby 1964): immediately after collection, the 8-10 cm cuttings were soaked

in a benomyl solution (150 ppm in water) for 30 minutes, then were basally trimmed to 6-8 cm, the basal 2 cm were dipped in an indole-butyric acid solution (4000 ppm in 95% ethanol) for five seconds, and the cuttings were stuck in a rooting medium in opaque plastic containers (25-cm³). The bottom two-thirds of the tubes were filled with a light potting-soil (1 peat: 1 sand: 1 redwood soil conditioner, plus micro-nutrients) and topped with rooting medium (1 peat: 1 N-charged redwood sawdust: 1 oak-leaf mold). The tubes were put on greenhouse benches under intermittent mist (schedule varied with season, keep containers damp) and 16-hour daylight. Bench temperature was not controlled: summer temperatures in the greenhouse were modified by whitewashing the windows. Cuttings were fertilized weekly with a 3N-10P-3K solution.

After the April 1980 set, cuttings were taken from the hedges periodically, on 27 August 1980, 23 February 1981, 1 September 1981, 25 June 1982, 8 September 1982 (green race cuttings only) and 7 November 1983. Cuttings were considered to have rooted when roots emerged out the bottom of the containers. Each experiment was continued for 12 months.

Results

Overall rootability

Shoot cuttings of juvenile and hedged-juvenile bishop pine rooted rapidly. The average time until 50% of the cuttings rooted (as defined above) was six months, and the average final rooting percent for cuttings from all clones and all setting dates was 88%. The root systems formed were multiple-branched and symmetric, and unrooted cuttings remained healthy for 12 months on the mist benches.

Time of year

The rooting curves for the different setting dates differed significantly (by chi-square analyses) in both rooting percents at 6 and 12 months and rates of rooting, as measured by the time to 50% rooting (Fig. 1). The overall shape of the rooting curves, however, was similar for all setting dates. There was an initial period of varying duration when rooting was slow, then a 2-3 month period when rooting increased rapidly, followed by a final phase of slow rooting. The points where rooting began to increase rapidly occurred at about the same time of year for all seven experiments. Those points were mostly in late winter and spring, generally regardless of the time of year that the cuttings were collected.

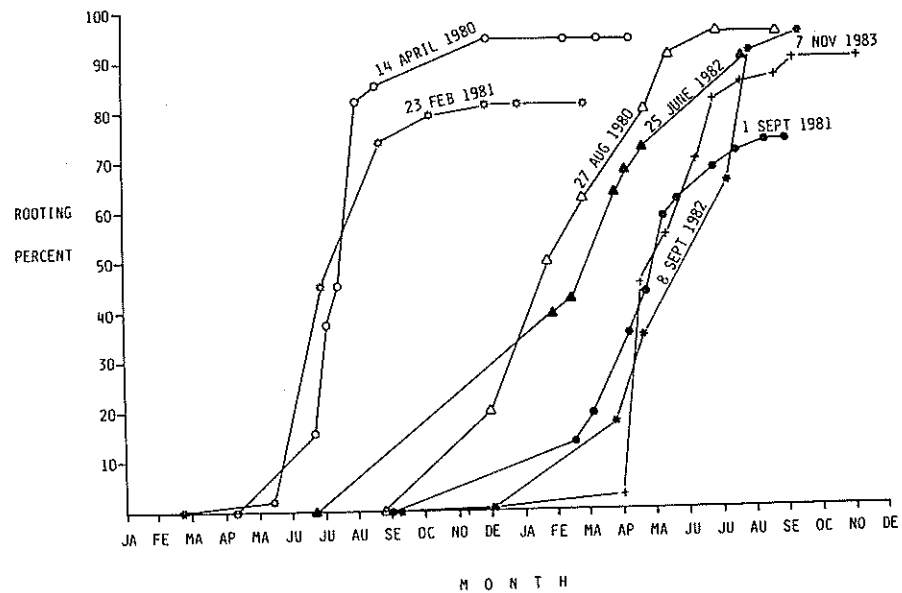


Figure 1. 12-month cumulative rooting curves of bishop pine cuttings set on 7 different dates. Samples sizes (N) and % mortality (M) for each rooting experiment: 14 Apr. 1980, N=62, M=6; 27 Aug. 1980, N=107, M=5; 23 Febr. 1981, N=177, M=20; 1 Sept. 1981, N=459, M=18; 25 Jun. 1982, N=408, M=1; 8 Sep. 1982, N=92, M=5; 7 Nov. 1983, N=86, M=8. Cuttings alive but unrooted after 12 months compose the group remaining beyond the indicated numbers that rooted and that died.

The duration of the initial period of slow rooting was related to the length of time between the setting date and early spring. Generally, cuttings set in summer (25 June 1982, 1 September 1981 and 8 September 1982) had a longer initial period of low rooting than cuttings set in winter (23 February 1981) and spring (14 April 1980). One curve, 27 August 1980, was unusual in having a very short time before rapid rooting began.

The points in the curves where the rate of rooting decreased also came approximately at the same time of the year for all experiments, in mid-late summer. Beyond this time, rooting was very slow and most of the mortality occurred during this final period.

The fastest rooting and lowest mortality occurred in cuttings taken from seedlings; cuttings taken from hedges generally rooted slower and had higher mortality. However, since only one set of cuttings was taken from seedlings, and no cuttings were taken from hedges during the same month as the seedlings, it is unclear whether this effect related to time of year or type of cutting donor. Among the hedges, no strong maturation pattern was evident, although cuttings taken when hedges were chronologically young (setting dates 27 Aug. 1980 and 23 Feb. 1981) rooted faster than cuttings taken when hedges were older.

Population, family and clonal differences

To investigate population, family and clonal variation, I analyzed rooting for the two experiments with over 400 cuttings (1 September 1981 and 25 June 1982). Mean rooting percents at 12 months for the September 1981 experiments were 64.9% (blue population), 78.3% (green) and 79.4% (transition); for the June 1982 experiment, the 12-month rooting percents were 77.2% (green population), 89.1% (transition) and 93.0% (blue). The means within each experiment were not significantly different. Rooting of families within populations also did not differ significantly in either experiment.

In contrast to the population and family levels, both the rate of rooting and the final rooting percent varied considerably among clones within families. The September 1981 and September 1982 experiments were used, as these had sufficient numbers of cuttings of the same clones in both experiments, and as the time of year when the cuttings were collected was nearly identical.

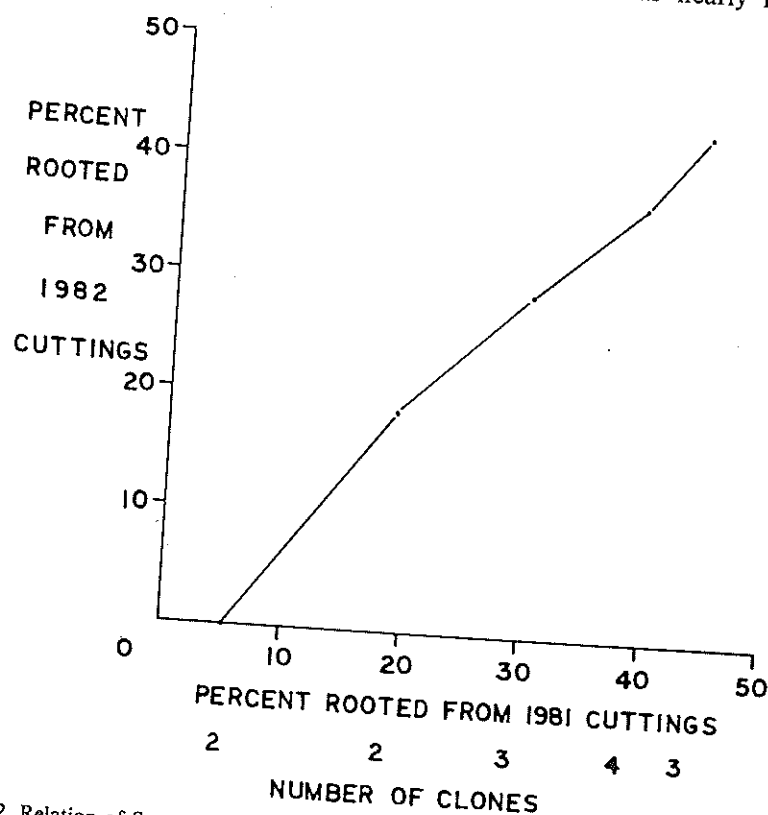


Figure 2. Relation of September 1982-collected to September 1981-collected rooting of cuttings from 14 clones of bishop pine. Data-grouped by 1981-outcome classes.

Fourteen clones were used, with 10-20 cuttings per clone for each experiment. The clones were grouped into five classes based on their rooting percent at eight months (0-0.10, 0.11-0.20, 0.21-0.30, 0.31-0.40, 0.41-0.50) in the 1981 experiment. Means were computed for each class for each experiment, and graphed, using 1982 means at 8 months as the dependent variable (Duffield & Liddicoet 1949) (Fig. 2). Clones with low 8-month rooting in 1981 were low in 1982, and those high in 1981 were high in 1982, indicating a clonal-genetic component to rooting.

Discussion and conclusions

Bishop pine's potential as an important forestry species depends, among other things, on the ease with which it can be grown in the nursery. Prior studies have shown that nursery practices for growing bishop pine seedlings are similar to Monterey pine. The results presented here indicate that vegetative propagation by rooting shoot-cuttings from hedges also is practicable for bishop pine. Bishop pine seedlings responded rapidly to hedging and produced abundant new shoots: Four-year-old hedges averaged an annual yield of 53 cuttings each. Overall rooting percents were generally higher for bishop pine than those reported for juvenile Monterey pine (Libby 1964; Puffer 1971; Libby et al. 1972; Barr 1973; Puffer & Maire 1974). The simple nursery procedures used in this study led to rooting percents over 85% from all experiments. No harmful fungal infections occurred up to 12 months on the mist bench, probably as a result of the benomyl fungicide. No topophytic problems resulted during subsequent growth of the rooted cuttings, regardless of the position on the hedge from which cuttings were taken. Ten months after the cuttings were set, the rooted cuttings had full, symmetric root systems and were ready for outplanting. Many of the cuttings rooted in this study were outplanted to native bishop pine sites in spring 1982 and as of winter 1986, over 85% had survived.

Several factors which can influence the final rooting percent and the rate of rooting of cuttings were suggested by this study and require further study. The time of year when cuttings begin to root rapidly seemed to affect rooting performance. Many cuttings began to root rapidly in late winter/early spring, continued at a high rate through spring and early summer, and slowed down in mid/late summer. In general, cuttings set in late winter and early spring began the period of rapid rooting sooner than cuttings set in late summer or fall. The variation among experiments in the exact date when the cuttings began rapid rooting probably resulted from annual seasonal differences in the rooting environment. In a year that had a longer winter than average (1981), cuttings did not begin to root rapidly until mid-spring, which was later than in other experiments.

These results compare with the general pattern in Monterey pine. In early studies with that species, when cuttings were not soaked in a fungicide prior to setting, Monterey pine cuttings rooted best when collected from dormant trees in mid-winter just prior to the spring flush (Libby 1964; Puffer 1971; Barr 1973; Cameron & Rook 1974; Puffer & Maire 1974). Cuttings set in spring died of fungal infections. In more recent rooting tests, when cuttings were soaked in fungicide, Monterey pine cuttings rooted most rapidly when collected during spring (W. Libby, pers. comm.). At that time, trees usually have high foliar nitrogen concentrations, a condition that might improve rootability (Fielding 1954).

A possible effect of maturation on rooting was due to the type of cutting donor. Cuttings from juvenile seedlings rooted better than those from hedges. This pattern was also found in Monterey pine, where cuttings from seedlings rooted better than from juvenile hedges (Libby, pers. comm.). In a rooting experiment with Monterey pine hedges, Libby et al. (1972) found that rooting fluctuated significantly from year to year, and was associated only weakly with chronological age of the hedges. Other effects, such as annual weather conditions and vigor of the hedges, which may affect rooting in a particular year, need to be studied under controlled conditions.

Population and family differences in rooting were not large and need have little effect on the choice of plantation stock. By contrast, clonal differences in rooting were significant and appeared to be inherited. A strong genetic component to rooting also has been found for other species (Duffield & Liddicoet 1949; Fielding 1954; Nienstaedt et al. 1958).

Overall, bishop pine can be readily propagated by rooted cuttings. This potential should allow efficient testing of this species in plantation trials, and eventually lead to mass propagation for reforestation on sites where bishop pine is superior.

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References

- Axelrod, D.I. 1983. New Pleistocene conifer records. Coastal California. University of California Press 127.
- Barr, W. 1973. Rooting *Pinus radiata* cuttings. Proceed. Plant Prop. Soc. 23: 77-78.
- Burdon, R.D. 1980. *Pinus muricata* - Recent New Zealand results. IUFRO Newsletter. Breeding *Pinus radiata* 4: 5-6.

- Cameron, R.J. and Rook, D.A. 1974. Rooting stem cuttings of *Pinus radiata*: Environmental and physiological aspects. N.Z. Jour. For. Sci. 4(2): 291-358.
- Cobb, F.W. and Libby, W.J. 1968. Susceptibility of Monterey, Guadalupe Island, Cedros Island, and bishop pines to *Scirrhia (Dothistroma) pini*, the cause of red band needle blight. Phytopathology 58: 88-90.
- Duffield, J.W. and Liddicoet, A.R. 1949. Variability of rooting in a small second generation population of *Pinus attenu radiata*. Jour. For. 47: 107-109.
- Duffield, J.W. 1951. Interrelationships of the California closed-cone pines with special reference to *Pinus muricata* D. Don. Ph. D. Diss., Univ. Ca, Berkeley.
- Doran, J.C. 1974. Variation in growth of *Pinus muricata* provenances and comparison with *Pinus radiata*. Aust. For. Res. 6(3): 19-24.
- Everard, J.E. and Fourt, D.F. 1974. Monterey pine and bishop pine as plantation trees in Britain. Quat. Jour. For. 68(2): 111-125.
- Fielding, J.M. 1954. Methods of raising Monterey pine from cuttings in the open nursery. For. Timb. Bur. Bull. (Austr.): 32.
- Fielding, J.M. 1961. Provenances of Monterey and bishop pines. Aus. For. Timb. Bur. Bull. 38: 1-30.
- Fielding, J.M. 1964. The possibility of using cuttings for the establishment of commercial plantations of Monterey pine. FAO World Consultation Forest Genetics and Tree Improvement. Stockholm. Vol. II 5/10: 1-8.
- Fielding, J.M. 1970. Trees grown from cuttings compared with trees grown from seed (*Pinus radiata*). Silvae Genet: 19: 54-63.
- Griffin, J.R. and Critchfield, W.B. 1976. Distribution of forest trees in California. USDA For. Ser. Res. Pap. PSW-82/1972.
- Libby, W.J. 1964. The rooting of Monterey pine. Proceed. Plant Prop. Soc: 280-287.
- Libby, W.J., Brown, A.G. and Fielding, J.M. 1972. Effects of hedging radiata pine on production, rooting and early growth of cuttings. N.Z. Jour. For. Sci. 2(2): 263-283.
- Nienstaedt, H., Cech, F.C., Mergen, F., and Wong, F. 1958. Vegetative propagation in forest genetics research and practice. Jour. For. 56: 826-839.
- Puffer, R.E. 1971. Rooting Monterey pine cuttings. Proceed. Plant Prop. Soc. 21: 87-89.
- Puffer, R.E. and Maire, R.G. 1974. Rooting Monterey pine cuttings. Proceed. Plant Prop. Soc. 24: 107-112.
- Schopmeyer, C.S. 1974. Seeds of woody plants in the United States. USDA For. Serv. Agric. Handbk. 450.
- Shelbourne, C.J.A. 1974. Recent investigations of wood and growth in *Pinus muricata*. N.Z. Jour. For. 19 (1): 13-45.
- Shelbourne, C.J.A., Bannister, M.H., and Wilcox, M.D. 1982. Early results of provenance studies on *Pinus muricata* in New Zealand. N.Z. Jour. For. 27(1): 50-66.
- Smith, P.C. 1983. Bishop pine provenance study. Progress report. University of California Extension, Eureka, Internal Report: 1-10.
- Schniewind, A. and Gammon, H. 1980. Strength and related properties of "blue race" bishop pine from three locations. Wood and Fiber 12(2): 131-141.
- Thulin, I.J. and Faulds, T. 1968. The use of cuttings in the breeding and afforestation of *Pinus radiata*. N.Z. Jour. For. 13(1): 66-77.