MANAGEMENT OF AN INDOOR, POTTED LOBLOLLY PINE BREEDING ORCHARD

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Abstract.--Since potted, indoor grown grafted ramets of loblolly pine can be made to flower earlier and more profusely than field grown ramets, more rapid completion of second generation breeding plans appears feasible. The management of Weyerhaeuser's potted breeding orchard near Hot Springs, AR is described, including a discussion of the cultural methods, flower stimulation methods and the breeding techniques that are currently being used on indoor grown trees.

Key words: Pinus taeda, early flowering, tree breeding, male and female strobili, gibberellins, water stress, out-of-phase dormancy.

INTRODUCTION

Weyerhaeuser Company is currently committed to shortening the generation turnover time of its loblolly pine breeding program by about 7 years, and is operationally using flower stimulation methods to induce earlier flowering on grafted, young select loblolly pine. The biological constraints on early flowering by loblolly pine have been discussed elsewhere (Dorman and Zobel, 1976, and Greenwood, 1977 and 1978). Young grafts of loblolly pine, even if mature scion wood is used, produce few female strobili and almost no male strobili for several years if they are established in the field.

Over the past several years we have developed a number of flower stimulation procedures which promote flowering on field grown and potted trees. However, our most consistent and effective results have been obtained on potted trees kept in a greenhouse.

WHY AN INDOOR, POTTED BREEDING ORCHARD?

Flower stimulation treatments have been evaluated on loblolly pine cloned by grafting for seed production and/or breeding purposes. The grafted ramets of these clones, ranging in age (from grafting) of from 1 to 4 years, were grown either in the ground in young seed orchards, or in pots both outdoors or in the greenhouse. Scions for these trees came from 4-12 year old select trees in progeny tests, and comprise the parent population for the second generation of our breeding program. The results of a variety of flower stimulation treatments are shown in Table 1, and are further discussed elsewhere (Greenwood, 1977, 1978 and 1979 and Ross and Greenwood, 1979). Operationally we are presently relying on two treatments, which are applications of $GA_{4/7}$ to developing buds on water stressed trees, and out-of-phase dormancy (Greenwood, 1978). While has no effect on male flowering, water stress alone in the greenhouse is promotive.

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While good results have been obtained on both field grown and potted trees, we are conducting our advanced generation breeding on indoor grown, potted trees for several major reasons: (1) poor male flowering in response to most of our treatments on small, outdoor grown grafted ramets has been observed (see Table 1). With the exception of wire girdling (Greenwood and Schmidtling, 1979 and Table 1) none of the treatments we tested promoted male

Table 1. Results of Flower Stimulation Treatments, Potted and Field Grown Trees.

Location	Treatments	% Clones with ♀	% Clones with ♂	Graft Age, Years
Magnolia, AR	GA	100	0	3-4
Seed Orchard	Control	50	0	
Comfort, NC	GA	10	0	3-4
Seed Orchard	Control	5	0	
Hot Springs, AR	GA + WS[1/]	92	54	3
Greenhouse, potted	WS	50	63	
Hot Springs, AR	GA + WS	100	0[2/]	4
Outdoor, potted	WS	60	0[2/]	
Hot Springs, AR	OPD[3/]	80	80	2
Greenhouse, potted	WS	20	0	

1/ GA = Gibberellin $A_{4/7}$, WS = Water Stress.

2/ GA treated branches only. Wire girdling resulted in male flowering on 80% of the clones, versus none for the controls.

3/ OPD = Out-of-Phase Dormancy.

flowering outside. However, Hare (1978) has found that GA applications do promote male flowering on 7-8 year old field grown loblolly pine. (2) Female flowering responses by field grown trees are inconsistent (compare the results for Comfort and Magnolia in Table 1), most likely because of variation in rainfall distribution throughout the summer. However, the scion age of the grafts at Comfort is considerably less than those at Magnolia. The average July and August rainfall is twice as great at the Comfort seed orchard as at Magnolia, and the conditions during which these tests were conducted were no exception. In our potted orchards, GA application without water stress during July and August is almost completely ineffective (Greenwood, 1979 and unpublished data), which would explain why GA applications at Comfort had very little effect. (3) Winter damage on potted trees grown outdoors was extensive last winter because of heavy snowfall, and windthrow of the larger potted trees is frequent. The extensive foliar development of the potted trees due to heavy fertilization and the confined root system makes them very unstable outdoors. (4) Out—of—phase dormancy, our most effective flower stimulation treatment for small, young grafts, requires greenhouse culture. This method is particularly useful because of the high frequency of male flowering obtainable after just two years after grafting in the early spring (see Table 1). (5) Breeding in a greenhouse is not hampered by bad weather, and pollen can easily be forced so that the problem of crossing early female strobili with pollen from late shedding males can be lessened in some cases.

MANAGEMENT OF A POTTED BREEDING ORCHARD

Potting Medium. Grafts are made on potted rootstock in 3 gallon pots, usually in the early spring and are kept well watered and fertilized. Summer grafts of soft tissue are also used when more ramets of some clones are required. They are repotted into larger containers in the fall, using a potting medium consisting of 1:1:2:2, (by volume), of peat:vermiculite:coarse quartz sand: hardwood bark. A medium consisting of 2:1:1 (by volume, sand:peatmoss: vermiculite also supports good growth. The high proportion of sand in these media permits good drainage and allows prompt buildup of water stress.

Fertilization. Essential elements are supplied by application of Osmocote[R] (9 month formulation, 18-6-12 analysis Sierra Chemical Co., 1001 Yosemite Dr., Milpitas, CA 95035), first by mixing directly into the Rotting medium at 6 g/1, and later by top dressing with 2-3 g/1 of Osmocote as recommended by the manufacturer. In mid summer, the trees are top dressed with ammonium nitrate at a rate of about .8 g/1 of pot volume. Trace elements can be added occasionally in the form of Peter's Fritted Trace Elements (R. B. Peters Co., 2833 Pennsylvania St., Allentown, PA 18104), but are probably not necessary when hardwood bark is used.

Table 2. Scion Elongation by 1975 Grafts in 68 1 Pots from 6/10/75 to 1/5/76. Two ramets each of 4 clones were included in each treatment.

	Fertilizer	Application Frequency	Rate	Scion Length		Scion Diameter	
1	5x Hoagland's Solution	1x per week	15 ml/1	145 cm	bc[1/]	22 mm	ab
2	9 mo. (18-6-12) Osmocote	1x per 9 mo.	1.3 g/1	174 cm	a	25 mm	a
3	3 mo. (18-9-3) Osmocote	1x per 3 mo.	.7 g/1	162 cm	ab	25 mm	a
4	Fertilizer mix[2/]	1x per mo.	.4 g/1	134 cm	c	19 mm	b

1/ Similar letters indicate no difference between treatments.

2/ 9:3:4 Urea:Superphosphate:KCL by volume.

We have compared the effects of four fertilization regimes over 1 growing season on grafted trees during the first season after grafting. Scion length and diameter after 1 growing season are shown **in** Table 2. The nine month osmocote treatment significantly promoted scion elongation compared with the Hoagland's solution or fertilizer mix. There was no significant difference between the response to the two osomocote formulations, but the three month formulation significantly outperformed the fertilizer mix. There was little difference among levels of foliar nutrients between all 4 regimes, although potassium was about 30-50% higher with our fertilizer mix. Soil pH was between 4.1 and 4.6 for all treatments. In our opinion the 9 month osmocote formulation is the regime of choice because it was the most stimulatory for vegetative growth and it is the most convenient treatment to apply. There was not sufficient flowering by the grafts used in this experiment after one year to evaluate the effect of the four fertilizer regimes on flowering, but there were no obvious differences. All the potted trees referred to in Table 1 were fertilized with Osmocote, and all have flowered very well.

Watering. Watering of the potted orchard is done automatically, using a "Spaghetti" watering system which consists of 1 1/2" diameter PVC laterals, with each tree served by leader tubing connected to an irrigation ring or turret in each pot (see Stuppy's Greenhouse Supply Co., 1212 Clay St., North Kansas City, MO 64116). Watering of an entire block can be accomplished by simply turning a valve or using a timer controlled solenoid.

The watering regime during the initiation and differentiation of strobili is probably the single most critical phase of the management of a potted breeding orchard. Failure to provide the right intensity and duration of water stress can result in a considerable reduction of the flower crop. Water stress is applied from June through September, and begins after a considerable amountRof vegetative growth has occurred. Stress is monitored by means of irrometers and a pressure bomb, and the regime followed depends on the size of the tree, and whether or not cones are already present on the tree.

Insect Control. Control of tip moth and seed and cone insects is carried out by yearly application of the systemic insecticide Disyston 15 g in late February, at a rate of .2 g/l, applied to the R soil surface. DeBarr (personal communication, 1978) recommended Furadan 10 g at rates as high as .6 g/l, but suggested that several rates be tested. In 1978, we have tried applications of .2 and .5 g/1 in late February and have noted no phytotoxicity symptoms at either rate. This year, we are trying rates as high as 1 g/l, and have not as yet seen any phytotoxicity clearly attributable to Furadan. The 1979 cone crop will represent the first real test of the effectiveness of these insecticides on protecting cones from insects.

Flower Stimulation and Breeding. Based on the flowering performance in response to the flower stimulation treatments that we have observed, breeding should be complete about 5 years after the selections have been grafted. This period would allow three breeding seasons, during which male and/or female strobili could be expected on almost all the clones involved. At present, our breeding plan is based on a six parent disconnected half diallel, with no relatedness tolerated between the parents within the diallel. A total of 15 crosses are made within each diallel, so each clone must be a male or female parent 2.5 times on the average, but 5 times at the maximum. Ideally, good pollen producers with few females can therefore act exclusively as pollen parents, and *vice versa.* In practice, however, the most efficient use of available strobili dictates some reciprocal mating, assuming that maternal effects are inconsequential. Assuming that 500 filled seed are required per cross, and that 50% of the females will survive and produce 30 seed/cone, then a total of 33 female conelets are required per cross, or 83 per 2.5 crosses. Over a 3 year period 1 ramet should produce about 44 conelets on the average, so a minimum of 2 ramets per clone will be needed.

CONCLUSION

While we have only been managing our indoor potted breeding orchard for a short time, the abundance of both male and female strobili on young grafts has resulted in pollination of over 1400 female strobili included in 4 diallels over the past two years. While we do not as yet have much data on seed yield per cone, preliminary results indicate that we may be able to expect at least 30 seeds per cone. At present, breeding loblolly pine indoors appears feasible.

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