FURTHER EXPERIENCES WITH PROPAGATION OF PISTACIA

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INTRODUCTION

In 1960 the senior author presented a report (8) to the Plant Propagators' Society describing experiences in propagating trees of the genus *Pistacia,* especially the fall-coloring shade tree *Pistacia chinensis* Bunge. Since then, there has been an upsurge of interest in California in the propagation, planting and growing of the pistachio nut of commerce, *Pistacia vera* L. Because of its timeliness, this paper will bring the subject of *Pistacia* propagation up-to-date.

PROPAGATION BY CUTTINGS

All *Pistacia* cultivars are topworked onto seedling rootstocks. The question is often asked, "Can they be propagated by rooting cuttings of mature trees?" Attempts to root cuttings fail so consistently that the subject is seldom mentioned in the literature. Of the hundreds of cuttings started at Chico and Davis no more than 5 percent have rooted, regardless of the time of year the cuttings were taken or the rooting compounds and treatments used. This unfavorable outlook should not, however, deter nurserymen and research workers from trying new techniques for rooting *Pistacia.*

On the other hand, and in common with other tree species, cuttings of *Pistacia* seedlings often root easily if taken during their first year of growth Some nurserymen have wondered if they could use young, vigorous seedlings to develop clonal rootstocks of uniform vigor and fast growth. Commercial pistachio producers certainly need more uniform rootstocks. But it is not known if, similar to other plant species (2, 7, 13), young *Pistacia* trees can be kept in the juvenile condition in order to produce large numbers of cuttings. Before they are utilized, however, such clones must be evaluated for growth compatibility with the cultivars to be topworked on them as well as for their ability to produce satisfactory crops. Repeatedly, it has been observed that not all select seedlings make superior rootstocks. Furthermore, comparisons should be made between seedling and cutting rootstocks. With certain plants cuttings produce inferior trees.

SPECIES USED FOR ROOTSTOCKS

Seedlings of several *Pistacia* species have been tested as rootstocks for the pistachio nut, but mostly *P. atlantica* Desf., and *P. terebinthus* L. are used commercially in this country. Since all *Pistacia* cultivars are topworked onto seedling roots the selection of these rootstocks and the methods used in producing them economically are important to nurserymen and growers. Thus far, the industry is based largely on seeds supplied from trees growing at Chico, California. Because these trees can no longer supply the demand for seed, other sources are sought. Any new sources that are discovered will represent untried species or hybrids. It is important, then, that these new sources be capable of producing thrifty, fast growing rootstocks compatible with the cultivars used for topworking them. The rootstock's ability to produce heavy crops can only be determined by long term trials. Hopefully, some will be found that prove superior to those now available.

Fortunately, 'Kerman' (pistillate) appears to be compatible with a wide range of rootstocks but 'Peters' (staminate) is variable. Other selections, including 'Lassen' (8) are known to make poor growth on some rootstocks so the value of any new *Pistacia* rootstock can never be taken for granted until it has been evaluated.

POLLINATION AND SEED PRODUCTION

Except for an occasional tree (12) all *Pistacia* are dioecious. That is, the sexes are on separate plants. They are wind pollinated. Furthermore, all species cross-pollinate easily so it is difficult to find pure species. In fact, there is so much doubt about a truly valid *Pistacia* species, except the pistachio nut *P. vera,* that it is better to identify elite seed-producing clones by an identifying source or location number and name rather than species name alone.

Pistacia are known to be pollinated by pollen drifting as much as half a mile and it may occur at greater distances. To produce seed of known parentage it is necessary that seed trees be isolated from all but the desirable pollinators or else bag the female flower clusters with pollen-tight covers and pollinate by hand. For natural pollination both sexes must bloom together. *P. atlantica* trees usually bloom in late March, ahead of *P. terebinthus*. Occasionally the two may overlap slightly and hybridize, though their hybrids are not easily distinguished. Likewise, later-blooming *P. chinensis* pollen-producing trees may overlap *P. atlantica* seed trees. Where this happens vigorous variants appear among *P. atlantica* progeny that are probably hybrids of these two species. Occasionally early blooming *P. vera* pollen trees may pollinate late *P. terebinthus* flowers.

Seeds of most *Pistacia* ripen in September and October. Ripe, fertile fruit of *P. atlantica* and *P. terebinthus* turn blue or blue-green.

They are harvested by knocking with poles or mechanical shakers onto sheets or collecting frames. Removal of the epicarps or hulls immediately after harvest is preferable while they are soft and easily scrubbed off. If dried on the seeds they attract storage insects and act as a germination inhibitor. Small quantities can be cleaned by scrubbing on a coarse screen but larger amounts are best cleaned mechanically. A vegetable peeler works well if modified so that clearance between the revolving disk and cylinder wall prevents the small seeds from escaping. To produce the best quality, freshly harvested and cleaned seeds must be dried as rapidly as possible to prevent molding and spoilage, preferably at temperatures below 100° F. Seeds spread thinly on screened bottom trays with air blowing over and through the trays will usually dry in three to four days. Seed is stored, dry, in plastic bags or other moisture tight containers at 35-40° F.

SEED PLANTING AND GERMINATION

Pistacia seeds can be planted almost any time but it is normally done in the spring. Seeds planted in November or December and subjected to winter conditions germinate better than seeds planted in March and April. However, starting *Pistacia* seedlings under glass or plastic during November and December is not recommended. Damping-off diseases are most prevalent at this time and are difficult to control.

Long time observations and research (unpublished) at Chico indicates that best germination of *Pistacia* seeds occurs when germination is initiated at 70° F. or lower, and that at 80° F. germination can be very poor and nonexistent at 90° F. or higher. Most growers and nurseries report a similar experience but a few in Arizona and California claim better results at 80° F. or higher, particularly with *P. terebinthus*. The reasons for this difference are not clear and are being studied. In the meantime, however, growers are advised to germinate their seed at the lower temperatures. (Caution: It requires very little direct sunlight on soil to warm it to 80° F. or higher at seed planting depth.)

Most *P. atlantica* seeds sprout without pregermination treatment other than soaking in water 1 to 2 hours before sowing. On the other hand, *P. terebinthus* seeds vary in their response and are more difficult to germinate. Normally, good results follow damp seed storage at 40° F. for 6 weeks and by germination at 70° F. or lower. Total germination following this cool storage occurs rapidly and uniformly within a few weeks. If seeds are germinated in "rag dolls" they should be checked daily and transferred to peat pots as the roots appear.

For growers who may wish to grow and fruit *P. vera* seedlings, an effective way to stimulate rapid germination is to soak the seeds in water at 40° F., changed every few days, for 2 weeks prior to planting.

CONTAINERS AND CONTAINER MEDIA

With a few exceptions, all *Pistacia* rootstocks are now grown in containers prior to transplanting to permanent field locations Many growers and nurserymen use manufactured pulp containers about 16 inches tall and 6 inches in diameter. Those preferring to make their own containers can form them by folding an 18 inch square of felt sheathing or tar paper into a cylinder held together at the edges by stapling to a lath. Equally satisfactory, though not usually employed, are heavy plastic bottom perforated bags of similar length and diameter Container grown seedlings help prevent high losses that frequently occur when nursery-grown *Pistacia* trees are bare-rooted prior to transplanting. Felt paper containers will disintegrate after 5 or 6 months in the nursery yard but, carefully handled, they can still be transplanted, intact, without disturbing the roots. Manufactured containers usually hold up to a year or more but must be removed at transplanting time because they are slow to break down.

Container growing media vary with the grower or nursery. Some use one of the University of California mixes (10); others buy commercial mixes, while still others prepare their own. Most mixes contain sand, ground bark, or peat in various proportions. Generally, a nutrient mixture containing nitrogen and other essential elements is added to give the young plants a quick boost and get them off to a good start. Some may add small amounts of a loamy soil to give the mix more adhesive properties so the ball of soil will hold around the roots when transplanted. For best results the soil in the containers should not differ greatly from the soil in which the tree will grow. All potting mixes should be clean and, preferably, sterilized by fumigation with methyl bromide or steam (11) to reduce damping-off fungi and other diseases, nematodes, and weed problems In fact, all plants grown for sale in California must be grown in soils that meet the requirements of the Plant Quarantine and Nursery Service for plants free of pests. To avoid soil-borne pests and diseases this practice should be universally adopted.

GROWING AND CARE OF PLANTS IN CONTAINERS

There are several methods for starting young plants in containers Each has advantages and disadvantages. One of the more promising was first suggested by Dwight Long as a result of work he started at Modesto (9), and continued at the Saratoga Horticultural Foundation (3), to prevent bending and circling roots in container-grown ornamental trees Later this work was elaborated upon by Harris, Long and Davis (4) and others (5, 6), establishing principles for effective production of high quality container-grown plants through good transplanting and root pruning techniques. The young seedlings are started in organic pots (usually 3 inch peat pots) since *Pistacia* roots can easily penetrate this type of container. Seeds or sprouted seeds

can be planted directly into the pots, or young seedlings may be transplanted into them before the roots develop extensively. For very young plants with short roots the terminal portion can be cut off to force branch rooting at an early stage. Seedlings with long roots require pruning to stimulate even distribution throughout the pot without detrimental bending (4).

The young plants should develop many lateral roots before transplanting into the large containers. Allowing the roots to grow through the peat pots half an inch or more and then rubbing them off to the pot before transplanting them will accomplish this. Also, seedlings in peat pots set over wire screen will "burn off" terminal roots and induce lateral rooting. Gallon containers are not tall enough to prevent root curling. The 16-inch and taller containers usually do well for one growing season.

Starting the young seedlings in, or transplanting them first into smaller containers have other advantages. If seeds do not germinate or grow well, only a small container is discarded. For transplanted seedlings only those that produce a thrifty, well-grown top and root system in the small peat pots need be transplanted, discarding the weak, slow-growing plants. Similar and further culling can occur when transplanting into the large containers. This culling can produce a uniform, high quality product. In selecting and culling for quality the evidence we have indicates that vigorous, well-grown *Pistacia* trees are produced on rootstocks with strong root systems.

A less satisfactory method is to plant seeds directly into large containers. This eliminates the necessity for transplanting and handling before being moved to the orchard. However, such plants usually produce a long taproot, with little or no side branching, that reaches bottom in 3 or 4 months Furthermore, this technique does not promote sufficient cullage and the top may be short for field planting.

Young *Pistacia* seedlings are quite succulent during the first 5 to 6 weeks of growth and sensitive to over-watering and damping-off diseases. Experienced growers and nurserymen are finding that optimum growth is best achieved in a soil kept continuously near field capacity for moisture and well supplied with nutrients. Opinions vary about the frequency of application and amounts of nutrients to apply to plants growing in containers, but it is generally considered better to apply small amounts at frequent intervals rather than large amounts at long intervals. Nurseries using University of California or commercial mixes, with balanced nutrients added, produce superior early growth. Without a doubt, nitrogen is the single most important element. Also important are calcium, potassium, phosphorus, magnesium and probably other lesser, but essential, elements. Blood meal or sewage sludge can be used to supplement inorganic mineral sources.

TOPWORKING THE SEEDLING ROOTSTOCKS

With close attention to detail, container-grown seedlings with sufficient caliper (⅜ inch or larger) at 6 inches above the ground level may be budded the first summer. Very unsatisfactory results have been obtained in trying to topwork *Pistacia* seedlings in containers. Standard practice is to transplant seedlings to their permanent orchard location before topworking. For growers preferring to topwork 2 feet or more above ground, a longer period of growth is necessary in order to attain enough height and diameter. There are indications that trees topworked at 2 feet or more produce less overgrowth at the bud union than those topworked near or below ground level, as has been demonstrated with citrus (1).

Although *Pistacia* trees are propagated by both budding and grafting, most propagators prefer the ordinary T-bud, either upright or inverted. It is faster and generally more successful than a scion graft and makes more economical use of scarce budwood. A few grafters report good success with whip grafts, and bark grafts, but others report results varying from fair to mostly total failure. One nurseryman successfully whip-grafted scions with terminal buds attached Another set 1 to 2 inch terminal scions as side grafts near the base of container-grown seedlings. Take of these scions was good but cost in time was a major disadvantage against this method. In 1953 we saved a valued *P. chinensis* tree at Chico by setting all available terminal and lateral buds. Few lateral buds survived but a high percentage of the terminal buds grew. These were cut with a moderately slanting cut immediately below the terminal bud similar to a side or bark graft with the bud inserted under the bark, the same as a T-bud. Other budding techniques that some propagators use successfully include the chip bud, ring bud and patch bud. Any one or all may be more successful at one time or another than the T-bud, but require more time to set.

Wherever *Pistacia* are grown and propagated opinions vary regarding the best time of the year to insert their buds. Some people believe April and May are the best months. Others believe these buds take better when set in late summer or early fall. There are proponents of both viewpoints in California. Most propagators, however, get the best results in September and early October if the rootstocks are in active growth and the bark slips well. At Chico (14) buds placed in March or April take poorly, if at all, with a marked increase as the time of budding is extended through the summer and fall. Failures in spring budding occur more often during rainy or cloudy, cool periods; but good bud take can occur during periods of warm, sunny weather in late April and May.

Opinions vary about the effect of temperature on bud take. Some propagators prefer to stop budding when temperatures go above 95 to 100° F feeling that bud-take decreases above these temperatures.

Others feel that temperature has little effect. There are only observational data to support either contention. Nevertheless it appears that with orchards on well established rootstocks, adequately irrigated and fertilized, temperature at time of budding is not of much importance.

Experience indicates it is important to use well grown budwood, produced either as water sprouts or strong terminal growth. Good budwood can be produced by cutting back branches on trees in early spring, forcing out new growth. This insures a greater supply of vegetative buds, for many of the lateral buds on the previous season's growth of mature trees are flower buds and only vegetative buds can produce new trees. Flower buds are distinguished by their larger size and plumpness.

Both rubber budding strips and non-adhesive vinyl nursery tape are used for tying *Pistacia* buds. Vinyl tape has the disadvantage that it does not disintegrate in sunlight and, therefore, must be cut away. One nurseryman reported better results using the clear form of this tape rather than the green colored form. Both ties are effective and work equally well.

Variability is still one of the facts of life in propagating *Pistacia* today. We know this plant to be as variable as the walnut in its behavior but very little is known about its basic physiology. There is much need for research in the laboratory and field on basic physiological, growth, and histological problems. One nursery ran a series of tests using several budders and budding techniques, varying the time of day the buds were set, using different sources and qualities of buds as well as location of buds on the scion. In no case was it possible to associate the variable results obtained with any one factor.

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MODERATOR MAIRE: Any questions on pistachio propagation?

ANDY LEISER: A question on transplant problems—have you tried mechanical diggers to transplant nursery trees so that you could grow them in nursery rows then transplant to the field? We have had fairly good success with a few Chinese pistacia up to 4 or 5 inches in diameter.

KARL OPITZ: Well, Chinese pistacia are easier to handle than *P. terebinthus.*

ANDY LEISER: They're hard, too, but we have handled them up to 4 or 5 inches—transplanting with mechanical diggers.

STEVE FAZIO: My question is directed to Mr. Joley, not so much on the propagation but adaptability. Can we use *Pistacia chinensis*—its production—as an indicator that *P. vera* will be adapted to that area?

LLOYD JOLEY: Let's say this. Back in 1954 I saw some *Pistacia chinensis* trees growing there at the University of Arizona in Tucson that were suffering somewhat from chlorosis. Whether *P. vera* will behave like that, I do not know for I did not see any *P. vera* trees

then in that area. I did, however, see some *P. vera* trees in the Cochise Stronghold at the same time that appeared to be quite normal in leaf color though they were small for lack of water.

RALPH SHUGERT: What's the economic dollar value given to the pistachio in California annually?

LLOYD JOLEY: It is low at the present time. I imagine if there are 500 tons produced this year it will be a large quantity, but this will be increasing each year from now on.

RALPH SHUGERT: What dollar value?

LLOYD JOLEY: Some of the growers have been getting as high as $1.00 to $1.10 a pound, some around 75 or 80 cents, depending on the quality.

KARL OPITZ: And there is a tremendous difference in the quality of these nuts, depending on how they are harvested and how they are handled thereafter, no matter what variety is involved.

JOE HALL: Are there any disease or insect problems that have been prevalent with pistachios?

LLOYD JOLEY: We have not seen any particular disease problems with the tree itself, other than the roots. Verticillium wilt can be a very serious disease. Oak root fungus also can be serious But as far as the tree top is concerned—no. In Texas, they have septoria leaf spot, but we have not had it here.

KARL OPITZ: Under other California conditions, that is, in areas where they should be grown — in the central San Joaquin and Sacramento Valleys—we have an excellent climatic situation and do not anticipate any problems with the top. The root problems can be serious, however.

HUDSON HARTMANN: What about germinating seeds of *Pistacia chinensis?* You described procedures for the other two. Is there any special treatment to promote germination of *P. chinensis* seeds?

LLOYD JOLEY: We have had all sorts of reports on *Pistacia chinensis* seeds and, I am beginning to believe, the problem is as variable as the reports In general, most *P. chinensis* seeds will germinate well without any treatment other than soaking them in water for an hour or two before sowing. But sometimes they will not germinate, no matter what you do; perhaps cold treatment would be useful in such cases. Yet we have used cold treatment and it did not seem to make any difference. I suspect that, in some cases, there is a failure somewhere in the germination process, especially failure to keep the germination medium sufficiently damp. Germination media can often appear damp on the surface yet be too dry at seed depth. Likewise temperatures above 75° F. can be detrimental. If there is some other answer we do not know about it.

MODERATOR MAIRE: Thank you very much, Karl Opitz and Lloyd Joley, for that very interesting presentation on propagation of pistachio

Now, to continue; Bob Gonderman is here from the Los Angeles State and County Arboretum. He has been doing some experimental work with certain rather difficult-to-root plants and we are lucky to have him. I am sure that Bob will have some interesting things to report. So, here is Dr. Bob Gonderman from the Los Angeles State and County Arboretum in Arcadia:

STUDIES WITH CUTTINGS OF DIFFICULT-TO-ROOT PLANTS

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In attempts to root cuttings of difficult-to-root plants, a number of variations of lesser-known methods have been tried. I have had some moderate success in rooting cuttings of pines, oaks, and eucalyptus, and perhaps our methods may enable propagators to produce better landscape plants more easily and cheaply.

Vegetative propagation of desirable clones is becoming more and more practical as we apply our present knowledge to old rooting problems and learn to benefit from past experiences, such as we may learn at this meeting. Our mission-oriented research has permitted a few publications, so some of you already know of some of my work.

We may think of rooting as the result of expression of the interaction of root promoting and inhibiting factors metabolized within the plant itself. Production and concentration of such factors may be investigated by taking cuttings at various growth stages—before, during, or after a flush of growth. With the assistance of my class members, we have rooted several reportedly difficult plants during their spring flush of growth. Usually these have been single experiments; they are not reported until enough repetitions have been made.

It is conceivable that rooting inhibitors may be leached from the plants if they are easily soluble. My early trials in this regard have yielded only promises so far. While leaching, we could at the same time infuse the cuttings with phenolic or proteinaceous substances for possible promotion of endogenous auxin production.

Another approach is to gather cuttings when the root promoting effects are highest. One of the physiologically favorable times appears to be during the spring growth season. Our class members taking