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PROGRESS REPORT ON THE MACADAMIA

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As far back as 1941, the macadamia was brought to the attention of readers of the California Avocado Society Yearbook ". . . as a possible interplant or supplementary crop or in some cases as a replant crop on a limited commercial basis." In the years which have followed, it has continued to attract the interest of increasing numbers of avocado growers as a possible commercial crop, especially those growers who find themselves threatened with loss of their orchards because of the presence of the soil-borne cinnamon fungus which causes the avocado root rot disease. Competent authority has shown the macadamia to be highly resistant, if not wholly immune to attack by the cinnamon fungus. It can be grown on lands on which avocado trees are declining due to infestation of the roots by the organism.

In 1941, the President of the Society appointed a committee to give special attention to subtropical fruits other than the avocado and to register and describe new varieties. This committee continues to function as the Subtropical Fruit Varieties Committee. Recognizing the possibilities of the macadamia in areas where the avocado root rot was making serious inroads, and realizing that good varieties of the macadamia would be needed in any replacement program, the Committee, in 1952, appointed a subcommittee to conduct a contest to find the best macadamia nuts grown in California. Cash prizes were offered as an inducement for owners of macadamia trees to submit samples. The contest ran for two years, attracted about 70 entries, and resulted in the describing, naming, and registering of three varieties by the Committee. The great amount of interest in the contest and the increasing number of requests for information on the macadamia prompted the members of the subcommittee to organize the California Macadamia Society. This Society, which came into being in November, 1953, now has a membership of about 220 persons. It publishes a yearbook of its own, now in its fifth volume, which serves as a medium for disseminating information on all aspects of macadamia culture.

Researches on various phases of macadamia culture and processing are in progress on the Riverside and Los Angeles campuses of the University of California and at the U.S. Department of Agriculture Western Region Research Laboratory at Albany, California. In addition, many persons have small trial plantings of their own for observing growth and productivity in their own particular situations. The number of trees now planted in California is estimated to be around 25,000.

Since the macadamia shows signs of becoming increasingly important in the avocado growing region of California, and since much of the early impetus to macadamia growing and research originated with the California Avocado Society, a report in this yearbook on how it stands at present in California seems to be in order.

NAMES AND TYPES

It is gratifying to report that, as a result of research in Australia, the confusion which has long existed with regard to botanical names and the species to which they were supposed to apply seems finally to have been cleared up by two systematic botanists, L. A. S. Johnson of New South Wales and L. S. Smith of Queensland. The latest — and, it is to be hoped, final — interpretation is that the correct names for the two species of **Macadamia** which are cultivated for their nuts are **M. tetraphylla** for the species which predominates in New South Wales, and **M. integrifolia** for the Queensland species. The name **M, ternifolia** has long, but improperly been applied to the "rough shell, spiny leaf" **M. tetraphylla** and, briefly, between 1954 and 1957, to the "smooth shell, smooth leaf" species **M. integrifolia.** Botanical evidence in the form of herbarium material in Australia, including the type specimens of the species **M. ternifolia,** is fairly conclusive that this name properly belongs to the gympie or maroochie nut of Queensland which has been long but erroneously known both as **M. minor and M. lowii.** So far as is known, M. **ternifolia** does not occur in California.

The cultivated species are easy to distinguish from each other. The mature leaves of **M. tetraphylla** tend to be long and narrow and to have 20 to 40 somewhat spiny teeth along their margins. The leaves of **M. integrifolia** are fairly short, and broad in relation to length. The margins are generally toothless, but sometimes a few teeth are present, rarely more than ten. The leaves of **M. tetraphylla** are sessile or subsessile, i.e., leaf stalks are absent or, at best, very short and inconspicuous. The leaves of **M. integrifolia** have distinct stalks from one-fourth to one inch, or more, long. **M. tetraphylla** most commonly has its leaves arranged in whorls or nodal groups of four on the stem, although three and five occasionally occur. **M. integrifolia** most commonly has its leaves in whorls of three, rarely in two or four. With a few exceptions, the flowers of **M. tetraphylla** are pink, while those of **M. integrifolia** are white. There are other differences between the species, but these need not be dealt with here, since those given above are the most conspicuous ones.

For convenience in horticultural references, the writer has suggested that varieties belonging to **M. tetraphylla** be referred to as "varieties of tetraphylla type" or "tetraphylla varieties," and that varieties belonging to **M. integrifolia** be referred to as "varieties of the integrifolia type" or "integrifolia varieties." From the time macadamias began to be cultivated in Hawaii, the two species were recognized as horticulturally different types. The terms "rough shell type" and "smooth shell type" came into use to distinguish **M. tetraphylla** and **M. integrifolia**, respectively. These terms are not sufficiently definitive, however, because many seedling trees of the first species produce perfectly smooth nuts and occasional trees of the second species produce nuts with some pebbling. The terms "spiny leaved" and "smooth leaved" are also used to some extent, but these terms are not entirely satisfactory either because some integrifolia trees have more or less spiny leaves and virtually all of the juvenile seedlings of this type are spiny leaved. The terms "Australian type" and "Hawaiian type" have been gaining use in reference to the tetraphylla type and the integrifolia type, respectively, especially in California. These terms seem to have come into being because all of the early selections by Australian horticulturists were of the former type and all of the selections by Hawaiian horticulturists were of the latter type. The terms

seem inappropriate, however, for, in the first place, all species and types of **Macadamia** originated in Australia, and, in the second place, some of the later selections made in Australia are of the integrifolia type. It would be absurd to say that these selections made among natural stands of a tree species native to Australia are of the "Hawaiian type." It is because of absurdities such as this, as well as the lack of definity in certain morphological features which have been used to distinguish them, that the writer suggests that the specific epithets "tetraphylla" and "integrifolia" might best be used as general terms in referring to the species as horticultural types. There is, of course, no objection to referring to particular varieties which were selected in Australia, Hawaii, and California as Australian, Hawaiian, or Californian varieties, respectively.

ADAPTATION

A survey of bearing seedling trees in California was begun in 1948 by Dr. C. A. Schroeder of the Department of Horticultural Science at the University of California, Los Angeles, and is being continued by me. This survey disclosed nearly 300 old, well-established specimens in the region between San Diego on the south and Santa Barbara on the north, mostly in coastal areas but in a few instances up to 70 miles inland. A few trees were located at Watsonville, in the San Francisco Bay region, and at Chico and Oroville, but, by and large, the region in which most of the trees were found corresponds closely to the region of commercial avocado production. The tetraphylla and integrifolia types appear to have closely similar, if not identical, adaptation characteristics.

Frost tolerance appears to be about the same as the Fuerte avocado or the lemon. There is, however, considerable variability among young seedling trees as regards ability to withstand cold. About 20 trees in a planting of 155 three-year-old seedling trees near Vista were killed or damaged to some degree in January, 1956 when temperatures were below freezing for about eight hours with a low of 24° F. for about three hours. Only eight trees out of 245 in a planting near El Cajon were killed or damaged at 22° F., duration of freezing temperatures not known. A survey soon after the sharp, early frosts of November 16 and 17, 1958 revealed no more damage to macadamias than had occurred on avocados, lemons, and oranges.

The macadamia can withstand considerable heat provided there is adequate moisture in the soil for it to draw upon. In the summer of 1955, Riverside County experienced a period of 22 consecutive days in which mid-day temperatures were over 100° F. Highs of 115°-117° were recorded on several days during this period, and relative humidities were often less than 5.0 per cent. Macadamia trees suffered virtually no damage or fruit drop during this heat wave while avocado trees and citrus trees suffered light to heavy damage and considerable fruit drop.

The macadamia seems to thrive on a wide variety of soils from fairly acid to slightly alkaline and from light sand to fairly heavy clay. Trees are flourishing on, some soils which, previously, were found to be unsuitable for growing avocados and citrus. In some areas and under some conditions, however, trees do tend to become chlorotic. Dr. Arthur C. Wallace of the Department of Horticultural Science at U.C.L.A. reported this tree condition iron-deficiency chlorosis which may be due to any of several factors: (1)

Genetic variability and susceptibility to chlorosis of the plants themselves; (2) Soil overly calcareous; (3) Excess of nitrogen from over-fertilization; (4) Over-irrigation.

The macadamia is singularly free from destructive insects and diseases in California. A particular point in its favor as a possible replacement for avocados in orchards which are declining because of avocado root rot is that it has been shown by Dr. George A. Zentmyer of the Department of Plant Pathology, University of California, Riverside, to be highly resistant, if not immune, to attack by the fungus which causes avocado root rot. In most cases where trees have died, the cause of death has been found to be extensive damage to the root systems by gophers, by drought, or by overzealous applications of weed killers or chemical fertilizers. It is true that an occasional tree dies from a cause yet undetermined, but whatever the cause it apparently -is not epidemic in nature.

PROPAGATION

The macadamia can be propagated by seed, by grafting, and by rooting cuttings.

Seedling trees are produced by planting seed in deep boxes or seed beds filled with sand or vermiculite. These may be in areas fully exposed to the sun or in greenhouses. If the seed beds are out of doors, germination may be enhanced during the cool months of the year with the use of bottom heat supplied by electric heating cables. Perhaps the most important point in seed germination is that the nuts be mature and freshly fallen from the tree. The germination percentage of nuts held in storage falls off rapidly with time.

The first seedlings begin to appear in about a month, but germination usually is anything but simultaneous, and additional seedlings continue to come up for several months after the first have appeared. Weak and chlorotic seedlings are discarded, while, strong seedlings, are transplanted to nursery rows in the field or to containers of various types and sizes, depending upon the preferred practices of the various nurserymen. Care is taken not to knock off the adherent cotyledons in transplanting, as loss of the cotyledons seems to retard vegetative growth. Seedlings are ready for grafting in a year to a year-and-a-half after germination.

Plantings of the macadamia up to about 1936 consisted almost entirely of seedling trees. This was so because up to 1926 no one had ever grafted a macadamia tree successfully, and the species had the reputation of being ungraftable. In that year, however, Ralph Moltzau, now with Libby McNeill and Libby in Hawaii but then a high school student helper at the Hawaii Agricultural Experiment Station, perhaps unaware that it couldn't be done, produced a number of successful grafts. The percentage of successful grafts remained low in subsequent years, however, militating against the use of grafted trees in commercial plantings. In 1936, Dr. W. W. Jones, now at the Citrus Experiment Station but then, also at the Hawaii Station, demonstrated that grafting percentages could be greatly increased by girdling branches to be used for scionwood well in advance of the time of use. This procedure made propagation of the macadamia so easy that it now seems strange to think that once it was considered virtually impossible, and, certainly impractical for commercial use. The only justification for

growing seedling trees now is to use them as rootstocks for good varieties.

Success in grafting to seedlings seems to be best if one follows a few simple rules. These are: (1) Preferably, graft in the months of February through May, or in September and October. During these months the trees grow vigorously, putting on new flushes of growth. Presumably, the cambium tissues which unite to form a successful union between stock and scion are most active at this time. During the hot summer months and the cold winter months, growth activity is slowed down or at a standstill: (2) Use vigorous seedlings only. Discard weak, slow-growing, and chlorotic seedlings, for these seldom develop into good trees even if grafted and the graft takes; (3) Use scions from branches of the chosen variety which have been girdled some time in advance. If possible, girdling should be done at least one month before scions are taken; three months are better, and up to a year is not too long. Girdling is perhaps the most important single factor in successful propagation by grafting, for it causes the scions to accumulate starch which serves as a reserve food supply until union has occurred; (4) Leave as many leaves or side branches as possible on the stock plant. Mr. E. F. Frolich and Dr. G. F. Ryan of the Department of Horticultural Science, U.C.L.A., have shown that both the chances of successful grafts and subsequent growth of the grafts are enhanced when leaves are present on the stock; (5) Bind the scion tightly to the stock with rubber grafting bands or vinyl grafting tape, and cover the entire scion with vinyl tape or grafting wax to preclude loss of moisture.

In California, a simple whip graft is used by most propagators on seedling trees up to an inch in diameter. In Hawaii, a side wedge graft seems to be preferred. Larger trees may be topworked using the cleft or the saw-kerf methods which are commonly-used for avocados.

Rooted cuttings are produced fairly readily by placing mature leafy branch terminals about six inches long in a bed of sand or vermiculite provided with bottom heat. The surrounding atmosphere should be at or near saturation so that the leaves are moist at all times. A high degree of relative humidity in the atmosphere is best accomplished in a greenhouse or an open-top chamber provided with a timed mist system.

Because virtually nothing is known of the performance of varieties as own-rooted trees grown from cuttings, propagation by cuttings is used primarily for producing trees for experimental use, not for commercial plantings.

VARIETIES

The macadamia has been under observation as a possible commercial crop in California for so short a time that the question of which type, tetraphylla or integrifolia, might be best for growing is still unsettled. Furthermore, the question of which, variety of one type or the other might be best adapted to growing commercially is still unanswered. It may be found, as with the avocado with its different horticultural races and numerous varieties, that no one type or variety is suited to all situations and that a number may have to be grown which fit into various microclimatic zones. In order to determine this point the University of California has initiated a test of varieties in two climatic zones, one test orchard being on the campus at Riverside, the other at the

South Coast Field Station near Tustin. This test will be extended to other zones as space and plant materials become available.

At present 51 clones have been propagated and are under observation. Two of these are named varieties of the tetraphylla type which originated in California. Twelve clones are selections made from the survey of bearing seedlings in California; three of these are tetraphylla selections, seven are integrifolia selections, and two are selections of natural hybrids between the two types. Seven clones are named varieties of the integrifolia type which originated in Hawaii. Fifteen clones are selections which were made in Hawaii, and are presently being evaluated there also; all are of the integrifolia type. Fifteen clones are selections made in Australia, none as yet named; of these, ten are of the tetraphylla type, the other five of the integrifolia type.

Unfortunately, variety evaluation is something which must be carried on over a long time, so it is not possible to make an unqualified recommendation as to which variety to plant at this time. Until a variety is shown to perform especially well in California, the only recommendation which can be made is that the grower stick with varieties of proven performance in Hawaii or Australia.

As noted previously, about 25,000 trees are now planted in California. The vast majority are seedlings. Doubtless many will be worked to established varieties, but many will reach maturity and fruit as seedlings. The latter offer a promising field for future selection of varieties which may be better adapted to the climate of California than varieties selected in and introduced from Hawaii and Australia.

OUTLOOK

From a strictly horticultural viewpoint, the macadamia is exceedingly promising as a new crop plant in southern California. As noted previously, it is well adapted to a wide range of soils and environmental conditions. It thrives in many situations where avocados and citrus fruits fail. It is free of any serious diseases and insect pests. Older seedling trees indicate that one can expect yields in California comparable to those in Hawaii. The quality of California grown nuts is equal to that of Hawaii and Australia grown nuts.

Whatever misgivings there may be about the place of the macadamia in California's horticulture these revolve largely around questions of the economics of production, not of culture of the tree. There is a wide divergence of opinion among persons who have given the matter considerable thought as to whether the macadamia can be produced profitably as an orchard crop in southern California. In recent years, enough persons have planted trees in various numbers from 1 up to 1400 so that we should begin to have some definitive answers to these questions in the not-too-distant future.