Chinese Chestnut Production in the Southeastern United States: Practice, Problems, and Possible Solutions

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ABSTRACT.— There are less than 400 acres of commercial chestnut orchards in the United States, with approximately half of these in the Southeast. Large numbers of Chinese chestnut seedlings are planted annually for home and game food production; however, knowledge about Chinese chestnuts, their propagation, fertilization, pests, harvest, storage and marketing is both scarce and lacking. Chinese chestnuts are sold in roadside markets and local farmers markets. There is no commercial marketing for the domestic supply is low and unpredictable. However, we yearly import 10 million pounds of European chestnuts to satisfy the U.S. market.

INTRODUCTION

The Chinese chestnut, *Castanea mollissima* Bl., was introduced into the United States in 1901 by G. D. Brill (Galloway, 1926). In 1904 the chestnut blight was discovered in New York on American chestnut, *Castanea dentata* (Marsh.) Borkh., and this stimulated interest in introducing Chinese chestnuts and other *Castanea* species that might be blight resistant. In 1912, W. Van Fleet of the U.S. Bureau of Plant Industry established a 900-tree test orchard of Asiatic chestnuts at Glendale, Maryland. Most of this earlier chestnut research and exploration was oriented toward finding a winter-hardy timber-type tree with characteristics of the American chestnut and hybridizing the introduced *Castanea* species with the American for superior blight resistance (McKay and Berry, 1960). The Chinese chestnut as a food crop was a spinoff from these projects, and seed was distributed to various individuals for establishment in regions formerly occupied by our native American chestnut. In 1927, R. D. Beattie searched the Orient for outstanding Chinese chestnut (Beattie, 1931). The first varietal selections from the Chinese chestnut were made in 1930 (Reed, 1946). These early selections were chosen entirely from desirable nuts sent by and established by cooperators; bearing habits and other characteristics of the original parent trees were not known. Small plantings were established throughout the Eastern United States in the 1940's and 50's; however, the present commercial acreage is less than 400 (Chase, 1976).

ORCHARD ESTABLISHMENT

The Chinese chestnut is suited to nut production

in a wide range of climatic and soil conditions. It is as cold hardy as the peach, and can withstand -20 F when fully dormant (Clapper and Gravatt, 1946; Crane, 1960). Chinese chestnut trees grow well on a large number of soil types if they are well drained. As much attention should be given to selecting a site for Chinese chestnut trees as to the soil in which they are planted. Since Chinese chestnut trees start growth activity in early spring following warm winters and are subject to injury, they should not be planted in frost pockets or on low land (Crane, 1960).

Before planting the chestnut trees the soil should be limed with dolomitic limestone to a pH of near 6.5 (Crane *et al.,* 1957). Dolomitic limestone is used rather than calcitic because of its magnesium content. Application of dolomitic limestone is the most practical and inexpensive way to apply magnesium and prevent a potassium—induced magnesium deficiency. After lime application, the soil should be subsoiled (30 in.) for two reasons: first, to increase the rooting zone and thus provide a greater soil volume for absorption of nutrients and water, and second, to increase the pH in the rooting zone to a value more conducive to root growth, in other words, to "encourage" root growth into the subsoil.

Most growers plant seedlings because they cost less than grafted trees. The nurseryman can grow a seedling at less expense than a grafted tree; therefore, he can sell the seedling at a lower price. However, several growers have planted orchards of improved varieties and state that grafted trees are superior to seedlings in nut production (Weaver, 1960; Wilson, 1958). Seedling trees are highly variable with respect to tree and nut characteristics. Some trees are unproductive. The nuts produced by different trees vary greatly in size, color, shape, amount of pubescence on the shell, and time and uniformity of maturity or harvest. So far as is known, all varieties of chestnuts are self-sterile. Two or more varieties or seedlings must be planted together to insure cross-pollination. Clapper (1954) reported that chestnut is wind-pollinated, but others believe that it is pollinated by insects (Szego, 1969).

After planting but during dormancy, 100 pounds of zinc sulfate and 1,000 pounds of 5-10-15 per acre are applied. The zinc is applied to prevent a lime-induced zinc deficiency. The high analysis potassium and low analysis nitrogen are used to build up the potassium content of the soil and prevent a nitrogen-potassium imbalance (Sparks, 1976). In early June, 1 pound of 10-10-10 is applied per tree on a 6-foot square. The fertilizer is applied in early June because substantial root growth on a newly transplanted tree does not occur until about this time. Leaf samples should be collected during the first season so the grower can plan the second season's fertilization. It is assumed that weed, insect, and disease control and the water supply to the tree are adequate. The supply of water to the transplant is of paramount importance because most of the roots that absorbed water in the nursery were left in the nursery.

To establish an orchard of uniform trees requires careful attention to cultivation. Newly transplanted or young Chinese chestnut trees cannot successfully compete with briars of various kinds or with sassafras, sweet gum sprouts or seedlings, trumpet vines, other weeds or grass. The trees must be cultivated, at least while they are young. Mowing and herbicides are common methods of weed and grass control in nut-producing orchards. Records from one Georgia grower with 20 acres of seedling Chinese chestnuts on a 25 x 25-foot planting show that yields of 2,700 pounds per acre can be expected, (Fig. 1). Two tons per acre yields have been achieved from an experimental planting of 174 seedling trees per acre (ten years old) at Byron, Georgia.

INSECT PESTS

Producers of chestnuts have long recognized that weevils are a major threat to production because they attack the nuts. Weevil-damaged nuts are likely to harbor a wide variety of mycoflora and be subject to spoilage (Wells and Payne, 1975). Unless controlled in some manner they often render the crop unfit for use. Two chestnut weevils, the large chestnut weevil, *Curculio caryatrypes* Boheman, and the small chestnut weevil, *Curculio sayi* Gyllenhal, are uniformly distributed in Eastern United States wherever chestnuts are grown (Gibson, 1969). A nut curculio, *Conotrachelus carinifer* Casey, is rather widespread in Southeastern United States on various species of oak, but has only been of recent concern to chestnut growers in Georgia (Payne *et al.,* 1972a). Several methods have been proposed for control including use of poultry (Reed,

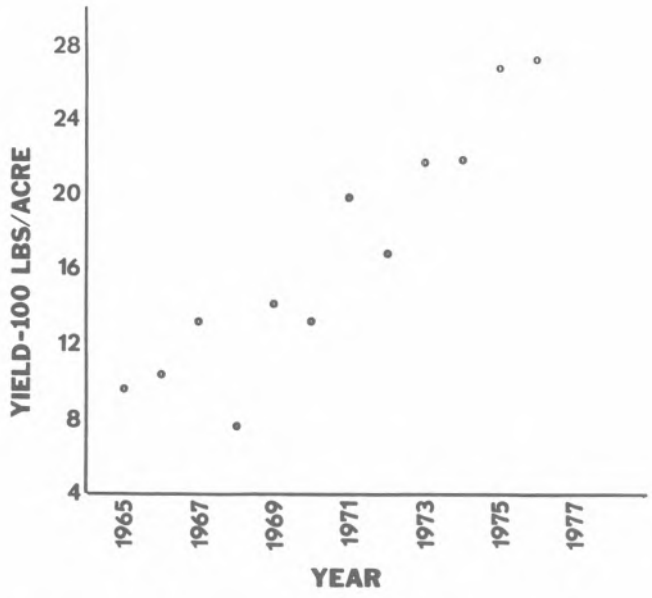

Figure 1. Yield data from a 20-acre seedling Chinese chestnut orchard, 1965-76, Cordele, Georgia. Trees were 15 years old in 1965.

1946) and hand collection, hot water, and burning (Anonymous, 1958; Beattie, 1931); however, insecticides are the primary method of control. Since the weevils (depending upon species) spend one to two, sometimes three years in the soil, in the larval, pupal, and adult stages, the soil can be treated with insecticides before the adults emerge (Payne *et al.*, 1972b; 1975b). Also, the adults emerge from the soil during April to August but do not oviposit in chestnuts until August and September. Thus, treatment with foliar pesticides can be effective if materials are applied before the adults oviposit in the developing nuts (Payne *et al.*, 1975b).

An Oriental chestnut gall wasp, *Dryocosmus kuriphilus* Yasumatsu, a recently discovered pest in the Southeastern United States, threatens the chestnut industry in this country (Payne *et al.*, 1975a; 1976). This cynipid wasp attacks the vegetative buds and disrupts the shoot growth through formation of galls. Growers with a few chestnut trees may reduce infestation by gathering and destroying the infested shoots.

DISEASES (PRE- AND POSTHARVEST)

Chestnuts are a perishable commodity easily spoiled by fungi and insects. Mature nuts are allowed to drop from trees and may lie for several days or weeks until gathered. Decay development may begin while the nuts are still on the tree (Fowler and Berry, 1958; Gravatt and Fowler, 1940) or while they are on the ground (Gossard and Kushman, 1954). Commercially, chestnuts may be held in refrigerated storage for several months before marketing. Losses due to fungi frequently occur, particularly at the consumer level (Woodroof, 1967). In experimental storage studies (Hammar, 1949) spoilage ranged from 5-10 percent after one month and 15-60 percent after seven months at 36 F. Wright (1960) reported that 62 percent of the kernels examined soon after harvest contained visible fungal infections. The most common fungi isolated from decayed tissues were *Phoma castaneae* Pk. and *Pestalotia* spp. Of minor importance were species of *Phomopsis, Penicillium, Alternaria, Fusarium, Rhizopus,* and others. Researchers in Italy and France have found that the most common genera of decay fungi isolated from European chestnut (*Castanea sativa* Mill.) kernels in storage were *Penicillium, Fusarium, Phoma, Aspergillus* (A. *niger* van Tieghem), and *Rhizopus* (Bidan *et al.*, 1958; Lanza, 1950; Riccardo, 1963).

Moldy nuts or nuts from which weevils have emerged are generally culled from the packing operations by flotation (Wilson, 1967). Nuts, containing weevils, however, are not separated by the flotation process. Weevils then emerge while the chestnuts are in storage or transit, and damaged nuts are generally discarded by the consumer, some might be incorporated into processed chestnut products or food combinations. The potential for consumption of spoiled chestnuts is increased by the absence of visible mold on many kernels with incipient fungal infections. *Penicillium* spp. were the fungi most frequently (40.7 percent) isolated from weevil-damaged chestnuts (Wells and Payne, 1975). Next, in order of frequency of occurrence, were *Rhizopus, Alternaria,* and *Aspergillus,* each comprising about 17 percent of the total mycoflora isolated. A high percentage of *Penicillium* and *Aspergillus* isolates from weevil-damaged Chinese chestnuts were capable of producing mycotoxins (Wells and Payne, 1975). No mycotoxins have been found on market chestnuts; however, a potential exists for toxin production in the event fungal development occurs on kernel tissues.

HARVESTING AND STORAGE

Chestnuts should be harvested daily as soon as some begin to ripen and drop to the ground (Hammar, 1949; Reed, 1946; Thrash, 1971). Traditionally chestnuts have been hand gathered from the ground after they have fallen naturally. This task is time consuming and the supply of labor for such work is decreasing yearly. At the time of initial nut drop, most Chinese chestnut seed do not have the uniform maturity necessary for once-over mechanical harvesting. However, Peterson and Monroe (1977) showed that when 4 to 9 percent of the nuts have dropped naturally a shake-catch harvesting system can effectively remove and handle nuts in burs. Morgan (1969) reported on a flame hulling process for the removal of burs and Peterson and Monroe (1977) developed a mechanical means of removing burs.

Chestnuts are starchy and are very different from most other nuts that contain large amounts of oil. Fresh chestnuts contain 40-45 percent carbohydrates, mostly in the form of starch, about 5 percent oil, and about 50 percent water (Woodroof, 1967). Fresh chestnuts, unless properly handled, dry out rather quickly and become hard and bony, in which condition they cannot be roasted or boiled satisfactorily without regeneration or soaking.

In the South, within a week the nuts on the ground or those in opened burs on the trees become dry or they mold and spoil. Under proper conditions chestnuts can be stored from the time of harvest to late April with assurance that only a small percentage of them may spoil. Only chestnuts free of mold or decay should be stored; they can be stored for four to six months at 32 F (Lutz, 1968), or up to 12 months if the moisture content of the chestnuts is maintained at about 40 percent (by maintaining a storage facility relative humidity of 65-70 percent) (Woodroof, 1963). It is almost impossible to keep some varieties from spoilage (Crane and McKay, 1946) and the ultimate solution to the problem of chestnut storage may be in introducing selections known to keep well under proper storage conditions.

OUTLOOK

There are several problems in the United States

that have limited the commercial production of Chinese chestnut (Chase, 1956; Hardy, 1949; MacDaniels, 1954; McKay and Crane, 1953; Wilson, 1952, 1967). These include insects, diseases, and a lack of concentration of plantings of standard cultivars, and no organization for handling and vigorously advertising the nut. Shipments to the markets have been sporadic with no effort to maintain a steady supply or meet the demand of any one market; hence the prices have fluctuated widely and have been generally uncertain. Fancy prices obviously cannot be expected from any fruit that has no U.S. standard grades and is generally unknown to the public. While there is a limited but loyal public buying Chinese chestnuts, there are those who have tried the nuts for the first time and found them hard, chalky, moldy, wormy, and mealy, probably because of inadequate insect control, handling, and storage. This has discouraged further purchases. This situation could be overcome by proper advertising and further development of the mechanized harvesting and postharvest treatments that currently exist for pecans and walnuts. Our climate and soils are satisfactory for growing chestnuts, but the combined problems of diseases, insects, harvesting, and marketing make chestnut culture a risky commercial venture at this time. In spite of all these problems, there is still a strong demand for chestnuts and chestnut products, for we import over 10 million pounds per year (Fig. 2).

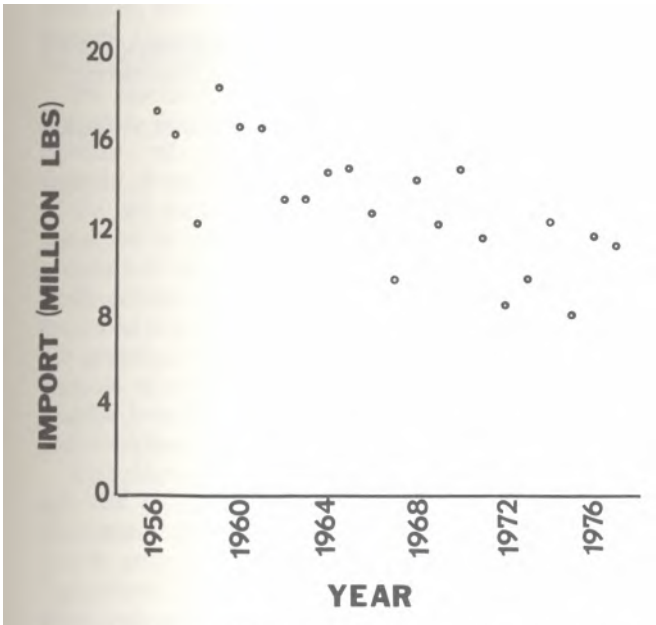

Figure 2. Yearly U. S. imports of chestnuts, primarily *Castanea sativa* Mill., from 1955-1977.

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