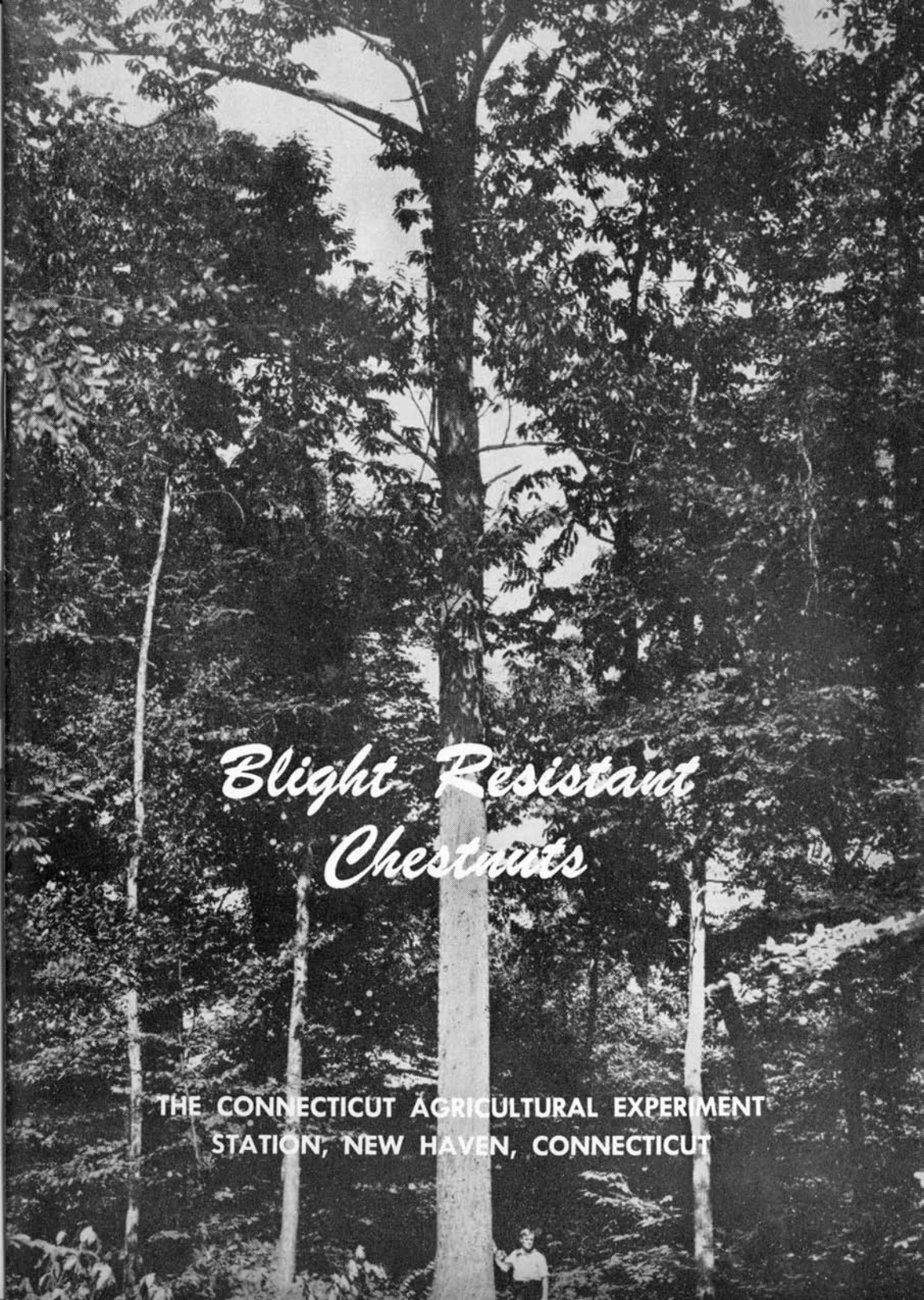

Blight Resistant Chestnuts

THE CONNECTICUT AGRICULTURAL EXPERIMENT STATION, NEW HAVEN, CONNECTICUT

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The cover photograph shows an American chestnut tree at Scotland, Conn., in 1905, before the days of the chestnut blight. The diameter breast high was 27 inches. The tree was 83 feet tall and sawed 662 board feet of lumber.

BLIGHT RESISTANT CHESTNUTS CULTURE AND CARE

Hans Nienstaedt[1] and Arthur H. Graves[2]

The native American chestnut *(Castanea dentata)* was formerly one of the most valuable forest trees of the Eastern United States (see cover). An erect, lofty trunk with wood that resisted decay, furnished ideal material for telephone and telegraph poles, mine timbers and props, construction timbers and sills. In many an old home in the Eastern states the original chestnut timbers that formed its framework, now 150 or 200 or more years old, are proudly displayed. A recent telephone bulletin (S. N. E. Tel. Co. for Feb. 1955, page seven) states that even today 11,000 native chestnut poles as well as 25,000 poles of southern chestnut are still in service.

But some time back in the 90's, a parasitic fungus, *Endothia parasitica,* entered this country, evidently on Japanese nursery stock. In the Orient, as is now known, this fungus had attacked the chestnut trees for such a long period that Oriental chestnut trees are now more or less resistant to the attacks. In this country, however, the fungus found a new and consequently susceptible victim, with the result that in somewhat more than half a century our fine native species, ranging from Maine to Alabama, has become practically extinct as a forest tree. There is no question that if we consider the rapid advance of the disease and the important position of chestnut in the eastern forest community, the chestnut blight (as it is generally known or the chestnut bark disease) is the most devastating catastrophe that eastern forests have ever experienced, at least within the memory of the white man. The loss to the American people in timber alone has amounted to many millions of dollars.

In the early years after the discovery of the disease, many thousands of dollars were spent in the attempt to prevent the spread of the fungus and save already diseased trees, all without result. Eradication of advanced spot-infections were attempted; barrier zones were laid down but they were jumped by the fungus to such an extent that all eradication work eventually was abandoned. The conclusion that could be drawn from this early experience was that the only hope for the fast-disappearing American chestnut was to develop hybrids which should retain the valuable timber characters of the American species and be blight resistant. This then has been the goal of a breeding program.

Breeding Disease Resistant Chestnuts

Ever since the chestnut blight fungus was discovered, the search for American chestnut trees possessing natural resistance to the disease has been going on, but so far the outcome of this work has not been encouraging. Highly resistant trees have not been found; the best has been a small number of partially resistant sprouts. These sprouts have been used in the development of hybrids.

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The chestnut breeding program in Connecticut had its beginning in 1931 when, under the sponsorship of the Brooklyn Botanical Garden, the first hybrid nuts were produced on Japanese trees on Long Island, N. Y. The pollen for these hybrids came from a large old American chestnut near Washington, D. C., being furnished by the then Office of Forest Pathology of the United States Department of Agriculture. The seedlings from these nuts were set out on the Sleeping Giant Plantation at Hamden, Conn., which since 1947 has been under the management of The Connecticut Agricultural Experiment Station.

These first Japanese-American hybrids appeared very promising both in their erect form and rapid growth (Figure 1). But it soon became evident that they were only partially blight resistant—in fact, in this respect they were intermediate between both parents. Further breeding would have been impossible had it not been for the inarching method described more in detail later.

Fig. 1 Japanese x American hybrid chestnut. This tree was 33½ feet tall at 17 years. Its form when grown under forest conditions is very good, but it is not resistant to the blight fungus. It is the parent of many of the best Chinese x (Japanese x American) hybrids.

Since these early crosses were made a large number of hybrids have been developed; the most important parents are: *Castanea dentata,* the American chestnut; *C. crenata,* the Japanese chestnut; *C. mollissima,* the Chinese chestnut; *C. sativa,* the European chestnut; *C. henryi,* the Chinese timber chinkapin; *C. seguini,* the Seguin chestnut; and *C. pumila,* the common American chinkapin. Several promising hybrids are now being tested, the best is the so-called CJA, a cross between the Chinese chestnut and selected first generation hybrids between the Japanese and American chestnut (Figure 2). Although there is a considerable amount of variation in the CJA crosses, they include what seems to be a sufficient number of desirable trees to make their planting as a forest tree worthwhile. It is, however, still too early to make this statement with complete certainty; further testing on a relatively large scale is required.

Fig. 2 Chinese x (Japanese x American) hybrid chestnut. This represents one of the most promising Connecticut hybrids. At 16 years it is 40 feet tall. Although grown partially in the open it is of good form. It is highly resistant to the blight fungus.

Another hybrid which has some promise combines the Chinese and the American chestnuts. These hybrids are primarily of two types; one combines the form of the American parent with intermediate resistance, the other shows more Chinese characteristics, being highly resistant but of poor form; only rarely do the trees combine high resistance with a good growth form. Considerably more breeding will be needed before this hybrid can be used for timber production.

While most of the better hybrids have the Chinese chestnut, the most resistant of the exotics, as one parent, there are a few in which this species has not been used. The so-called Essate-Jap, of the combination *((C. crenata* × *C. pumila)* × *C. crenata)* × *C. crenata,* especially, has possibilities as a forest tree; it rates high in resistance and the form is relatively good (Figure 3);

Fig. 3 ***((C. crenata x C. pumila) x C. crenata)*—the Essate x Jap hybrid chestnut. In spite of the C. *pumila* parent, the common chinkapin, which is a small bush, this hybrid has a good growth form. It is highly resistant to the blight fungus.**

much improvement, however, will be needed before it can be put out in forest plantings.

A limited amount of breeding toward good orchard-type trees has been done in Connecticut and one good hybrid has been developed. It combines the prolificness of *C. seguini* with a high degree of resistance from *C. mollissima* (Figure 4). Its nut is of medium size and of excellent flavor and texture. Unfortunately it is not entirely winter hardy in Connecticut, a trait it inherits from its Seguin parent; after further field testing it may find a use as an orchard and home garden tree at a more southern latitude.

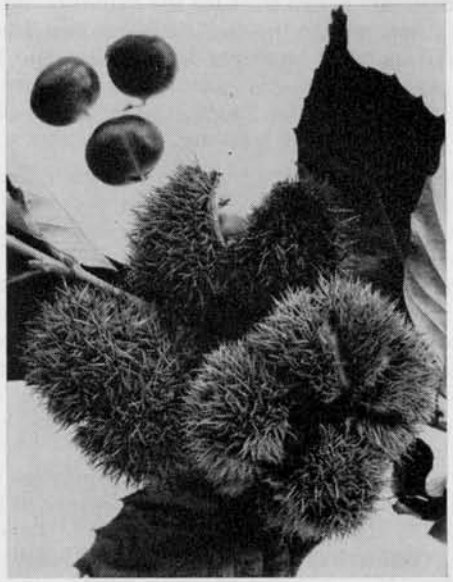

Fig. 4 C. *mollissima* x C. *seguinii* hybrid chestnut. Burrs and nuts as they look when they are mature in the first week of October. The nuts are of the very highest eating quality.

No discussion of chestnut breeding in the United States, however brief, would be complete without mentioning the work done by the United States Department of Agriculture at the Beltsville Experiment Station in Maryland. The work there has been centered around the Chinese-American hybrid and its backcrosses to the Chinese parent. Some very promising hybrids have been developed.

The cooperation between the United States Department of Agriculture and The Connecticut Agricultural Experiment Station has been close. Since 1947 a total of 15 experimental hybrid chestnut field plots have been established in 10 different eastern states. The plots consist of equal numbers of Connecticut and USDA hybrid seedlings, as well as a special introduction of Chinese chestnut, and will make it possible to evaluate the young trees with regard to winter hardiness, blight resistance and general growth performance. During the early years of the breeding work The Division of Forest Pathology contributed funds annually toward its support.

Evaluating the Past and Future of Chestnut Breeding Work

For 25 years intensive chestnut breeding has been underway in Connecticut and at Beltsville, and in that time a relatively few hybrids have been developed which, after further testing, may prove to be worthwhile as forest trees. Compared to the progress that has been made in corn breeding, for example, within the same length of time, this certainly seems slow advance. However, the length of time that has to elapse before a hybrid tree can be evaluated and before it reaches the flowering stage, makes tree breeding slow, the chestnut breeder is further handicapped because only a limited amount of material has been available for selection of desirable parent trees for the hybridization due to difficulties in introduction from China and to the elimination of the American chestnut as a forest tree. Other factors could be mentioned which would further show why the development of a blight resistant chestnut of necessity must be a slow process. It must suffice to summarize by stating that when all factors are considered the progress in the chestnut breeding work has been quite satisfactory.

Looking into the future it may again be worthwhile to compare with the breeding of farm and truck garden crops. A high degree of uniformity is required in these crops, necessitating selection and breeding through several generations. In forest tree crops a high level of uniformity is not necessary and not even desirable. Common spacing of the seedlings in forest plantations is 6 x 6 feet, or about 1200 seedlings per acre. As the stands grow older this number decreases rapidly; weaker or diseased individuals are eliminated through natural selection, or are removed in early thinning operations. Monetary returns will be concentrated on 40-50 percent of the original number of trees planted and the largest part of the returns will come from the final cut which may concentrate on as little as 10 percent of the original number of trees planted. It will therefore be feasible to plant a segregating hybrid population of which perhaps 40 percent combine a desirable timber form with resistance to the blight fungus. It seems entirely possible that a hybrid fulfilling these standards already has been developed in the Connecticut CJA or the USDA Chinese-American hybrid. Large scale tests of these hybrids are still required before their planting can be considered safe investment. In the meantime, provisions should be made for quantity production of hybrid seed of these combinations, and at the same time breeding for their perfection and for the improvement of other promising hybrids must be continued.

Chestnuts for Forest and Orchard

The Japanese chestnut was the first Asiatic chestnut to be introduced to the United States; it has never been planted on a large scale for three reasons. It is not as winter hardy as the Chinese chestnut, it is less resistant to the blight fungus, and its nuts are of inferior texture and flavor.

The European chestnut has never been of importance in eastern North America. It is only slightly more resistant to the disease than the American chestnut. Since the blight fungus was discovered in Europe during the thirties, severe losses have occurred within its native range in the Mediterranean countries.

The Chinese chestnut is the most promising of the exotics both as a forest and as an orchard tree. During the last three decades a large number of experimental plots have been established in the forests over the eastern half of the country by the United States Department of Agriculture. At least one introduction has shown a favorable development under a variety of climatic conditions. However, it is too early to release this introduction for general forest planting, and the United States Department of Agriculture and The Connecticut Agricultural Experiment Station emphasize that they do not distribute chestnut seedlings to the general public.

For orchard purposes both seedling material and grafted plants of named varieties of the Chinese chestnut have been available at a number of nurseries in recent years.[1]

Of the named varieties four in particular should be mentioned. *Abundance.* This has a nut of very good color with very little down on the shell and has an excellent flavor. The use of this variety is on the increase. The *Kuling, Meiling* and *Nanking* are three newer varieties released by the United States Department of Agriculture in 1949 for commercial use. The *Kuling* and the *Meiling* are very similar and the nuts are of good quality and size (35-40 nuts per pound). The *Kuling* is a more upright tree than the others and the branches are more slender. The *Nanking* is a precocious and regular bearer with heavy crops. A few nuts have split shells when they fall; this may be a drawback especially if the nuts are to be stored. The nuts will average 30 to 43 per pound, and mature late in the season.

Other named varieties are *Carr, Hobson, Reliable, Stoke, Yankee* and *Honan,* but they are all more or less inferior to the varieties mentioned above.

Seedlings of the Chinese chestnut are highly variable with regard to time of first crop, prolificness, nut quality, tree form, etc. Generally, they are superior to the Japanese and European species as nut producers. Being variable the species lends itself to improvement through selection. There is no reason why such selections cannot be developed by the amateur as a hobby or by the commercial grower. Carefully kept records will reveal the desirable trees; by propagating them vegetatively they can be tested on a larger scale under a variety of conditions. After they have proven themselves in such a test they may finally be made available for general use.

Characteristics that should be looked for in selecting Chinese chestnut for orchard production are:

Good-orchard type growth form. This can of course be modified by pruning, but extreme branching types should be avoided.

A high degree of resistance to the chestnut blight fungus and other diseases.

Early bearing with heavy and regular crops.

The buns should open readily, so that the nuts drop freely.

The nuts should be of a rich brown color, with little down on the shell. The shell must remain intact when the nut matures, split shells result in poor storing. The nuts should store well. The pellicle (the thin skin immediately surrounding the kernel) must separate easily from the kernel. The flavor of the cured, raw nut should be sweet and "nutty" and the texture should be tender and crisp.

[1] A list of nurseries handling Chinese chestnuts may be obtained from the Department of Genetics, The Connecticut Agricultural Experiment Station, Box 1106, New Haven 4, Conn.

Chestnut Culture

Where to Plant Chinese and Hybrid Chestnuts

Chinese and some hybrid chestnuts can be grown over most of eastern United States from Georgia to southern Michigan, and into southern New England. How far north in New England they will thrive has not been definitely determined, but it seems reasonable to expect that they will develop satisfactorily in Massachusetts when planted under the right conditions. Peaches and Chinese chestnuts are similar in their requirements to climate and soil, but chestnut will grow farther north and south than the peach. Frost pockets must definitely be avoided as a planting site; on gentle northeast or north facing slopes the danger of frost damage in late spring or early fall is at a minimum.

A good soil texture is more important than a soil of high fertility; heavy, cold and wet clay soils are definitely undesirable, while loams, sandy loams, even sandy and gravelly soils will give good growth. Good soil drainage is important; a high watertable is unfavorable, while a porous soil of large waterholding capacity will result in good development. Chinese and hybrid chestnuts require a pH of 6.2 – 6.5, but will still produce good crops at a pH as high as 7.0. Soils high in alkali content are not chestnut soils. Dr. Jesse Diller of the U. S. Department of Agriculture has found that the following plants are indicators of good chestnut sites: Yellow poplar, Northern red oak, cucumber tree magnolia, black and yellow birch and sugar maple; of the shrubs, spice bush, and of the lesser vegetation, maidenhair fern, bloodroot, Jack-in-the-pulpit, squirrelcorn, and dutchman's breeches. A heavy growth of broomsedge, sumac, hardpines and heavy sod is evidence of a poor chestnut site, and an area where black ash, red maple, willows and alder are common, will be too wet.

Planting and Soil Maintenance

Planting of seedlings is the only way to establish chestnut plantations; direct seeding is almost always a 100 percent failure due to rodent damage. Chestnut plants two feet tall make good stock for field planting. A two year transplant, that is one that after one year's growth has been transplanted, will usually meet this requirement.

For orchards, a spacing of 25′ x 25′ is recommended; this relatively close spacing insures good cross fertilization. Later, when the crowns meet, every other tree may be removed to give a final spacing of 50′ x 50′. In the home garden the trees should be no more than 60′ apart. Chestnuts are practically completely self sterile, necessitating the planting of at least two or more seedlings; or, if grafted varieties are used, a mixture of two or more varieties or of grafted stock and seedlings. In forest plantings 8′ x 8′ or 10′ x 10′, spacing is necessary to ensure good timber development and natural pruning.

Spring planting is usually more successful than fall planting, but fall planting carefully performed will give satisfactory results. A two year old chestnut seedling has a very well-developed root system, and the only way of planting that can be recommended is the dug-hole method. A seedling well planted in a carefully dug hole has a better chance of surviving drought periods. It is of course important that the root collar of the plant is kept at ground level and that the soil be tamped firmly in place around the roots.

In the first two years after planting seedlings may suffer severe injury from drought, and it may be necessary to water during prolonged dry spells. Also, during the first four to five years it is necessary to keep down grass competition around the trees. This can be done either by clean cultivation or by heavy mulching with leaves, woodchips or sawdust. If heavy undecomposed mulching is used it may be advisable to add about one half pound of nitrogen (nitrate of soda or ammonia nitrate) per 100 pounds of mulching material. In orchards, application of commercial fertilizer will help insure heavy and regular nut crops. One to two pounds of a 6-8-6, 5-10-5 or 5-9-5 commercial fertilizer for each year of tree age is recommended until twenty pounds is reached, this level is then maintained for future annual application. Fertilizer should be applied in late spring or early summer. At the time of planting, fertilizer should not be placed in the hole, but about one pound can be applied around the tree and worked into the topsoil. In later years the fertilizer can be broadcast under the tree to about one foot beyond the spread of the crown. Where barnyard manure can be obtained at a reasonable price its use is well worthwhile.

Pruning

Pruning should be kept at a minimum; excess pruning cuts down the nut producing crown area. However, to facilitate the use of power equipment in the orchard, low branches should be removed during early years, allowing the trees to form heads at five to six feet above the ground. In later years branches should be removed only where they interfere with each other, or where they are dead. Die-back frequently occurs in drought periods. Pruning is best done in the dormant season.

Harvesting and Storing Nuts

In Connecticut the nuts of the Chinese chestnut, as well as the other species and hybrids, mature during September and drop from the last week of that month until the middle of October. However, there is a Japanese form which ripens as early as September 1, or even, in favorable years, in August.

Chestnut is a perishable crop and collections of the nuts should be made at least every other day during the harvest period. To make collection easier the grass should be cut low.

After collection the nuts must be cured; this is best done by placing them in trays with hardware cloth bottoms in a relatively cool room (68°F) for from two to four days. The nuts dry easily, thereby losing much in palatability and eventually their germination capacity. The cured nuts can be stored over winter in metal cans at a temperature of 32-36°F. and a relative humidity of about 70 percent. The cans should be furnished with a number of small holes for ventilation; if mixed with damp sand the nuts may be stored in open containers, then the top layer of nuts should be covered with three inches of sand. If cold-storage facilities are not available, the nuts may be buried in the ground in a well drained location in a small mesh wire cage and mixed with sand. If they are overwintered in this way (stratified) they should be taken out of the ground before germination is well started—about the last of March in this latitude. Otherwise the radicles become tangled and break off when the nuts are removed.

Pest and Disease Control

There are four major insect pests in the chestnut orchards in Connecticut. In some years the spring cankerworms may develop to the point where they cause serious defoliation. Spraying with "Scalecide" not later than the middle of April will kill the eggs. The larvae are easily destroyed with an application of DDT (two to three pounds of 50 percent wettable powder in 100 gallons of water) in the beginning of the fourth week of May, in this latitude.

In orchards where spraying with DDT is standard practice, a buildup of the mite population may occur. The mites are barely visible to the naked eye, but their damage is characteristic. The leaves lose their lustrous green color and turn grayish or yellowish green; if the attack is serious partial defoliation of the trees may result. In the winter the reddish egg masses can be found on the trunks of the trees, especially just below the branches. Control is obtained by spraying with "Aramite" (15 percent wettable powder) at the rate of six to seven pounds per acre. One spraying in the middle of June with a follow-up about two weeks later has given good results.

Where the Japanese beetle is prevalent, control measures may be necessary, although this insect usually does more damage to the American and Chinese chestnut than to the Japanese. Foliage damage is easily controlled with an application of DDT (two to three pounds of 50 percent wettable powder in 100 gallons of water). For more permanent control ground application of grub infested areas with chlordane, Aldrin or Dieldrin as 5 percent dust, at the rate of 200 pounds per acre, is recommended.

The most serious pest is the chestnut weevil; there are two species, both attacking the nuts. In years of heavy infestations the feeding of the larvæ inside the nuts may destroy practically the entire crop. DDT is used for control. Spray with four pounds of 50 percent wettable powder per 100 gallons of water, the first time about five weeks before the nuts are expected to fall; at New Haven, Conn., this would be about the middle of August; two additional sprayings at 10 to 12 day intervals are necessary to insure complete control. More recently control of the insect in the ground has been attempted by the use of toxaphin, chlordane, parathion or BHS; the results of early experiments were not promising, but the method deserves further study (Leeuwen, 1953).

In the nut the larvae may be controlled by the "hot water treatment", the infested nuts being submerged in water kept accurately at 120°F. for 30-45 minutes, depending on the size of the nuts.

Other insects that may cause some damage are the chestnut aphid and the two-lined chestnut borer; the latter may kill young trees which already are weakened from drought or transplanting damage.

Mice, rabbits and deer can do serious damage to young trees. The root feeding of the mice may kill trees as large as two inches in diameter; frequent baiting directly in the runways with "Warfarin" or other coumarin poisons will give good results. Expose the runway for a short distance, put the bait in place, and cover the runway with a board. In this way re-baiting is a simple matter. Fencing is the surest protection against rabbits and deer, but it is expensive. ZIP, a Goodrich repellent, is effective if sprayed or painted on trees, but applications must be repeated several times during the winter months.

In the north the only disease that deserves mention is the chestnut blight. Using resistant stock is the answer. If only partially resistant trees are used they may be kept alive and in bearing condition by using the inarching method (Figure 5). When a blight lesion develops, suckers arise below the lesion or at the base of the tree. First the diseased bark is carefully cut away, and also two or three of the layers of wood immediately underlying the lesion. The area is then painted over. Next, by grafting the suckers in the healthy bark above the diseased area the translocation of food between crown and root is maintained and the tree remains healthy. The sucker (scion) continues to grow through the years and may eventually replace the diseased trunk. If the scion itself is attacked it too can be inarched in the same manner. It is important to note that in orchards of partially resistant hybrids no trees need be lost if this inarching method is employed.

Fig. 5 Inarching. Suckers developing below the blight lesions are grafted into the healthy bark above the lesion. The grafts are tied in place with cotton string and the unions sealed with parafin or grafting wax. a. Recently completed inarchings. b. Only through repeated inarchings has it been possible to keep this tree alive.

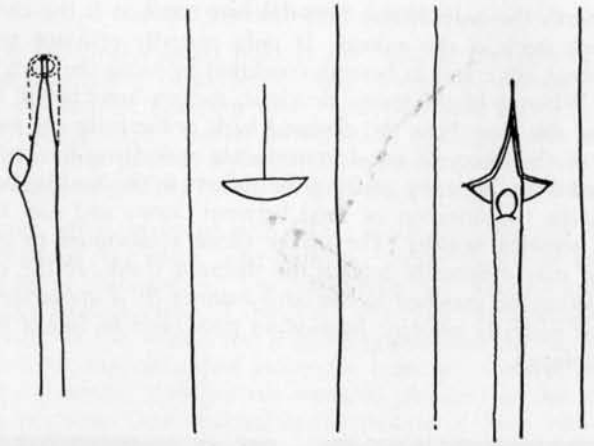

Fig. 6 **Details of inarching technique. The sucker (left) is cut to a wedge shape with two opposing cuts, and forced into an inverted T cut on the stem (center). The bark below the horizontal cut is cut away in order for the sucker to slide in unopposed. The graft is tied and waxed as shown in Figure 5.**

Chestnut Propagation

Sexual propagation:

Three methods may be used for the growing of chestnut nursery stock depending on the amount and value of the seed planted. For the hobbyist or small woodland owner who may want to raise a few trees, it is easiest to plant the nuts directly after they have been cured in the fall in eight inch clay pots in a 50-50 mixture of sand and commercial peat moss. The nuts are planted point down about two inches apart and should be covered about one half inch. Smaller nuts may be planted somewhat more shallowly. The pots should be placed in a well-drained location and the spaces between the pots filled in with sand to cut down evaporation. It is important that the pots be completely enclosed in a small mesh wire screen to keep out rodents. In late November or early December the pots should be covered with a good layer of leaves to prevent them from freezing. In the middle of March when the nuts start to germinate the leaves are removed. By the middle of May the plants should be up four to six inches and can be transplanted to the nursery; partial shade and watering may be necessary for a while after transplanting.

With our valuable hybrid material the usual procedure has been to store the nuts over the winter in the cold-storage room and plant them in open cold frames in late March or the first days of April. They are planted in a sand-peat moss mixture and kept in the coldframe until the following spring when they are transplanted to the nursery. Depending on their development they are kept here one or two years until they are transplanted to the permanent location.

For large scale plantings of standard nursery material the stored nuts may be planted directly in the nursery beds. This should be done in late March or the first days of April. If the conditions are right a good seedling fourteen to eighteen inches tall should be grown in one season. If the seedlings are to be

transplanted a spacing of three inches by five inches may suffice, but if seedlings are to be grown two years in the seedbed, a four inch by six inch, or six inch by six inch, spacing will be better. If there is danger of severe mouse damage it may be well to drench the nuts with ZIP before they are planted; this compound does not interfere with the germination of the nuts.

Vegetative propagation:

Attempts to root chestnut cuttings have so far been attended with very poor results. Numerous different hormone treatments have been tried, but in all cases the results have been practically negative. Layering, and the related method stooling (Schad et al, 1952), may give good results. In stooling the parent plant is cut down to the ground during the winter following transplanting. In the spring it will send up numerous shoots; when they reach five to six inches they are earthed to about half their height. More earth is added as the shoots grow, but no more than half their height is ever covered. When the mound reaches six to eight inches no more soil is added. The following winter the mound is carefully removed and all shoots are cut from the parent stock whether or not they are rooted. The rooted shoots are handled as ordinary nursery stock. If treated rightly the stools may be used year after year. Ground layering has been successfully done at our Sleeping Giant Plantation. By this method young shoots are covered with soil, having been first slit on the underside. (Figure 7).

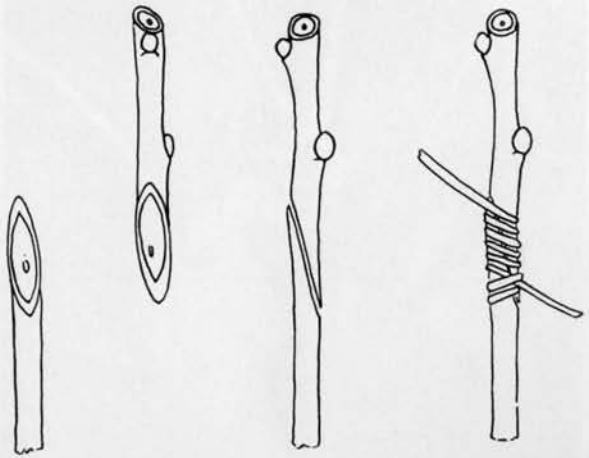

Fig. 7 **Details of the splice graft method. The basal end of the scion (B) is cut obliquely with a smooth cut. The stock (A) is cut similarly, the cut surfaces fitted together, cambium to cambium (C), and tied with raffia or rubber grafting strips (D). The union and cut end of the scions are waxed with grafting wax.**

Air layering is said to be successful on young seedlings, but our experiences with seedlings and older trees have not been encouraging. One drawback to the stooling method and air layering of young seedlings is the fact that it only can be used on young plants of unknown productivity and growth-form. What is needed is a simple and cheap method for the propagation of older trees of proven qualities.

The best method for the vegetative propagation of older selected chestnut trees is grafting, and of the various grafting methods the most satisfactory is the splice graft (Figure 7). With the right handling of scions, good rootstock and proper technique, this method should be close to 100 per cent effective.

Scions are best collected in late February or early March. The growth of the last season is best. A sturdy shoot 3/16 to 5/16 of an inch in diameter, with well developed buds one to two inches apart, makes good scions. The shoots are cut to a length of 10 inches to 12 inches, and made into small carefully labeled bundles. These are packed in moist sphagnum moss and stored in a cool place; best in a cold-storage room at about 36°F., but an unheated basement will do.

Two year old Chinese seedlings or transplants make good root stocks. Do not attempt grafting on stock that has just been transplanted; well established plants give better results.

The best time for grafting at New Haven, Conn., is around May 1st, as soon as the buds on the rootstock start to open and the bark slips easily.

Half the secret of successful grafting is a sharp knife. An ordinary sturdy jackknife made of good steel and well honed is satisfactory. As a preliminary, to save wear on the knife, cut the rootstock with a pair of shears three to four inches above the ground. and wipe off the dirt on the stock with a cloth. The details of the graft are in Figure 8.

Fig. 8 Topworking chestnut by the veneer crown graft method. Three scions are being inserted between the bark and wood on the cut stock. Notice the sandrawers which have been left to prevent drying out of the stock.

The grafts should be examined frequently during the first summer and the binding cut whenever it shows signs of girdling the plant. On fast growing grafts staking may be necessary to prevent breakage.

Topworking should be standard practice in any orchard grown from seedling material. In this type of orchard there are apt to be trees of low productivity and quality; they can be topworked to more desirable types. In top-

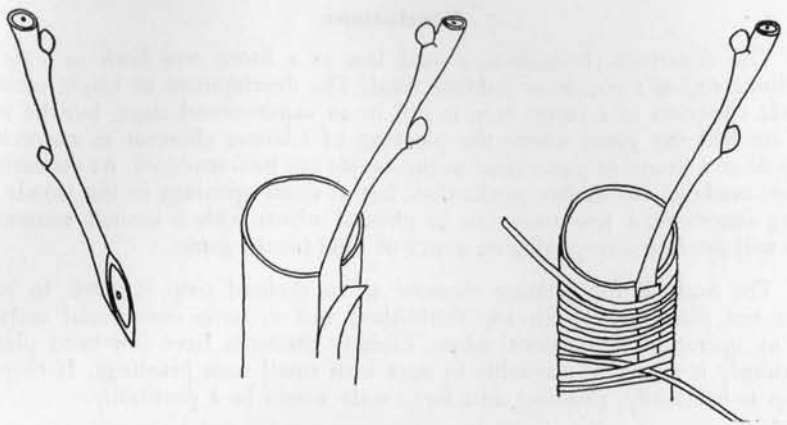

Fig. 9 Details of the veneer crown graft method. The basal end of the scion (left) is cut with an oblique cut. If irregular the edges of the cut are smoothed off. Two parallel cuts are made in the stock the width of the scion apart and the scion inserted with the cut surface toward the wood of the stock (center). The graft is tied with cotton string or grafting tape (right) and the union and all cut surfaces waxed with grafting wax.

working the main branches of the tree are sawed off some distance from the crotches and the cut surfaces smoothed with a sharp knife. One or more smaller branches below are left intact to act as "sapdrawers". One or more scions are inserted in the cut branches depending on their size. The veneer crown graft has given satisfactory results with chestnut. The details of the technique are shown in Figures 9 and 10.

Fig. 10 Ground layering of Japanese Forest Type Chestnut showing good root formation at the right of upper label.

Conclusions

The American chestnut is a total loss as a forest tree both as a timber producer and as a source of wildlife food. The development of blight resistant hybrid chestnuts as a forest crop is still in an experimental stage, but the work has reached the point where the planting of Chinese chestnut as an orchard crop or as a source of game food in the woods can be considered. As yet material is not available for timber production, but in small openings in the woods and along fencerows a few trees can be planted which with a limited amount of care will produce a very valuable source of food for the game.

The outlook for Chinese chestnut as an orchard crop is good. In many areas test plantings are already established and in some commercial orchards are in operation. In regions where Chinese chestnuts have not been planted previously it might be advisable to start with small scale plantings. If they develop satisfactorily, planting on a large scale would be a possibility.

Davidson and Reed, in their book "The Improved Nut Trees of North America", discuss the possible returns from chestnut orchards. Using various per acre yield figures, their estimated annual gross income on a per acre basis ranges from $440 to $950 per acre per year for an orchard in full production. This indeed is a very promising return from a semi-intensive crop.

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