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DWARF APPLES.

U. P. HEDRICK.



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§Connected with Grape Culture investigation.

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DWARF APPLES.

U. P. HEDRICK.

SUMMARY.

At the request of the horticultural societies of the State this Station undertook a comparative test of dwarf and standard apple trees. This bulletin is a final report of the test, which was carried on for ten years.

For the standard trees, French Crab stocks were used. For the dwarfs, Doucin and French Paradise stock.

Sites for the tests were selected with reference to climate and soil in three widely separated parts of the State as follows: Kinderhook, Columbia County, in the Hudson Valley; Fayetteville, Onondaga County, in central New York; and Carlton, Orleans County, on the shores of Lake Ontario, in western New York.

The general plan of the test was to grow a permanent orchard of standard trees with fillers on Doucin stock and between these trees on Paradise stock. The orchards were set with 27 varieties represented by 1193 trees; 114 were on French Crab, 424 on Doucin and 655 on Paradise stocks.

The care taken of the orchards was that commonly given commercial orchards in New York except in the matter of pruning. Summer pruning is part of the recognized yearly treatment of dwarf trees. In this ten years' test no satisfactory time nor method could be found to prune these trees which did not promote a weak, sickly growth. This invariably died back the next winter.

The results show:

1st.—That the union between stock and cion is poorer with Doucin and French Paradise stocks than with the French Crab and that varieties unite less well on French Paradise than on Doucin stocks.

2nd.—Doucin and French Paradise stocks are less hardy than French Crab, and of the two dwarfs French Paradise is much less hardy.

3rd.—The greatest weakness of the dwarfing stock for New York is the surface-rooting habit, in which character the two stocks cannot be distinguished. Evil results following surface-rooting are winter-killing, uprooting of trees by wind, suckering and injury in cultivation.

4th.—Suckers from both dwarfing stocks proved much more troublesome than with the standard trees.

5th.—The trees on the three stocks attain the size commonly ascribed to them; those on French Crab are full sized; on Doucin, half dwarf; on French Paradise, true dwarfs. In this test the dwarfing effect of the dwarf stock was not as marked as is commonly reputed. We conclude that distances apart commonly recommended for dwarf trees bring them much too close; in New York Doucins should be set half and the true dwarfs one-third as far apart as standard trees. If the cion is permitted to strike root, greater distances must be allowed.

6th.—Trees on French Paradise come in bearing soonest, Doucin next and French Crab last. The differences in time of bearing would not be very material in commercial orchards.

7th.—The test has not been such that a safe conclusion can be drawn as to which stock makes the most productive orchard.

8th.—There were no marked differences in size, color and quality of the apples on the three stocks.

9th.—The advantages of dwarf trees appeal to amateur rather than professional apple growers. Thus, the trees take less space and therefore permit a greater variety in orchard or garden and they are handsomer ornamentals.

INTRODUCTION.

Especial interest in dwarf apples at the New York Agricultural Experiment Station began in 1901, when the State Fruit Growers' Association, The Eastern New York Horticultural Society, and the Western New York Horticultural Society appointed committees to confer with the authorities at the Station for the purpose of locating experimental orchards of dwarf apples. At this time the country was in one of the periodic revivals of interest in dwarf fruits which have several times held sway in eastern America. Nurserymen, the horticultural press and a number of prominent fruit growers

were recommending the planting of dwarf trees. But there was a well-defined motive behind the movement which led the horticultural societies of New York and this Station to cooperate in the planting of dwarf apples.

San José scale had come into the State and was rapidly spreading. It was known that it could not be exterminated and it was feared that it could not be controlled. It was thought at that time that the scale could be best controlled by fumigating the trees under tents and it was believed that full grown standard trees could not be thoroughly sprayed. Since it was certain that dwarf trees could be easily fumigated and thoroughly sprayed, fruit growers asked for an experiment to determine whether dwarf apples could be grown profitably in commercial orchards. Had it not been for this apprehension of grievous disaster from San José scale, it is doubtful if the fruit growers would have called for the investigation, or the Station have voluntarily undertaken it.

While dwarf trees are by no means novelties in American fruit culture, yet there is a surprisingly large number of fruit growers who have misconceptions about them. What are dwarf trees? How is the dwarfing brought about? These questions must be answered before we can proceed to a rational discussion of the experiment in hand.

DWARF TREES.

Dwarf trees are plants which by various means are made to grow smaller than normal specimens of the same species or variety. In this instance the word "dwarf" does not carry with it an implication of unhealthiness or of weakened vitality. Animals and plants are so often dwarfed through disease or through lack of vitality that we associate the word with lack of health; but a dwarf tree may be as healthy and may have as much vitality as a normal tree, so that "diminutive trees," and "miniature trees," are rather more applicable than "dwarf trees".

Fruit trees are dwarfed in several ways; as, by growing on stocks which dwarf the top, by restricting the root-run and by pruning to check or suppress the top. Horticulturally speaking, particularly as the term is applied to fruit trees, in America at least, dwarf trees are those which are grown on dwarfing stocks. Here, it may be remarked that tree-like forms usually succeed very well on bushes

or smaller growing plants of the same species or, often, of closely related species. The cases are few, however, where varieties or species of small stature and port can be profitably grafted on plants of larger size. Unfortunately, there are no known relationships of plants which serve as accurate guides in the matter of grafting. The affinities of stocks and cions are determined only by trial, and so far there is a sad lack of systematically arranged experiments in this field of horticulture.

When dwarfing is produced by grafting on another stock, the tree takes on the size, and to some extent the habit, of the plant upon which it is grafted. Thus, the pear on quince takes the size of the quince tree; an apple on the bush-like Paradise, the size of this miniature apple tree; on the half-dwarf Doucin, an apple variety of normal size takes the form and habit of the Doucin. In none of these cases, as we have indicated before, is there a lessening of health or vigor.

Just how large-growing plants are dwarfed by grafting them on small-growing ones, is, as yet, not well determined. Undoubtedly, the lessened supply of food and moisture provided for the top of the tree by the smaller root-system of the dwarfing stock is one cause of dwarfing. This cause is suggested—indeed is almost established—by the fact that in a hungry or thirst-parched soil, dwarfed trees succumb much more quickly than those on roots of normal size for the plant. Probably another cause of dwarfing is the barrier which grafting imposes on the ascending and descending currents of plant food. True, such a barrier exists in all grafting, for a time at least, but in the case of the small or slow-growing stock the barrier is greater and more permanent. Assimilated food is prevented by this barrier from descending from the cion into the stock. This is shown by the enormous swellings just above the graft-union in many dwarf trees. The upper figure in Plate IV shows such a swelling in the case of a normal-growing variety of the apple grafted on Doucin, a dwarfing stock.

From what has been said one sees at once that in an experiment with dwarf fruit trees we are to be greatly concerned with dwarfing stocks. If space could be spared it would be profitable to discuss the whole subject of stocks as well as the closely related one of the reciprocal influence of stock and cion, but a full discussion of either subject would go to the length of a volume—as interesting as long. We cannot here attempt more than to discuss stocks for apples.

STOCKS FOR APPLES.

Nurserymen in Europe and America list and describe at least a dozen and perhaps a score of stocks upon which apples are worked. The more one studies the descriptions of these forms the more sceptical he becomes, however, of the distinctness of several of them and the more certain he is that with present knowledge we are all at sea as to what stocks we really have upon which to work apples. Until we have somewhere a careful test, side by side, of all apple stocks, an experiment best carried on in the Old World, we can only roughly throw apple stocks into two groups, standard and dwarfing stocks, in each of which are several more or less distinct forms.

Standard stocks.—What we in America call standard stocks, in England more commonly called free stocks, known also in both countries as Crab and French Crab stocks, are seedlings of the common apple, *Pyrus malus*. There is a mistaken notion in America that these stocks come from seeds of *Pyrus baccata*, or hybrids of it, which constitute our crab apples. It is doubtful if true crab seeds are often, if ever, planted for standard stocks. In Europe, crab stocks are those which come from wild apples, or trees which are escapes from cultivation; while stocks grown from the seeds of cultivated apples are called Free stocks. In America we make no such distinction. In fact until recent years all, or nearly all, standard stocks for this country were imported from France and Belgium under the name "French Crab" with the implication, too often given credence by nurserymen, that they were seedlings of true crabs.

There are, then, at least two kinds of standard stocks; those grown from seeds of wild apples and seedlings of cultivated varieties. Were choice possible, there should be no hesitation on the part of fruit growers to take seedlings from wild trees. It is difficult, however, to obtain seeds from wild trees and most of the apple stocks now used by nurserymen come from seeds taken from cider mills. Since all cultivated varieties of apples and crabs may go to the cider mill, the resulting seedlings cannot fail to be variable, giving good, bad and indifferent stocks. It is not strange that wide variations are to be found in individual trees of every variety of the apple, due, as we think, to stock and soil and not, except in rare cases, to inherent variation in varieties. We cannot leave

this subject without expressing the opinion that one of the things most to be desired in apple growing is a vigorous standard stock of constant habit. Such a stock will probably have to be propagated from cuttings or layers.

The ancients, unquestionably, and fruit growers down through the Middle Ages, if they grafted at all, used standard stocks, taking such seedlings as circumstances placed at their disposal. Probably until comparatively recent times, a very great majority of fruiting apple trees were on their own roots — themselves seedlings. However, a study of Varo, Cato, Columella, Vergil and Pliny, sturdy Roman farmers and writers of and before the Christian era, shows that the art of grafting was well known to them and was practiced in growing apples as well as other fruits. Apple seeds were probably planted for stocks, then, two thousand and more years ago, though the nursery practices may not have been the same.

In America the general use of apple stocks did not begin until the Nineteenth Century. Colonists from the Old World brought apple seeds and not trees. Varieties of new fruits seem scarcely to be mentioned until after Revolutionary times. As settlements spread westward, apple seeds were planted though, if, when the seedlings reached fruiting age, the product was not desirable, the trees were grafted to sorts of better character. One or two nurseries existed before the Revolutionary war, but seedling apple trees to be kept for their own fruit or to be grafted over were the rule until well into the Nineteenth Century.

Dwarfing stocks.— Apples are dwarfed by grafting or budding them on small-growing forms of the cultivated species of this fruit. What are these species? Scarcely any two botanists who have studied the apple agree. Possibly the best authority we now have is C. K. Schneider, a German. He separates apples from pears, as do many modern botanists, putting them in the genus *Malus*.¹ In this genus Schneider puts three species, *Malus sylvestris* Miller, *M. pumila* Miller and *M. baccata* Borkhausen, which contribute to our edible apple flora. The last named, distinguished chiefly by its small fruits and caducous calyx, counts only in what we in America know as Crab apples. To the two former and their hybrids belong large-fruited, edible apples. Of the two species, *Malus pumila*, the *Pyrus malus* of Linnaeus, is far the more important in

¹ Schneider, C. K. Handbuch der Laubholzkunde 1:714-725. 1906.

fruit growing. According to Schneider, the various species in which botanists have put the several dwarfing stocks are all identical with *Malus pumila*. Accepting this authority, then, we must look upon dwarfing stocks as diminutive forms of the species from which come most of our cultivated apples.

This Station is in a region of many nurseries, many of them long-established. The writer, therefore, has exceptional opportunities to observe the seedlings used in nursery work. Not infrequently apple seedlings are not budded, or buds fail. Watching these hedge-rows of seedling apples, or much more often, a seedling tree, one finds that the variation in the size of the plants coming from miscellaneous seeds is considerable. Unquestionably, careful selection of the dwarfest forms of these seedling trees would give us dwarfing stocks similar to those now in common use. Unquestionably, too, the dwarf, or unproductive, or scraggly-growing trees of this or that variety to be found in many orchards owe these qualities to the stock and not the cion.

Though dwarfing stocks have been used for centuries, as we shall see, no one, botanist or horticulturist, has put well-made descriptions of them on record. About the year 1875 a collection of stocks for apples was grown, in a comparative test, at Chiswick, England. Eighteen supposedly distinct sorts, obtained from reliable sources, were compared. Several were found to be identical so that the number was reduced from eighteen to eight as follows: French Paradise, English Paradise, English Nonesuch, English Broad-leaved Paradise, Doucin, Dutch Paradise, Pommier Franc, and Crab. The last two are free-growing, or standard, stocks so that we are now concerned with but the first six. From European books we have compiled the following brief notes on these six stocks since they are the ones most commonly used in the Old World in dwarfing apples and include the stocks with which we are to be concerned in discussing the work of this experiment.

French Paradise.—This, the Pommier de Paradis of the French, is probably the dwarfest of the several stocks and has the reputation, ungrafted, of being the most precocious in bearing as it is also in season of blooming and fruiting. Grown to maturity, this apple is described as being very dwarf, compact in habit, productive and bearing very good, early autumn, dessert apples, golden-yellow in color with a reddish blush, and of a brisk, agreeable, acid flavor.

Independent of its value as a dwarfing stock it is said to be a useful orchard or garden plant. The derivation of the name is obvious—the forbidden fruit of which Adam and Eve ate.

European writers maintain that French Paradise is too tender and delicate to be used generally in orchard work and that its place is indoors in pots or for special situations in the garden as trained plants. [The root system of this stock is small, fibrous, very close to the surface and takes hold of the soil so slightly that trees several years of age can easily be pulled by hand from the ground. The stocks may be propagated from cuttings but are more commonly grown from mound layers. In some quarters trees on this stock have the reputation of being short-lived and of producing fruits that run small as the trees come to full maturity. Undoubtedly there are several strains of French Paradise of which the best known are the Pigmy and Miniature stocks of Rivers. Some believe that French Paradise is the Dwarf Apple of Armenia.

Probably French Paradise is the oldest of dwarfing stocks for the apple. According to Koch, *Die Deutschen Obstgehölze*, 1876, French Paradise was known in France at the beginning of the Fifteenth Century at which time an account of it appeared in *De Natura Stirpium* by Jean de Ruelle. This stock was not in use in America until about the middle of the Nineteenth Century, when a plantation of dwarf trees was made by Ellwanger & Barry of Rochester, New York.

English Paradise.—This stock is often confused with the French Paradise from which it differs widely, being more vigorous, not so dwarf, and in having more woody and fewer fibrous roots. It is said to thrive on comparatively poor soils, whereas French Paradise must have a fairly fertile root-run. I can find no record of the origin of this stock. There is much to lead one to think that it is either a strain of, or is identical with, Doucin. As grown on the grounds of this Station it appears to be identical. It is not much used in America as a dwarfing stock.

English Broad-leaved Paradise.—This half-dwarf stock is hardly to be distinguished from the older and better-known Doucin but has a distinct origin having been raised from seed of the Nonesuch apple by Thomas Rivers, the noted English nurseryman, about 1820. It is a more vigorous stock than the English Nonesuch raised at the same time and from similar seed by Mr. Rivers. Occasionally one hears

of this stock in America but here, as elsewhere, it seems to have been more or less confused with Doucin.

English Nonesuch.—This is a vigorous dwarf or half-dwarf stock raised by Thomas Rivers of Sawbridgeworth, England, from seed of the Nonesuch apple planted in 1820. It is the dwarfest of the English dwarfing stocks commonly used. According to Mr. Rivers it is "as dwarf but more hardy and vigorous than the French Paradise; it produces tufts of fibrous roots from every bud below ground, and it appears to be quite indifferent as to whether it will produce leaves or roots." This apple tree is peculiar, besides its dwarfness, in having very downy leaves and a much-knotted stem. It is said to stand transplanting particularly well. The differences between these dwarf seedlings of Nonesuch and the parent tree suggest that any surface-rooting seedling is more or less dwarf, a fact borne out by the observations of many. There are no records of the use of this stock in America.

Doucin.—The Doucin is a French stock which roots and grows much more freely than the French Paradise, the root-system differing greatly in having many more woody roots which strike downward to a greater depth. Many growers claim that there is little or no difference between this and the strong-growing Broad-leaved English Paradise—at least as nurserymen sell the two. Some say that Doucin can be distinguished from the Broad-leaved by a tap-root which the latter lacks. When permitted to bear fruit, the apples of Doucin are a greenish-yellow with a decided blush and are sweet—the flavor giving the name from the French "douceur"—sweetness.

It is hard to say how long the Doucin stock has been used, but at least it was well known in France and England in the middle of the Eighteenth Century for Duhamel du Monceau mentions it in his *Traité des Arbres Fruitières*, 1768; as does Philip Miller in his *Gardener's Dictionary*, 1759. This is the chief dwarfing stock used in America, at least in name, for here all half-dwarfing stocks, as English Paradise and Broad-leaved Paradise, go as Doucin.

Dutch Paradise.—This is a clean, moderately vigorous stock somewhat intermediate between the dwarf French Paradise and the half-dwarf English stocks. It has the reputation of sending out suckers very freely—suckering so freely as often to be a nuisance in a garden. The plant, ungrafted, is low and scraggly, its habit having given it the name "Dutch Creeper." This is one of the

old dwarfing stocks, Miller mentioning it in his *Gardener's Dictionary* in 1759 as follows: "There is another apple which is called the Dutch Paradise Apple, much cultivated in the nurseries for grafting Apples upon, in order to have them dwarfs; and these will not decay or canker as the other, nor do they stint the grafts near so much, so are generally preferred for planting Espaliers or Dwarfs, being easily kept within the Compass usually allotted to these trees." It seems never to have been introduced into America.

The origin of dwarfing stocks.—These few notes on stocks may give some fruit growers a better conception of what the several apple stocks are — their origin, introduction and uses. In particular, it is important to have in mind that they are but surface-rooting, dwarf plants of the common apple. We must get away from the notion that they come from distinct species. No doubt there are many true dwarf apples among the wild trees that are found wherever the apple has been cultivated long. No doubt, too, many of the small trees in standard orchards are on accidental dwarfing stocks. It is possible that the common apple is a hybrid, in some of its varieties at least, between a standard tree and a dwarf apple and that these miniature plants that occasionally appear are dwarf segregations. The fact that these surface-rooting dwarfs are easily propagated from cuttings and layers while standards are not, further indicates the distinctness of these strains even though they may occasionally come from the seeds of some variety normal in size of plant and manner of rooting. This brings us to a discussion of the propagation of dwarfing stocks.

Propagation of dwarfing stocks.—Some of the dwarfing stocks sucker so freely, as the Dutch Paradise, that the readiest means of propagation is to detach the sucker and use it as a stock. Some dwarfing stocks are propagated from root-cuttings. But, unquestionably, the chief method of propagation is by mound-layering. Well-established plants are made to stool by cutting them off a few inches from the ground. When these stools have made sufficient growth, usually in the summer of the second season, their bases are buried in a mound and by fall a rooted plant will have formed. These, if sufficiently vigorous, may be grafted the following winter or budded the next summer. The small stocks in a stool are grown in the nursery row for an additional year.

Occasion is taken to say that it would be a great boon to apple

culture if standard trees could be propagated in some such manner and thus avoid the great variation in plants which we must always have in stocks grown from seed.

DISCUSSION OF THE EXPERIMENTS.

SITES AND SOILS.

Three sites were chosen for experiments: One at Kinderhook, Columbia County, in the Hudson Valley, on the farm of Edward Van Alstyne; another at Fayetteville, Onondaga County, on the farm of F. E. Dawley, and the third at Carlton, Orleans County, on the farm of Albert Wood & Son. The distribution of orchards in eastern, central and western New York gives quite distinct climatic and soil conditions for the three orchards. Topography and soil must now be described somewhat in detail.

The Van Alstyne orchard.—The village of Kinderhook, near which this orchard is located, is in the northeastern part of Columbia County, two or three miles east of the Hudson River. The orchard is about a mile south and east of the village on a level plateau about 100 feet above the Hudson which at this place is but a few feet higher than sea level. The land is sufficiently high and rolling to give good air drainage.

The soil is a sandy loam, rather deep, with a porous subsoil of the same sandy loam, considerably heavier but of such physical make up as to give very good natural drainage. A chemical analysis of this type of soil from an adjoining field shows it to be deficient in organic matter, nitrogen and lime, but amply supplied, for fruit crops, at least, with phosphorus and potassium. The land, though of but moderate productiveness for farm crops, is well adapted for apple culture, a fact at once patent to the passerby from the behavior of several neighboring orchards in approximately the same soil. Orchardng is the leading industry in the neighborhood.

The climate is ideal for the apple, falling short, if at all, only in the rainfall which is not always sufficient to supply the moisture needed by this fruit in the growing season in a soil not especially well adapted for the conservation of moisture. The apple, here, seldom or never suffers from winter temperatures; but peach wood is often killed back and the pear is occasionally injured by cold.

The Dawley orchard.—Fayetteville, the seat of the Dawley orchard, is east and a little south of Syracuse in the eastern part of

Onondaga County. The Dawley farm is rolling land on one of the high, level parts of which the dwarf orchard is planted, the lay of the land being such that the air drainage is very good as is, also, the water drainage in the somewhat open, stony land.

The land is a stony loam of the type designated by the United States Department of Agriculture as Miami stony loam. It is a brownish soil with some silt and some sand with an average depth of about 12 inches. The percentage of stone and gravel is large — possibly from 20 to 30 per ct. The subsoil, from one to three feet in thickness, is a clay loam or clay, more or less stony, and rests on limestone or shale. The soil is well supplied with phosphorus, potassium and lime but is somewhat lacking in organic matter. It is well adapted to the culture of general farm crops, alfalfa in particular, and apple trees thrive in it very well.

The winters in this region are cold, too cold for successful peach culture, and occasionally apples are injured. Of more importance is the rainfall which in this region is rather greater and somewhat better distributed throughout the growing season than in either of the other two orchards. Possibly, too, moisture is conserved better in the soil of this orchard than in the other two. At any rate, during the ten years the Station has maintained its experimental plantations, this orchard has suffered least from drouth.

The Wood orchard.—The Wood orchard is between two and three miles from the southern shore of Lake Ontario near the village of Carlton in the north-central part of Orleans County. The Wood farm is on one of the level plains a half-hundred or more feet above Lake Ontario and between three and four hundred feet above sea level. The farm, though level, the orchard land almost dead level, is naturally well drained and winds from the lake keep the air sufficiently on the move to give good air drainage.

The soil is widely different from that of the other two orchards under test. It belongs to the Dunkirk series and is a sandy, silty loam, dark brown or grayish in color and a foot deep, underlain with a yellowish, heavy silt loam from two to three feet deep, under which, in its turn, is a very heavy silt loam. This land, as in the case of the other two orchards, is deficient in organic matter but well supplied with potassium and phosphorus. Grain crops usually respond to lime though leguminous cover-crops grow very well in the dwarf orchard without liming. This soil is especially well adapted

for apples, the neighborhood, and more particularly the Wood farm, being unsurpassed in the State for crops of apples.

The climate of this region permits the culture of all hardy fruits. The water of Lake Ontario, from 10 to 15 degrees warmer in winter and cooler in summer than the air, gives a most equable climate. The mean annual precipitation is about 35 inches of which 9 inches falls during the growing months of June, July and August—too little unless high cultivation is practiced to conserve the moisture.

PLAN OF THE TESTS.

These tests were planned in 1902 by Professor S. A. Beach, then of this Station. The Wood orchard was set in the autumn of 1903, the Dawley and Van Alstyne orchards in the autumn of 1904. The following year, 1905, the present writer took charge of the horticultural work at the Geneva Station. This test, planned by Beach, has, therefore, been carried on for nine of the ten years of the life of the experiment by the author of this bulletin.

Briefly stated, the general plan of the three experiments was to grow a permanent orchard of standard trees with fillers of varieties on Doucin stock and between these fillers on Paradise stock. The distance between trees in the Wood orchard is fifteen feet; in the other two, twelve feet.

The Van Alstyne orchard was planted to 306 trees on the three stocks as follows: Standard trees, 27; on Doucin stock, 153 trees; on Paradise, 126. These were distributed among the following varieties: Baldwin, Boiken, Holland Pippin, Hubbardston, Jonathan, Lady, McIntosh, R. I. Greening, Rome, Sutton, Wealthy and Wagener.

The Dawley orchard was planted with 512 trees, the number on each stock being: Standard, 42; Doucin, 161; Paradise, 309. The following are the varieties: Alexander, Baldwin, Boiken, Esopus, Gravenstein, Green Sweet, Grimes, Hubbardston, Jacob Sweet, Jonathan, Longfield, McIntosh, Monmouth, Northern Spy, Pumpkin Sweet, R. I. Greening, Rome, Sutton, Wagener, Wealthy, Wolf River, Yellow Transparent.

In the Wood orchard there were originally 375 trees: 45 on standard, 110 on Doucin and 220 on Paradise stocks, distributed among the varieties Alexander, Baldwin, Ben Davis, Boiken, Gravenstein, Holland Winter, Jonathan, Lady, McIntosh, Monmouth, R. I. Greening, Rome, Sutton, Bismark, Twenty Ounce and Wealthy.

The stocks, with a very few exceptions, were purchased from Louis Leroy, Angers, France, and were French Crab for the standards, Doucin and French Paradise for the dwarfs. Later, to fill vacancies, a few trees worked on Doucin and English Paradise were used from a purchase of these stocks made from Wm. Fell, Hexham, England. The trees were budded on the Station grounds and were set, in the case of the Wood orchard, at one year from the bud and in the other two orchards, two years from the bud. A few trees were purchased from local nurseries to fill vacancies, but these have all been discarded in studying the results.

CARE OF THE ORCHARDS.

The three orchards received the care commonly given commercial orchards in New York except in particulars to be mentioned.

Cultivation.—The trees were usually given clean cultivation until August first, or thereabouts, and then a cover-crop was put in to turn under in fall or spring as the case demanded. For most part leguminous cover crops were sown, but the condition of the trees in several instances indicated a non-leguminous crop and in one or two seasons the crop failed to catch or could not be planted. The trees were sprayed for the several pests common to the apple as required. Full details of care in cultivation and spraying need not be discussed.

Cion-roots and suckers.—Beginning with the first year it was found necessary to go over the orchards each spring and cut such roots as sprung from the cion and such suckers as came from the stocks. This was no small task, the first operation requiring that more or less earth be removed and replaced. It may be said that the trees should not have been set so deep as to make this necessary. Shallow planting was tried in the Dawley and Van Alstyne orchards but with disastrous results with the surface-rooting Doucin and Paradise trees, many of which were blown over with even moderate winds; others suffered from sun, plow and cultivation. It was found necessary to hill up these shallow-rooted trees by plowing toward the rows.

Pruning.—We may as well confess that the pruning of these trees has been most unsatisfactory. A bad start was made, as the trees, for most part, were cut to whips at transplanting time. (See Plate I.) No doubt, in the light of later experience, it would have

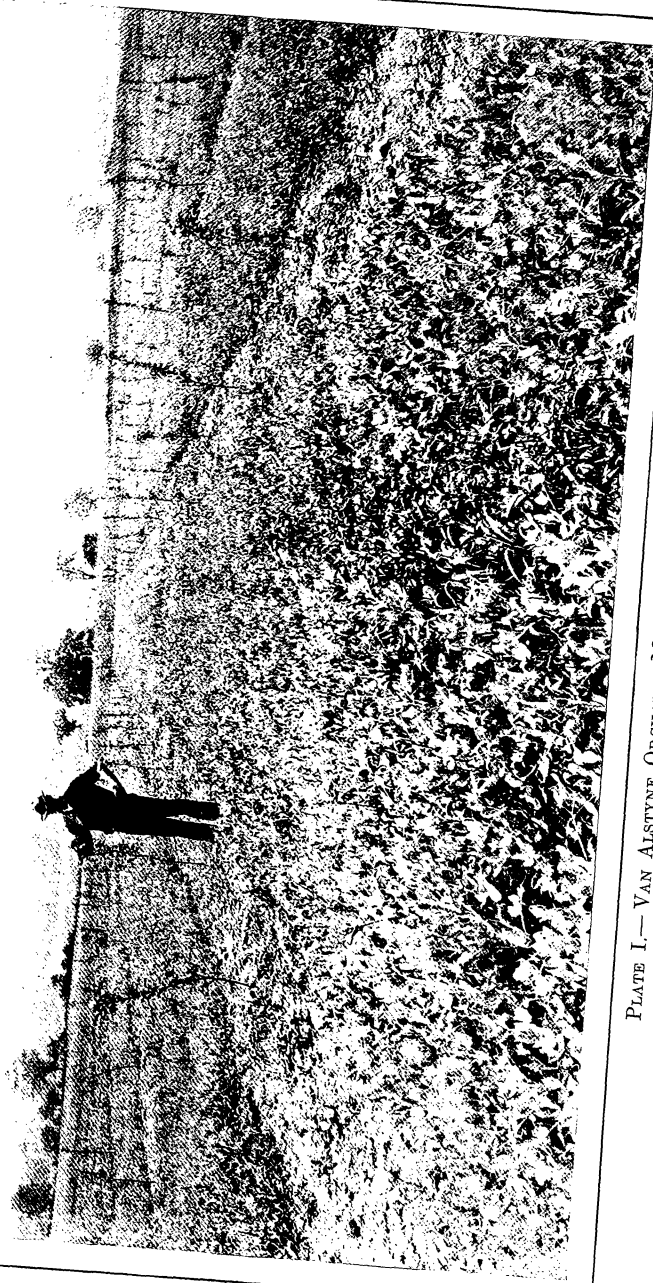


PLATE I.—VAN ALSTYNE ORCHARD: MANNER OF PRUNING AT TRANSPLANTING.

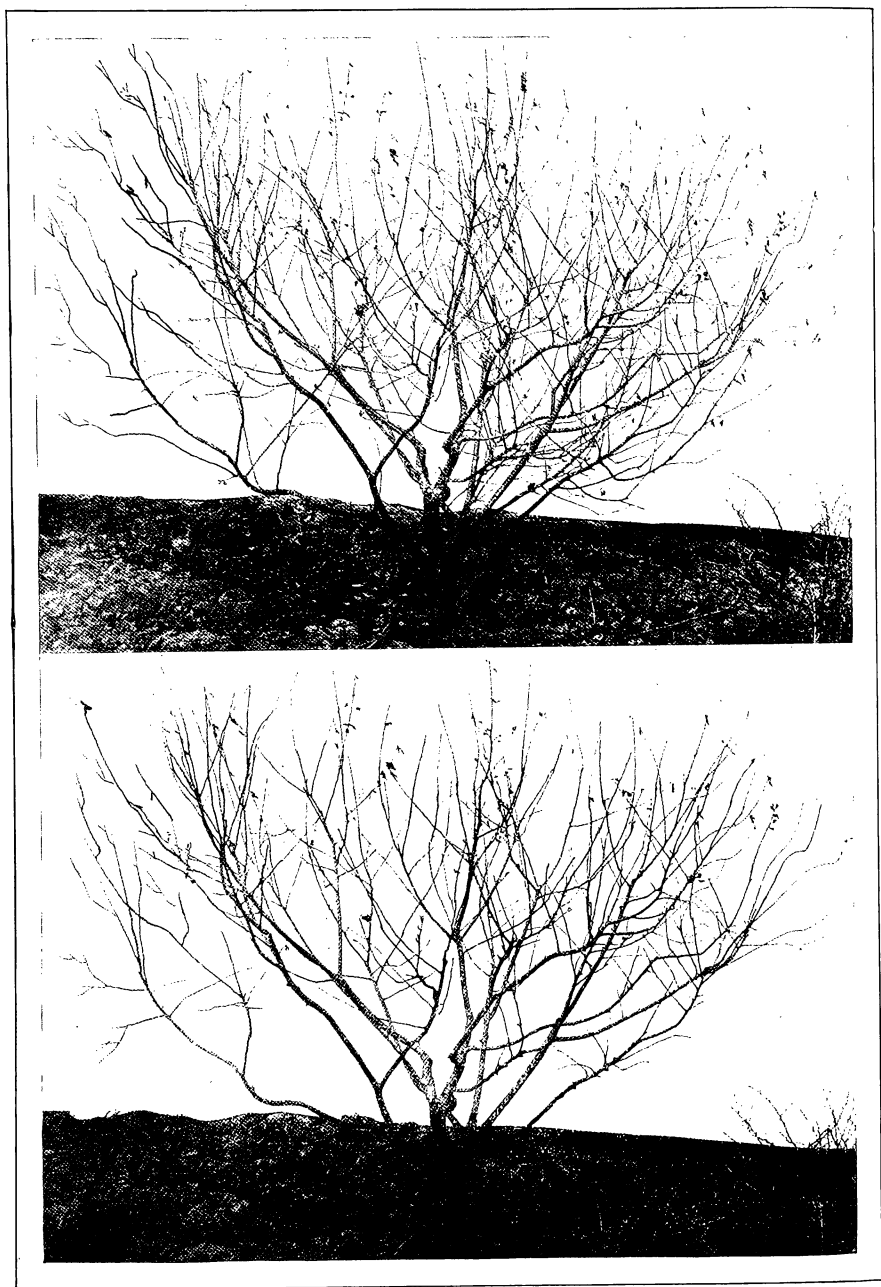


PLATE II.—TREE ON DOUCIN STOCK BEFORE AND AFTER PRUNING.

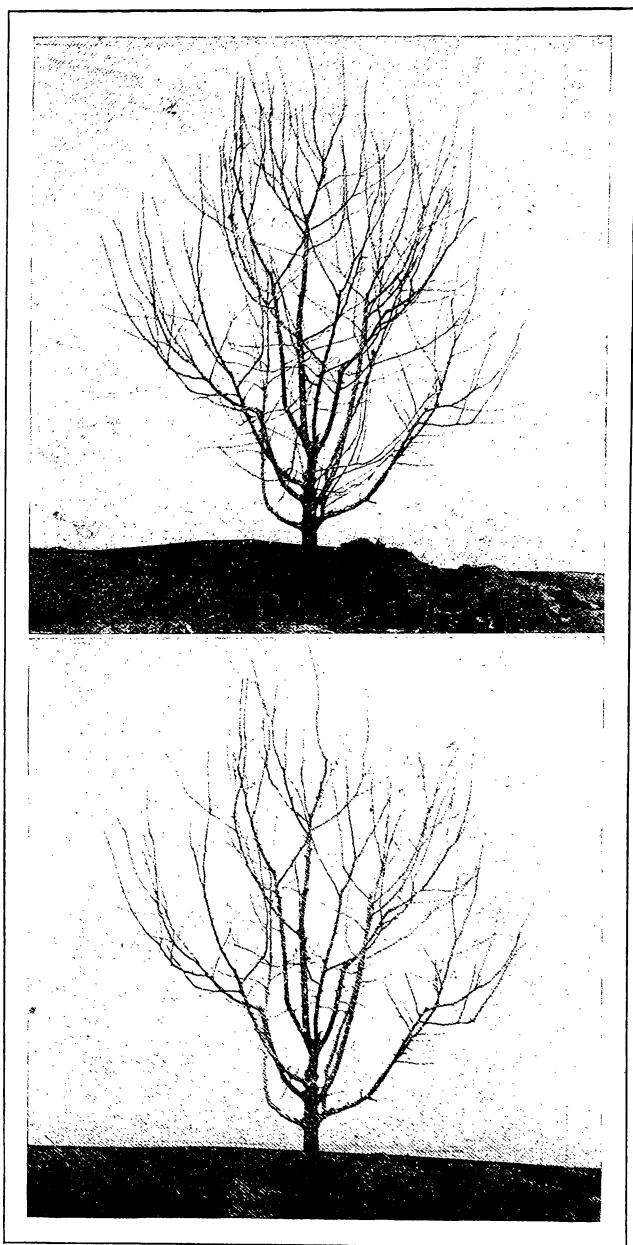


PLATE III.—TREE ON PARADISE STOCK BEFORE AND AFTER PRUNING.



IV.—DEFECTS OF TREES ON DOUCIN STOCK; UPPER, PROTUBERANCE ABOVE UNION; LOWER, SUCKERING HABIT.

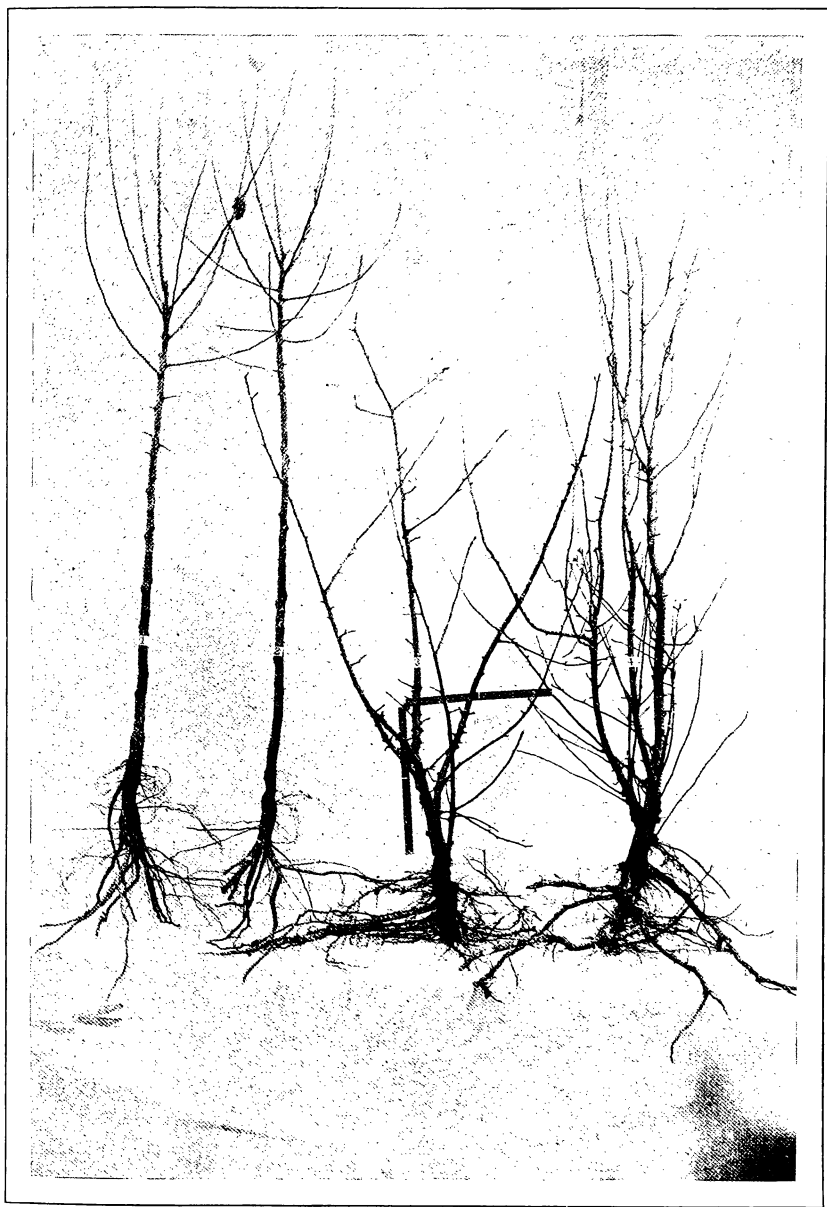


PLATE V.—ROOT SYSTEMS OF APPLE TREES: LEFT, BUDDED STANDARD; SECOND, GRAFTED STANDARD; THIRD, PARADISE; RIGHT, DOUCIN.

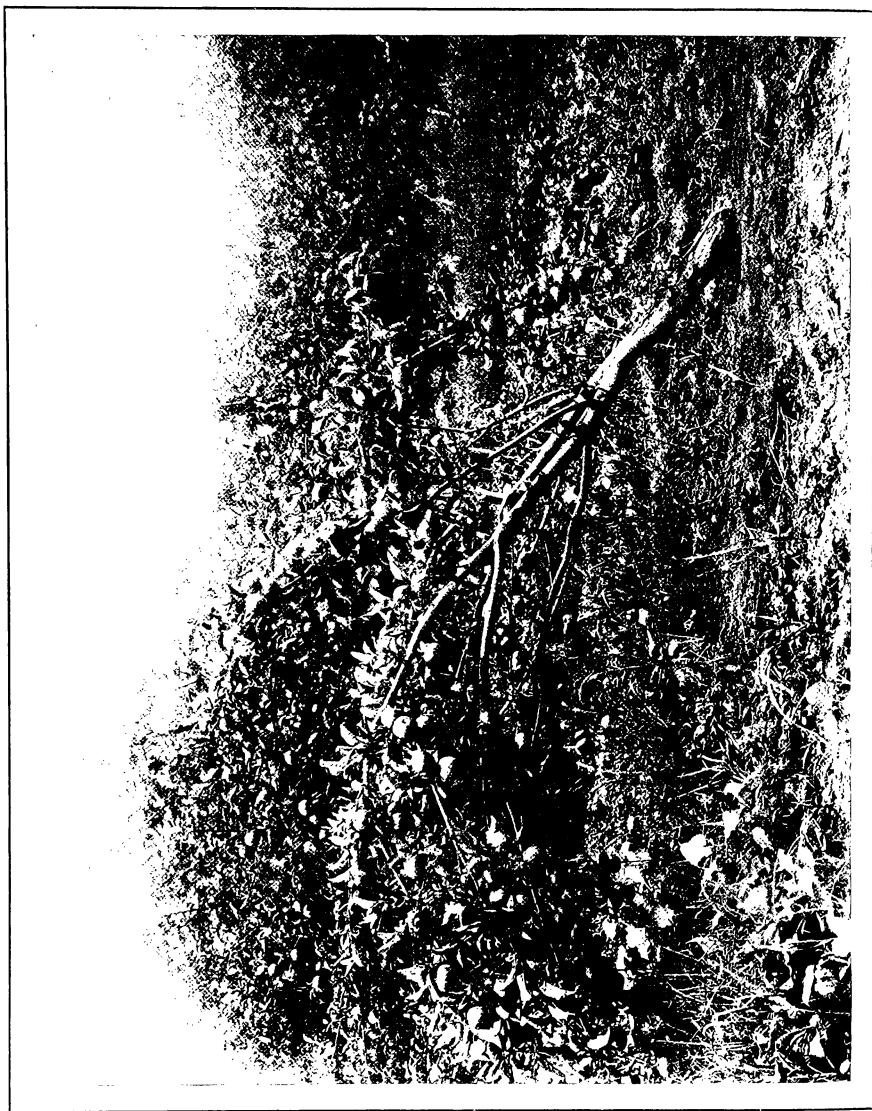


PLATE VI.-- WAGENER APPLE TREES ON PARADISE STOCK BLOWN OVER, TEN YEARS FROM SETTING.

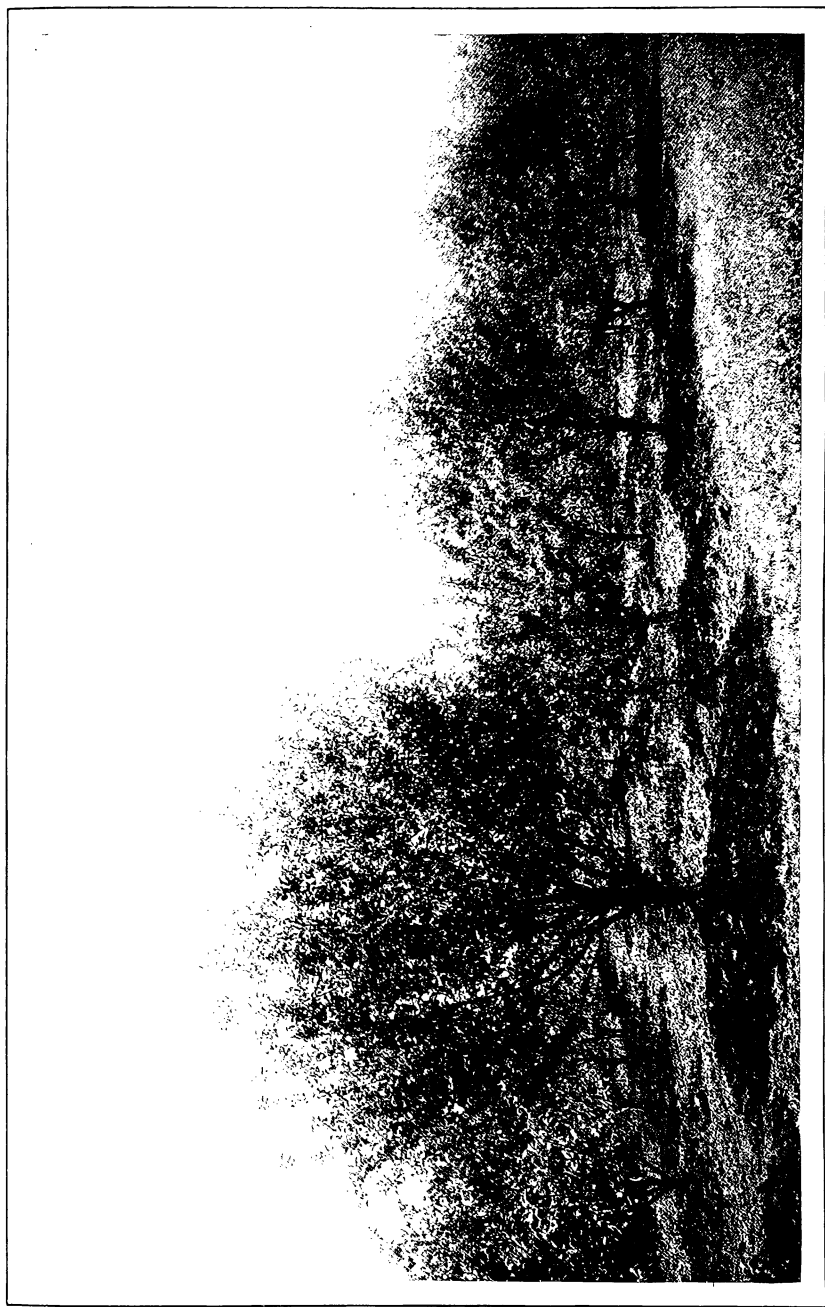


PLATE VII.—WOOD ORCHARD: TREES ON FRENCH CRAB, DOUCIN AND PARADISE STOCKS.

been better to grow the trees in nursery rows a year longer and then make the start toward forming the heads. The trouble in cutting to a whip at transplanting time is that branches fail to break forth as abundantly as they do in the nursery row unchecked by transplanting.

Summer pruning, supplementing winter pruning, is part of the recognized yearly treatment of dwarf trees. The more it is desired to restrict the growth, the greater the need of summer pruning and the greater the amount necessary. There is, however, much divergence of opinion as to methods in summer pruning. Scarcely any two authorities on growing dwarf trees agree as to the amount of wood to be taken out or the proper time to do the work. Some growers use the knife and shears, while others say that pinching back with finger and thumb suffices. All agree that the practice must be largely regulated by season, soil, health of tree, age of tree and the variety. The difficulties in the way of laying down rules that would be fair in this comparative test of twenty-six varieties of apples on three stocks, three quite distinct soils and in three somewhat different climates, are patent to any one who has tried to prune in the summer.

The winter pruning of the trees, though more difficult than in training standard trees, gave comparatively little trouble. It consisted of cutting out crossed branches, surplus branches and, of course, such few as were injured or diseased. It was necessary to head back the wood on the Paradise and Doucin trees more severely, depending upon the variety, than the standards, otherwise the pruning was much the same on all. (Plates II and III show the method of pruning in the winter.)

For the first two seasons but little summer pruning was attempted, the trees being small and none too vigorous. Then began a series of experiments, no one of which proved satisfactory, the details of which belong to a separate bulletin. Suffice to say, in the light of ten seasons' work with dwarf apples, the training of the plants is the most difficult and the least satisfactory operation in growing these trees. Indeed, it is hardly too much to say that if dwarf apples must be headed back or pinched in during the growing season, it is impossible to grow them in the trying climate of New York. In no one of the attempts at summer pruning have we been able wholly to avoid weak, spindling second growths which would not mature

and succumbed to the cold of the next winter. When it was thought that reasonable success in time and manner of summer pruning had been attained one season, sooner or later identical treatment proved a failure because of some decided difference in weather when the work was repeated. We have been forced to conclude that the great variations in temperature and moisture in the summer and the cold winters in New York almost or quite debar the summer pruning here that is practiced in the Old World.

Mishaps.—The three orchards have had the usual mishaps, expected and unexpected, common to apple culture. A few trees did not start growth, several were girdled by mice, a loose colt destroyed one, sheep injured several, apple-blight took its toll and a few sickly, unhappy specimens for no apparent reason refused to thrive and were pulled out. Yet out of the total of 1118 trees the percentage of loss was comparatively small from the causes mentioned, but from three other sources of trouble the number of missing or replaced trees at the end of the experiment was large, quite too great for profitable orcharding. A surprisingly large number of trees were winter-killed; many failed to make a good union, with death or failure as a result; and the surface rooting habit of the dwarf trees caused an unexpected number of deaths and failures. These three troubles must later be discussed in detail.

MEASURING THE RESULTS.

It would seem that the efforts expended and the money spent in this ten-year test of dwarf and standard apples should give decisive results. But the conclusions that can be drawn are far from final. In the first place we have not learned in the test, long as it was, how best to care for dwarfs, especially in the matter of summer pruning and in preventing the disastrous surface rooting. Then, again, we are not able comprehensively to compare yields from the three stocks; and crops of fruit are, of course, the ultimate criteria. Trees one year old at setting and ten years set are not bearing sufficiently well to gauge productiveness, especially when it is remembered that varieties on the three stocks begin bearing at different ages. The many mishaps, too, especially the winter-killing the first two years, help to prevent decisive results.

The men who own the trees, those who have carried on the test and the many apple growers in the State who have annually or

occasionally visited the orchards, all agree that dwarf apples should not be planted in commercial plantations. This conclusion is forced by the behavior of trees in general rather than by specific things that can be set down in a bulletin in exact statements and tables of figures. From the nature of this test with its many factors and present incompleteness, reliance will have to be placed upon statements of opinions.

The union of stocks and cions.—The value of a stock is greatly reduced if the union between the consorting parts of the tree is poor. There is no question but that varieties unite unequally well with different stocks. The point is well worth establishing as to which varieties make the best unions with the three distinct stocks used in this test; but, unfortunately, the data are not conclusive enough to make a critical analysis. There were not enough cases in which one could unhesitatingly say that death or failure was wholly due to a poor union.

The following figures, however, show conclusively with which stock apples, irrespective of variety, unite best: thirty-one trees on Paradise are reported to have broken off at the union during the ten years' test; four on Doucin; none on French Crab. There were, too, a considerable number of trees in which there were enlargements above the union as shown in the upper half of Plate IV. These, however, seem to affect the vigor of the tree little or not at all. There were no enlargements on standard trees in this test though they may occasionally be seen in orchards of standards. The number of these deformities on the two dwarfing stocks seems to be about the same though it is impossible to give the exact number since one can hardly say when an enlargement at the union becomes abnormal. These figures seem to indicate that the union between stock and cion is poorest on the Paradise, next so on Doucin and best on the standard.

Winter-injury.—It is impossible to discuss hardiness of the three stocks comprehensively in this Bulletin. To do so would carry us far afield since the three orchards have quite different climatic conditions and there are twenty-seven varieties of unequal hardiness. The following figures, grouped for the three orchards and roughly given, seem sufficiently accurate to indicate the relative hardiness of the three stocks.

Of the 600 trees on French Paradise, 57, or 9.5 per ct., are marked

as having died of winter-injury; of the 404 Doucins, 18, or 4.45 per ct., were winter-killed; on the French Crab but 3, or 2.75 per ct. succumbed to cold. Of course one can seldom be quite certain as to what causes the death of trees but in these orchards when there was reasonable doubt the cause of death was put down as "unknown." The figures given, are, in the judgment of the writer, much strengthened by the facts that the numbers of dead trees from causes "unknown" run in about the same proportion for the three stocks and that some of the dead trees had suffered from previous winter-injury.

That the dwarfing stocks are less hardy than the French Crab occasions little surprise when one remembers that their roots are much nearer the surface of the ground. The French Paradise is reported everywhere in Europe to be tender to cold and it is to be expected that it would be less hardy in the trying climate of New York than either of the other two stocks. Most of the deaths from winter-injury occurred in the Dawley and Van Alstyne orchards, where, it will be recalled from the descriptions given, the cold is more severe than in the Wood plantation.

Undoubtedly the injury from winter-killing was more severe the first and second seasons because of the trees having been planted in the autumn. From the experience with fall planting in these three orchards, it may be laid down as a rule that dwarf trees should not be planted in the autumn in a climate as cold as that of New York.

Surface-rooting.—Without any question the greatest weakness of dwarfing stocks for New York orchard conditions is the surface-rooting habit of both Doucin and Paradise. In this respect the two stocks cannot be distinguished — the roots of one are as near the surface as those of the other. Plate V shows the rooting habit of the three stocks. Several evils follow surface-rooting. We have seen in a previous paragraph that the dwarf trees suffered most from winter-injury — no doubt in part because of the nearness of the roots to the surface. In respect to yield of fruit and size of tree, the results in this experiment are almost worthless because of another trouble which comes from the roots being too close to the surface of the ground.

About ten per ct. of the dwarf trees in the three orchards, sooner or later, either blew over or their roots were so exposed that the trees had to be reset or replaced. Plate VI shows a tree on Paradise

blown over the last year of the experiment. Such trees are out of the experiment so far as tree-growth and yield of fruit are concerned. Undoubtedly, too, some of the trees that refused to thrive did so because of the exposed condition of their roots. In a damper climate, in sod or under a mulch system, surface rooting might not prove so disastrous. This experiment all but demonstrates that dwarf apples can not be successfully grown under the high cultivation methods of New York. It may be asked why the trees were not set deeper. The answer is that if the trees be set sufficiently deep so that the cion touches ground it strikes root and the tree ceases to be a true dwarf. Many trees that pass for dwarfs are not dwarfs at all. They were set on dwarf stocks but the cion has taken root and the tree has become a standard, or, more correctly, half standard and half dwarf.

The several dwarfing stocks are surface-rooting plants, according to all accounts, but it is probable that this fault is accentuated by the manner of propagation. Plants grown from cuttings and layers usually fail to produce the tap-roots and the deep-growing root systems that most seedlings have. This is a matter that would need consideration in any attempt to grow standard stocks from cuttings — a method with many advantages in eliminating variability from orchard trees.

No doubt, too, much of the suckering of the dwarfs which so vexed the souls of the experimenters came from root wounds made by the plow or cultivator. This brings us to the matter of suckering.

Suckering.—Suckers from both of the dwarfing stocks proved more or less troublesome. It would be hard to say whether Doucin or Paradise suckered most, but the weight of evidence seems to be against the Doucin. Both stocks are readily propagated from layers and stolons, either roots or stems striking root freely. It would, then, be expected that suckers would appear more freely than on standard stocks which come from seed and can be grown vegetatively only with difficulty. Presumably, however, there would have been far fewer suckers to contend with in these orchards under a sod or a mulch system of cultivation, for certainly the unavoidable injury to the shallow roots of the dwarf trees by plow and cultivator would stimulate the formation of suckers. The lower half of Plate IV shows the suckering habit of the Doucin stock.

The size of the trees.—What is the comparative size of varieties on the three stocks? It would seem that by giving figures of height and spread of tree and diameter of trunk the question could be easily and accurately answered. Not so; such figures are distinctly misleading. Could the reader see the trees, eye-sight would be much better than figures to show the size of tree. The eye sees a distinct difference in varieties on the three stocks which figures do not show, for the reason that the difference is in habit of growth quite as much or more than in size. Thus, the Paradise trees are dwarf because of a very short trunk, the diameter of which is often nearly that of a Doucin or Standard; the shoots of Paradise spring up to an amazing height from a dwarf frame-work so that figures make the trees seem unduly high. So, too, the slenderer and more straggling growth of the Doucin trees magnifies the height and spread of trees on this stock if figures be followed closely. The photograph reproduced in Plate VII gives a much better idea of the size and habit of the trees than would figures. It shows that a tree worked on Paradise is not only dwarfed but takes on the habit of growth of the Paradise; on the Doucin, the habit of Doucin; on French Crab, the habit of the Crab. It shows, too, what we have been taught, that true dwarfs grow on Paradise and half-dwarfs on Doucin.

We must, however, state disappointment in the dwarfing effects of the two stocks. There is not nearly the difference in size that we had expected between trees on the three different roots. No doubt, the failure to find a workable method of summer pruning had much to do with the vigorous growth of the dwarfs. It is certain that man must aid the stock very materially in dwarfing trees by severe pruning and training in both winter and summer. It is to be feared, despite efforts to prevent it, that some of our trees took root from the cion and so added to their size.

A glance at the photographs shows that both Paradise and Doucin trees must have far more room as the trees grow in New York than is commonly recommended for them by either European or American writers. The distances recommended for Paradise range from six to twelve feet and from eight to sixteen feet for Doucin. From experience with the trees in these experiments, but more particularly judging from an orchard of trees on Paradise and Doucin at the Station, much older than the trees under discussion, we should say

that in cultivated orchards, apples on Paradise should be planted from fifteen to eighteen feet apart; on Doucin twenty to twenty-five feet, depending upon soil and variety. This means that in this State where standards are set from forty to fifty feet apart, Paradise should be set one-third and Doucin one-half as far as standards. On poorer soils, in sod and where heavy summer pruning can be practiced, lesser distances may suffice.

Fruit-bearing on the three stocks.—The measure of the value of a stock is, of course, the yield of fruit. Hardly less important in this test, at any rate, is the time the varieties came into bearing since one of the chief virtues of dwarfing stocks is to bring the variety grafted on them into early bearing. Still another point which the fruit grower wants settled is how different varieties respond in crop bearing on the three stocks. We come now to a discussion of these questions.

Yield of fruit.—The figures showing yield of fruit are not of much value. The crops were not harvested nor the amounts of fruit taken by men from the Station. Mistakes and omissions have been detected. Even had there been no mistakes, figures taken at this time would hardly be fair as to the amount of fruit borne on the three different stocks; for, as we have pointed out, the orchards were set on a filler plan which gives more than twice as many trees on Paradise as on Doucin and more than three times as many on Doucin as on French Crab. Then, too, the trees have suffered unequally from winter-killing, shallow-rooting and other troubles, as has been shown. The figures indicate, then, only approximately what commercial orchards on the three stocks will bear in the first ten years of their existence — trees set at one and two years from the bud. Since the three orchards are on quite different soils and grown in very distinct climates, each plantation must be considered by itself.

The Van Alstyne orchard was slow in coming in bearing, none of the trees yielding fruit until 1907, the third year from setting, when one fruit was borne on a standard tree, and three on a Doucin. In 1908 trees on all three stocks bore, but on no stock was there an average of an apple per tree; in 1909, 27 French Crab trees bore 28 apples; 135 Doucin, 246 fruits; and 100 trees on Paradise bore 175 specimens. In 1910 the crop was a failure and the few fruits were not counted. The first yield of fruit worth taking into account,

then, was borne in 1911, trees 9 years from the bud and 7 from setting. The yields per tree for 1911 and the three remaining years of the test are shown in Table I.

TABLE I.—YIELDS IN VAN ALSTYNE DWARF APPLE ORCHARD.

Number of trees.	Stock.	YIELD PER TREE.			
		1911.	1912.	1913.	1914.
		<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
27.....	Crab.....	13	18	37½	79⅔
135.....	Doucín.....	10	21½	23	79
100.....	Paradise.....	7	15	14	36

The Dawley orchard bore its first fruit in 1906 when there were 83 apples on 300 Paradise trees, 23 on 157 Doucín trees and none on the 37 standards. In 1907 the Paradise trees, bore 96 apples and the Doucíns 13, standards none. In 1908 there were 567 apples on Paradise, 224 on the Doucín and 7 on the standard trees. In 1909 the Paradise trees averaged about 2 apples to the tree, the Doucín 4 and the standards less than an apple. The 1910 crop was almost a total failure and it was not until 1911 that the yield could be taken in pounds, the averages per tree for the next four years running as is shown in Table II.

TABLE II.—YIELDS IN DAWLEY DWARF APPLE ORCHARD.

Number of trees.	Stock.	YIELD PER TREE.			
		1911.	1912.	1913.	1914.
		<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
37.....	Crab.....	3	3	0	81
157.....	Doucín.....	5½	17½	2	51
300.....	Paradise.....	5⅓	16	⅓	70

In the Wood orchard, 1 apple was borne on a Boiken on Paradise the first year set. The second year, 1906, the trees on Paradise

bore 180 specimens on 192 trees, the Doucin 9 on 100 trees, while none of the 42 trees on French Crab bore. In 1907 the Paradise trees produced an average of a little over 4 apples per tree, the Doucin 2 apples per tree, while the 42 French Crabs bore 26 fruits. In 1908 the yield came up to 14 apples per tree on Paradise, 4 apples for each tree on Doucin and, all told, 17 apples on Crab. The yield in 1909 on Paradise was 30 apples per tree; on Doucin, 14 specimens; on French Crab but 18 apples for the 42 trees. As in the other two orchards the 1910 crop was a failure. Table III shows the yields per tree for the three remaining years of the test.

TABLE III.—YIELDS IN WOOD DWARF APPLE ORCHARD.

Number of trees.	Stock.	YIELD PER TREE.		
		1911.	1912.	1913.
		<i>Lbs.</i>	<i>Lbs.</i>	<i>Lbs.</i>
42.....	Crab.....	4½	13	39
100.....	Doucine.....	27	14½	61
192.....	Paradise.....	27	18½	50

Before comparing the yields for the three stocks we must first account for the tardiness with which the trees came in bearing and the small yield for the ten-year period. No doubt the excessive pruning to which the trees have been subjected in order to form good heads and the experiments in summer pruning have retarded bearing and kept the yield low. It must be remembered, too, that the trees were cut back to whips at planting. Several late-bearing sorts, two of which, Northern Spy and Sutton, are not yet in bearing, have made the average time of coming in bearing late and reduced the average yield. The last statement would be made plain if space permitted the publication of tabular data for the varieties and trees.

As the figures stand, the honors for productiveness seem to lie between the French Crab and Doucin trees. If we calculate the number of trees per acre for the different stocks, however, allowing the smaller distances between trees for the dwarfs, then the Paradise, per acre unit, is most productive for this first ten years, Doucin next

and French Crab last. So many exceptions could rightly be made to such a calculation that it is not worth making. Those who have had to do with the experiment have been surprised at the comparatively small yield of the trees on Paradise. Few, indeed, are the Paradise trees that have been bent to the ground with a load of fruit as they are so often depicted.

Again we caution readers against drawing sweeping conclusions from these figures. The trees on all three stocks are just coming into commercial bearing and, as every fruit grower knows, the idiosyncrasies of trees coming in bearing are too many and varied to make data from them very reliable.

Time of bearing.—In considering age of bearing, it is important to keep in mind the age of the plants. Trees were budded for these experimental orchards in the summer of 1902. The Wood orchard was set in the autumn of 1903 and the other two orchards a year later. As has been recorded, a considerable number of the trees, especially on Paradise, were lost the first and second winters through injury from cold. Most of these were replaced from a reserve supply budded in 1902; a few, however, were purchased from nurserymen and except in one or two instances were of the same age. Trees set later than 1906 and those budded on our grounds after 1902, have been discarded. What are the facts as to the earlier bearing of dwarfing stocks?

In all three of the orchards, as the figures given show, the Paradise trees came in bearing soonest. But in no one of the three orchards was there what could be called a commercial crop on any of the stocks until the tenth year after setting, when, if we take an average of the three orchards, the trees on French Crab bore 66.5 pounds each; on Doucin 63.65 pounds; and on Paradise 52 pounds. The figures must be thus roughly combined or else given in detail at a length of several pages of tabular matter, in either case the showing being much the same; namely, that the dwarfing stocks bring apples into commercial bearing somewhat earlier than do crabs.

These figures, we hasten to say, are hardly fair to the dwarfing stocks. No question but that the orchard conditions in this test have been better suited to the standard trees so that both in the matter of yield and in time of coming in bearing the figures favor the French Crab stock. On the other hand, there is no question but that the eye always favors the dwarf trees. One sees dwarf

trees loaded with fruit and jumps to the conclusion that they have come in bearing earlier and are more productive than the larger standard trees which cold figures show to bear more fruit, either per tree or per acre, but not so apparent to the eye. Dwarfs are much more spectacular than standard trees — hence, in part, their reputation for early and productive bearing.

It is interesting to confirm the expectation that varieties which come in bearing early on standard trees would behave the same on Doucin and Paradise. In the three orchards, varieties maintained very closely the relative time for bearing on the three stocks. Thus, Boiken, Bismarck, Alexander, Wealthy, Wagener, Wolf River, Ben Davis, Yellow Transparent and Rome are the early bearers on the dwarfs as we have long known them to be on standards; while Northern Spy, Sutton and Lady are, as on the larger trees, very late in coming in bearing, with Baldwin, R. I. Greening, Jonathan, Esopus, Grimes, McIntosh and Hubbardston in their usual place in the procession that varieties form in coming in bearing on standards.

Size, color and quality of apples on the three stocks.— From a commercial standpoint, and this is a test of commercial plantings, the results as to effects of the three stocks on size, color and quality, are, in a word, nil. There were, it is true, individual trees on Paradise and Doucin that bore particularly large apples and others that produced a handsomely colored crop, but when the product of all the trees of a variety was compared one had to declare that the fruit on one stock was quite as large and attractive as that on either of the other two. Nor was there any difference in the flavor of the apples from the three stocks.

Statements, so far as the apple is concerned, at least, that the product of dwarf trees is larger and better colored arise largely from two facts. As one compares the fruit of a variety on a dwarf and a standard tree, that on the small tree, being closer to the eye and more strikingly contrasted with the foliage, makes a better appearance. When the fruit is picked and compared, usually there is no difference. Again, dwarf trees are commonly pruned more severely, the crop thinned and the trees, all in all, given better care, which, of course, makes a far more attractive crop than the less well-cared for standards produce. Grown under as nearly identical conditions as possible, as in the care of these trees, it is doubtful

whether there is much difference in the product of the trees on the three stocks.

The statements just made hold only for the apple in the gross — for the whole crop. Had the experimental orchards been near the Station, or the conditions such that a more careful study could have been made, it is possible that some generalizations could have been made as to the influence of the three stocks on size, color and quality. Certain it is that there are slight differences in ripening dates and, as all know, a difference in time of maturity usually means more or less difference in size and color. Any study of this kind, and such a study is much needed, must be made in tests where all conditions are more uniform.

"What varieties do best on the dwarfing stocks?" — Every fruit grower going into the test orchards asked this question. A little consideration shows that it can be answered only in the most general way. Varieties have not done equally well in the three orchards; none of the trees are yet near their maximum usefulness; the question of longevity must be taken into account; the use for which the apple is wanted, whether for home or market, is a factor. Without discussing these several factors or giving reasons, the writer, after the experience of several years, can express his judgment as to the varieties that are and are not suited for dwarfing stock.

All things considered, possibly McIntosh, Wealthy and the little Lady have been most satisfactory on dwarfs. Jonathan, Esopus, Grimes, Alexander, Wagener, Boiken and Bismarck have been very satisfactory. Twenty Ounce has been the most unsatisfactory; it failed to make a good union at the start and even the trees that made the best union have been unhappy on either of the dwarfing stocks. Baldwin, R. I. Greening, Rome, Ben Davis, Northern Spy, Sutton, the best known of the remaining 27 sorts, have not taken especially kindly to the dwarfing stocks.

CONCLUSIONS.

We may conclude from the work at this Station with dwarf apples:

First. In America it is difficult if not impossible to get varieties on the dwarfing stock one may choose because of confusion in stocks. Even could one be sure of the stock the cost of the orchard per tree, and more particularly per acre, since many trees are required, is high.

Second. In the cold climate of New York there is much danger of winter-killing or winter-injury to the tenderer dwarf trees. The French Paradise stock is particularly tender to cold.

Third. The union between stock and cion when dwarfing stocks are used is not as good as in standard trees. A considerably greater loss must be expected from the breaking of trees because of poor unions. Trees on French Paradise make poorer unions than those on Doucin stocks.

Fourth. Many varieties throw out roots from the cion if the union is at or beneath the surface of the ground. This entails annually the task of removing roots springing from the cion, otherwise the dwarf trees quickly cease to be dwarfs. Many so-called dwarf orchards are not such, for upon examination it will be found that the root system comes chiefly from the cion.

Fifth. All dwarfing stocks have relatively shallow root systems which, under the conditions in which apples are generally grown in New York, are undesirable for several reasons; the trees, young or old, loaded or unloaded, blow over; the orchard cannot be properly cultivated; unquestionably, the shallow-rooted dwarfs suffer more from the annual American drouth than do the deep-rooted standards; lastly, root injuries from plow and cultivator are more frequent with shallow-rooted stocks, accounting in part for the suckering habit of dwarf apples. Because of such injuries it may be expected that the roots of dwarf trees will more often be diseased than those of standards.

Sixth. The suckering habit of the dwarf stocks is a vexatious trouble with which growers of dwarf trees must contend. Many suckers probably come, as we have said, from root injuries, but since dwarf stocks are usually propagated from cuttings or layers it is reasonable to suppose that they sucker more freely than the average standard tree.

Seventh. To secure true dwarfs undoubtedly there must be some summer pruning. In the exceedingly variable summer climate of New York it is very difficult to find a method and a time to prune satisfactorily in the summer. On the one hand, the results for which summer pruning is done do not always attend and on the other hand positive harm often follows because of the weak, sickly, second growth which so often is an after effect and which nearly always succumbs the succeeding winter.

Eighth. The data secured in this test show that the trees on dwarfing stocks come into commercial bearing somewhat earlier than do those on standard stocks. But, while the trees are not old enough to give reliable data on productiveness, there are no indications that the dwarfs come in bearing sufficiently early or bear enough fruit to make them profitable as compared with standards. This test, of course, offers no evidence, but no one expects from the behavior of dwarfs elsewhere, that the trees will live as long as do standards.

Ninth. It is a common claim that dwarf apple trees produce larger, handsomer and better-flavored fruits than standard trees. There is little in these three orchards to substantiate these claims. There are differences between trees on the three stocks but they are as often as not in favor of standards as of dwarfs.

Tenth. The chief advantages of the dwarf trees are such as appeal to the amateur rather than the professional apple grower. Thus, a dwarf tree takes less space and a greater variety can therefore be grown in a garden or orchard and the plants are handsomer ornamentals.

