BULLETIN NO. 569 APRIL, 1929

New York State Agricultural Experiment Station

Geneva, N. Y.

SEEDLING FRUIT STOCKS

H. B. TUKEY

PUBLISHED BY THE STATION
UNDER AUTHORITY OF CORNELL UNIVERSITY

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INTRODUCTION

Fruit trees are made up of two unlike individuals, namely, a root of one kind, usually a seedling, upon which is worked the desired variety either by budding or by grafting. In the past the root stocks have come largely from Europe, but embargos either laid down or contemplated have been directed at shutting off importations so that in the near future American nurserymen will be dependent upon domestic supplies. It is because of the imminence of the quarantine measures, June 30, 1930, that this report, in the nature of a progress report, is made, giving the information that has been accumulated thru three seasons of investigation in the production of fruit tree stocks in New York State.

Most of the fruit tree stocks used in the propagation of fruit trees in America today are seedling stocks, that is they have been produced from seed, in contrast to clon stocks propagated vegetatively by layers, root cuttings, and the like. Most scientific interest has centered upon the production of superior clonal stocks with the idea in mind of securing greater uniformity in the orchard, yet the fact remains that the nursery trade is dependent upon seedling stocks. Accordingly, to meet the present emergency, the investigations reported here have been directed upon seedling production and the bulk of this report treats of that phase of the problem.

SEEDAGE

SOURCES OF SEED

The first step in seedling production is securing and handling the seed. In this respect, the source of the seed has proved equally important to the method of handling after it has been secured.

Domestic vs. foreign seed.—Theoretically there should be no difference between seed from a foreign source and that from a domestic source, but in actual practice the domestic supplies have given better stands of seedlings. This is especially true with cherry and pear seed, and less a factor with apple seed. In the case of both Mazzard and Mahaleb seed the difficulty is often in securing the seed sufficiently early to effect the after-ripening necessary to germination. As will be shown later, cherry seeds require a long period of stratification and if received too late the seed will not germinate well. For example, two separate lots of Mazzard seed were received on March 12 in one season, and a shipment of Mahaleb seed on February 22, while on another occasion Mahaleb seed was received December 24. The spring shipment, of course, did not germinate until the second season, while the late fall shipment gave poor germination. Altho this factor has nothing whatsoever to do with the viability of the seed and might be overcome, yet it is one of the problems involved in securing a good stand of seedlings and must not be minimized.

The figures which follow give a comparison between stands of seedlings from different sources:

Kind of Seed	Source	Percentage Stand
Mazzard	Austria	2
Mazzard	Germany	2
Mazzard	New York	25
Mazzard	Pennsylvania	74
Mazzard	Virginia	70
Mahaleb	Austria	5
Mahaleb	France	0
Mahaleb	Germany	50
Mahaleb	Washington	92
Myrobalan	California	90
Myrobalan	France	70
Myrobalan	New York	65
Myrobalan	New York	90
Sargent cherry (*Prunus serrulata sachalinensis*)	Massachusetts	80
European bird cherry (*Prunus padus*)	Austria	90
Sour cherry (*Prunus cerasus*)	New York	80
Apple	France	70
Apple	France	82
Apple	Germany	60
Apple	New York	88
Apple	Vermont	85
Apple	Washington	76
Pear	Austria	10
Pear	France	5
Pear	Germany	20
Pear	California	86
Pear	Oregon	80
Pear	Washington	85
Pear	New York	80

It appears that these differences, which are mostly in favor of domestic seed, are due largely to handling and could probably be overcome. The fact that good foreign seed is sometimes received and that the seed is used satisfactorily in the places of its origin speaks for itself, yet in practice the superiority of domestic seed warrants consideration.

Apple seed.—Domestic seed supplies must rely largely upon cultivated varieties of fruit, and since cultivated varieties are of widely different types, special consideration must be given to the selection of varieties most likely to give viable seed and uniform and vigorous seedlings.

In three seasons' tests the following varieties of apples have proved satisfactory from the standpoint of viability of seed, vigor of growth, and uniformity: Ben Davis, Rome Beauty, Winesap, Wealthy, McIntosh, Whitney, and Northern Spy. Quite by contrast are Baldwin, Rhode Island Greening, and Tompkins King which have given low germination, poor vigor, and variability. As compared with the standard seedlings from French crab seed, the superior varieties mentioned above have been equal, or nearly equal, tho each variety has tended to exhibit certain characteristics in its offspring. For example, Winesap, Wealthy, Vermont crab, and Liveland Raspberry have given many seedlings with branch roots, whereas *Malus baccata* and Whitney have given characteristic straight roots. Ben Davis, McIntosh, and Rome Beauty have been intermediate between these two groups. French crab has tended to produce some branch roots, whereas German apple has been noticeably straight. Northern Spy has given seedlings which tend towards slenderness, altho they are not weak.

A glance at the following figures will give further comparison with these and other varieties. The seedlings were grown during the season of 1926. At the completion of the growing season only the largest plants were dug and measured. The percentage of these which were graded as No. 1, that is 3/16 to 1/4 inch in diameter just above the collar, is given in the last column and conveys some idea of the relative vigor.

Variety	Characteristics of Seedlings in 1926	Percentage of Best Plants Grading No. 1 ($\frac{3}{16}$ to $\frac{1}{4}$ Inch)
Baldwin	Roots straight and seedlings irregular and weak	57.1
Ben Davis	Some branch roots	68.0

French crab	Mostly straight roots	76.7
Hibernal	Mostly straight roots	57.1
McIntosh	Mostly straight but more branching than Northern Spy	85.0
Minnesota seed	Mostly straight, less vigorous than French crab	77.5
Northern Spy	Straight roots, slender tops	68.0
Rhode Island Greening	Weak plants like Baldwin	34.4
Rome Beauty	A few branch roots	92.5
Tompkins King	Irregular and weak seedlings like Baldwin	0.0

The performance and characteristics of seedlings grown in 1928 are shown in Table 1.

TABLE 1.—COMPARISON OF TYPE AND GRADE OF SEEDLINGS PRODUCED BY VARIOUS VARIETIES AND SPECIES OF APPLE.

VARIETY	NUMBER OF SEEDLINGS	OBSERVATIONS	PERCENTAGE GRADED AS No. 1 ($\frac{3}{16}$ TO ¼ INCH)
French crab	1,295	A few branched roots	25.6
German apple	965	Mostly straight roots	15.0
Liveland Raspberry	63	Branching roots	28.5
Malus baccata	200	Straight roots with many fibers	25.0
Malus floribunda	15	——	33.0
Malus prunifolia	370	Straight roots with many fibers	34.0
Malus ringo	——	——	——
Malus sibericum	105	——	31.0
Malus sp. No. 350.	500	——	20.0
Malus sp. No. 24365	205	Well-branched roots	31.7
Minnesota crab	120	A few branched roots	25.0
Vermont crab	650	Strong, well-branched roots	30.0
Wealthy	54	Branched roots	18.5
Whitney	288	Many straight roots	17.0
Winesap	230	Branched roots	47.0

The results with apple varieties as seedling parents are corroborated in general by those secured by other workers (14, 15, 23),[1] who recommend seedlings of such varieties as Fameuse, Winesap, Delicious, McIntosh, Spy, Ben Davis, Gano, Jonathan, and Tolman, as comparing favorably with French crab seedlings.

Pear seed.—It will be seen from Table 2 that pear varieties, too, produce seedlings with certain characteristics. Kieffer, and other oriental hybrids (*Pyrus communis* x *P. serotina*), produce larger seedlings and ones less subject to leaf-spot than do the pure French pear varieties (*P. communis*). Altho pear seedlings in general have

[1]Refers to Literature Cited, page 33.

characteristic straight roots with few side branches, seedlings of the oriental hybrids have, if possible, even straighter roots. Ussuriensis roots (*P. ussuriensis*), altho similar to those of the oriental hybrids, carry a regular undulation or twist which serves to identify them.

TABLE 2.—COMPARISON OF TYPE AND GRADE OF SEEDLINGS PRODUCED BY VARIOUS VARIETIES OF PEARS.

Variety	Number of seedlings	Observations	Percentage graded as No. 1 ($\frac{3}{16}$ to ¼ inch)
Bartlett	359	Straight root	20.7
Beurre d'Anjou	149	Branched roots, strong plants	25.9
Beurre Clairgeau	41	Poor plants	21.8
Beurre Hardy	304	Straight roots	7.2
Burkett	380	Very straight roots, tall plants	23.1
Dept. No. 26591	55	Branched roots, strong plants	49.0
Doyenne Boussock	——	Poor stand	——
French pear	2,265	Mostly straight roots	27.6
Garber	160	Strong plants	31.2
German pear	1,732	Few branched roots	11.9
Kieffer	270	Straight roots	20.3
Old Home	10	Very straight roots	30.0
Seckel	95	——	15.7
Sudduth	445	Straight roots	7.8
Tyson	7	Poor stand	0.0
Winter Nelis	9	Branched roots	44.0
Worden Seckel	36	Poor stand	16.6

Beurré d'Anjou, Bartlett, Burkett, Beurré Hardy, and Winter Nelis have produced seedlings of desirable type. Bartlett seedlings, which are likely to be depended upon for commercial supplies, tend to have straight roots, whereas among Winter Nelis and Beurré d'Anjou seedlings are many with branch roots. Tyson, Doyenné Boussock, and Worden Seckel seed have given poor stands. Tests in other parts of the country have shown the desirability of Bartlett and Winter Nelis as parents for seedling stocks (15, 24).

Plum seed.—There has been little difficulty with Myrobalan plum seed (*Prunus cerasifera*), whether from wild sources or from cultivated

TABLE 3.—COMPARISON OF TYPE AND GRADE OF SEEDLINGS PRODUCED BY VARIOUS VARIETIES AND SPECIES OF PLUMS.

Variety	Observations	Percentage stand	Percentage graded as No. 1 ($\frac{3}{16}$ to ¼ inch)
Golden cherry	Minor leaf-spot	25	100.0
Myrobalan	Minor leaf-spot	90	100.0
Prunus cerasifera	Minor leaf-spot	60	100.0

varieties. Golden Cherry, DeCaradeuc, and wild Myrobalan have all proved satisfactory and not widely different (Table 3).

Peach seed.—Only two types of peach seed have been tried, namely, the commonly used Carolina "naturals" and Muir, a California yellow canning peach. The Carolina naturals gave 90 per cent stand and produced vigorous seedlings 50 inches high. Muir, on the other hand, has given smaller seedlings, 30 to 35 inches high; poor germination, 40 per cent stand; and greater variability. Furthermore, natural seed is smaller than Muir so that more seeds are secured in a given measure. It has been pointed out by others (4) that pure white seedlings are more vigorous than yellow seedlings. Carolina naturals behave as homozygous white, producing seedlings with pure green foliage, while Muir seedlings carry the yellowish tinged foliage characteristic of yellow-fleshed peaches. More recently it has been shown that some of the white honey peaches produce desirable seedlings. The explanation given here on a basis of color may account for this fact. At all events, the Carolina naturals have proved satisfactory.

Cherry seed.—Cherry seed presents more difficulties than seed from apples and pears, both in the source from which it is derived and in its handling after it is secured. Nurserymen, thru experience, have selected late-fruiting types from which to secure seed for seedling production, such as wild Mazzard and Mahaleb. The wisdom of this course has since been justified by a comparison of seed taken from varieties of cultivated cherries of different ripening season (20). From Table 4 it will be seen that the late-ripening sorts produce the most viable seed, that the early-ripening kinds produce little or no sound seed, and that varieties ripening at intermediate dates produce an intermediate proportion of viable seed. Such cultivated varieties, therefore, as Downer, Oswego, Black Republican, and Abundance are desirable so far as soundness of seed is concerned, while Early Purple, Coe, Governor Wood, and Black Tartarian are practically worthless.

Among the sour sorts the same relation holds, so that seed from Brusseler Braune, Suda, Chase, and English Morello is sound, while that from Dyehouse and Early Richmond is of no value.

Sour cherry seedlings are very subject to leaf-spot, while Mazzard seedlings rank next in susceptibility. The Sargent cherry is resistant, Mahaleb next, and *P. padus* practically immune. Altho there seems to be some natural resistance on the part of some cultivated varieties of sweet cherries, the results are disappointing. What appears to be a resistant variety one year, succumbs to leaf-spot the next. Seed-

TABLE 4.—RELATION BETWEEN RIPENING OF FRUIT AND SOUNDNESS OF CHERRY SEED.

VARIETY	NUMBER OF SEEDS	DAYS BETWEEN BLOOMING AND RIPENING	PERCENTAGE SOUND SEED
Sweet Cherries (*Prunus avium*)			
Abundance	1,915	82	94.5
Black Republican	3,320	80	91.0
Black Tartarian	2,437	62	7.2
Downer	8,879	70 (picked 10 days later)	98.3
Eagle	1,850	64 (picked 5 days later)	61.9
Early Purple	2,494	48	00.1
Elton	2,025	60	00.0
Governor Wood	2,275	53	7.2
Knight	1,600	56	00.0
Lambert	2,220	78	55.0
Mazzard (Geneva)	4,420	86	100.0
Mazzard (Virginia stratified)	454	over 80	97.5
Mazzard (Virginia unstratified)	624	over 80	93.2
Napoleon	1,809	75	60.1
Oswego	3,922	95	100.0
Schmidt	2,396	71	72.8
Windsor	1,855	79 (picked 7 days earlier)	43.7
Sour Cherries (*P. cerasus*) and *P. mahaleb* and *P. tomentosa*			
Brusseler Braune	1,525	82	94.5
Chase	1,835	76	75.0
Dyehouse	2,075	63	00.4
Early Richmond	2,540	50	00.7
English Morello	2,290	84	100.0
English Morello (cannery)	3,007	picked early	70.9
Mahaleb (France)	796	over 80	100.0
Mahaleb (Austria)	1,211	over 80	100.0
Montmorency	2,515	68	84.2
P. tomentosa	394	over 80	100.0
Suda	2,775	80	99.9

lings from the wild Mazzard seem no different from those of cultivated sweet cherries. Plants that grow vigorously seem to be able to "keep ahead" of the leaf-spot, while slower-growing individuals succumb. Observations upon the characteristics, percentage stand, and percentage of No. 1 plants produced by various varieties and species of cherries are shown in Table 5.

Importance of the pollen parent.—In all this discussion the seedlings have been the result of open-pollination, that is, the pollen parent is unknown and may be any or all of several varieties. Since the male parent plays just as great a part in determining the characteristics of the offspring as does the female parent, this factor appears important (5, 6, 7, 9). Table 6 shows how important it may be where there is

TABLE 5.—COMPARISON OF TYPE AND GRADE OF SEEDLINGS PRODUCED BY VARIOUS VARIETIES AND SPECIES OF CHERRIES.

VARIETY	OBSERVATION	PERCENTAGE STAND	NUMBER	PERCENTAGE GRADED AS No. 1 ($\frac{3}{16}$ TO $\frac{1}{4}$ INCH)
	Sour Cherries (*P. cerasus*)			
Brusseler Braune.	Defoliated by leaf-spot	25	23	4.0
Chase..........	Defoliated by leaf-spot	50	70	0.0
English Morello..	Defoliated by leaf-spot	80	143	0.7
Montmorency...	Defoliated by leaf-spot	75	65	0.0
Suda...........	Defoliated by leaf-spot	40	49	8.0
European bird cherry (*P. padus*)	No leaf-spot	90	335	52.0
Sargent cherry (*P. serrulata sachalinesis*).....	Minor leaf-spot	80	79	35.7
Mahaleb (*P. mahaleb*).....	Minor leaf-spot	90	210	16.6
	Sweet Cherries (*P. avium*)			
Abundance......	Some leaf-spot	25	40	75.0
Black Republican	Some leaf spot	25	65	76.0
Black Tartarian.	——	0	0	0.0
Governor Wood..	——	0	0	0.0
Mazzard........	——	25	100	75.0

no opportunity for more potent varieties to effect fertilization. With Baldwin and Rhode Island Greening as pollen parents the seed of McIntosh has proved worthless, while with Delicious as the pollen parent the seed has been satisfactory.

TABLE 6.—PERFORMANCE OF MCINTOSH APPLE SEEDLINGS WITH DIFFERENT POLLEN PARENTS.

POLLEN PARENT	NUMBER OF SEED	NUMBER OF SEEDLINGS PRODUCED	GRADED AS
Baldwin...................	114	2	2—No. 2
Rhode Island Greening......	46	0	0
Delicious.................	94	62	12—No. 1 25—No. 2 25—No. 3

It must be remembered that, while on the face of it this is an important consideration, had other varieties been available for cross-pollination, the Baldwin and Rhode Island Greening pollen would not have played so important a part, since both of these varieties are notoriously poor pollinizers. Nevertheless, when a choice exists between seed from sections where poor pollination and undesirable varieties are likely to be met with and sections where good pollination and potent varieties are the rule, then the choice naturally lies with the latter. From the practical standpoint, therefore, seed from such a region as western New York, where Baldwin and Rhode Island Greening predominate, is to be avoided in favor of seed from a section like the Pacific Northwest where desirable varieties are interplanted commercially.

Conclusions on source of seed.—In short, domestic seed has proved more satisfactory from the practical standpoint. If cultivated varieties of fruits are used as seed parents, attention should be paid to particular varieties, avoiding some and selecting others. Some varieties tend to stamp their offspring with certain characteristics. Cherry seed should be taken from late-ripening sorts. Carolina naturals have proved satisfactory as peach stocks. Seed should be avoided from certain sections in which a high proportion of the cultivated varieties are of an undesirable type, or where poor pollination often occurs.

HANDLING AND STRATIFYING THE SEED

Danger from heating.—Seed can be seriously injured by careless handling while being gathered and cleaned. Stone fruit seeds seem especially liable to injury. In some seedling sections it has been the custom to plant pomace from the cider mills, without any effort to clean the seed, and with satisfactory results. Yet the practice is not always successful. Apple and pear seed collected in 1927 and not cleaned gave low germination in 1928, compared with similar seed that was cleaned.

The chief danger lies in heating. If no heating occurs the possibility of injury is lessened, but not eliminated. It has been shown that stratifying seed without removing the pulp decreases the percentage of germination (8, 19). Cherry seed secured from a canning factory in 1927, and which had lain in a pile for 48 hours with particles of flesh adhering after coming from the pitting machine, gave no germination. The embryos were discolored, the injury possibly being due to heating in the pile. It is of interest to note that in the seed-producing sections of Europe (12) the seed is always dried carefully and in the shade.

Principles involved in stratification.—Seed of the hardy fruits, unlike that of tomatoes and corn, will not germinate immediately it is mature. It must go thru a period of so-called "after-ripening" in which internal changes are brought about essential to germination. These processes are carried on effectively at a temperature of 41°F and under moist conditions (19).

In nature these conditions are approximated during winter months, and from this the idea has arisen that seed must be frozen before it will germinate (22). On the contrary, it has been shown that not only is freezing unnecessary, but also that freezing may actually be harmful (19). Any set of conditions that will approximate a range in temperature of 38 to 41°F and that will keep the seed moist will effect after-ripening. Stratifying in moist sand in an ice-house or in a cool cellar, in the ice compartment of a refrigerator, or bedded down out of doors will all give satisfactory results.

There are some advantages to stratifying under controlled conditions. First of all, the processes of after-ripening are speeded up since there is no period during which after-ripening is not going on. On the other hand, in out-of-door stratification the processes go on very slowly during the severe winter months while the seed is frozen. The chief disadvantage lies in the fact that in seasons of late springs the seed may after-ripen and begin to germinate before the land is prepared to receive it. Packing with ice, however, will hold the seed dormant.

Early vs. late stratifying of cherry seed.—Late shipments of cherry and plum seeds do not germinate the first year following planting, for the reasons given in the preceding paragraphs. Cherry seed requires about four months in which to after-ripen. If received dry during November and December and stratified out-of-doors, there is not a sufficiently long period under the cool, moist conditions needed for after-ripening and the seed lies dormant the following season. It is this requirement of a long period which has led to the recommendation that cherry seed be stratified as soon as it has been gathered (17). The point is not that it must not be allowed to dry out, but that if it is not stratified early, there will not be sufficient time during fall and spring to effect after-ripening.

Proof of this statement is found in three seasons' handling of several hundred pounds of many different lots of cherry seed. In 1927 the season's seed supply was held dry after harvest until stratified on November 7 in wet sand in the ice-house. It germinated satisfactorily when planted the following spring. One lot of Virginia Mazzard seed was not received until December 9. Stratified under the same conditions on that date, it germinated satisfactorily in the field the following spring. In 1928, 11 lots of Mazzard seed, which had been held dry at room temperature since harvest in August, were stratified on October 17, and when taken from the ice-house on February 15, 1929, they germinated. On April 9 a count of germinating samples showed 97 per cent germination. Table 7 shows other instances with Mazzard, sour cherry, Mahaleb, and Myrobalan plum seed.

TABLE 7.—EFFECT OF STRATIFICATION ON FIELD GERMINATION OF DIFFERENT FRUIT SEEDS PLANTED APRIL 7, 1928.

KIND	POUNDS OF SEED	DATE STRATIFIED	FIELD GERMINATION
Mazzard.......	0.5	Feb. 23, 1928	none
Mazzard.......	5	Nov. 7, 1927	good stand
Mazzard.......	1	Not stratified	none
Mazzard.......	1	Nov. 24, 1927	good stand
Myrobalan.....	3	Sept. 1, 1927	good stand
Myrobalan.....	4	Nov. 7, 1927	good stand
English Morello.	2	Nov. 7, 1927	good stand
Montmorency..	2	Nov. 7, 1927	good stand
P. padus.......	2	Nov. 24, 1927	good stand
Sargent cherry	0.5	Nov. 24, 1927	good stand
Mahaleb.......	1	Nov. 7, 1927	good stand

Stratifying other seeds.—Apples and pears require a shorter time for after-ripening than do the stone fruits. Four to 6 weeks is sufficient for apple and pear seed, 12 weeks for peaches, 12 to 16 weeks for plum seeds, and, as indicated in the preceding paragraphs, 16 to 20 weeks for cherries. It is best not to stratify apple and pear seed too early under artificial conditions because they germinate at a relatively low temperature and may begin germination in storage soon after they have completed after-ripening. Stratification under artificial conditions should be begun at such a time that, in accordance with the figures given above, the seed will be ready for planting at planting time. If the seed starts too early it may be checked by placing cakes of ice on the boxes, or otherwise holding it at low temperature. If the seed is not kept damp, after-ripening will not proceed, while if the temperature is either too high or too low the processes will be slowed down and a longer time will be required. It has been found advisable to examine the boxes of seed each month and sprinkle them with water if they become dry. The corners are especially likely to be overlooked.

Time of planting.—Fall planting may take the place of stratification, tho in the case of peaches, cherries, and plums the date should be in early fall so that there may be sufficient time elapsed for the after-ripening to be completed. Peach seed is well adapted to fall planting, but the small size and more delicate nature of apple and pear seed make them better suited to spring planting. Where fall planting has been done, a crust may form on the soil which prevents the seedlings from pushing thru. A spike tooth harrow has been used effectively to break such a crust, and with no appreciable loss of seedlings, even tho done when the cotyledons of the seed were well exposed.

Spring planting should be done early, but there appears to be such a thing as planting too early. In 1928, some lots of Mazzard seed were planted the first week in April, at which time they were beginning to germinate. Then followed a period of snow and temperature below freezing. The stand from the early plantings was very poor, altho later plantings were satisfactory. The conditions may have been unusual, yet they indicate the possibility of damage from too early planting of seed artificially after-ripened which has already started.

SEEDLING CULTURE

Two types of roots are used by nurserymen, namely, straight roots and branch roots. The straight roots are used primarily for bench-grafting, while the branch roots are preferred for lining-out and budding. New York State nurserymen grow budded trees almost exclusively and are, therefore, especially interested in the branch-root seedling. Four methods have been used in the tests reported here as follows: First, growing in one year from seed; second, growing in two years from seed; third, digging at the end of the first year from seed and growing a second season; and fourth, transplanting early during the first season of growth.

FROM SEED IN ONE YEAR

The first method, namely, growing in one year from seed, needs no lengthy explanation. It is the common method employed with various modifications in domestic seedling sections (10), and tends to produce a high proportion of straight roots (3, 18). In these tests the seed has been planted in the field and in beds as early in the spring as possible, the seed having been first after-ripened by stratification in an ice-house in moist sand. To utilize horse labor, the rows have been placed 36 inches apart, excepting in a few rows used for comparative purposes which were 18 inches apart. So far as growth of seedlings is concerned there was no difference between the two distances. In other tests seed was sown broadcast in beds, and in rows in beds.

Cultivation has been frequent and thoro in the field, a one-horse cultivator being found most satisfactory and the land being worked after each rain so as to prevent the formation of a crust. Whenever a crust has formed in early spring before the seeds have broken thru the ground, the crust has been broken either with a spike-tooth harrow, hand cultivator, or garden rake, depending upon the size of the plat. The injury has not been large enough to be noticeable and the benefit has been marked.

To prevent the possibility of a crust forming, tests have been made in which the seed has been covered with sand, with a mixture of sand and soil, and with soil alone. In a moist season such as that of 1927 there was no difference between any treatments for the reason that the soil was kept soft by frequent showers and no crust formed. In the drier season of 1928 the advantage was with the soil-covered seeds for the reason that the soil retained moisture better and resulted in a much better germination, whereas the sand-covered seed came more slowly and gave a poorer stand. If a covering material is essential, it would seem that one with better moisture-holding properties than sand would be desirable.

This method of growing, namely, from seed in one year, has been tried with apples, pears, plums, peaches, and Mahaleb and Mazzard cherries. The results are discussed separately for each class of stock in the following pages.

FROM SEED IN TWO YEARS WITHOUT TRANSPLANTING

In the second method, namely, growing for two years from seed without transplanting, the same procedure has been followed as in growing for only the one season, the only difference being that the seedlings have had two growing seasons in which to develop. The results with apples, pears, plums, and Mahaleb and Mazzard cherries will be discussed under each class of stock.

FROM SEED IN TWO YEARS BUT TRANSPLANTED THE SECOND SEASON

In the third method, namely, growing for two years but with transplanting the second season, the seed was first sown thick, both broadcast and in rows in beds in early spring, being handled similarly to the method of growing from seed in one year. The point in mind, however, was to keep the plants from growing too large the first year, and so they were sown thick tho at varying distances and in different manner. The only attention given during the growing season was to pull large weeds whenever they appeared, and to dust with a mixture of lead arsenate, sulfur, and nicotine to check leaf-skeletonizer, mildew, and aphis, respectively. The plants were left in the beds until the following spring, when they were dug and graded. The grades from different planting distances will be discussed later.

Before lining out the second season the roots of the plants were trimmed, the method being to cut them in bunches with pruning shears. The idea was to break the tap root and produce branching. The small seedlings were then lined out in the field 1½ inches apart in rows 3 feet apart. The distance between rows was determined by ease of horse cultivation and might have been 18 inches so far as the growth of seedlings is concerned. The results from this method with apples, pears, plums, and Mahaleb and Mazzard cherries have been promising and will be treated under the discussion of each class of stock.

TRANSPLANTING THE FIRST SEASON

By the fourth method, namely, transplanting early during the first season of growth, the most desirable type seedlings have been produced. The seed was after-ripened as for the other methods by stratifying in moist sand in an ice-house.

Time of sowing.—Planting was done in cold frames before the out-door season had opened, some in flats and some in the soil of the cold frame. Both methods were successful, the former making it easier to handle the seedlings and the latter being done more cheaply. Sowing was done about the middle to the last of March, depending upon the season, just so as to have the plants the proper size by the time transplanting to the field could be done. As will be shown further on, the best results were obtained with the smallest plants. Large plants did not transplant well. For this reason seeding in the cold frames may be delayed until the last week of March or the first week of April in a normal season, and because the seedlings grow so much faster under glass than in the open, they will be ready for transplanting within three weeks. Seedlings from seed sown April 12 in 1927 were transplanted on May 8, while in 1928 seed sown March 27 produced seedlings fit for transplanting by May 1. In 1929, seed sown April 5 was ready for transplanting April 25.

The seed should not be sown too thick and the plants should be given plenty of air, or they may damp-off. Cherries are especially likely to be affected, pears next, and apples least. Sprays have been tried but have not given complete control. On the other hand, attention to ventilation, crowding, and watering has prevented serious damping-off losses. Mildew on Mazzard cherries has been a further concern if the plants are kept too wet and not given sufficient ventilation. The plants have always been hardened off before transplanting, but flats set out without hardening off have stood temperatures at and just below freezing without any visible injury. Apples appear the most hardy of the classes tried.

FIG. 1.—Apple seedling too large for most successful transplanting. Altho apparently ideal from the standpoint of ease of handling, seedlings this size are not so well adapted to transplanting as are smaller sizes.

Time of transplanting.—Transplanting has been done from the middle of April until the first week in June, the majority of the work being done the last of April and the first two weeks in May. By the first week in May the plants had developed stiffness in the cold frame and had developed the third pair of true leaves, as shown in Fig. 1. While this was a desirable size for ease of handling, it proved less adapted to transplanting than the smaller sizes. The size which has done the best is that which is just developing the second pair of true leaves, and which seemed at first to be ridiculously small (Fig. 2). The larger the plants, the greater the mortality and the more severe the check attending transplanting. As an illustration, Wealthy plants transplanted late, June 3, produced no No. 1 plants, 41.9 per cent No. 2's, and 58.1 per cent No. 3's. In a normal season, as has been said in the preceding paragraph, seed sown in the cold frame the last week in March or the first week in April, just as the season is opening, will grow sufficiently rapidly under glass to be ready for transplanting within three weeks, which will be about the time that the land will be ready.

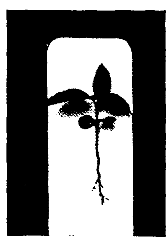

FIG. 2.—Apple seedling proper size for transplanting. (One-fourth natural size.)

Method of transplanting.—Three methods have been used in transplanting, namely, by hand with dibbles, with transplanting boards, and with automatic transplanting machinery. When dibbled by hand there have been many "goose-neck" seedlings produced, due to the planters not taking care to trim the tap root and placing the plant crooked in the soil. With proper supervision this could be overcome, but the fact remains that American labor does not take kindly to this work.

The planting board method has proved the best under the present conditions. There are several boards available, the type used in these tests being shown in Fig. 3. Planting boards have been de-

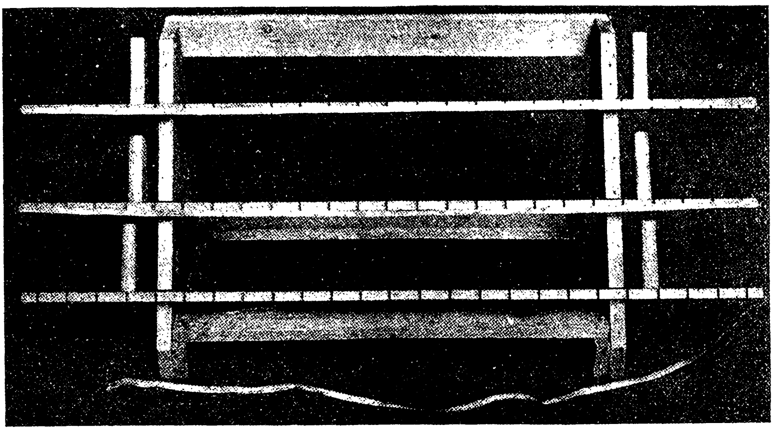

FIG. 3.—Planting board used in transplanting.

veloped in various evergreen seedling nurseries, but most that the writer has seen are too heavy for handling soft succulent plants, such as fruit stock seedlings. The type that has been used in these tests has the advantages of being light to handle and offering protection to the seedlings. As a general statement, the board must be relatively short so as to adapt itself to unevennesses in the soil, and the planting edge must be as narrow as possible and yet give the board proper strength, so as to avoid as much roughness of the surface soil as possible. Notches $\frac{1}{4}$ inch deep and $\frac{3}{16}$ inch wide have proved best, the notches being $1\frac{1}{2}$ inches apart and the board 3 feet long. An elastic drawn across the front of the board has helped to hold the seedlings in place, but has not been entirely satisfactory for the reason that under field conditions it becomes too delicate an operation to fasten and release the band without snapping the seedlings. If the plants are the proper size and drawn down into the notches, they will catch on the seed leaves and be held in place fairly well without the band. Some additional hold like the band, however, is desirable.

A second type of board, pictured in Fig. 4, has been used during the season of 1929. This board is patterned after the board just described, but it is better adapted to very small plants in that it permits them to be placed low in the ground. Other improve-

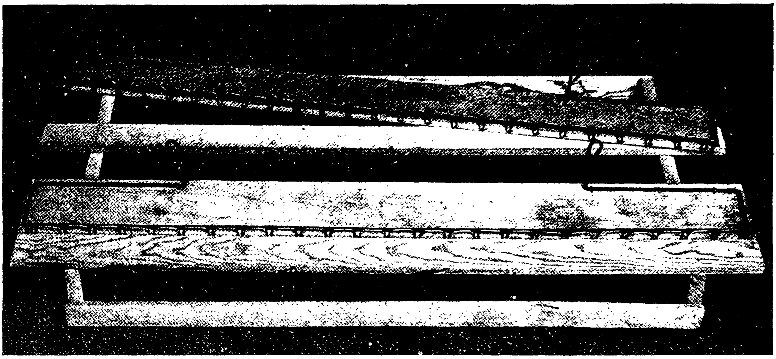

FIG. 4.—A new type board better suited to transplantıng very small seedlings.

ments are being made which will facilitate the work, but the method is essentially the same regardless of the particular design of the board.

The plants are taken from the flats or the cold frames, the tap roots are cut, the roots dipped into muddy water, and the plants strung into the notches of the planting board, pulling them into the notches so that the seed leaves will catch and help to hold the seedlings in place. Dipping the roots in mud not only prevents drying out but also gives weight to the seedlings and helps to hold them in place in the board. The frame of three boards is carried to a prepared trench, the seedling roots are placed straight against the straight side of the trench, and firmed into place. The board is removed, leaving the seedlings properly spaced and with straightened roots. Furthermore, American help does not object to this method.

The use of automatic transplanting machinery has not proved practical. Several hundred thousand plants have been used with three different types of transplanters. The difficulty lies in getting the plants to grow after the machine has placed them in the soil. First of all, in order to have the plants large enough for the fingers of the machines to grasp them they must be so large that they do not transplant well and suffer a severe check. In the second place, the machines so far devised have not been able to put the plants straight into the soil, resulting in a high proportion of "goose-neck" seedlings which break when dug and are otherwise worthless. Furthermore, machines have not yet been developed which will work in the heavy soils under which these tests have been conducted.

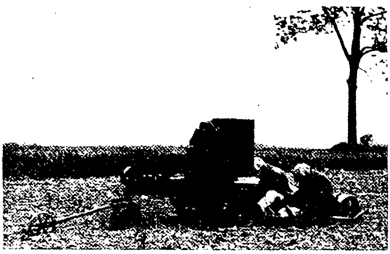

FIG. 5.—One type of self-propelled, self-guiding machine transplanter with improvised water tanks used in transplanting tests.

Two machines that have been used have worked on the principle of drawing themselves, as shown in Figs. 5 and 6. They can be geared down to plant 2 inches apart, in one case the slow speed of 7 feet a minute having been attained, and they are operated at low cost. A third type has been tractor drawn, which with a special feeding attachment, has also gone slow enough to plant 3 inches apart. The speed of operation is sufficiently high, 30,000 seedlings having been set by two men in one day, and the work can be done without the drudgery that American labor objects to, so that the method deserves attention. If a machine can be developed that will overcome the objections given above, it will be an asset to seedling production.

Watering at planting.— Comparison has been made between watering-in the seedlings when they were transplanted and not watering-in. In no instance has there been any noticeable benefit from watering-in. With plants of small size, transplanted in early spring, the mortality has been low. With plants of large size, the mortality has been high whether watered-in or not. With machine planting, streams of water have been run into the furrow into which the plants were being

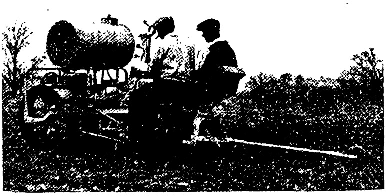

FIG. 6.—A more elaborate automatic transplanter.

set. Aside from aiding in straightening the root by the action of the water striking it as it came into position in the soil, there has been no benefit from watering.

Irrigation.—Overhead irrigation was tried in only one season and that a wet one so that the observations are not of great significance. It may be noted, however, that the seedlings under irrigation were affected by leaf-spot and mildew and were not benefited by irrigation. On the other hand, the plants which were not irrigated developed into saleable plants. Table 8 shows the poor results from this test, the figures of which may be compared with those for the non-irrigated seedlings in Table 12.

TABLE 8.—EFFECT OF OVERHEAD IRRIGATION ON TRANSPLANTED SEEDLINGS IN 1928.

STOCK	NUMBER	PERCENTAGE GRADED AS		
		No. 1 (3/16 to 1/4 inch)	No. 2 (2/16 to 3/16 inch)	No. 3 (Below 2/16 inch)
Ben Davis	38	11.7	52.9	35.4
French crab	23	0.0	26.5	73.5 (mildew)
German apple	11	0.0	90.9	9.1 (mildew)
Rome Beauty	30	10.0	30.0	60.0
French pear	65	46.2	53.8	0.0
Mahaleb	130	46.1	38.4	15.5
Downer	10	0	100.0	0.0 (leaf-spot)
Mazzard	28	0	44.4	65.6 (leaf-spot)
Prunus monticola	24	16.6	83.4	0.0
De Caradeuc	18	55.5	44.5	0.0

Fertilizers.—In both 1927 and 1928 different fertilizers were applied to seedlings. In 1927, 80 rows of Mahaleb seedlings, averaging about 1,000 to the row, were given different fertilizer treatments in varying amounts as shown in Table 9.

A guard row, receiving half the fertilizer applied to the row adjacent, was left between each fertilizer row, thus overcoming any cross-feeding effect. The soil is a Dunkirk clay loam, level, and uniform. The seedlings were kept clean cultivated thruout the season and were dug and graded in the fall of the year with the results shown in the table. It will be seen that there has been no effect from any of the nitrogen fertilizers used. There is a noticeable effect, however, from various distances apart in the row, yet there is no correlation between fertilizer application and growth.

Again, during the season of 1927, on a similar soil, applications of nitrate of soda, ammonium sulfate, and urea were made to 12 rows of transplanted apple and Mazzard seedlings, averaging 500 plants to the row,with no noticeable differences in growth or foliage color and no measurable differences when the seedlings were dug and graded. Likewise, during the seson of 1928, on an Ontario loam, nitrate of soda was applied to pear, apple, and cherry seedlings just after they had broken thru the ground with no visible or measurable response. Bone meal applied at planting to every other row of 200 rows, each 75 feet long, of apple, pear, and cherry seed resulted in no visible or measurable differences. In short, of the several hundred thousand seedlings of various kinds that have been grown with and without fertilizer treatment on the heavy, fertile soils of the region, none have responded to fertilizer applications.

TABLE 9.—EFFECT OF FERTILIZERS UPON MAHALEB SEEDLINGS.

Applications in pounds per acre	Number of plants per row	Percentage graded as			
		Extra (1/4 inch and over)	No. 1 (3/16 to 1/4 inch)	No. 2 (2/16 to 3/16 inch)	No. 3 (Below 2/16 inch)
None.	847	1.65	43.32	17.70	37.30
Ammonium sulfate, 1,000.	856	0.46	44.85	17.91	36.76
Calcium nitrate, 3,000.	878	3.41	43.05	19.39	34.16
Urea, 250.	918	0.10	49.78	18.51	31.59
Urea, 500.	1,134	0.70	38.44	16.75	44.09
Urea, 1,000.	1,207	0.91	34.29	19.63	45.15
None.	1,235	0.48	35.87	17.48	46.15
Ammonium sulfate, 2,000.	1,322	0.23	33.43	17.17	49.16

Spacing.—While there has been no response to fertilizer applications, there has been a marked response to the distance between individual plants. Table 9 already referred to in which plants were thinned out to various distances in the row, the rows being 3 feet apart, shows a striking correlation between distance and size. But to carry the point one step further, a glance at Table 10 will show the importance not of total area but of *evenness* of spacing. In this test apple seedlings were grown in a bed in rows 6 inches apart, in a bed broadcast evenly, and in a bed broadcast unevenly. With the plants close together in rows 6 inches apart, the percentage of small plants, 2/32 inch in diameter, was 71.8, yet only 60 plants were grown to the square foot. On the other hand, with half as many plants again to the square foot, or 91.2, the percentage of small plants, 2/32 inch in diameter, was only 24.7. Furthermore, with an even broadcasting of the seed so as to secure an even spacing of individual plants, the number of plants per square foot was 91.2 and the small plants 24.7 per cent, while with an uneven broadcasting the small plants were 38.6 per cent, altho the plants to the square foot were less, namely, 84.

TABLE 10.—SIZE OF APPLE SEEDLINGS AS AFFECTED BY PLANTING DISTANCE.

Planting distance	Number of seedlings	Plants per square foot	Percentage graded in inches as					
			8/32	6/32	5/32	4/32	2/32	Below 2/32
In rows 6 inches apart thinned.....	251	14.6	6.3	11.9	29.8	39.8	0.0	11.9
In rows 6 inches apart thinned.....	274	16.0	6.5	21.8	20.4	40.1	0.0	10.9
Broadcast and thinned..........	1,574	91.2	1.5	6.9	20.0	39.3	24.7	7.3
Broadcast unevenly.	1,450	84.0	1.0	4.8	12.4	34.5	38.6	8.6
In rows 6 inches apart unthinned..	1,029	60.0	0.4	0.0	4.2	15.5	71.8	7.7

Thruout all of this work, involving three seasons and the production of several hundred thousand seedlings, the most obvious and the simplest factor has been one of the most importance, namely, spacing. In an effort to find some more spectacular method of accomplishing the same results, it would seem that the simpler and most apparent method is often overlooked.

RESULTS WITH APPLE SEEDLINGS

Fig. 7 shows the types of roots developed by the various methods that have been discussed in the preceding pages. The first method, namely, growing in one year from seed, has given a high proportion of straight roots. In all instances during three seasons the seedlings have been barely large enough to meet the No. 1 grade (3/16 to 1/4 inch in diameter) and they have been largely straight roots; altho as has been shown in the discussion of sources of seed (page 5), some lots of seed tend to produce a greater proportion of branch roots than do others. Size of seedling has been determined very largely by the distance between individual plants as has been shown in the discussion of spacing. The proportion of No. 1 grade has never run over 50 per cent, and normally around 25 to 30 per cent. Insect and disease troubles have not been serious, tho leafhoppers were present in 1926 and in 1927. Applications of bordeaux mixture benefited the plants in general, tho no measurements were made to determine to what extent.

In the second method, namely, growing for two years from seed, the larger grades of seedlings have predominated. Altho the proportion of No. 1 grade (3/16 to 1/4 inch in diameter) has been above 50 per cent in all cases and in some instances reaches over 80 per cent, the stock is undesirable. Nurserymen to whom it was shown would not consider planting it at any price provided other stock could be secured. In general, the tops were coarse and branchy, and the straightness of the roots was accentuated by a second season's growth.

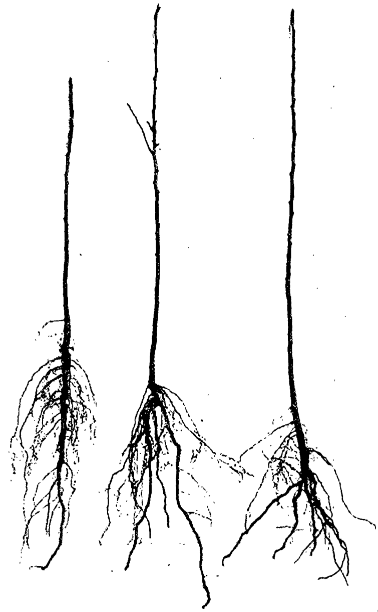

FIG. 7.—Apple seedlings. Left to right, from seed in one year, transplanted during the first season, and transplanted at the end of the first season and grown a second season.

In the third method, namely, digging at the completion of the first season's growth and subsequently growing for a second season, the roots have been of the type shown in Fig. 7. Altho a branch character was induced, the branching in some instances was too low on the stock. As a consequence, the side roots might be cut off in trimming the stock for lining-out purposes, leaving a straight-root seedling. It is important, then, in trimming the small seedlings preparatory to the second season's growth to cut back to within 3 inches of the crown. While the seedlings of this type may not be ideal, they offer a cheap source of supply and a supply which can be produced with little bother. In an emergency it would seem a desirable method for local nurserymen to employ.

The plan followed in this method, as already discussed, has been to grow the seedlings close together during the first season so as to keep them small, and to plant them out in rows the following season for a second season's growth. The grades from different planting distances are shown in Table 10. First of all it will be recalled that an *even* spacing between individual plants has been the important factor in determining size.

The grades produced the second season from these different size plants are shown in Table 11. The plants 2/16 inch and below when planted 1½ inches apart in rows 3 feet apart produced too high a

TABLE 11.—SECOND SEASON GROWTH OF FRENCH CRAB SEEDLINGS OF DIFFERENT SIZES.

Size when planted	Number of seedlings	Percentage graded when dug as			
		Extra (Over 1/4 inch)	No. 1 (3/16 to 1/4 inch)	No. 2 (2/16 to 3/16 inch)	No. 3 (Below 2/16 inch)
2/16 inch and below	1425	0	32.8	52.6	14.4
2/16 to 3/16 inch...	736	0	53.2	46.7	0
3/16 to 1/4 inch....	256	20.3	50.0	29.7	0

proportion of No. 2 grade. The plants 3/16 to 1/4 inch produced too high a proportion of the "extra" grade. The most desirable size has seemed to be the 2/16 to 3/16 inch grade, which is the commercial No. 2 grade. In other words, growing the plants one year evenly spaced at a rate of 91.2 to the square foot produced 8.4 per cent which were a No. 1 grade and which could be used for lining out and budding, and 59.3 per cent which could be lined out close together in rows for a second season's growth. Planted at this close distance 53.2 per cent of these developed to a No. 1 grade. Unfortunately, a wider spacing was not included in the test. Based on the importance of spacing as shown in these tests, anyone contemplating the use of this method should plan to space the smaller plants further apart, so as to afford them better opportunity to make the desired grade.

By the fourth method, namely, transplanting early during the first season of growth, the most desirable apple seedlings have been produced, as shown in Fig. 7. This is the branch root seedling which New York State nurserymen prefer and which three seasons' experience in these investigations shows to be better suited to local lining-out and budding purposes than the straight root. The grades produced in 1927 and 1928 at different planting distances are shown in Table 12.

The proportion of No. 1 grade has run in the neighborhood of 50 per cent with seedlings planted 3 inches apart in the row. When the plants were set 1½ inches apart in the row the proportion of No. 1 plants was lowered to the neighborhood of 30 per cent. The wet season of 1927 raised the grade as compared with the seedlings grown under similar surroundings the season of 1928.

In tests of these transplanted stocks in 1928 as lining-out stocks for budding, they were outstandingly superior to any other type and compared favorably with the imported French seedlings.

TABLE 12.—GRADES OF TRANSPLANTED APPLE SEEDLINGS AT DIFFERENT PLANTING DISTANCES.

VARIETY	DISTANCE APART IN INCHES	NUMBER OF SEEDLINGS	PERCENTAGE GRADED AS		
			No. 1 (3/16 to 1/4 inch)	No. 2 (2/16 to 3/16 inch)	No. 3 (Below 2/16 inch)
		1927			
Ben Davis	1½	336	42.2	25.0	32.8
Rome	1½	367	60.4	20.4	19.2
Whitney	1½	700	35.0	26.8	38.1
		1928			
French crab	1½	372	30.9	40.3	28.7
French crab	3	192	53.6	33.3	13.0
German apple	1½	350	34.3	37.1	28.5
German apple	3	221	57.4	29.8	12.8
McIntosh	1½	303	25.0	40.2	34.8
McIntosh	3	187	42.8	30.5	26.7

RESULTS WITH PEAR SEEDLINGS

Fig. 8 shows the types of roots that have been developed by the various methods discussed in preceding pages. As with the apple, the first method, namely, growing in one year from seed, has given a high proportion of straight roots, the roots being even straighter than those of the apple. Altho in the discussion of varieties of pears for seedling production it has been shown that there is some varietal difference in the tendency to produce branch roots, yet the proportion is so small as to be of no great significance under the conditions of these tests.

Pear seedlings have tended to size up better than apple seedlings, provided leaf-blight has not become severe. In both seasons, however, leaf-blight has been a serious problem. That it is not a new one is to be observed by a glance over early American literature dealing with stock production where scores of suggestions will be found as to how to control "rust" on pear seedlings, ranging all the way from a mixture of iron rust in the soil (1, 2, 21) to liberal applications of organic fertilizers. In general, the suggestions have been directed at increasing the vigor of the seedlings (11). That the idea may be significant. in spite of the fact that leaf-blight is known to be due to a causal organism, is shown by experiences in these tests where vigorous growing seedlings were attacked little or not at all. On the other hand, the weaker or smaller growing seedlings have been the first to succumb. Whether this is due to any natural immunity of vigorous seedlings or whether the more rapidly growing seedlings merely outgrow and keep ahead of the injury, is a matter of conjecture. Field observations, however, indicate the value of vigor. It has been shown by other workers (16) that the disease can be controlled by bordeaux mixture.

FIG. 8.—Pear seedlings. Left to right, from seed in one season, transplanted during the first season, transplanted at the end of the first season and grown a second, and attacked by leaf-blight.

In the second method, namely, growing for two years from seed, the seedlings were of even larger grade than with apples. Almost every seedling developed to a No. 1 size or greater. For practical field planting, however, the stocks were worthless, the roots being straight and coarse and the tops heavy and branched. In some instances the roots were 2/16 inch in diameter at 3 feet in the ground, and with no strong lateral roots whatsoever.

In the third method, namely, digging at the completion of the first season's growth and subsequently growing for a second season, the roots have been of the type shown in Fig. 8, and while of a branch type, the branching in some instances was too low on the stock so that the lateral roots might be removed in the trimming previous to lining-out for budding. As with the apple, therefore, it is important to trim the roots of the young seedlings to within 3 inches of the crown prior to planting the second season.

The plan in this method has been to grow the seedlings close together the first season so as to keep them small, and to plant them out in rows the following season for a second season's growth. The grades from different planting distances are shown in Table 13,

TABLE 13.—SIZE OF FRENCH PEAR SEEDLINGS AS AFFECTED BY PLANTING DISTANCE.

How planted	Number of seedlings	Plants per square foot	Percentage graded in inches as			
			8/32	6/32	4/32	2/32
Broadcast unevenly....	319	55.6	1.2	14.1	34.8	39.1
In rows 6 inches apart..	1,446	100.8	2.4	8.6	24.0	51.7
Broadcast evenly......	6,120	118	0.0	3.9	34.3	52.2

where it will be observed that the results are not unlike those for the apple, except that the pear seedlings have made stockier plants than have the apple seedlings. The results of the second season's tests may be seen in Table 14. The higher proportion of smaller plants the second season is due entirely to leaf-blight. Not only

TABLE 14.—SECOND SEASON GROWTH OF FRENCH PEAR SEEDLINGS OF DIFFERENT SIZES.

Size in inches when planted	Number of seedlings	Percentage graded when dug as			
		Extra (1/4 inch and over)	No. 1 (3/16 to 1/4 inch)	No. 2 (2/16 to 3/16 inch)	No. 3 (Below 2/16 inch)
2/16 and below.....	508	0.0	0.0	20.0	79.7
2/16 to 3/16.......	988	1.3	30.3	68.4	0.0
3/16 to 1/4........	382	19.8	39.8	40.3	0.0

was the top growth much less but root development was weakened. Fig. 8 shows the difference between the root development of a seedling which had no leaf-blight and one which was seriously affected.

Altho this procedure offers a method for growing pears cheaply and with a branch root, yet it is not so well adapted to the pear as to the apple for the reason that the seedlings are subject to leaf-blight thru two seasons. Furthermore, since pear seedlings are likely to make sufficient size in one season, it would seem better to work toward a method which will give the desired type in one season of growth.

Only by the fourth method, namely, transplanting early during the first season of growth, have first-class branch pear seedlings been produced, as shown in Fig. 8. Unfortunately, the importance of early transplanting was not recognized soon enough and the majority of transplanted pear seedlings were set out at a late date and did not survive. With the few that have been planted early, however, the proportion of No. 1 plants has been better than 60 per cent, a figure higher than with the apple.

RESULTS WITH CHERRY AND PLUM SEEDLINGS

In Figs. 9, 10, and 11 are shown the types of Mazzard and Mahaleb cherry and Myrobalan plum seedlings produced by growing from seed in one year and by transplanting early during the first growing season.

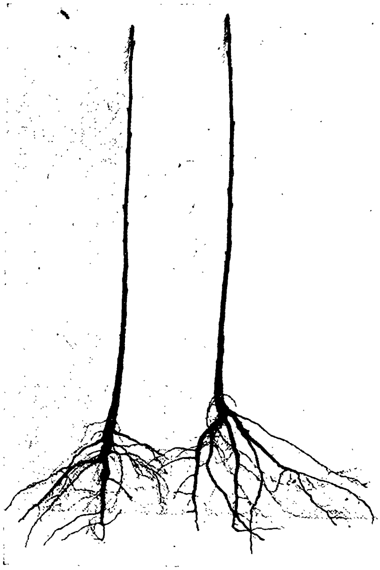

FIG. 9.—Mazzard seedlings. Left to right, from seed in one season, and transplanted during the first season.

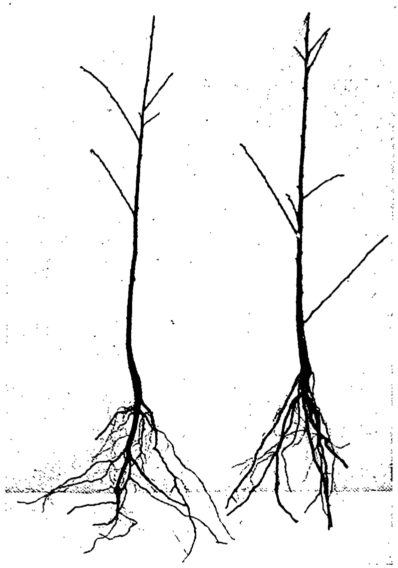

FIG. 10.—Mahaleb seedlings. Left to right, from seed in one season, and transplanted during the first season.

The tables on pages 5 and 7 give the grades produced by the first method, and Table 15 shows the grades produced by the second. The proportion of No. 1 plants is high in both cases, much higher than with either apples or pears.

First of all, from comparisons in the figures, it will be noticed that the Mazzard and Mahaleb cherry and the Myrobalan plum all tend to produce a fairly well branched root from seed without transplanting. The transplanted stocks have a better branching root system, yet it is a question whether or not they are more desirable. Nurserymen to whom the non-transplanted Mahaleb, Mazzard, and Myrobalan seedlings were shown considered them satisfactory.

In the second place, the Mazzard stock is very subject to leaf-spot and in the transplanting that has been done there has been severe loss from this cause. Apparently, the plants do not recover from the check of transplanting before leaf-spot attacks them. As a consequence they are frequently stunted. In the tests that have been made there has been no special resistance to leaf-spot shown by any of the Mazzard types tried. Where leaf-spot has not proved serious, on the other hand, the growth of the transplanted Mazzard stocks has been so much greater than desirable that an over-size stock has resulted.

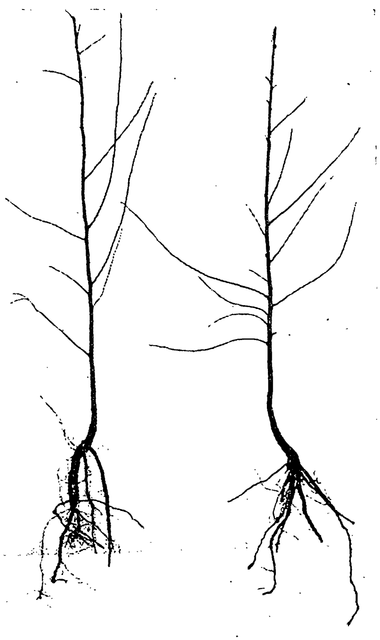

FIG. 11.—Myrobalan seedlings. Left to right, from seed in one season, and transplanted during the first season.

Mahaleb and Myrobalan stocks are not so subject to leaf-spot and transplant readily, but they, too, are likely to grow too large and be undesirable for this reason. It will be noticed from Table 15 that with Myrobalan plants 3 inches apart in the row, the percentage of "extra" grade has been high, 15.6, no small plants whatsoever being produced.

The fact that these stocks grow to large size when transplanted offers the possibility of budding the stocks the same year the seed is sown. In 1927, it was possible to do so with Mahaleb, Mazzard, and Myrobalan seedlings, and in 1928 the practice was repeated on Mahaleb and Myrobalan stock and could have been done on Mazzard stock. Whether there is any application to this method, such as spacing the transplants further apart in the permanent rows, to be budded and left to produce nursery trees, has not been determined, altho it has been tried in other sections (13). It does emphasize the point, however, that it is not difficult to secure size on Mahaleb, Mazzard, and Myrobalan seedlings in the vicinity in which these tests were conducted.

It has been observed, as with pear seedlings, that leaf-spot and aphis are not so severe upon rapidly growing seedlings. Whether this is due to the seedlings growing away from these two troubles or whether the factor is one of resistance, has not been determined. It has been shown (16) that leaf-spot can be controlled with bordeaux mixture, and in these tests commercially satisfactory control has been secured by what would not be considered overly thoro applications. Nevertheless, the importance of vigor is not to be overlooked.

TABLE 15.—GRADES OF TRANSPLANTED CHERRY AND PLUM SEEDLINGS AT DIFFERENT PLANTING DISTANCES.

KIND OF STOCK	DISTANCE APART IN INCHES	NUMBER OF SEEDLINGS	PERCENTAGE GRADED AS			
			Extra (Over 1/4 inch)	No. 1 (3/16 to 1/4 inch)	No. 2 (2/16 to 3/16 inch)	No. 3 (Below) 2/16 inch)
			1928			
Mahaleb	1½	160	0	62.5	37.5	0.0
Mazzard	1½	80	0	12.5	37.5	50.0
Mazzard	3	150	0	30.0	56.7	13.3
Downer	1½	50	0	0.0	40.0	60.0 (leaf-spot)
Downer	3	55	0	18.1	54.3	27.6 (leaf-spot)
Myrobalan	1½	307	2.2	48.9	48.8	0.0
Myrobalan	3	160	15.6	84.4	0.0	0.0
P. monticola	1½	254	3.5	29.5	39.3	27.7
P. monticola	3	165	6.0	45.4	36.3	12.3
			1927			
Mahaleb	1½	160	0	51.8	32.0	26.2 (large)
Mazzard	1½	900	0	51.2	14.1	34.6
Downer	1½	356	0	63.4	14.0	22.6
Oswego	1½	692	0	42.1	14.4	43.5
P. virginiana	1½	543	0	37.5	9.2	53.3 (very branched, large)
P. tomentosa	1½	636	0	42.1	22.4	35.5

Since the Mazzard cherry is merely a wild form of *Prunus avium* and since sweet cherry varieties are cultivated forms of *P. avium*, the Downer and Oswego sweet cherries have been considered in the same category thruout these discussions. Likewise, the Myrobalan plum, also called the Cherry plum, belongs to the same species as does the cultivated variety De Caradeuc, *P. cerasifera*. Furthermore, since *P. monticola* is so closely related to *P. cerasifera*, all three are discussed as tho they were the same type.

DIGGING AND HANDLING THE STOCK

There is very little information regarding the best time to dig seedlings, the time being determined to some extent by the shipping season. That is, since nurserymen desire seedlings in early January so that they may be trimmed preparatory to lining-out, the producer of seedlings must dig his seedlings at a sufficiently early date to have them graded and delivered to his customers by this time. There is some reason to believe that in some sections of long growing season digging has been done too early.

In two seasons' experiences with method of handling, it has been found that apple and pear seedlings may be handled with less concern as to their subsequent performance than may cherry and plum seedlings. In the fall of 1927, just before the ground froze up for the winter, Mahaleb seedlings still having green leaves were dug and the leaves sweated off by the approved nursery method. The stock appeared bright and live, but when lined-out in various parts of the country the following year it did not prove the equal of stocks that had been more carefully handled. Pears and apples under the same conditions were satisfactory.

The evidence is that Mazzard and Mahaleb stocks can not be handled with too much care. It must be recalled that all seedling stocks are planted not merely to grow the following season, but to start off early in the spring, make vigorous growth, develop a good root system, and eventually produce a strong nursery tree. A moments reflection upon these points only serves to emphasize the importance of careful handling.

LITERATURE CITED

1 Anonymous. Pear seedlings. *Horticulturist*, **3,** *191. 1848–49.*

2 ————. Raising pear and plum stocks. *Horticulturist*, **3,** *253. 1848–49.*

3 Barry, Patrick. The Fruit Garden, *New York: Saxton, 1851.* (See page 105.)

4 Connors, C. H. Further notes on peach breeding. *Proc. Amer. Soc. Hort. Sci.*, **25,** *125. 1929.*

5 Crandall, C. S. Growth of apple seedlings. *Proc. Amer. Soc. Hort. Sci.*, **1921,** *13. 1922.*

6 ————. Oldenburg as female in apple crosses. *Proc. Amer. Soc. Hort. Sci.*, **1923,** *13. 1924.*

7 ————. Whitney and seedlings from Whitney crosses. *Proc. Amer. Soc. Hort. Sci.*, **1922,** *98. 1923.*

8 Davis, O. H. Germination and early growth of *Cornus florida*, *Sambucus canadensis*, and *Berberis thunbergii*. *Bot. Gaz.*, **84,** *225. 1927.*

9 Dorsey, M. J. Some characteristics of open-pollinated seedlings of the Malinda apple. *Proc. Amer. Soc. Hort. Sci.*, **1919,** *36. 1920.*

10 Elliott, F. R. American Fruit-Growers' Guide. *New York: Saxton. 1855.* (See pages 54, 183, 184, 261.)

11 Field, T. W. Pear Culture. *New York: Moore. 1858.* (See page 49.)

12 Howard, W. L. Rootstock studies in Europe. *Proc. Amer. Soc. Hort. Sci.*, **1921,** *250. 1922.*

13 McClintock, J. A., The possibility of producing fruit tree stocks in the southern United States. *Proc. Amer. Soc. Hort. Sci.*, **1927,** *132. 1928.*

14 Maney, T. J. The search for better stocks. *News for Nurserymen*, **5,** *No. 8, 4. March 10, 1929.*

15 Scott, L. B. [Production of stocks.] *Ann. Rpt. Amer. Assoc. Nurserymen*, **53,** *100. 1928.*

16 Stewart, V. B. Some important leaf diseases of nursery stock. *Cornell Univ. Agr. Exp. Sta. Bul. No. 358. 1915.*

17 Swingle, C. F. Plum and cherry seed stratification. *Nat. Nurseryman*, **33,** *1927. 1925.*

18 Taylor, Yardley. Hints on nursery culture. *Horticulturist*, **4,** *192. 1849–50.*

19 Tukey, H. B. Studies in fruit seed storage and germination. *New York State Agr. Exp. Sta. Bul. No. 504. 1924.*

20 ————. The viability of seed from certain cherry varieties. *Proc. Amer. Soc. Hort. Sci.*, **1927,** *129. 1928.*

21 Washburn, John. Special manures—pear seedlings. *Horticulturist*, **3,** *251. 1848–49.*

22 Watson, Alexander. The American Home Garden. *New York: Harper & Bros. 1859.* (See page 204.)

23 [Yerkes, G. E.] Domestic production of root stocks. *Mimeographed contribution, United States Dept. Agr. 1926.*

24 [————, and Scott, L. B.] Domestic production of fruit and rose stocks. *Mimeographed contribution, United States Dept. Agr. 1928.*