UNITED STATES DEPARTMENT OF AGRICULTURE

FOREST SERVICE

SEED AND NURSERY PRACTICE

Shelterbelt Project

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Plains Shelterbelt Project

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SEED AND NURSERY PRACTICE

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INTRODUCTION

At the outset it is granted that there is no substitute for broad experience in nursery work in deciding upon proper methods and practices to follow. In no sense can this manual be regarded, therefore, as a substitute for experience, but rather as the present Regional Office standards and as a general reference guide for all important activities and problems associated with the seed collection, extraction, and nursery propagation of the deciduous tree species grown for shelterbelt planting. It is not to be construed as a guide for nursery and seed practices under all conditions, but only those conditions under which the deciduous shelterbelt nurseries are operated, i.e., under one-year lease, furrow irrigation, and various soil types and exposures, and where no provision can be made to practice rotation with soiling crops.

It is expected that under overhead irrigation, in protected sites, and desirable nursery soil of known productivity, many of the factors pointed out herein would be of little consequence. It is also recognized that this manual is not complete in every detail associated with seed and nursery work.

The material included in this manual is based upon information assembled from various sources. Every nurseryman and State officer in charge of nurseries, and the Lake States Forest Experiment Station, have contributed information either directly or indirectly to its preparation, as well as cooperating agencies outside the Forest Service organization. It is to be expected that considerable additional information will be obtained each succeeding year that will supplement or modify some of the recommendations made herein. Such supplemental information and revisions as may be necessary will be issued from time to time by the Regional Office for incorporation in this manual.

D. S. OLSON
Chief of Timber Management

Lincoln, Nebraska

March 23, 1936.

IT IS EXPECTED

IN THE REPRINTING OF ANY PART OF

THE SHELTERBELT PROJECT

SEED AND NURSERY PRACTICE HANDBOOK

THAT CREDIT OF AUTHORSHIP

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OR CONTRIBUTING AGENCY

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SECTION A

IRRIGATION IN SHELTERBELT NURSERIES

RECTANGULAR SHARP CRESTED WEIRS

Instructions for the construction and use of the Rectangular Sharp Crested Weir for measuring water. (Refer to the accompanying detailed drawing and the table of weir discharges which form a part of these instructions.)

1. Definition of a Sharp Crested Weir

A weir consists of a bulkhead or wall built across a stream or ditch at right angles to the flow of water with an opening cut in the top of the wall through which the water is allowed to pass. The opening is called a "weir notch". The bottom edge of the notch over which the water flows is called the "crest". The bottom portion of the ditch immediately upstream from the weir is called the "weir pond". The height of the water surface in the weir pond above the weir crest is the "head". This is measured a few feet upstream from the weir. If the flow of water over the weir crest discharges into free air before striking the level of the water on the downstream side, the weir is said to have "free discharge". A weir with a sharp upstream corner or edge so formed that the water springs clear of the crest is called a "sharp crested weir".

2. Shape of the Weir Notch for a Rectangular Weir

The notch which is cut in the top of the wall must have

(a) Its sides true, straight and rigid. The crest must be level and the sides must be vertical at a 90 degree angle to the crest. The sides must be accurately spaced so as to give the correct length of the crest.

(b) The upstream edges of the crest and the two vertical sides must be made sharp and flush with the upstream fall of the weir by beveling the downstream edges outward and downward about 45 degrees to insure free passage of air under the sheet of water as it flows over the weir.

3. Weir Pond Construction

The weir pond is made by enlarging the normal size of the ditch, making it wider and deeper for some distance upstream from the notch. This enlargement is for the purpose of making practically a still-water condition before the water flows over the weir.

To construct a weir pond the procedure is

(a) Commencing at approximately 50 feet upstream from the weir, widen the ditch or stream by tapering gradually from the normal size of the ditch to the full size of the weir wall or bulkhead. The water must approach the weir in straight lines without swirling or eddy of current.

(b) Deepen the ditch or stream by gradually lowering the normal bottom grade line from the point where the enlargement starts to the bottom of the weir bulkhead.

(c) The banks are raised upstream starting at the weir and continuing upstream 50 to 100 feet depending (1) upon the grade of the ditch and (2) how close to the head of the ditch the weir is placed. This should not be closer than about 50 feet. Experience has shown that a distance less than 25 feet between the weir and the supply pipe discharge point usually causes too great a surface disturbance of the water to permit of an accurate measurement of the head "H" and is liable to result in an increased velocity of waterflow over the weir. The amount of raise should be only enough to give a free fall of water from the weir crest to the water level below.

(d) The pond must not be allowed to fill with silt and sediment or other debris.

(e) The bottom of the ditch for a short distance downstream from the weir should be protected from scouring due to water falling over the weir notch with an apron of rock or plank.

4. Installation of Weir

After the ditch has been widened and deepened, the weir is installed in accordance with the standard weir plans furnished by the Regional Office and which form a part of these instructions. Care should be used in the installation of the weir to insure that

(a) The wall is set true and vertical.

(b) That the stakes are driven solid and to required depth.

(c) That the joints are tight.

(d) That the notch is properly centered over the center line of the ditch.

(e) That the crest is perfectly level and set at the proper elevation above the ditch bottom level.

(f) That all dimensions of the notch conform accurately to the construction plan.

(g) That every precaution is taken to prevent water from washing under the bottom or around the sides of the weir.

(h) That the soil is properly filled in and tamped around the weir and the ditch bank brought flush with the top of the weir.

(i) That the ditch just below the weir is adequately lined with rock or plank to prevent scouring due to the water falling over the weir notch.

5. Installation of Measuring Gauge

The weir gauge which is used to measure the depth of water flowing over the weir crest may be an ordinary ruler or a hard wood stick graduated to feet and inches, but it is preferable to have it graduated to feet, tenths and hundredths of a foot. It should be set upstream from the weir notch a distance of 6 feet on a solid post driven into the ground and just far enough from the ditch bank to insure that it will always be in the water. The reason for placing the gauge as described is that the depth of water "H" (see attached plan) from which the flow over the weir is computed is measured vertically from the crest to the horizontal plane or the still-water surface in the pond upstream from the weir. There is a decided curving downward of the water surface near the weir notch and it is necessary to get beyond the effect of this curvature, called the "draw down," in order to get the correct depth of water "H".

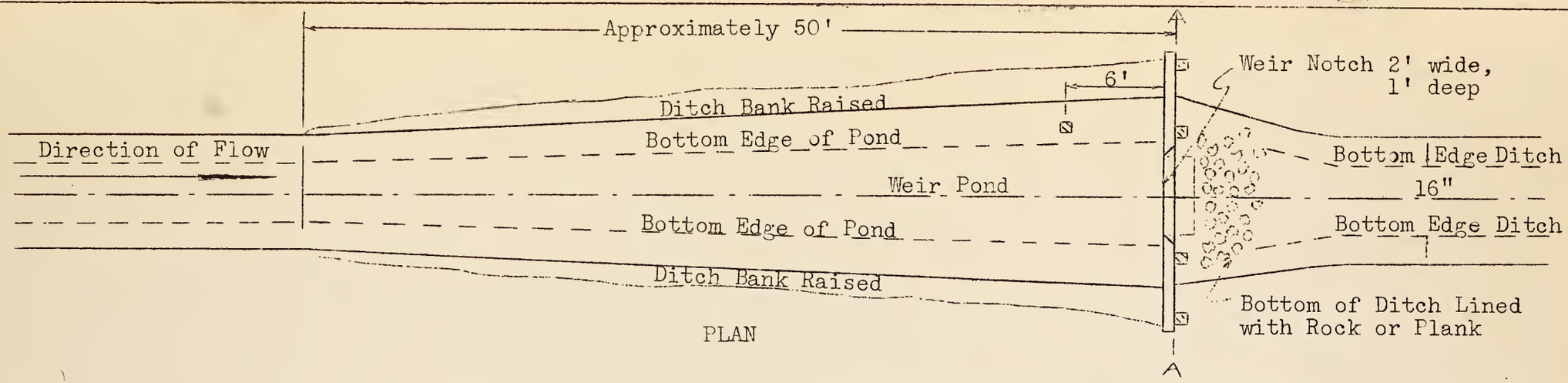
The zero of the gauge should be set accurately level with the weir crest. This may be done with a straight-edge and a good carpenter's level. The crest and gauge levels should be checked carefully for settlement or frost action.

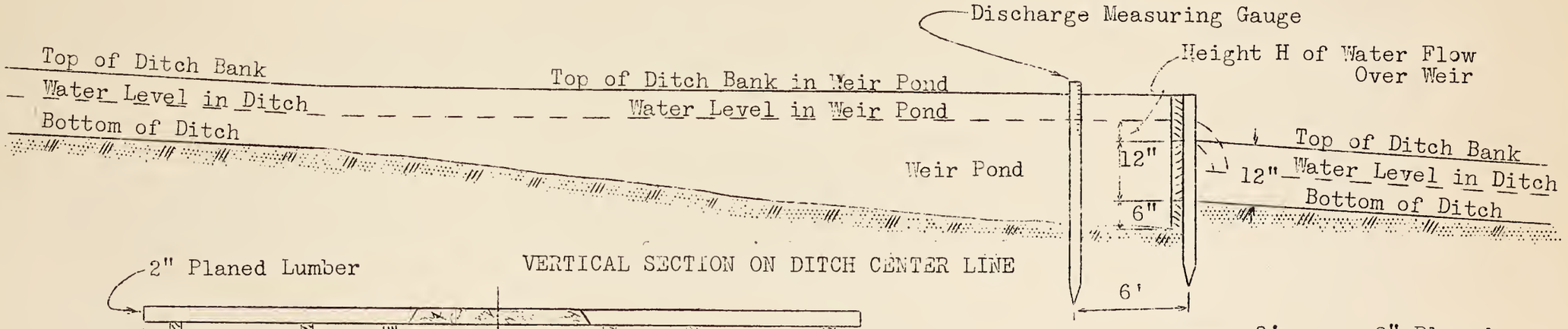
In order to obtain a correct measurement of the water flowing over the weir, it is necessary that the depth of water "H" be determined accurately. This means that the gauge must be placed accurately and read carefully. After the gauge post has been set in a vertical position, any wooden rule graduated to inches and sixteenths may be fastened to the post, the zero end being set accurately level with the weir crest.

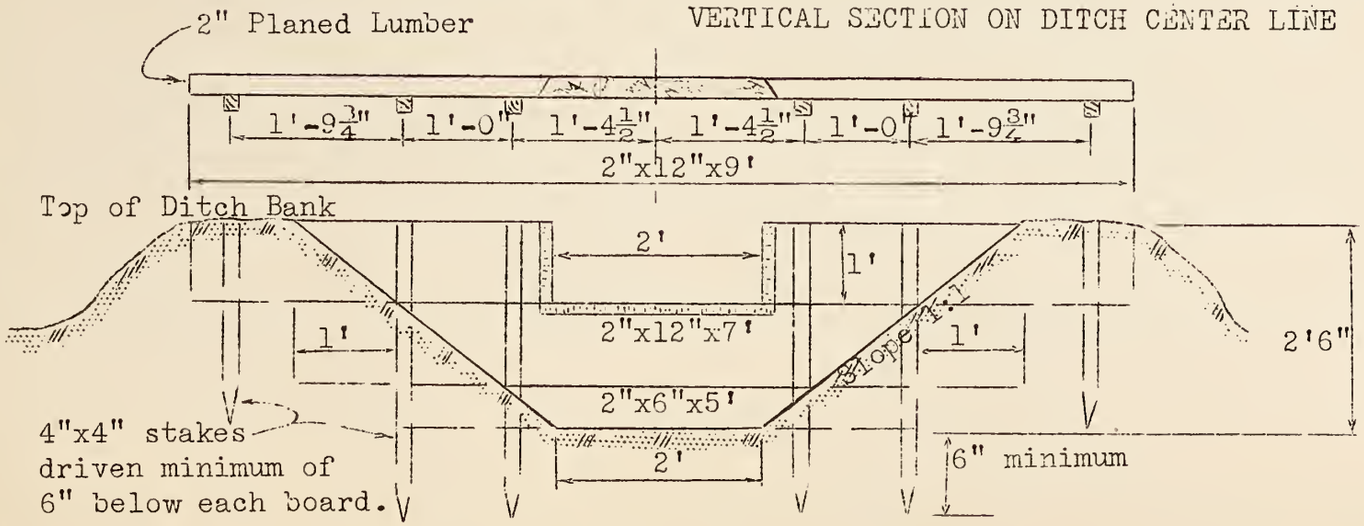
6. Table of Discharges Over a Two Foot Rectangular Weir

A weir notch two feet long and one foot deep has been selected to meet the requirements of all anticipated flows of water which will be used in the irrigation of nurseries. The accompanying Discharge Table shows the discharges in cubic feet per second and gallons per minute for different heights "H" of water flowing over the weir, expressed in tenths and hundredths of a foot as well as in inches and fractions. The figures in this table showing the amount of height "H" of water flowing over the weir correspond to the graduations on the weir gauge. By reading the gauge carefully where the water level appears on it and going to the Discharge Table with this figure, the amount of water flowing over the weir is obtained. Example: Water level reading on measuring gauge is 3 1/8".

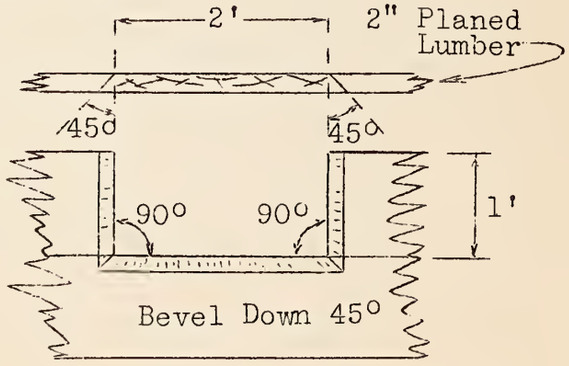
Find 3 1/8" under column "Head "H" in Inches"; to the right of this figure under column "Discharge in Gallons Per Minute" is 389, which is the amount of water flowing over the weir. If the water level is part way between 3 1/8" and 3 1/4" on the gauge, say at 3 5/16", the difference between 411 and 389, which is 22, is divided by 2. The amount of water flowing over the weir is 389, plus 11, which equals 400 gallons per minute.







DETAILS OF WEIR - SECTION AT A - A



DETAILS OF WEIR NOTCH

CONSTRUCTION DETAILS FOR WEIR AND WEIR POND

DISCHARGE TABLE FOR A 24" RECTANGULAR SHARP CRESTED WEIR WITH END CONTRACTIONS

Computed from the formula $Q = 3.247LH^{1.48}\,\frac{0.566L^{1.8}}{1 + 2L^{1.8}}\,H^{1.9}$

Head "H" in Feet	Head "H" in Inches	Discharge in Cu.Ft. Per Second	Discharge in Gallons Per Minute	Head "H" in Feet	Head "H" in Inches	Discharge in Cu.Ft. Per Second	Discharge in Gallons Per Minute
.01	1/8	.006	3	.51	6 1/8	2.33	1049
.02	1/4	.018	8	.52	6 1/4	2.40	1080
.03	3/8	.034	15	.53	6 3/8	2.46	1107
.04	1/2	.052	23	.54	6 1/2	2.53	1139
.05	5/8	.072	32	.55	6 5/8	2.60	1170
.06	11/16	.096	43	.56	6 3/4	2.67	1202
.07	13/16	.122	55	.57	6 13/16	2.74	1233
.08	15/16	.146	66	.58	6 15/16	2.81	1265
.09	1 1/16	.176	79	.59	7 1/16	2.88	1296
.10	1 3/16	.206	93	.60	7 3/16	2.96	1332
.11	1 5/16	.236	106	.61	7 5/16	3.03	1364
.12	1 7/16	.270	122	.62	7 7/16	3.10	1395
.13	1 9/16	.304	137	.63	7 9/16	3.17	1427
.14	1 11/16	.340	153	.64	7 11/16	3.25	1463
.15	1 13/16	.378	170	.65	7 13/16	3.32	1494
.16	1 15/16	.416	187	.66	7 15/16	3.40	1530
.17	2 1/16	.456	205	.67	8 1/16	3.47	1562
.18	2 3/16	.496	223	.68	8 3/16	3.56	1602
.19	2 5/16	.540	243	.69	8 1/4	3.63	1634
.20	2 3/8	.588	265	.70	8 3/8	3.71	1670
.21	2 1/2	.632	284	.71	8 1/2	3.78	1701
.22	2 5/8	.677	305	.72	8 5/8	3.86	1737
.23	2 3/4	.723	325	.73	8 3/4	3.94	1773
.24	2 7/8	.769	346	.74	8 7/8	4.02	1809
.25	3	.817	368	.75	9	4.10	1845
.26	3 1/8	.865	389	.76	9 1/8	4.18	1881
.27	3 1/4	.914	411	.77	9 1/4	4.26	1917
.28	3 3/8	.965	434	.78	9 3/8	4.34	1953
.29	3 1/2	1.02	459	.79	9 1/2	4.42	1989
.30	3 5/8	1.07	482	.80	9 5/8	4.51	2030
.31	3 3/4	1.12	504	.81	9 3/4	4.59	2066
.32	3 13/16	1.18	531	.82	9 13/16	4.67	2102
.33	3 15/16	1.23	554	.83	9 15/16	4.75	2138
.34	4 1/16	1.28	576	.84	10 1/16	4.84	2178
.35	4 3/16	1.34	603	.85	10 3/16	4.92	2214
.36	4 5/16	1.40	630	.86	10 5/16	5.01	2255
.37	4 7/16	1.45	653	.87	10 7/16	5.10	2295
.38	4 9/16	1.51	680	.88	10 9/16	5.18	2331
.39	4 11/16	1.57	707	.89	10 11/16	5.27	2372
.40	4 13/16	1.63	734	.90	10 13/16	5.35	2408
.41	4 15/16	1.69	761	.91	10 15/16	5.44	2448
.42	5 1/16	1.75	788	.92	11 1/16	5.53	2489
.43	5 3/16	1.81	815	.93	11 3/16	5.62	2529
.44	5 1/4	1.88	846	.94	11 1/4	5.71	2570
.45	5 3/8	1.94	873	.95	11 3/8	5.80	2610
.46	5 1/2	2.00	900	.96	11 1/2	5.89	2651
.47	5 5/8	2.07	932	.97	11 5/8	5.98	2691
.48	5 3/4	2.13	959	.98	11 3/4	6.07	2732
.49	5 7/8	2.20	990	.99	11 7/8	6.15	2768
.50	6	2.26	1017	1.00	12	6.25	2813

a-4-f

PIPE DISCHARGE DATA

TABLE SHOWING LOSS OF HEAD IN FEET PER 100 FEET OF PIPE

Gallons Per Minute Discharge

Inside Diam. of Pipe	10	20	30	40	50	60	80	100	150	200	250	300
1½"	1.4	5.2	11	18.8	28.4	39	68					
2 "	0.50	1.8	3.8	6.6	9.9	14	24	35.8	76			
2½"	0.17	0.61	1.3	2.2	3.3	4.8	8	12	25.5	43.1		
3 "	0.07	0.25	0.54	0.91	1.4	1.9	3.3	5	10.5	17.8	27.2	
3½"		0.11	0.24	0.40	0.60	0.85	1.5	2.2	4.8	8	12	17
4 "			0.13	0.22	0.34	0.46	0.80	1.2	2.6	4.4	6.7	9.3
4½"				0.12	0.17	0.25	0.44	0.64	1.4	2.3	3.4	4.8
5 "					0.11	0.15	0.26	0.4	0.88	1.5	2.2	3.1
6 "							0.10	0.14	0.32	0.62	0.92	1.3

1 pound per square inch equals 2.31 feet per head.
1 foot of head equals 0.433 pounds per square inch.

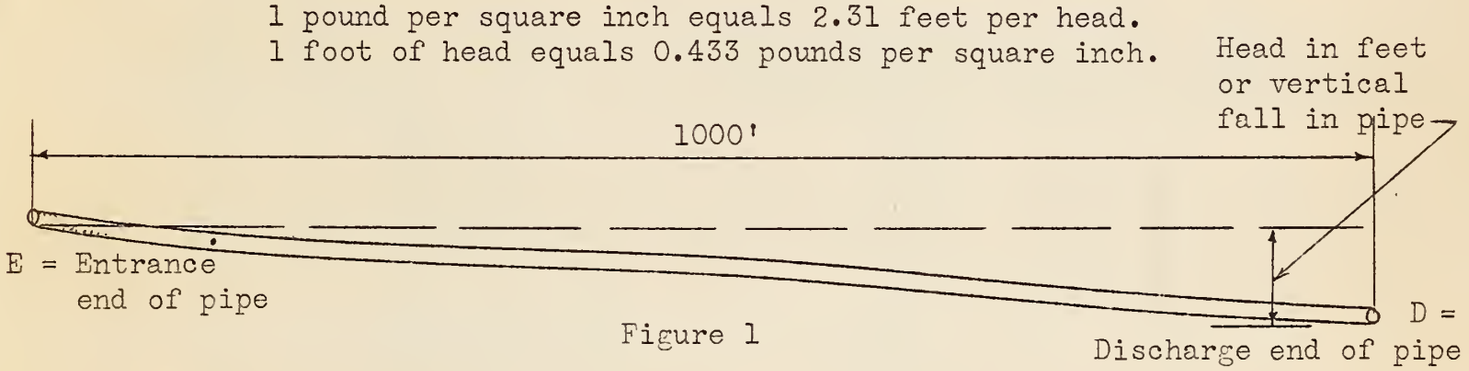


Figure 1

Discharge in pipes is cut down by friction against the walls of the pipes more than by any other thing. This is known as "Loss of Head" in the pipes and is measured usually in feet per 100 feet of pipe. Head in feet in pipes means the amount of vertical fall between the end where water enters the pipe and the end where the water discharges from it. In addition to the head caused by vertical fall in the pipe, there is the head caused by the pressure of water in the main or at the pump. This pressure on the pipe is measured in pounds per square inch. Pressure in pounds per square inch is expressed in feet of vertical head by multiplying the pounds per square inch by 2.31. This figure added to the total vertical fall in feet in the pipe gives the total head in feet on the pipe at the discharge end.

Example: (See Figure 1). Suppose a pipe line is to be laid from the main pipe "E" in a city water system to the nursery at "D."

Length of pipe E-D = 1000 feet.
Vertical fall from E to D = Head fall in pipe = 10 feet.
Pressure in main pipe at E = 30 pounds per square inch.
Head feet in pipe at E = 2.31 x 30 = 69 feet.
Total head feet at D = 69 + 10 = 79 feet.

Suppose the nurseryman has 1000 feet of 2 inch pipe which he wants to use and he needs a discharge of 50 gallons per minute at "D." Will the 2 inch pipe be large enough?

Look in the table showing "Loss of Head in Feet Per 100 Feet of Pipe" opposite 2 inch diameter and under 50 gallons per minute, find figure 9.9, which represents the head in feet of loss per 100 feet of pipe due to friction. Since the length of the pipe is 1000 feet or 10 times the unit of 100 feet, we multiply the loss head for 100 feet by 10. 10 x 9.9 = 99, which represents the total loss of head in feet in the pipe due to friction. The total loss of head at "D" in the 1000 feet of pipe, due to friction, is, therefore, 99 feet, and the total head in feet at "D" we have already found to be 79 feet. It is readily seen that the 2 inch pipe is too small to carry the 50 gallons per minute because the amount of head loss, 99 feet, from friction, is greater than the total available head, 79 feet, at "D," and there would result only a trickle of water at "D" instead of the desired 50 gallons per minute.

Let's try the next size pipe. Opposite $2\frac{1}{2}$ inch diameter under 50 gallons per minute, find 3.3 which equals the head in feet loss per 100 feet for $2\frac{1}{2}$ inch pipe. 3.3 x 10 = 33, which is the total feet head loss for 1000 feet of $2\frac{1}{2}$ inch pipe. The nurseryman should use the $2\frac{1}{2}$ inch pipe because it will deliver the desired 50 gallons per minute at "D" with only 33 feet friction loss in the total available 79 feet head.

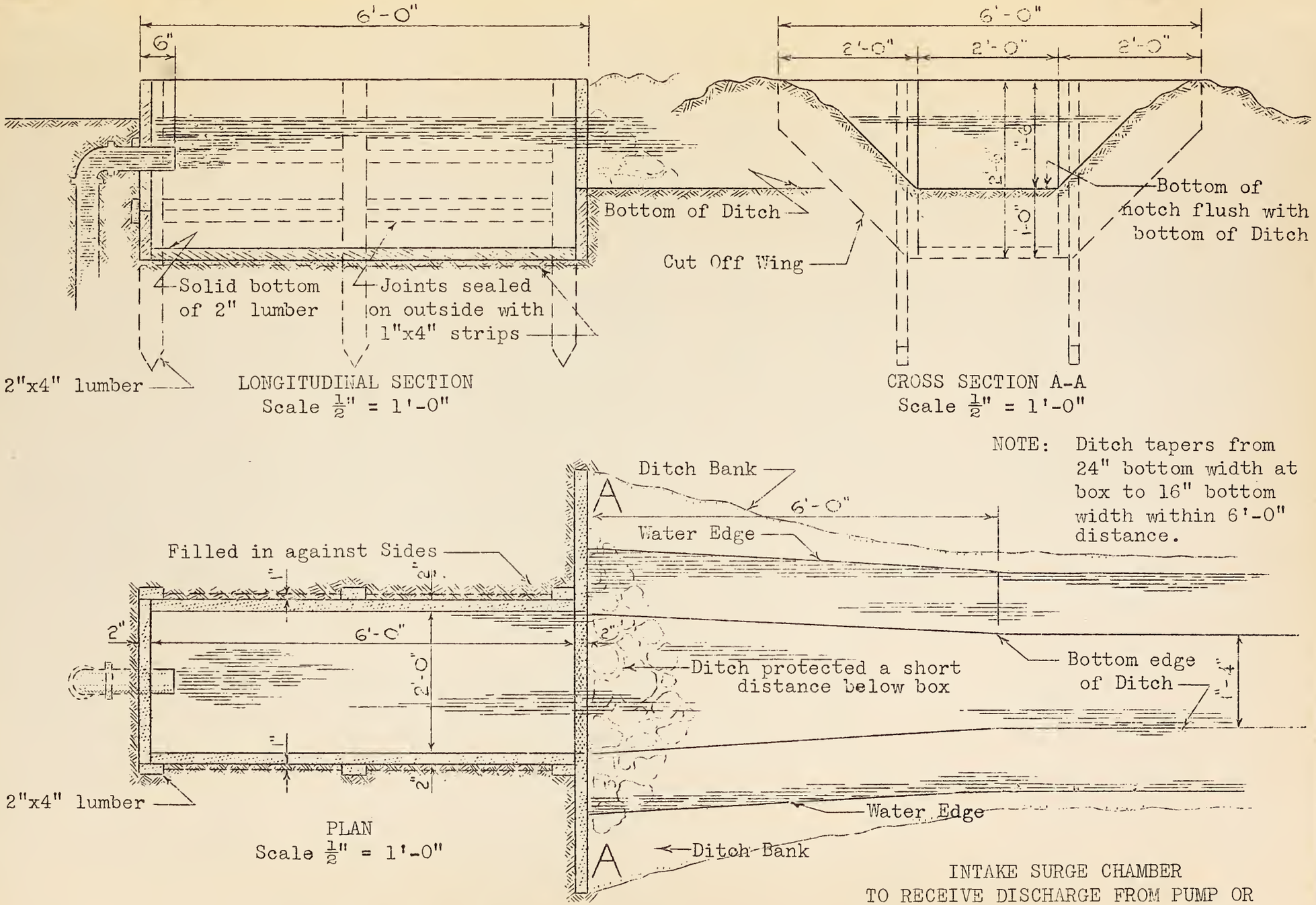
If the 1000 feet of pipe had been level so that "D" was the same elevation as "E", the total available head at "D" would have been only 69 feet. The nurseryman could still use the $2\frac{1}{2}$ inch pipe.

If the water had been received at "E" from a gravity flow ditch, the total head at "D" would have been 10 feet and to deliver 50 gallons per minute at "D", it would have been necessary to use a $3\frac{1}{2}$ inch pipe because the friction head loss for 1000 feet of that size pipe is 10 x .6 = 6 feet, which is less than the total head of 10 feet.

NOTE:

It is highly desirable that your irrigation and hydraulic problems be referred to the Regional Office, if time permits. Complete details should be given as to

(a) Amount of water desired - gallons per minute.
(b) Source of water - city system, pump, or gravity.
(c) Length in feet to deliver water.
(d) Total head or fall in feet from intake to discharge end.
(e) Pressure in pounds per square inch, if water source is from water system.
(f) Size in inches of pump, name of maker and kind (centrifugal or otherwise) with horse power and speed in revolutions per minute.
(g) Lift, vertical, in feet from source water level to pump. If from well, give depth of same and inside diameter of casing.
(h) Diameter and width of belt pulley on pump.
(i) Kind of power to be used for pumping.
(1) Tractor or engine, (2) Rated horse power, (3) Diameter of pulley wheel.



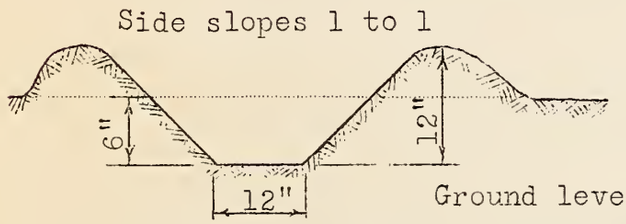
CONSTRUCTION DETAILS FOR INTAKE SURGE CHAMBER AND TAKE-OFF

INTAKE SURGE CHAMBER
TO RECEIVE DISCHARGE FROM PUMP OR
WATER SYSTEM FOR IRRIGATION DITCHES

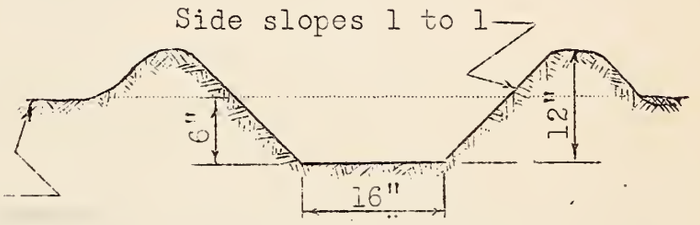
CONSTRUCTION OF DITCHES

Since the main and lateral ditches used in nursery irrigation are relatively small, construction is not a difficult problem. In lighter soils, a plow furrow may be used to mark the line, after which the small ditching machine is used for the remainder of the construction process. In heavier soils, it will be necessary to plow the dirt loose and then remove it with the blade ditcher. In most instances, a ditch with a bottom width of from 12 to 16 inches, a depth of 12 inches and side slopes of 1 to 1 will suffice to carry the small quantities needed in nurseries.

The following tables will be of service in estimating carrying capacities of two standard ditches under conditions indicated:



Ditch No. 1, Figure No. 1



Ditch No. 2, Figure No. 2

Ditch No. 1
Water Depth 6 Inches

Slope		Approximate Discharge	
In. Per 100 Ft.	Ft. Per 100 Ft.	Cu. Ft. Per Sec.	Gallons Per Min.
1/4		.22	99
1/2		.33	148
3/4		.41	184
1		.47	212
1 1/2		.57	256
2		.68	306
2 1/2		.74	333
3		.82	369
3 1/2		.89	400
4		.94	423
6		1.16	522

Ditch No. 2
Water Depth 6 Inches

Slope		Approximate Discharge	
In. Per 100 Ft.	Ft. Per 100 Ft.	Cu. Ft. Per Sec.	Gallons Per Min.
1/4		.28	126
1/2		.42	189
3/4		.52	234
1		.60	270
1 1/2		.73	329
2		.88	396
2 1/2		.96	432
3		1.05	473
3 1/2		1.15	517
4		1.21	545
6		1.49	670

The figures representing discharge in gallons per minute in the above tables are computed on the basis of a water depth of 6 inches. This depth may be increased somewhat if more capacity is necessary. There is danger of breaks in ditch banks, however, if the water level is carried too high.

It is sometimes necessary to carry a ditch down steep slopes to reach some particular area. If the slope exceeds 18 inches per 100 feet in ditches of cross section, as shown in No. 1 and 2, erosion is likely to result. If the slope is short in length, the water can often be conducted in a trough made of 1"x12" plank or a simple drop may be made with sand bags. The bags may be moved from place and represent very little investment. Sand bags may be used to advantage in many places to prevent erosive action of irrigation water. A dam may be quickly thrown in place by their use and as quickly removed.

The problem of carrying irrigation ditches over depressions or ravines may be solved by making a fill across the depression with a slip scraper and running the ditch across the fill. When such procedure is attempted, the fill and ditch banks must be well compacted or serious breaks may result. Often a simple flume is necessary since the ravine to be crossed must be left clear to carry flood water away.

Following is a simple flume design in common use for farm ditches:

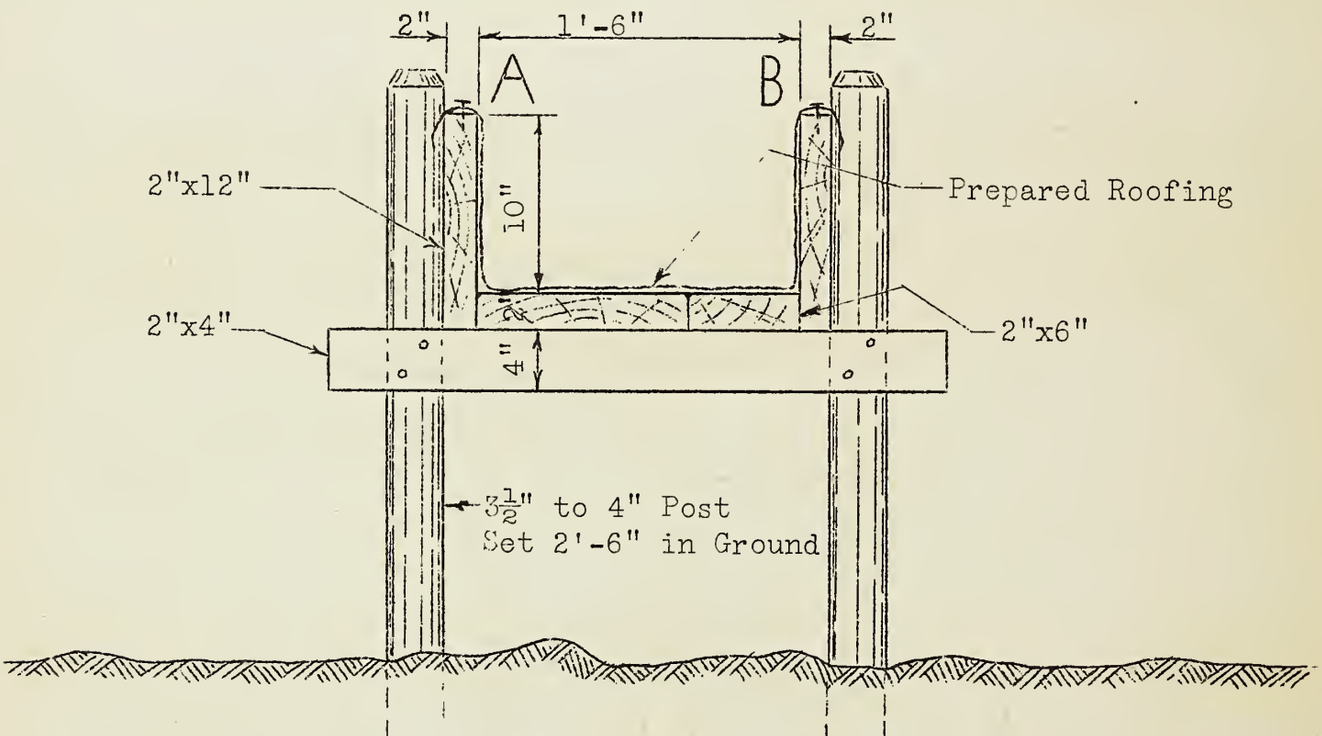


Figure No. 3
A simple flume for crossing ravines or depressions

The posts are spaced 8 feet apart along the length of the flume. The prepared roofing is laid lengthwise of the flume and where joints are necessary, they are made by cementing the edges together with cement, which is supplied with roofing materials. The edges at "A" and "B" are securely nailed with roofing nails.

DIVERSION OF WATER

It is usually necessary to dam a main ditch or lateral to divert water to rows. Canvas dams, portable metal checks or sand bags may be used. It is poor practice to cut the main ditch bank to secure water for a few rows.

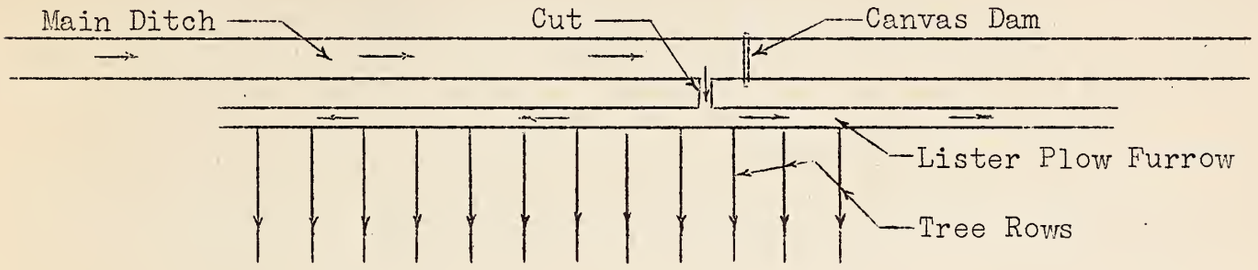


Figure No. 4
Diverting water from main ditch to a plow furrow
and thence to the rows

Water diverted from a main ditch or lateral should be carried in a lister or plow furrow run parallel and adjacent to the main ditch. From this furrow diversion can often be made to 15 or 20 rows at one time. It is relatively easy to cut the banks of the lister ditch or dam it at intervals with a shovel.

Instead of cutting the banks of the main ditch, it is often desirable to divert water through a simple box made of 1"x6" or 1"x8" material. The box must be set in place and damp earth tamped around it or a leak will occur resulting in a "break."

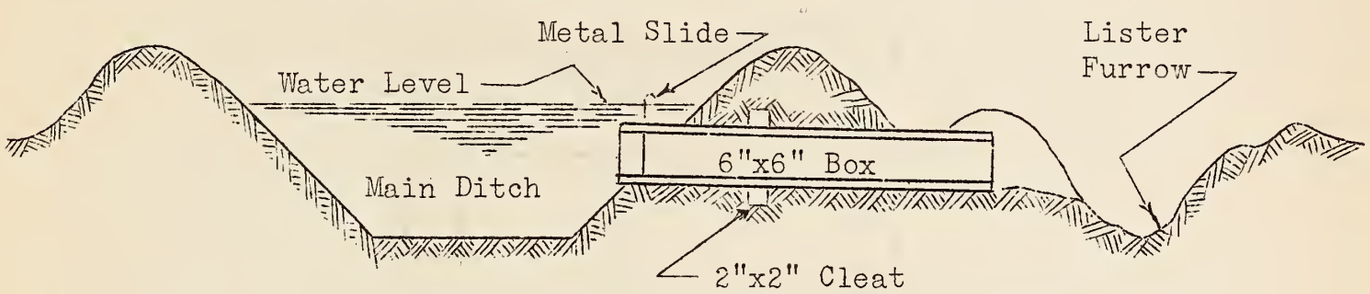


Figure No. 5
A 6"x6" box with metal slide shut-off for conducting
water through a ditch bank

Canvas dams are easily and cheaply made and are effective in ditches of small size. The 14 ounce canvas is securely nailed to a piece of 2"x4" material. The 2"x4" is laid across the ditch with the loose end of the canvas upstream. Then several shovels full of dirt are placed on the cloth to hold it down. After the water is turned in a few extra shovels full of dirt may be necessary to stop leaks. Several dams should be made so that one may always be in place before removing the one where irrigation has been completed.

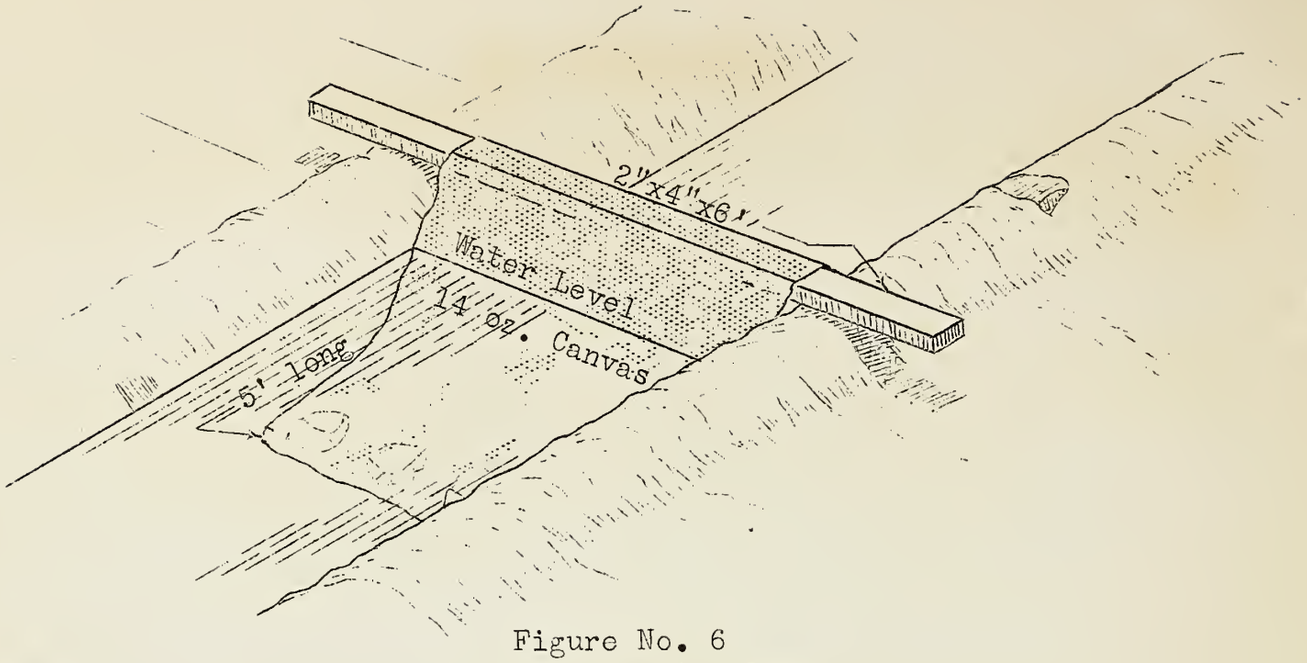


Figure No. 6
A canvas dam in place

The portable metal dam has some advantages over the canvas dam in that it is more durable and has a greater diversity of uses. Figure No. 7 shows a common design. This portable unit is set securely in a ditch and one or both of the shut-off slides opened if it is desired to allow some water to pass the dam. This unit can be set in a ditch bank with a slide open and used in place of the 6"x6" box shown in Figure No. 5.

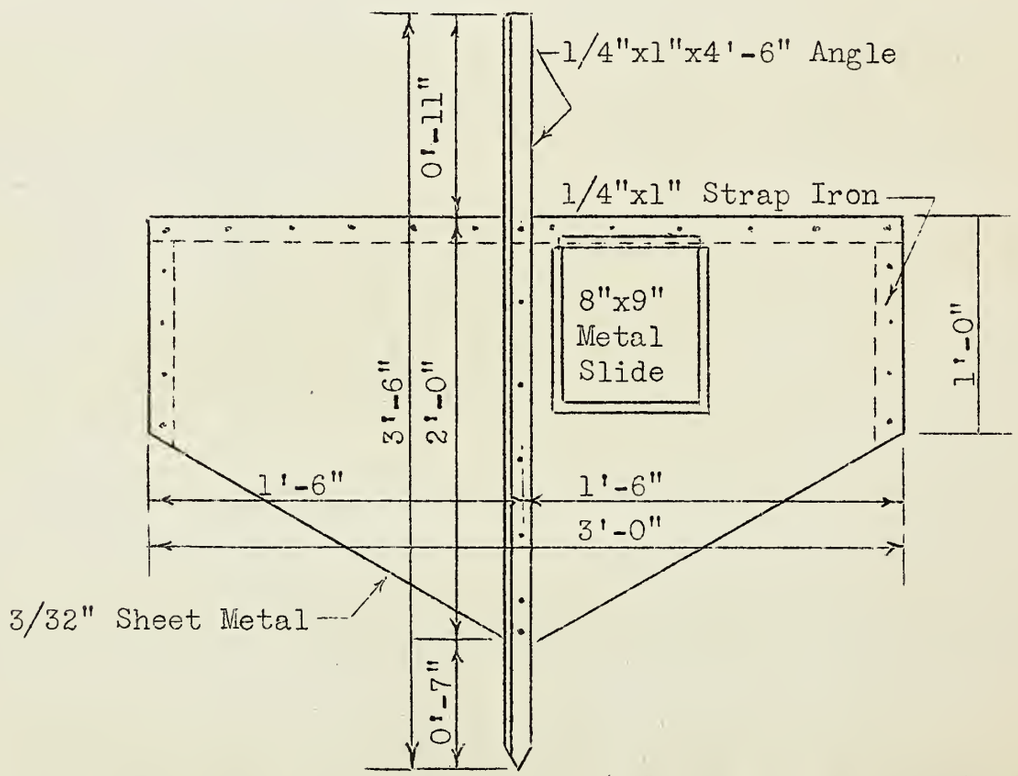


Figure No. 7
A portable metal dam of proper dimensions for main ditches of 16" to 24" bottom width. Smaller units of lighter design are recommended for laterals. One or more metal slides for by-passing water may be used.

LEVELING THE GROUND SURFACE

Fields which appear smooth and uniform to the eye may cause considerable trouble when an attempt is made to apply irrigation water. Small irregularities of a few inches may either divert the flow from the tree rows or cause a pool of dead water to form. The irrigation leveler, consisting of a frame from 16 to 24 feet long with cross-members spaced at uniform intervals, dragged over the ground surface removes these minor irregularities by cutting off the high points and filling in the depressions. The action is somewhat like a plane smoothing the surface of a board.

Leveling may be necessary for several seasons to produce the best results, but considerable benefit will result from one or more applications in the same season. The leveler should be used only when the ground surface is fairly dry and in good tilth so that the dirt will move readily ahead of the cross-members. If possible, the leveler should be drawn once lengthwise of the field, once crosswise, and once diagonally each season after the soil has been plowed or disced preparatory to planting. In sandy soils where three applications would be likely to produce a state of pulverization, which would be conducive to blowing, one application may have to suffice. Isolated high points and deep depressions may require the use of a blade road grader or slip scraper.

DIRECTION AND LENGTH OF TREE ROWS

Since most of the nursery sites are fairly level, the tree rows may be carried directly down the slopes as indicated on the contour map. In a few cases erosion has resulted and difficulty has been encountered with getting water penetration to the subsoil where rows were carried down slopes of $2\frac{1}{2}$ feet per 100 feet on rather tight, difficult soils.

The following slopes are the maximum down which tree rows should be carried:

Rather tight and difficult soils	... 1.5	feet per 100 feet
Sandy loams	... 1.75	" " " "
Very sandy soils	... 2.00	" " " "

Where steeper slopes exist, the rows may be located on the contour or across the slope.

The distance which water may be economically carried down tree rows varies with the slope, the head of water available, and the soil type. For instance, on sandy loam soils, when water is turned into a tree row, the stream will advance down the row at a uniform rate of so many feet per minute for a certain distance. Then the rate of advance gradually slows down until a point is reached where little or no progress can be noted. It is evident that the part of the tree row near the point of diversion at the main ditch is then being over-irrigated whereas the far end of the row will be getting no water at all. For sandy loam soils a "carry" of from 450 to 650 feet down a tree row should ordinarily produce good results. The distance may be increased somewhat on tighter soils. The exact distance which should be used for the given slope, head of water, and soil can be deter-

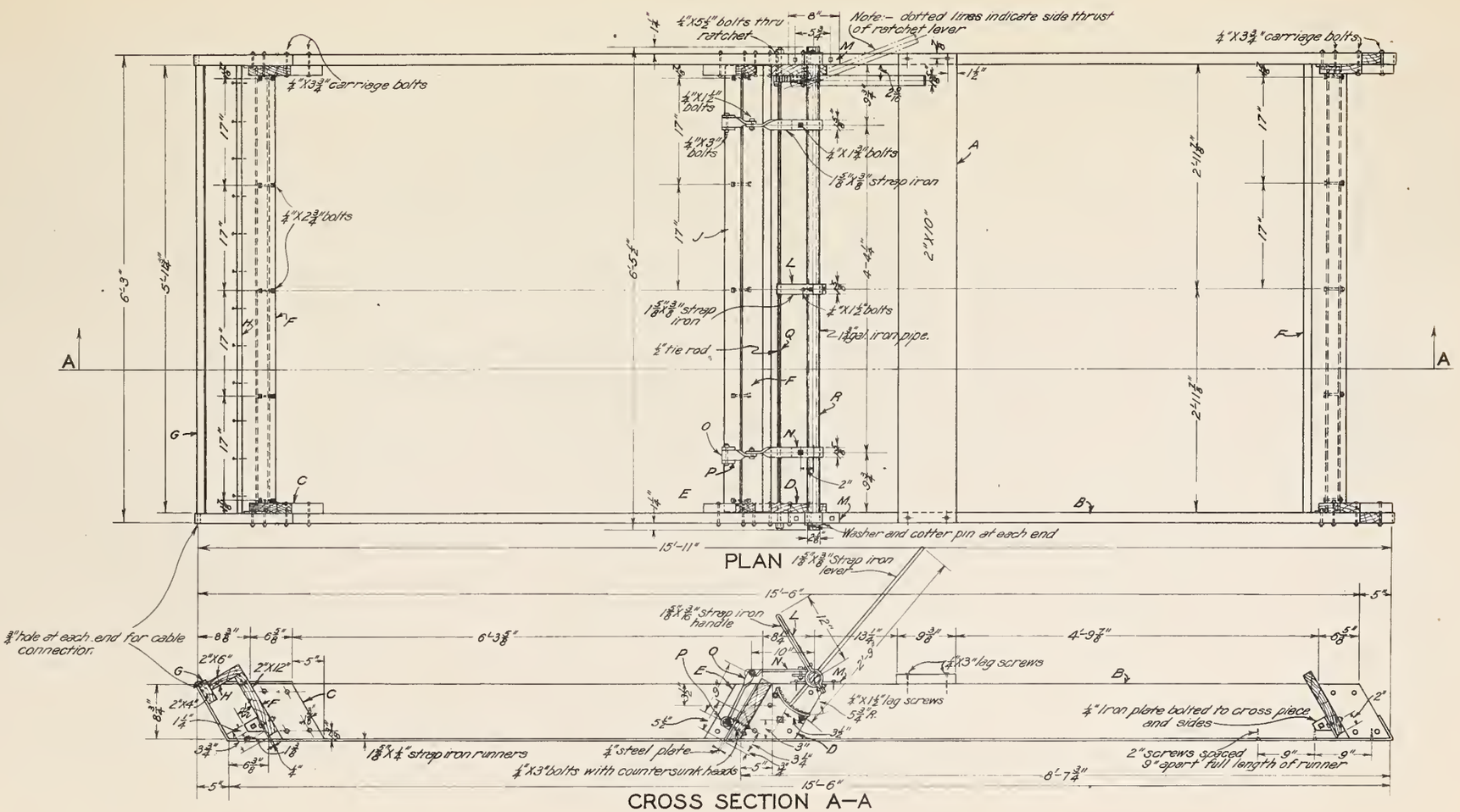
mined only by experience with the particular field in question.

When difficulty is experienced in carrying the water the full length of the rows due to rapid percolation, it is often the best procedure to try using a larger head, that is to increase the quantity of water entering each row. A second expedient consists of plowing a shallow trench down one row through which a fairly large head may be carried to the far end of the field where it may be diverted to several rows which could not be reached by ordinary means. Often the canvas hose will solve the difficulty in the most satisfactory manner.

R-2
Forest Service
PLANS FOR
LEVELER
BESSEY NURSERY
Nebraska National Forest

Note: this implement [illegible] recommended for small sections, especially in [illegible]ing sections where water lines and rises are much in the way.

Scale



BILL OF MATERIAL

PART	DESCRIPTION AND SIZE	PART	DESCRIPTION AND SIZE	PART	DESCRIPTION AND SIZE
	Lumber	K	2 pc. strap iron ⅛"X¼"X17'-10½"		2 machine bolts ¼"X3"
A	1 pc. 2"X10"X8'-0"	L	1 pc. " " ⅛"X⅜"X30¾"		2 " " ¼"X1¼"
B	2 pc. 2"X10"X16'-0"	M	2 pc. " " ⅛"X¼"X10¾"		2 " " ¼"X1½"
C	1 pc. 2"X6"X6'-0"	N	2 pc. " " ⅛"X⅜"X19½"		2 " " ¼"X1½"
D	1 pc. 2"X8"X4'-0"	O	2 pc. " " ⅛"X⅜"X10"		1 " " ¼"X2¾"
E	1 pc. 2"X4"X4'-0"	P	1 pc. " " ⅛"X⅜"X 5½"		2 " " ¼"X5½"
F	1 pc. 2"X12"X18'-0"	Q	1 pc. round iron rod ½"X6'-5½" (threaded both ends)		4 lag screws ¼"X3"
G	1 pc. 2"X4"X6'-0"	R	1 pc. gal. iron pipe 1½"X6'-5½"		4 " " ¼"X1½"
H	1 pc. 2"X6"X6'-0"		2 cotter pins ¼"X3" & 2 washers 2¼" dia (for 1½" gal. pipe)		52 wood screws 4"X 14 gauge
	Hardware		28 carriage bolts ¼"X3¾"		1 lb. 20d nails
I	2 iron plates ¼"X3¾"X6'-4½"		19 machine bolts ¼"X2¾"		
J	1 Steel plate ¼"X5½"X5'-11½"		2 machine bolts with ctrsunk heads ¼"X3"		

Drawn by R.F.B. 9-24-32 Denver Colo

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UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Plains Shelterbelt Project

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SECTION B

SHELTERBELT SEED PRACTICE

SEED COLLECTION

General

The seed collector is charged with the responsibility of (1) selection of seed areas and seed trees, (2) collection of mature seed, (3) collection of viable seed, (4) safe care of seed from the time it is collected until it is delivered to the extractory, and (5) maintenance of the necessary seed collection records.

Selection of Source

Collectors should be definitely aware that seed collected from hardy native or approved exotic trees is the initial and most important step towards a successful shelterbelt. It is the foundation upon which the Shelterbelt program rests. It is hoped that in the future the seed collectors will be more selective so as to avoid collecting any seed from weak or inferior trees. It is far better to fall short of the collection quota than to compromise by obtaining seed of questionable source and hardiness.

Collection of seed from selected specimen trees or groups of trees that show exceptional form and vigor and of proven hardiness, should be given a separate accession number from the other collections. Every effort should be made to make up the entire seed quota from such trees.

The Lake States memorandum of September 10, 1934, "Outline for Seed Collecting", copies of which are available, should be studied by each collector and the instructions therein pertaining to location of seed sources carefully observed. In short, these instructions are to confine collection as far as possible to within the Shelterbelt Zone, and to the same latitude as that in which the seedlings are to be planted. (See Fig. 1, Seed Zone Map)

Time of Ripening

Maturity of seed is important. Immature seed is definitely of lower keeping quality than well-ripened seed, and will also show lower germinative capacity. On the other hand, data are available to show that certain species, such as viburnums, crataegus, and a few others, may germinate more readily if the seed is collected while still relatively immature.

Failure to follow closely the progress of ripening for species such as elm, caragana, etc., that hold their seed for only a few days after maturity, may result in loss of the crop. Also for some other species it is often necessary to collect the seed immediately after ripening to guard against loss by birds and rodents. For all these species frequent inspections to determine the exact ripening date is necessary rather than depending on the average ripening date.

Color is usually the most reliable indicator of seed maturity. Fleshy or pulpy fruit, such as mulberry, hackberry, plum, and chokecherry, will become more deeply colored and soft when mature. Dry fruited species, such as ash, locust, and oak, generally assume a darker color when ripe and the seed kernel loses its soft milky form and becomes firm. Since for some species the first seed to ripen and fall is usually of poorest quality, it is generally advisable to wait until such seed has fallen before making the collections.

Cutting Tests

Quality or viability of the seed should always be determined by actual cutting test for individual trees before the seed is collected, if a careful examination of the area in advance discloses that a variation in viability by individual trees exists. When this practice is carefully followed it will result in the elimination of weeviled and hollow seeds before any considerable labor and money is expended. A small size wire nipper should be standard equipment for all seed collectors and strawbosses in charge of collecting crews. With this tool a quick examination of the seed on individual trees can be made.

Care of Seed Immediately After Collection

Care of the seed immediately after collection before it reaches the extractory is of the utmost importance. With few exceptions, freshly gathered seed will heat if piled and left undisturbed for as little as one or two hours for some species. Individual circumstances, therefore, will dictate the action necessary for the collector to take in order to insure that the seed is sufficiently clean and dry to arrive at the extractory without having heated. Supplying adequate aeration is the essential factor in handling freshly collected seed.

Records

The collector will be responsible for keeping the necessary records set forth in this section of the manual. Records have been reduced to a minimum in order to simplify this part of the work as much as possible. Every effort must be made to maintain these records, since the whole accession number system is tied directly back to the records originally submitted by the seed collector. If he fails to fulfill his part, all future records for that accession number are largely without value.

Equipment

In addition to adequate transportation equipment, a collecting crew should have for the season's work: ladders (Fig. 2 illustrates a convenient type), picking bats, heavy leather gloves (for certain species), bamboo poles of various lengths, sacks, tags, twine, small wire nippers, seed strippers, and tarpaulins. Eight ounce duck tarpaulins 14 by 16 feet are preferred since on heavier tarpaulins the seed bounces badly when it lands, much of it bouncing entirely off the sheet and being lost.

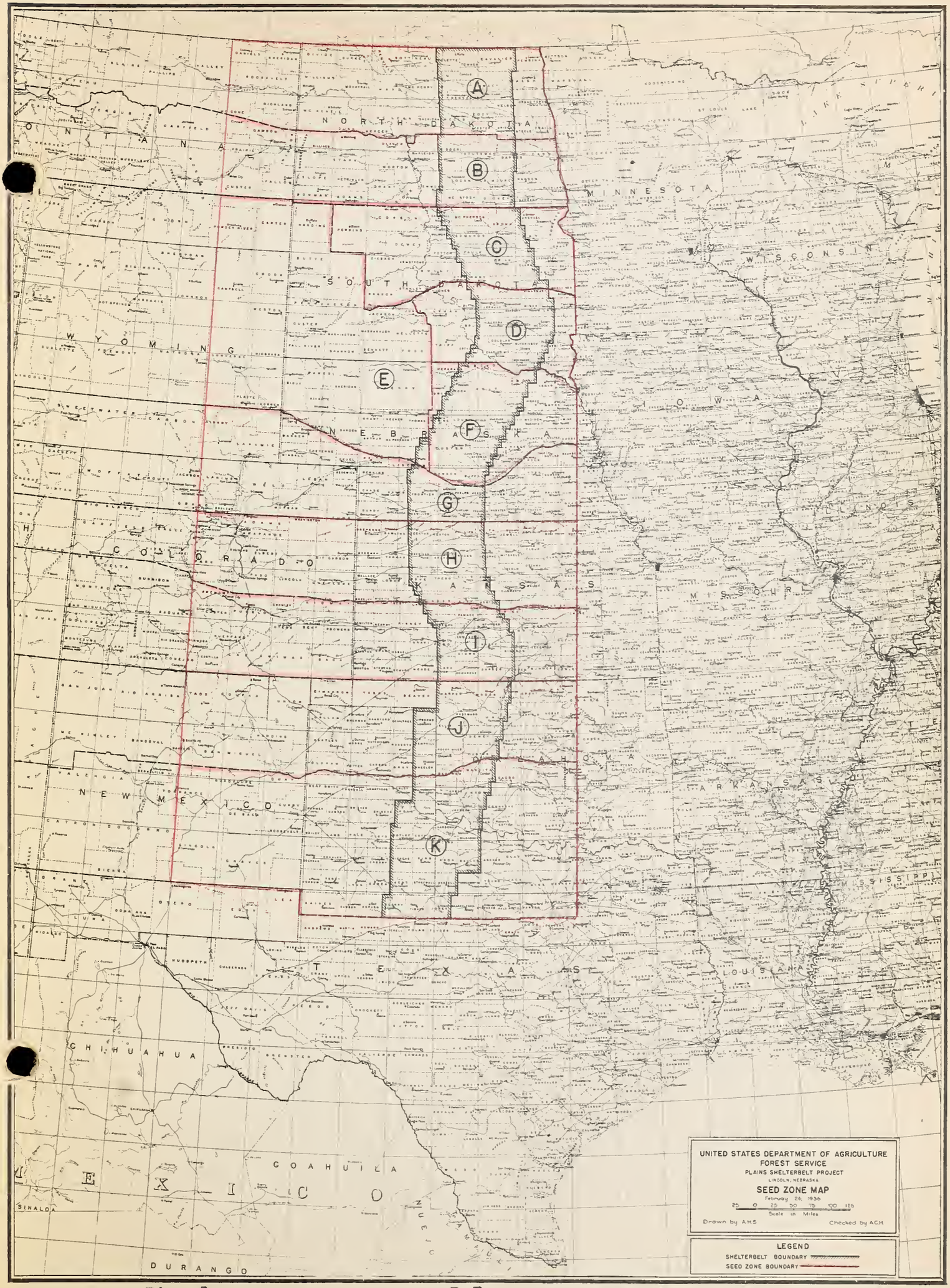
A
B
C
D
E
F
G
H
I
J
K
NORTH DAKOTA
SOUTH DAKOTA
MONTANA
WYOMING
NEBRASKA
COLORADO
KANSAS
NEW MEXICO
OKLAHOMA
TEXAS
MINNESOTA
IOWA
MISSOURI
ARKANSAS
LOUISIANA
ILLINOIS
WISCONSIN
CHIHUAHUA
COAHUILA
DURANGO
SINALOA
UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PLAINS SHELTERBELT PROJECT
LINCOLN, NEBRASKA
SEED ZONE MAP
February 26, 1936
25 0 25 50 75 100 125
Scale in Miles
Drawn by AHS
Checked by ACH
LEGEND
SHELTERBELT BOUNDARY
SEED ZONE BOUNDARY

Fig. 1

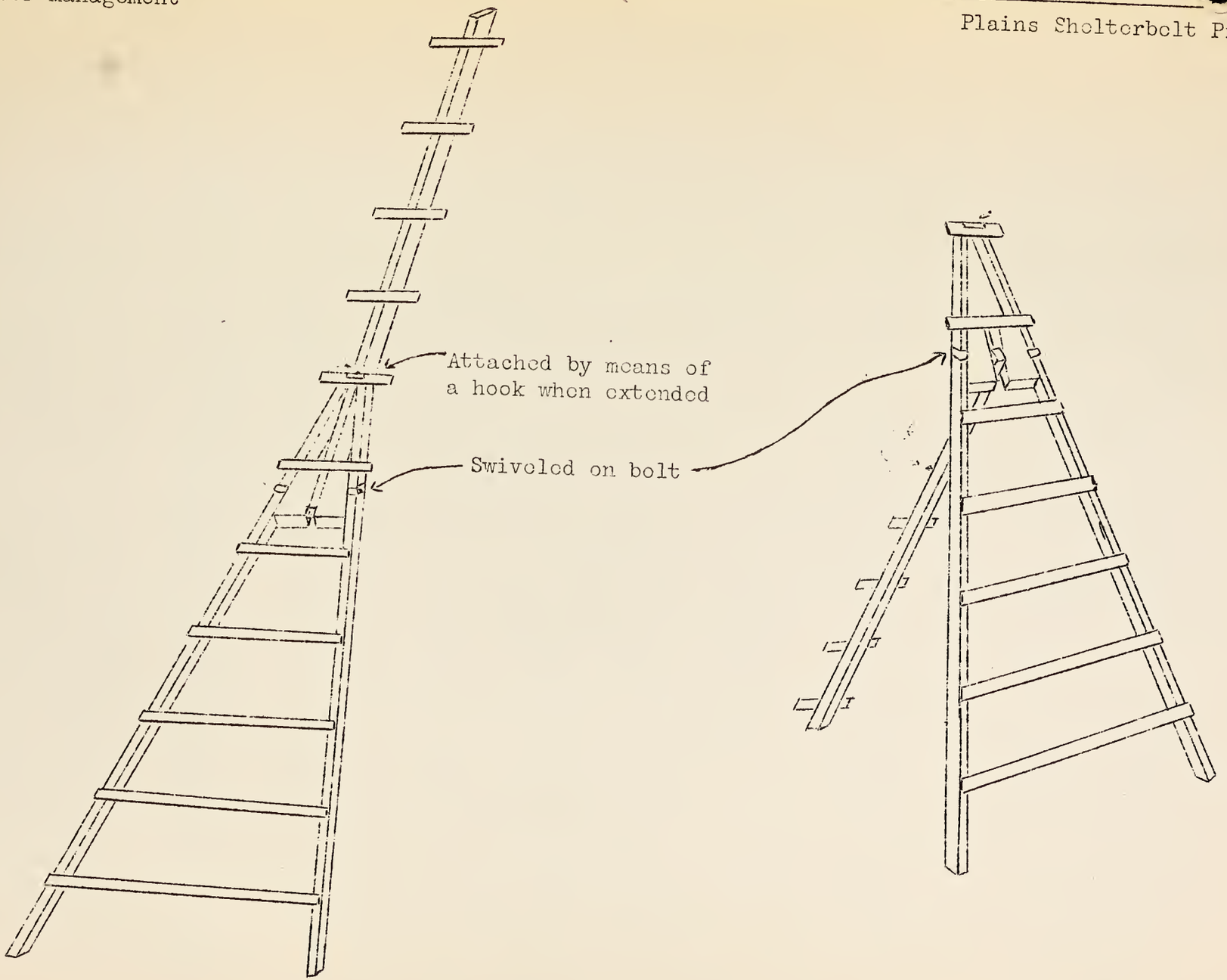

Fig. 2

Illustration showing principle of convertible seed pickers' ladder Developed by Nebraska

General

For administrative purposes, as well as from the standpoint of future inspection or follow-up work, it is necessary that a record be maintained of the original source of all seed. This will be done by giving the seed an identifying number which follows it through the nursery and to the field when planted. Likewise all purchased nursery stock and wildings will be given such a number. This identifying number has been designated as the accession number.

Seed Collectors' Identification Records

The initial step in maintaining the accession number system is the responsibility of the seed collector. He will be supplied with printed labeling tags for field use as illustrated in Fig. 3.

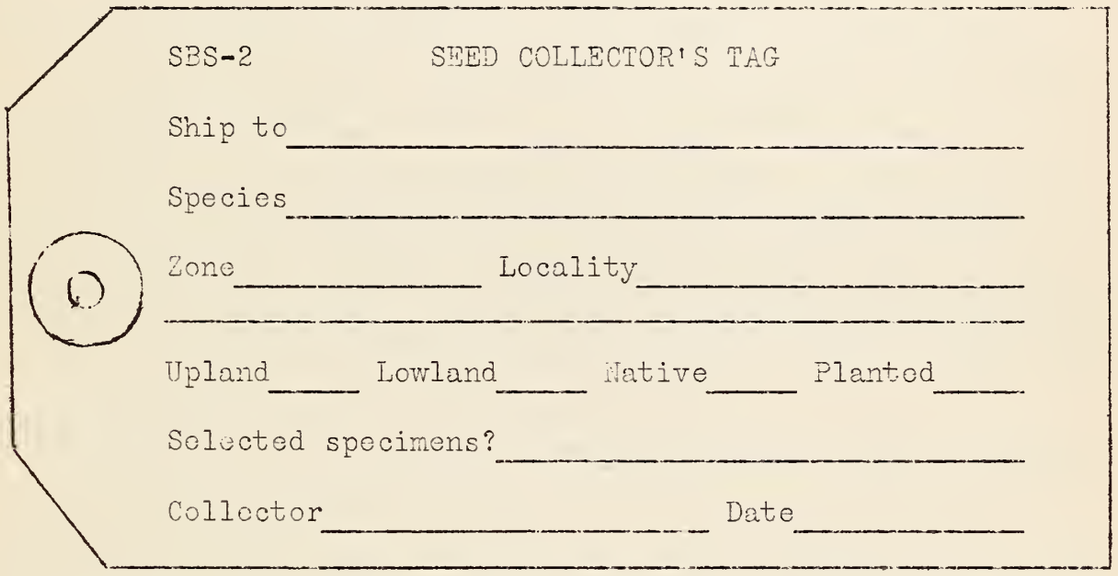

Fig. 3 Form SBS-2, Seed Collector's Tag. To be stamped on back of Government shipping tag Form 341.

Lowlands are defined as river bottom subject to periodic overflow or where the water table is high. Irrigated trees will be considered as lowland trees.

Each lot of seed sent in to the extractory by the collector will be identified by the above label. The nurseryman in charge of the extractory is then responsible for assigning all seed collection lots from comparable localities and conditions the same accession number. As stated before, collections from the selected specimen trees or groups of trees will be given a separate accession number.

The standard for combining collection lots can be stated briefly. The general run of collections (not the selected specimens) from any one zone in each State of each species from native upland trees should be combined under one accession number. Collections from native lowland trees will be grouped similarly. Nothing will be gained by so separating the general run of collections from introduced species such as caragana, Russian olive, Chinese elm, etc., except for the selected specimens or for varietal strains. Ordinarily, therefore, one accession number per zone for each State will suffice for such species.

It should be clearly understood that the responsibility for combining seed lots and assigning accession numbers rests with the nurseryman in charge of the central seed extractory. The seed collector is responsible for supplying the information necessary to intelligently combine the various collection lots.

The Composition of the Accession Number

The accession number given the seed will show the following information: zone (See Fig. 1), year of collection, and accession number. For example, E35-1, E35-2, etc.; the "E" stands for the zone designation, "35" for the year 1935, and "1" for the accession or serial number. Occasions will arise where seed is carried over from year to year; therefore it is desirable to include the year of collection in the identifying number. The accession or serial number will run consecutively upward from No. 1 by States (not by zones) for all collections made from any one year's crop by the State unit. A new series of accession numbers will be started each year.

Purchased Seed or Nursery Stock

All seed purchased by the State or Regional Office, or contributed by other Government agencies, that cannot be thrown into a larger lot, will be designated by the letter "P", for example, E35P-3. All seed vendors will be asked to fill out the card illustrated in Fig. 4. This card, if properly filled out by the seed vendor, will give the necessary information to give the seed the complete accession number. In this case the year of purchase will be used instead of the seed year in the event the seed year is unknown. Likewise, purchased nursery stock will be handled the same way. An accession book entry will be made for all such purchased stock.

SBS-3 SEED VENDOR'S CARD

Species_____ Price_____ Wt._____

Year Coll._____ Locality_____

Upland_____ Lowland_____

Native_____ Introduced_____

How stored_____

Remarks_____

Signed_____
(Vendor)

Fig. 4 Form SBS-3. Seed Vendor's Card (size 3 x 5)

Seed From Outside Sources

Seed obtained outside the Shelterbelt seed zones, but of known origin, for example Chinese elm seed from Washington State, will be designated by the letter "W" in place of the zone designation. Seed obtained outside the Shelterbelt Zone but of unknown origin, such as purchases from seed houses, will be designated by the letter "X" in place of the zone designation.

Transfer of Seed and Nursery Stock Between States

Seed which is collected in one State and assigned an accession number and then subsequently transferred to another State, will be assigned a new accession number in the receiving State, taking the home State's zone and year designation but the receiving State's series of accession numbers. In the accession record book the home State's accession number will be referred to as the source of the seed. In transferring seed, therefore, from State to State it is necessary that the home State be certain that the seed is properly labeled with its accession number. The same procedure applies to nursery stock and wildings that may be transferred from State to State. In all cases an entry is made in the receiving State's accession record book.

Accession Record Book

Records of accession numbers as assigned will be kept in a bound book as a permanent record. Appropriate accession record book entries are as follows, using Nebraska as an example:

E36-1 American elm seed
110 lbs. green weight collected from native upland trees on John Smith farm near Ord, Nebr., May 12.

75 lbs. green weight collected from native upland trees on Harry Johnson farm near Ord, Nebr., May 13.

(Where numerous collections are made which are included under one accession number, allow space for subsequent entries.)

W36-2 Chinese elm seedlings
10 M 12-18 seedlings purchased from House of Gurney, Yankton, S.D. Seed source Washington. May 15.

B36-3 Chinese elm seed
20 lbs. clean seed transferred from N.D., May 19. North Dakota accession number, B36-12.

Other Administrative Seed Records

Form SBS-1, Extractory Seed Record, illustrated by Fig. 5, will serve for recording all information pertaining to the care and disposal of seed.

After the seed is distributed to the nurseries for planting, Form SBS-1 and the accession record book will be transferred to the State Director's office where the essential information will be available for later follow-up work in the nurseries and on the strip. In case a quantity of seed is held over in storage, a duplicate Form SBS-1 will be filled out and sent to the State Director.

Form SBS-5a, Seed Source Record Card for Field Use illustrated by Fig. 4a, will be used by field men to record currently new seed sources as they are located. These cards will be turned in to the State Director's office at periodic intervals as determined by the State Director, and the information recorded on Form SBS-5.

SBS-5a SEED SOURCE RECORD CARD
(For Field Use)

Species _____

Owner's Name _____

Address _____
(Give explicit directions for locating on back of card)

Est. No. acres or trees _____

Av. ht. seed bearing trees _____

Date _____ Name _____

Fig. 4a Seed Source Record Card for Field Use
(Size 3 x 5)

Form SBS-5, Seed Source Record Card illustrated by Fig. 4b, will serve as the State Office record of available seed sources for each species. It is designed so that a yearly entry can be made recording the amount of seed collected from each source.

SBS-5 SEED SOURCE RECORD CARD

Species _____

Owner's Name _____

Address _____

Further directions for locating _____

_____

_____

_____

_____

Estimated number acres or trees _____

Average height seed bearing trees _____

Pounds rough weight collected:

_____ 1935	_____ 1936	_____ 1937	_____ 1938	_____ 1939
_____ 1940	_____ 1941	_____ 1942	_____ 1943	_____ 1944
_____ 1945	_____ 1946	_____ 1947	_____ 1948	_____ 1949
_____ 1950	_____ 1951	_____ 1952		

Date _____ Name _____

Remarks: _____

_____

_____

_____

_____

_____

Fig. 4b Seed Source Record Card (Size 5 x 8)

SBS-1 EXTRACTORY SEED RECORD

Accession No._____ Species_____ State_____

Date Rec'd	Source	Rough Weight	Shipped To	Date	Lbs.	Balance Dry	Balance Strat.

Total Rough Wt. _____
Total Clean Wt. _____
Extrac. Factor % _____
Seeds per Pound _____

Extractory Test %_____ Lake States %_____
Cleaning Method_____
Storage & Pretreatment_____

Fig. 5 Extractory Seed Record
(size 5 x 8)

SEED EXTRACTION

General

Each State will be equipped with a central extractory for the extraction and drying, winter storage and stratification, and finally shipping the seed to the nurseries for sowing.

The ideal extractory will contain adequate floor space and be equipped with running water, electricity, sewer drain, and should be insulated so that winter work is possible. It will also be desirable to have in conjunction a root cellar or basement, or a nursery storage warehouse where the temperature can be maintained between 35 and 45° F. during the winter months for stratifying seed.

Seed Cleaning

Cleaning seed is a job requiring considerable judgment and ingenuity. It is desirable to select a limited number of capable men for this operation and keep them at it steadily rather than continuously breaking in new men, having a large crew one day or week and only a few men the next. More seed will be cleaned and a better job accomplished as the men become more familiar with the work.

Seed Extraction Equipment

Standard equipment at an extractory should include electric motor, seed macerator, rotary dryer, a large fan, fanning mill, tanks and barrels, stratification boxes, and storage cans for dry storage of seed. Of necessity there will be considerable miscellaneous equipment.

One seed cleaning device has been perfected by Nebraska which, when used in conjunction with a fanning mill, is capable of extracting the seed of a high percentage of the deciduous species, as well as cedars. This machine is of all metal construction made on the principle of a threshing machine with a cylinder and concaves. The metal cylinder is 12 inches long, 5 inches in diameter, and has tempered steel rivets projecting and spaced at 1-inch intervals. These teeth mesh with teeth projecting in a similar manner from the concaves, of which there are two, set opposite each other on the front and rear sides of the cylinder. A feeding hopper is set above the cylinder, while the discharge is at the bottom. The size of the discharge opening is controlled by a metal slide, thereby enabling the operator to hold the material in the cylinder until thoroughly macerated if such procedure is necessary. To the cylinder is attached a graduated V pulley which enables this machine to be powered by a 1/2 HP electric motor. The number of RPM can be controlled by the V pulley, and can be varied from approximately 400 to 1700 RPM. For most types of seed about 800 RPM is the most satisfactory speed.

This machine has been used very successfully for depulping fleshy fruits, such as plums, chokecherry, mulberry, buffalo berry, Russian olive, red cedar, etc. To handle these fruits it is necessary to have a continuous flow of water going into the machine to wash the pulp and seed through the discharge as soon as they are macerated to the proper fineness. Following the macerating operation, the seed of most of the pulpy species can be separated from the pulp by floating in water. The good seed will sink, while the pulp and light seed will float off the top if the proper agitation is applied to the water.

Seed of such species as ash, black locust, honey locust, caragana, etc., which are threshed dry, are separated from the wings, leaves, and other refuse by putting through a fanning mill.

Other devices have been used for extracting seed, such as fruit-presses, cider presses, clothes wringers with the rollers wrapped with stove wire, food choppers, motor driven washing machines, etc. Most of these are of limited adaptability insofar as range of species they will handle.

A rotary seed dryer developed by the North Dakota organization for drying red cedar seed will greatly expedite all seed drying work at the seed extractory. This drier (see Fig. 6) consists of a 32-inch screen wire cylinder 32 inches long with wooden ends of one-inch lumber. The three 1 x 3 inch baffle boards equally spaced on the circumference of the cylinder pick up the seed as the drum revolves. The seed picked up by the baffle boards is slowly spilled in a thin stream as the baffle board reaches the top of its revolution. Warm air supplied by a heater and an electric fan is forced through the cylinder and hastens the evaporation of moisture. A band of belting is placed around one end of the drum to provide track for the power belt. Power is supplied from an electric motor, 1/8 HP. The motor is slowed down with a set of washing machine gears to operate the drum from 12 to 15 RPM.

This machine dried 20 pounds of red cedar seed in one hour's operation, whereas, screen wire trays of seed showed only slight drying after a week's exposure in the same room.

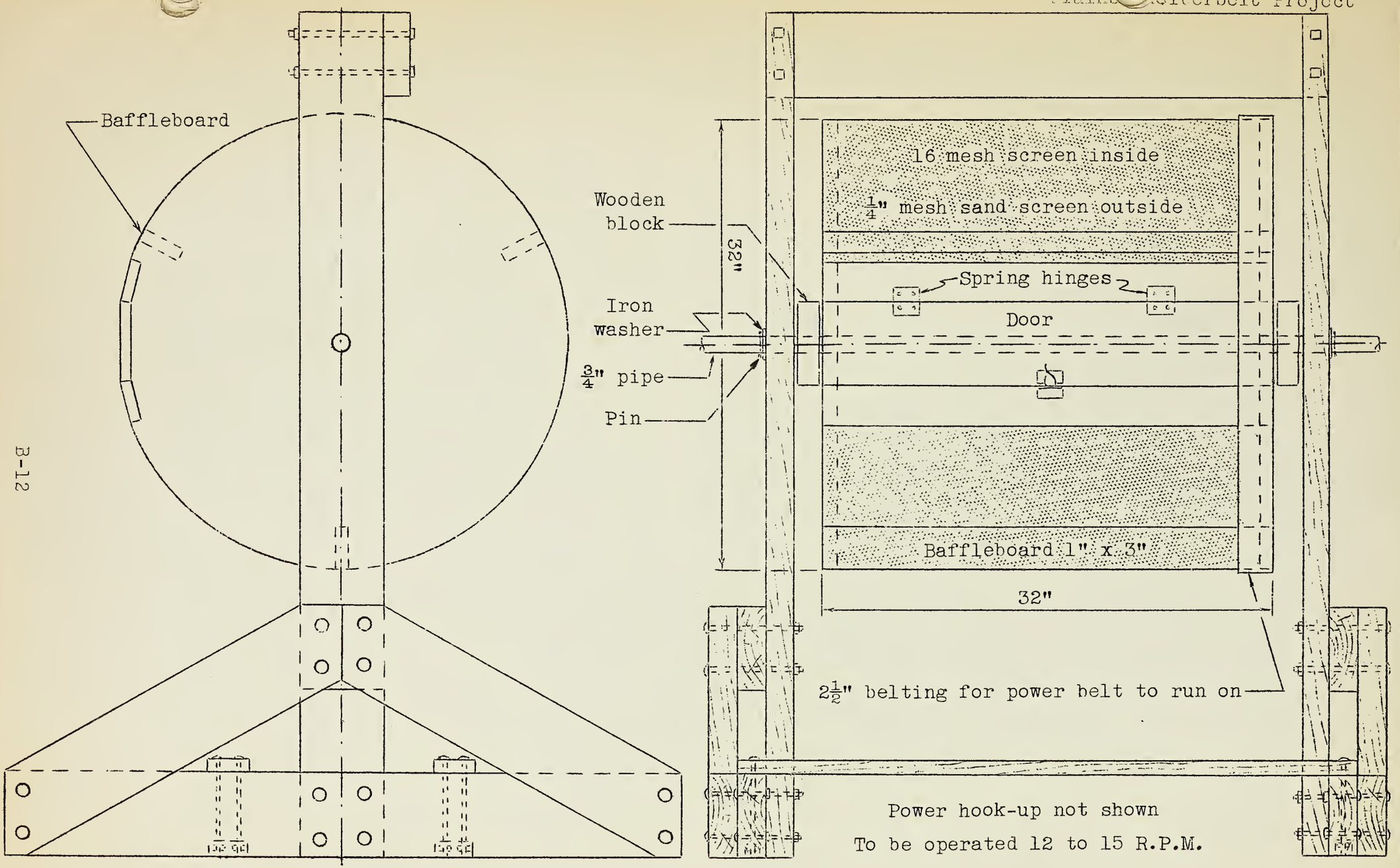

Fig. 6
ROTARY SEED DRIER
(Developed by North Dakota)

DRY STORAGE OF SEED

Storage of seed is a vital process in its effect on the vitality of the seed. The essential part of the seed, the embryo, is alive just as a dormant plant is alive although the seed is in a comparatively inactive stage. As storage conditions in our packing sheds or heel-in conditions affect the vitality of the seedlings, so the conditions under which seed is stored affect the vitality of the seed. Conditions should be such as to keep the embryo in an inactive state. The temperature should therefore be kept fairly low and uniform, about 50° F. preferably, and the atmospheric humidity relatively low. Extremes in both temperature and humidity are injurious and must be avoided. Storage under moist conditions, with proper temperature and an available supply of oxygen, may be sufficient to start germination and will result in a loss of vitality and also may cause the seed to heat.

For best results seed in dry storage should be kept in tight containers. This is especially essential where seed is to be held over in storage a year or more, since a constant high oxygen content keeps respiration at a high point with a constant loss in vitality. In no event should seed be piled so that it will be under appreciable pressure.

Much is yet to be learned about the longevity or period of time the seed of many of the shelterbelt species will retain their viability. Fairly reliable information is available for some species. For example, all nurserymen know that American elm will under normal conditions lose its vitality in just a few weeks, and that green ash, caragana, and locust can be held over for a number of years quite successfully.

SEED TESTS

Seed testing is an important phase of our seed and nursery work, and no seed should be sown that has not been tested in some manner before sowing. Germination tests are the most reliable indication of a seed's vitality. Every effort should be made, therefore, to submit samples of all summer and fall collected seed to the Lake States Forest Experiment Station for germination tests whether the seed is fall sown or not, since the results of the tests will indicate to the nurseryman what success he can expect. In some cases it may be possible by means of the tests to detect partial or total failure of fall sown blocks in time to resow to viable seed. Seed samples of spring collected species will not be sent to the Test Laboratory unless there is ample time to make complete tests before sowing in the nurseries.

In submitting samples to the Lake States Forest Experiment Station, fill out for each accession number a Form M-5166 showing the proposed method of winter storage and special pretreatments, and send in with sample of 5000 seeds to the Lake States Forest Experiment Station, University Farm, St. Paul, Minnesota. Samples should be taken from the thoroughly mixed lots making up each accession number, and should be sent in currently as collection quotas are completed or approximately completed, and in no event later than December 1. Letters of transmittal will be sent with each sample or group of samples submitted with 2 copies of the letter to the State Director, who in turn will furnish the Regional Office with a copy.

Many nurserymen desire to run their own germination tests as an immediate check on all seed they intend to sow. This is done by counting out several hundred seeds of each species and placing them between moist blotting paper, folds of cloth, or in moist sand or soil, and holding at proper temperature. Some difficulty may be experienced from the seed molding if the medium is other than soil or sand. After the proper period has elapsed, which varies according to the species, the percentage of viable seed can be determined by counting the seed which have germinated. Unreliable results may be obtained from such tests if they are not allowed to progress far enough. Most seeds should not be counted as having germinated until the appearance and unfolding of the first leaf or leaves which may or may not be the cotyledons. The mere appearance of the radicle should not be construed as germination, since many weak seeds are capable of putting forth the radicle but exhaust their vitality in so doing and subsequently perish.

Cutting tests especially for fall sowing is the most feasible method for the nurseryman to determine the percentage of seed viability. This is done by counting out one or two hundred seeds and cutting them open with a sharp knife or small wire nipper. The embryo of good seeds is sound, fills the cavity completely, and is of good color, usually white.

SEED PRETREATMENT

Seed Dormancy

Many species of seed although viable are incapable of germinating immediately upon maturity or upon leaving the parent plant. This condition is known as dormancy or delayed germination, and is usually a characteristic of seed produced in late summer or autumn.

The type or causes of dormancy of the seed are usually inherent within the seed. Perhaps the most important causes in order of priority are: (1) Seed coats which prevent or delay the intake of water; (2) embryo dormancy or after ripening; (3) other less important causes such as imperfect or rudimentary embryos,

seed coats which are impermeable to gases, and embryos which are incapable of exerting sufficient force or pressure to rupture the seed coat. Numbers (1) and (2) above or a combination of both are the major causes of shelterbelt species seed dormancy.

Acid Scarification

To expedite the germination of seeds whose coats are impermeable to water, examples of which are locust, hackberry, and coffee tree, some form of treatment that will render the seed coat permeable to water is recommended. Acid scarification if properly used is very successful. Concentrated sulphuric acid sp. gr. 1.84 is used for this purpose. The details of this and other treatments are given under the discussion of the individual species.

Mechanical Scarification

Mechanical scarification for the impermeable seed coat type of dormancy is also widely practiced among nurserymen. It has perhaps been more widely used in preparing juniper seed for sowing than for any other species. The seed is scarified in a round drum at least 3 feet in diameter lined with No. 2½ grade 30E silicon carbide sandpaper. This drum when rotated slowly, 20 to 30 RPM, has an abrasive effect on the seed that eventually reduces the thickness of the seed coat, rendering it permeable to water. The length of treatment varies according to the nature of the seed. Usually when the seed coat can be punctured by pressure of the thumb nail, scarification has progressed far enough.

Stratification

The embryo dormancy characterizes many species such as green ash, Osage orange, Russian mulberry, etc., and may be broken by stratifying the seed in a moist medium at temperatures slightly above freezing. Stratification is also helpful to seeds possessing impermeable seed coats, since it permits such seeds to absorb water over a long period of time. Fall planting in moist soil has the same effect.

Sand or peat are the stratification mediums that are commonly used by commercial and Government nurseries. Sand has been used more extensively than peat because of its ready availability. On the other hand, peat is favored over sand because of its texture, comparative weight, and moisture holding capacity. Peat is more difficult to separate from the seed than sand in the spring prior to sowing, but since the bulk of the seed is broadcast sown, no harm will be done by sowing the peat along with the seed. Stratifying seed which retain their pulp, such as Russian olive and hackberry, in pure peat is dangerous, since it is apt to heat. In such cases, stratifying in sand or mixtures of sand and peat is the safer procedure.

Stratification can best be done in rooms where the temperature can be artificially controlled. The optimum temperature is 41° F. for stratifying most seeds, but no harm is done if the temperature should vary from 35 to 45° F. However, wider variation should be guarded against. For that reason basement cellars, root cellars, and nursery packing sheds are to be desired for storing stratified seeds.

To facilitate handling and distribution of the seed in the spring, it is important that the dry seed going into each individual container be weighed in the dry condition before mixing with the peat and the weights recorded on the card record attached to the container.

The peat should be thoroughly granulated or shredded and be just moist enough so that no free water can be squeezed from it by closing the hand firmly on a small handful. This can best be done by soaking the granulated peat in a barrel or tank for several days before mixing with the seed, adding no more water at each application than will be taken up by the peat. The excess moisture can be removed by applying pressure to the peat. A small box with drilled holes in sides and bottoms can be easily constructed to serve as a press box for removing the excess moisture. Moistening the dry peat with a hose just before mixing with the seed results in uneven moisture conditions, and therefore it is necessary that the peat be thoroughly soaked and the excess water removed.

The correct proportion of peat and seed will vary for the different types of seed. A safe rule is that each seed should be practically isolated. Usually 50 to 60 per cent peat by volume will accomplish this result. The seed and peat should be thoroughly mixed before puting into the boxes. The boxes should be firmly but not solidly packed.

The following table taken from the North Dakota seed report shows the number of pounds of dry peat moss required to stratify 100 pounds of seed on a 50-50 volume basis:

Species	Weight of Peat
Hackberry	24
Russian olive	48
Black haw	60
Chokecherry	24
Green ash	115
Lilac	56
Wild plum	28
Red cedar (scarified)	24

At three week intervals throughout the winter each box of stratified seed should be emptied on to a clean floor, water added if necessary by sprinkling, shoveled over, aerated for an hour or so, and then put back into the box. More uniform stratification will thus be assured, and molding and heating will be prevented.

Sand stratification in outside pits or large containers is approved for such large seeded species as oak, walnut, apricot, and plum. Seed stratified outside, especially in midwinter, should be allowed to soak up moisture first, since stratification is primarily a process of moisture absorption and freezing will reduce this absorption. Stratification from the outset at below freezing temperatures is definitely not recommended.

Seed of some species, such as plum, chokecherry, lilac, honeysuckle, etc., will often sprout in stratification as spring approaches even though the temperature is maintained at or close to 41° F. and the usual stratification period has not elapsed. Frequent inspections of the stratified seed is, therefore, necessary, and if sprouting is observed the seed should be placed in cold storage at from 32 to 34° F., and maintained at that point until it is sown.

In the spring when the seed is removed to be sent to the nurseries for planting, extra precaution should be taken to make certain that the seed will arrive at the nurseries in good condition. Drying out and heating should be guarded against.

Water Soaking Just Prior to Sowing

The absorption of water is necessary for all species before germination can take place. Many spring sown species which are characterized by embryo dormancy, impermeable seed coat, or for which no actual dormancy exists, will have their germination period shortened by soaking in water or very moist sand prior to sowing. Species such as green ash, sumac, mulberry, and lilac are assisted in this manner. In fact there is evidence to show that many other species, even elms, respond readily to such presowing absorption of water.

In soaking seed in water prior to sowing, care should be taken to change to fresh water each day, otherwise the water becomes sour and has a detrimental effect. Placing the seed in running water, if possible, is recommended.

Any treatment that will shorten the germinating period after sowing is helpful, since this period is the most critical of the entire nursery season. Therefore the shorter it can be made the less danger of losses there will be from heat, damping off, drought, etc.

SEED COST RECORDS

Objective

The objective of seed cost records will be to obtain the cost by major species of clean seed by the pound as it is ready for nursery sowing, with a break-down to collection and extraction costs. Minor species will be grouped collectively, and cost per pound computed on a pro rata basis. The State Director will designate the major and minor species within his State. Ordinarily any species grown on an experimental basis of approximately 10 M seedlings or less will be classified as a minor species.

Procedure

Records will be maintained in the State office, as provided in Circulars FC-4 and FC-64. Charges to Activity 37.11, Seed, on payrolls as submitted by the field supervisory force, will be further broken down by field man to approximate collection and extraction hours for the major species, with minor species grouped collectively.

In addition, other charges to 37.11, Seed, such as all Forms 26, all expense accounts, and those supply and transportation vouchers which cannot be charged directly to species, will be totaled at the end of the Fiscal Year and charged back to the species arbitrarily by the Forest Officer in charge of nurseries, who is in the logical position to know the approximate correct distribution of such items. Vouchers specifically chargeable directly to species will be absorbed by those species.

All transfer of charges from 37.11, Seed, to 27, Nurseries, will be on the basis of clean seed sowed at the individual nurseries. Charges for species which are direct-seeded will be transferred to Activity 26.1. Activity 37.11, Seed, will retain charges for seed carried over as surplus, but nurseries will absorb charges for all seed sown and for all seed which must be discarded. Charges for discarded seed will be arbitrarily prorated to the individual nurseries. Activity 26.1 will absorb charges for discarded seed of species ordinarily direct-seeded.

Seed report costs as outlined above will be due in the Regional Office, Division of Timber Management, by August 1 for the preceding year's collection.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Plains Shelterbelt Project

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SECTION C

SHELTERBELT NURSERY PRACTICE

GROUND PREPARATION

General

A properly prepared seed bed is the initial step of a successful nursery season. Since nursery stock production is an intensive form of crop culture, it is essential that the preparation of the soil be given much closer attention than would ordinarily be done in the production of general farm crops.

Preparation of the soil resolves itself into, first, preliminary preparation, and second, preparation immediately preceding sowing. While our present system of nursery leases permits little in the form of soil management for future production, yet insofar as possible ground treatment should be such as to produce the most desirable results not only for the current year but for the following years as well.

Preliminary Preparation

Proper handling of crop residues, if present, and fall or early winter plowing constitute the preliminary preparation.

Crop Residues

Coarse and relatively heavy amounts of cornstalk, stubble, or other crop residues, if improperly handled when the ground is prepared, will cause considerable difficulty in subsequent cultivation operations. In addition it may contribute to rapid drying out of the soil.

Should such material be present, it should be thoroughly disced or otherwise cut before plowing, discing being preferred. Heavy residues for which this treatment is inadequate should be removed or burned.

Fall Plowing

Relatively deep fall or early winter plowing is ordinarily preferred for the following reasons:

1. It exposes a maximum surface of soil to the mellowing or mechanical influence of alternate freezing and thawing, thereby resulting in good tilth.

2. Roughened condition aids in catching snow and will prevent a considerable amount of run-off which might otherwise result from late fall, winter, or early spring rains. If necessary the moisture catching capacity can be increased by listing after plowing is completed.

3. Shortens the preparation period in the spring, thereby lessening the rush work and also permits sowing to be done over a longer period.

4. Allows seed bed to become settled.

5. Permits some decomposition of crop residues into organic fertilizers.

6. May help in the destruction or checking of certain insect and disease pests.

Good tilth (the mechanical condition of the soil) is highly important in nursery work, since the soil must be finely pulverized to permit intimate contact with the seed. Fall or winter plowing will do much to provide the desired tilth, whereas spring plowing, unless carefully done and timed to favorable weather and ground condition, usually results in lumpy ground. This is particularly true with heavier soils.

In plowing the operator should strive to secure a narrow furrow slice standing somewhat on edge. Seldom is it advisable to plow at an operation more than 1½ or 2 inches deeper than has been the custom on that particular site. Unless fall sowing is practiced, fall plowed areas should be left standing in rough condition over winter.

Preparation Immediately Preceding Sowing

Soil moisture conditions should be closely watched, and when favorable the entire area should be disced and if necessary cross-disced. The necessary leveling should also be done at this time. (See Irrigation Section on Land Leveling) If the area is subject to blowing it may be advisable to prepare each individual block just preceding sowing rather than the entire area at one time. Ordinarily on fall or winter plowed areas discing at the proper time in the spring will constitute adequate preparation. In some instances harrowing with a spike tooth or acme harrow will be necessary to pulverize the soil further. Rolling or packing should seldom be necessary.

Spring Plowing

In the event that fall plowing could not be accomplished or if the ground following fall plowing should become packed from heavy fall or winter rains, spring plowing will be necessary. Avoid spring plowing when the ground is too wet, particularly with the heavier soils since a rough, cloddy seed bed will usually result. It is far better in the long run to delay plowing a week than to create a cloddy seed bed.

Discing or harrowing should immediately follow the spring plowing operation before the surface soil has a chance to dry out.

Fertilizer

In many cases it may be highly desirable to add organic fertilizer to the soil upon which nursery stock is to be grown. Of those which might be used, well-rotted barnyard manure is no doubt the most satisfactory. It not only supplies plant food, especially nitrogen in the form readily usable by plants, but adds humus to the soil. In many instances this latter point is of even greater importance than the plant food supplied.

However such fertilizers should be used carefully. A close study of the soil should be made considering principally its apparent fertility (largely based upon growth and production of preceding crops), and the general physical condition of the soil.

Avoid using organic fertilizers containing a high percentage of coarse, totally undecayed plant material such as corn or kaffir stalks or fresh wheat straw. Such residues decay slowly, are difficult to incorporate into the soil, and the process of decomposition may affect the available nitrate supply in the soil during the early part of the following season.

Organic fertilizer should, as far as possible, be applied to the soil in the fall and disced thoroughly into the soil before plowing.

If it is deemed necessary to add fertilizer of this sort to the soil in the spring, care should be taken that the fertilizer used is well-rotted. It should be applied as a top dressing after plowing, using a light application, then thoroughly discing into the soil.

Definite rates of application are difficult to state. The number of tons of barnyard manure which should be added to an acre for best results varies according to a number of conditions, principally with the condition and grade of the fertilizer itself. Ordinarily through the region in which the Shelterbelt nurseries are located, 8 to 10 tons per acre of a well-rotted grade applied in the fall as indicated is entirely safe, and increases the growth and quality of the seedlings produced the following season.

SEED SOWING

As ye sow so shall ye reap! Poor production in the nurseries can in many instances be attributed to faulty sowing. The mistakes made at this stage cannot later be corrected.

Assuming well prepared seed beds and properly handled seed of good quality, sowing resolves itself into three primary factors as follows: season to sow, density of sowing, and depth of sowing. The method employed in sowing the seed is secondary, as is also the practice of ridging the rows following sowing.

Sowing Season

All species are governed by the nature of their seed dormancy in determining the optimum sowing season from a germination and survival standpoint. Species with stone seeds such as plum, cherry, Russian olive, and hackberry, which are characterized by impermeable seed coat dormancy, respond readily to either fall sowing, which is preferable, or stratification followed by early spring sowing.

Seed of leguminous species such as black and honey locust and Kentucky coffee tree, characterized by an impermeable seed coat, respond better to some form of scarification, such as soaking in acid which renders the seed coat permeable to water, followed by moderately late spring sowing.

Species characterized by both impermeable seed coat and embryo dormancy will ordinarily respond better to late fall sowing, or a short period of stratification followed by early spring sowing.

Spring ripening species which have no seed dormancy, will be sown as soon after ripening as possible. Later summer and fall ripening species having no seed dormancy will ordinarily be stored dry and sowed in the spring, except burr oak and post oak which should preferably be fall sown immediately upon ripening, or if this is not possible, should be stored in such a manner as to avoid drying.

However, the season for sowing seed with the greatest degree of safety of germination and survival is not in all instances the best sowing season when the development of the proper type seedling for shelterbelt planting is taken into consideration. Black locust, for example, will develop into a seedling too large to handle to best advantage if sown in its normal season, i.e., moderately late spring. Therefore, the sowing of this species is often delayed until late June in order that its development will be retarded. Similarly caragana, another legume, while handled with the greatest safety by early spring sowing, often does not produce the optimum seedling for shelterbelt planting in one season by so doing. By sowing the seed in August and securing several inches growth during

the fall months, a much better grade of seedling will be produced the following year. Therefore, if circumstances permit, the nurseryman will take such factors into consideration when planning his sowing operations.

Fall Sowing

In general, fall sown seed will produce a better rooted and better caliper seedling than if stratified and sown in the spring. These advantages are not all net gains, since fall sowing may sometimes result in a complete failure under certain conditions.

Fall sown seed of species having seed dormancy or impermeable seed coat should have direct contact with the moisture in the soil throughout the winter. Dry cold ground is the same as dry cold storage, which is obviously unsatisfactory. Although sown in moist soil, if the ground freezes and remains frozen throughout the winter before any moisture absorption can take place, a failure can perhaps be expected since moisture absorption is negligible in frozen soil. These points are of minor importance in the south where the ground alternately freezes and thaws, and adequate moisture is quite dependable due to winter precipitation.

If the nursery soil is heavy, alternate freezing and thawing will bring the seed to the surface, exposing the seed to drying winds, rodents, and birds. This frost heaving is a common occurrence on the heavier soils in open winters, and should be guarded against by throwing a ridge of soil over all fall sown seed.

Perhaps the most serious danger to be encountered in fall sowing is that an unseasonably early warm spring will cause the seed to germinate, and subsequent severe weather will destroy them. This again can be largely prevented by maintaining a ridge of soil over the seed, thereby retarding germination until such a danger is past. However, melting snows, rain, and wind may level such ridges, and before the damage can be repaired warm weather may cause the seeds to sprout, and then of course ridging over will smother the seedlings.

Summarizing the above points: (1) Fall sowing if successful will produce a better grade of seedling than the same seed from spring sowing; (2) fall sowing is not a safe practice in dry soil (it is better practice to stratify the seed and delay sowing until spring); and (3) all fall sowing, regardless of the nature of the soil, should be ridged over with a fairly broad, flat ridge to a depth of 3 to 4 inches.

Spring Sowing

Nurserymen as a whole are agreed on several factors with regard to spring sowing. Seed having had some form of pretreatment involving the absorption of water, such as soaking in water or stratification, or acid treatment followed by soaking in water, should be placed in direct contact with moist soil when sown, and moisture should be maintained until the seedling is well established. Such seed should not be sown in dry soil unless it is possible to irrigate immediately following sowing, since to establish an equilibrium the dry soil will absorb the moisture from the seed, thereby retarding germination with a consequent loss in the vitality of the seed.

On the other hand, seed which has been scarified by acid treatment or mechanical means, can be sown in moderately dry soil with no loss in germination or vitality, provided adequate moisture is received in due time. Likewise seed of species such as elm, catalpa, and desert willow, which may be spring sown without pretreatment of any kind, can be safely handled by sowing in dry soil.

The careful nurseryman, therefore, who is operating without overhead irrigation, varies his spring sowing according to the nature of the seed and amount of soil moisture. Seed that has absorbed water as a part of its pretreatment is sown only in moist soil and under favorable conditions, while seed which has not previously absorbed moisture can be sown either in moist or dry soil with no unfavorable results, provided that when moisture is received it is sufficient to germinate the seed and get the seedling established.

Density of Sowing

No seedling is judged to be of the premium grade for shelterbelt planting unless it has a well-developed root system, a caliper between 3/16 and 5/16 inch just above the root collar swell, and a proper balance between root and top. This standard may vary somewhat for individual species, but in general it will hold true for most of the major species.

With 30-inch rows center to center and 3-inch bands as the present standard in the shelterbelt nurseries, it is believed that for most species and conditions, production of at least 150 M seedlings of premium grade can be attained per acre per year. This presupposes a final stand of approximately 9 usable seedlings per linear foot of row. For certain nurseries, especially in the south and for certain species, greater production per acre can no doubt be attained. However, an average of 150 M usable seedlings of optimum size and quality over a range of species for any one nursery can be considered a very creditable achievement.

Sowing density to produce 150 M usable seedlings per acre will be governed by the viability of the seed and the ratio that exists between viability and ultimate final stand. While the viability of the seed can always be determined by germination tests, the ratio between viability and ultimate final stand varies greatly. Numerous factors influence this ratio, such as soil, weather conditions (especially during the germination period), intensity of the nursery care, growth habits of the species, and lastly and most important, the nature of the seed. Large seeded species such as plum, apricot, honey locust, and many others which produce a sturdy vigorous growth immediately upon germination, can normally be expected to show fewer losses during and immediately following germination than small seeded species such as elms and mulberry. Seedlings from small seeded species on the other hand are normally very delicate during early life, and large losses can very quickly occur from soil crusting, heat, wind burn, drought, and damping off. For all species a certain percentage of losses is unavoidable and should be provided for.

The careful nurseryman, therefore, knowing the germination percentage of his seed varies his sowing density for each species according to what his judgment and experience indicates to be the proper density for that species, having in mind the maximum production of premium grade seedlings.

As a guide for the nurseryman to follow, the sowing density as given in the discussion of individual species indicates the number of viable seed to sow per linear foot to attain a stand of 150 M per acre. Deviations from this schedule are, of course, permissible, but in no case should the nurseryman increase his sowing rates promiscuously in order to compensate for questionable nursery practices.

Much is yet to be learned about the proper sowing density in shelterbelt nursery work. Definite administrative experiments are being undertaken to determine the desirable ratio between viable seed and ultimate final stand of usable seedlings for the various species in order to produce the maximum quantity of optimum size and quality seedlings per acre consistent with the conditions existing. The tendency, especially with a surplus of seed on hand, is to oversow and by so doing one often defeats quality, and in real heavy sowings one is apt to create conditions that induce almost total losses, such as results from damping off.

Width of Row

While 30-inch rows center to center and 3-inch bands have been adopted as standard in the Shelterbelt nurseries for the present, definite administrative experiments are under way to prove or disprove the desirability of this standard. The width of row is dependent largely upon the possibility of adapting cultivating and digging equipment. During the 1935 season the width of row varied from 18 to 45 inches. The concensus of opinion among the nurserymen using

the wider width was that the rows could profitably be narrowed, while those using the narrower widths advocated widening. Whether the present standard of 30 inches is the final answer will not be definitely known for several years. Nurserymen are encouraged to try out different row spacings on a small portion of their nursery acreage as a check against the present 30-inch standard.

The following table shows the number of linear feet per row and the number of usable seedlings per linear foot necessary to produce 150 M usable seedlings per acre:

Distance between rows center to center	Linear ft. of row per acre	Ave. No. of usable seedlings per foot to produce 150 M per acre
45	11562.7	13.0
42	12445.7	12.0
39	13410.8	11.0
36	14520.0	10.0
33	15840.0	9.4
30	17424.0	8.6
27	19342.2	7.7
24	21780.0	6.8
21	24891.4	6.0
18	29040.0	5.0

Width of Band

It has been definitely demonstrated that the wider bands greatly increase weeding costs, and for that reason the standard has been set at 3 inches. However, the most desirable width of band from the standpoint of producing quality seedlings is as yet to be definitely established. It is fairly certain, however, that wide bands over 6 or 8 inches tend to produce spindling seedlings in the center of the band if the stand is sufficiently dense to crowd out weed development, while in the very narrow bands it is difficult to obtain quantity production.

Depth of Sowing

Nurserymen agree that the depth to sow seed should primarily be determined by the size of the seed. Other factors influencing the depth of sowing are the vitality of the seed, susceptibility of the species to pre-emergence damping off, consistency of soil moisture, type of soil (shallower sowing for clay soils as against deeper sowing for sandy soils), whether the seed rows are ridged over following sowing, irrigation system to be followed, the intensity of germination culture that is practiced, and finally season of sowing. Fall sown seed can be safely sown to a 50 per cent greater depth than the same species spring sown.

Under the practices generally followed in the Shelterbelt nurseries, the following rule is believed to be a safe guide in guaging the depth to sow the seed: Sow all seed to a depth below the soil level of three times the average diameter of the clean seed kernel, but in no event less than 1/4 inch.

Thus 1/4 inch becomes the sowing depth of a great number of the Shelterbelt species, such as honeysuckle, mulberry, lilac, sumac, and many others. Very few species will be sowed at a depth greater than 1 inch.

According to Dr. Hartley, excessive covering, especially for very small seed is an important factor in causing gaps in nursery rows. He states further that "absolutely mechanical prevention of emergence is rare; what more often happens is that a soil cover that is too deep or too hard delays the seedling below the ground until they have become weakened and susceptible to infection, either at that stage or within the first days after they succeed in emerging."

Sowing Methods.

The method of sowing seed is, as stated before, second in importance to the primary factors of season to sow, density of sowing, and depth of sowing. With the primary factors under adjustment, the objective to attain, no matter what sowing method is followed, is evenness of distribution. With hard, dry seeds, this might easily be secured by drill sowing, but few of the shelterbelt species are hard and dry when sown because of pre-treatment. No satisfactory mechanical sower is available so far as known that will sow all types of seed in 3-inch bands.

Many nurserymen contend that careful broadcast hand sowing is the only feasible method of sowing in bands that insures complete and even distribution. However, there has been developed during the past season a riding broadcast sower that is well worthy of recommendation. This machine was adapted from an ordinary two-row corn planter. The following quotation is from a letter by the Kansas State Director on the development of this machine:

"The tree seed planter developed at the Kansas shelterbelt nurseries is an Oliver corn planter that has been worked over to make it meet the requirements for planting tree seeds.

"The first change, made in an attempt to make the corn planter meet the demands for a tree seed planter, was boring more and larger holes in the seed plates. We were unable to secure a satisfactory rate of seeding in this way. We then discarded the seed boxes and all of their accessories, and substituted a funnel with a spout two inches in diameter, which extends down almost to the ground line when the shoe is in the ground.

"The seeds of whatever species are being planted are poured into the mouth of the funnel from a sack, or bucket, or a water sprinkler that has the nozzle removed and the spout cut back to the desired size of opening.

"The next difficulty encountered was the fact that the shoe on the planter cut too deeply into the loose soil, and the drill row made by the shoe was not wide enough to allow the desired spread of the seeds. To remedy this condition, the sides of the shoe were spread and a steel sole inserted that gave a spread of five inches. This wide sole solved the depth of planting and the spread of the seeds in the drill rows, but the seeds were not covered. To secure coverage it was necessary to attach a pair of discs directly behind the shoes. To make room for the discs it was necessary to use a longer axle and spread the wheels. The discs can be set to cut any desired depth and cover the seeds as desired.

"For spring seeding, it is very necessary that the soil covering the seed be firmed over it. To meet this requirement a pair of press wheels have been attached behind the discs. The pressure of these wheels can be adjusted by a lever.

"Other changes that were made was the location of seats for the men that feed the seeds into the funnel hoppers, and the attachment of a tail board for the driver to stand on, and which allows the driver to regulate depth of planting by varying the distance that he stands from planter."

The only other band sower of promise is also adapted from a two-row corn planter equipped with fertilizer attachment. In this case, it was possible with some modification, to sow the seed through the fertilizer hopper. This machine needs considerable improvement, however, before it will successfully handle all species, particularly the winged seeds such as ash and elm.

Broadcast sowing by hand necessitates several operations, namely, opening the band, distributing the seed, covering, firming, and in some cases ridging the rows. It is obvious, therefore, that any mechanical method that will do all these operations at once will reduce sowing costs materially.

However, careful sowing should be the objective rather than low costs, since in the final analysis sowing costs are a relatively small part of the per M cost of producing seedlings. Conversely, the final per M costs may be greatly increased by a poor job of sowing that results in low production.

Ridging Rows

Ridging the rows following spring sowing is endorsed with reservations by nurserymen. Few question the practice for fall sowing. It is a custom of long standing among nurserymen, although not practiced when stock is produced under overhead sprinkling system, or when grown under intensive production, as in beds.

Ridging rows following spring sowing is practiced for a number of reasons: (1) to show where the young plants are to come up (this will permit cultivation when delayed germination occurs); (2) to keep the top soil from drying down to the seed; (3) in passing along with an ordinary garden rake, the crust which forms on the heavier soils after a rain can be removed; (4) raking down the ridge after the seed starts to sprout, but before the sprouts reach the ground level, removes the first crop of weeds which would otherwise come up with the plants and be destroyed only by a great amount of hand labor, and in weedy ground, at a sacrifice of a considerable number of young plants; (5) removing the ridge at the proper time permits the seedling to come up through fresh, soft soil; and (6) keeps the seed from being washed out by excessive heavy rains or blown out by hard winds.

Good judgment on the part of the nurseryman will determine whether or not to ridge the rows. Ordinarily if an abundant supply of soil moisture is present, and if the species sown is one that can be expected to germinate within a few days, ridging should not be practiced. Weather conditions and soil type are other factors that will influence the nurseryman's decision. Ridges 3 inches high are adequate. Higher ridges prevent heat and air from penetrating to the seed which may result in the seed rotting if the ground is wet for long periods. Moisture, oxygen, and proper temperature are the three essentials for germinating seed, the lack of any one of which will prevent the process entirely. It is obvious, therefore, that the ridge must not be too high.

BED PROPAGATION FOR DECIDUOUS SPECIES

General

Where beds are used they will ordinarily be 4 feet wide and of indeterminate length. Drilled rows spaced 6 inches apart and running lengthwise of the bed are preferred instead of broadcasting the seed. Only species that require shading and intensive wind protection are to be grown in beds. For the present, definite information is lacking as to how much bed propagation will be necessary, since reliable data for many of the species, i.e., whether shading and wind protection are necessary, is not available.

Method of Supporting Shade

The Oklahoma State Forest Nursery at Stillwater, Oklahoma, has adopted a system of supporting the lath shade for beds that is considered suitable for use in the Shelterbelt nurseries where shading is necessary. In this system the shade is placed 8 to 12 inches above the beds on #9 galvanized wire supports. The wires, one on each side of the bed, are anchored at the ends and held up by intermediate supports every 12 feet; i.e., two stakes are driven in on opposite sides of the bed and a 1" x 4" x 4' board is placed on top of the stakes, holding the two wires in place over the beds. A 5/8" x 14" galvanized turnbuckle is placed on one end of each wire so the supports can be tightened at any time it is necessary. This system is applicable to any length of bed.

Snow Fence Construction

Snow fence or lath frames are customarily used in nurseries for shading purposes. Snow fence is preferred in most instances. Through information received from Region 9, Nebraska has adopted a system of constructing snow fence at a cost of approximately $5.00 per hundred feet, of which approximately 40% is labor. The details of this system will be furnished upon request.

Bed Irrigation

Some form of sprinkling system must be resorted to for bed irrigation, since furrow irrigation is not practical. With a small area of less than an acre and water available under pressure, the sprinkling can be done through the use of garden hose and lawn sprinklers. For larger areas this is not practical, and the only recourse is through the use of Skinner or overhead sprinkling.

GERMINATION CULTURE

All the cultural activities following sowing of the seed up to the time that germination is complete, have been grouped under the term "germination culture". More specifically the following operations are included in this term: raking down or removing ridges, breaking crust, and any irrigating or cultivating that is intended as an aid to germination.

Our experience this past year indicates that careful germination culture is quite important, particularly with light seeded species and on heavy soils.

Removing Ridges

Removing or raking down ridges requires good judgment as to proper time and careful supervision in order to attain desired results.

When germination is even and fairly consistent, it is not difficult to determine the proper time to remove the ridges. In this case it will be done as the seedlings approach the soil surface level, i.e., when they are within 1/8 to 3/16 inch of the surface. However, when the seed continues germinating over a period of several weeks, it becomes more difficult for the nurseryman to determine the correct time to remove the ridge. Under this condition, careful judgment and experience on the part of the nurseryman will often lead him to forego removing the ridge until a fair percentage of the sprouting seedlings have progressed into the ridge itself. While some losses may then occur when the ridge is finally removed, the final stand resulting warrants this procedure.

Careful supervision at all times during this operation is essential. Workmen so engaged , unless they have had previous experience in nursery work, often display scant appreciation of the nature of the job they are performing. They should be definitely aware that removing ridges is one of the most delicate and painstaking operations of the entire nursery season. To insure care on the part of the workmen, some nurserymen require that the laborers perform this operation down on their knees, using their hands instead of a rake. This method, while considerably slower than raking, is under certain conditions and for some species justified because of the better quality of the work. The workman down on his knees using his hands can always judge the proper depth, while careless workmen with rakes are very apt to go too deep and break off the emerging seedlings, or uncover too little with the result that the value of the operation is lost entirely.

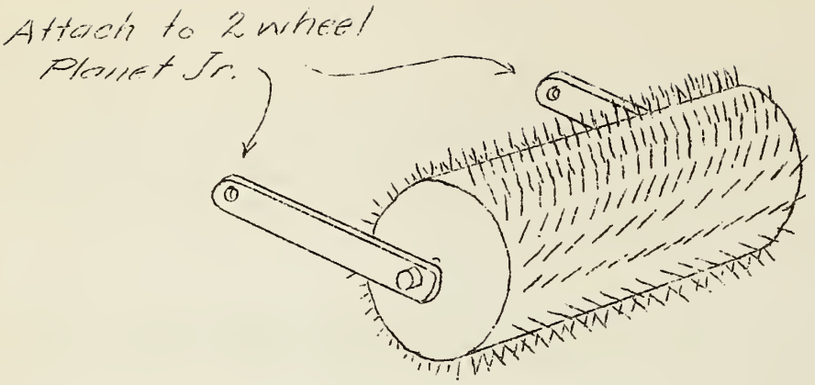


Fig. 1 "Crust Breaker". A simple device for pulverizing the crust.

Breaking Crust

The rotary crust breaker is recommended for use in all nurseries for handling the soil crusting problem. This consists of a round wooden cylinder set with nails. (See Fig. 1) This wooden cylinder can be of varying dimensions, but experience in a number of nurseries indicates that a cylinder about 5 to 8 inches in diameter and 15 inches in length is the most satisfactory. Nails are driven one inch apart in each direction into this cylinder and the heads clipped off, leaving an inch or two projections. By attaching this cylinder to an ordinary two wheel push plow, the device serves effectively in breaking the crust. It may be used even though half the seedlings have emerged, provided the nails are kept straight. The two wheel push plow for carrying the roller is preferred rather than handles attached to the axis of the cylinder, because the operator can then readily adjust the pressure to meet the varying hardness of the crust.

Irrigation During Germination Period

Ordinarily where (1) sufficient soil moisture is available at the time the seed is sown, (2) where proper cultural practices to conserve this moisture are followed, and (3) where careful practices are followed with respect to seed treatments to hasten germination, irrigation during the germinating period will not be necessary.

With overhead sprinklers obviously no problem is involved, since water can be applied as needed, but furrow irrigation presents a different problem, since an average of 2 to 3 acre inches of water is the minimum that can usually be applied under this system. This amount of water applied to sprouting seed is apt to increase damping off, and if applied in the heat of the day, to result in burning.

Also in heavy soil, crusting and baking with their attendant difficulties follow applications of water. It is desirable, therefore, if at all possible to follow such practices as will insure the successful germination of the seed without irrigation, especially where furrow irrigation is practiced. Circumstances will arise where this is impossible, but it is nevertheless a desirable objective to attain.

A workable plan for irrigation based on the survey figures should be available before any sowing is done in order that no delay be encountered should irrigation become necessary.

Cultivation During Germination Period

Nurserymen generally agree that close and shallow cultivation during the germinating period provides aeration which will aid materially in increasing the rate of growth, and possibly aid in controlling damping off. In many instances during the germination period the crust breaker will serve to a small degree in doing cultivation work.

If the nurseryman is successful in bringing a stand of seedlings through the germination period and past the damping off stage, his stock has passed through the most critical period. However, there are other dangers that may be encountered, some unavoidable and others to which his alertness may determine the success of the crop. To name just a few of the nursery hazards, any one of which may reduce his production materially, there are hail, grasshoppers, grubs, termites, labor shortage, and severe late and early frosts.

Controlling Size and Quality of Seedlings Through Cultural Practices

Ordinarily, careful nursery practice will bring the crop through once the stand is established. Yet over and above the mere bringing the seedlings through the season is another objective that will tax the nurseryman's skill and ingenuity. This objective is to produce seedlings of the most desirable size and quality.

Optimum size for field planting for each species is yet to be definitely determined, but seedlings with a caliper of 3/16 to 5/16 inch just above the root collar swell, and possessing a well-branched, compact root system are generally considered the nurseryman's objective for most species. A few species, notably coffee tree, catalpa, and others, have different natural habits, and for them the optimum size will vary.

The quality objective of the nurseryman is to produce solid, woody, well-ripened seedlings which all agree are essential for high field survival when planted under average Plains conditions.

The long growing season in the south as against the comparatively short growing season in the north, and the rapid rate of growth of some species such as Chinese elm and black locust as against the slower growth rate for other species such as green ash and hackberry, influence the practices of the nurseryman throughout the season. It is desirable to put as much growth on the seedlings during the early part of the season as is commensurate with the growth habits of the species. This will enable the nurseryman to better control safely the ultimate size of the seedlings through cultural practices, and also produce the quality of seedling desired. It is obvious that if very little growth is obtained early in the season, and the nurseryman is faced with the necessity of forcing the seedlings during the late growing season, an undesirable situation exists since such seedlings are soft, succulent, and subject to severe injury from frost and are more difficult to handle safely in storage. Furthermore when finally planted in the field, they are susceptible to shrinkage before becoming established with resultant low survial.

The logical approach to the problem of increasing or retarding growth is through the density of sowing, and it is expected that in another season considerable definite information will be available on this subject.

Increasing or forcing growth through the application of commercial fertilizers is to be largely avoided until factual data are available to establish definitely that such practices will not reduce the quality of the seedlings produced.

Experiments should be conducted on all species practical to determine if increased caliper might not be obtained by trimming back seedlings in midsummer. Both root and top pruning should be experimentally tried to see whether all root and top development cannot be confined to 10 and 15 inches respectively without weakening the seedling.

Regulation of moisture is another means of controlling growth, but is generally considered a dangerous practice if carried to extremes. If an abundant supply of soil moisture is available throughout the season, growth is fairly consistent, and barring early frost will continue until late in the season. The growth rate of the seedling may materially decrease during the heat of the summer, but unless excessively retarded it will increase again during the cooler, early fall months provided abundant moisture is available. Therefore, for species that need to be held back or retarded, cultural practices open to the nurseryman are: (1) hold off all irrigation; (2) deplete the soil moisture through discontinuing all cultivation thereby packing the soil; and (3) late sowing of moisture sapping plants such as oats, wheat, or rye between the seedling rows. When such practices can be followed without weakening the seedlings, the problem is to a certain extent solved.

In summarizing, to avoid the production of succulent seedlings, the careful nurseryman will endeavor to obtain as much of the required growth on the seedlings as possible early in the season, and during the latter part of the season direct his activities to the ripening or hardening off the seedlings.

Cultivation

Nursery stock requires intensive cultivation, and if it is to be fully effective several major points must be recognized.

The fundamental purpose of cultivation is to keep the soil in which the stock is growing free of competing weeds. Cultivation is also a means of keeping the soil, and particularly the surface soil, in good physical condition. This latter point is made even more important where surface irrigation is practiced during the growing season.

Much of the success of cultivation will depend upon the physical condition of the soil at planting time. These soils which are naturally "mellow" or "friable" or which have been properly prepared previous to sowing, will be much easier to cultivate than soils which are run together, hard, packed, and cloddy.

A number of points for the nurseryman to observe in his cultivation operations follow:

1. Cultivation of nursery stock must be relatively shallow. Seldom will a penetration of cultivating tools to a depth greater than four inches be desirable. Deeper cultivation, especially close to the rows, will often result in actual damage through the destruction of the spreading shallow roots of the seedlings; consequently care must be exercised in the choice of tools used in cultivating. Excellent equipment for this purpose are 6-inch duckfoot shovels or 6-inch flat sweeps. Sweeps or shovels should be chosen which will give a full cut or cover, since the type of cultivation desired is designed to cut off weeds rather than to kill them by covering with soil. Therefore the size of the shovel to be used will be determined by the spacing between the cultivator standards or shanks. The use of long, narrow shovels is discouraged since they penetrate too deeply and frequently cause damage to the roots of the stock.

2. A major point which largely determines the effectiveness of cultivation is that of thoroughness. A careless job of cultivation is nearly worthless, or may actually be harmful in case of mechanical injury to the stock. If the job is not thorough, it may cultivate the weeds rather than destroy them, and make their later removal or destruction more difficult. Constant attention to this point is imperative.

3. Of scarcely less importance in cultivation is the matter of timeliness. Competing growth should also be destroyed while it is yet in the seedling stage. Allowing weeds to grow to an average of three inches or more seldom can be excused under nursery conditions, except late in the season after the desired seedling growth is obtained. To do so invariably makes cultivation more difficult, more expensive, less effective, and many times will cause an unnecessary drain on the soil moisture by the weeds.

4. To obtain these conditions constant supervision is necessary, not only while the cultivators are running but between times as well. Nurserymen should plan for inspections of their entire nursery at regular intervals to determine the need for cultivation.

5. It is needless to say that sharp tools that scour are essential. Deep cultivation which kills weeds primarily by covering can be accomplished with dull tools, but this is not true of shovels and sweeps which are designed to cut weeds just beneath the surface of the soil.

6. A requisite in the growing of nursery stock is that crusting and baking of the surface soil be held at a minimum if good growing conditions are to be maintained. This means that the soil must be cultivated after each heavy rain or following irrigation. To break the crust effectively, very close attention must be given the soil to determine the proper time when cultivation is to be done. As a general rule, begin cultivating as soon as the surface soil is dry enough to crumble. Such cultivations need be only deep enough to stir the upper one or two inches of the soil. Spring-tooth cultivators are excellent for this purpose.

7. In this connection, if irrigation is done by means of shallow furrows, it is important that the ditches themselves be filled or cultivated following irrigation, even if the remainder of the soil does not tend to crust.

8. Hand cultivation within or closely adjacent to the rows follows the same general principles as outlined above. Hoeing to be effective should be done when weeds are in the seedling stage, i.e., three inches or less in height. To delay such work beyond this stage is costly and inefficient. Sharp hoes are an absolute necessity, both for ease of operation and effectiveness. It should be kept in mind that the hoe is primarily a cutting tool and is designed to cut weeds by drawing it through the soil beneath the surface rather than by chopping and digging. Hoes should be sharpened on the upper rather than the bottom edge. Hoes with the blade cut down to a two-inch width "gooseneck" are helpful in close work. If the seedling band is sharply defined, a wheel hoe will greatly expedite the hoeing job and will also do good work.

9. Hand weeding likewise must be timely. However, in order to be done effectively, it should be delayed until weeds are two or three inches high in order that they can be readily grasped with the fingers. Weeding immediately after a rain or irrigation is not desirable. The weeds are turgid and break readily. The weeders hands soon become covered with slick mud, and it is difficult to get a good grasp upon the plants to be pulled. Furthermore, the soil becomes packed by the weeders working down the rows when the ground is still wet. Such soil will form clods when turned with the cultivating tools. A much better practice is to delay weeding until after the surface of the soil and the plants themselves are relatively dry.

A desirable and easily made tool to facilitate hand weeding and cultivation is illustrated in Fig. 2. This is known as the "Parker Cooning Stick" since it was developed at the Parker Nursery, Tecumseh, Oklahoma. If well made with heavy guage tin, this type of hand weeder will give excellent service.

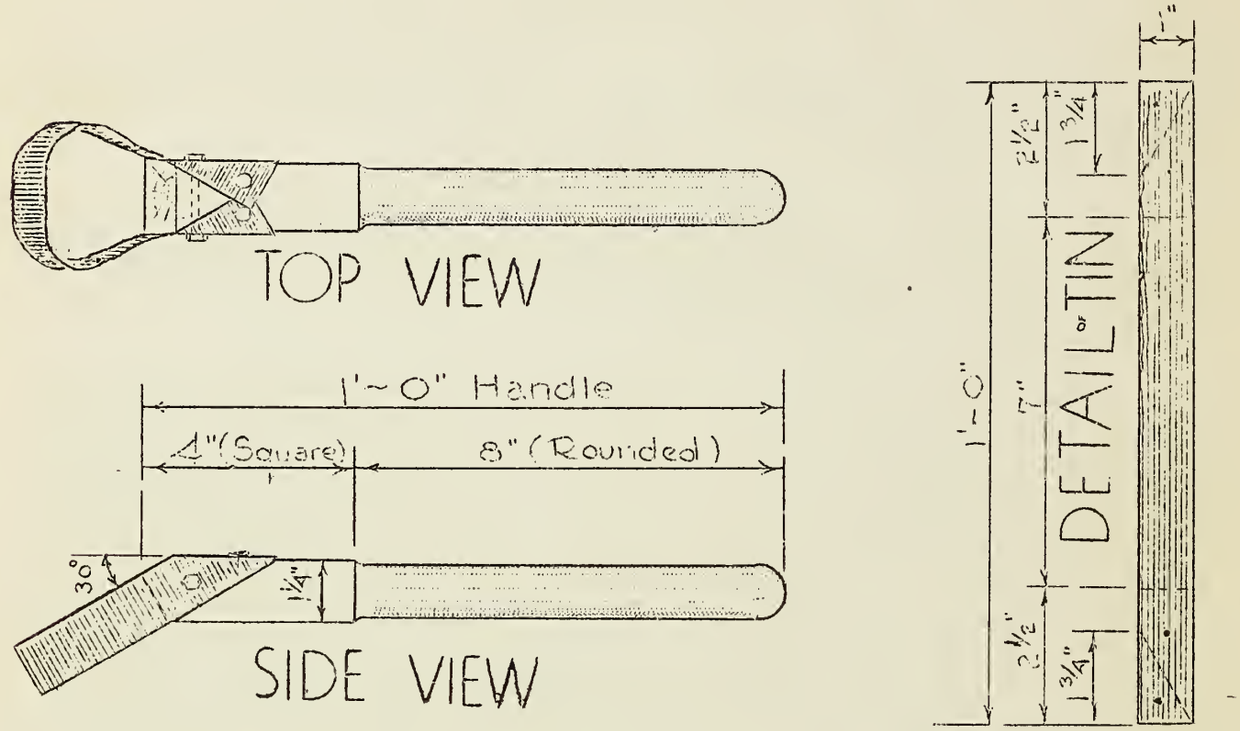


Fig. 2 Parker Cooning Stick. A hand weeder constructed from 1 x 12 inch strap of 20 guage tin and a $1\frac{1}{4}$x$1\frac{1}{4}$x12 inch woodon handle.

TOP PRUNING

Top pruning shelterbelt planting stock is desirable to bring the top root ratio into a better balance. Although no exact data are available, it is believed that this will insure a better survival of the seedlings when planted out in the strips.

In general it is recommended that all overgrown tree species except American elm be pruned back so that an approximate ratio of 1 to 1½ exists between length of root and length of top. For example, if root lengths are 10 inches, top length will be 15 inches. For shrub species an approximate ratio of 1 to .75 is recommended, i.e., if roots are 10 inches, the top will be cut back to a height of approximately 8 inches.

It is desirable to prune just before the seedlings are sent to the strip for planting in order to avoid the drying back from the cut ends while in storage or in the heel-in beds, and to reduce weight in shipment. It is, however, readily apparent that for some species having excessive top growth that an initial pruning to within 3 inches of the standard by some mechanical method before the seedlings are undercut and pulled will be desirable for the following reasons: (1) will reduce the bulk to be handled considerably; (2) will greatly facilitate grading the seedlings; and (3) having the tops all the same length will aid materially in securing even root collars in the bundles when the seedlings are graded and tied. This latter point is important when the final pruning is made, since it will insure all seedlings being cut off at the proper length.

As yet no definite recommendations can be made as to the proper device for top pruning seedlings. It is believed that a satisfactory mechanical clipper can be adapted to cutting the seedlings back while still in the nursery rows. For the final pruning before sending to the strips, the most frequently used method is a sharp, broad ax and a solid block of wood. Whatever system is practiced, the objective should be to obtain a clean cut rather than severance by bruising or crushing.

DIGGING

General

Every operation under the nurseryman's supervision is vital, but the digging operation if carelessly done may destroy all the investment that has gone into the trees to this time. The nurseryman is definitely responsible for seeing that the seedlings are not unnecessarily injured during this process.

The digging operation comes at the time of the year that weather conditions are more or less treacherous, especially in the northern States. There is a pressure of time on this operation, but care should be exercised that stock is not undercut very far in advance of the pullers, as a severe freeze on stock cut and lifted but not pulled might mean a complete loss. All pulled stock left over night should be either in a building safe from freezing or heeled in or buried in soil outside.

The press of the season should increase the precautions against possible damage rather than increase the hazards in favor of gaining time. In other words, the stock had better be frozen up in the ground and left for spring digging than to be damaged by improper handling.

All care and precautionary measures exercised in digging seedlings in the nurseries apply in a general way to the collection of wildings.

Spade Digging

As a rule spade digging will not be necessary or advisable for deciduous seedlings, except in the case of wildings. Roots of large trees along the edges of the field or abandoned hedges may sometimes interfere with mechanical digging in the nurseries and necessitate a small amount of spade digging.

In spade digging in the nursery, parallel trenches about 6 inches or so from the seedling row should be dug to the required depth, usually 10 to 12 inches. The rows should then be undercut from each side with a sharp spade. The block of soil may then be broken down and the seedlings pulled in much the same manner as mechanically dug seedlings.

Wildings, such as cottonwood growing on river sandbars, may ordinarily be pulled without digging of any kind if the ground is moist. In dry soil it may be necessary to insert a sharp spade along side the wilding at an angle so as to cut the root 8 or 10 inches below the surface. Prying upward on the spade will then loosen the soil sufficiently to pull the wilding without danger of stripping the lateral roots or breaking the stem.

Mechanical Digging

Under no condition should the digging and pulling operation be done while the ground is hard and dry. If this condition exists, irrigating 3 to 6 days prior to digging is advised to insure against damaged stock.

The most satisfactory type digger is a U-shaped blade, either on wheel chassis or straight beam chassis. In all cases a digger should be equipped with a lifter attachment unless the ground is very loose. There are a number of good commercial diggers. In mentioning these it should not be gathered that others are not equally satisfactory, but present experience in Shelterbelt nurseries have proved the following to be satisfactory if properly handled and adjusted: the Cole, the Whitney, the Onarga, and the Bragg.

Adequate power, either horsepower or tractor power, is essential to do a good job of digging. Insufficient power will result in the digger running from side to side at uneven depths and doing a ragged job of cutting the roots. If tractor power is used, sufficient clearance or shields must be provided beneath the tractor to avoid injuring the seedlings.

A properly adjusted digger will not require additional weight to hold it into the ground at a constant depth under ordinary operating conditions. Adjustments may be necessary and constant watching is required to see that it does not creep too near the trees on one side or the other, thus short-cutting the lateral roots. The operator should see that the digger is started far enough out in the turn row to be at the required depth before reaching the seedlings, and that it remains at a nearly constant depth throughout the entire rows. For most species 10 or 11 inches is a satisfactory depth at which to undercut the seedlings.

Keep the digger sharp at all times. The bevel, of course, must be on the top side of the blade, that is, on the inside of the U in order to get a smooth cut and to hold the blade in the ground. Blacksmith sharpening usually softens the metal in the blade so that it will not hold an edge as well. A good file sharpening at short intervals is better.

Before any digging is started the outfit should be worked on idle ground until it functions properly. If this is done there will be no damage to the stock by the digger not working at the proper depth or by green teams trampling the seedlings while they are becoming accustomed to this type of work. Even if well-broken teams are used for power, some trouble may be expected at the outset, since there are few loads that feel more solid and immovable to a team not familiar with the work than a tree digger. A little time and patience at the start on breaking them into the job will be well rewarded.

Pulling Stock

In pulling stock the puller should grasp as many seedlings as he can conveniently pull without undue exertion. Pulling in quantities lessens the amount of root stripping in addition to speeding up the operation. The pull should be at an angle back towards the puller as he works up the row, since this will assist in freeing the roots from the soil.

Care of Stock Immediately After Pulling

The pulling crew should be so organized that one man will be engaged in temporary heeling in as soon as the pullers deposit the seedlings. To play safe the seedlings should be exposed to air the shortest practical length of time. There can be no excuse for the exposure of the roots more than 5 to 8 minutes on a dry, clear, windy day. On humid, cloudy days longer exposure may be permitted.

The nurseryman may find it convenient to cover the seedlings temporarily with tarpaulins or moist packing material instead of soil while awaiting transportation to the temporary heel-in beds or to the grading shed.

Seedlings in temporary heel-in beds awaiting grading should have the soil well firmed about the roots as discussed under permanent heel-in, since in the event of a cold snap heavy losses may occur from frosted roots if they are at all exposed to the air.

Freshly pulled stock, if stored in a grading shed awaiting grading, should be closely watched since this stock is in a state of handling where heating and molding may readily occur due to leaves that may still be adhering to the stems.

The nurseryman should remember at all times that the accession number is to follow the stock from the nursery, through the storage operation, and out to the planted strips. It is his responsibility to see that the number of the stock is not lost and that stock of the same species but of different accession numbers is not mixed.

GRADING

As previously stated, the preferred size seedling for shelterbelt planting will for most species range in caliper from 3/16 to 5/16 inch just above the root collar swell. For all species a well-branched, compact root system approximately 10 inches in length is desirable. Grading will therefore be primarily on the basis of caliper and root system and not height of the seedling.

One grade will suffice for the preferred size seedlings, since nothing will be gained by further separation within this grade. In addition there will be one grade of oversize seedlings above 5/16 inch, one grade below the preferred size ranging from 1/8 to 3/16 inch, and finally the rejects or culls. Instructions for disposition of culls will be issued at digging time.

Local conditions by States will govern the details of the grading process. In the north the comparatively short fall season will necessitate a different procedure than in the south. Also if the seedlings are to be heeled in over winter instead of being kept in inside storage, grading will necessarily be a fall and spring operation rather than an all winter job.

It is highly desirable to select and train a small crew of men rather than depend on the ordinary run of laborers for grading seedlings, because this is an operation requiring good judgment to secure best results.

During grading, leaves still adhering to the trees should be shaken or stripped off, since they may cause the bundles to heat and mold while in storage.

All seedlings that show excessive injury from the digging and pulling operation such as split or skinned roots, severe bruises, or showing appreciable amounts of grub or termite injury, should be discarded in grading. Low survival may be expected from such seedlings when planted out in the strips.

Long, side laterals, especially if they occur on larger stock, should be cut off just prior to tying the bundles. Side laterals should not be longer than 5 inches.

Seedlings should be counted and tied in bundles of 100. Keep the root collars even. Ordinarily one double wrap tie per bundle will suffice. This should be just above the root collar. Care should be taken to see that the lath yarn is not drawn so tight as to cut through or unnecessarily bruise the bark on the outside seedlings.

WINTER STORAGE

General

It is quite generally agreed that fall digging and winter storage or heel-in of nursery stock is merely an administrative necessity. Technically the seedlings would be in better condition for field planting if they could be pulled in the spring at the proper time and transferred with a minimum of handling to their new location in the strips. With a small program, the available time in the spring would probably permit the situation to be so handled. However, the size of the Shelterbelt program permits only a small percentage of the seedlings to be left in the nurseries for spring digging.

Winter storage or heel-in is, therefore, a necessary evil, the purpose of which is to have the stock assembled in proper grades and numbers for prompt delivery to the planting crews during the rush season in the spring. It exposes the seedlings to numerous hazards, all of which must be overcome to maintain the seedling in as near the natural dormant state as possible.

In no other nursery operation will carelessness so completely destroy the crop as it will during the storage season. There is also no other operation over which there can be imposed such absolute control. In other words, storage conditions are man-made, while cultural conditions are only influenced by man. Therefore the responsibility for loss of stock in storage can in no way be attributed to weather conditions, disease, insects, rodents, and the various other hazards that beset the stock in the field. Instead the responsibility rests squarely within the organization.

Inside Storage

For the present our available storage facilities are admittedly inadequate. Therefore the stock so stored will need closer inspection and all operation will need closer supervision than would be necessary if we possessed standard nursery warehouses.

Inside storage of nursery stock resolves itself into the control of (1) temperature, (2) humidity and moisture, and (3) aeration or ventilation.

The temperature should be maintained as close to freezing as is reasonably safe, considering means of control. A temperature of 34 to 38° F. is very satisfactory and will hold the seedling dormant indefinitely. Furthermore, fungi are comparatively inactive if the temperature remains low.

Temperature control and ventilation will work hand in hand. During the fall months the temperature within the storage house will

be reduced by opening ventilators at night and closing them during the day. During the winter, when it may be necessary to raise the storage temperature occasionally, the ventilators should be opened during the day when outside temperature is above freezing and closed at night. Correct temperature during the spring may be approached by the method used in the fall to reduce the temperature, i.e., open ventilators at night and keep closed during the day.

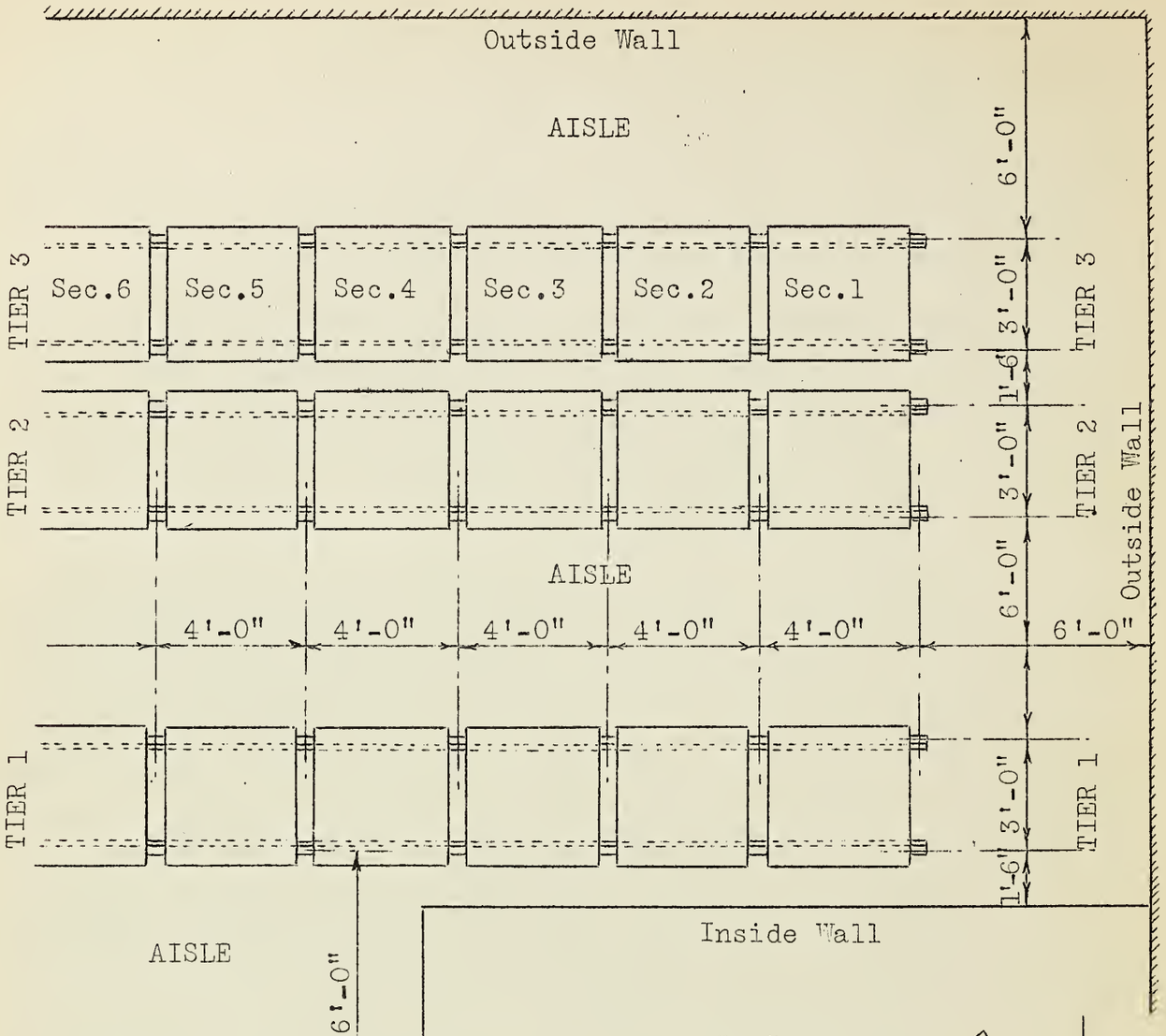
Humidity and moisture factors are of utmost importance in winter storage. About 85% relative humidity represents the optimum condition, but no danger exists if the humidity should vary between 80 and 90%. A daily check with a wet and dry bulb psychrometer at opposite ends of the storage should be made to determine the relative humidity existing. Humidity can be increased by sprinkling walls and floors of the storage room.

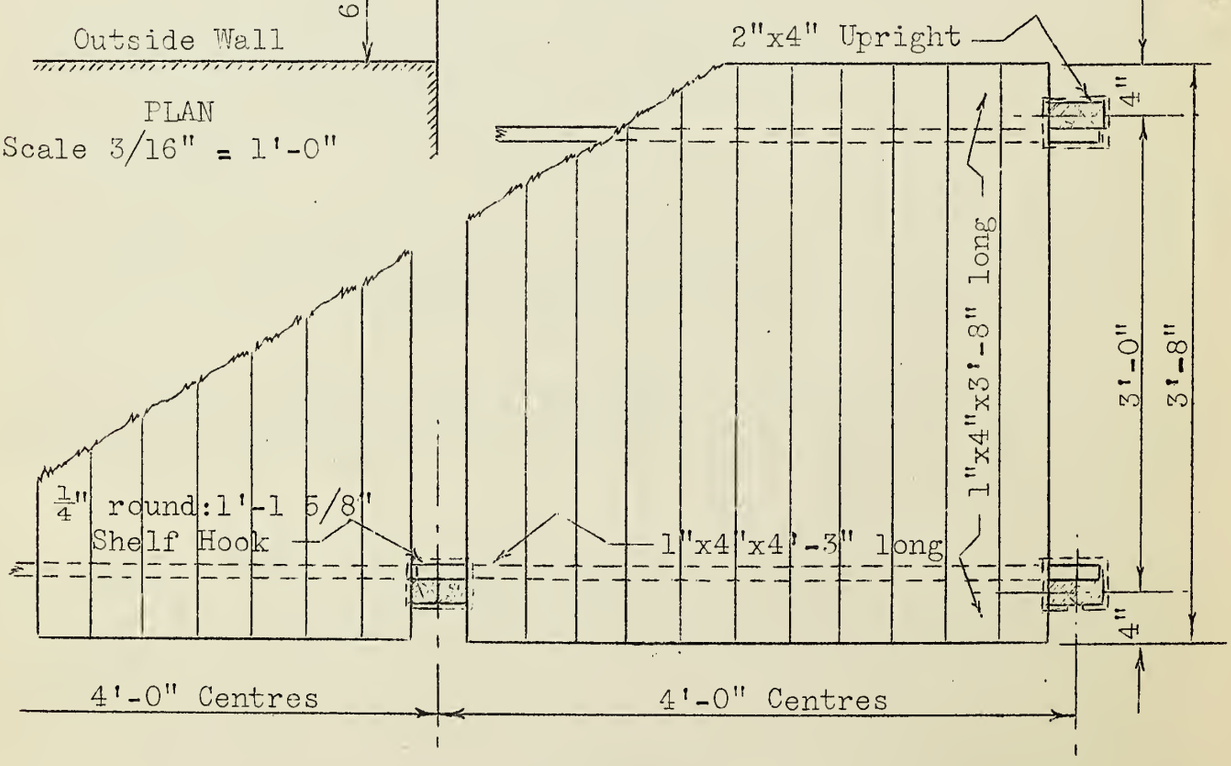
Figure 3 illustrates a desirable plan of an inside storage room. This plan can be varied to suit the dimensions of any storage warehouse. In general, 4 to 6-foot aisles between every two tiers of stock are necessary to permit the workmen to move freely. Six-foot aisles are preferred if possible. A six-foot space should be allowed between the first tier of stock and outside storage walls. This may vary according to the effectiveness of the insulation, but in any event it is best to play safe and keep the stock well away from the outside walls, especially in the northern States. An 18-inch free space for ventilation purposes should be allowed between the inside walls and the first tier of stock, also between the two successive tiers. The individual sections should be 4 feet long and separated by 2x4's as illustrated.

Figure 4 illustrates a convenient system of setting up the tiers for racking the seedlings. It is patterned after the system in use at the Plumfield Nursery at Fremont, Nebraska. No nailing is required, which makes it a quick and easy method to set up and take down with no breakage of lumber. The shelving is easily and quickly inserted by means of the shelf hook. The shelves permit the racking of seedlings from floor to ceiling without creating excessive pressure in the bottom of the pile, and is a very convenient method of keeping the various species and grades separate.

Seedlings should be piled with roots out and tops in. Tops may be allowed to overlap. No danger exists from this overlapping if the tops are clean of leaves, are not exposed to dripping moisture, and aeration provided.

Roots of the seedlings should be protected with a light covering of shingletow or sphagnum moss. All packing material should be soaked in a tank and then allowed to drain before using. Handled in this manner, it will absorb sufficient moisture to make unnecessary frequent sprinkling, provided the humidity in the storage is properly maintained. The use of dry packing material should be avoided since it is desiccating to the seedling roots.





DETAIL
Scale 3/4" = 1'-0"

Fig. 3

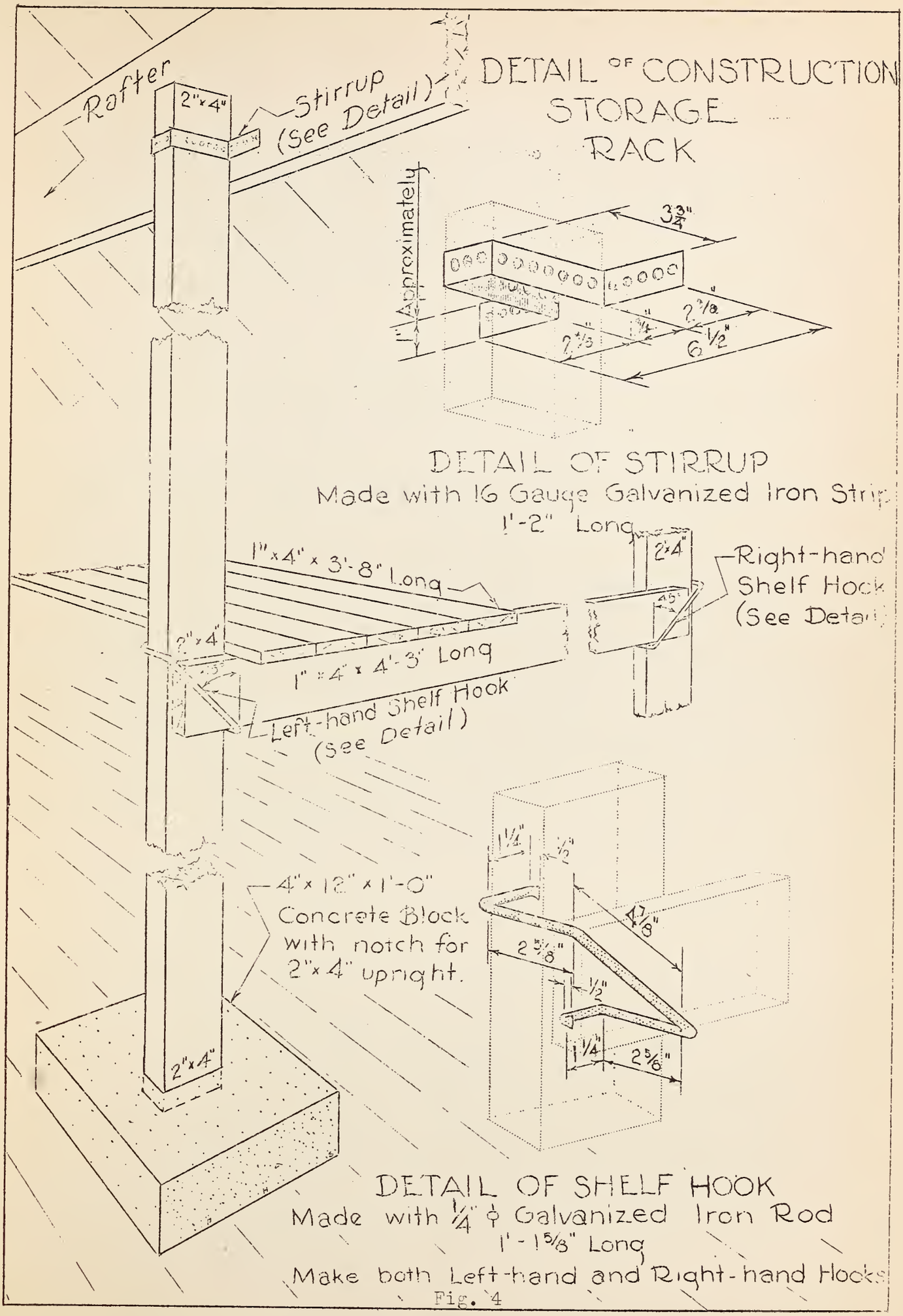

DETAIL OF CONSTRUCTION
STORAGE
RACK
Rafter
2"x4"
Stirrup
(See Detail)
Approximately
1"
3 3/4"
2 1/8"
2 1/2"
6 1/2"
DETAIL OF STIRRUP
Made with 16 Gauge Galvanized Iron Strip
1'-2" Long
1"x4"x3'-8" Long
2"x4"
1"x4"x4'-3" Long
Left-hand Shelf Hook
(See Detail)
2"x4"
Right-hand
Shelf Hook
(See Detail)
45°
4"x12"x1'-0"
Concrete Block
with notch for
2"x4" upright.
2"x4"
1 1/4"
1/2"
4 7/8"
2 5/8"
1/2"
1 1/4"
2 5/8"
DETAIL OF SHELF HOOK
Made with 1/4" ϕ Galvanized Iron Rod
1'-1 5/8" Long
Make both Left-hand and Right-hand Hooks

Fig. 4

Heel-in Storage

Outside "heel-in" conditions vary widely from north to south, and therefore local conditions will dictate details of the heeling-in procedure. In general, heel-in sites should be located on sandy soil, with adequate drainage, and on an all-weather road. Water should be available and it is desirable also to provide for wind protection. A warehouse or other suitable building is necessary adjacent to a heel-in site for assembling orders and packing out the stock to the strips.

The two southern States expect to proceed with more or less continuous planting throughout the winter. Their problem in such heel-in beds will not be as definitely "winter storage" as in Kansas and farther north.

The seedlings in the heel-in bed must go into the winter reasonably moist in order to stand the storage, yet they should not be water logged. The soil or sand should be firm around the roots. Sand or sandy loam is preferred to heavier soils. It may be necessary to cut strings on large bundles of stock to allow the roots proper spread. If this should become necessary, twigs may be set upright between the opened bundles to avoid the need of recounting when retied in the spring. There is often a tendency to neglect the back side of the bundle when heeling-in. Be sure sand or soil is worked in around the bundles.

Drainage should be provided for in the heel-in site to insure against the heel-in beds becoming water logged. Alternate freezing and thawing under such conditions may cause serious damage. Soil that can drain away to such an extent that it will not adhere to the roots when bundles are removed from the beds will expedite operations in the spring.

Bundles of seedlings with irregular root collar line should be covered deep enough to be sure all roots are covered. A little stem in the soil will do no damage, but a little root in the air will result in a dead seedling. Covering the tops with soil at least one-half of their length is generally regarded as a safe practice.

It seems worth while on most heel-in sites for winter storage after the ground has frozen several inches, to entirely cover the seedlings with straw, dry shingletow, or similar material, that will permit some aeration and yet prevent a warm spell in the middle of the winter from thawing the ground and even starting the sap to moving. This condition followed by a severe freeze is very damaging to the seedlings. It is usually necessary to put a little dirt on top of the straw to keep it from blowing.

Plan of the Central Heel-in Bed

A description and figures illustrating the method and procedure followed by Nebraska in laying out their central heel-in beds follows. This system lends itself readily to adoption by other States using the heel-in system of winter storage.

A. The individual bed.

1. Figure 5, entitled "A Plan for a Central Heel-in Bed", illustrates a practical method. A bed 5 feet wide will usually accommodate from 10 to 20 bundles of seedlings in a row across the bed (100 seedlings to a bundle), depending upon size. The length of the beds and the number of beds are limited only by the space available. For the premium grade seedling, an average of approximately 750 square feet of bed space, exclusive of roads, etc., is necessary to heel in 100 M seedlings under the system outlined herein.

2. Each individual heel-in bed is given a number which should be posted in a conspicuous place. This is necessary in order that the bed may be readily identified.

3. In order that various species of trees, sizes, etc., may be easily located in any given bed, it is necessary that a record be kept of their location. In the suggested plan (Fig. 5) all measurements are taken from the 0+00 Station which is located at the east end of each bed.

   For example: 17,900 caragana P-31-1, 12/18", are heeled-in in Bed 2 starting at the east end or Station 0+00. These trees are tied in bundles. They are found to occupy 21 lineal feet of bed when "heeled-in". Therefore these caragana are listed on the heel-in bed records as being located in Bed 2 - Station 0+00 to Station 0+21.

   If 27,500 caragana P-31-1, 8/12", are next "heeled-in" in Bed 2, a 3 foot space (header) is left between this group and the previously "heeled-in" trees. This makes it possible to remove one group without disturbing the other. These last trees would then be recorded as being located in Bed 2, Station 0+24 to Station 0+49, assuming they occupied 25 feet of bed.

   In order to avoid the necessity of measuring from the 0+00 Station each time additional trees are heeled-in, it is suggested that reference stakes be established at the west end of each new lot of trees heeled-in. (See Fig. 13)

B. The series of beds.

1. It is important that ample room be left for roads between every two beds and at the end of the beds. The dimensions shown have proved adequate but if plenty of space is available, 18-foot roads between the beds might prove more satisfactory.

2. An 8-foot space should be left between the beds (Fig. 5). This can be reduced to 5 feet if the amount of greund available is limited.

C. Heeling-in the Seedlings. (Steps in the procedure)

1. Dig open 10 or 12 feet of bed (or less if the amount is not needed) of sufficient depth to accommodate the roots of the seedlings. The root collars should rest from one to two inches below the original ground level.

2. The starting end of the bed should be sloped to give the bundles the proper position. (Fig. 6)

3. Distribute the bundles in a row across the bed spacing them far enough apart to allow plenty of soil to come in contact with the roots on all sides. (Fig. 7)

4. Shovel dirt against trees as shown (Fig. 8). (The men should use their feet to pack the soil around the roots.)

5. A pole 7 feet long and 2 inches square or 2 inches in diameter is next placed across the bed. (Fig. 8)

6. The second row of bundles is then distributed (Fig. 9) and dirt shoveled in (Fig. 10).

7. The pole is now behind the second row of bundles and the roots are covered with soil. Then two men, one on each end of the pole grasp it and pull it forward until the bundles attain the desired angle (between 45 and 60° with the horizontal). The opening that is created in the soil directly behind the bundles by this forward movement of the pole is filled in with dirt and firmed. After a number of rows have been "heeled-in", one or two men are detailed to start at the beginning and cover the tops of the seedlings with soil to a depth of one-half to two-thirds of their height, raising the top of the bed above the ground level. The top of the bed should be crowned as illustrated (Fig. 12), making sure that the shoulders of the crown extend out far enough to thoroughly cover the roots of the outside bundles of seedlings. This crown effect provides drainage to take care of excessive moisture.

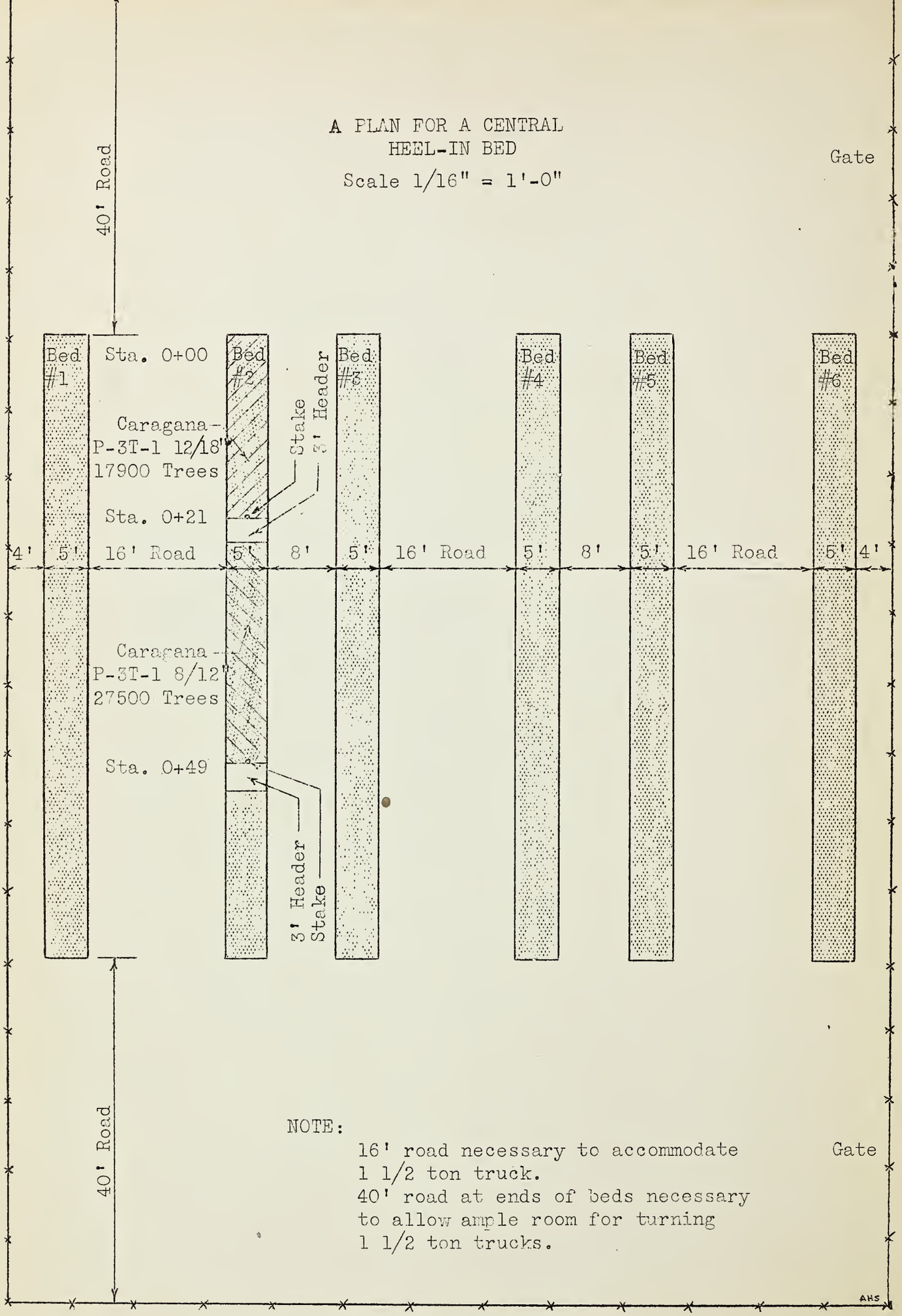
D. Record keeping.

1. It is expected that each State will want to devise their own forms for keeping the necessary records of stock in the heel-in beds and in the storage warehouses. For administrative purposes, a record is necessary of the amount of stock by species, grades, and accession number, transferred from each nursery to the central point, a daily heel-in or storage record, and an inventory by beds and by species.

In addition to the above records, it is good practice to set a stake, mentioned previously, in the heel-in bed after a shipment of seedlings is heeled-in. Suggestions for marking the stake are shown in Figure 13, and it is set just beyond the last row of seedlings to which it refers. This stake serves as a double check and is a ready reference in the field.

A PLAN FOR A CENTRAL
HEEL-IN BED

Scale 1/16" = 1'-0"



NOTE:

16' road necessary to accommodate 1 1/2 ton truck.
40' road at ends of beds necessary to allow ample room for turning 1 1/2 ton trucks.

Figure 5

METHOD OF PLACING SEEDLINGS IN THE HEEL-IN BED

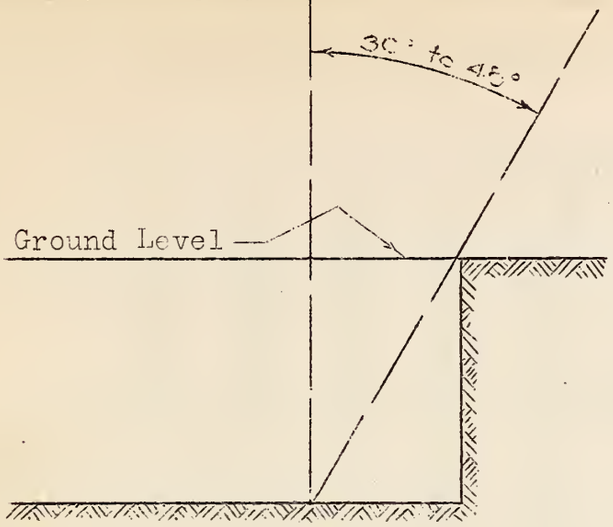


Figure 6

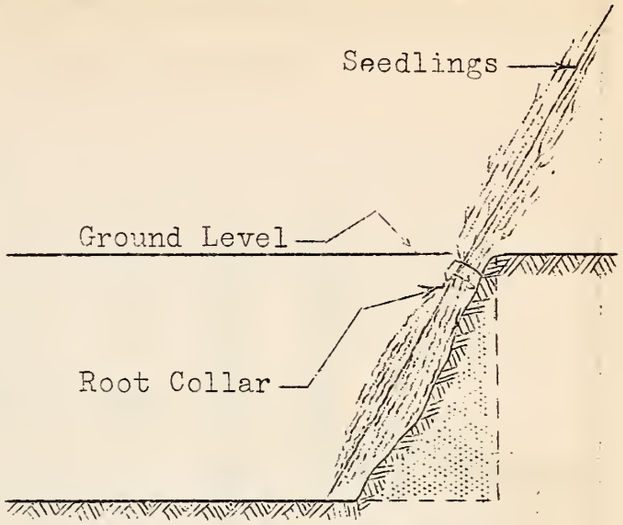


Figure 7

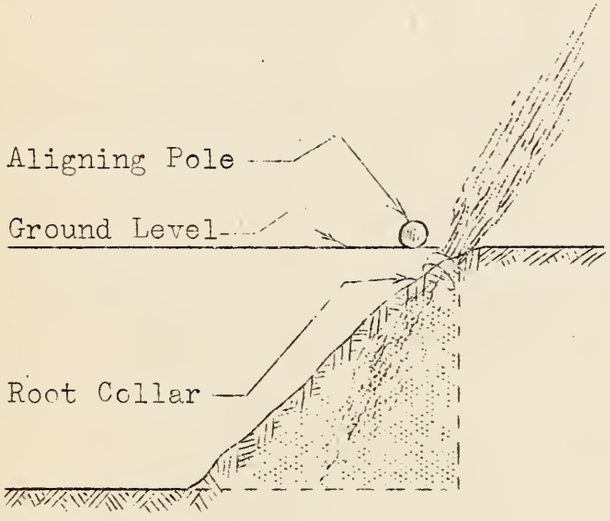


Figure 8

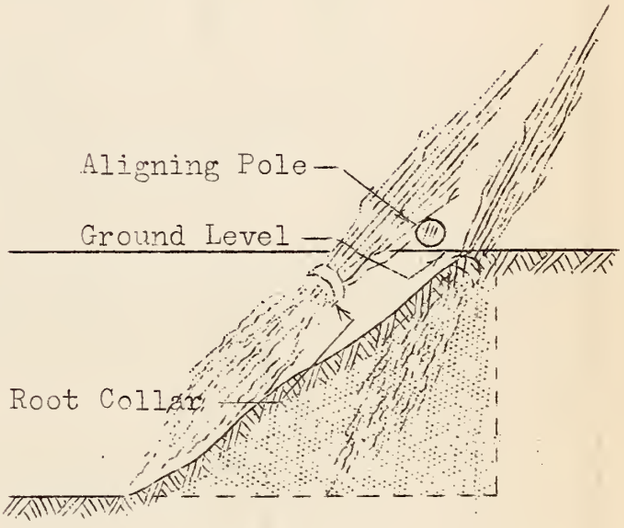


Figure 9

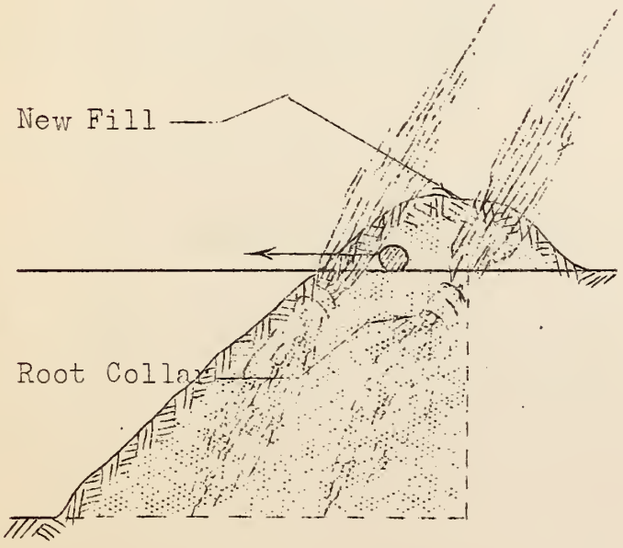


Figure 10

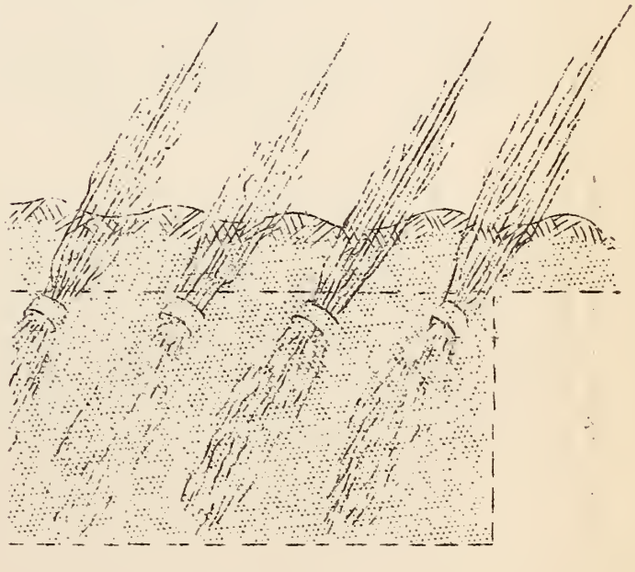


Figure 11

METHOD OF PLACING SEEDLINGS IN THE HEEL-IN BED

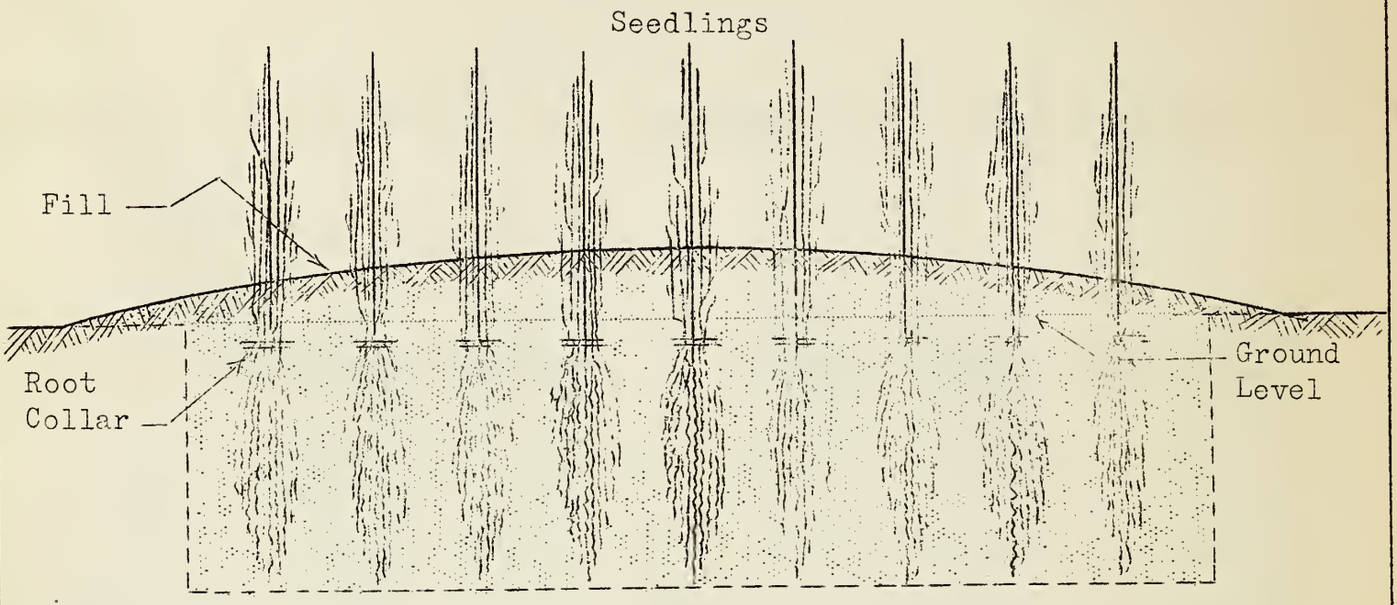


Figure 12

Bed No. _____ Sta._____ To Sta._____

Species _____

Accession No. _____

Grade _____

No. Bundles _____

No. Trees _____

From _____ Nursery

Figure 13

DAMAGED STOCK

Between the time the seedlings are dug in the fall and planted out in the strips, they may be subjected to injury from freezing, drying, and heating. Also under certain conditions rots and molds may infect the seedlings and cause losses. Ordinarily all of these factors are subject to the control of the nurseryman if suitable facilities are available and proper care is exercised.

Frozen Stock

Freezing of the roots while exposed to air is one of the most common causes of stock damage. Above all else if stock becomes frozen do not handle while in that condition. Allow it to thaw out slowly in the dark with plenty of moisture. If additional moist packing can be added without disturbing the stock it may be beneficial. If stock, as it begins to thaw, can be sprinkled with cold water it draws frost out with less damage.

There are degrees of freezing damage that may be represented by seedlings that mold and decay completely to those which show no injury. All seedlings that show any considerable amount of shriveled bark or roots in the spring and a brown or tough clinging cambium layer are probably killed. A very good check is to take seedlings which are on the questionable line and bury them completely for a week under moist dirt. If a healthy appearance cannot be restored in that manner, they are definitely a poor risk to plant in the strip.

Damage from Drying

A shriveled appearance is the first visible evidence that the seedling is suffering from drying. The cambium layer may have a green appearance, but if upon cutting it you find it dry or clinging instead of moist, it is in a weakened condition. Usually if it is difficult to cut through the bark to the cambium layer with your thumb nail on a one-year seedling, it has dried too much for best planting results and the seedling is weakened. Stock in this condition should be tested as described under the paragraph on freezing.

Restoring Damaged Stock

The cause of this shriveling is due to only partially filled cells which results in the collapse of the cell walls. If they are completely buried in moist soil, the transpiration drain on the stem is not only cut off, but an actual absorption of water takes place in the stem as well as roots. This will again fill the collapsed cells and restore vigor to the seedlings unless, of course, they have actually been bursted by freezing or become inactive from too long drying.

When the cells are filled to turgidity, the seedlings have a much better chance of survival when planted out. Too long a time buried from the air will result in decay. A week's time is usually adequate. However this will vary with temperature, requiring a longer time at lower temperatures and shorter at higher. The same results may be accomplished by completely submerging the stock in a tank or creek, but one-half as long a period will be required for this method as with burying. The burying plan is preferred.

The above procedure applies only to deciduous stock and is not workable for conifers. Any actual drying in the latter is permanent injury, as the sap in conifers is resinous and once dried is impervious to water.

Stock which has heated in storage to such an extent as to show injury should be discarded as worthless.

So much stress has been placed on damage from drying that there may be a tendency to keep stock too wet, particularly the tops in indoor storage. Molded or decayed tops whenever found should be thoroughly aired in order to stop this condition, but roots must remain carefully protected during this process.

Regardless of what has happened to the seedling in the way of freezing, drying, heating, or other injury, the nurseryman will be responsible for seeing that questionable stock is not sent to the strips for planting. The loss from planting a seedling already dead or dying is several times the actual loss of the seedling. It would be throwing good money after bad to plant them.

ADMINISTRATIVE EXPERIMENTS

Each nurseryman should conduct some experimental work, either planned by supervisory officials or instigated by the nurseryman himself.

Many of our present nursery practices are based on commercial nursery practices within the Plains Region. The commercial nurseryman's problems are in many respects the same as our own. It is necessary, however, that we should plan to improve upon the present nursery practices in order to insure the production of the optimum size and quality seedlings at the lowest possible cost.

There has been definitely set up by the Regional Office and State offices a set of administrative experiments to be carried out in conjunction with the nursery operations in each State. There will be other experimental requirements put upon the nurseryman from time to time from other divisions, departments, or bureaus. It is desirable that the nurseryman cooperate with our experimental agencies. The nurseryman not only can aid very materially in securing experimental data, but can profit very substantially himself by becoming familiar with the details of the experiment.

There are many minor details that confront the nurseryman daily on which he may secure data of value to the remainder of the nursery organization. These may or may not necessitate setting aside comparative units to verify the conclusions. The man who is constantly alert for new definite facts is producing data that may be of considerable value to the entire nursery organization.

Some of the more common factors for constant observation and recording are growth rates of the various species throughout the season as influenced by stand density, excess moisture, wind protection, row spacing, width of band, and cultivation practices.

One of the most important things in conducting experimental work or observations is to do so without any previous opinions. Be just as willing to accept a conclusion one way as the other. If definite opinions are held before results are reached, they will consciously or unconsciously influence results. This mental attitude of the investigator is just as vital as any other condition for <u>unbiased</u> conclusions.

Detailed discussion of present experiments or future would only be a repetition of instructions from other sources, but the nurseryman should realize that experimental work at his nursery, which may disrupt his production program to some extent, may result in information of considerably more value than the few seedlings involved. It adds to the sum total of nursery knowledge for his and others advantage, and also gives the experimentor training that has a vast value.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Plains Shelterbelt Project

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SECTION D

PROTECTION IN SHELTERBELT NURSERIES

METEOROLOGICAL

While the seedlings are in the nursery, heat, cold, rain, hail, and wind are forces of nature over which the nurseryman has no control. He can to a certain degree ameliorate the effects of all of these forces except hail, the most destructive and most devastating.

Heat

Ordinarily extreme heat will not have any effect on well-established seedlings unless it is associated with drought. However, extremely high temperature will destroy young tender seedlings, even though plenty of moisture is available, by heating the soil surface to a degree that will burn the seedlings at the ground line, or by causing the seedlings to transpire at a rate faster than they can replenish their moisture supply from the soil. Shading and irrigating by means of overhead sprinklers are the only proved effective control measures at such times. In the Shelterbelt nurseries only seedlings grown in beds can be protected by shading. Only a small percentage of the nursery areas will be equipped with overhead sprinklers.

Stand density is regarded by many nurserymen as an important factor in reducing heat losses. The mutual protection from heat afforded the seedlings growing in close association with each other must be recognized, since such seedlings by shading the soil in the band reduce the surface soil temperatures and thereby reduce the losses from burning at the ground line. Mutual shading of the seedlings also results from such close association which undoubtedly reduces the amount of sun scald injury.

The nurseryman must recognize, however, that unfavorable conditions may also result from too dense stands, such as rapid depletion of soil moisture, resulting in drought losses, increased damping off, and loss of growth or production of spindly seedlings. These factors must also be given consideration in deciding on stand density. In other words, the point of diminishing returns is reached when too much emphasis is placed on one consideration alone, thereby creating conditions that result in losses from other causes. The ideal stand density is attained when all associated factors are in proper balance, i.e., when each is given its due weight. Protecting the seedling from heat injury by increasing stand density may result in a "boomerang" if carried too far.

Different species of seedlings during the early stages apparently show different degrees of sensitivity to heat. While no definite rule is established, there seems to be a parallel between the size of the seed and the susceptibility of the seedling to heat injury. Large seeded species such as oak, honey locust, plum, chokecherry, etc., appear to be less susceptible to heat injury than small seeded species such as elm, mulberrry, and others.

Frosts

Unseasonably late or early killing frosts are occasionally encountered. Injury from this cause will ordinarily be limited to the three northern States. Effective protective measures against late frosts such as covering seedlings with straw, etc., are not readily adaptable to large scale nursery operations, and when spring losses occur under ordinary conditions they are largely unavoidable. However, it is a well known fact that local terrain has a marked effect on frost severity, and therefore the most effective method of protecting against spring as well as fall frost damage is to avoid locating nursery sites in so-called frost pockets or frost areas.

If the nurseryman succeeds in obtaining proper size seedlings by mid August or thereabouts, and bends every effort thereafter towards ripening or hardening off his seedlings, he will ordinarily be prepared for even the early killing frosts. In the north it is inviting disaster to have succulent seedlings later than September 10. All irrigating and cultivating, therefore, should cease in the three northern States by August 15 in North Dakota, ranging to September 1 in Nebraska.

Some species such as Chinese elm and Russian mulberry are persistent late growers. Chinese elm is less susceptible to frost injury, however, and shows little effect from early frosts unless they are exceptionally severe. Mulberry on the other hand may suffer killing back to the ground from the first frost in the fall. Some commercial nurseries in the Plains Region have a practice of defoliating mulberry with a spray made by dissolving one pound of copper sulphate in 50 gallons of water. Although little is known concerning the merits of this practice, it is perhaps advisable to consider it at least on a small scale where the seedlings remain succulent and growing abnormally late. A two-weeks' period after the spray is applied is necessary to result in complete hardening off.

Tops of seedlings may suffer severe killing back by frosts, but unless the root crown is injured such seedlings will ordinarily sprout from the root collar and establish a new stem. Thus it can be said that the root crown or collar is the "heart" of the seedling, because when it is dead the seedling is dead regardless of the condition of the other parts. For species which are tardy in ripening or if an unusually early killing frost is forecast, the nurseryman can protect the seedlings from being killed outright by hilling up his seedling row much as one would hill up a row of potatoes. The soil cover on the root crown will in most cases protect it from injury. Hilling up the rows can be quickly and easily accomplished with a cultivator equipped with disc shovels.

Rain

Normal rainfall holds no fear for the nurseryman. However, the nursery survey should provide data for determining logical drainage methods in case of rainfall above what the soil will absorb without run off. One of the nurseryman's first thoughts should be to provide drainage for all low areas to insure against water standing in his fields after each heavy rain if his soil type is such as to prevent rapid percolation.

Wind

Location of Shelterbelt nurseries in natural protected sites if possible is the logical approach to the problem of wind protection.

There is some evidence that remarkable results can be obtained by protecting seedlings from wind. Some species, notably American elm and hackberry, apparently respond readily to wind protection by greatly increased growth over comparable seedlings not so protected.

The most critical period in the life of a seedling is during establishment, and this is the time that wind protection should be provided if possible. During the 1935 season in a number of nurseries efforts were made to provide wind protection through the use of vegetative windbreaks. While some nurserymen are in favor of continuing this practice, it is definitely agreed that vegetative windbreaks are of small aid to young seedlings during the period they need protection the most, because windbreaks of this type are not effective until later in the season. Another weakness of vegetative windbreaks is that they sap the soil of moisture which if not replenished by rainfall or periodic irrigation, results in stunting the seedlings in the immediately adjacent rows.

Therefore, vegetative windbreaks are not to be recommended except along irrigation ditches or along fence rows or edge of the field. Sorghum, cane, sweet maize, and sunflowers, or a mixture of all, are perhaps the most desirable for this purpose.

Snow fences whenever obtainable are recommended for use in the nursery blocks, particularly during the germinating period. All nurserymen are encouraged to determine, by using snow fences, the effect of intensive wind protection on the various species of seedlings as against unprotected seedlings.

Wherever the lay of the land permits or where there is any choice in the matter, the nursery rows should run at right angles to the prevailing summer wind. The destructive hot winds usually come from a southerly direction, and the successive rows of seedlings running east and west will serve to break up the sweep of the wind near the ground.

PATHOLOGICAL*

Introduction

On the basis of field observations made during the past season, it soon became evident that considerable losses from damping-off and root rot were occurring among several species of deciduous seedlings. American and Chinese elms were the most universally infected. During the present winter, tests for control of these losses are being made under greenhouse conditions. Although we cannot recommend definite control measures at this time, we have during the course of the study, secured some pertinent information which should be of considerable value in reducing future losses.

Description of Losses

In general there have been three types of losses: those due to pre-emergence and post-emergence damping-off, and losses caused by top wilts.

Pre-emergence losses take place before the seedlings appear above the soil. These may be a result of direct infection of the seed or infection of the radicles soon after germination. Incidentally, these losses explain to a considerable extent the presence of failed spots in seed rows. Failed spots are, therefore, not only due to poor quality of seed.

Post-emergence losses occur soon after the seedlings appear. Infections usually take place at or just below the soil level. Typically the seedlings fall over in true damping-off fashion. After the seedlings have developed the first leaves, losses from this source are generally light, Losses are frequently heavy during the cotyledon stage.

Top-wilts may cause losses still later in the season, but can come most any time, depending upon weather conditions. They have been much less severe than either of the other two.

Methods of Study

In order to determine the causal organisms it was first necessary to secure isolations from diseased American and Chinese elm seedlings growing in the different nursery soils. Samples of most of the shelterbelt nursery soils were, therefore, secured, placed under greenhouse conditions, and sowed with seed of these two elms. By keeping samples of all the soils under the same conditions for uniform damping-off, we were not only able to isolate the fungi responsible but were able to also determine the approximate severity of infection of the soils.

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*Pathological Protection as applied to Shelterbelt Deciduous Nurseries by Ernest Wright, Associate Pathologist, Division Forest Pathology, U.S.D.A.

Results of the Study

None of the soils tested were found to be entirely free from losses due to fungous infection. The information secured is tabulated below by states, for Chinese elm. American elm seed was too low in viability for reliable tests, but it is believed that these ratings will hold for both species. The results are based on combined pre-emergence and post-emergence losses.

Species: Ulmus pumila

(Many of last year's nursery soils are included so that each state organization may check up to their own satisfaction the reliability of the classification on the basis of last year's results.)

State	Soils
Texas	Rayland and Chillicothe - both probably will have moderate losses without treatments. Rayland probably slightly more severe than Chillicothe.
Oklahoma	Enid and Noble - losses will probably be light. Oklahoma City - moderately heavy losses should be expected unless treatments are made. Tecumseh - heavy losses can be expected. Chinese and American elm should not be concentrated here. Noble appears the most favorable of this year's nurseries under natural conditions, that is, without treatment.
Kansas	Abilene and Winfield - losses moderate without treatments. Winfield heavier than Abilene. Salina - no tests run. Manhattan - moderately heavy losses occur. McPherson - very heavy losses may be expected on this soil. Of this year's soils tested for Kansas, Winfield appears the most promising for the elms.
Nebraska	Fremont - losses moderate without treatment. Arlington - lesses somewhat heavier than on Fremont soil. York and North Platte soils not tested.
South Dakota	Brookings soil, last year's site - losses very heavy, should not be used if can be avoided. Baltic soils - losses moderately heavy without treatment. Pierre and Rapid City soils not yet tested.
North Dakota	Valley City - moderately heavy losses without treatment. Enderlin - probably heavier losses than Valley City. Bismarck and Mandan soils not yet tested.

Losses on the different soils varied considerably. The heaviest losses occurred on the soils from Brookings, Oklahoma City, and McPherson. McPherson soil was the worst of all giving only 3 per cent emergence and 100 per cent damping-off. The percentage lost under the conditions of our tests are greater than will ever be experienced in the field, yet all soils were treated in the same manner so that results should be comparable. The ratings are based on several repetitions. If practical, it appears advisable to avoid those soils giving heaviest losses in each state if in accordance with field evidence.

None of the soils so far tested should be sowed with American or Chinese elm seed without attempting some control measures as a matter of precaution, at least on a part of the areas. It is our plan to make recommendations before sowing time for the elm seed and in representative cases we plan to supervise the treatments and study the results in the field. We hope to have this information in the hands of the Directors of the southern states by not later than April 10, and to assist in the installation of some tests at that time, working north as sowing operations progress.

As soon as the other soils not tested are received we will conduct similar studies to determine relative losses, and will then issue short reports to the respective states concerned.

Factors Contributing to Damping-off Losses

1. The depth of sowing elm seed is very important. Pre-emergence losses increase with depth of sowing. American and Chinese elm seed should not be buried more than 1/4 of an inch at the most.

2. It is likewise important to very carefully level off the areas to be seeded so that water will not stand in puddles in the seed rows. Such accumulations of water along with other weather factors may result in heavy damping-off losses even though spotty. Drainage should be satisfactory at all times. This applies to seed beds in general.

3. Avoid sowing the seed of the same species in the same soil area as occupied the year before. Alternation of species is desirable. By successive sowings in the same soil contained in pots increasingly greater losses was induced.

4. By testing out a number of agricultural crops we secured the following indications: Areas occupied by potatoes, sweet clover, alfalfa and corn are potentially dangerous crops to follow with sowings of American or Chinese elms. These crops are readily infected with the same damping-off fungi affecting elm seedlings, hence, they may tend to build up infection. On the other hand, from the tests so far attempted, wheat appears to be the most favorable rotation crop preceding elm seedlings, since it does not become infected readily by the elm fungi. The susceptibility of these crops are merely indicated at this time as a matter of interest, since field evidence is necessary before coming to definite conclusions. No doubt further modifications will be needed in the future. Additional crops are now being tested and will be reported upon at a later date.

5. Density of sowing of any seed is of vital importance. There is a tendency to believe that the heavier the sowings the larger will be the number of seedlings which survive. Actually damping-off once started will generally progress faster through a dense stand of seedlings than through a less dense one. Just how dense the stand should be can only be determined by actual field tests, since correlation with the local climate and soil conditions are necessary. Another factor is the effect of mass emergence. When many seedlings push through the soil they generally remove the soil in clods and frequently expose the still ungerminated or the recently germinated seedlings to desiccation, which of course is detrimental. The density factor must be determined more or less for each nursery site and can best be decided by the nurseryman. Too sparse sowing on the other hand may make it very difficult for the seedlings to get through the surface crust in which case pre-emergence damping-off may overtake them.

Effect of Injury to Cotyledons

In our greenhouse tests we have noticed that in compact soils, where the elm seedlings come up with great effort, they may tear off their cotyledons or at least injure them badly. Further tests indicate that the seedlings are readily stunted and many times killed by removing or injuring the cotyledon. Hence, it appears important to avoid any injury to the cotyledon. This would be especially true when breaking the soil crust mechanically just prior to emergence of the seedlings.

Russian Mulberry

Losses in Russian mulberry seedlings have been rather high, particularly in the south. The losses again are most common in the early stages and resemble damping-off, although it is the result of bacterial infection in this case. Preliminary tests at Woodward, Oklahoma, by Lamb have indicated that effective control can be secured by treating the soil with a formaldehyde solution. He obtained best results by treating the soil with a 1 - 100 commercial formaldehyde solution applied 48 - 72 hours before sowing. Further tests will be made again this year, but it is suggested that some of the states might try this treatment on a part of the area intended for mulberry so that a wide range of conditions may be obtained.

Top Wilts and Leaf Blight

We have not found top wilts a general menace so far, and it will be unnecessary to follow a regular spraying schedule until more is known about these wilts.

Leaf spots of chokecherry and green ash occurring late in the season were quite common last year. In nurseries adjoining woodland or brush areas, especially along streams, it would be well to locate the chokecherry and green ash areas as far as possible from the wild species in order to possibly reduce the intensity of the infections.

These leaf blights rearely kill the seedlings, but they do cause premature leaf fall and hence may result in reduced growth. This would be especially true if infection should take place early in the fall or in late summer. We hope to try some spray tests on these species this year, but until the actual tests are made, it would be hazardous to make any suggestions, since they may prove ineffective and not warrant the cost in time or money.

Storage Problems

Control of Chinese elm root rot.-- Tests carried on last year by Lamb have been continued by us this winter. We have at last secured what looks to be several promising means of control, due largely to the efforts of Baker and Livingston. While we could report the results at this time, it appears advisable to follow the treated plants after they are planted in order to obtain evidence on survival. We do not, however, expect the treatments to be detrimental in any way. At a later date, considerably in advance of digging this fall, we will issue a special memorandum setting up our recommendations in detail.

Seed treatments to prevent molds.-- This is considerable of a problem in itself and so far no satisfactory results have been obtained.

General Suggestions

In the handling of many seedlings this winter, we have noticed quite a number of especially tight bundles with the binding cords cinched very securely about the plants. In some cases the rope has actually become imbedded in the stems of the outside seedlings, thus causing wounds or partial girdles and at the same time weakening the seedlings mechanically. In addition to this, very compact bundles are undesirable since they will heat internally because of poor aeration.

Another important factor appears to be the size of the wound caused by root pruning in the fall. Tap roots of Chinese elm in particular are commonly severly wounded during pruning because they are very thick and succulent. The wounds moreover do not callus over readily under storage conditions, and these wounds easily become infected with the root rot organism. It is suggested, therefore, that an early spring pruning could be tried in an experimental way this year to study the effect on the root system. Such prunings could be made after the seedlings are about six weeks old, running a sharp knife about six inches below the soil surface, leaving the plants in place. If this practice is successful, it will modify the root system by encouraging laterals. Following this pruning the plants may be more drought resistant and certainly the size of the tap root to be pruned in the fall will be smaller, so that the wounding and lifting operations should be less severe. This appears desirable from the pathological viewpoint.

It is also suggested that each nurseryman could aid us very materially by keeping an accurate date record of losses in his nursery which he believes to be due to damping-off or other parasitic fungi, so that we may later correlate these losses more accurately with weather conditions.

These general suggestions may be out of order here and may also be impractical, but they appear somewhat desirable since our main object is to simplify pathological difficulties as much as possible. They are intended merely as suggestions and not as criticisms.

BIOLOGICAL*

The problems involved in protection of nursery stock, from the time of seed planting to the time of removal of stock from the heel-in beds to the field for final transplants, can be roughly divided into two parts.

They are: Protection of seeds; protection of seedlings in heel-in beds; and protection of stock held over on the ground.

I Seeds:

A. Protection of seeds, in beds, against:

1. Mice
2. Ground squirrels
3. Moles

II Young stock:

A. Protection before removal from the ground

1. Rabbits
2. Mice
3. Pocket gophers
4. Moles

B. Protection in heel-in beds

1. Rabbits
2. Mice

Field Mice

Protection of seeds against mice is, often times, a matter of utmost necessity. When mice start taking seeds their depredations occur night after night. Various species of white-footed field mice (Peromyscus), at times various species of meadow mice (Microtus),

*Biological Protection as applied to Shelterbelt Nurseries by Harold Haecker, District Agent, Bureau of Biological Survey.

and the pretty, little, brown, pocket mice (Perognathus) are the usual banditti. All are endowed with rapacious, little appetites so keenly whetted that they will often eat nearly their own weight of foods in a day's time. Venturing forth nocturnally, they, by some marvelous preceptivity, locate the seed beds; which they naively consider a festive board set with delectable morsels in manifest preparation for their rivalry. Down the rows they go digging out the seeds where they are planted and wasting no time where seeds are not planted.

We bear with these dainty little brigands when their feasts are confined to the sunflower, and like seeds, which they enjoy so much; but must change our attitudes when a valuable seed bed is endangered. Thus, at times, a necessity for protection arises.

Two protective measures can be employed. Seeds can be coated with materials which render them distasteful to mice; or the mice can be removed from the area. The former measure will not be discussed here as considerable equipment is required, at present, for coating the seeds. What few mice are found in nurseries can easily be removed by the use of poisoned grain. The grain used should be of the steamed and crushed whole-oats variety. Its use is extremely advisable as there is no danger of birds picking it up when it is properly used in conjunction with bait boxes.

Bait boxes can be made by the use of yeast boxes, prune boxes or similar containers. These are previded with tight lids, so fastened that they can be opened and yet fastened shut. Four openings are constructed, one on each side of the box. Openings can be made an inch and a quarter in height and from two to three inches in length. The lower side of the opening should be at a height of an inch and a half from the floor of the box. Poisoned grain placed in such boxes is protected from moisture, is not scattered, and is not exposed to birds. Bait boxes should be placed every few rods over the seed beds. They can be lightly covered with straw and yet prove effective. If the necessity for immediate and quick control arises, poisoned grain can be sprinkled lightly throughout the rows. A handful is sufficient for about ten rods.

Mice require considerable cover. Weeds along fence rows make ideal cover, as does tall, or matted grass. A weedy condition also provides a good source of food for mice and is thus always attractive to them. Where there are weeds mice are present. Often it is necessary to use straw mulches in seed beds. This of course attracts mice.

A clean seed bed or nursery is far less apt to be bothered than is one which is unkept.

Ground Squirrels

Any broad statement concerning control work in the squirrel group is justly open to some question. The Family Sciuridae, which includes all squirrels, comprises at least 240 species in North America. Many of these should not be controlled. The rule for control work in this group can best be determined by the damage being done.

Control of ground squirrels in the Plains Region seems, for the most part, to be comparatively simple. A teaspoonful of strychnine poisoned oats scattered around the mouth of the burrow will generally do the work. This grain should be placed to the side of the runway leading from the burrow. It is advisable to always make a survey of area surrounding the plantings. This reveals the location of the burrows and gives a clue as to the amount of area that must be protected. Usually, a strip 15 or 20 rods in width surrounding the planted areas is sufficient to keep ground squirrels from doing damage within the seed beds. Most species of ground squirrels differ considerably from mice in their choice of habitat. The Richardson ground squirrel, in particular, is extremely fond of bare-picked pasture lands. This propensity leads him to clip the grass, or vegetation surrounding his burrow, until it is possible for him to see some distance. The thirteen-lined Spermophile, on the other hand, seems to enjoy a certain amount of grassy cover.

Moles

Moles have been included in the list of those animals that at times require control. This is not because they generally feed upon seeds but because they frequently root up the planted rows. This rooting bares the seed to the sun, or gets them out of the line of the row making cultivation impossible.

Often the runway will proceed down, and under, a row of seeds. The first rain after the runway has been made washes it full of dirt. An irregular row is formed, and instead of 2 or 3 inches deep, seeds are under 6 or 8 inchesof soil.

After the seeds sprout, and have become small shoots, moles push up their runways again directly under the row. The tiny, new root system serves to hold the ground above the runway together more securely. Air pockets formed under the rows dry up the tiny shoots. Often if the roots form an obstacle in the runway they are cut off, much after the fashion of pocket gopher.

Garlough, in his "Research Studies on the Shelterbelt" July 1 to September 30, 1935, describes a poisoning method worked out by Noble E. Buell which seems fairly successful in the Plains District. Outside of this area we cannot vouch for the method. The bait material, most readily accepted seems to be raisins or oatmeal treated with formula R.F.A.-76, which is a strychnine formula prepared at the Control Methods Research Laboratory, Denver, Colorado. The bait material should be used in the proportion of 16 pounds of material to 1 ounce of poison. "The runway being 1 inch to 3 inches below the surface, the entrance into the runway should be made as small as possible. In most cases due to the dry sandy texture of the soil the aperture made caves in and so has to be enlarged in order to have a reasonably clean bait placement. The opening is then covered with heavy paper which in turn is covered with soil to exclude all light and to minimize the tendency of the mole to make repairs which generally ruined the bait."

Various types of mole traps probably will be as economical for small scale work, as the poisoning method. The out-of-sight mole trap and the gillotine type have been used with success.

It will be found that moles will have to be taken out of the seed beds themselves as well as a small surrounding area.

After the seeds have sprouted and have become small shoots the problem changes slightly. It will be found that in addition to controlling the Families mentioned above, rabbits and pocket gophers will have to be controlled. In the early summer and summer season it will be found that many rabbits will accept salt. Salt can be mixed in the proportion of 4 pounds to the one ounce of strychnine alkaloid. This is placed in a 4-inch length of pine 2x4 which has a hole $1\frac{1}{2}$ inches in diameter drilled in the broad surface to a depth of 3/4 inch. The salt is placed in this depression and allowed to harden. It should be replaced as is needed. Accumulations of dirt should be removed frequently. If a mound of dirt is thrown up about the surrounding surface to a height of approximately 1 foot and a breadth of 4 feet, it will be found that the rabbits will visit the bait spot more frequently. The salt block is placed on the top of this mound and staked down with a short length of #9 telephone wire which is inserted through a small hole in the block. The salt method works best when there is ample moisture on the surrounding vegetation. When the season becomes drier poison oats can be scattered throughout the seed bed and will account for many rabbits. If trees are left in the ground through the winter, heads of poison maize, Kaffir corn, or ear corn wired to a lathe at a height of about 10 inches above the surrounding soil or snow seems to be an effective rabbit poisoning method. The lathe should be firmly placed in the ground.

Trapping rabbits is seldom an effective control measure.

Pocket Gophers

Pocket gophers are easily controlled by the use of poisoned grain. The procedure is simple. All species of pocket gophers live in runways excavated below the ground surface at a depth varying from 4 inches to a foot or more. The dirt from these runways is thrown upon the surface in a fan-shaped mound which may be seen at intervals varying from a few yards to several rods.

To poison pocket gophers it is necessary that the bait be placed in the runway or tunnel made by the animal. It is then necessary to completely close the opening through which the bait has been inserted. A problem at once arises as to how these runways are to be found. The most successful method is to take a small, blunt probe and poke into the soil in the vicinity of the mound until a hollow is found. If the mound is carefully examined it will be noted that on one side, a depression indicates where the last dirt was thrown out. The runway is found on the side of the mound where the depression is located. Generally, a lateral varying in length from a few inches to 2 or 3 feet connects the runway and the mound. When the tunnel has

been found make a small opening into it by digging away the dirt with a trowel or small spade. Clean the dirt out of the mouth of the tunnel until its surfaces are left smooth. With a long-handled tablespoon carefully insert a spoonful of bait. The opening is then closed by inserting a wad of grass, or a small piece of sod, as a plug and piling loose dirt over the opening. After two nights an opening can be made in the runway at the bait spot and left. If this opening is plugged a gopher remains in the runway, and it will in all probability be necessary to attempt to remove it by the use of a trap such as the Macabee or the Victor.

It will be found necessary to remove pocket gophers from the area of a planting for a distance back of nearly a quarter of a mile. If they are allowed to remain in the nursery or vicinity, they will surely eventually clip the roots of a great many trees.

Trees heeled in for the dormant period will require protection from various species of rabbits and mice. The control of mice needs no further discussion as they can be controlled by the methods given above. Should they develop runways under straw, or mulch, poisoned grain will remove them with no danger to other species. The only caution is: watch for their signs and remove them before trouble starts.

Rabbits, however, are a different problem. The beautiful, pure white winter raiment of the varying hare and white-tailed jack rabbit gives them a virtuous aspect that entirely belies the full measure of perversity contained in this small coat. At times the snowshoe rabbit or varying hare will come to heel-in beds and dig through the snow to get at the tender young stock. Jack rabbits seem to delight in traveling through an area of plentiful feed in order to bite off young shoots, which they often leave lay without eating. Though the cottontail is the pee-wee of the family, he is usually a jump or two ahead of the other members in thinking up ways to destroy trees. All considered, it is necessary to remove rabbits from the vicinity of heel-in beds or stock left over in the ground. This can be done generally by the use of ear corn, or heads of milo maize or Kaffir corn. These are treated with strychnine coatings which do not seem to interfere with their acceptability. The greatest problem in winter rabbit control work is to keep the bait in working order. It has been found that a lathe stuck in the ground has some attraction for rabbits. By wiring the ears of corn or milo maize heads to the lathe at a height of 10 inches above the surrounding surface of the ground or snow, the bait is kept in good working order in spite of blowing snows. Poison stations of this kind should be placed every few rods. It is often advisable to prebait with untreated grain before the actual poisoning operation.

The use of the dirt mound described above is also very valuable in winter rabbit poisoning. By making the rounds of the bait stations every few days, and brushing the snow back from the mound, rabbits can be contacted with the bait very successfully.

It has not been possible in this paper to discuss control work in great detail. The foregoing outlines are given merely to serve as an indication of how work should be done. No mention has been made of the use of repellents. We feel that in time a good rabbit repellent will be devised that can be used on nursery stock with efficiency and safety. There is not one at present. The above work outlines, it must be remembered, apply only to the Great Plains District.

ENTOMOLOGICAL*

INSECT CONTROL IN NURSERIES ON THE GREAT PLAINS

The large-scale production of hardwood seedlings in the Great Plains States is so recent a project that very little is known about the insect problems that may develop in the nurseries. In the newly established shelterbelt nurseries a number of insect pests have already been encountered. Some of these are very difficult to control, and the general recommendations in the following pages will, in many instances, have to be supplemented after further experimental work has been carried out. In the shipment of nursery stock to the field there is danger of transporting pests on the seedlings, and every effort should be made to prevent such a distribution. Although this danger cannot be eliminated entirely, it can be reduced by close inspection of the stock. Unusual insect infestations or problems in the nurseries should be brought to the attention of the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, so that necessary investigations can be made.

For convenience of discussion, the insects most likely to cause damage to nursery stock are grouped according to their feeding habits under the following headings: Insects feeding on the roots, insects girdling the stems, leaf-feeding insects, sap-sucking insects, insects feeding in the shoots or buds, and insects affecting seed.

Insects Feeding on the Roots

Some of the most serious nursery pests, and the most difficult to control, are insects that feed on the roots. White grubs and termites have been the worst offenders, with minor damage by wireworms and a root borer. Soil poisons or fumigants offer the best possibilities for control, but there is always danger of injuring the seedlings. Recent experiments have indicated that it is dangerous to use crude white arsenic and lead arsenate in seedling nurseries and that the aresenic will remain in the soil and continue to cause injury for a number of years.

White Grubs: White grubs are the larvae of the large, well known May beetles or "June bugs". These larvae are white, fleshy grubs with a brown head and three pairs of prominent legs. The body is held in a curved position. They are general feeders on the roots of plants and, although more common in grass land, at times are serious nursery pests. Soon after the roots of forest-tree seedlings are eaten off, the foliage wilts, and the seedlings can be pulled with ease. When only part of the roots are destroyed the trees may be dwarfed.

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*Contributed by J. A. Beal, Entomologist, Forest Insect Laboratory, U. S. Bureau of Entomology and Plant Quarantine, Fort Collins, Colorado.

In South Dakota, Nebraska, and possibly in Kansas, the more injurious species require 3 years to complete their life cycle. The small first-year grubs, from eggs deposited in the soil late in the spring of the current year, generally cause little damage unless they are very numerous. Most of the damage occurs during the second year of development when the grubs are feeding heavily through the entire season. Feeding the third year continues only until midsummer, when the grubs transform to pupae and adults in the soil, emerging the following spring. Adults are emerging each year, and consequently grubs in all stages can be found at any time. In North Dakota it is likely that 4 years are required for some species to develop, while in the South the life cycle may be completed in 2 years.

Fumigation by flooding the infested soil with carbon disulphide emulsion has given some success in control, but the results vary in different soils and under different temperature and moisture conditions. Since the grubs go deep for the winter, this method can be used only during warm weather when they are feeding within a few inches of the surface. As the surface dries the grubs go down; consequently, fumigation while the upper soil is moist, or a day or two after irrigation, would probably be most effective.

A 50-per-cent emulsion, consisting of equal parts of carbon disulphide and a special soap solution, is used for this purpose. Treatment consists of diluting this 50-per-cent stock emulsion in the proportion of 1 quart to 50 gallons of water and applying it at the rate of 3 pints per square foot of soil surface. Late in the afternoon while the ground is still warm is the best time for application. The making of 6 or 8 holes per square yard will also aid in the penetration of the gas. These can be made with a broom handle or similar stick and should be about 5 inches deep. Puddling should be avoided, and the solution should not come in contact with the foliage since there is danger of burning. In the handling of carbon disulphide there must be no smoking or fires since the strong vapor in confinement is explosive. Containers should be kept tightly closed to prevent rapid evaporation and loss of the gas in storage.

Young seedlings are more susceptible to injury by the emulsion than the older stock with well-developed root systems. Tests with the above dosage on hardwood seedlings at Baltic, South, Dakota, in July, and on the conifers at Halsey, Nebraska, in September showed no damage from the chemical. It is possible that a weaker mixture, with more water for better soil penetration (for example, 1 pint to 50 gallons of water and applied at the rate of 2 quarts per square foot) might be effective. However, as these emulsions have not yet been tried on younger stock in shelterbelt nurseries, no recommendation as to the use of carbon disulphide emulsion on a large scale will be made until the results of further tests are known.

Termites: Termites, or white ants, resemble somewhat the true ants except that they are cream colored and the body is not constricted between the thorax and abdomen. Termites live in colonies in the soil or in wood and never work exposed on the surface. They feed on wood or other organic matter. While principally destructive to wooden structures, one species has caused considerable damage in the southern nurseries by feeding on the roots of seedlings. It is not likely that they will become important in the more northern nurseries.

In regions where termites are common, nursery soil should be kept free of all decaying wood and of as much other organic matter as possible, since such material harbors termite colonies. Some preliminary tests with several chemicals against termites in the shelterbelt nursery at Oklahoma City gave promising results in control. Although the chemicals when applied late in September had no apparent harmful effect on the seedlings, they should be tested on younger stock and in several nurseries with different soil types before being recommended for general use on a large scale.

The most promising chemicals and their methods of application are as follows:

(1) Paradichlorbenzene: Work paradichlorbenzene crystals into the soil to a depth of 3 or 4 inches with a hoe or other implement, at the rate of 3½ pounds per 100 square feet, taking care to keep the crystals at least 2 inches from the seedlings.

(2) Carbon disulphide: Dilute a 50-per-cent carbon disulphide emulsion in the proportion of 3 pints to 50 gallons of water and apply this mixture at the rate of 2 quarts per square foot of soil surface, taking care to prevent puddling and contact with the foliage. Application is similar to that suggested for white grubs, but the dosage is stronger and it is possible that there would be danger of injuring the younger seedlings early in the summer.

(3) Orthodichlorbenzene: Prepare a 50-per-cent stock emulsion by thoroughly mixing 1 gallon of soft water, 1 pound of soap, and 1 gallon of orthodichlorbenzene, or in these proportions. Add 3 pints of this stock emulsion to 50 gallons of water and apply this mixture at the rate of 2 quarts per square foot of soil surface, being careful not to wet the foliage. This emulsion is very unstable and the liquid should always be kept well stirred both during preparation and application, to prevent the chemical from separating out. This mixture cause no evident injury to well-developed seedlings in September.

Wireworms: Wireworms are slender larvae of uniform width, with a hard, tough, brownish or yellowish skin. They are the larvae of click beetles and feed on the roots of a large variety of plants. Wireworms are likely to be numerous in soil that has been in sod for several years, and occasionally may cause some damage in nurseries that have been under cultivation. Control is very difficult in soil where nursery stock is being grown because treatments severe enough to affect the insects would probably also destroy the seedlings.

Root Borers: The larvae of a species of long-horned beetle of the genus Prionus were found feeding on the roots and killing seedlings in the nursery on Farm Island near Pierre, South Dakota. These larvae were thick, whitish grubs 1 to 2 inches long. They differ from white grubs or May beetle larvae in that the legs are inconspicuous and the body is not held in a curved position. These borers normally work in the roots of larger plants or trees, and the larvae were left in the soil when the site was cleared for the nursery in the spring. After cultivation for another season or two there will probably be no further trouble from this insect, and it is not anticipated that it will be a pest in nurseries established in cultivated land.

Insects Girdling the Stems

The cutworms and grasshoppers have been placed in this group although they are not always true stem girdlers but may feed also on the buds and foliage.

Cutworms: Cutworms are the larvae of the night-flying noctuid moths or "millers". Many species work on the seedlings at or just below the ground line, but a few species of climbing cutworms and the army cutworms feed on the upper stems, buds, and foliage. Feeding in most cases takes place at night, and during the day the larvae may be found hiding in the soil near the injured seedlings. Although some species overwinter as pupae or adult moths, most of the cutworms pass the winter as partially grown larvae and start work during the first warm days of spring. The worst damage is likely to occur when the seedlings are coming up, and during a single warm night a great many seedlings may be cut off.

Cutworms can be controlled by scattering poisoned bran mash over the nursery in the evening, and their early discovery will prevent much damage. The bait should be made up as follows:

	Large Quantities	Small Quantities
Coarse wheat bran	100 pounds	5 pounds (1 peck)
Crude arsenic or paris green ...	5 pounds	4 ounces
Molasses or syrup	2½ gallons	1 pint
Water	10-12 gallons	2 to 3 quarts

The poison, molasses, and most of the water should be combined and then evenly mixed with the bran. The solution should be stirred constantly while applying it to the bran to prevent the arsenic from settling out. Enough water should then be added to make a crumbly mixture that will just stick together when tightly squeezed in the hand.

The bait should be thinly scattered over the nursery at the rate of 10 to 20 pounds (dry weight) per acre. Since the cutworms feed at night, and the bait is not attractive after it has dried out, it is necessary to spead it during a warm evening or late in the afternoon.

Where damage was serious the previous spring, and cutworms have again been found in the soil, it is advisable to make a scattering of the bait some warm evening just before the seedlings come up, to prevent heavy damage later. Frequently serious losses occur before the injury is noticed and before treatment can be applied.

Several species of army cutworms occur in the Plains States. When abundant, large numbers of the larvae will travel together over the ground, destroying vegetation as they advance. Different species occur at different times during the season. Poisoned baits, sprays, or dusts can be used to stop their progress. Also, to protect the nursery, a deep furrow with vertical sides can be plowed at a right angle to the line of march. The larvae falling into this furrow can be killed by dragging a log through it, or shallow holes can be dug at intervals in the furrows and the worms that collect in them crushed or destroyed with kerosene.

Grasshoppers: Grasshoppers will feed on nearly all cultivated plants and may occasionally become nursery pests. The infestation usually comes from areas adjacent to the nurseries, since the grasshoppers seldom originate in cultivated land.

Eggs enclosed in sacs or "pods" are laid in the soil late in the summer or in the fall, usually in grain stubble, meadows, and sod along ditch banks, fences, and roadsides. In the southern States the eggs may hatch as early as February, but in the north hatching usually does not occur until May or June. The young grasshopper nymphs resemble the mature insects, except that the wings are not fully developed and not functional until the final or adult stage. Although maturity is reached in 40 to 70 days, the hoppers may continue to feed until cold weather. There is usually only one generation a year.

During the early nymphal stages the young hoppers feed near the place where they hatch, and can readily be poisoned at this time. In the later stages they move about in search of food and if numerous may infest the nurseries. Considerable migration may occur following the cutting of adjacent hay and small grain fields. The nurseries can be protected from such migrations by spreading poisoned bran mash in a barrier strip, from several rods to a hundred feet or more wide, around the nursery. Several applications at intervals of 4 or 5 days will usually be necessary. A couple of deep furrows with vertical sides can also be used around the edge of the nursery to trap young grasshoppers. As they collect in these furrows they can be killed by daily applications of poisoned bait. After the insects have developed to the flying stage, these barriers will be of no value.

The poisoned bait is prepared as follows:

Coarse wheat bran (free from shorts or flour)	100 pounds
Crude arsenic	5 pounds
Cane molasses (low grade such as blackstrap)	1½ gallons
Water	10 to 12 gallons

Spread the bran out on a tight floor or similar surface, to a depth of 8 to 10 inches. Thoroughly mix the required quantities of water, arsenic, and molasses in a container. Gradually splash the solution, which should be continually stirred to prevent settling, over the bran and work it into a mash with a shovel or rake until it contains no lumps and is moist throughout.

This bait should be spread thinly and evenly at the rate of 10 pounds (dry weight) per acre, or more heavily if the insects are very numerous. It should fall into flakes when scattered with the hand and in this form will be safe for use. If left on the ground in lumps there is danger that livestock will pick up the poison. As the mash dries it becomes less attractive, and it is necessary to apply it when the grasshoppers are starting their first feeding of the day, usually early in the morning. In the case of migrations the hoppers may feed at almost any time where food is found. Spread the bait on a clear day, preferably when the temperature is between 70 and 85° F.

A mixture of half bran and half sawdust or, better, 60 per cent bran and 40 per cent sawdust can be substituted in the above formula, but this mixture is not always as satisfactory as bran alone. Most sawdusts if fairly fine and a year or more old are suitable. Although fresher sawdust from cottonwood can be used, fresh pine sawdust is not suitable. Two quarts of liquid sodium arsenite (4 pounds per gallon material) or 2½ pounds of dry sodium arsenite can be substituted for the 5 pounds of crude arsenic. Five pounds of paris green can also be substituted, but this is much more expensive. Calcium arsenate, sodium arsenate, or lead arsenate should not be used.

Leaf-Feeding Insects

A great many species of insects feed on foliage but these can be discussed in a few groups since the control measures for the species within a given group are very similar. The common method of control is to spray a poison such as lead arsenate on the infested foliage so that the poison will be taken into the digestive tract with the food of the insect.

Caterpillars: Caterpillars are the larvae of butterflies and moths. They are wormlike, either smooth, spiny, or hairy, with three pairs of true legs and usually five pairs of false or prolegs, including the anal pair.

Insects of this group can be readily controlled by applying a spray of lead arsenate mixed in the proportion of 1½ to 2 pounds (powdered form) to 50 gallons of water. Other arsenicals such as calcium arsenate or paris green may be used, but with them there is greater danger of burning the foliage. A sticker such as fish oil or linseed oil, at 1 pint per 50 gallons of spray solution, will make the poison adhere to the foliage and give protection for a longer period.

Blister Beetles: The blister beetles are of medium to large size, slender, with the portion between the head and wing covers (the prothorax) narrowest. The body and wing covers are comparatively soft. The color may be black, grayish, tan, or some other shade, either plain, spotted, or striped. Only the adults feed on the foliage, infesting a variety of plants. In the nurseries certain species prefer Caragana and locust foliage, although other seedlings may also be attacked. These beetles are distributed over the entire Plains region but in 1935 damage was most prevalent in some of the northern nurseries, the adults occurring from the middle of June into August. The larvae of some species feed on grasshopper eggs and therefore are beneficial in this stage.

Spraying the foliage with 1½ pounds of lead arsenate to 50 gallons of water will protect the seedlings, largely by repelling the beetles, although some will be poisoned. As the new growth comes out beetles will return to feed on this portion, and it will be necessary to spray several times to give good protection. The use of a sticker in the spray is not advisable where these repeated applications are made. Sodium fluosilicate applied as a dust has given good control of certain species, but there is some danger of burning the foliage.

Flea Beetles: The flea beetles are a group of very small leaf beetles, usually of metallic color. They are very active, have the hind legs fitted for leaping, and jump vigorously when disturbed. They eat very small holes through the leaves. The adults of some species are rather general feeders on foliage while others attack only one species or related species of host plants. The larvae of most species live on roots in the soil but are generally not serious in this stage.

Flea beetles are difficult to control because the arsenicals are apparently distasteful and repel them. However, fairly heavy doses of lead arsenate, 2 to 3 pounds to 50 gallons of water, will give considerable protection if thoroughly applied to all the foliage. Several applications at about 10 day intervals may be required.

Sap-Sucking Insects

Sap-feeding insects cannot be controlled by stomach poisons, such as the arsenicals, because the plant parts that would carry the poison are not eaten. They feed by inserting their beaklike mouth parts into the plant tissues and drawing out the juices. Contact insecticides, that kill by coming in contact with the body, must be used. There are a great many insects with sucking mouth parts, but the most common ones encountered in nurseries are the aphids and scale insects.

Aphids: Aphids, or plant lice, are small, soft-bodied insects averaging about the size of a large pinhead. Many are green but some are yellowish, brown, or black. The sucking out of the sap from the stems or leaves seldom kills the host, but heavy feeding may cause wilting, discoloration, or even dwarfing of the seedlings. During the summer of 1935 in a number of nurseries, the new shoots of Caragana seedlings were heavily infested with a black aphid commonly found on legumes.

A number of generations are produced during a single season, and the aphid population builds up rapidly under favorable conditions. Infestations should, therefore, be treated early. The usual recommendation for control is a spray made up of 1 pint of a 40-per-cent nicotine sulphate solution in 100 gallons of water, and the addition of 3 to 4 pounds of common laundry soap or fish-oil soap as a spreader. In smaller quantities, 1 teaspoon to 1 gallon of water plus a tablespoonful of soap makes a comparable spray. Where directions for aphid control are given on the container of the nicotine solution purchased, these should be followed. Pyrethrum and derris compounds have also been used successfully against aphids.

Scale Insects: Scale insects usually resemble tiny scales of wax or very small galls attached to the bark or leaves. They can be divided into three general groups, the following representatives of which are most likely to be encountered: (1) The armored scales, which are flattened and either oyster-shell shaped, pear shaped, or rounded in outline, and covered with a waxy excretion. Included in this group are the oyster-shell scale, San Jose scale, Putnam's scale, scurfy scale, elm scurfy scale, and pine needle scale. (2) The tortoise scales, which are tortoise shaped or globular, and either naked or with a portion covered with a cottony substance. In this group are the pine tortoise scale and the cottony maple scale. (3) The mealybugs, which are oval in form and soft bodied, and usually appear as if they had been dusted with flour. The European elm scale belongs to this group, but during its third stage it lacks the dusty covering and has a white waxy fringe around the outer edge of the body.

While scale insects are not likely to cause serious damage to seedlings, because of the short time they stay in the nursery, the stock should be kept free from scales since there is danger of transporting the pests to the field. The most common control measure is to spray with a dormant strength miscible oil, oil emulsion, or lime sulphur during dormancy, preferably in the spring just before the buds open. Such sprays are on the market under different proprietary names and should be used according to the directions of the manufacturers. With the dormant strengths of the heavy oils there is a possibility of injury to some of the thin-barked seedlings. During the growing season a summer white-oil emulsion or a summer strength of lime sulphur may be used, but these are not usually so effective as the dormant sprays. Usually none of these treatments will give complete control in one season and consequently if only a small portion of the nursery stock is infested it should be destroyed and not sent to the field. Under more serious conditions it is possible that fumigation might be used for some of these scale insects at the time of shipment. Any evidence of scale insect infestations should be brought to the attention of the Bureau of Entomology and Plant Quarantine.

Insects Feeding in the Shoots and Buds

Several species of pine tip moths attack the two and three needle pines. The larvae feed in the buds and shoots and repeated injury deforms the trees and retards height growth. These insects are frequently introduced into isolated pine plantations on nursery stock. Once established they are very difficult to control and every effort should be made to prevent their introduction.

Two species occur in the Midwest winter as pupae in the soil, the moths emerging early in the spring to deposit their eggs on the needles and shoots. Consequently these moths may be readily distributed in the egg stage on spring-dug stock. The eggs can be destroyed by dipping the seedlings in a 2-per-cent white-oil emulsion. All hard pine stock in nurseries infested with tip moths or adjacent to native timber where the insects are present should be thus treated before spring shipment. Assistance will be given by the Bureau of Entomology and Plant Quarantine in the procedure of treating in cases where this is necessary.

Another species of pine tip moth occurring east of the Mississippi, in the Central and Southern States, and into eastern Texas, winters as a pupa in the shoots. With nursery stock from these regions it is necessary to remove all infested tips as well as dip the stock for the early spring eggs, to prevent the introduction of this species.

Insects Affecting Seed

Practically all seeds are subject to infestation with some species of insect, and at times the percentage of viable seed is seriously reduced. Very little is known regarding the habits and control of these pests.

Insects that continue to work in the seed after collection can usually be destroyed by fumigation with carbon disulphide. However, the dosages required for different insects and seeds, and in containers of different tightness, still remain to be worked out. Anywhere from 1 to 40 pounds per 1,000 cubic feet of space has been suggested under various conditions. The quantity varies with the resistance of the insect and the seed, the size of the seed, and the depth to which the insect is embedded in the seed.

The seed is usually placed in a watertight container such as a can or barrel, then the chemical is poured into a shallow dish or on a cloth at the top of the seed, since the gas is heavier than air, and the container closed with a tight cover or several layers of heavy wrapping paper. Exposure is frequently for 24 hours, but a much lighter dosage is usually effective if an exposure of 48 hours is given. If the container is not tight a larger quantity of the chemical is required. The temperature should be 70° F. or above for best results. The seed should be dry at the time of fumigation, and should be removed and aired after the treatment. Carbon disulphide is inflammable and should be handled with great care.

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
Plains Shelterbelt Project

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SECTION E

SHELTERBELT SPECIES

FROM SEED TO SEEDLING

Acer ginnala Maxim. - Ginnala maple, Amur maple

Acer tataricum L. - Tatarian maple

Type of fruit: Consists of winged, compressed samaras in pairs borne in clusters.

Season to collect: Late August and September.

Where to locate: Exotic high shrub planted at experiment stations, nurseries, park cemeteries, and private grounds. Often planted as hedge.

Collecting method: Hand pick into picking bag.

Immediate care needed: Avoid heating.

Cleaning method: Rub and fan.

Extraction factor: 75%.

Seed per pound: 15,000

Type seed dormancy: Probably embryo dormancy.

Seed storage and pretreatment: This species should be sown immediately or stratified over winter at a low temperature. Stratify immediately after collection.

Notes on nursery propagation: Sow 20 viable seeds per linear foot. No difficulty should be experienced in growing these species under our standard nursery practices once a stand is established.

Ailanthus altissima Swingle - Tree of Heaven, Ailanthus

Type of fruit: Consists of oblong samaras with the compact seed in the middle hanging in large clusters.

Season to collect: September and October.

Where to locate: This species is a medium tall tree native of China, being introduced into this country in 1751. It has been widely planted from Nebraska south to Texas. In some cases it is regarded as a weed tree.

Collecting method: Flail clusters from trees on to tarpaulin or hand gather into picking bags.

Immediate care needed: None, if seed is thoroughly ripe when collected.

Cleaning method: Separate seed from cluster.

Extraction factor: 85 to 90%.

Seed per pound: 17,000

Type seed dormancy: No dormancy.

Storage and pretreatment: Dry storage. Seed is sowed without pretreatment of any kind.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. This species grows readily from seed and is apt to grow too large, since it is extremely vigorous.

Amelanchier alnifolia Nutt. - Alder-leaf service berry, Juneberry

Amelanchier humilis Wied. - Service berry, Juneberry

Type of fruit: A small berry-like pome enclosing 4 or more seeds. Blue-black or dark purple when ripe.

Season to collect: July.

Where to locate: Shrub found in wooded draws and hillsides adjoining river bottoms in North Dakota, South Dakota, and Nebraska.

Collecting method: Hand gather into picking bag.

Immediate care needed: Avoid heating.

Cleaning method: Spread out and moisten until soft, then macerate and separate pulp and seed by flotation method. Avoid excessive drying.

Extraction factor: 2%

Seed per pound: 63,000

Type seed dormancy: Probably embryo dormancy.

Seed storage and pretreatment: Fall sow in beds and mulch if at all possible. If spring sown, stratify 120 days at 41° F. prior to sowing.

Notes on nursery propagation: Sow 25 seeds per linear foot of row in beds. This species will probably have to be grown in beds and will no doubt require shading until other methods have been found to be practical. It will probably require 2 years to produce a usable seedling.

Bumelia lanuginosa (Michaux) Pers. - Gum elastic, Chittimwood, Buckthorn, Woolly buckthorn

Type of fruit: A one-seeded, berry-like drupe. Black when ripe.

Season to collect: October.

Where to locate: High shrub native throughout Oklahoma in sandy woods and thickets ranging into Texas.

Collecting method: Hand gather into picking bag.

Immediate care needed: Avoid heating.

Cleaning method: Soak the seed in water until fermentation starts. Then the pulp can be easily removed by washing.

Extraction factor: 20%

Seed per pound: Extremes reported from 3,656 to 6,781.

Type seed dormancy: No dormancy.

Storage and pretreatment: Dry storage until ready to sow, then soak in concentrated sulphuric acid 20 minutes. The Lake States Forest Experiment Station reports that this method gave the best results of any method tried.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. Our results during the 1935 season in Oklahoma indicate that this species will need two years in nursery row to develop into seedlings of optimum size for field planting.

Caragana arborescens Lam. - Caragana, Siberian pea tree.

Type of fruit: Small dehiscent pod.

Where to locate: High shrub widely planted as farmstead windbreak hedge throughout the northern and central Great Plains.

Season to collect: July. Watch carefully progress of seed ripening and be prepared to gather quota in one week or less, since pods open and discard seeds immediately upon ripening. Catching seed as it falls by spreading burlap beneath hedges has been reported from Canada.

Immediate care needed: Will mold and heat readily if freshly gathered pods are piled even 3 and 4 inches deep. Spread thinly to dry and turn frequently.

Cleaning method: Thorough drying will cause pods to open and discharge practically all seeds. Balance can be threshed out by running through macerator. If dried in open air it should be kept under screens, since under the sun's hot rays the pods will throw seed to a distance of 20 feet when opening. Separate pods from seed by fanning.

Extraction factor: May run as high as 40% from dry, well-filled pods; usually much lower.

Seed per pound: 15,000 to 18,000

Type seed dormancy: No dormancy.

Storage and pretreatment: Dry storage. Some indication that seed responds readily to light mechanical scarification. Do not use hot water or other treatment.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. Dr. I. L. Baldwin, University of Wisconsin, College of Agriculture, is conducting an investigation to determine whether it will be profitable to inoculate seed of this species to promote nursery growth and development.

Caragana seedlings are a favorite food of defoliating insects, and should be watched closely for this injury.

Caragana when possible should be early fall sown. Under favorable conditions, two to three inches growth may then be obtained during fall months. The second season will then produce optimum size seedlings. It is desirable on heavy soils to ridge up the young seedlings from fall sowing to prevent as far as possible frost heaving. In spring uncover and mow sprouts to just above ground level to promote a stocky, well-branched seedling. If not fall sown, this species should be sown early in the spring. Some experiments should be undertaken on a few rows of spring sown seedlings to determine if better quality seedlings might not be produced by cutting back seedlings in midsummer.

Catalpa speciosa Warder - Catalpa, Hardy catalpa, Western catalpa

It is important that the collectors distinguish this species from Catalpa bignonioides, since the latter species while closely resembling the speciosa is much inferior. Fruit is an easy distinguishing feature. Catalpa speciosa has a stout, thick-walled capsule rarely more than three to a cluster containing light brown seeds with rounded wide-fringed wings at each end. Catalpa bignonioides has a slender thin-walled capsule often more than three to a cluster containing seeds silvery gray with pointed fringed wings at each end.

Season to collect: Any time after killing frosts.

Where to locate: Medium tall tree planted in farmers' groves and woodlots from central Nebraska south. Not native in Shelterbelt Zone.

Collecting method: Strip pods from trees by using hooked knives.

Immediate care needed: None if thoroughly ripe.

Cleaning method: Dry pods thoroughly, then by light beating and shaking seeds can usually be separated out.

Extraction factor: From dry pods, 26%.

Seed per pound: 13,600 to 36,600 are extreme limits reported.

Type seed dormancy: No dormancy.

Seed storage and pretreatment: Lake States report best results with 50° F. dry storage for two months prior to sowing. Gave considerably better results than water soaking. Oklahoma nurserymen recommend dry cold storage through the early part of the winter. Then stratify for 60 days prior to sowing.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. Apparently the seed will rot if sown too early, therefore, sowing should be delayed until ground warms up and favorable moisture conditions exist.

Celtis occidentalis L. - Hackberry

Celtis reticulata Torr. - Hackberry, Palo blanco

Celtis reticulata vestita Sarg. - Hackberry, Palo blanco

Celtis laevigata Willd. - Sugarberry

Type of fruit: One-seeded drupe.

Season to collect: Following frost to November in north. Till February in south. Desirable to gather as early as possible, however, since hackberries are a favorite bird food. More easily gathered after leaves fall.

Where to locate: Medium tall native trees found on rocky hills and ridges, canyon valleys, and slopes, locally throughout Shelterbelt Zone. Celtis occidentalis, distinguished by its large dark fruit, is found from the Canadian border as far south as Kiowa County, Oklahoma, according to Sargeant's Manual of Trees. Other species easily distinguished by their orange red or yellow fruit are found southward from central Kansas.

Collecting method: If conditions permit, spread tarps below trees and collect by dropping on to tarp. Otherwise collect into picking bags.

Immediate care needed: Avoid heating.

Cleaning method: Remove leaves, stems, and twigs. Not necessary to depulp.

Approximate extraction factor: When berries are dried after early collection they will lose up to 30% by weight.

Seed per pound: 1600 to 2200 for c. occidentalis. 2400 to 4000 for others. Larger seeds from eastern sources.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Common nursery practices thus far have been to either fall sow or stratify in sand for 3 months prior to spring sowing. However Lake States Forest Experiment Station reports that 84% germination obtained by soaking in concentrated sulphuric acid for two hours, washing in water, then repeating acid treatment for two hours. This procedure should be followed for spring sown seed which has not been stratified. Several nurserymen reported success with acid treatment during the 1935 season.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. Hackberry is one of the slower growing nursery species. In the north it is desirable to encourage growth by cultural practices in order to obtain usable size in one season. Apparently responds very favorably to wind protection, and all nurserymen are encouraged to try intensive wind protection on portions of their hackberry acreage to get comparative results with unprotected trees.

Cercis canadensis L. - Redbud, Judas tree

Type of fruit: The fruit is an oblong, flat, many-seeded pod 2 to 4 inches long, often hanging on the tree into the winter.

Where to locate: Low tree native ranging southwesterly from southeastern Nebraska as an undergrowth tree along the borders of fields, hillsides or valleys.

Season to collect: Late fall.

Collecting method: Flail pods from trees or hand pick.

Immediate care needed: None if dry when gathered.

Cleaning method: Will clean nicely through macerator followed by fanning.

Extraction factor: 21% from dry pods.

Seed per pound: 14,400

Type seed dormancy: Probably impermeable seed coat.

Seed storage and pretreatment: Store dry over winter until prior to sowing. Determine by actual test the proper length of sulphuric acid treatment to which this species responds. Probably 10 to 15 minutes will be adequate.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. Nursery handling during the early part of the season will probably be approximately the same as for black locust. It will not grow to extreme size in one year, however.

Chilopsis linearis DC. - Desert willow, Flowering willow

Type of fruit: A slender, elongated, thin-walled capsule 7 to 12 inches long persistent on the branches during the winter.

Season to collect: After killing frosts throughout winter.

Where to locate: Tall shrub native along banks of streams and depressions in the desert through western Texas and southwest. Becoming extensively planted in Oklahoma.

Collecting method: Hand gather pods.

Immediate care needed: None if gathered dry.

Cleaning method: Dry pods thoroughly, then light beating and sifting will separate out seed.

Seed per pound: 85,000 to 100,000.

Type seed dormancy: No dormancy.

Storage and pretreatment: Lake States recommends dry storage at 50° F. for 2 months prior to sowing.

Notes on nursery propagation: Sow 50 viable seeds per linear foot. Delay sowing until soil warmth and moisture are favorable. Seed will rot if sown too early. This species will grow to extreme size in one year unless a fairly dense stand is maintained.

Colutea arborescens L. - Bladder-senna

Type of fruit: Inflated pod with papery walls.

Season to collect: Fruit ripens from August to October.

Where to locate: Infrequently found as an ornamental shrub from Kansas to Texas. Native of Europe.

Collecting method: Hand gather pods.

Immediate care needed: None.

Extraction factor: No information.

Seed per pound: No information available. Probably about 25,000.

Type seed dormancy: Probably impermeable seed coat.

Seed storage and pretreatment: Dry storage until sowing. Determine correct length of sulphuric acid treatment for each lot of seed. Probably 10 to 15 minutes will be adequate.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. This species seems to make considerable growth in one year in a nursery. Probably very easily handled.

Cornus asperifolia Michx. - Roughleaf dogwood.

Cornus florida L. - Flowering dogwood.

Cornus stolonifera Michx. - Red-osier dogwood

Type of fruit: A one-seeded drupe in clusters. Seed is a two-celled stone.

Season to collect: Late July to October, depending on species.

Where to locate: Of these shrub species, the roughleaf dogwood will be the only one used to any appreciable extent. It is found locally in Kansas south to Texas. Do not gather from isolated trees.

Collecting method: Hand gather fruit into picking bag.

Immediate care needed: Avoid heating.

Cleaning method: Ferment in water to soften pulp, wash out seed. Clean as soon after collecting as possible.

Extraction factor: Roughleaf dogwood 18%. Flowering dogwood 46%.

Seed per pound: Roughleaf dogwood 16,600 to 21,000. Flowering dogwood 4,800.

Type seed dormancy: Probably both impermeable seed coat and embryo dormancy.

Storage and pretreatment: Stratify 120 days in moist peat at 41° F. Fall sowing may also be successful.

Notes on nursery propagation: Sow 40 viable seed per linear foot. These species should grow readily in our nurseries, although little direct information is available. May require shade. Can also be grown from cuttings.

Crataegus spp. L. - Haw, Hawthorn, Thornapple

Type of fruit: A pome-like drupe with 1 to 5 bony one-seeded nutlets.

Season to collect: September to November.

Where to locate: Generally native shrub throughout entire region. Found in thickets along banks of streams.

Collecting method: Pick fruit into picking bag.

Immediate care needed: Avoid heating.

Cleaning method: Soak fruit in water until soft. Then macerate through small threshing machine and separate pulp and seed by flotation method. Do not permit excessive drying.

Extraction factor: Approximately 20%.

Seed per pound: 7,700 to 16,000 are the extremes reported.

Type seed dormancy: Both impermeable seed coat and embryo dormancy.

Seed storage and pretreatment: As yet there has been no pretreatment method developed that is adapted to large scale production. In general it is believed that the seed should not be allowed to dry out. Should be placed immediately into stratification at 41° F. and held there until germination starts. This may take 1 to 2 years. Do not sow until actual tests show that the seed is ready to germinate. Probably sulphuric acid scarification or mechanical scarification prior to stratification will be helpful.

Notes on nursery propagation: Very little information available. Apparently this species develops a long tap root and is difficult to transplant. Therefore it should not be allowed to remain in the nursery row more than one year without transplanting or root pruning. Crataegus can also be propagated by cuttings.

Elaeagnus angustifolia L. - Russian olive, Oleaster

This exotic species has been widely planted for windbreak purposes throughout the Plains Region. From observation it would seem that there are numerous varieties of this species, and there are some indications that a variation in hardiness exists. Specimens characterized by spiny branches, small white seed, and narrow leaves are believed to be much hardier than others, and therefore it is urged that seed collections be confined as much as possible to such specimens, especially for North and South Dakota and northern Nebraska.

Type of fruit: Drupe-like with mealy outer flesh and ellipsoid striate stone.

Season to collect: October to December.

Where to locate: High shrub planted as farm windbreaks, parks, and experiment stations.

Collecting method: Strip fruit of trees on to tarp or into picking bags. Ladders necessary. Seed from the desirable small-seeded spiny form is much more difficult to gather. Stripping tool can be made in general form of a miniature rake, the handle being 5 or 6 inches long, mounted on a cross piece having teeth consisting of ten-penny nails spaced so that the distance between the nails is the same as the diameter of the nail.

Immediate care needed: Will heat unless aerated, especially from early collections. Usually safest to spread out to dry.

Cleaning method: Break up pulp through macerator with water.

Seeds per pound: (with pulp) 1060 to 3800. Wide variation in varieties.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Fall sow or stratify at 41° F. for 3 months prior to spring sowing. Since this species is characterized by an impermeable seed coat, it is believed that considerably increased germination can be obtained by depulping or even breaking up pulp prior to fall sowing or placing in stratification. This will permit more ready access of moisture to seed coat proper. Seed spring sown without stratification apparently will respond to a two-hour concentrated sulphuric acid treatment.

Notes on nursery propagation: Sow 40 viable seeds per linear foot. Germinates unevenly and is ordinarily subject to heavy losses in the early stages, therefore it is desirable to practice dense sowing. Seed is relatively inexpensive.

This species often suffers severe loss shortly after emerging from soil spattered on to the leaves by heavy rains. Dirt adheres readily because of pubescent leaves. Therefore while seedlings are young, it is desirable to brush off dirt after each rain. One commerical nurseryman follows the practice of sowing this species under overhead in braod flat bands on soil surface with a covering of straw mulch. Germinating seed comes up through straw mulch which serves to keep dirt from spattering on the leaves.

It might be possible for Shelterbelt nurserymen to allow weed growth to come up with the seedlings and for several inches on each side of the bands. Weeds would prevent dirt spattering and should be allowed to remain until seedlings are passed danger point from dirt injury.

Fraxinus pennsylvanica lanceolata (Borkh) Sarg. - Green ash

Fraxinus campestris Britt. - Prairie ash

J. M. Aikman in his report on Native Trees and Shrub Communities of the Shelterbelt Zone states that prairie ash is regarded by some authorities as a separate species, by others, a variety or westward form of the green ash. He further states that a typical prairie ash tree in comparison to green ash has a crown round in outline rather than elongate, a rough appearance resembling the burr oak, shortened internodes, pubescent twigs, and shorter, thicker, more compact leaves. The girth is much reduced as compared to that of the eastern form, but the ratio of the girth to the height is increased. It is more compact and drought-resistant than the eastern form of the green ash.

Collectors are urged to distinguish between these two forms or species where possible.

Type of fruit: One-seeded, winged samara in clusters.

Season to collect: Late September to midwinter.

Where to locate: Medium tall tree native along streams and in draws virtually throughout the entire Shelterbelt Zone. Do not collect from old groves, windbreaks or timber claims unless they contain exceptional specimen trees. Inspect carefully for weevil before collecting.

Collecting method: Ladders and picking bags essential. Collect by picking clusters from trees, avoiding leaves and stems as much as possible.

Immediate care needed: If at all green or damp spread out to dry.

Cleaning method: When thoroughly dry seed will be detached from clusters and majority of wings removed by running through macerator. Remove refuse and light seed by careful fanning.

Extraction factor: Approximately 75%.

Clean seed per pound: 14,500 to 18,000.

Type seed dormancy: Embryo dormancy.

Storage and pretreatment: Fall sow 50% of quota acreage when possible. For spring sowing hold in dry storage until 60 days prior to sowing. Then stratify in moist sand or peat. Check and aerate every 3 weeks. Another acceptable practice that has produced good results is to hold seed dry until 10 days prior to sowing. Then soak in cool water up to time of sowing, changing water daily. Soaking in wet sand for 10 days to 2 weeks also acceptable.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. Under ordinary conditions it is desirable to ridge rows following spring sowing, since germination will take from one to three weeks. The germinating seedling is flexible and tough, and therefore good results have been obtained in removing ridges by cross harrowing with a spike tooth harrow.

Gleditsia triacanthos L. - Honey locust

Gleditsia triacanthos inermis Pursh. - Thornless honey locust

Type of fruit: Elongated, many-seeded, light to dark brown, indehiscent pod. Legume.

Season to collect: October to January.

Where to locate: Medium tall tree planted as windbreaks and street trees throughout Shelterbelt Zone south from central South Dakota to Texas. Native ranging south and southwesterly from southeastern South Dakota and eastern Nebraska.

Collecting method: Gathering from ground after pods fall is cheapest and most practical method. As far as possible obtain seed from thornless variety. Examine for weevils and poor seed before collecting.

Immediate care needed: None if not too green.

Cleaning method: Crush pods by flailing, then dry thoroughly and thresh through macerator, followed by fanning. Dry pods essential for this method. A thousand pounds of pods have been threshed in this manner in one day.

Seed per pound: 2800 to 3000

Extraction factor: 20% from dry pods.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Dry storage over winter. Prior to sowing soak in concentrated sulphuric acid for one hour. Wash and sow. If more convenient, acid treatment can be applied at the extractory and followed by washing and drying. Treated seed so handled can be kept at least 5 months with no loss in germination according to recent report by the Lake States Forest Experiment Station. Nurserymen are also encouraged to try some mechanical scarification.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. If soil moisture and temperature conditions are favorable, very prompt and even germination can be secured by soaking the seed in cold water for 12 hours following the acid treatment. This should not be done, however, if the seed is to be sown in dry soil.

Gymnocladus dioicus (L.) Koch. - Kentucky coffee tree

Type of fruit: Pod 6 to 10 inches long, 1½ to 2 inches wide, dark red brown. Remains on tree unopened into winter.

Where to locate: Medium tall tree native south and southwesterly from southeastern South Dakota and eastern Nebraska in bottomlands and rich soil. Has not been widely planted.

Season to collect: Late fall, throughout winter and spring.

Collecting method: Gathering pods from ground in early spring before sowing is most practical method.

Immediate care needed: None.

Cleaning method: For fresh pods dry thoroughly, then break up by beating followed by fanning. Most feasible method is to gather pods one year in advance of needs and store in open bins outside. The pods will deteriorate to such an extent that they will break down with very little resistance. The broken pods can then be separated from the seeds by fanning.

Extraction factor: 40% from dry pods.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Dry storage until just prior to sowing. Lake States Forest Experiment Station reports 95% germination in 25 days from 4 hour treatment in concentrated sulphuric acid followed by washing in water just before sowing.

Notes on nursery propagation: Sow 16 viable seeds per linear foot. This species in the nursery develops an enormous tap root in comparison to top growth. It presents no particular nursery problem if stand can be established. Root pruning in midsummer should be experimentally tried.

Hicoria pecan Engle. & Grabus - Pecan

Type of fruit: An oblong nut enclosed in thin husk.

Season to collect: Late October to December.

Where to locate: Medium tall tree native in rich bottomland in Oklahoma and Texas.

Collecting method: Gather from ground after shaking or flailing from trees.

Immediate care needed: None.

Cleaning method: No cleaning necessary. Avoid drying.

Seed per pound: Possibly 100. Varies according to size of nut.

Seed storage and pretreatment: Fall sow directly into strip or stratify over winter in moist sand.

Notes on nursery propagation: It is hoped that this species will respond to direct seeding and no nursery growing will be necessary.

Hippophae rhamnoides L. - Sea buckthorn, Siberian sandthorn

Type of fruit: Orange colored drupe about 1/4 to 1/3 inch in diameter borne in compact clusters.

Season to collect: September.

Where to locate: Exotic shrub planted at experiment stations, old nurseries, rarely in parks. Not widely planted.

Collecting method: Hand pick into bags.

Immediate care needed: Avoid heating.

Cleaning method: Macerate and wash. Avoid excessive drying.

Extraction factor: 27%

Seed per pound: 25,000

Type seed dormancy: Probably impermeable seed coat.

Seed storage and pretreatment: Fall sow or stratify over winter.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. This species should probably be handled much the same as buffalo berry.

Juglans nigra L. - Black walnut

Juglans rupestris Engelm. - Little walnut, Texas walnut, Western walnut

Type of fruit: Fruit is a round drupe with a fleshy indehiscent exocarp enclosing a hard thick-walled nut.

Season to collect: October and November.

Where to locate: Black walnut is a medium tall tree native from northern Nebraska south to Texas. Widely planted. Texas walnut native throughout Shelterbelt Zone in western Oklahoma and Texas. Texas walnut has small nut with thin husk while black walnut has larger nut with thicker husk.

Collecting method: Gather from ground after frost when nuts fall.

Immediate care needed: None.

Cleaning method: Husks crumple readily after drying and can be removed by running through corn sheller. Desirable to remove husks since there is some indication that husks transmit a fungus to the seedling.

Extraction factor: 65%

Seed per pound: 32 to 45, black walnut. 78, Texas walnut.

Type seed dormancy: Both impermenable seed coat and embryo dormancy.

Seed storage and pretreatment: Whenever possible fall sow or direct seed into the strips. When this is not possible stratify seed in moist sand outside in piles or in pits.

Notes on nursery propagation: Sow 15 viable seeds per linear foot. Walnuts will develop large deep tap roots in one season in nursery. It is desirable to cut off this tap root in midsummer by undercutting at a depth of 8 to 10 inches. Select cool, cloudy weather for this operation and follow immediately with irrigation.

Juniperus virginiana L. - Eastern red cedar

Juniperus scopulorum Sarg. - Rocky Mountain red cedar

Juniperus monosperma Sarg. - Juniper

Juniperus asheii

Type of fruit: Berry-like, succulent fleshy strobile, blue or blue-black when ripe.

Season to collect: Late fall.

Where to locate: J. virginiana is native on river bottomlands throughout the Shelterbelt Zone except in extreme north and south. J. scopulorum requires two years to mature its fruit and is native west of the western border of the Zone in North and South Dakota and Nebraska. One year berries of this species can be distinguished in that they are whitish green in color. J. monosperma is found throughout the foothills in southern Colorado extending into western Oklahoma and Texas. J. asheii is locally found in the Arbuckle Mountain region in Oklahoma. Preliminary investigations indicate that J. asheii is very resistant to the cedar apple rust.

Collecting method: Strip seed into picking bags or on to tarpaulins.

Immediate care needed: Avoid heating.

Cleaning method: Depulp through macerator with water. Pulp and light seed may then be removed by flotation method.

Extraction factor: 20 to 40%.

Clean seed per pound: Various counts on hand ranging from 10,000 to 50,000 seeds per pound, depending on species, season, and locality. J. monosperma and J. scopulorum are the heaviest.

Seed storage and pretreatment: J. virginiana responds to scarification followed by stratification in moist peat for 100 days at 41° F. J. asheii and J. scopulorum apparently will seldom germinate the first year following ripening. Acceptable treatment on basis of present information is to hold seed in fruit for one year, then clean, scarify and fall sow or stratify at 41° F. for 100 days if spring sown. J. monosperma apparently responds to fall sowing or 30 to 60 day stratification period prior to spring sowing. Scarification apparently not necessary.

Notes on nursery propagation: All these species will be grown in beds under the customary conifer nursery practices.

Lonicera tatarica L. - Tatarian honeysuckle

Lonicera tatarica var. siberica Pers. - Siberian honeysuckle

Type of fruit: Many-seeded berry.

Season to collect: July and August.

Where to locate: Widely planted as ornamental low shrub on lawns and city parks. Also for hedge purposes.

Collecting method: Hand gather from bushes.

Immediate care needed: Avoid heating.

Cleaning method: Depulp through macerator followed by washing out seed.

Seed per pound: Tatarian honeysuckle, 125,000 to 185,000.
Siberian honeysuckle, 120,000.

Type seed dormancy: Probably embryo dormancy.

Seed storage and pretreatment: Store dry until 60 days prior to spring planting. Then stratify at 41° F.

Notes on nursery propagation: Sow 50 viable seeds per linear foot. Commercial practice is to propagate from cuttings. It is believed from limited observations and reports that propagation from seed under our standard practices will be successful. Prof. N. E. Hansen, South Dakota State College at Brookings, grew 25 M of these seedlings largely to usable size in one season in open row.

Malus baccata Borkh. - Siberian crab

Type of fruit: Small pome 1/4 inch and up in diameter.

Season to collect: September and October.

Where to locate: Nurseries, experiment stations, and occasionally farm orchards.

Collecting method: Hand pick into picking bags.

Immediate care needed: Avoid heating.

Cleaning method: Keep in small piles or boxes until soft, then macerate and wash out the seed. Dry in the shade.

Extraction factor: 3%

Seed per pound: 77,000

Type seed dormancy: Probably embryo dormancy.

Storage and pretreatment: Stratify at 41° F. for 75 days prior to sowing. This species should be spring sown.

Notes on nursery propagation: Sow 40 viable seeds per linear foot. No information but should grow readily under our standard practices.

Morus alba tatarica (L.) Loud. - Russian mulberry

Morus rubra L.-Red mulberry

Morus nigra L.-Mulberry

Red mulberry is the native species found locally from southeastern South Dakota, eastern Nebraska, central Kansas, Oklahoma, and Texas.

Morus alba, white mulberry, is a native of China and has been planted in large quantities in eastern United States. Not hardy in Shelterbelt Zone except in far south.

Morus alba tatarica, most widely planted in the Plains States, is the hardy form of the white mulberry, and apparently was first introduced by the Russian Mennonites, presumably into Kansas.

Morus nigra, probably a native of Persia, has been introduced into the southern states of the Shelterbelt Zone and has been extensively planted.

Type of fruit: Numerous one-seeded drupes aggregated into a berry-like syncarp.

Collecting season: Late May in south to July in Nebraska and southeastern South Dakota.

Where to locate: Medium tall tree planted in farmers' groves and hedges. Ranging southwesterly from southeastern South Dakota.

Collecting method: Visit trees every three days and shake off fruit on to tarpaulins.

Immediate care needed: Fruit may heat if stored in piles.

Cleaning method: Mash and ferment for several days, then wash out in water or run through macerator. Poor seed and pulp can be floated off.

Extraction factor: 2 to 3%.

Seed per pound: 200,000 to 300,000.

Type seed dormancy: Both impermeable seed coat and embryo dormancy.

Storage and pretreatment: Store cold and dry until 60 days prior to sowing. Then stratify at 41° F. Alternate treatment is to soak in water for 5 days prior to sowing, changing to fresh water daily.

Notes on nursery propagation: Sow 50 viable seeds per linear foot. Mix bulking material with seed, such as fine sand or sawdust. Sow early enough so that seedlings will become established before summer heat sets in. Try to obtain sufficient early season growth to make possible early hardening off. Seedlings apparently subject to sun scald.

Mulberry is a persistent late grower and is frequently injured by early fall frost, especially if such frosts are at all severe. To handle this situation, some commercial nurserymen spray the mulberry seedlings in the early fall after sufficient growth is attained with a solution of copper sulphate, made by dissolving one pound of copper sulphate in 50 gallons of water. This defoliates the seedlings, thereby resulting in earlier hardening off. This treatment should be tried on a small scale, especially in South Dakota and Nebraska.

Pinus ponderosa Laws - Ponderosa pine, Western yellow pine, Bull pine

Type of fruit: A woody cone maturing at the end of the second season. Mostly falls soon after ripening and discharges seeds.

Season to collect; Late August and September.

Where to locate: Native in the outlying foothills of Rocky Mountains, and in Black Hills and Pine Ridge country of South Dakota and Nebraska.

Collecting method: Robbing squirrel hordes easiest, but for purposes of selection it is best to gather cones from selected trees. Ladders and hooked knives on long poles desirable equipment.

Immediate care needed: Cones can be stored in sack without injury from heating.

Cleaning method: Solar heat method of extraction suitable. Spread cones thinly on tarpaulins or in racks stirring occasionally until they open. Then separate seed from cones by shaker method. Wings can be removed from seeds by flailing or rubbing in sacks followed by fanning.

Extraction factor: 1 to 1½ pounds of seed will ordinarily be secured from a bushel of cones.

Seed per pound: Will range from 10,000 to 20,000, depending on locality, season, and degree of dryness.

Seed storage and pretreatment: Store dry in tight containers. No pretreatment necessary.

Notes on nursery propagation: Will be handled according to accepted conifer nursery practices.

Platanus occidentalis L. - Sycamore, Buttonwood

Type of fruit: A syncarp or head one inch in diameter containing numerous elongated akenes.

Season to collect: Late September throughout fall into winter.

Where to locate: High tree native on good soil and favorable sites from southeastern Nebraska ranging southwesterly.

Collecting method: Flail from tree or hand gather.

Immediate care needed: None.

Cleaning method: The only cleaning necessary is to macerate balls in order to free the seed.

Seed per pound: Information desired. Probably around 100,000.

Type seed dormancy: Probably no dormancy.

Seed storage and pretreatment: Spring sow. Stratify 60 days at 41° F. in moist peat prior to sowing.

Notes on nursery propagation: Sow 60 viable seeds per linear foot. Very little direct information. Some indication that this species needs to be shaded during early life.

Prunus americana Marsh. - Wild plum

Prunus angustifolia Marsh. - Chickasaw plum

Prunus angustifolia watsonii Waugh. - Sand plum, Western Chickasaw plum

Type of fruit: One-seeded drupe. Variously colored from yellow to dark red when ripe. Softens when ripe.

Where to locate: Common as low or high shrub in thickets throughout Zone. P. americana found north from the southern third of Kansas. Other varieties common from Kansas to Texas.

Season to collect: August and September.

Collecting method: Hand gathering from bushes or from ground after fruit has fallen or been shaken off is most feasible method.

Immediate care needed: Avoid heating.

Cleaning method: Spread out to avoid heating and keep moist until pulp disintegrates. Then run through macerator at 450 RPM and wash over screens. Often water-logged skins will not float out but can be dried and blown out through clipper fanning mill.

Extraction factor: 15 to 30% depending on size of fruit.

Clean seed per pound: Chickasaw plum, 770. Others 800 to 1500, depending on season and locality.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Desirable to keep seed moist in sand and fall plant at earliest opportunity. If not possible, retain in stratification over winter at 41° F. and sow early in spring.

Notes on nursery propagation: Sow 18 viable seeds per linear foot. No particular problem presented once the stand is established. Will ordinarily attain satisfactory size in one season.

Prunus armeniaca L. - Apricot, Russian apricot

Type of fruit: Large one-seeded drupe.

Where to locate: Exotic low tree or high shrub variously planted in farm orchards from Nebraska south to Texas.

Season to collect: June and July.

Collecting method: Probably best to purchase pits in small lots from individual farmers. Avoid purchase of pits that have been cooked.

Immediate care needed: None.

Cleaning method: Pits will usually be purchased already cleaned.

Seed per pound: 200 to 300.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Seed apparently will withstand ordinary drying without injury. Sow as late in fall as possible or stratify in moist sand 45 days prior to spring sowing.

Notes on nursery propagation: Sow 18 viable seed per foot. This species will grow to large size in one season if given optimum conditions. Desirable therefore to retard growth by dense sowing within limits.

Prunus virginiana L. - Eastern chokecherry

Prunus virginiana melanocarpa (A. Nels.) Gray - Western chokecherry

Type of fruit: A one-seeded drupe, dark colored when ripe.

Where to locate: High shrub preferring favorable sites along streams and lowlands. However, crowds out into open canyons and draws on to more or less sandy soils. East line of Shelterbelt Zone is approximately boundary between the two species.

Season to collect: Collect after fruit turns dark in color - late July to September.

Collecting method: Hand gathering into picking bags most feasible.

Immediate care needed: Avoid heating.

Cleaning method: Preferable treatment is to spread the fruit indoors three or four inches thick to prevent heating, and spray with hose once or twice daily to keep wet until the pulp rots down. (If fermentation takes place in deep containers such as barrels, there is a tendency of the juice to turn to wine and in just a few days the wine turns to vinegar, pickling the pulp so that further decomposition is stopped and depulping is difficult.) Following rotting down of the pulp, depulp through macerator at not more than 450 RPM to avoid cracking seed, supplemented by washing on screens and some rubbing, then float off pulp and skins.

Extraction factor: 20% from clean fruit.

Clean seed per pound: 4300 to 5800. Clean fresh fruits per pound approximately 1200. 60 pounds of fresh fruit per bushel.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Early fall planting preferable in all cases. If not possible stratify immediately after cleaning in moist sand until such time as fall planting can be done. Do not permit excessive drying. Most chokecherry seed if kept moist and not mixed with sand will heat and mold readily. If stratified from early fall over winter, seed may germinate in stratification unless held at low temperature. Early spring sowing is therefore essential.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. No particular problem is presented in growing chokecherry once a stand is established. Subject to leaf blights which cause defoliation. (See Protection, Pathology) It is believed that sufficient growth can be obtained in one year in all states. There is some evidence to show that chokecherry seedlings if dug early in the fall or kept in warm storage will start secondary root growth. Therefore, fall planting or early spring planting out to the strips may be essential for successful handling of this species.

Quercus macrocarpa Michx. - Bur oak, mossy cup oak

Quercus stellata Wang. - Post oak

Type of fruit: A nut (acorn) more or less enclosed in cup-like hull.

Where to locate: Bur oak is a medium tall tree native throughout Shelterbelt Zone or along eastern boundary on rich bottomlands or ravines and hillsides. Post oak is a medium tall tree native from Kansas south. Locally found but not common in Shelterbelt Zone. Bur oak acorn is deeply set in fringed cup. Post oak is set in a rather small, unfringed cup.

Season to collect: Late August and throughout September.

Collecting method: Flail off trees and gather from ground.

Immediate care needed: Fumigate immediately with carbon disulphide in tight containers. See "Protection, Entomology". Avoid drying by holding in cool, humid atmosphere.

Cleaning method: Bur oak hulls difficult to detach. It is not essential that they be removed before sowing.

Seed per pound: Wide variation from north to south in number of bur oak acorns per pound. From 35 to 100 is probably extreme range for dehulled acorns. Freshly collected post oak acorns average 239 per pound.

Type seed dormancy: No dormancy for either species.

Seed storage and pretreatment: If at all possible fall sow or direct seed these two species. When stratified they sprout early in the spring and it is difficult to sow early enough to be through before this happens. If not stratified or held in cool, humid atmosphere, drying will render acorns useless. Stratify in sand at temperature near freezing.

Notes on nursery propagation: Sow 16 viable seeds per linear foot. This species develops excessively long tap root, but comparatively little top growth in one season in nursery. Try some undercutting in midsummer on cool, cloudy day followed by immediate irrigation. For the present oak will be mostly direct seeded and not nursery grown.

Rhamnus davurica Pall. - Siberian buckthorn

Type of fruit: Clusters of small black berries.

Season to collect: August and September.

Where to locate: This is an exotic low shrub not widely planted as yet. For the present it may be impossible to locate outside of experiment stations and experimental grounds.

Collecting method: Hand pick into picking bag.

Immediate care needed: Keep from heating. Wash out seed as soon as possible.

Cleaning method: Macerate, wash, and dry in shade.

Approximate extraction factor: No information. Probably 22%.

Seed per pound: Approximately 24,000.

Storage and pretreatment: Store dry. Stratify 90 days prior to sowing at 41° F. May also be fall sown.

Notes on nursery propagation: Sow 20 viable seed per linear foot. No information available but should handle readily under our standard nursery practices.

Rhus trilobata Nutt. - Skunk brush, skunk sumac, Ill-scented sumac, Aromatic sumac

Type of fruit: A many-seeded, compact cluster.

Season to collect: August to November. Desirable to gather early since birds are fond of the fruit.

Where to locate: Low shrub native from Texas into North Dakota on dry hillsides and sand ridges.

Collecting method: Hand pick into picking bag.

Immediate care needed: None.

Cleaning method: Soak and run through macerator. Wash, dry, and fan.

Extraction factor: 50%.

Seed per pound: 10,600. Clean berries per pound, 6,900.

Type seed dormancy: Probably both impermeable seed coat and embryo dormancy.

Storage and pretreatment: Fall sow or stratify. Stratify 4 months in moist peat at 41° F. If not stratified try concentrated sulphuric acid treatment for 20 minutes prior to sowing.

Notes on nursery propagation: Sow 25 viable seeds per linear foot. Should respond readily to our standard nursery practices.

Ribes aureum Pursh. - Flowering currant, Golden currant

Ribes odoratum Wendl. - Flowering currant, Buffalo currant

J. M. Aikman in his report on Native Trees and Shrub Communities of the Shelterbelt Zone states that the flowering currant is the only shrub found universally throughout the entire Zone.

Type of fruit: A juicy berry containing several seeds.

Season to collect: Fruit ripens in midsummer and should be collected shortly after ripening.

Collecting method: Hand gather from bushes.

Immediate care needed: Avoid heating.

Cleaning method: Ferment in water to soften pulp. Seed can then easily be removed by washing.

Approximate extraction factor: 4%.

Clean seed per pound: 200,000.

Type seed dormancy: Probably embryo dormancy.

Storage and pretreatment: Either fall or spring sowing will probably be successful. If spring sown, store dry until 90 days prior to sowing, then stratify in moist peat at 41° F.

Notes on nursery propagation: Sow 40 viable seed per linear foot. This species can ordinarily be expected to make a rapid growth, and therefore should be adapted to handling by our standard nursery practice. Propagates from cuttings very readily.

Robinia pseudoacacia L. - Black locust, Yellow locust, Acacia

Type of fruit: 4 to 8 seeded, light brown pod.

Season to collect: Late fall after leaves have fallen.

Where to locate: Medium tall tree not native in Shelterbelt Zone. Widely planted as street tree, farm plantings, and timber claims from Nebraska south.

Collecting method: Flail on to canvases after leaves have fallen.

Immediate care needed: None.

Cleaning method: Seed macerator together with fanning mill very satisfactory.

Extraction factor: 30%.

Seed per pound: 26,000.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Dry storage over winter. Test seed to determine proper length of acid treatment. May vary from 20 minutes to an hour or more, according to variation in seed lots. Mechanical scarification also successful.

Notes on nursery propagation: Sow 35 viable seeds per linear foot. If early sown, advisable to sow fairly dense to retard growth. Late sowing may be safest method for time being. Cutting back in midsummer to just above ground will also retard growth.

Rosa laevigata Michx. - Cherokee rose, Carolina rose

Type of fruit: Pear-shape, bristly fruit about 3½ to 4 cm. long.

Season to collect: Fall.

Where to locate: This is an exotic evergreen shrub introduced from China. Planted to serve as fences in the far southwest.

Collecting method: Hand gather.

Immediate care needed: No information.

Cleaning method: No information.

Seed per pound: No data.

Type seed dormacy: Probably embryo dormancy.

Seed storage and pretreatment: Stratification over winter recommended.

Notes on nursery propagation: This rose is propagated from roots, seed, layers, and cuttings. Roots or cuttings can be direct planted. Seed should be sown into the nursery.

Sambucus canadensis L. - American elderberry

Type of fruit: A berry-like drupe with 3 to 5 one-seeded nutlets hanging in cymes.

Season to collect: Fruit ripens in July and August and should be immediately collected.

Where to locate: Low shrub native in all Shelterbelt States.

Collecting method: Hand gather.

Immediate care needed: Avoid heating.

Cleaning method: Mash and ferment and wash out pulp in water. Avoid excessive drying.

Extraction factor: 13%.

Seed per pound: 175,000.

Type seed dormancy: Probably embryo dormancy.

Seed storage and pretreatment: Stratify 90 days prior to spring sowing. Germinates early in the srping.

Notes on nursery propagation: Sow 35 seeds per foot. This species should grow readily in our nurseries under our standard nursery practices to a usable size in one season.

Sapindus drummondii H. & A. - Western soapberry, Wild China, Chinaberry, Indian soap plant

Type of fruit: One-seeded drupe growing in clusters with yellow semi-translucent flesh, turning black in late winter. Retained on trees over winter.

Season to collect: Any time after frost.

Where to locate: Medium tall tree native in Shelterbelt Zone from southern Kansas south on moist clay soils or dry limestone uplands. Not commonly planted.

Collecting method: Flail or pick direct from trees on to tarps using pole pruners or knives or hand gather into picking bags.

Immediate care needed: May heat under pressure.

Cleaning method: Because of impermeable seed coat dormancy, it is recommended that this species be depulped. Spread out on floor about four inches deep. Sprinkle with water twice daily until pulp softens. Then depulp through macerator, running at slow speed, or by rubbing over screens.

Extraction factor: 30% from rough weight to depulped seed.

Seed per pound: With pulp, 480 to 575. Depulped, 1700.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Dry storage over winter. Just prior to sowing treat two hours with concentrated sulphuric acid. Wash and sow.

Notes on nursery propagation: Sow 20 viable seeds per linear foot. Very little information as to nursery habits of this species. Apparently very drought resistant and should get along with little or no irrigation water.

Shepherdia argentea Nutt. - Buffalo berry, Bull berry, Squaw berry

Type of fruit: One-seeded small berry.

Season to collect: September till December.

Where to locate: High shrub native along river bottoms in Nebraska to North Dakota in western part of States.

Collecting method: Spread tarpaulin in opening in thickets. Break off fruit-bearing limbs and branches and beat off on tarp. Hand collecting slow and difficult.

Immediate care needed: Avoid heating.

Cleaning method: Sift out twigs, thorns, leaves. Ferment in water, then depulp through threshing machine. Separate pulp and seed by flotation method.

Approximate extraction factor: 5%.

Seed per pound: 30,000 to 40,000.

Type seed dormancy: Impermeable seed coat.

Storage and pretreatment: Fall planting preferable. Stratify for 90 days in moist peat at 41° F. prior to sowing in spring.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. Stratified seed germinates early, and therefore must be sown early in the spring. This species will probably require 2 years to grow to usable seedlings. Should be grown in moderately dense stands to give protection to each other.

Symphoricarpus vulgaris Michx. - Buck brush, Coral berry, or Indian currant

Symphoricarpus occidentalis Hook. - Wolf berry

Type of fruit: A two-seeded berry in clusters.

Season to collect: September throughout fall.

Where to locate: Low shrub native throughout Zone. Generally found in moist draws and hillsides, often as undergrowth.

Collecting method: Clusters easily gathered.

Immediate care needed: Avoid heating.

Cleaning method: Mash and ferment fruit, then wash out with water or run through macerator.

Extraction factor: 5 to 10%.

Type seed dormancy: Probably both impermeable seed coat and dormant embryo.

Storage and pretreatment: Treat the seed in concentrated sulphuric acid for 75 minutes, followed by 90 to 120 days stratification at 41° F. Otherwise the impermeable seed coat requires seed lying in the ground over one summer followed by after ripening the following winter.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. Direct information lacking on seed propagation, but should be adapted to growing under our standard nursery practice. Grows readily from both stem and root cuttings.

Syringia vulgaris L. - Common lilac

Syringia sp. - Various others

Type of fruit: An oblong, leathery, loculicidal capsule with two winged seeds in each of two cells in terminal or lateral panicles on branches of previous seasen.

Season to collect: Late June in south to August in north.

Where to locate: None of the lilacs are native but have been widely planted as ornamental low shrubs and hedges throughout entire Shelterbelt Zone.

Collecting method: Hand gather clusters.

Immediate care needed: If at all green provide aeration to avoid heating.

Cleaning method: Since it is difficult to clean thoroughly, it is necessary only to macerate to such an extent that the seed is no longer enclosed in the capsule.

Extraction factor: For clean seed the extraction factor for some species is less than 1% from rough weight as collected.

Clean seed per pound: Extremes reported range from 54,600 to 115,000.

Type seed dormancy: Probably impermeable seed coat.

Seed storage and pretreatment: Three months stratification in peat at 41° F. If stratified must be closely watched in spring, since it germinates early. Alternate treatment from dry seed which gave good success during the 1935 season at the Rapid City, South Dakota, nursery follows: Seed was placed in hot water several days, changing the water every day until the seed softened. It was then sown in beds. Seedlings attained a size up to 8 inches by the end of the season.

Notes on nursery propagation: Sow 40 viable seeds per linear foot. Commercial nurserymen propagate lilac largely from root suckers. Very little direct knowledge of propagating from seed. Unless the nursery site is well protected from wind or under overhead, it may be best to grow in beds, confining row sowing to an experimental basis. Lilac will probably be a two-year species throughout all States.

Toxylon pomiferum Rafn. - Osage orange, Bois d'arc, Bow wood

Type of fruit: Fruits drupaceous united into a compound fruit (syncarp) resembling large green orange. Each fruit contains 200 to 300 seeds similar to apple seeds.

Season to collect: Collect any time after frost.

Where to locate: Medium tall tree native throughout south. Widely planted as hedgetree as far north as central Nebraska. Not hardy farther north.

Collecting method: Gather from ground after fruit falls. Confine collection to fruits from trees which show no killing back. Portion of quota should be obtained from thornless varieties.

Immediate care needed: None.

Type seed dormancy: Dormant embryo.

Seed per pound: 12,000.

Seed cleaning, storage and pretreatment: Mash and store in piles in wet condition over winter to prevent drying out of seed and hasten decomposition of pulp. Separate out seed by washing in water. If depulped during winter, seed should be stratified. If depulping is postponed until sowing time, can be sown at once because winter storage recommended is essentially the same as stratification. Alternate method is to collect and clean in fall, store dry over winter, and soak in fresh water changed daily for 5 to 7 days prior to sowing. This latter treatment makes seed slimy and difficult to handle, which can be overcome by mixing 4 pounds of fine, dry sawdust per 100 pounds of seed. This cuts the slime and makes hand or machine sowing easy.

Notes on nursery propagation: Sow 30 viable seeds per linear foot. No particular problem presented once the stand is established.

Ulmus _____ - English elm (?)

Little is known of this species except that it exhibits remarkable form and reaches considerable height. Locally found throughout Kansas as street tree. Seed habits not known definitely. Reproduces by root sprouts, and for that reason it may develop into one of the most important species for shelterbelt planting.

Wherever this species is known to occur, it should be watched closely and seed habits ascertained. If seed can be obtained, every effort should be made to secure stand of seedlings. Also obtain all suckers possible.

Ulmus americana L. - American elm, White elm

Type of fruit: A winged samara with seed in center hanging in clusters.

Season to collect: Fruit ripens as leaves unfold in spring. Falls soon after ripening, therefore, collecting season short.

Where to locate: Medium tall tree native throughout Shelterbelt region along streams and sometimes on higher land.

Collecting method: Confine collections to native trees, i.e., do not collect from street trees unless definite proof exists as to their native origin. Seed of better vitality will be obtained if collections are confined to later ripened seed. Early ripened seed falls first. On a still day, collection can easily be accomplished by 5-man crew having large light drop cloth and bamboo poles. By tying corners of drop cloth to poles, it can be easily moved about, raised and lowered as necessary, as the seed is flailed or shaken from the trees.

Immediate care needed: Seed heats and spoils in very few hours if sacked or piled green. Can be avoided by light drying and frequent turning.

Cleaning method: No cleaning necessary except such drying as may occur before seed is sown.

Extraction factor: 50% or over if fairly ripe when gathered.

Clean seed per pound: 90,000 to 100,000 when dry.

Seed storage: Although storage of this species is not a common practice, the seeds can be stored for one year at a low temperature, provided the air is humid, according to data published by the Lake States Forest Experiment Station. This should be tried in North and South Dakota in order to have seed available for early spring sowing.

Notes on nursery propagation: Sow 50 viable seeds per linear foot. Sow seed as soon after collection as possible, since it loses vitality rapidly under normal storage conditions. It is also subject to heavy losses during germinating period from heat and damping off. Therefore it is desirable to sow as early in season as possible. If soil moisture and other conditions are favorable for immediate germination, "pre-germinate" seed before sowing by mixing in moist sand for several days. Mixing with moist sand just prior to sowing also helps greatly to secure even distribution on windy days. Ridge lightly if soil is dry. Avoid soil crusting as much as possible.

This species responds readily to adequate moisture. In the north to play safe it should be hardened up by September 1 to 10, since it is very susceptible to killing back if not hardened. If little early season growth is obtained in the northern States, it is advisable to retard growth for the balance of the season and hold two years in nursery. Second year's growth will result in too large a seedling if cultural practices are not carried out so as to retard growth.

Ulmus parvifolia Jacq. - Chinese elm, Leather leaf elm

Type of fruit: A compressed nutlet surrounded by a membranous wing.

Season to collect: September usually.

Where to locate: This is an introduced medium tall tree that is becoming widely planted throughout the southern Plains States.

Collecting method: (See American elm)

Immediate care needed: Will heat readily, therefore, it should be spread out thinly to dry and turned at frequent intervals.

Cleaning method: Seed drying only.

Seed per pound: Probably about 50,000.

Type seed dormancy: No dormancy.

Storage and pretreatment: Cool dry storage from time seed is dried until following spring.

Notes on nursery propagation: Sow 40 viable seeds per linear foot. Should handle the same as other elms. Washington nurseries report that they have had good success with spring sowing after the ground warms up. Seedlings will make considerably slower growth than Ulmus pumila.

Ulmus pumila L. - Chinese elm, Siberian elm

Type of fruit: Winged samara with seed in center hanging in clusters.

Season to collect: April in south to June in north.

Where to locate: High exotic tree planted throughout Zone as street tree, experiment stations, and farm windbreaks. Purchase from nurseries in Washington State to be certain of pure strains. When locally collected make effort to get seed from Myers original importation. Avoid trees with signs of canker or other weaknesses. Unless collections are from trees isolated from American elm by several hundred feet, a hybrid may be obtained if the two species should flower and pollinate at the same time.

Collecting method: Same as for American elm. Otherwise, use tall ladders and hand pick. Watch seed as it ripens and collect as soon as it starts to turn brown, since it falls soon after ripening.

Immediate care needed: Spread out thinly to dry. This seed will heat and spoil in two hours if packed green into shipping bags.

Extraction factor: 50% or over if fairly ripe when collected.

Seed per pound: 55,000 when dry.

Seed storage: Seed can be successfully held over in storage for one year in sealed containers. Advisable to hold at low temperatures. Try with both low and high humidity.

Notes on nursery propagation: Sow 40 viable seeds per linear foot. Will germinate faster than American elm, otherwise nursery handling much the same except that sufficient growth will always be obtained for Chinese elm in one season if seed is sown at proper time. Responds readily to presowing treatment in wet sand if soil moisture and temperature conditions are favorable for prompt germination. Seedlings are difficult to handle in storage on account of Chinese elm root rot. Should be repiled frequently and kept fairly dry in comparison to the other species.

Vitex agnus-castus L. - Chaste tree, Hemp tree, Monk's pepper tree

Vitex negundo L.

Type of fruit: A small drupe enclosing stony seed.

Season to collect: July 15 to October 15.

Where to locate: Used as an ornamental shrub in Shelterbelt Region of Oklahoma and Texas.

Collecting method: Strip from bushes by hand.

Immediate care needed: None.

Cleaning method: Flail off dry outer husks and clean with fanning mill.

Extraction factor: 75%.

Seed per pound: 59,200 when thoroughly dry.

Type seed dormancy: Probably embryo dormancy.

Storage and pretreatment: No data available as to length of time, but this seed should be stratified prior to sowing. Spring sowing is recommended.

Notes on nursery propagation: No information available.

Viburnum lentago L. - Sheep berry, Black haw

Type of fruit: A drupe with a one-seeded compressed stone. Blue-black or black in color when ripe.

Season to collect: August and September.

Where to locate: This shrub is native under favorable conditions in North and South Dakota.

Collecting method: Hand gather.

Immediate care needed: Avoid heating.

Cleaning method: Soften in water and depulp.

Extraction factor: From rough weight to clean partly dry berry not depulped, 60%.

Seed per pound: 2,180 retaining hulls.

Type seed dormancy: Probably both impermeable seed coat and embryo dormancy, mainly embryo dormancy.

Seed storage and pretreatment: Stratify immediately following collection.

Notes on nursery propagation: Viburnum ordinarily, whether fall or spring sown, does not germinate the first spring. However, the root sprout is made the following fall even though no upward growth is made. The following spring the seedlings appear above ground. For this reason should be stratified one full year from time of collection and sowed in the late summer or early fall before the root sprouts appear on the stratified seed. Samples of the stratified seed should be tested from time to time to determine when they are ready to germinate.