BED DENSITY AND SIZE OF PONDEROSA PINE SEEDLINGS AT THE BEND NURSERY

by

James W. Edgren, Associate Plant Ecologist
Pacific Northwest Forest and Range Experiment Station
Forest Service, U. S. Department of Agriculture
Portland, Oregon

At the U. S. Forest Service nursery near Bend, Oregon, ponderosa pine is drill-sown in beds containing six rows each. A standard eight-row drill is used with the third and sixth shoe blocked. In November 1962, a study1/ was started to determine the effects of growing ponderosa pine at different densities in these beds.

METHODS

First-year seedlings, from seed collected at 4,500 feet on the Wallowa-Whitman National Forest, were thinned to densities of 5, 10, 15, 20, 25, 30, and 35 seedlings per foot of row. These densities correspond to 30, 60, 90, 120, 150, 180, and 210 seedlings per lineal foot of bed, or one-fourth as many on a square foot basis. Two replicates of the experiment were installed in each of two beds, making a total of four clusters, each containing seven 4- by 4-foot areas, one for each density. The individual area consisted of a 2-foot-long plot spanning the nursery bed plus a 1-foot buffer at each end (fig. 1). Densities were assigned at random to areas within each cluster.

Seedlings were lifted in April 1965, two seasons after thinning. Trees from border and inside rows of each plot were placed in separate groups, bundled, and shipped to us in Portland for evaluation. Upon arrival, trees in all groups were counted and culls removed. Any seedlings whose size was less than one-half the apparent average in its group in any three of four characteristics--root size, stem diameter above cotyledonary node, needle complement, and top length--was culled. So, too, were any seedlings having multiple stems equal in length, stem swellings that would interfere with diameter measurements, broken tops, or major lateral roots broken off.

Number of trees available in the smallest group determined size of the sample to be used from all groups. The smallest group contained 15 seedlings. Accordingly, trees in each group were randomly arrayed

1/ This study was cooperatively planned by Howard Hopkins and Harold Dahl, Region 6 National Forest Administration, and William I.Stein and James M. Trappe, Pacific Northwest Forest and Range Experiment Station. Trees were thinned by Hopkins and Dahl, assisted by Charles Bigelow and James Betts of the Bend Nursery. The latter two men also supervised lifting and shipment.

on the laboratory bench and 15 selected systematically to represent the group. For example, if the group contained 150 trees, each 10th tree was selected, or if a group contained 20 trees, 3 out of 4 were selected. The shipment contained approximately 10,000 seedlings of which 1,260 were selected for determination of size and weight.

On every sample tree, height was measured from the cotyledonary node to the base of the terminal bud. Diameter was measured far enough above the cotyledonary node to avoid the slight enlargement of the stem in that area. Each seedling was then clipped at the cotyledonary node; top and root were ovendried and weighed separately. Total weight was obtained by adding top and root weight. Top-root ratio was computed by dividing weight of tops by weight of roots.

Size and weight differences between seedlings grown at different densities were tested for statistical significance by analysis of variance techniques.

RESULTS

Density at which seedlings grew in the seedbed affected their stem diameter--the higher the density, the smaller the average diameter (fig. 2). Generally, successive increases of 30 seedlings per lineal foot of bed caused successively smaller decreases in average stem diameter. For example, a change from 30 to 60 seedlings per lineal foot of bed reduced average seedling diameter by 0.9 mm.--from 7.1 to 6.2. But changing from 150 to 180 seedlings per lineal foot of bed reduced seedling diameter only 0.2 mm.--from 4.8 to 4.6. This inverse relationship between seedling density and average stem diameter is statistically significant. However, average diameters for successive densities differed from each other only at the three lowest densities (table 1). At densities greater than 90 seedlings per lineal foot of nursery bed, no further significant reduction in seedling diameter occurred.

Average dry weight also decreased as seedling density in the nursery bed increased (fig. 3). However, trends were not confirmed statistically as clearly as for diameter. At 30 seedlings per lineal foot of bed, total dry weight of the average seedling differed from that at any other density except 60 per lineal foot (table 1). Densities greater than 60 seedlings per lineal foot of bed caused no further significant reduction reduction in average weight per seedling.

Height and top-root ratio were not significantly affected by differences in seedbed density (fig. 2, table 1). Although greater density generally appeared to have reduced seedling height, the differences were not large and, more important, did not show a consistent trend. Average height varied only 0.8 cm. among densities, and individual heights varied greatly within each density. Change in top-root ratio was consistent but too small to differ significantly between densities (table 1).

By position in the nursery bed, total dry weight, root weight, and top-root ratio all differed significantly between seedlings from outside and inside rows. Since average top weight did not differ significantly because of position, the difference can be traced to the roots--

seedlings from outside or border rows produced heavier roots than seedlings from inside rows. Top-root ratio for seedlings growing in outside rows as 1.86; for those in inside rows, 2.16. Undoubtedly, seedlings in border rows have more room for root growth than those in inside rows.

APPLICATION

In growing seedlings, the nurseryman aims to raise as many seedlings of desired size as possible per lineal foot of bed. This study shows that manipulation of seedbed density affects the average size of seedlings produced. Now, let's examine how many seedlings of a given stem diameter were produced at different densities,

The second lowest density, 60 per lineal foot, produced the most seedlings with stem diameter of 6 lion. or larger (table 2). The lowest density produced the highest proportion of that size but couldn't equal the second lowest because of the limited total number of seedlings present at the lowest density. Higher densities failed to produce the same number of seedlings 6 mm. or larger as produced at a density of 60 per lineal foot. For example, at 210 seedlings per lineal foot of bed, an increase)f 150 seedlings, there were 38, or 3 less, with stem diameter of 6 mm. or larger.

Total number of seedlings 5 mm, and larger increased with greater density. A density of 60 seedlings per foot of bed produced 53 seedlings 5 mm, or larger; at 210 per foot, 58 of the additional 150 seedlings were larger than 5 mm,

Nearly all seedlings at a bed density of 60 per lineal foot were 4 mm„ or larger, An increase of 150 seedlings per foot of row, to 210, resulted in 119 additional seedlings 4 mm, or larger and only 31 more smaller than 4 mm,

Seedbed density influences number of seedlings produced of a given size or larger, whether size is measured as stem diameter (table 2), or as total dry weight (table 3).

The foregoing data provide a basis for decision making in nursery administration, If the administrator wishes 3-0 ponderosa pine seedlings 6 mm. cr larger in stem diameter, he will conserve seed and minimize culling by sowing only enough seed to produce 60 seedlings per lineal foot of bed. If seedlings smaller than 5 mm in stem diameter are desired, his sowing rate should be high enough to produce at least 210 seedlings per foot of bed, If the production goal is seedlings 5 non. and larger, the relatively small number of seedlings gained at higher densities must be weighed against the higher costs of seed and of culling.

There is also the possibility that low density may shorten the time required to grow an acceptable seedling. This gain may be even more important than maximizing production of acceptable seedlings in a single crop.

At this stage in our research, we do not know which bed density produces seedlings best able to survive under various field conditions. I believe this is the direction future research on density in ponderosa pine seedbeds should take.

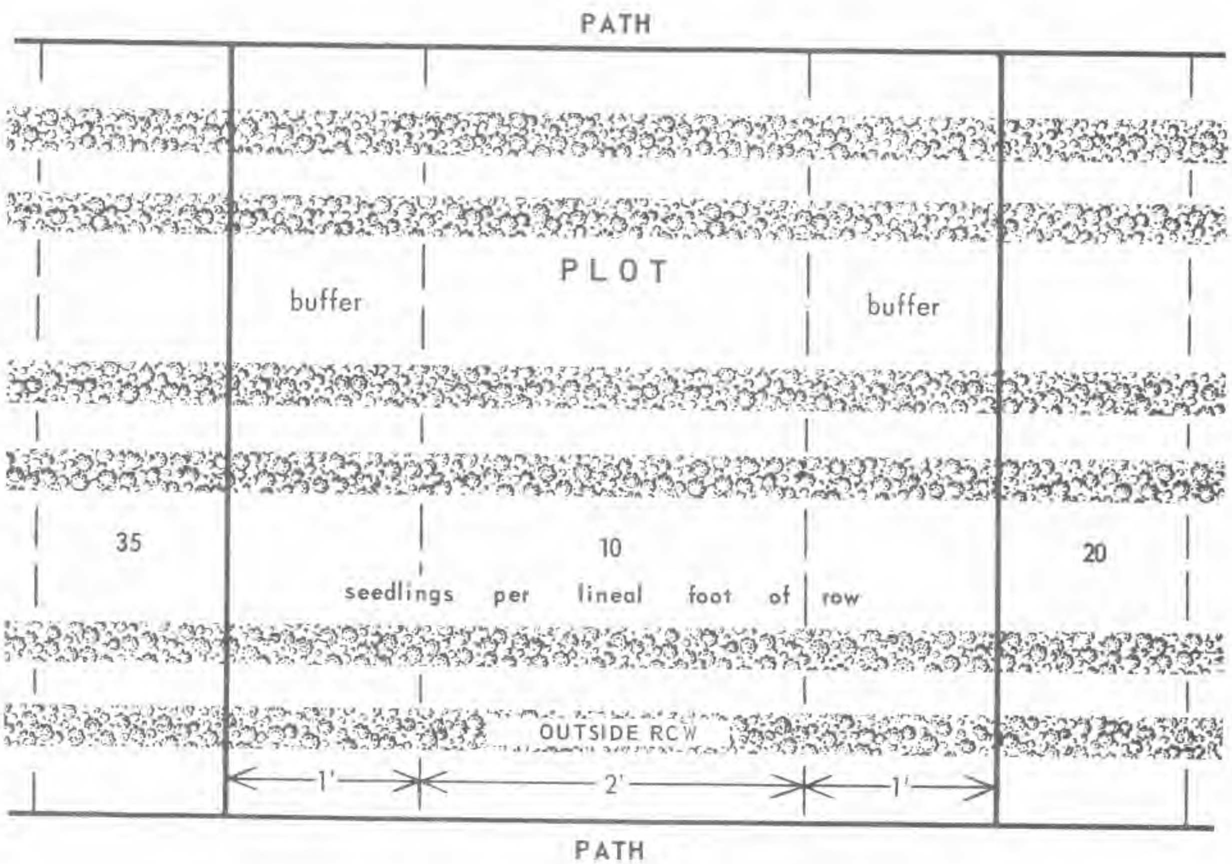

Figure 1. - -Arrangement of plot and buffer strips spanning a 4- by 4-foot area thinned to one density.

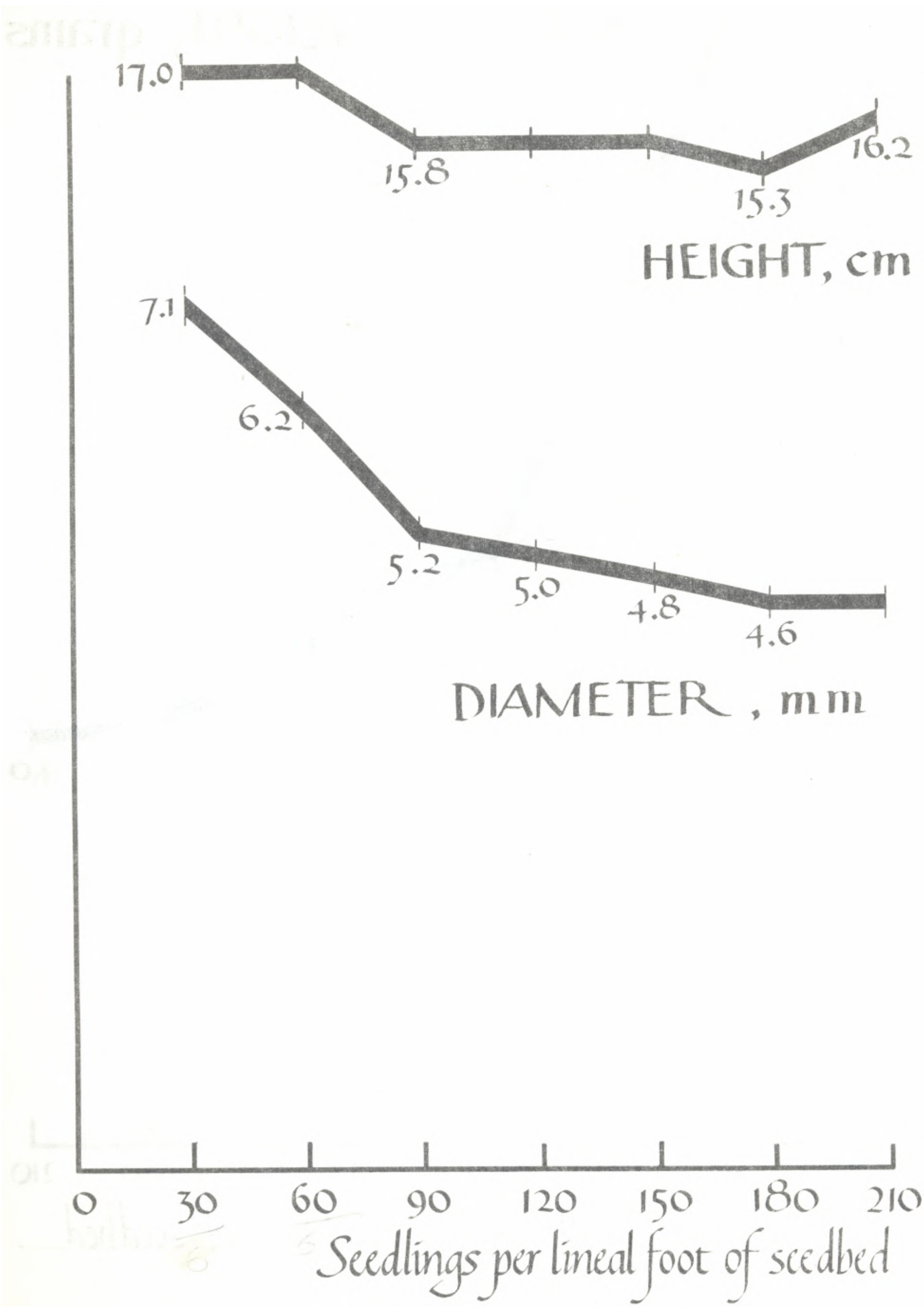

Figure 2. - -Average height and diameter of 3-0 ponderosa pine seedlings following growth at different densities. Each mean represents 120 seedlings.

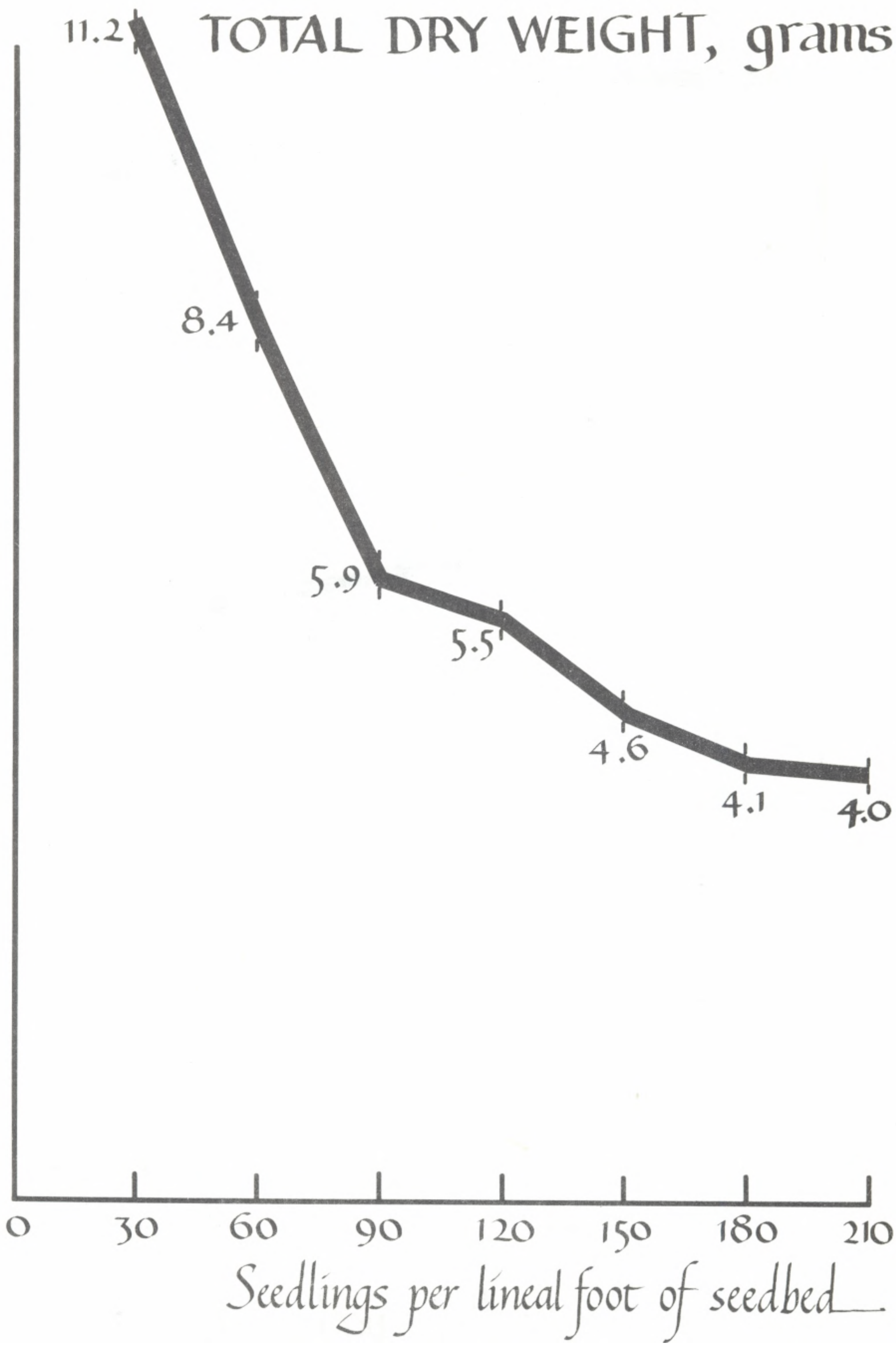

Figure 3.--Average dry weight of 3-0 ponderosa pine seedlings following growth at different densities. Each mean represents 120 seedlings.

Table 1.-- Average size of seedlings grown at different densities.

Number of seedlings per lineal foot: Of row	Number of seedlings per lineal foot: Of bed	Stem diameter	Top height	Weight: Top	Weight: Root	Weight: Total	Top-root ratio
		--Millimeters--		---------Grams---------			
5	30	7.1	17.0	7.2	3.9	11.2	1.9
10	60	6.2	17.0	5.6	2.8	8.4	1.9
15	90	5.2	15.8	3.9	2.0	5.9	2.0
20	120	5.0	15.8	3.6	1.8	5.5	2.0
25	150	4.8	15.8	3.1	1.5	4.6	2.0
30	180	4.6	15.3	2.8	1.3	4.1	2.1
35	210	4.6	16.2	2.7	1.2	4.0	2.2

Note: Individual averages in columns 3 to 8 not connected by a continuous line differ significantly at the 95-percent level. Each average represents 120 seedlings.

Table 2.--Seedlings of given stem diameter or larger produced at different densities

Seedlings/ft.	Total number of seedlings per lineal foot of bed	Stem diameter (millimeters)									
		2	3	4	5	6	7	8	9	10	11
		Number									
5	30	--	--	30	29	26	20	12	4	1	--
10	60	--	60	59	53	41	25	13	2	--	1
15	90	--	90	87	69	33	11	2	--	--	--
20	120	--	120	115	80	35	12	2	--	--	--
25	150	150	148	141	81	33	6	3	1	--	--
30	180	180	176	149	94	34	7	--	--	--	--
35	210	210	206	178	111	38	4	2	--	--	--

Table 3.--Seedlings of given total dry weight or larger produced at different densities

Total number of seedlings per lineal foot of bed	Total weight (grams)											
	0	2	4	6	8	10	12	14	16	18	20	20
	Number											
30	--	30	29	28	22	19	13	10	7	5	2	2
60	--	60	58	46	31	18	13	9	5	4	1	1
90	--	90	78	45	30	14	6	3	--	--	--	--
120	--	120	98	54	32	13	6	2	2	1	--	--
150	150	148	100	45	25	10	8	3	--	--	--	--
180	180	178	103	58	27	9	4	--	--	--	--	--
210	210	204	128	57	21	6	--	--	--	--	--	--