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A TEST FOR CORRELATION BETWEEN VARIATION IN SPECIFIC GRAVITY AND VIABILITY WITHIN A SEED GROUP OF SCOTCH PINE SEED

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Introduction

One of the recognized problems of the forest nurseryman is that of securing a uniform stand of rapidly developing seedlings in the seed beds. That is of securing uniform germination and uniform development after germination. This is important from many standpoints, including avoidance of heavy root competition, avoidance of great variation in density within a seed bed, causing variation in stock and wasting of space, and for pathological reasons (excess density promoting fungal activity).

One of the factors which limits the possibility of securing the ideal density is variation within a seed lot. When it is possible to separate the seeds of uniformly desirable characteristics from the heterogeneous mixture received at the nursery, then it will be possible in a large measure to calculate and secure a uniform seed bed stand of desired density. The nurseryman will then be in a better position to meet his planting stock demands with the amount and character of stock desired.

Within a given seed group, there is patently, a considerable variation in viability and vitality represented. These characteristics may be correlated with such physical properties as size, weight, and specific gravity.

With regard to size, Champion (7) states, "It has been shown many times, with various tree species in many countries, that germination of seed and early development is influenced by size of the seed used. He showed that in growing sal (Shorea robusta), a very marked correlation between size of seed and tree per cent, height growth, and vigor.

Deen (10) has investigated weight and found, in testing longleaf pine seed, that it is correlated with viability, in so far as seed falling below a certain level do not germinate, and that this line of demarcation is sharp. The influence of weight is being further investigated by the Black Rock Forest.

Since specific gravity provides a convenient means of mechanical separation through the medium of liquids, and is an easy and practicable method, it was adopted for investigation. It appears logical that size, degree of development, and plant food stored might be correlated with specific gravity, and through these, viability and vitality would be affected.

Historical

The method of using water and salt solutions in seed selection has long been known to gardening. Yokoi (23) states that it has been in vogue in China and Japan for over 275 years. This method has been used to separate light seed, foreign seed, and debris from seed collections.

Considerable attention was given to this idea of specific gravity and seed characters by investigators throughout the 19th century. There was no consensus of opinion developed for this

method, some coming out strongly for and others equally strongly against. It is perhaps significant that the method has not been adopted generally by agriculture, although it is used to a limited extent. Nevertheless, very marked increases in viability and yield have been recorded and photographed, from the denser portions of the seed over the less dense portions, when separations were made by this method! Investigations have also shown that, in the seed of certain plants, the seed of higher S.G.* retain their viability better than do those of lower S.G.

The positive results have probably been matched by an equal number of negative results. These facts may point to an inconsistent relation between S.G. and properties of the resulting plants.

Causes for Variation in Specific Gravity. The chief constituents of seeds and their S.G.'s are as follows:

Table I

From Clark (6)

Fats	0.91 to 0.96
Legumin	1.285
Protein	1.297
Starch	1.53
Cellulose	1.53
Ash	2.50
Water	1.00
Air	0.001293

Clearly, any variation in S.G. within a given seed mass must be due to variation in the proportion of the constituents present. (Furthermore, it is logical to expect a variation in the properties of seed exhibiting such variation.)

Wiley (22) demonstrated that variations in composition do occur, in his determinations of variation of food compounds

* Specific Gravity.

in American wheat, which are reported as follows:

Proteids	8.58 to 17.15%
Carbohydrates	66.67 to 76.05%
Gleuten (wet)	12.33 to 39.05%

Similar determinations have been run on corn, in which a higher S.G. is associated with higher protein, as was the wheat. Such variations in composition were shown to be associated with differences in climate, seasons, soil fertility, fertilizing treatment, and other similar factors.

The above-mentioned variations are not consistent with what would be expected from the table of S.G.'s; e.g., protein is of relatively low S.G. Therefore, the increased S.G. with increased protein must be due either to a corresponding increase of the high S.G. starch (1.53) or to fewer air-filled interstices being present in the better nitrogen-supplied seed.

Clark (6) demonstrated that the S.G. of seeds also varies because of structure. A grape seed which had a S.G. of 1.13 was made up of an endosperm with a S.G. of 1.25 and a seed coat of S.G. 1.35. The third constituent, causing this seeming paradox, was imprisoned air.

The presence of air space may be due to shrinking because the seed did not mature; that is, leaving a high water content endosperm which subsequently shrinks. For this reason, when a part of a crop has not matured properly, S.G. will probably be found to be a key to ripeness.

The water content of seed will vary for reasons other than ripeness causing variation in S.G. of the seed of a group. This fact is demonstrated by Clark (6) in his determinations of

changes in S.G. in seed from the fresh to the air-dried condition. This seed, Hamburg grape, showed changes of from 0.01 to 0.10 as the seed dried.

This change in amount of variation was not progressive, and therefore the seed did not retain its absolute relative position on the S.G. scale, although the general trend remained the same. (See Fig. 1).

Another manner in which air space may be present is in a general looseness or lack of compaction between the parts of the endosperm and between the endosperm and the seed coat. These conditions of looseness were found by Clark (6) to increase as the S.G. progressed downward.

In pine seed, the seed coat is thin to the extent that it may be ignored in considering S.G.

The Problem

For the purpose of this problem, the following hypothesis was set up to be proved or disproved:

1. There is a correlation between viability and S.G. in a given lot of Scotch pine seed.

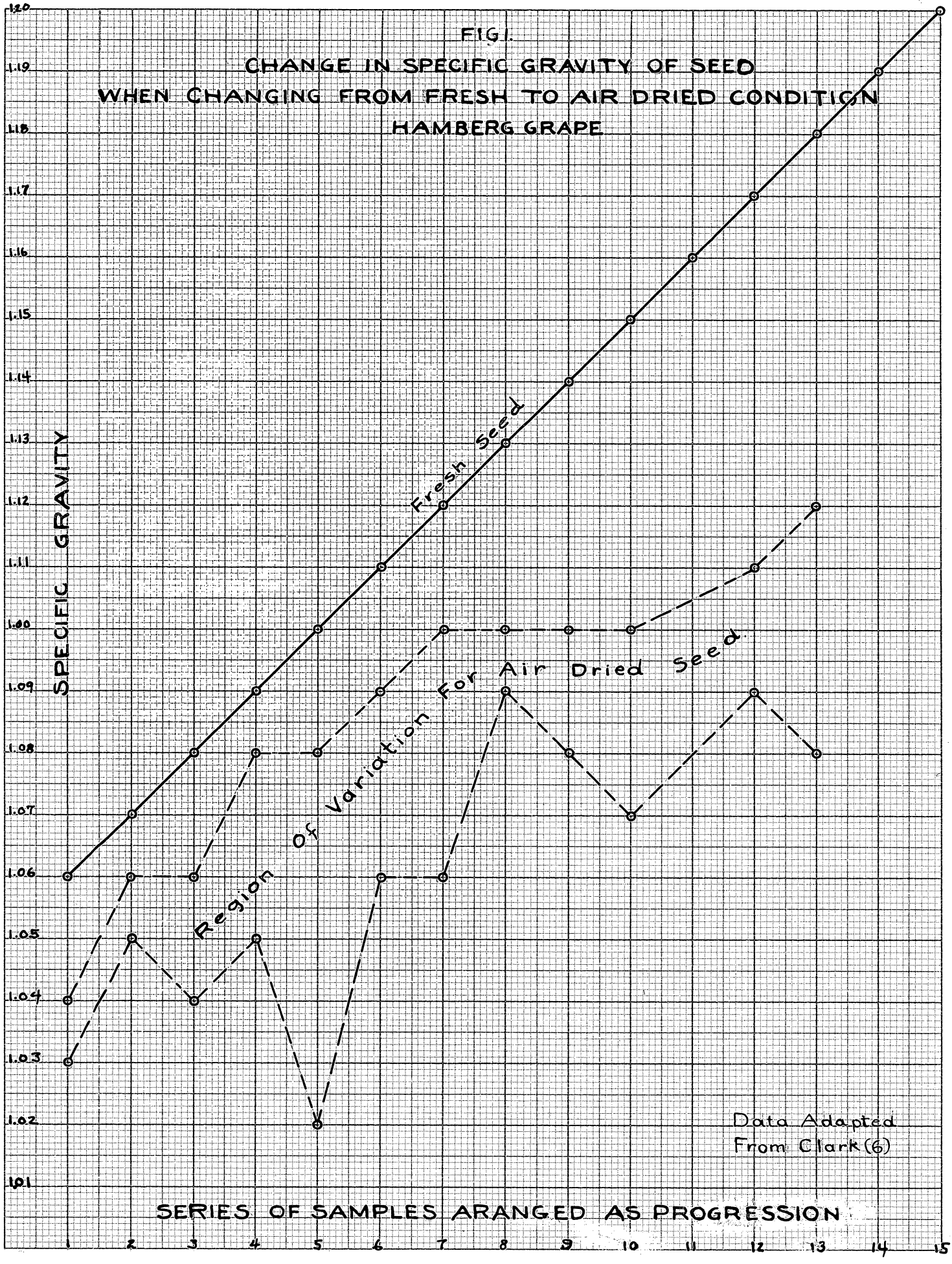
2. S.G. increase with size of seed to an extent and uniformity which causes a desirable grading according to size when separated by liquids.

Method

A series of mixtures of various S.G.'s was made up from Ethyl alcohol and water, to delineate the effective limits of

FIG I.

CHANGE IN SPECIFIC GRAVITY OF SEED
WHEN CHANGING FROM FRESH TO AIR DRIED CONDITION
HAMBERG GRAPE



Data Adapted
From Clark (6)

separation. Later another series was set up within these limits.

Table II

Table of Specific Gravity Groups

Specific Gravity	Number of Seed			Percent Floating
	Sinking	Floating	Total	
.838	458	31	489	6.4
.846	346	46	492	9.3
.851	427	50	477	10.5
.860	428	133	561	23.7
.865	389	151	540	27.9
.871	257	222	479	46.3

Enough seed was dropped into the beakers containing the solutions to make up the samples. (This established groupings of seed, all of which were of higher S.G. than the separating fluid. Thus the consecutive groups had increasingly higher percentages of their numbers removed by taking away those of the lowest S.G.) The floating seed were poured off and the other seed collected by pouring the liquid through a tea strainer. The seed were then spread out to dry, and later counted into groups of 100 each. Floaters were also counted to determine percentage of separation. (See Table II.)

The 100 seed samples were then planted in sterile sand flats and placed in a greenhouse and germinated for 30 days. Six separation groups and a check were run in triplicate. (See Table III.)

The seed used for the test were from a shipment of imported Scotch pine (P. sylvestris) seed, collected in 1934 and cold-stored in a sealed container.

Table III.

Record of Germination

Planted January 6

Number of Flat	Specific Gravity Group	Date of Observation																			Total Germ. in 30 days%
		1-17	1-18	1-19	1-20	1-21	1-22	1-23	1-24	1-25	1-26	1-27	1-28	1-29	1-30	1-31	2-1	2-2	2-3	2-4	2-5	
1	0.871	1	14	5	5	3	3		6	4	5	0	0	0		1	0	1	0	1	0	49
2	0.860	1	3	1	2	2	2		8	1	2	0	2	0		3	0	1	3	1	1	33
3	0.865	0	2	1	2	4	3		5	1	3	2	1	1		3	1	2	2	3	1	37
4	0.865	0	0	0	3	4	4		6	1	2	1	0	0		2	2	0	2	1	1	29
5	.860	0	0	0	0	2	0		2	1	1	5	1	0		2	1	2	0	1	0	18
6	.871	1	2	0	1	2	2		6	6	3	2	2	0		2	1	0	1	0	0	31
7	.851	0	2	0	3	1	1		4	0	4	0	0	0		2	0	2	1	0	0	20
8	Check	0	5	0	1	2	2		8	3	2	1	0	1		5	3	0	1	0	0	34
9	.838	0	0	0	1	0	0		2	0	3	0	0	0		3	0	2	1	0	0	12
10	.846	0	1	0	3	3	4		10	5	4	1	2	3		7	2	2	4	2	0	53
11	.838	0	0	0	0	0	0		5	2	3	2	0	1		3	0	2	1	1	0	20
12	.846	0	0	0	1	0	0		4	0	0	1	0	0		1	0	0	1	1	0	9
13	.851	0	0	0	1	1	1		6	4	1	1	0	1		5	1	0	2	1	0	25
14	Check	3	3	3	4	1	2		6	0	4	3	0	2		5	0	2	1	1	0	40
15	.838	1	4	2	3	6	4		3	1	4	1	0	1		3	4	0	1	0	0	38
16	.871	1	2	0	3	2	2		8	1	3	1	2	0		1	1	1	2	2	1	33
17	Check	0	7	2	7	2	2		9	7	3	1	1	1		2	1	0	1	0	0	46
18	.865	0	1	0	0	4	3		4	1	5	1	1	1		2	0	0	3	2	0	28
19	.851	2	11	3	3	10	5		8	1	0	1	0	1		5	0	1	0	0	0	51
20	.860	0	3	0	3	0	0		2	1	2	3	2	0		1	1	1	0	1	0	20
21	.846	1	16	2	8	3	3		7	0	3	1	2	1		2	1	0	2	2	0	54

Results

The first interesting observation was the variation of S.G. for the seed lot tested falls a narrow range, about 90% of the seed falling between a S.G. of .830 to .900.

A glance at Table I discloses that this lot of pine seed has a S.G. considerably lower than that of any of its constituents, other than air. This indicates the normal presence of considerable quantities of air within the seed coat. Since air has a relatively great variation from the mean S.G. of Table I, a relatively small variation in the quantity present would have a sharp effect on the position that a seed would occupy within the narrow range of S.G.'s present. This effect could quite conceivably upset the results which may have been possible had S.G. been determined exclusively by the active components of the seed.

The curve of % separated over S.G. (Fig. 2) shows a rapid rise after about S.G. .854, as would be expected if there is a normal distribution of S.G. about the mean. The distribution is slightly skewed as shown (approximately) in Fig. 4 .

There was no apparent grading according to size from one S.G. group to another. However, the type of separation used is not well adapted to demonstrate such grading. Subsequently a separation of the last 6% of seed in each of the tails of the normal distribution curve of S.G. was made, for purpose of size comparison. (Table V.) These were the seed falling below S.G. .838 and those above .896. A definite grading tendency was thus brought out, and is graphically presented in Fig. 4 . This probably represents the extremes in grading effect, since it was

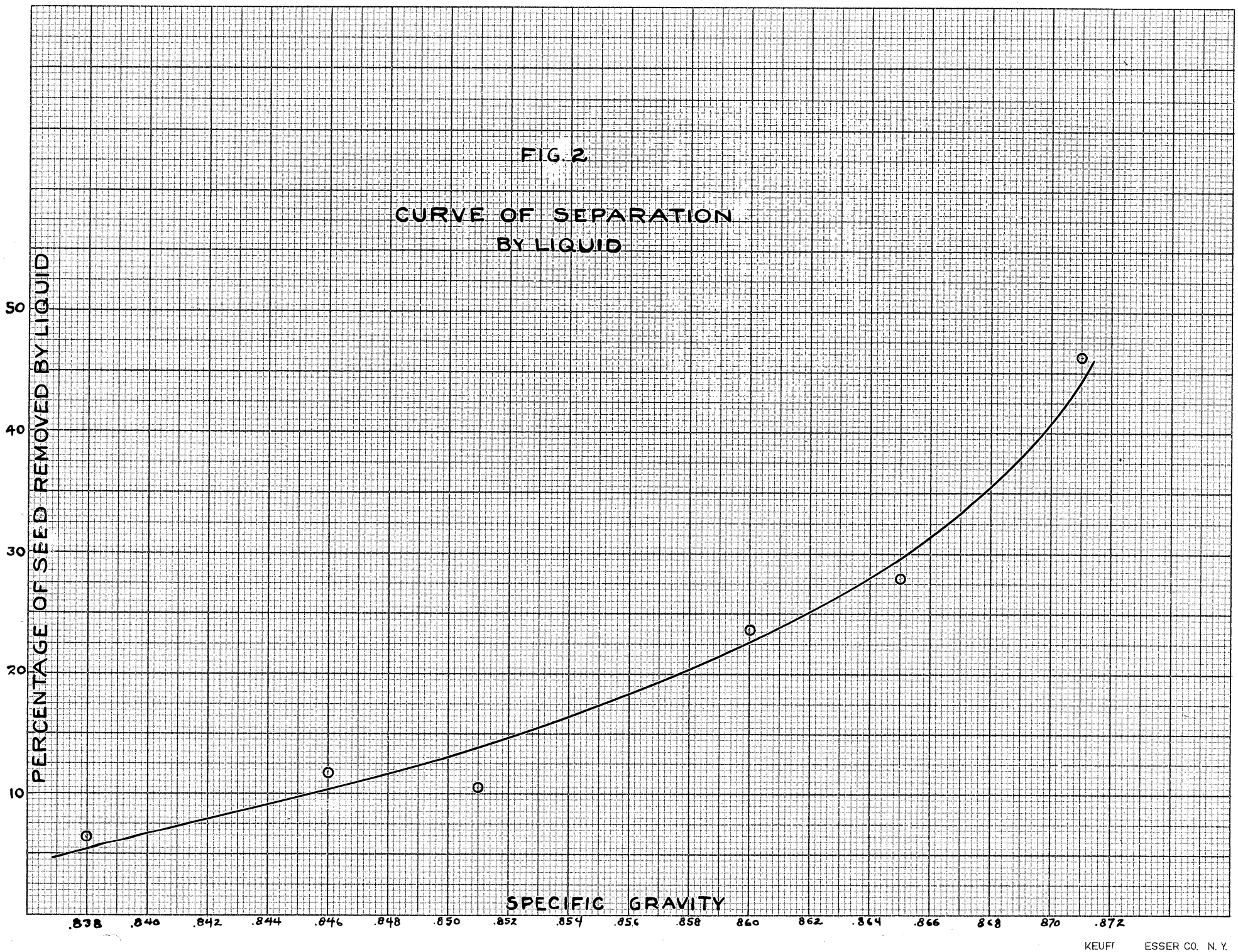


FIG. 2
CURVE OF SEPARATION
BY LIQUID
PERCENTAGE OF SEED REMOVED BY LIQUID
50
40
30
20
10
SPECIFIC GRAVITY
.838
.840
.842
.844
.846
.848
.850
.852
.854
.856
.858
.860
.862
.864
.866
.868
.870
.872
KEUFFEL ESSER CO. N. Y.

FIG 3

REGRESSION CURVE

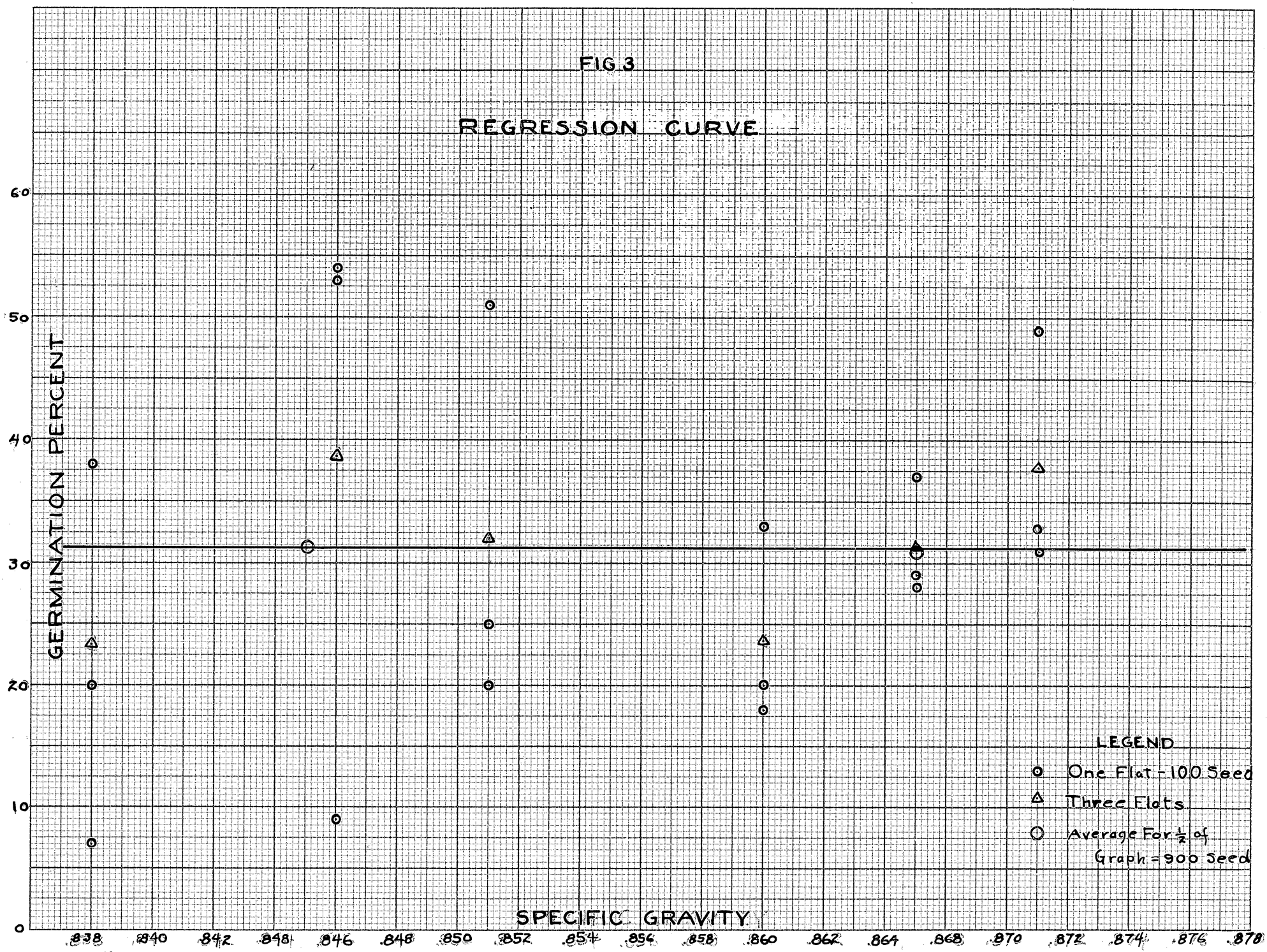
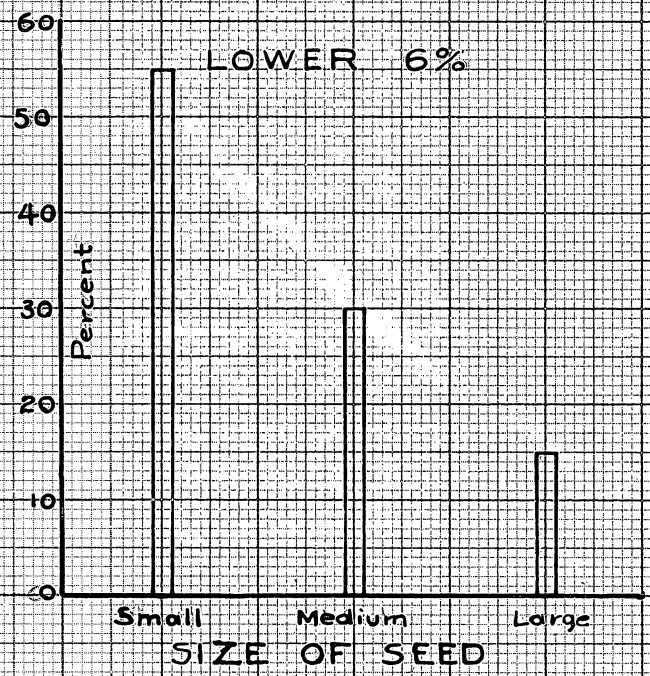
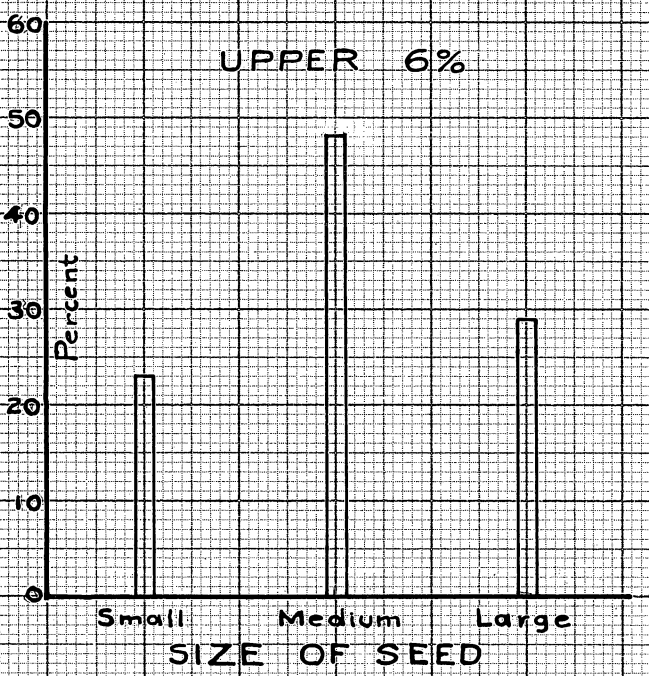
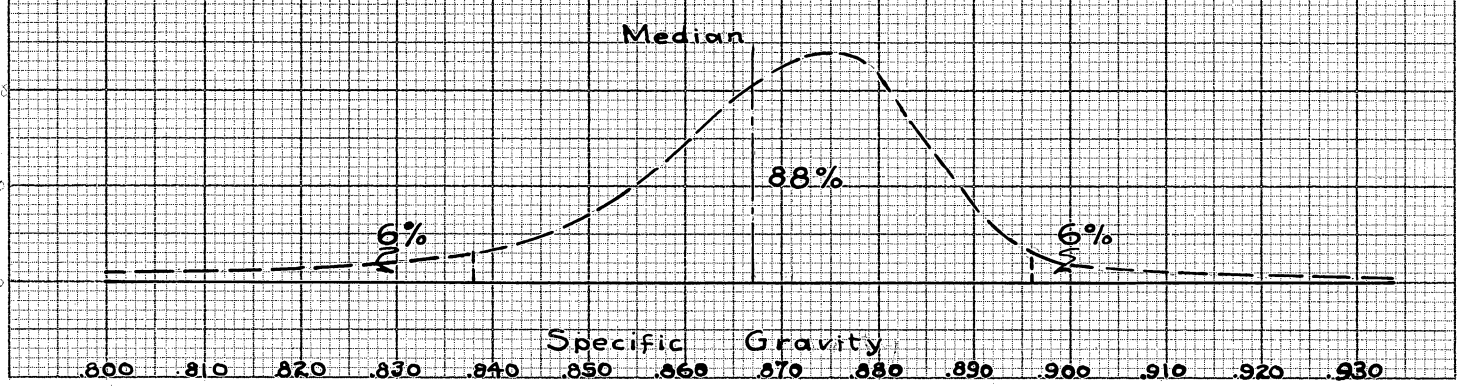


FIG. 4

DIAGRAMATIC REPRESENTATION OF DISTRIBUTION OF SEED SIZES IN THE EXTREMES OF THE NORMAL DISTRIBUTION CURVE OF SPECIFIC GRAVITY







taken from the extremes of S.G.

Gevorkiantz (12) found, that in pine seed the darker-colored portion of the seed group gives better germination. It is interesting to note that no apparent grading as to color occurred in the above-mentioned groups. In fact, as brought out in Table V, the two groups are almost identical in this respect, a condition which is probably more or less coincidental. However, if Gevorkiantz's findings apply to Scotch pine, the above would tend to bear out the results of this experiment.

Germination was marked by extreme variability without order. In fact, the maximum and minimum in germination per cent fell within a single S.G. group. The cause for this inconsistency was not determined. The temperature was uniformly 66° to 68°F., which is considerably below the optimum, which was shown by Haasis (13) to be 75° F. for Pinus rigida, 67°F. falling about 1/3 the way down the scale of optimum temperature for that species. That this may have been the cause for poor germination is apparently borne out by a difference in germination between the two shelves on which the flats were placed. The lower shelf of 12 flats had an average germination of 28.7%, while the 9 flats on the shelf about 18" higher and on a level with the thermometer, had a germination of 37.2%. Baldwin (1) found that for red spruce, the total germination was the same for temperatures ranging from 50° to 82° F. after 35 days. It seems unlikely that the effective temperature range for Scotch pine is enough higher to show this much effect, and consequently the difference

Table IV

Summary of Germination Record - 30 days

	Specific Gravity Group					
Check	.838	.846	.851	.860	.865	.871
%	%	%	%	%	%	%
34	12	53	20	33	37	49
40	20	9	25	18	29	31
46	38	54	51	20	28	33
Average: 40.0	23.3	38.7	32	23.7	31.3	37.7

Table V

Classification of Seed Occurring in the Tails of Specific Gravity, Normal Frequency Curve

Specific Gravity	Size of Seed	Color of Seed				Broken Seed	Totals
		Very Light	Light	Dark	Black		
0.838	Large	2	2	3	0	0	7
and	Medium	0	5	7	1	0	13
under	Small	0	6	11	7	0	24
Totals		2	13	21	8	0	44
0.896	Large	2	5	4	2	0	13
and	Medium	0	2	16	4	7	22
over	Small	0	4	5	2	0	11
Totals		0	11	24	8	7	46

in germination between the two shelves is attributed to accident.

The germination was plotted as the dependent variable against specific gravity (Fig. 3). The data had no apparent trend. Therefore, an average germination for all groups exclusive of check was taken and a horizontal line was drawn through the point this plotted. This curve balanced and fell in such a way that it is obvious that the plus and minus deviations are a minimum. Therefore, the curve is correctly placed. This shows perfect, no correlation between the two variables, germination and S.G., within this seed group.

The reader will notice in Table IV that, while the germination of the check has an average higher than that of any of the separation groups, it does not have the maximum for single flat germination. The highest check was #4 from the highest S.G. group and the four highest germinations were well distributed in the S.G. group range. This would serve to dispel a belief of a possible toxic effect from the alcohol bath, and also to make the check appear normal with regard to the germination of the separation groups.

Summary

I. The range in S.G. within the seed group tested is very narrow, being only about .069 S.G. units.

II. There is no marked grading effect as to size, when the seed of the lowest S.G. are removed from a seed group.

III. There is perfect, no correlation between the viability variation and the specific gravity variation within a seed group for Scotch pine.

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