

Kansas State Agricultural College.

EXPERIMENT STATION.—Circular No. 11.

DEPARTMENT OF AGRONOMY.

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*The Relation of Size, Weight and Density of Kernel to Germination of Wheat.**

BY

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This investigation was carried on during the fall of 1909 at the Kansas State Agricultural College as a part of the work required of graduate students in agronomy.

The object of this experiment was to determine the difference, if any, in the vitality or germination of large and small, and heavy and light, kernels.

Standard varieties of winter wheat, Turkey and Kharkof usually, were used in this investigation, being wheat grown on the Agricultural College farm in 1909.

The experiment was conducted along four general lines, namely:

1. Kernels separated by weight.
2. Kernels separated by size.
3. Kernels separated by density.
4. Kernels separated by size and density.

In this investigation a germinating bed of new style was used. The bed consisted of wood fiber plates. These took up water like a sponge and held enough so that water could be

*The accompanying paper reports the results of an experiment conducted by J. G. Lill in the fall of 1909, as a part of the work required of graduate students in agronomy at the Kansas State Agricultural College. The object of the investigation, as the author points out, was to determine the relation of the size, weight and density of the kernel to the germination of wheat. It is a question concerning which considerable diversity of opinion obtains. The results of this experiment are considered to be sufficiently comprehensive to warrant their publication at this time.

squeezed out of them after the tests. The following is the way the bed was operated: The plates were moistened and the sample or part of the sample placed in a plate. These kernels were then covered with a piece of damp paper, and the next plate, which had been treated in the same manner, placed on it. Fifty or more plates could be placed in a stack, which would hold between 1200 and 2500 kernels. The germinating bed or stack was then placed in a booth that could be closed. A gas burner was placed in the booth to keep the temperature constant. A pan of water placed above the flame kept the air saturated and prevented evaporation from the plates. The principal reasons for the use of a bed of this description were: Great economy of space, cheapness and lightness of material, ability to control conditions and subject comparative samples to the same conditions.

The only fault that has been found with the bed, and it is apt to occur in any germinator, is that certain fungi grow in the wood fiber from which the plates are made and this necessitates frequent sterilization of the plates.

The conditions for the germination of the wheat, throughout the experiment were kept at about the optimum. The temperature was kept at about twenty degrees centigrade, although twice it fell to about ten degrees, due to the failure of the gas supply. Although the conditions varied to some extent for the different series of tests, the conditions for the germination of comparative samples were almost the same, as the samples were placed in the same stack and usually in adjacent plates.

The usual time required for the germination of the samples was four days, though when the temperature fell the time was lengthened to six days.

In all tests complete records were kept of average weights, germination, and numbers of kernels used, but where these data were too bulky for good presentation only the averages or condensed tables are given, as in test No. 1. The average weight and number of kernels in each head were recorded but only the average germination and total numbers of kernels are given.

The results of the different tests are given as follows:

TEST No. I.

Comparing the germination of the heavier and lighter kernels in the same head.

In this test heads of wheat were used which were selected by the Agronomy Department for breeding experiments.

Each head was separated into two samples of kernels, one heavier and one lighter than the average weight of all the kernels in the head. This separation of samples necessitated a large amount of weighing, as the total number of kernels in each head was weighed first in bulk, then separately as the average weight per kernel was determined and the weight of each compared with the average weight of the kernels in that head. On account of the time taken in weighing the kernels only 246 heads were used, including 7679 kernels. The scales used were the Agronomy Department analytical balances, Eimer & Amend No. 12,969, weighing to 0.0001 of a gram. The summary of this test is shown in the following table:

GRADE.	No. of kernels tested.	No. of kernels germinated.	Percentage of germination.
Heavier than average	4,707	4,684	98.74
Lighter than average	2,972	2,877	96.80
Total	7,679	7,525	97.99

This summary indicates, first, that a difference of over one per cent exists between the germination of the heavier and the lighter kernels of the head, in favor of the heavier; second, that the heavier kernels do not exceed the average as much as the lighter kernels drop below it. For example, the germination of the kernels heavier than the average exceeds the average germination by 0.75 per cent, while the germination of the kernels lighter than the average falls below the average germination 1.19 per cent.

The original data recorded indicated that the average weight of the kernels of the head does not affect the germination; that is, there is no constant difference in the germination of kernels from heads with only large or only small kernels. The chances for error in this test were slight but constant. Some of the samples were infected by grain moth but the injured kernels were discarded. The number of kernels used in this

test minimizes the probability of error and serves to make more accurate the results of the test.

TEST No. II.

A comparison of the germination of the larger and the smaller kernels as separated by graduated sieves.

Two samples of wheat were secured in the grain laboratory and sieved or screened into five grades, thus grading the wheat entirely according to size. The sizes of the screens and grades were as follows:

Grade 1, kernels which would not pass through a 2.50 mm. mesh, Average weight of several of the samples of this grade, 0.0368 grams.

Grade 2, kernels which would pass through a 2.50 mm. mesh but would not pass through a 2.25 mesh. Average weight for this grade, 0.0332 grams.

Grade 3, kernels which would pass through a 2.25 mm. mesh but would not pass through a 2.00 mm. mesh. Average weight for this grade, 0.0310 grams.

Grade 4, kernels which would pass through a 2.00 mm. mesh but would not pass through the tailings screen of unknown measure. Average weight for this grade, 0.0246 grams.

Grade 5, kernels which would pass through the tailings screen of unknown measure. Average weight for this grade, 0.0172 grams.

The object of this test was to determine the difference, if any, between the germination of the different grades or sizes.

Duplicate tests were made, using about 400 kernels to the sample of each grade. The following table gives the results in percentages of the germination of each grade.

Table giving the germination of the grades of wheat where the grain was graded entirely by size:

GRADE.	Per cent of germination.				Size in mm.	Av. wt. in grams.
	Sample No. 1.	Sample No. 2.	Sample No. 1.	Sample No. 2.		
Grade 1....	98.0	99.0	94.0	95.8	Above 2.50.	0.0368
Grade 2....	89.0	96.0	92.0	95.3	From 2.50 to 2.25.	0.0332
Grade 3....	88.0	98.0	91.0	96.8	From 2.25 to 2.00.	0.0310
Grade 4....	90.0	95.0	93.5	96.3	From 2.00.	0.0246
Grade 5....	86.0	96.0	89.1	93.3	Below grade 4.	0.0172

The results of this test indicate that, first, there is a slight difference between the germination of the larger and smaller kernels as separated by sieves, but that this difference is not constant; second, the largest kernels do not always germinate the best; and third, the smallest kernels usually, although not always, germinate the poorest.

TEST No. III.

The comparison of the germination of kernels of different densities.

The object of this test was to determine, if possible, the relation between the density and the germination of the kernel.

By the term "density," as here used, is meant the specific density of the kernel, its weight in proportion to its size, or weight per unit volume.

The separation of the wheat according to the density of the kernels was accomplished with a wind-blast grader—the theory being, and later by actual tests was proven to be a fact, that kernels of greater density would fall first, while kernels of lesser density would be carried farther in proportion to their density, so that by catching the falling kernels in divisions or boxes placed at certain distances from the blast they would be graded according to density, with the first grade nearest the blast.

The graders used in this test were of two kinds. The first one was a long tin tube from which the kernels were blown and allowed to fall into boxes placed at certain distances on the floor. The second was a deep, narrow channel between two pieces of tin, closed except at the extreme end, so that the kernels were affected by the same blast all through the grader. The bottom of this grader was divided into six divisions that could be opened for the removal of the kernels that fell into them. Both blasts were run by a motor and a centrifugal fan. The motor was so arranged that the speed was constant.

This experiment was carried on with seven different samples of unsieved wheat, including several varieties. The following table gives the summary of the tests. In this table each column of figures represents the germination of a separate original sample graded into six grades according to density, grade No. 1 being the most dense and grade No. 6 the least dense.

RESULTS OF BLAST GRADING.

GRADE.	Per cent of germination.							No. of kernels tested.	Av. wt. per kernel in grams.
	Sample No. 1.	Sample No. 2.	Sample No. 3.	Sample No. 4.	Sample No. 5.	Sample No. 6.	Sample No. 7.		
Grade 1.....	98.8	98.7	94.9	97.7	96.0	97.4	95.1	881	0.0828
Grade 2.....	93.6	98.0	95.8	97.8	98.5	95.4	93.5	2,000	0.0818
Grade 3.....	89.6	96.0	94.4	94.5	95.2	90.8	93.0	2,000	0.0298
Grade 4.....	86.6	96.0	92.0	92.7	95.4	100.0	90.5	1,000	0.0255
Grade 5.....	70.5	91.3	78.0	70.0	90.0	52.0	92.4	500	0.0200
Grade 6.....				51.9	81.0		56.2	200	

This table indicates, first, that the kernels that fall first, or the kernels of greater densities, germinate best; second, that the germinating ability decreases as the kernels are carried farther or as the density lowers.

The chief source of error in this test is in only having a limited number of kernels in some of the samples, so that an accident or error would result in a large error in the results, and in having a small sample the class was not adequately represented as in sample 6, grade 4.

TEST No. IV.

A comparison of the germination of kernels of different densities and sizes.

This test was to determine the relation of the size and density to the vitality of the kernel.

The wheat used was sieved into five grades by means of the graduated sieves, and then each grade further separated according to density by the wind blast, thus dividing each original sample into about thirty smaller samples, each differing from the others in size or density. The usual size of the samples was 200 kernels, but the number sometimes fell below this because of the limited number of kernels available.

The results are given in the following tables. Each table represents a separate original sample taken at random. The vertical columns of figures in these tables give the germination of kernels of the same size, as separated by the sieves, but of different densities as determined by the blast. The horizontal lines give the germination of kernels of the same density, as separated by the blast, but of different sizes. In these tables the samples marked "No. 1," or the first grades, show the germination of the largest or the densest kernels while the grades marked "No. 6" or "No. 5" show the germination of the smallest or the least dense kernels. Thus, the upper left-hand figures in each table give the germination of the largest of the densest and the densest of the largest kernels, while the

lower right-hand figures give the germination of the smallest of the least dense and the least dense of the smallest kernels. In these tables the average weight of the kernels of each sample is given just to the right of the figures giving the germination of the sample:

SAMPLE No. I.

DENSITY.	Sieve grade Nos.									
	1		2		3		4		5	
	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.
Grade 1.....	97.0	0.0376	100.0	0.0376	98.4	0.0818	100.0	0.0244	100.0	0.0190
Grade 2.....	98.0	.0377	97.0	.0367	98.5	.0817	99.5	.0249	99.0	.0199
Grade 3.....	93.0	.0339	90.0	.0342	94.5	.0806	98.0	.0236	96.0	.0187
Grade 4.....	71.0	.0273	79.0	.0269	79.0	.0251	87.5	.0213	87.0	.0165
Grade 5.....	52.0	.0213	56.0	.0206	58.0	.0171	68.0	.0148	74.0	.0124
Grade 6.....	4.0	.0130	31.0	.0166	30.2	.0125	31.8	.0102	45.0	.0078

Vertical columns give germination of kernels of the same size.
Horizontal lines give germination of kernels of same density.

SAMPLE No. II.

DENSITY.	Sieve grade Nos.									
	1		2		3		4		5	
	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.
Grade 1.....	98.0	0.0400	100.0	0.0373	100.0	0.0366	100.0	0.0320	100.0	0.0207
Grade 2.....	98.0	.0388	97.0	.0368	97.5	.0352	95.5	.0293	98.5	.0224
Grade 3.....	88.0	.0376	94.5	.0328	95.0	.0336	96.5	.0270	94.5	.0197
Grade 4.....	87.0	.0340	92.5	.0327	89.5	.0307	90.5	.0249	95.0	.0168
Grade 5.....	66.6	.0316	78.7	.0294	78.1	.0300	85.7	.0218	88.5	.0136
Grade 6.....									79.5	.0115

Vertical columns give germination of kernels of the same size.
Horizontal lines give germination of kernels of same density.

SAMPLE No. III.

DENSITY.	Sieve grade Nos.									
	1		2		3		4		5	
	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.	Per cent of germ.	Wt. in grams.
Grade 1.....	100.0	0.0339	97.9	0.0500	98.9	0.0341	98.8	0.0301	.....	.....
Grade 2.....	97.5	.0332	96.5	.0354	98.5	.0358	96.5	.0271	99.5	0.0205
Grade 3.....	97.0	.0341	95.0	.0311	95.5	.0277	94.5	.0242	95.5	.0151
Grade 4.....	90.9	.0301	.....	.....	95.3	.0249	88.0	.0211	91.0	.0108
Grade 5.....									73.9	.....

Vertical columns give germination of kernels of the same size.
Horizontal lines give germination of kernels of same density.

CONSOLIDATED TABLE.
 Giving the germination percentage of the density grades.

DENSITY.	Per cent of germination.			Average per cent.
	Sample No. 1.	Sample No. 2.	Sample No. 3.	
Grade 1.....	99.08	99.6	98.9	99.19
Grade 2.....	98.40	97.9	97.7	98.00
Grade 3.....	94.30	95.7	95.5	95.16
Grade 4.....	80.70	90.9	91.3	87.63
Grade 5.....	61.60	76.6	73.9	71.70
Grade 6.....	23.40	79.5		53.95

These tables indicate that, first, the germination of wheat is dependent upon the density; second, the germination of wheat seems to be independent of the size of the kernel.

CONCLUSION.

The results of this investigation indicate that—

1. The heavier, better developed kernels in a head of wheat germinate better than the lighter kernels in the same head.
2. Grading according to size will not select the kernels which will germinate the best.
3. The germination is directly correlated with the density of the kernels.
4. The germination is independent of the size of the kernels.

The above points have been indicated by the results of the tests. It is believed that the samples used were large enough to give accurate determinations of the germinating ability of the different samples of wheat.

Approved:

ED. H. WEBSTER, *Director.*

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