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Cultural Practices and Test Weight In Oats[1]

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Of the several criteria of seed quality in oats, weight per bushel, or test weight, is most universally used. The standard test weight for oats is 32 pounds per bushel, but with present-day varieties and production practices, oats produced in the Corn Belt often exceed this value by from 3 to 6 pounds.

The oat seed characteristics which have been found to be correlated with test weight are: hull percentage, seed shape and size and plumpness and density of the caryopsis. Test weight in oats has been proven to be an inherited characteristic. Barring diseases such as rust, which may materially affect test weight, generally, there is little variety by environment interaction for this characteristic.

Since high test weight in oats is a desirable characteristic, cultural practices which reduce or increase it are of importance. This paper is a summary of test weight data of oats from a series of experiments which involved different rates and dates of seeding oats.

Materials and Methods

The data reported in this study were collected from oat yield tests grown at Ames, Iowa, in 1954 and 1955. In all experiments the plots were four rows wide and eight feet long with a spacing of one foot between rows. The two center rows of each plot were harvested for yield and test weight determinations. The experimental design for each experiment was either a split plot or a randomized block with three or four replications.

In the fertilizer and date of planting tests the oats were seeded at the rate of three bushels per acre by volume. For the rate of seeding studies, the oats were sown at one, three, and five bushels per acre. The number of oat varities included in an experiment ranged from two to ten and except in one or two instances were varieties adapted in Iowa. In neither season did oat diseases cause appreciable damage to the crop.

In the 1954 fertilizer experiment ammonium nitrate was broadcast on the oat plots after seeding to give rates of 0 (check), 20, 40, and 80 pounds of nitrogen per acre and in 1955 a 160 pound rate was added. For date of nitrogen application experiments, 40 pounds

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of nitrogen were applied immediately after seeding, and two, four and six weeks later in 1954, and one, two, and three weeks later in 1955. All the test areas were fertilized before planting with 300 pounds of 0-20-20 to insure adequate phosphorus and potassium for optimum plant growth.

The test weight, in pounds per bushel, was determined upon the oat grain from each plot according to the official procedure in the Grain Grader's Primer (3).

Experimental Results

The average test weights of oats harvested from the rate of nitrogen application experiments in 1954 and 1955 are presented in

Table 1

The test weights of oats grown on land receiving different rates of nitrogen application.

Nitrogen per acre (lbs.)	Test weight (lbs. per bu.) *1954*	*1955*
0	32.1	37.7
20	31.2*	35.7*
40	30.4*	36.5*
80	30.4*	35.7*
160	......	34.8*
No. of varieties	10	3

*Denotes significantly lower than check

table 1. The test area in 1954 was low in nitrogen with the result that yields were increased greatly by nitrogen fertilization; in 1955 there was little yield response to even the highest rate of nitrogen application. In both years, however, the test weights were reduced by the application of nitrogen. Even at the 20 pound rate the reduction was statistically significant in both years, being 0.9 of a pound and two pounds per bushel in 1954 and 1955, respectively. Similar results were reported by Burnett (2) who found that, except in cases where the soil was very low in nitrogen, the application of inorganic nitrogen fertilizer reduced the test weight of the oats. Conversely, Brieba (1) found that fertilization of oats with nitrogen generally resulted in increased test weights.

The data here seem to indicate that regardless of the yield response of oats to nitrogen fertilization, the application of 20 pounds or more of nitrogen per acre will result in reduced test weight.

The mean test weights of oats fertilized with 40 pounds of nitrogen per acre at varying intervals after seeding in 1954 and 1955 are given in table 2. There was a slight but non-significant increase in the test weight when the nitrogen fertilizer was applied two weeks after planting, but when applied four and six weeks after the oats were sown a significant decrease resulted. There is no apparent explanation for the reduction in test weight when the

Table 2
Test weights of oats fertilized with 40 pounds of nitrogen per acre at varying intervals after planting.

Date of application (Wks. after planting)	Test weight (lbs. per bu.)	
	1954	*1955*
0	30.4	36.5
1	......	35.7
2	30.9	37.1
3	......	34.8*
4	29.0*	......
6	28.3*	......
No. of varieties	10	3

*Deotes significantly lower than the check

nitrogen was applied one week after seeding in 1955. In general, it appears that nitrogen fertilization of oats could be delayed up to 2 weeks after planting without causing a significant decrease in test weight. In fact, it may be possible to increase the test weight slightly by delaying the nitrogen fertilizer application until 2 weeks after planting.

In the date of planting experiment in 1955 (table 3) the highest test weight was obtained from the earliest seedings (April 2 and April 9). Plantings made on April 16 and April 23 produced grain which averaged 2 pounds per bushel lighter in test weight, while those planted on April 30 or later were reduced from 4 to 11 pounds per bushel. Perhaps the most important factor contributing to the reduced test weight from delayed planting was the shortened grain-filling interval in the later plantings. The interval of kernel development for the first planting was 32 days; for later plantings it was progressively reduced to a low of 18 days for the planting on May 21.

Table 3
Test weights of oats planted at different dates in 1955.

Date of planting	Test weight (lbs. per bu.)
April 2 (ck)	37.9
April 9	37.5
April 16	35.9*
April 23	35.4*
April 30	33.7*
May 6	33.5*
May 13	29.0*
May 21	26.6*
No. of varieties	8

*Denotes significantly lower than first date of planting

The effect of planting rate of oats upon the test weight of the harvested grain is evident in table 4. The results are similar for all three experiments, with the lowest and highest seeding rates

Table 4

Test weights of oats from different seeding rates.

Rate of seeding (Bu. per acre)	Test weight (lbs. per bu.)		
	1954	*1955a*	*1955b*
1 (ck)	39.6	35.4	33.1
3	31.0	36.7*	36.5*
5	31.3*	37.0*	37.1*
No. of varieties	10	8	2

*Denotes significantly higher than the check

producing the lowest and highest test weight grain, respectively. A similar situation was noted by Frey and Wiggans (4) when they obtained reduced stands from planting seed oats which germinated poorly.

To explain the relationship between planting rate and test weight of oats observed, the weights per 100 kernels and seed size expressed as number of kernels per 100 cc. were determined (table 5) for Clintland and Mo. 0-205 varieties grown in experiment

Table 5

Test weights, weights per 100 kernels, and kernels per cc. for oats at different rates per acre in 1955.

Rate of planting	Test weight	Weight per 100 kernels	Kernels per 100 cc.
(Bu./A.)	(lbs. per bu.)	(gms.)	
	Mo. 0-205		
1	33.0	1.99	2300
3	35.7	2.18	2250
5	36.5	2.07	2430
	Clintland		
1	34.2	2.02	2340
3	36.5	2.21	2340
5	38.3	2.14	2460

1955b (table 4). Seeds produced from the one and three bushel planting rates were approximately the same size but those from the latter rate were ten percent heavier. Furthermore, the seeds produced from the five bushel planting rate were smaller than those from the one bushel rate; however, they were also heavier. These data would account for the comparative test weights of the oats produced from the three planting rates. Even though the seeds produced from the one and three bushel planting rate were approximately the same size the latter rate gave a higher test weight because it produced heavier seeds, thus giving greater density to a volume of the grain. The five bushel planting rate gave a higher test weight than the one bushel rate because not only was the kernel weight greater but also more kernels were present in a volume. The five bushel planting rate produced a higher test weight than the three bushel rate, because the kernel size was reduced more percentagewise than was the weight per 100 kernels. For Clintland and Mo. 0-205 the increase in number of kernels per 100 cc. was 4.9% and 7.4% respectively, while the decrease in weight per 100 kernels was only 3.2% and 5.0% respectively.

Discussion

It was possible to explain the "mechanical reasons" for higher planting rates producing heavier test weight seed. Of more interest, however, are the possible reactions of an oat plant, physiological or otherwise, which caused the kernel size and weight to be affected by planting rate. Data pertinent to an interpretation of these phenomena are presented in table 6. The yeild in grams,

Table 6

Yield in grams, and number of heads and kernels per square foot, and number of kernels per head for two oat varieties in 1955.

Rate of planting	Grams per sq. ft.	Heads per sq. ft.	Kernels per sq. ft.	Kernels per head
(Bu. per acre)				
		Mo. 0-205		
1	26.8	41.9	1347	32
3	30.9	48.5	1417	29
5	30.9	67.3	1493	22
		Clintland		
1	26.7	30.2	1322	44
3	30.6	43.7	1385	32
5	27.1	67.0	1266	19

number of heads and kernels per square foot, and number of kernels per head were calculated for Mo. 0-205 and Clintland grown in experiment 1955b (table 4). In neither variety did the one bushel planting rate produce a maximum yield of grain, but the three bushel rate gave maximum yields in both.

There was a steady increase in the number of heads per square foot from the one, three, and five bushel rates of planting due to a larger number of seeds being sown per square foot at the higher rates. The number of kernels produced per square foot was greater with increased planting rates of Mo. 0-205, but with Clintland the number of kernels was highest at the three bushel planting rate. The number of kernels per head from the one and five bushel planting rates were 32 and 22 for Mo. 0-205 and 44 and 19 for Clintland.

The data in tables 5 and 6 suggest the following hypothesis to explain the physiologic reaction which resulted in reduced test weight from lower planting rates. This probably resulted from an interaction of three factors: (1) the number of kernel produced per head; (2) the maximum food-producing ability of a tiller, and of a given area of land; (3) the competitiveness for food between the vegetative and the floral and grain parts of the plants.

There was a tendency for the oats sown at one bushel per acre to compensate for the lower number of heads per square foot by setting more kernels per head. Each variety had a certain genetic potential for kernel size when grown under a given set of environmental conditions, and in this experiment maximum kernel size was produced in both varieties at the lower seeding rates. At the five bushel rate the genetic potential for kernel size was not reached for Mo. 0-205 because there were too many kernels produced per head for the food supply available. For Clintland there were so many plants per square foot at the five bushel rates that the vegetative plant parts dominated the competition for food material early in the season, thus reducing the number of kernels per head and the seed size. Later, when the kernels were being formed, the competition for food materials shifted away from the vegetative tissue to the grain. At the one bushel planting rate the food-producing ability of the leaves and stem of a tiller was not great enough to completely fill the large number of kernels produced on a head. The kernels thus were of maximum size but not maximum weight. This was not due to a limitation of water or nutrients from the soil but to a limitation of the capacity of the leaves of each tiller to produce food materials. At the three bushel rate the food material produced by a tiller, assuming it was equal to a tiller from the one bushel rate, was divided among a smaller number of kernels per head, resulting in better filled seeds. This would explain the differential in weight of kernels of the same size from the one and three bushel planting rates.

With the five bushel planting rate each tiller was able to produce enough food materials to completely fill the reduced number of kernels produced on each head. However, since the size of the kernels was smaller, due to competition for food products early in the season, not as much food material was stored in each kernel. This would account for the reduced weight per hundred kernels for the five bushel planting rate when compared to the three bushel rate.

In Clintland a smaller number of kernels were produced per square foot at the five than at the three bushel planting rate because there was an overabundance of vegetative tissue for the soil resources available for plant growth at the time when the flowers were being differentiated. However, with a shift from vegetative to grain production later in the season, all the food materials produced in the vegetative tissue were stored in the seeds and resulted in plump kernels. Although not subject to a statistical test this is indicated by the fact that the decrease in seed weight from the three to five bushel planting rates was only 3.2 percent in Clintland while it was 5.0 percent in Mo. 0-205.

It should be possible to test the hypothesis presented above by making the proper comparisons of one, three, and five bushel planting rates on low, medium, and high fertility soil. It also could be tested by manually limiting the number of seeds which developed on oat heads.

Summary

A series of experiments conducted in 1954 and 1955 in which test weights were determined upon a number of oat varieties grown with different cultural practices gave the following results:

1. The application of nitrogen fertilizer to oats, in quantities as low as 20 pounds of N per acre, resulted in a significantly lower test weight than when no nitrogen was used.

2. When compared at equal nitrogen fertilization rates, the test weight of oat varieties was not reduced if the application was made within 2 weeks after planting. However, at later dates of application, there was a marked reduction in test weight.

3. Delayed planting resulted in a lowering of the test weight.

4. The test weight was lowest for the one bushel per acre seeding rate, intermediate for the three, and highest for the five bushel rate.

5. The increased test weight resulting from higher planting rates was hypothesized to result from the interaction of the factors (a) number of seeds produced per head, (b) the food producing-capacity of one tiller and of a given area of land, and (c) the potential size of seeds as determined early in the season.

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