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INFLUENCE OF SEED SIZE ON WINTER WHEAT PERFORMANCE TESTS[1]

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The Kansas Agricultural Experiment Station conducts performance tests of winter wheat varieties at 16 locations across Kansas. Planting rates have been dictated by the results of long-term studies at each location. These tests traditionally have been planted on a constant seed-weight basis (equal weight of seed of each cultivar planted/unit area) or on a constant seed-volume basis (equal volume of seed of each cultivar planted/unit area, volume based on the average test weight of test entries).

In the early 1980s, complaints were made that winter wheat performance tests in Kansas and neighboring states were biased against large-seeded entries. The argument was that planting on a volume or weight basis used more seeds/unit area for small-seeded varieties than for large-seeded varieties. This seemed reasonable, because Kansas sorghum, corn, and soybean tests all are planted on an equal viable seed-number basis or are planted heavy and thinned to uniform plant populations. However, little published evidence shows such a bias occurring in the hard red winter wheat region of the Great Plains, and there are published data to the contrary. A 13-year study in Nebraska reported an

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11 percent yield reduction for the small seed compared to the large seed of a variety when planted at a constant seed number (2). When plantings were made on an equal-weight basis, the yield of the small-seed fraction was only reduced by 3 percent. The applicability of these results to modern varieties might be questioned, because the research was done from 1911 to 1923 on the variety Turkey. However, in a study at Colby, KS from 1980 to 1984, the yields of the small-seed fractions of three different varieties were decreased relative to the yields of the large-seed fractions when planted on a constant seed-number basis (4).

The seed size controversy has resulted in some changes in planting rate practices. By 1987, 14 of 16 Kansas wheat performance test locations were planted on a constant seed-number basis. Tests in Oklahoma currently are being planted on a constant seed-number basis, whereas Texas adjusted for seed size for 2 years but is no longer doing so. Tests conducted in Nebraska have never been adjusted for seed size.

The objective of a wheat performance test is to identify differences among varieties that are genetically controlled. To do this, the effects of physical differences among seed lots on performance must be kept to a minimum. This study was designed to determine which planting method, equal seed number or equal seed weight or volume, best limits the effects of seed size differences among seed lots on performance in a wheat variety performance test.

Procedure

Tests were conducted at Hays, KS for the crop years 1988 and 1989. Identical tests were conducted at Hays and Colby, KS in 1990. All plots were planted with a hoe drill at 1-ft row spacing. Plots at Hays consisted of four 13-ft rows that were trimmed to 8 ft at harvest. The Colby plots had five 15-ft rows that were trimmed to 10 ft for harvest. The Hays tests were planted on or just before Oct. 1, whereas the Colby test was planted on Sept. 22. All plots were harvested when grain was combine ripe.

Seed of TAM 107 and Norkan produced at Hays in 1987 was used in the 1988 test. Small and large seed-size fractions of each cultivar were obtained by running the samples over a series of slotted screens. Thousand kernel weight (TKW) and volume weight of the bulk, small, and large fractions are reported in Table 1. Seed of each fraction was planted at 60 lb/ac at an equal seed volume. The volume used gave a 60 lb/ac planting rate with seed that had a 60 lb/bu volume weight. The fractions were also planted at equal seed numbers based on the number of seeds required to plant 60 lb/ac with a

Table 1. Characteristics of wheat seed planted and yield and volume weight obtained from three seed fractions planted on a constant seed-number or constant seed-volume basis at Hays, KS in 1988 and 1989.

Planting Basis and Seed Fraction	Seed Planted: TKW g/1,000 seed 1988	TKW 1989	Seed Planted: Volume Weight (lb/bu) 1988	Volume Weight 1989	Yield (bu/ac) 1988	Yield 1989	Volume Weight (lb/bu) 1988	Volume Weight 1989
Constant Seed Number								
Large	36.8	34.4	62.9	61.3	23.6	44.3	56.1	57.5
Bulk	30.2	30.8	62.0	60.3	23.5	41.5	55.8	57.3
Small	26.2	24.9	61.3	59.6	21.6	39.9	55.2	57.5
LSD .05					NS	3.6	0.9	NS
Constant Seed Volume								
Large	-	-	-	-	23.3	42.7	55.8	57.2
Bulk	-	-	-	-	23.6	40.4	55.9	57.5
Small	-	-	-	-	23.6	39.6	56.1	54.4
LSD ≤ .05					NS	NS	NS	NS

Table 2. Characteristics of wheat seed planted and combined mean yield and volume weight obtained from five seed sources planted on a constant seed-number or constant seed-weight basis at Hays and Colby, KS in 1990.

Planting Basis and Seed Source	Seed Planted: TKW (g/1,000 seed)	Seed Planted: Volume Weight lb/bu)	Planting Rate (lb/at): Yield (bu/ac) 45[1]	Yield 60[2]	Volume Weight (lb/bu) 45	Volume Weight 60
Constant Seed Number						
Hays Large	45.5	58.3	75.6	75.9	60.5	60.5
Hays Bulk	32.4	57.9	73.2	75.6	60.5	60.6
Hays Small	21.3	56.8	71.7	72.7	60.2	60.3
Colby	36.5	58.8	75.7	76.5	60.6	60.5
Manhattan	23.4	49.5	70.9	71.3	60.1	60.0
Constant Seed Weight						
Hays Large	-	-	75.6	74.9	60.5	60.5
Hays Bulk	-	-	74.3	73.7	60.5	60.4
Hays Small	-	-	75.6	75.5	60.5	60.6
Colby	-	-	73.6	76.1	60.6	60.3
Manhattan	-	-	72.1	74.8	60.4	60.3
LSD .05			3.1		0.5	

[1]Actua1 planting rates for treatments planted on a constant seed-number basis were 63.8, 45.5, 29.9, 51.3, and 32.9 Ib/ac for the Hays large, Hays bulk, Hays small, Colby, and Manhattan sources, respectively.

[2]Actual planting rates for treatments planted on a constant seed-number basis were 85, 60.7, 39.9, 68.4, and 43.8 lb/ac for the Hays large, Hays bulk, Hays small, Colby, and Manhattan sources, respectively.

TKW of 32 g. The experimental design was a randomized complete block with four replications of each of the 12 treatments (two cultivars, three seed fractions, and two planting methods). Data presented are the means of the two cultivars.

Seed of TAM 107 produced at Hays in 1988 was used for the 1989 test. Similar seed-size fractions were produced from the bulk as in 1988, and the same treatments were used.

The 1990 test was expanded to include two locations and additional seed sources. Three sources of TAM 107 were used; two produced at Hays or Colby in 1989 and a third distributed by the Kansas Agricultural Experiment Station for use in the 1990 Kansas wheat variety performance test (designated the Manhattan source). The Colby source was large seed, and the Manhattan source was small seed. They were not subdivided into fractions. The Hays source was subdivided as in 1988 and 1989, into large, bulk, and small fractions. The experimental design was the same as in previous years, but a complete set of the treatments was planted at both 45 lb/ac and 60 lb/ac planting rates. Because some of the seed sources also differed greatly in volume weight, equal weights of seed were planted instead of equal volumes as in 1988 and 1989.

For all measured traits, data were analyzed by analysis of variance procedures, and a least significant difference (LSD .05) was calculated to compare means. Data from 1988 and 1989 were analyzed and are presented separately, but because there were no significant treatment by location interactions between the two 1990 locations, those data were analyzed over locations and are presented as means.

Results

Yields were low in 1988, and no significant differences were measured among mean yields of treatments (Table 1). However the yield of the small-seed fraction planted on a seed-number basis was 2 bu or 10 percent below that of other treatments. There was a significant decrease in volume weight and a 1.5-day heading delay for the small-seed fraction when planted on a seed-number basis. Heading was delayed by 0.8 days for the small-seed fraction when planted on a volume basis, but the difference was not significant. Emergence may have been a factor in 1988, because the small-seed fraction had a reduced percent emergence when planted on a seed-number basis. But the percent emergence was not different for small seed and large seed when planted on a volume basis.

Yields in 1989 were higher, and significant differences among means for treatments were measured (Table 1). When planted on a seed-number basis, the yield of the small-seed fraction was reduced by 10 percent compared to the large-seed fraction. There were no significant differences among the yields of treatments planted on a seed-volume basis. No significant differences were measured among any treatments for volume weight, heading date, or percent emergence in 1989. When planted on a seed-number basis, the small-seed fraction showed a small, but significant, height reduction compared to the large-seed fraction. In 1990, leaf rust reduced yield somewhat at Hays but had only a minor effect at Colby. The average mean yields for treatments at Hays and Colby were 60 and 88 bu/ac, respectively. Significant differences occurred among mean yields of treatments (Table 2). The yields of the small-seed Manhattan source and the small-seed fraction of the Hays source were reduced from 4 to 6 percent relative to the large-seed fractions at both the 45 and 60 lb/ac planting rates, when planted on a seed-number basis. When planted on a seed-weight basis, yield of the small-seed Hays fraction was not different from that of the bulk and large-seed fractions, but yield of the Manhattan source was significantly reduced relative to the large-seed fractions at the 45 lb/ac planting rate. The small-seed Hays fraction and the Manhattan source were also significantly shorter, had reduced volume weight, and were 1 to 2 days later heading when planted on a seed-number basis. These differences were not observed when they were planted on a seed weight-basis. Treatments did not differ in percent emergence at Hays in 1990; stand counts were not made at Colby.

The simple correlation between seed number planted for each treatment in 1990 and the mean yields in Table 2 gave an insignificant R value of .146 (df = 18). The simple correlation between weight of seed planted and mean yield gave a highly significant ($P \leq .001$) R value of .751.

Discussion

Plant emergence has been implicated as one factor influencing the relative yield of seed fractions of different sizes from the same variety when planted on a constant seed-number basis (4). This did not appear to be a factor in our study. Differential emergence occurred only in 1988, when no significant yield differences were measured. In 1989 and 1990, differential emergence did not occur, and the yields of the small-seed fractions were reduced relative to those of the large-seed fractions. Therefore, the reduced vigor of plants derived from the small seed was primarily responsible for these yield reductions. Reduced vigor of plants arising from small seed is well established (1, 2, 3).

When the number of seeds planted was increased for the small-seed fractions of the same source, by planting on a weight or volume basis, reduced plant vigor was apparently compensated for by the increased number of plants. Only the Manhattan seed source in 1990 gave a reduced yield when planted on a weight basis. This source was probably the poorest one tested, because it had a low TKW as well as a low volume weight. The other small-seed fractions tested had volume weights similar to those of the large-seed fractions. However, when the number of seeds planted for the Manhattan source was increased further, by planting at the 60 lb/ac rate, its yield increased by 2.7 bu and was not different from that of other treatments.

The results of these tests agree with previously published reports (2,4). When planted on a constant seed-number basis, within normal ranges of planting rates, the small-seed fractions will yield 4 to 10 percent less than the large-seed fractions of the same variety. This bias can be alleviated by planting on a seed-weight basis. The increased number of plants for the small-seed fractions can compensate for differences in seedling vigor. The simple correlations on the 1990 data show that yield was responding to weight of seeds planted and not to number of seeds planted.

Planting on a constant-volume basis is probably a viable alternative, because seed volume weights usually do not vary as much as TKW. From 1987 to 1990, the average variation from the highest to the lowest values among seeds of entries in the Kansas performance tests was 17 percent for volume weight but was 49 percent for TKW.

Conclusions

Our results support those of the long-term study of the variety Turkey (2). The recommendation that wheat performance tests be planted on a constant seed-weight or seed-volume basis is still valid for modern cultivars.

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