QUALITY OF SEED AND ITS INFLUENCE ON GROWTH AND YIELD OF WHEAT

by

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INTRODUCTION

Most of the important crop plants are reproduced by seeds. In the life cycle of the plants the seeds germinate and produce seedlings. This vegetative phase is characterized by increase in the number and size of roots, stem and leaves. The reproductive phase is reached in which the plant flowers and produces seed. Since seed is borne on the plants, it has definite relations with the developmental stages of the plant such as germination and growth and their effect on yield.

Seeds produced in different geographical localities under varied conditions may behave in different manner in germination, seedling growth, tillering capacity and other plant characteristics, when sown in the same locality under comparable environmental conditions. It appears that environmental variations in factors such as temperature, humidity, wind, rainfall, soil and sunlight have a direct effect on the quality of seeds produced. So it is not the genetic factor alone which is responsible for the quality of seeds but several environmental factors also affect this.

There may be large variations in yield, quality of the seed, seedling growth, time of maturity, disease resistance and winter-hardiness of the same variety grown from seed that differed in age, size, weight, germination and perhaps in other respects. There is little doubt that seed which is viable and contains a live embryo may frequently be parasitized by fungi that become more or less harmful after planting, the degree depending upon the infection and environmental factors, which are conducive for the development of the fungus. In the years of serious seed shortages the source and quality of seed is of special interest. Use of adapted seed has great value in successful crop production. Growers and seedsmen, who have seed left over from one sowing season to another, ordinarily use the old seed as the new seed is likely to be more costly. The seeds of plants according to Pearson and Harper (1945) as reported by Crocker (1953) are of great economic importance as they constitute 80 percent of the world's food supply and 75 percent of the food eaten directly by man. The seed and seed products used as food and in various industries greatly exceed the economic value of seeds for planting purposes.

A limited amount of data pertaining to this problem was obtained at the Kansas Agricultural Experiment Station in 1942, 1943 and 1944. It was therefore considered desirable to investigate further into the problem.

The investigations reported in this thesis were made to study the variations in growth and development of winter wheat from eight lots of seed.

REVIEW OF LITERATURE

Literature dealing with the relation between characteristics of seed and the growth and yield of the succeeding crops is reviewed in the following paragraphs.

Lill (1910) conducted the experiment with those types of kernels based on weight, size and density. In these investigations he indicated that:

(1) Well developed heavier kernels in a head of wheat germinated better than the lighter kernels in the same head.

(2) Grading according to size would not select the kernels which germinated the best.

(3) The germination was directly correlated with the density of the kernels.

Cumming (1914) compared the seedling growth from large seeds and small seeds of garden crops. His findings were the weight and sizes of the plants when compared at different stages of growth indicated a continuous and permanent advantage in favor of plants from large seed. Plants grown from large seed possessed more leaves of greater surface area, and hence better assimilative powers.

Schmidt (1924) concluded that the seeds of lima beans, soya beans, buckwheat and corn having medium weights produced better plants than either seed of lighter weight or abnormally heavy seed. Kiesselbach (1924) gave an extensive review of all the available data pertaining to relative grain yields from different grades of seeds. He conducted extensive experiments and reported that the yield of three cereals, winter wheat, spring wheat and oats, was 18 percent less in case of small seed than large seed when space planting was such as to permit the maximum individual plant development. Small seed yielded 10 percent less when equal numbers of seed were sown per acre at an optimum rate for the larger seed, and 5 percent less when equal weights of seed were sown per acre at an optimum rate for the larger seed. Unselected seed yielded 4 percent less than large seed when equal numbers were sown per acre and 1 percent less when equal weights were sown.

In a comparison of fanning mill grades of winter wheat during a 17 year period the heaviest one-fourth yielded 0.3 percent more and lightest one-fourth 2 percent less than the unselected. Similar results were obtained in case of oats. Zavitz (1927) reported the effect of the size of the seed of the different small grains on the yield of grain and straw. The planting of seed was done at a uniform spacing so that the same number of seed were planted. The large plump seed of winter wheat yielded 6.5, 7.8 and 37.6 bushels per acre more than small plump seeds, shrunken seed and split seed respectively.

Leukel (1936) studied the germination and seedling size of shrunken and plump seeds of spring wheat. The test weights of these seeds were determined and ranged from 39.5 to 60.8 pounds per bushel. Test weight showed little relation to viability but shrunken seed produced such small weak seedlings that sowing of wheat testing less than 50 pounds per bushel was not recommended. Kernels of wheat testing 60 pounds per bushel were about twice as heavy as those testing 50 pounds.

Stoa et al (1936) concluded that the reduction in test weight of one-third, that is from 60 down to 40 pounds per bushel, was associated with a reduction in the weight of an individual kernel of nearly two-thirds. The seedling weights were reduced nearly as much. In general seeds less than half normal size were unsuitable for sowing.

Sunseon and Peltier (1936) conducted an extensive seed source comparison of winter wheat varieties in the field and greenhouse as to winterhardiness. The seedlings mostly in the five to eight leaf stages had given highly significant hardiness differences within the same variety when different sources were compared. The most conspicuous variable in the condition of the seed was the difference in size. The plants produced from small kernels were less hardy as shown in 32 comparisons.

Kiesselbach (1937) observed that there was 31 days difference in time of maturity, 29 inches variations in plant height and 38 percent variations in yield of open pollinated corn in which the seed was produced in different localities. He explained this as variation between unadapted regional strains.

Harlan and Pope (1922 and 1926) reported that the premature harvested barley kernels germinated and produced small seedlings, when the seed had attained only one-seventh of their normal weights.

Koehler et al (1934) concluded that mature seed corn was more vigorous than immature seed corn. The stages of maturity were milk, late milk, dent, mature and husking. Laboratory germination tests showed that seedling vigor was much better in seed harvested at the more mature stages than in the milk and late milk stages. The tests also showed approximately 10 percent dead kernels in the first and last stage.

Seed innoculation at planting time with several fungi capable of causing seedling disease in all cases had the greatest effect on immature seed.

Roca (1949) concluded that the process of germination involved various factors predominating among which was the action of enzymes. The enzymatic activity could be effected when the altitude at which the development took place did not correspond with that to which the seed was acclimatized.

Scheck and Fetzer (1950) observed the carbohydrate protein ratio was about 5.1 in cultivated cereals but only 3.1 in wild cereals. The germinating ability of seeds increased with increasing protein content and decreasing carbohydrate protein ratio. They further stated that the germination vigor could be increased by supplemental fertilizing at flowering time. A high sugar content of seeds was also important for good germination because of the accompanying increase in osmotic value and water imbibition.

Robertson and Lute (1933) reported that seeds of wheat, oats and barley kept in dry storage under cool semi-arid condition in Colorado exhibited a gradual decline in germination. The germination was approximately 10 percent lower at the end of the 10 year period than when the seeds were one year old. Their conclusions in the year 1937 regarding this problem was that after 15 years of storage, the average germination percentage for various seeds were as follows: Wheat 80.5, unhulled barley 95.8, naked barley 73.9, rye 8.2, and corn 36.0. The drop in germination was as great or greater from the tenth to fifteenth year as it was from the first to the tenth year.

Dungan and Koehler (1944) found a marked decrease in yield from old seed which primarily caused a reduction in field stand and also to a less extent a lowered yield per plant.

Haferkamp et al (1953) concluded that many seeds, namely wheat, oats, corn, were viable after storage for as long as 31 to 33 years. Varietal as well as generic differences in seed longevity were observed. Viability seemed to be retained longer by seeds which had been stored with the hulls intact than by those which had been threshed before storage. Chaff and hulls were found to have a decided inhibiting effect on the growth of mold.

Crocker (1953) stated that the yield of crops in general had been affected by the stand of seedlings obtained by the dryness or the wetness of the growing season and by lack of soil homogenity. Smaller plants and decreased production were found to increase with age of the wheat seed. The field planting was arranged in plots from different seed lots of each species. The results showed that old and fresh seeds produced plants of similar quality.

Tervet (1944) studied the pathological aspect of the problem. He found that the variations in the amount of smut on oats from seed lots within one variety as great as may be found between certain varieties. It was shown that variations in the amount of smut occurred with plants from seed lots of one variety grown in different years in the same locality and between plants from seed lots of the same variety grown in one year in widely different localities. It was found that the more vigorous seedlings of oats were less frequently attacked by smut than the weaker seedlings. It was also apparent that plants from large seed were more vigorous than plants from the smaller seeds as indicated by rapidity of germination, percentage of germination and weight and height of the seedlings.

MATERIALS AND METHODS

The problem of seed quality discussed in this thesis includes studies of germination, seedling growth, tillering capacity and their effect on yield.

The seed samples received for trial from different places differed from each other particularly in age, test weight and size of kernels. Furthermore the quality of the samples may have been influenced differently by the environmental conditions under which they were grown.

The studies were undertaken with eight seed samples of three varieties, namely Wichita, Pawnee, and Kiowa. Two seed samples of Kiowa from Ashland (Kansas), two of Wichita from Dodge City (Kansas), three of Pawnee from Collyer (Kansas) and one of Pawnee from the Agronomy Farm (Kansas State College, Manhattan, Kansas) were received for this work.

The summarized details of the seed samples are shown as follows.

Sample No.	Name of the place	Name of the person from whom the seed was received	Variety	Test weight lbs./bu.	Description
2	Ashland (Kansas)	Mr. Bill Anderson Through Bennie Bird County Agent	Kiowa	52.6	Certified seed, grown in 1953
4	Ashland (Kansas)	Mr. Bill Anderson Through Bennie Bird County Agent	Kiowa	61.3	Certified seed, grown in 1953
3	Dodge City (Kansas)	Mr. Ben Zimmerman Fidelity State Bank	Wichita	63.0	Certified seed, grown in 1952
1	Dodge City (Kansas)	Mr. Ben Zimmerman Fidelity State Bank	Wichita	56.2	Certified seed, grown in 1953 from 1952
6	Collyer (Kansas)	Mr. Arthur Morrel	Pawnee	60.7	Certified seed, grown in 1952, used for 1953
5	Collyer (Kansas)	Mr. Arthur Morrel	Pawnee	51.5	Certified seed, selected light berries, grown 1953
7	Collyer (Kansas)	Mr. Arthur Morrel	Pawnee	58.3	Certified seed, selected heavy berries, grown 1953
8	Manhattan (Kansas)	Kansas State College Agronomy Farm	Pawnee	61.7	Certified seed of 1953

Field Plot Experiment Sown in Fall 1953

One trial was conducted at the Agronomy Farm of Kansas State College. The eight samples of seed were sown in field plots in a randomized block design with four replications. This system was used to avoid soil heterogeneity and to permit a satisfactory comparison of the various observations made in the field. The results obtained on germination, tillering and yield were analyzed statistically.

The seed was planted at a slightly higher than the normal seeding rate. The size of the kernels and test weights were determined in the laboratory. The number of seeds planted on each plot was determined from the weight of seed planted and the size of the kernels. It took about one week for the emergence of seedlings and the dates of emergence of each plot were recorded. The germinated seedlings were counted in 80 feet of drill row, which consisted of two five-foot samples from each of the eight drill rows in the plot. This made it possible to calculate the percentage kernels that germinated in each plot.

Samples of 100 plants were taken from individual plots for counting the number of tillers at the completion of the fall growing season. These samples were dug from the plots, brought to the laboratory, washed and the roots were removed. The actual green weight of 100 plants was recorded before the plants wilted. The tillers were counted and then the plants were left for air drying. The air dried plants were weighed.

The field plots were cut back to a uniform length for determination yield. The height measurements of the plants were recorded at 10 different places in each plot to find the relative length of the straw from the different seed samples. The plots were harvested and threshed with the combine. The estimated number of heads was determined by counting the number of stems in 40 feet of drill row in each plot by the same plan as was used to estimate emergence in the field. The number of heads was then calculated on an acre basis.

The yield of each plot was weighed separately and the test weight was also determined. The sample of 500 kernels was weighed to find out the size of kernels.

The analysis of variance was calculated, where it was considered necessary, following methods outlined by Snedecor (1946) and Paterson (1939).

Nursery Plot Experiment Sown in Spring 1954

Eight seed samples each with 120 kernels were sown for germination and emergence studies in the spring at the Agronomy Farm. There were four replications of this trial. The percentage germination was determined by counting the number of plants in each row. Later 25 plants were taken for counting the number of tillers. The plants were weighed green. This study was undertaken to obtain additional data on comparative emergence of the eight samples under field conditions.

Greenhouse Experiment

An accurate germination study was made by sowing 400 kernels of each sample in a replicated trial over a small plot in the greenhouse. The samples were randomized within each block. Time of emergence of each sample was closely observed to find out the exact number of hours taken for the emergence of seedlings of each sample. The height of the seedlings on two different dates at an interval of nine days was recorded to find out the average increase of growth per day. It was considered necessary to keep eight seedlings in each line where 400 kernels were sown. All other plants were uprooted to provide sufficient space for the growth and development of the few remaining plants. The eight plants were dug out later. The plants were washed and roots removed before taking the green weights. The tillers were counted and the plants were left to dry in the air. The air dried plants were weighed again. This piece of work was undertaken to investigate the rapidity and vigor of germination and the rate of growth among the different seed samples.

DATA AND RESULTS

The studies relating to this problem were made under three broad heads.

(1) Rapidity of emergence and germination percentages of the seed samples.

(2) Growth of the plants at initial seedling and later stages.

(3) Yield and related data on the crop from the seed samples.

Influence of the Quality of Seed on Rapidity of Germination and Emergence

Under Greenhouse Conditions. It was essential to observe the plots closely to find out the differences in the rapidity of emergence of the different samples. The total number of hours taken for emergence was calculated from the time of planting to the time of emergence.

Table 1. Showing the rapidity of emergence in seed samples.

Sample No.	Variety	Number of hours taken in emergence			
		Replications			
		I	II	III	Average
2	Kiowa (light)	70.3	66.0	64.7	67.0
4	Kiowa (heavy)	66.0	65.5	64.5	65.3
3	Wichita (old)	66.6	67.5	65.5	66.5
1	Wichita (new)	52.0	54.0	52.5	52.8
6	Pawnee (old)	62.0	61.7	64.0	62.5
5	Pawnee (small)	53.3	52.0	53.2	52.8
7	Pawnee (large)	53.0	53.0	51.5	52.5
8	Pawnee (A. F.)	50.0	47.0	53.0	50.0

L. S. D between averages at 5% = 3.1; at 1% = 4.1

The results abstracted from the above data are graphically presented in Plate I, Figure 1.

It is clear from the data that Wichita seed sample No. 1 took significantly less time to emerge than sample No. 3 of the same variety, the average difference being 13.7 hours. Kiowa seed sample No. 4 emerged 1.7 hours earlier than sample No. 2. The difference in time of emergence in these samples, however, was insignificant.

There was striking difference, highly significant, in time of emergence between Pawnee No. 8 and No. 6, sample No. 8 (new

Plate I

Fig. 1. Number of hours in emergence of seed samples in greenhouse experiment.

Fig. 2. Percentage germination of seed samples in greenhouse experiment.

Plate I

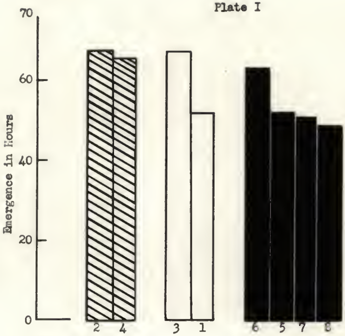

Figure 1.

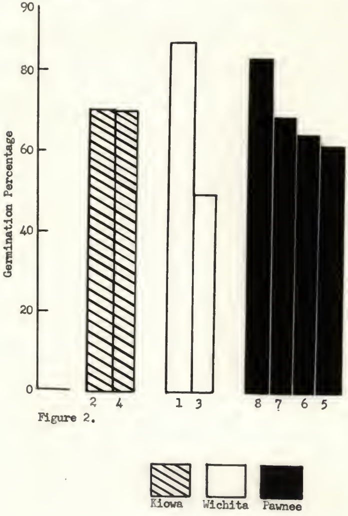

Figure 2.

seed) having emerged 12.5 hours earlier than No. 6 (old seed). Differences in time of emergence between samples 8, 5 and 7 were insignificant.

The germination counts of the seedlings were recorded at two different intervals (to find out the total germination percentages) the last count being made after emergence was complete.

Table 2. Showing the percentage germination in seed samples.

Sample No.	Variety	Replications I	II	III	Average
2	Kiowa (light)	74.5	74.5	79.5	76.1
4	Kiowa (heavy)	72.0	79.0	77.0	76.0
3	Wichita (old)	46.0	49.0	52.0	49.0
1	Wichita (new)	88.0	89.5	84.5	87.3
6	Pawnee (old)	71.0	62.0	59.0	64.0
5	Pawnee (small)	54.0	67.0	64.0	61.6
7	Pawnee (large)	74.0	69.0	62.5	68.5
8	Pawnee (A. F.)	84.0	77.0	88.0	83.0

L. S. D between averages at 5% = 9.0; at 1% = 12.0

The results are presented graphically on Plate I, Figure 2. The better germination of Wichita seed sample No. 1 (new) as compared to sample No. 3 (old) was highly significant. There was not an appreciable difference in germination between seed samples of Kiowa No. 2 and No. 4.

Among the Pawnee seed samples, No. 8 was superior at the 1 percent level of significance to all others in average germination and the differences among Nos. 6, 5 and 7 were not significant. The emergence and germination data have further been consolidated with a view to examine critically their relation to the test weight and size of kernels as shown in Table 3.

Table 3. Showing the rapidity of emergence and germination percent in relation to size of seed and test weight.

Sample No.	Variety	Test weight lbs./bu.	Kernel size gm/1000	Time to emerge hours	Germination percent
1	Wichita (new)	56.2	21.7	52.8	87.3
3	Wichita (old)	63.0	35.1	66.5	49.0
2	Kiowa (light)	52.6	18.4	67.0	76.1
4	Kiowa (heavy)	61.3	25.4	65.3	76.0
5	Pawnee (small)	51.5	14.8	52.8	61.6
7	Pawnee (large)	58.3	22.1	52.5	68.5
6	Pawnee (old)	60.7	25.5	62.5	64.0
8	Pawnee (A. F.)	61.7	25.3	50.0	83.0

Data revealed that new seeds of Pawnee and Wichita in samples 8 and 1 respectively gave significantly higher germination and emerged earlier as compared to old seed of the same varieties in sample Nos. 6 and 3. There appears, however, no relationship between the size of the seed and test weight in rapidity of emergence and germination in old seeds. Bigger size of kernels and heavier test weight in new seed sample No. 7 was found to be better in germination percentage than sample No. 5 (small), and took less time in emergence.

Under Field Conditions. The experimental plots were observed closely after sowing to determine the exact time of emergence. The observations made in the field showed that Pawnee Nos. 5, 7, 8 and Kiowa No. 4 all took seven days for emergence. Sample No. 2 of Kiowa, No. 1 of Wichita and No. 6 of Pawnee emerged after eight days, whereas Sample No. 3 of Wichita took nine days for its emergence. The differences in emergence as evident from field observation were illustrated in Plate II, Figure 1.

Table 4. Showing the percent emergence in the field.

Sample No.	Variety	Percentage emergence Replications I	II	III	IV	Average
1	Wichita (new)	11.2	23.2	26.6	26.9	21.2
3	Wichita (old)	20.7	21.1	26.5	23.4	22.9
2	Kiowa (light)	25.9	23.3	43.1	37.4	32.4
4	Kiowa (heavy)	16.3	17.6	26.5	16.3	19.1
5	Pawnee (small)	6.3	8.3	7.9	8.5	7.7
7	Pawnee (large)	9.8	10.8	14.5	12.9	12.0
6	Pawnee (old)	22.3	28.3	20.0	30.2	27.8
8	Pawnee (A. F.)	13.5	21.0	27.9	30.7	23.3

L. S. D between averages at 5% = 8.2

It was observed that there was not an even distribution of moisture throughout the field. This caused irregular germination and presented a patchy appearance at the time of recording seedling counts. The results thus obtained varied a great deal in the average germination percentages which cannot be attributed to the variations in seed samples but to soil moisture. The rains were received later during fall 1953, which introduced enough moisture in the field and the germination was then improved somewhat.

In order to collect additional data for the comparative studies of germination, the seed samples were again sown in spring 1954, when there was sufficient moisture for proper germination.

Table 5. Showing emergence percentages during spring 1954.

Seed sample	Variety	Replications I	II	III	IV	Average percentage
2	Kiowa (light)	69.2	65.8	74.2	74.1	70.8
4	Kiowa (heavy)	88.3	82.5	73.3	81.7	81.4
1	Wichita (new)	89.1	82.5	80.8	80.0	83.1
3	Wichita (old)	65.0	78.3	65.0	70.8	69.7
5	Pawnee (small)	52.5	67.5	65.3	63.3	62.1
6	Pawnee (old)	65.3	62.5	67.5	73.0	71.4
7	Pawnee (large)	69.2	69.2	74.1	73.3	71.4
8	Pawnee (A. F.)	73.3	85.8	76.6	71.2	78.7

L. S. D between averages at 5% = 7.7; 1% = 10.5

The emergence percentages are shown in Plate II, Figure 2. It was found that Kiowa No. 4 emerged significantly better than sample No. 2 at 1 percent level of significance.

Wichita No. 1 was superior to No. 3 in average emergence. The difference in average emergence percentages among Pawnee Nos. 8, 6 and 5 was highly significant. Pawnee sample No. 7 emerged significantly better than No. 5 at 5 percent level only.

Wichita No. 1 and No. 3 differed in test weight, size of kernel, and age. The old seed of sample No. 3 with abnormally high test weight and bigger size of kernel gave poor results in germination and time of emergence compared with new seed of normal test weight and medium size kernels in sample No. 1.

The fresh seed of Pawnee sample No. 8 showed better response in average emergence than No. 6, which was old, but almost the same test weight and size of the kernel as in No. 8.

The fresh or new seed with heavier and bigger kernels proved their worth in giving better stand than the lighter and small seeds.

Plate II

Fig. 1. Number of days in emergence of seed samples under field conditions in the fall.

Fig. 2. Percentage emergence of seed samples under field conditions in the spring.

Plate II

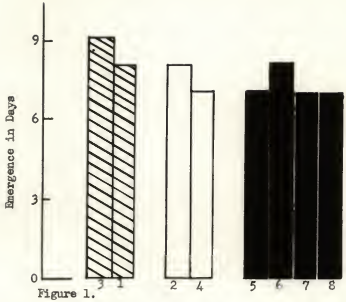

Figure 1.

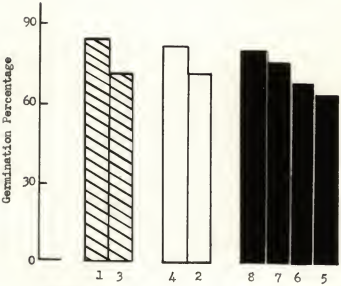

Figure 2.

Influence of Quality of Seed on Initial Plant Growth

The object of this study was to find the variation among the seed samples in initial seedling growth. To investigate the initial or early plant growth, height measurements of the young plants were recorded. These data were obtained in the greenhouse on the same plants that were observed for germination and emergence.

Table 6. Showing the height in cm. of seedlings seven days after planting.

Seed sample	Variety	Replications I	II	III	Average height per plant
2	Kiowa (light)	4.8	8.4	10.2	7.8
4	Kiowa (heavy)	7.7	8.5	10.8	9.0
1	Wichita (new)	9.4	12.0	11.8	11.0
3	Wichita (old)	5.8	8.8	10.3	8.3
6	Pawnee (old)	6.2	6.3	8.5	7.0
5	Pawnee (small)	6.1	7.0	7.8	6.9
7	Pawnee (large)	8.2	9.2	6.3	7.9
8	Pawnee (A. F.)	9.7	10.0	10.3	10.0

L. S. D between averages at 5% = 2.2; 1% = 3.1

Data given in the table show that sample No. 1 was significantly superior at 5 percent level to No. 3 in average height. Sample No. 4 averaged a little taller than No. 2, but the difference was not significant. The greater height of sample No. 8 compared with No. 6 was significant. There was no significant difference in the average heights of samples No. 5 and 7.

No appreciable difference was found between the heights of samples No. 7 and 6. The average difference in plant heights of Pawnee samples No. 8 and 6 was 3 cm. and of Wichita samples

No. 3 and 1 was 2.75 cm. It is probable these differences were due to the early start in growth in case of new seeds which took less time for emergence. The seeds which were old in both of these varieties were heavier in test weight and bigger in size of kernels, and took more time to emerge. The early growth of the seedling was more rapid in the new seeds having normal test weight and size of kernels. Differences in height of plants seven days old from samples of three varieties, Kiowa, Wichita and Pawnee, are shown in Plate III.

The second measurements of plant heights were recorded 17 days after the planting and are reported in Table 7.

Table 7. Showing the heights in cm. of young plants 17 days after planting.

Seed sample	Variety	Replications I	II	III	Average height per plant
2	Kiowa (light)	16.4	17.0	15.2	16.2
4	Kiowa (heavy)	17.5	18.6	18.0	18.0
1	Wichita (new)	21.4	23.5	21.1	22.0
3	Wichita (old)	17.2	17.2	20.2	18.2
6	Pawnee (old)	17.6	18.9	16.4	17.6
5	Pawnee (small)	13.9	15.0	14.3	14.4
7	Pawnee (large)	18.5	17.0	16.4	17.3
8	Pawnee (A. F.)	19.4	18.2	16.3	17.9

L. S. D at 5% = 2.1; and 1% = 2.8

It was found that sample No. 1 was significantly taller than No. 3. Between Kiowa No. 4 and No. 2 there was no significant difference in height. Pawnee No. 7 was found to be superior in height to No. 5 at the 1 percent level of significance.

Plate III

Differences in the height of seven day old plants

Top row (left to right) Wichita No. 1; Wichita No. 3; Kiowa No. 4; Kiowa No. 2.

Bottom row (left to right) Pawnee Nos. 8, 7, 5 and 6.

Plate III

Table 8. Showing difference in heights of plants grown in the greenhouse at two ages in relation to kernel size and test weight of seed.

Sample No.	Variety	Height of plants cm. After 7 days	After 17 days	Difference	Increase in height per day	Test wt. lbs./bu.	Kernel size gm/1000
2	Kiowa (light)	7.8	16.2	8.4	0.93	52.6	13.4
4	Kiowa (heavy)	9.0	18.0	9.0	1.00	61.3	25.1
1	Wichita (new)	11.0	22.0	11.0	1.20	56.2	21.7
3	Wichita (old)	8.3	17.2	9.9	1.10	63.0	35.1
6	Pawnee (old)	7.0	17.6	10.6	1.10	60.7	25.5
5	Pawnee (small)	6.9	14.4	7.5	0.83	51.5	14.8
7	Pawnee (large)	7.9	17.3	9.4	1.00	58.3	22.1
8	Pawnee (A. F.)	10.0	17.9	7.9	0.37	61.7	25.3

Data presented in Table 8 indicate that the average increase in height per day was quite apparent in sample Kiowa No. 4 compared with No. 2 and in Pawnee samples 7 compared with No. 5. The differences in height apparently associated with differences in size and test weights of the kernel, sample No. 2 of Kiowa and No. 5 of Pawnee having lower test weights and smaller kernels. Plants of those samples showed slightly less growth and smaller average increase per day. Hence the new seeds, bigger in size and higher in test weight, gave better results in initial development of plants. The old seed of Wichita sample 3 was slow in producing new growth at early stages of the plant as compared to sample 1 of the same variety.

Influence of Quality of Seed on Subsequent Growth

The processes involved in growth are very complex. Attempts have been made to measure growth by the amount of solid material or dry matter produced. Therefore green weights and air dry weights of the plants were determined in these experiments and the number of tillers were counted to find out the growth in each seed sample, as shown in Table 9.

Data have been analyzed statistically and L. S. D's were calculated for the comparison of average number of tillers, green weights and air dry weights (dry matter) per plant.

L. S. D at 5%	for tillers	2.2;	at 1%	2.9
" "	green weight	.67	"	.93
" "	dry matter	.22	"	.30

Table 9. Showing comparative growth under field conditions in relation to test weight and kernel size.

Sample No.	Variety	Tillers per plant	Green weight gm/plant	Dry weight gm/plant	Test weight lbs./bu.	Kernel size gm/1000
2	Kiowa (light)	8.4	1.9	0.67	52.6	18.4
4	Kiowa (heavy)	9.2	2.7	0.34	61.3	25.1
3	Wichita (old)	10.6	3.3	1.17	63.0	35.1
1	Wichita (new)	8.3	2.5	0.34	56.2	21.1
5	Pawnee (small)	9.1	2.0	0.69	51.5	14.3
7	Pawnee (large)	11.7	2.6	0.91	58.3	22.1
6	Pawnee (old)	10.0	2.3	0.33	60.7	25.5
8	Pawnee (A. F.)	9.3	2.3	0.80	61.7	25.3

From the foregoing data it appears that Kiowa sample No. 4 was insignificantly different from sample No. 2 in the larger number of tillers it produced. The average plant weights both green and dry were somewhat higher in sample No. 4 than in sample No. 2. There was higher test weight and bigger size of kernels in sample No. 4 in comparison with sample No. 2. It appears that higher test weight and bigger kernels are probably associated with better results in the development of growth. The seed in both of the samples was new. Sample No. 3 of Wichita showed its superiority over sample No. 1 at 5 percent level of significance in producing larger average number of tillers, increase in dry matter and more green weight per plant. The comparative studies made in this experiment revealed better growth performance of Wichita No. 3. This might be attributed to high test weight, and bigger size of the kernels. The seed was one year old. The seed of Wichita No. 1 was new, low in test weight, and small in size in comparison with sample No. 3.

Pawnee sample No. 7 was significantly better than No. 5 at the 5 percent level in producing more dry matter and larger number of tillers per plant. It is therefore concluded that Pawnee seed sample No. 7 was decidedly better in ability to grow than sample No. 5 of the same variety. The samples of Pawnee Nos. 7 and 5 were obtained from the same lot of seed by separating the heavy, or large, and light, or small, seeds. The heavy berries of Pawnee with higher test weight and bigger size of kernel were found to be better in growth than the light berries with low test weight and small size of the kernels.

Pawnee seed samples Nos. 3 and 6 were not significantly different in respect to developing number of tillers, dry matter and green weights per plant. There were not appreciable differences in their test weight and size of the kernels. Pawnee sample No. 3 was new seed and No. 6 was one year old seed. The difference between 6 and 7 was also insignificant. The data indicate that seeds of heavier kernels with higher test weight showed better performance in respect of growth of three samples of wheat. In this study difference in age of the Pawnee seed did not affect the growth of the plants.

Similar studies of growth and development were made in the greenhouse. The seedlings grown for germination studies were thinned out and eight plants of each seed sample were kept for the observations, reported in Table 10.

Data have been analyzed statistically and L. S. D's were calculated for the comparison of average number of tillers, green weight and air dried weight (dry matter) per plant of different seed samples. Analysis of variance for the number of tillers has been worked out and found that the F ratio showed insignificant results; hence L. S. D has not been calculated for this.

L. S. D at	5% level	1% level
Green weight	9.9	12.04
Dry matter	.85	1.18

Table 10. Showing comparative growth in the greenhouse in relation to test weight and kernel size.

Sample No.	Variety	Tillers per plant	Green weight gm/plant	Dry weight gm/plant	Test weight lbs./bu.	Kernel size gm/1000
2	Kiowa (light)	26.0	28.1	3.5	52.6	18.4
4	Kiowa (heavy)	31.0	36.5	4.2	61.3	25.1
3	Wichita (old)	27.9	46.2	5.3	63.0	35.1
1	Wichita (new)	27.1	47.7	6.3	56.2	21.7
5	Pawnee (small)	25.5	25.6	3.7	51.5	14.8
7	Pawnee (large)	32.6	36.2	5.0	58.3	22.1
6	Pawnee (old)	27.2	30.2	4.2	60.7	25.5
8	Pawnee (A. F.)	31.7	36.5	4.9	61.7	25.3

The plants of Kiowa No. 4 appeared to be somewhat better than No. 2, as shown in Plate IV. Statistical analysis of the data, however, showed insignificant differences.

Seed samples Nos. 3 and 1 showed no appreciable difference in growth as was evident from the data.

Although Pawnee No. 7 had more tillers than No. 5 the difference was not significant. No. 7 produced significantly higher green weight and more dry matter. Pawnee sample No. 7 had heavy berries with higher test weight and bigger size of kernel as compared to light berries with less test weight and smaller size in sample No. 5. The plants of Pawnee 7 and 5 are shown in Plate V which gives an idea of the appearance of better growth. Heavier kernels with high test weight seeds gave better growth as compared with low test weight seeds and lighter kernels. There were insignificant differences between Pawnee samples Nos. 8 and 6; 6 and 5; and 6 and 7 in average number of tillers, green weights and dry matter.

Results obtained in the trial sown during spring agreed with those sown in fall in respect of number of tillers excepting Kiowa Nos. 2 and 4. Kiowa sample No. 2 showed larger number of tillers per plant than No. 4. However, the difference was not significant.

Influence of Quality of Seed on Yield and Other Factors

Observations made before the harvest of the field plots for yield test showed that there was only little difference in

Plate IV

Comparison of plant growth in two seed samples of Kiowa. Left to right: Kiowa Samples Nos. 4 and 2.

Plate IV

Plate V

Comparison of plant growth amongst seed samples of Pawnee.

Left to right: Pawnee Samples Nos. 7, 6 and 5.

Plate V

time of emergence of the heads among the seed samples of the same variety. The time of heading and of maturity of the three varieties was quite different, the plots of Wichita being earliest to mature, Pawnee being the next and plots sown with Kiowa seed samples being the last to mature. A slight variation in time of maturity was noticed in the seed samples of the same variety. Seed samples having higher test weight with bigger size of kernels headed a little earlier than the rest, and their heads changed to light yellow in color a little sooner.

The plots were harvested for yield comparison when the grains in the ear became hard. The yield of all the plots was calculated in terms of bushels per acre. The test weight and size of the kernels of the crop harvested also were determined for the respective plots.

It may be pointed out that 20 pounds P_2O_5 per acre from superphosphate was applied at sowing time, and 42 pounds of nitrogen per acre from ammonium nitrate was added in the experimental plot during the month of February.

Table 11. Showing yield of grain in bushels per acre.

Sample No.	Variety	Replications				Average
		I	II	III	IV	
2	Kiowa (light)	45.0	43.2	44.6	44.5	44.3
4	Kiowa (heavy)	43.1	43.5	39.1	42.5	42.0
1	Wichita (new)	41.3	45.4	45.8	40.5	43.2
3	Wichita (old)	41.4	41.2	39.4	40.5	40.6
5	Pawnee (small)	43.4	41.0	47.7	46.8	44.7
7	Pawnee (large)	43.5	43.6	42.7	44.0	43.4
6	Pawnee (old)	43.5	45.5	45.4	45.4	44.9
8	Pawnee (A. F.)	41.7	43.5	47.7	45.9	44.6

Analysis of variance worked out for the above data showed that the calculated value of F for differences between seed samples did not exceed the reading of F for P = .05, therefore differences in average yield in bushels per acre of the seed samples are regarded as insignificant. The largest difference in the average yield of seed samples of the same variety was between samples Nos. 1 and 3 of Wichita in which the crop from new seed was superior to that from old seed.

The studies made prior to the harvesting of the plots showed that seed of lower test weight and smaller size of kernels produced less growth as compared to those with higher test weight and larger size of the kernels. It is probable that plants showing less growth were in a better position to take advantage of limited moisture and the increased soil fertility than those having more growth.

The data in Table 12 reveal that size of kernel and test weight were much higher in the crop harvested than in the seed planted. All the seed samples of three varieties improved in their development of size and test weights. Highest size of kernel and test weight were obtained in Wichita seed samples No. 1 and No. 3. Kiowa seed sample No. 2 with light kernels and low test weight and No. 4 with high test weight and heavy kernels both yielded grain of fairly good size having no appreciable difference in test weight. Size of kernels and test weight of all harvested samples of Pawnee were better than the seed that was planted. Size of the Pawnee seed sample No. 5 was

Table 12. Showing size and test weight of seed planted and plant height, acre yield, kernel size and test weight of crop harvested.

Sample No.	Variety	Seed planted		Crop harvested			
		Kernel size gm/1000	Test weight lbs./bu.	Plant height inches	Yield bu./acre	Kernel size gm/1000	Test weight lbs./bu.
2	Kiowa (light)	18.4	52.6	31.4	44.3	31.7	63.7
4	Kiowa (heavy)	25.4	61.3	30.4	42.0	32.5	63.6
1	Wichita (new)	21.7	56.2	30.5	43.3	35.9	63.6
3	Wichita (old)	35.1	63.0	31.2	40.6	35.7	64.6
5	Pawnee (small)	14.8	51.5	34.3	44.7	29.9	63.6
7	Pawnee (large)	22.1	58.3	33.4	43.5	29.0	64.1
6	Pawnee (old)	25.5	60.7	32.2	44.9	30.1	65.5
8	Pawnee (A. F.)	25.3	61.7	30.2	44.7	29.6	63.3

less than No. 7 but both have yielded almost the same size of kernels with slight variation in their test weights. There was not much variation in yield, size of kernel and test weight of all the Pawnee samples. Size of the grain produced did not appear to be associated with the acre yield. The variations in plant height immediately before harvesting, too, had no influence on the yield.

Influence of Quality of Seed on Number and Size of Heads

Further studies were made to find the number and size of heads produced from each seed sample.

Table 13. Showing the number of heads per acre.

Sample No.	Variety	No. of heads 1/10000 acre Replications I	II	III	IV	Average
2	Kiowa	208	212	253	245	229
4	Kiowa	253	228	244	223	237
1	Wichita	189	204	180	182	189
3	Wichita	239	208	188	186	205
5	Pawnee	225	231	211	190	214
6	Pawnee	231	231	305	217	246
7	Pawnee	245	252	207	239	236
8	Pawnee	261	267	243	272	261

The average number of heads per acre was higher in Kiowa No. 4, Wichita No. 3, Pawnee Nos. 6 and 8. All these seed samples had higher test weight and bigger size of the kernels than the Kiowa No. 2, Wichita No. 1, Pawnee Nos. 5 and 7, which showed comparatively fewer heads per acre. Better performance of growth was responsible for the production of a large number of heads.

Since some of the seed samples produced higher yield with fewer heads, it was therefore considered essential to determine the size of the heads.

The data in Table 14 reveal that better growth resulting in more heads per acre was not responsible for higher yields. Higher yields were obtained in seed samples of each variety which produced the least number of heads in all cases as shown in Plate VII, Figure 2. It is interesting to note that the increased size of heads was the main factor in obtaining higher yields. It was concluded that the increased size of heads in Wichita No. 1 compared with No. 3, Kiowa No. 2 compared with No. 4, and Pawnee No. 5 compared with No. 7 was sufficient to overcome the influence of the greater number of heads and resulted in higher acre yields.

In the study of number of plants and number of heads per acre between seed samples of the same variety, it was found in each case that the crop from the large seed produced more heads in relation to the number of plants than the crop from the small seed as shown in Plate VII, Figure 1.

Seed samples giving less yield had fewer plants per acre but the number of heads per acre were greater (Plate VI, Figure 1). The plants in the thinner stands were enabled at early stages to make better development in growth. This resulted in greater production of heads per acre (Plate VII, Figure 2). Size of the heads remained small (Plate VI, Figure 2) as these

Table 14. Showing the number of plants and heads and size of heads compared with acre yield.

Sample No.	Variety	No. of plants per acre in thousands	No. of heads per acre in thousands	Difference in thousands	Yield bu/acre	Size of head in grams of grain
2	Kiowa (light)	488	2,294	1,806	44.3	0.52
4	Kiowa (heavy)	390	2,379	1,979	42.0	0.48
1	Wichita (new)	397	1,837	1,490	43.2	0.62
3	Wichita (old)	345	2,055	1,709	40.6	0.53
5	Pawnee (small)	331	2,142	1,811	44.7	0.56
7	Pawnee (large)	279	2,359	2,080	43.4	0.50
6	Pawnee (old)	399	2,462	2,067	44.9	0.49
8	Pawnee (A. F.)	438	2,608	2,220	44.6	0.46

Plate VI

Fig. 1. Relation between acre yield in bushels and number of plants per acre.

Fig. 2. Relation between acre yield in bushels and size of heads in grams.

P_5 = Pawnee sample No. 5 (light kernels)

P_7 = Pawnee sample No. 7 (heavy kernels)

K_2 = Kiowa sample No. 2 (light kernels)

K_4 = Kiowa sample No. 4 (heavy kernels)

W_1 = Wichita sample No. 1 (new, light seed)

W_3 = Wichita sample No. 3 (old, heavy seed)

Plate VI

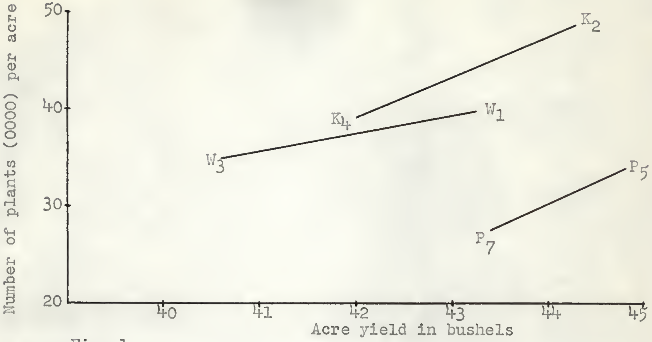

Fig. 1

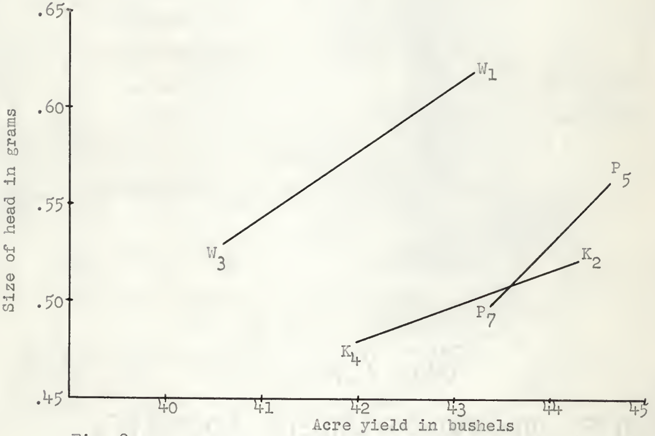

Fig. 2

Plate VII

Fig. 1. Relation between number of plants and number of heads per acre.

Fig. 2. Relation between acre yield in bushels and number of heads per acre.

P_5 = Pawnee sample No. 5 (light kernels)

P_7 = Pawnee sample No. 7 (heavy kernels)

K_2 = Kiowa sample No. 2 (light kernels)

K_4 = Kiowa sample No. 4 (heavy kernels)

W_1 = Wichita sample No. 1 (new, light seed)

W_3 = Wichita sample No. 3 (old, heavy seed)

Plate VII

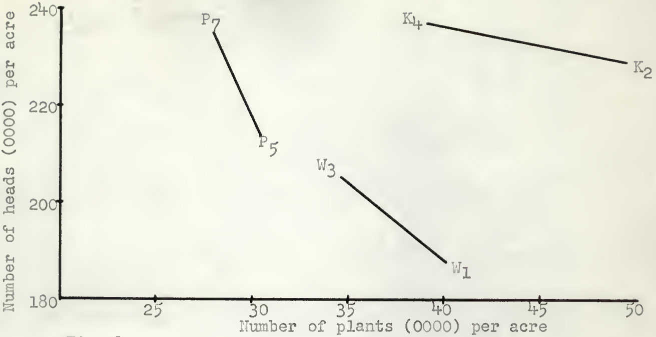

Fig. 1

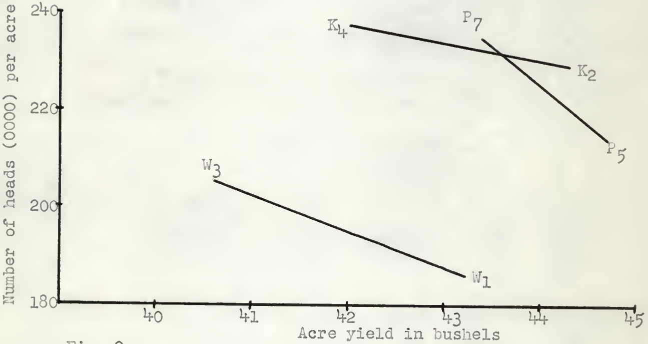

Fig. 2

plants had to feed large numbers of tillers and heads during a period of spring drought.

Hence it may be concluded that the plant population influencing the competition among plants was an important factor in crop production for high yields.

DISCUSSION

The purpose of these studies was to ascertain the effect of quality of seed of winter wheat on growth and yield. Large differences in the rapidity of emergence and germination percentages of some seed samples were found in these studies under greenhouse conditions. It was revealed that the new seed of samples Wichita No. 1 and Pawnee No. 8 gave significantly better germination and more rapid emergence than one year old seed samples, No. 3 Wichita and No. 6 Pawnee. The Wichita samples Nos. 1 and 3 differed from each other in test weight, size of kernel and age whereas Pawnee Nos. 8 and 6 in age and location where grown and only slightly in test weight and size of kernel. The response of these samples in germination and rapidity of emergence were quite alike under field conditions. The findings gave convincing evidence that speed of germination was greatest with light seed of Wichita No. 1 and was less with one year old seed which had higher test weight as shown in sample No. 3.

The results obtained were in conformity with findings of Schmidt (1924). It is apparent from the germination tests made in the greenhouse and in nursery plots sown in spring that new seed with heavier test weight and bigger size of kernels as in Pawnee No. 8 and Kiowa No. 4 gave significantly better germination than the lighter test weight and small size of kernels of Pawnee 7 and 5 and Kiowa 2 respectively. The results obtained in this study were in accord with the findings of Kiesselbach and Helm (1917) in which they reported a close relationship between the size of wheat seed and its sprout value to its relative ability to germinate. Similar results were obtained by Stoa et al (1936) in that reduction in test weight was associated with the size of kernels, and the germination percentage of seeds was found to decrease accordingly.

The studies made in the greenhouse revealed that the new seeds bigger in size and higher in test weight of the three varieties gave better results in initial plant development. In the initial stage a superiority in favor of the plants from heavy seed was evidenced by greated height of young plants seven days old. The apparent superiority was further demonstrated in height of plants 17 days after planting. The lesser growth of old and heavy seeds as Wichita No. 3, and Pawnee No. 6, compared with new and heavy seed as Pawnee No. 8 was not so great as the difference in plants grown from light compared with heavy, new or fresh seed. The early superiority of growth was maintained at later stages. These findings were in agreement with Schmidt (1924) and with observations made by Leukel, (1936) on seedling size. He found that shrunken seed produced small weak seedlings as compared to size of seedlings from plump seed.

Comparative studies of growth made under field conditions in respect to tillering, dry matter and green weight revealed that individual plants from seed samples of heavy kernels made better growth. Among the samples studied in these investigations the number of plants per acre was smaller for seed samples of heavy test and bigger size of kernels as compared to light test weight and small size of kernel. More plants per unit area resulted from sowing small kernels at the normal rate in pounds per acre than large seed, and therefore more plants per acre were obtained from samples of small size of kernels. The individual plants from seed samples of heavy test weight and bigger size took advantage of comparatively more space to develop. The results indicated that it was not only heavy test weight and bigger size which was responsible for better tillering, but the thin stands promoted better tillering, whereas the thick stands limited the number of tillers.

Results of the comparative studies made under greenhouse conditions were in favor of heavy test weight and bigger size of kernels, although the differences in number of tillers per plant were insignificant. The results obtained under field and greenhouse conditions were in conformity with Hector (1936) who indicated the factors responsible for tillering were rate of seeding and size of the seeds.

Acre yield produced from seed samples of low test weight and small size of kernels did not differ significantly from the yields produced from seed samples of high test weight and large size of kernels. The size of kernel, test weight and plant height immediately before harvest seemed not to be associated with yield of the seed samples. All the seed samples planted showed considerable improvement in the test weight and size of the kernels of the crop harvested. Number of heads per acre was more in the crop from samples of heavy test weight seed and bigger size of kernels than from the light test weight and small size of kernels. It was found that the yield advantage of greater numbers of heads per acre had offset the influence of small heads in these seed samples. Higher yields were obtained in these studies with fewer but slightly larger heads. The bigger size of head was the main factor to obtain higher yields.

Slightly increased yield in bushels per acre obtained from samples with small size of kernels was in accord with findings of Voelcker (1906), who made investigations on barley kernels. The results obtained agreed closely with Kesselbach and Ratcliff (1917) and William and Welton (1911) in winter wheat.

It was concluded from the investigations made in this thesis that plant population influencing the competition among plants was an important factor in production of high yields. The comparative increase in acre yield in bushels was in favor of light small seeds under normal soil fertility. It was evident that more seeds to the acre were sown and more plants grew where small seed was used. It was shown in this study, however, that individual plants from large seed produced more growth than those from small seed. It seems therefore that the acre yield advantage of the samples having small seed was probably due to the larger number of plants per acre.

SUMMARY

The problem of quality of seeds and the influence of quality on growth and yield was tackled by investigating the germination, seedling growth, tillering capacity and finally the yield. Eight seed samples of winter wheat, namely, two of Kiowa, two of Wichita and four of Pawnee were received for this study. The seed samples of the same variety differed from each other in age, test weight and size of the kernel.

In general results of the study indicate that:

(1) In seed samples of large kernels and higher test weight germination was significantly better than in samples of light test weight and small kernels.

(2) Germination in general was more rapid in the new light seed of Wichita than it was in old heavy seed of the same variety.

(3) The seeds of high to medium test weight produced better young plants from the standpoint of quantitative measurements than did seeds of lighter test weights or of old seeds even though the latter were heavy. The order of superiority of the plants corresponded to the order of the test weight of the seed except in case of Wichita No. 3, which was abnormally heavy but had a low rating apparently due to deterioration with age.

(4) In comparative studies of growth made under field conditions, tillering, air dry weights and green weights of plants were greater where heavy rather than light seeds were planted.

(5) Larger numbers of seedlings per acre were found in plots planted with small seed than with large seed. The drill setting was not changed for the different samples.

(6) Differences in yield per acre between seed samples were insignificant. It is noteworthy, however, that in every case the acre yield from small seed was more than from large seed of the same variety.

(7) Heads averaged larger in size in the plots planted with small seed than with large seed of the same variety. The difference was sufficient to overcome the influence of the greater number of heads from seed samples of bigger size of kernels.

(8) In this experiment more heads per acre were produced where the large seed was planted even though there were fewer plants per acre. This might have been due to less competition in the early part of the spring season when the plants were tillering.

(9) In the crop harvested the size of kernel, test weight and plant height seemed to have no effect on acre yield from the different seed samples.

(10) The test weight and size of kernel in every case were greater in the crop harvested than in seed that was planted.

(11) The relative increase in bushel yield under the field condition was in favor of sowing seed of small kernel size. It

appears evident that if small seed is sown, more plants per acre are needed to produce the best yield, as plants from such seed will likely tiller less and grow less vigorously than plants from large seed.

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QUALITY OF SEED AND ITS INFLUENCE ON GROWTH AND YIELD OF WHEAT

by

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The problem of quality of seed and its influence on growth and yield of wheat was studied by investigating the germination, seedling growth, tillering capacity and yield. This work was undertaken with eight samples of winter wheat. The samples included two of Kiowa from Ashland (Kansas), two of Wichita from Dodge City (Kansas), three of Pawnee from Collyer (Kansas) and one of Pawnee from the Agronomy Farm (Kansas State College, Manhattan, Kansas). These samples of seed were sown in field plots in a randomized block design with four replications. Greenhouse studies were made to obtain further information on rapidity of emergence, germination and comparative growth. The samples also were sown in experimental nursery plots in a randomized block system for germination studies during spring 1954.

Studies made on germination revealed that new, light seed of Wichita took less time for emergence than old, heavy seed of the same variety. The germination percent of new or fresh samples in which the kernels were large was significantly higher than samples of lighter test weight and small size of kernels.

Another investigation showed that the seed samples of high to medium test weight produced better young plants from the standpoint of height measurements than seed samples of lighter weight or old, heavy seeds. The order of superiority of the plants corresponded to the test weight except in the case of old, heavy seed of Wichita sample No. 3. In studies of relative growth made under field conditions, tillering, air dry weight and green weight were greater from the samples having heavy kernels. Similar results were obtained in the greenhouse study, but the differences were not significant.

In the field plot experiment larger numbers of seedlings per acre were obtained from seed samples of small size kernels and fewer plants per acre from samples having large kernels. The drill setting was not changed and therefore more small seeds than large seeds were planted. The individual plant from large kernels had more space on account of thin seeding. Hence it was not the big size of kernels only which was responsible for large number of tillers and more growth but there was more space per plant for the development of better growth.

Differences in yield per acre were insignificant but in each case the yield was somewhat higher from samples having small size kernels than from large seed of the same variety. Size of the ear or head was also greater from small seed. Increased size of the head from small seed was sufficient to overcome the influence of the greater number of heads per acre that were obtained from seed samples of bigger size of kernels.

The size of kernel, test weight and plant height in the harvested crop seemed to have no effect on yield. The test weight and size of the kernel in each case was greater in the crop harvested than in the seed that was planted.