AGRONOMIC AND QUALITY CHARACTERISTICS OF
SELECTED LARGE-SEEDED WHEAT LINES

By

F. Phyll Cammack

Bachelor of Science

Brigham Young University

Provo, Utah

1977

Submitted to the Faculty of the Graduate College
of the Oklahoma State University
in partial fulfillment of the requirements
for the Degree of
MASTER OF SCIENCE
May, 1979

OKLAHOMA STATE UNIVERSITY LIBRARY

AGRONOMIC AND QUALITY CHARACTERISTICS OF

SELECTED LARGE-SEEDED WHEAT LINES

Thesis Approved:

Edward L. Smith
Thesis Adviser

M. B. Kirkham

Robert M. Reed

Lewis H. Edwards

Norman N. Durham
Dean of the Graduate College

1029335

ACKNOWLEDGMENTS

The author wishes to extend his sincere appreciation to Dr. Edward L. Smith, his major adviser, for the assistance, encouragement and helpful suggestions he gave throughout the course of this study.

Appreciation is also expressed to other committee members, Dr. Lewis H. Edwards, Dr. Mary Beth Kirkham, and Dr. Robert M. Reed, for their guidance and constructive criticism in the preparation of this thesis.

The author is deeply grateful to Dr. Robert D. Morrison for his assistance in conducting the statistical analysis and appreciation is expressed to Dr. D. C. Abbott for assistance in the quality analyses.

Great appreciation is extended to the Department of Agronomy of Oklahoma State University for the financial support provided to make this graduate study possible.

The assistance given by members of the Small Grains Breeding section in planting, harvesting, and threshing of this study is greatly appreciated.

The author wishes to express special thanks to his wife, Kathy, for her encouragement, patience, and typing assistance given throughout the course of this study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

The current and projected world food requirements demand increasing efforts in the production of basic food crops. For centuries wheat has been a primary world food source. One way of increasing world food production is through the development of higher yielding cultivars of this staple food crop.

Grain yield in wheat is a complex character controlled by many genes and it is a character that is influenced to a greater of lesser degree by the environment in which the plant is grown. Because of the complex nature of yield, indirect selection on the basis of certain yield related traits may be more effective than selection for yield per se. Grain yield in wheat can be considered as a geometric representation of three components: number of spikes/unit area, kernels/spike, and kernel weight (6). If yield is the product of these components, more progress might be made in increasing yield potential by concentrating on one or more of these components.

Kernel weight is a major component of yield in wheat. It has been shown not only to be a character that has higher heritability than yield but also an important contributor to yield (13). Although genetic variation for kernel weight exists among adapted wheat cultivars, very little effort has been made to improve wheat cultivars through selection for kernel weight (26). It may, therefore, be profitable to use kernel weight as a basis for indirect selection for yield.

This study was concerned with a group of F_5 lines that had been previously selected for high kernel weight. The primary objectives of this study were: (1) to evaluate this group of 54 F_5 lines for yield, kernel weight, and other agronomic characters, (2) to determine the presence of genotype by environment interaction for kernel weight and other agronomic traits, (3) to determine what effect an increase in seed size per se might have on quality characteristics of these lines.

CHAPTER II

REVIEW OF LITERATURE

Grain yield in wheat is a complex character controlled by many genes and it is influenced to a great degree by environmental factors. Because of its complex nature, breeding for increased yield potential is difficult. Indirect selection for yield based on selection of yield-related traits offers a possible alternative to selection for yield per se. Since yield related characters are often more simply inherited than yield itself, selection based on these traits should be more efficient than selection for yield per se.

Grafius (6) expressed grain yield as a geometric figure in which three components of yield are represented. The edges of the figure represent the number of tillers per unit area, the average number of kernels/spike, and the average weight of the kernels. Based on this model, the easiest way to increase yield by breeding would be to increase the shortest edge of the figure while holding the others constant. Considering the relative influence of all three components on yield, Smith (25) emphasized the importance of kernel weight in the development of Great Plains wheat cultivars with increased yield potential.

Donald (4) proposed that grain yield in wheat could be maximized through the development of a plant ideotype which was based on the optimum expression of certain yield-related characters. His proposal included a large spike as a potential sink for photosynthate which could be a limiting factor in yield. He indicated two possible reasons why the number and potential size of the grains, rather than total assimilates may be limiting factors in grain yield. First, if plant parts responsible for photosynthesis are removed or shaded, other parts compensate for this loss indicating that not all organs are functioning at maximum capacity. Second, if grain number is reduced an increase in kernel weight does not always occur.

The importance of kernel weight as a component of yield has been demonstrated by McNeal (16), Amonsilpa (2), Sidwell et al. (24), and Knott and Talukdar (13). McNeal (16) found kernel weight to be an important component of yield in a cross between 'Lemhi', a soft white wheat and 'Thatcher', a hard red wheat. From a diallel analysis of five winter wheats, Amonsilpa (2) found that kernel weight contributed substantially to grain yield and concluded that breeding procedures that concentrate primarily on kernel weight would be more effective in increasing yield than selection for yield per se. Sidwell et al. (24) also concluded that kernel weight would be the easiest yield component to improve by direct selection and that selection for kernel weight would correspondingly be more effective in increasing yield than selection for yield per se. Knott and Talukdar (13) selected for kernel weight in the progeny of a cross between two spring wheat cultivars, one with low kernel weight and good yield, the other with large kernels and low yield. Large seeded lines were obtained that were superior in yield to either parent.

With respect to a geometric representation of yield, Grafius and Weibe (7) stated that selection for yield components should be based on the expected genetic gain for those components. Selection should be made for those components of yield with high heritabilities and subsequent high expected genetic gain. Sidwell et al. (24) and Ketata et al. (12) reported moderate narrow-sense heritabilities of 43 and 65%, respectively, for kernel weight in studies with hard red winter wheat populations. Johnson et al. (9), working with winter wheats, and Sun et al. (27), working with spring wheats, also reported moderate to high heritabilities for kernel weight with values ranging from 51 to 85%.

Tiller number has also been reported to have moderate heritability values by Sidwell et al. (24) and Ketata et al. (12). Narrow-sense heritability estimates obtained by Sidwell et al. (24) for this trait were lower than those obtained for kernel weight indicating selection for kernel weight would be more effective than selection for tiller number. McNeal (16) estimated heritabilities for yield and various yield components by regressing F_3 progenies on F_2 plants. He found all values to be low. Johnson et al. (9) also reported low heritability estimates for grain yield in winter wheats but moderate heritabilities for kernel weight.

Several investigators have reported that kernel weight is controlled by relatively few genes. Sharma and Knott (23) studied yield components in spring wheat. They reported that kernel weight appeared to be controlled by four or fewer genes. Heritability estimates for kernel weight in this cross ranged from 37 to 69%. Reddi and Heyne (20) also estimated the number of genes involved in kernel weight. In two winter wheat crosses they estimated that two genes were responsible for genetic variation in kernel weight, although heritability estimates from the same study were low to intermediate in magnitude.

The importance of additive gene action in the inheritance of kernel weight has been expressed by several workers. Paroda and Joshi (18) stated that the utility of component analysis of yield depends on the relationships of components to yield and to each other, the heritability of components, and the nature of genetic systems controlling the expression of each component. In a six-parent diallel cross of spring wheats Paroda and Joshi (18), working in India, found a predominance of additive genetic variance for kernel weight and concluded that selection and breeding for this trait should be emphasized. Sun et al. (27), working with spring wheat, reported additive gene action to be the most important type of genetic variation in the inheritance of kernel weight although dominance effects were also observed.

Epistasis was reported by Sun et al. (27) for kernel weight in a four year study of spring wheat when parents differed in kernel weight. It was suggested that epistasis was more important when parents were diverse. Ketata et al. (12) were unable to detect the presence of epistasis in the inheritance of kernel weight in a winter wheat study.

Heterosis for kernel weight has been reported by several investigators. Johnson et al. (9) reported heterosis for kernel weight and yield in a short X tall winter wheat hybrid. The F_1 mean for kernel weight was significantly larger than that of either parent. In the F_2, however, the mean approached that of the large-seeded parent. Weibel (28) reported heterosis for several characters in five hard red winter wheat hybrids. A comparison of F_1 means to mid-parent values indicated heterosis for kernel weight, yield, and plant height. Calculation of percent heterosis for kernel weight in a study by Sun et al. (27) showed that heterosis varied from -4 to 31% depending on the hybrid and the year grown.

Interrelationships between yield components and yield have been reported by several workers. In winter wheat, Sidwell et al. (24) found tiller number to be most highly associated with yield. The phenotypic correlation for the association between tiller number and grain yield was 0.68 and positive in sign. Kernel weight had a low positive phenotypic correlation of 0.28 with grain yield. Genotypic correlations were of lower magnitude than phenotypic correlations for kernel weight indicating that environmental effects or non-additive effects or both were acting on this character.

A significant positive phenotypic correlation of 0.57 was observed by Knott and Talukdar (13) for the association between kernel weight and grain yield. A compensating effect was observed for kernels/plot and kernel weight. As kernel weight increased, kernels/plot decreased, however, the increase in kernel weight had a greater effect on grain yield than did the decrease in kernels/plot.

In a seven-parent diallel, Fonseca and Patterson (5) found a high positive correlation between yield and number of spikes, an intermediate positive correlation between yield and kernel weight and a low negative correlation between kernels/spike and kernel weight. Based on phenotypic path coefficient analysis, the direct influence on yield by number of spikes, kernels/spike, and kernel weight, respectively, were 0.976, 0.718, and 0.317. Working with dwarf spring wheats, Sethi and Singh (22) found very low phenotypic correlations between kernel weight and yield. Weibel (28) reported a high positive association between plant height and kernel weight.

Adams (1) reported that the development of yield components in many crops is sequential in time. He suggested that yield components are genetically independent characters but are often negatively associated. He stated that the negative relationships were due largely to competition for growth substances by sequentially developing characters. Working with durum wheats, Lee and Kaltsikes (15) found interdependence among yield components. They estimated that 62% of the phenotypic variation for kernel weight was determined by the influence of spikes/plant and kernels/spikelet which developed before kernel weight. Johnson et al. (10) showed a compensating effect of yield components in two hard red winter wheats. 'C.I. 13678' equaled or exceeded 'Pawnee' at five locations for grain yield. C.I. 13678 also exceeded Pawnee for number of kernels/spike but was below Pawnee for kernel weight at all five locations. Although C.I. 13678 showed a reduction in kernel weight in relation to Pawnee, the increase in kernels/spike of this cultivar was of sufficient magnitude to produce a high yield level.

McNeal et al. (17) found selection for kernel weight and kernels/spike to be effective in increasing grain yield. However, kernels/spike decreased as selection was made for increased kernel weight. Conversely, it was noted that kernel weight increased as selection was made for kernels/spike. Yield was altered by selection for yield components but yield components were not altered by selection for yield. Lebsock and Amaya (14), working with durum wheats, found similar results and suggested that selection for kernel weight in F_2 and F_3 would be an effective method of indirect selection for yield and test weight. Low to intermediate positive phenotypic correlations were noted for the association between kernel weight and yield and between plant height and yield. Johnson et al. (9) also observed a positive phenotypic correlation between plant height and kernel weight in winter wheats.

It has been suggested that kernel weight is a stable component of yield. Paroda and Joshi (18) indicated that kernel weight seemed to be the most reliable yield-contributing character. Ketata (11) showed that kernel weight was the component of yield least subject to environmental influences. Asana, as cited by Schmidt (21), noted that kernel weight contributed to yield and yield stability under drought and high temperature stress. On the other hand, Worzella (29) found from a two year study on soft red winter wheats that interannual correlations for kernel weight were significant but low indicating that this trait was influenced by environmental conditions.

Transgressive segregation for kernel weight in wheat was observed by Reddi and Heyne (20). However, Sharma and Knott (23), working with spring wheat, did not observe transgressive segregation for kernel weight and concluded that all genes for large kernels were contributed by one parent in the cross they studied.

In general, kernel weight in wheat appears to be an important component of yield and there are strong indications that selection for kernel weight might be an effective method of increasing grain yield potential.

CHAPTER III

MATERIALS AND METHODS

Materials

Fifty-four F_5 lines, the two parents, and four check cultivars were used in this study. The F_5 lines were developed from a 'Lovrin 6' X 'TAM W-101' cross made in 1972. The four check cultivars were 'Triumph 64', 'Osage', 'Newton', and 'Vona'.

Lovrin 6 is an experimental line developed in Romania. Its pedigree is 'Fiorella'/'Bezostaia 1' (26). It is a winter wheat but poorly adapted to Oklahoma. Lovrin 6 was selected for use in this cross because of its large seed size. Of all the lines evaluated at Oklahoma State University during the past ten years, Lovrin 6 has been superior in kernel weight. TAM W-101 is a hard red winter wheat developed at the Texas Agricultural Experiment Station. Its pedigree is 'Norin 16'/3/'Nebraska 60'// 'Mediterranean'/'Hope'/4/'Bison' (19). TAM W-101 is medium in height and maturity and has good milling and baking characteristics. It is currently one of the leading cultivars in Oklahoma. The remaining four check cultivars were chosen to represent a range of types presently grown in the Southern Great Plains.

The progenies from the Lovrin 6 X TAM W-101 cross were handled according to a modified pedigree system of breeding. F_2 space plants were grown at Stillwater in 1975. Selections were made among F_2 plants on the basis of seed size and general appearance. Progenies were grown as F_3 head rows in 1976. Selection in F_3 was based solely on seed size. Several heads were taken from each selected F_3 head row. Progenies of selected plants were grown as F_4 head rows in 1977. These F_4 head rows were visually selected on the basis of agronomic characters and seed size and the entire row was harvested. Kernel weight was measured on the rows that were harvested and 54 lines were eventually selected to be used in this study.

Field Layout

The experimental design was a randomized complete-block with two replications. Each block consisted of 60 entries. Plots consisted of two rows 3.7 m in length with 30.5 cm spacing between rows. The study was planted on agronomy research stations at three locations: Stillwater, Lahoma, and Haskell, Oklahoma. Seeding dates for the three locations were: Stillwater, 27 October; Lahoma, 24 October; and Haskell, 18 October, 1977. Soils for the three locations were Kirkland silt loam, Pond Creek silt loam, and Taloka silt loam for Stillwater, Lahoma, and Haskell, respectively.

Plots were seeded with a tractor-mounted cone planter at a rate of 180 seeds/plot (50.4 kg/ha). Adjustments were made for differences in kernel weight to insure that the same number of seeds were planted in each plot. At maturity, plots were hand shortened to 3.05 m to eliminate end-of-plot bias. The plots were harvested with a two-row Suzue binder at Stillwater, Lahoma, and Haskell, respectively, on 15 June, 23 June, and 13 June, 1978. Bundles were threshed with a Vogel nursery thresher.

Characters Evaluated

Grain yield, kernel weight, test weight, kernels/spike, tiller number, and plant height were measured on each plot at all three locations. Data for wheat protein, flour protein, flour yield, specific sedimentation, mixing time, and mixing curve height were obtained from a 150 g sample of grain which was a composite of the three locations. The following measurements were made on the six agronomic characters.

Tiller Number

Tiller number was expressed as the number of fertile spikes/30.5 cm^2 plot area. Tillers in a 30.5 cm section of each of the two rows were counted just before harvest and a mean for each plot was calculated.

Plant Height

Plant height was taken as the distance, in centimenters, from the soil surface to the tip of the tallest spike, excluding the awns. This character was expressed as an average of the upper-story heads for each plot.

Kernels/Spike

The number of kernels/spike was calculated from six upper-story spikes taken from each plot. The spikes were threshed in bulk and the kernels were counted to determine the mean number of kernels/spike.

Kernel Weight

Kernel weight was determined from the six spikes taken from each plot. The weight of kernels from the spikes was divided by the number of kernels produced and kernel weight was expressed in g/1000 kernels.

Grain Yield

Grain yield was measured as the weight of threshed grain from each plot recorded in g/plot and later converted to kg/ha.

Test Weight

A standard-size sample of grain from each plot was weighed on a Fairbanks Morse test weight apparatus to determine test weight which was measured in lb/bu and later converted to kg/hl.

Microquality determinations were made in the wheat quality laboratory at Oklahoma State University. A 150 g composite of seed from three locations was used for quality determination. Wheat and flour protein percent, flour yield, specific sedimentation, mixing time, and mixing curve height were determined for each entry. Samples were milled on a Brabender Quadrumat Senior laboratory mill to determine flour yield. A Ten-Gram laboratory mixograph was used to determine dough-mixing properties including mixing time and mixing curve height. Standard sedimentation procedures were used to measure specific sedimentation. Wheat and flour protein percentages were determined by the Kjeldahl procedure.

Statistical Analyses

Standard analyses of variance were conducted on the six previously mentioned agronomic characters to detect significant differences among entries, locations, and the presence or absence of genotype by environment interaction. An analysis of variance was conducted separately for each location as well as for the combined locations. No statistical analyses were conducted on quality characters since these were determined from composite samples. Differences among means were examined in reference to least significant difference (L.S.D.) values. Coefficients of variation (C.V.) were also calculated. Phenotypic correlation coefficients were calculated for all two-way comparisons among characters measured. Phenotypic correlation coefficients were taken from the total source of variation line of the analysis of variance printout.

CHAPTER IV

RESULTS AND DISCUSSION

Analysis of Variance

Mean squares for the six agronomic traits at each of three locations are presented in Table I. Differences among genotypes were highly significant (0.01 probability level) for all six characters measured at each of the three locations. Significant mean squares for replications were obtained in some cases: for test weight and plant height at Stillwater, for grain yield at Lahoma, and for grain yield and tiller number at Haskell. The significant mean squares for replications indicated that the blocking of the experiment was effective in removing extraneous variation, thereby increasing the precision of the experiment.

Mean squares from the combined analysis of variance for six agronomic traits are presented in Table II. Highly significant differences among genotypes were observed for all characters. Differences among locations were significant for five of the six characters. Tiller number was the only character that did not have a significant mean square value for location. A highly significant (0.01 probability level) genotype by location interaction was observed for grain yield, kernel weight, test weight, and plant height, while the genotype by location interaction for tiller number was significant at the 0.05 probability level. Kernels/spike was the only trait that did not show a significant genotype by location interaction effect.

A significant genotype by location (environment) interaction means that genotypes did not respond similarly in the different locations. Genotype by environment interactions can have important implications in a breeding program. They can influence the decision to breed for genotypes having wide or narrow ranges of adaptation as well as whether selection should be based on performance at one location or at two or more locations (3).

Previous reports on kernel weight in wheat have indicated that this trait tends to be a stable character which is relatively unaffected by environmental differences (11) (21). A possible explanation for the presence of significant genotype by environment interaction for kernel weight in this study could be that the lines used in this test were selected for high kernel weight. Previous reports have dealt mainly with genotypes having standard kernel weight values. The TAM W-101 parent and adapted checks in this study, in general, showed little evidence of genotype by environment interaction for this trait, as will be discussed later in more detail.

Correlation Coefficients

Phenotypic correlations for all possible two-way comparisons among six agronomic traits are presented in Table III. Correlation coefficients are presented for combined locations as well as for each location separately. Correlations between kernel weight and grain yield and between kernel weight and test weight were low in magnitude for all comparisons and positive in sign with the exception of the Lahoma data set which showed low negative coefficents. Correlations between kernel weight and kernels/spike were intermediate to high in magnitude and negative in sign.

The correlations between kernel weight and tiller number as well as those between kernel weight and plant height were generally very low in magnitude and inconsistent with regard to sign.

Correlations between grain yield and tiller number were low to intermediate in magnitude and positive in sign. Test weight and plant height had low but positive correlation coefficients. Correlations between grain yield and test weight were positive in sign but inconsistent in magnitude ranging from low to intermediate. All other comparisons had low correlation values.

Sidwell (24) reported a low positive correlation between kernel weight and grain yield, an intermediate positive correlation between grain yield and tiller number and a low negative correlation between kernel weight and kernels/spike. The correlations reported in this study agree with those of Sidwell in sign but differ in magnitude. The correlations between tiller number and kernel weight in this study were very low in magnitude and inconsistent in sign. Hsu and Walton (8) reported these two traits to be highly negatively associated. From a breeding standpoint, the negative correlations between kernel weight and kernels/spike which were of intermediate magnitude in this study may indicate a possible problem in the simultaneous improvement of these two characters.

Comparison of Means of Agronomic Data

Agronomic data for 54 F_5 lines and six check cultivars representing means of the three locations are presented in Table IV. Grain yield and kernel weight data are presented in this table but these traits will be discussed in more detail later in this chapter. Test weight ranged from 67.8 kg/hl for OK78324 to 79.0 kg/hl for Triumph 64. The overall mean was 73.4 kg/hl. Lovrin 6 ranked very low (57th) for test weight and was substantially below the overall mean value. Kernels/spike ranged from 20.3 to 37.5 with a mean of 26.6. The check cultivars, Vona and Newton, ranked first and second for this trait with values of 37.5 and 37.2, respectively. Lovrin 6 ranked 50th with a value of 23.3 while TAM W-101 ranked 25th with a value of 27.3

Tiller number values ranged from 28.8 to 44.0 with a mean of 38.4. In general, adapted cultivar checks ranked high for this trait and were substantially above the overall mean value. Lovrin 6 ranked last for tiller number with a value of 28.8. The mean for plant height was 89.0 cm. With the exception of Triumph 64 and Osage, the check cultivars were below the overall mean value. Lovrin 6 and TAM W-101 were relatively short in stature ranking 58th and 48th, respectively, for plant height. The highest value for plant height (104.8 cm) was recorded for OK78337.

Comparison of Means of Quality Data

Quality data for 54 F_5 lines and six check cultivars representing determinations made on seed composites of three locations are presented in Table V. Of the quality traits examined, wheat protein percent, flour yield, specific sedimenation, and mixing time are of particular interest in this study. Wheat protein had a mean of 14.9% and ranged from 13.2% for OK78304 to 17.2% for OK78318. As might be expected, OK78318 which ranked first for protein ranked low (51st) for grain yield. With the exception of Lovrin 6, the check cultivars were slightly below the overall mean for wheat protein percent. Lovrin 6 ranked low for grain yield and test weight which might account for its high protein value of 16.9%.

OK78351 ranked first in flour yield with a value of 71.2% which was 2.2% higher than Triumph 64, the next highest entry. With the exception of Vona, flour yields for the check cultivars were above the overall mean of 60.7%. Several lines had flour yields of less than 50% which would be unacceptably low for the milling industry. The mean for specific sedimentation was 4.6 units. TAM W-101 was above the mean for this trait while Lovrin 6 and Triumph 64 were below the mean. Most of the F_5 lines were in the range of Triumph 64 (4.2 units) to TAM W-101 (5.3 units), although a few were below 4.0 units. Mixing time ranged from 2.0 to 4.8 min with a mean of 3.2 min. With the exception of Triumph 64, all adapted check cultivars were above the mean. Most F_5 lines were in the range of Triumph 64 (2.5 min) to Vona (4.0 min) for mixing time, although a few lines were lower than Triumph 64.

Grain Yield Performance

Mean yields for 54 F_5 lines and six check cultivars at each of the three locations are shown in Table VI. Mean yields were 2060.3 (30.2 bu/a), 2315.6 (34.4 bu/a), and 2008.4 kg/ha (29.8 bu/a) for Stillwater, Lahoma, and Haskell, respectively. Although Lahoma had the highest mean yield, the means for the three locations were not greatly different.

OK78322 ranked first for overall yield with a three-location mean of 2904.0 kg/ha and appeared to be very stable for yield across the three locations. It was the highest yielding entry at Stillwater and Haskell and ranked second at Lahoma. In terms of the L.S.D. value, it was significantly higher than TAM W-101 at Stillwater and Haskell but was not significantly different from TAM W-101 at Lahoma. TAM W-101 ranked second for overall yield with a three-location mean of 2534.0 kg/ha. At

Stillwater, TAM W-101 was only slightly above the location mean but it had the highest yield at Lahoma. OK78311 and OK78314 ranked third and fourth, respectively, for overall yield but they were not significantly different from TAM W-101 in terms of the three-location mean. OK78302 ranked fifth for overall yield. This selection was significantly higher than TAM W-101 at Stillwater, significantly lower at Lahoma but not significantly different at Haskell. Lovrin 6 ranked very low for yield (57th) and was significantly lower than TAM W-101 at all three locations.

Kernel Weight Relationships

Mean kernel weight for the F_5 lines and check cultivars at each of the three locations are presented in Table VII. Kernel weight means were 41.6, 43.0, and 40.2 g/1000 for Stillwater, Lahoma, and Haskell, respectively. At all locations, nursery means exceeded Triumph 64, the adapted check cultivar with the highest kernel weight value. OK78337 ranked first for the three-location mean kernel weight. It was quite constant for this trait in each location having values of 50.4, 51.0, and 50.0 at Stillwater, Lahoma, and Haskell, respectively. In terms of L.S.D. values, this selection was significantly higher than Lovrin 6, the large seeded parent, at Stillwater but not at the other two locations. OK78321 and OK78338, ranking second and third respectively, were significantly higher than Lovrin 6 at Stillwater but not at Lahoma and Haskell. OK78322, the fourth ranking entry, was significantly higher in kernel weight than Lovrin 6 at Stillwater, significantly lower at Lahoma and not different at Haskell. Based on the the three-location mean (Table VII), four selections exceeded Lovrin 6 in kernel weight but none were significantly greater, indicating no transgressive segregation for this trait. All four of these F_5 selections were significantly higher in kernel weight than TAM W-101 at each of the three locations.

The three-location mean kernel weight of the 60 entries was 41.7, while the mean of the 54 F_5 selections was 42.5. This value (42.5) is near the mid-parent value (42.9) and is substantially larger than the highest adapted check, Triumph 64, which had a value of 39.9. Based on the three-location mean, four selections exceeded the kernel weight value of Lovrin 6 (47.2), the large seeded parent, and 24 selections equaled or exceeded the mid-parent value. Forty-nine selections exceeded the value of TAM W-101 (38.5) and 41 selections exceeded the value of Triumph 64 for this trait.

Comparison of Elite Lines

Agronomic and quality data for eight lines and four check cultivars are presented in Table VIII. These elite lines consisted of the four selections having the highest mean grain yield and the four selections having the highest mean kernel weight values. These are the lines that would be of particular interest in a breeding program in which kernel weight and yield were to be emphasized.

OK78322 ranked first for yield, fourth for kernel weight, and second for tiller number. This selection ranked 46th for kernels/spike. Particular attention should be given to this selection in the breeding program because of the combined high values for yield and kernel weight. OK78311 ranked third for yield, sixth for tiller number but ranked low (54th) for kernel weight. It was rather high for kernels/spike, ranking fourth for this trait. These two lines had essentially opposite responses for kernel weight and kernels/spike. OK78322 had a high kernel weight value but was low for kernels/spike, while OK78311 had a low kernel weight value but was high for kernels/spike. The four high-yielding selections ranked high for tiller number (second, fourth, sixth, and ninth). This is in agreement with other workers who have suggested that tiller number is an important component of yield (5) (25). However, with the exception of OK78311, these lines had low values for kernels/spike. In plant height these four high-yielding selections were similar to Triumph 64. In test weight they were not greatly different from TAM W-101.

In most cases quality characteristics were at acceptable levels for these high-yielding lines. However, OK78314 was below the check cultivars in wheat protein and flour yield, while OK78311, OK78314, and OK78322 had relatively short mixing times, being similar to Triumph 64 in this regard.

The five F_5 selections with the highest kernel weight values had yield ranks that were in the range of the adapted checks. Yield ranks for these five large-seeded lines were, 1st, 11th, 21st, 33rd, and 40th while the five adapted cultivars had yield ranks of 2nd, 6th, 20th, 31st, and 45th (Table IV).

Kernels/spike values were low for this group of high kernel weight lines. This is consistent with the inverse relationship observed for these two traits in the correlation studies (Table III), and suggests that an increase in one of these traits is likely to be accompanied by a decrease in the other.

OK78337 and OK78321 were similar to TAM W-101 in test weight, while OK78338 and OK78353 ranked rather low for this trait, suggesting that some degree of seed shriveling was present in these two lines. With the exception of OK78321, these lines ranked low for tiller number. OK78321 had a high value for tiller number and also a high value for grain yield.

Plant height of these four lines varied from short to tall. OK78337 was the tallest entry in the test while OK78353 was nearly the same height as Lovrin 6.

The introduction of large-seeded genotypes into a breeding program has raised the question as to what effect an increase in seed size per se might have on quality traits. Concern has been expressed specifically in regard to flour protein percent and flour yield. In this study (Table VIII), the differences between wheat protein and flour protein of the four selections with the highest kernel weight values ranged from 1.1 to 2.7 percentage points. This compares with a difference of 1.0, 2.2, and 3.3 percentage points for TAM W-101, Newton, and Lovrin 6. Apparently the large seed size of these lines did not adversely affect flour protein percent. In terms of flour yield percentages, three of the four elite lines were similar to TAM W-101 and Newton. The exception, OK78321, was quite low, having a flour yield value of 52.0%. Dough-mixing times for these lines were within the range of the checks. Of these four lines, OK78337 had the shortest mixing time. Its value of 2.5 min was similar to that of Triumph 64.

Kernel weight response by individual location for the eight elite lines and four checks are presented in Figure 1. Lovrin 6, the large-seeded parent, was inconsistent for kernel weight across locations, being exceptionally low at Stillwater. With the exception of OK78337 and OK78322 those entries which ranked high for kernel weight were variable across locations but none showed the same type of response pattern as Lovrin 6. OK78322 and OK78311 both of which ranked high for yield were stable for kernel weight across the three locations. OK78322 had consistently high kernel weight values at all three locations, while OK78311 had relatively low kernel weight values, being in the range of TAM W-101. The adapted cultivar checks (TAM W-101, Triumph 64, and Newton) represented in Figure 1 were stable for kernel weight across environments.

Asana, as cited by Schmidt (21), concluded from a study of spring wheats in India that kernel weight was an environmentally stable component of yield and contributed to yield and yield stability under drought and high temperature stress. The same stability for kernel weight was observed for adapted cultivars in this test. However, as shown in Figure 1, three of the large-seeded lines (OK78321, OK78338, and OK78353) as well as Lovrin 6, the large seeded parent, were somewhat unstable for kernel weight across three environments. The fact that the lines in this test were selected for high kernel weight may have contributed to significant genotype by environment interaction for kernel weight, in contrast to the report by Asana, as cited by Schmidt (21).

Mixogram data for the eight elite lines and four checks are presented in Figure 2. Newton had satisfactory dough mixing properties while Triumph 64 had a questionable mixing curve. Lovrin 6, TAM W-101, OK78302, OK78321, OK78338, and OK78353 had mixing curves similar to Newton. OK78314 and OK78337 had mixing curves that were better than Triumph 64 but not as good as Newton. OK78311 and OK78322 had mixing curves similar to Triumph 64. In general, the eight elite F_5 lines shown in Figure 2 were satisfactory in terms of overall milling and baking quality characteristics.

CHAPTER V

SUMMARY AND CONCLUSIONS

Fifty-four F_5 selections from a cross of Lovrin 6, a large-seeded wheat from Romania, with TAM W-101, an adapted semidwarf wheat cultivar were evaluated for agronomic and quality characters in replicated tests at three locations in Oklahoma in 1978. Selection for seed size had been practiced in the F_2, F_3, and F_4 generations of this cross. The experimental design was a randomized complete-block with two replications. Each block consisted of 60 two-row plots. Rows were 3.7 m long and 30.5 cm apart. The test was planted at Stillwater, Lahoma, and Haskell at a rate of 180 seeds/plot (50.4 kg/ha). Grain yield, kernel weight, test weight, kernels/spike, tiller number, and plant height were measured on each plot. A three location composite of seed was analyzed for quality characteristics. Wheat protein, flour protein, flour yield, specific sedimentation, mixing time, and mixing curve height were measured for each of the 60 entries.

Analysis of variance tests conducted on agronomic data indicated significant differences among genotypes at each location for the six characters measured. Significant differences among locations were observed for five of the six characters. Tiller number was the only character that did not show significant differences among locations. Genotype by environment interaction was significant at the 0.01 probability level for grain yield, kernel weight, test weight, and plant height. Tiller number was significant at the 0.05 probability level while kernels/spike did not show a significant genotype by environment interaction effect.

Associations among the six agronomic traits were examined by computing phenotypic correlation coefficients for each location separately as well as for combined locations. Kernel weight was negatively associated with kernels/spike and had the highest correlation coefficients of all comparisons. This comparison had correlation values ranging from -.506 to -.724 for Stillwater and Lahoma, respectively. This intermediate to high negative association may indicate possible limitations for simultaneous improvement of these two characters in a breeding program. Correlations between kernel weight and yield and between kernel weight and test weight were low in magnitude for all comparisons and all were positive in sign with the exception of Lahoma data set. Associations between kernel weight and tiller number and between kernel weight and plant height were very low in magnitude and inconsistent with regard to sign. Tiller number was positively associated with grain yield with low to intermediate correlation coefficient values.

One F_5 selection, OK78322, was superior in yield to all other entries, including TAM W-101, the highest yielding adapted check cultivar. Several selections had kernel weight values that were equal to Lovrin 6 but had significantly higher yield values than Lovrin 6. Four lines had higher overall mean kernel weight values than the high parent, Lovrin 6, but these differences were not statistically significant. Tiller number appeared to be an important component of yield. The four highest yielding selections had very high values for tiller number. Adapted check cultivars also had high values for tiller number.

The four selections with the highest grain yield plus the four selections with the highest kernel weight values (designated as elite lines in this study) tended to be less stable across locations for kernel weight than adapted check cultivars. However, two elite lines, OK78337 and OK78322 which ranked first and fourth for kernel weight, respectively, were relatively stable for this trait across three locations. The adapted check cultivars, TAM W-101, Triumph 64, and Newton showed consistent responses for kernel weight across three locations.

Concern has been expressed as to what effect an increase in seed size might have on quality traits, specifically on flour protein and flour yield. Examination of four elite lines in this study having high kernel weight (Table VIII) indicated an increase in seed size per se did not adversely affect flour protein percent. In terms of flour yield percentages, three of the four elite lines were similar to TAM W-101 and Newton. The exception, OK78321, was quite low, having a flour yield of 52.0%. Dough-mixing times for these four elite lines were within the range of the checks.

If kernel weight is an important component of yield, as it has been reported to be, then selection for kernel weight may be more effective in increasing yield than selection for yield per se. The five F_5 selections in this study with the highest kernel weight values had yield ranks that were in the range of the adapted checks. Selection based on kernel weight appeared to be effective in identifying high yielding lines as evidenced by the performance of OK78322. In this test OK78322 showed superiority for grain yield, kernel weight, test weight, and tiller number ranking, respectively, first, fourth, fourth, and second for these characters. This line would be of particular interest in a breeding program where kernel weight and yield were to be emphasized.

LITERATURE CITED

1. Adams, M. W. 1967. Basis of yield component compensation in crop plants with special reference to the field bean (*Phaseolus vulgaris*). Crop Sci. 7:505-510.

2. Amonsilpa, S. 1975. A genetic analysis of kernel weight and other characters in a diallel cross involving five winter wheat parents. (Unpub. M.S. Thesis, Oklahoma State University).

3. Comstock, R. E., and R. H. Moll. 1963. Genotype-environment interactions. In W. D. Hanson and H. F. Robinson (ed.) Statistical genetics and plant breeding. Publ. 982. Nat'l. Acad. Sci. - Nat'l. Res. Council. Washington, D.C., p. 164-194.

4. Donald, C. M. 1968. The breeding of crop ideotypes. Euphytica 17:385-403.

5. Fonseca, S., and F. L. Patterson. 1968. Yield component heritabilities and interrelationships in winter wheat. Crop Sci. 8:614-617.

6. Grafius, J. E. 1956. Components of yield in oats: A geometrical interpretation. Agron. J. 48:419-423.

7. Grafius, J. E., and G. A. Weibe. 1959. Expected genetic gain in yield in small grain: A geometical interpretation. Agron. J. 51:560-562.

8. Hsu, P., and P. D. Walton. 1971. Relationships between yield and its components and structures above the flag leaf node in spring wheat. Crop Sci. 11:190-193.

9. Johnson, V. A., K. J. Biever, A. Haunold, and J. W. Schmidt. 1966. Inheritance of plant height, yield of grain, and other plant and seed characteristics in a cross of hard red winter wheat. *Triticum aestivum L.* Crop Sci. 6:336-338.

10. Johnson, V. A., J. W. Schmidt, and W. Mekasha. 1966. Comparison of yield components and agronomic characteristics of four winter wheat varieties differing in plant height. Agron. J. 58:438-441.

11. Ketata, H. 1971. Performance of three hard red winter wheat varieties sown in different planting arrangements. (Unpub. M.S. Thesis, Oklahoma State University).

12. Ketata, H., L. H. Edwards, and E. L. Smith. 1976. Inheritance of eight agronomic characters in a winter wheat cross. Crop Sci. 16:19-22.

13. Knott, D. R., and B. Talukdar. 1971. Increasing seed weight in wheat and its effect on yield, yield components and quality. Crop Sci. 11:280-283.

14. Lebsock, K. L., and A. Amaya. 1969. Variation and covariation of agronomic traits in durum wheat. Crop Sci. 9:372-375.

15. Lee, J., and P. J. Kaltsikes. 1972. Diallel analysis of correlated sequential characters in durum wheat. Crop Sci. 12:770-772.

16. McNeal, F. H. 1960. Yield components in a Lemhi X Thatcher wheat cross. Agron. J. 52:348-349.

17. McNeal, F. H., C. O. Qualset, D. E. Baldridge, and V. R. Stewart. 1978. Selection for yield and yield components in wheat. Crop Sci. 18:795-799.

18. Paroda, R. S., and A. B. Joshi. 1970. Genetic architecture of yield and components of yield in wheat. Indian J. Genet. 30:298-314.

19. Porter, K. B. 1974. Registration of TAM W-101 wheat. Crop Sci. 14:608.

20. Reddi, M. V., and E. G. Heyne. 1970. Inheritance of plant height, and kernel weight in two wheat crosses. Indian J. Genet. 30:109-115.

21. Schmidt, J. W. 1975. Development of winter wheat varieties for low rainfall, non-irrigated areas. Pages 65-73. Proc. 2nd Int'l. Winter Wheat Conf., Zagreb, Yugoslavia.

22. Sethi, G. S., and H. B. Singh. 1974. Relative importance of some yield contributing characters in triple dwarf wheat. Indian J. Agric. Sci. Vol 44(9):585-590.

23. Sharma, D., and D. R. Knott. 1964. The inheritance of seed weight in a wheat cross. Can. J. Genet. Cytol. 6:419-425.

24. Sidwell, R. J., E. L. Smith, and R. W. McNew. 1976. Inheritance and interrelationships of grain yield and selected yield related traits in a hard red winter wheat cross. Crop Sci. 16:650-654.

25. Smith, E. L. 1976. The genetics of wheat architecture. Oklahoma Academy of Science 6:117-132.

26. Smith, E. L. 1979. Oklahoma Agricultural Experiment Station, Stillwater, Oklahoma. Personal communication.

27. Sun, P. L. F., H. A. Shands, and R. A. Forsberg. 1972. Inheritance of kernel weight in six spring wheat crosses. Crop Sci. 12:1-5.

28. Weibel, D. E. 1956. Inheritance of quantitative characters in wheat (abstract). Iowa State Coll. J. Sci. 30:450-451.

29. Worzella, W. W. 1942. Inheritance and interrelationship of components of quality, cold resistance and morphological characters in wheat hybrids. J. Agr. Res. 65:501-522.

APPENDIX A

TABLES

TABLE I

MEAN SQUARES FOR SIX TRAITS FROM THE ANALYSES OF VARIANCE AT EACH OF THREE LOCATIONS FOR 54 F_5 LINES AND SIX CHECK CULTIVARS

Source of Variation	df	Grain Yield	Kernel Weight	Test Weight	Kernels/ Spike	Tiller Number	Plant Height
Stillwater							
Replication	1	2.70	0.97	12.87**	4.41	15.41	529.20**
Genotype	59	36.59**	54.09**	6.56**	30.19**	30.60**	135.83**
Rep. X Genotype	59	13.61	13.60	0.93	6.20	16.12	13.27
Corrected Total	119	24.91	33.57	3.82	18.08	23.29	78.37
Lahoma							
Replication	1	35.75*	2.85	0.92	4.03	66.01	0.68
Genotype	59	41.07**	38.88**	5.05**	27.63**	53.87**	112.30**
Rep. X Genotype	59	9.01	3.43	0.29	2.86	20.69	16.84
Corrected Total	119	25.13	21.00	2.66	15.15	37.52	64.04
Haskell							
Replication	1	42.60*	10.09	1.30	9.63	88.41*	14.70
Genotype	59	47.04**	60.54**	14.42**	21.33**	34.19**	151.53**
Rep. X Genotype	59	7.92	8.08	0.55	4.36	18.70	7.92
Corrected Total	119	27.62	34.11	7.43	12.82	27.00	79.18

*, ** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE II

MEAN SQUARES FOR SIX TRAITS FROM THE COMBINED ANALYSIS OF VARIANCE OF 54 F_5 LINES AND SIX CHECK CULTIVARS

Source of Variation	df	Grain Yield	Kernel Weight	Test Weight	Kernels/ Spike	Tiller Number	Plant Height
Location	2	717.14**	237.16**	43.55*	284.94**	337.63	8442.99**
Replication (Loc)	3	27.04	4.64	5.03	6.03	56.61	181.53
Genotype	59	83.07**	121.01**	21.46**	68.18**	69.58**	352.70**
Loc. X Genotype	118	20.83**	16.25**	2.29**	5.49	24.54*	23.48**
Rep. X Genotype (Loc)	177	10.18	8.37	0.59	4.48	18.50	12.68
Corrected Total	359	29.74	30.72	4.85	16.85	30.98	120.49

*, ** Significant at the 0.05 and 0.01 levels of probability, respectively.

TABLE III

PHENOTYPIC CORRELATION COEFFICIENTS FOR ALL POSSIBLE TWO-WAY COMPARISONS AMONG SIX AGRONOMIC TRAITS MEASURED ON 54 F_5 LINES AND SIX CHECK CULTIVARS

	Kernel Weight	Test Weight	Kernels/ Spike	Tiller Number	Plant Height	
Grain Yield	.265**	.328**	-.045	.368**	-.067	Combined
	.358**	.436**	-.088	.464**	.208*	Stillwater
	-.194*	.138	.138	.456**	-.101	Lahoma
	.393**	.604**	.072	.273**	.212*	Haskell
Kernel Weight		.128*	-.564**	-.091	-.131*	Combined
		.104	-.506**	.042	.011	Stillwater
		-.180	-.724**	-.322**	-.074	Lahoma
		.343**	-.578**	.033	.005	Haskell
Test Weight			.174**	.093	.244**	Combined
			.081	.159	.296**	Stillwater
			.171	.152	.378**	Lahoma
			.114	.142	.338**	Haskell
Kernels/ Spike				-.068	.076	Combined
				-.070	.082	Stillwater
				.077	.159	Lahoma
				-.048	.149	Haskell
Tiller Number					.193**	Combined
					.056	Stillwater
					.138	Lahoma
					.162	Haskell

*, ** Significant at the 0.05 and 0.01 levels of probability, respectively.
Associated degrees of freedom are 358 and 118 for combined and individual locations, respectively.

TABLE IV

AGRONOMIC DATA FOR 54 F_5 LINES AND SIX CHECK CULTIVARS

Entry No.	Selection Number	Grain Yield (kg/ha)	Kernel Weight (g/1000)	Test Weight (kg/ha)	Kernels/ Spike	Tiller Number	Plant Height (cm)
1	OK78301	2349.0(9)	41.7(32)	73.9(32)	29.0(10)	36.3(43)	89.0(32)
2	OK78302	2517.2(5)	44.0(16)	75.1(15)	24.5(41)	43.5(4)	97.5(8)
3	OK78303	2253.7(15)	45.1(13)	74.8(18)	24.5(42)	37.7(32)	77.8(56)
4	OK78304	2175.2(24)	40.8(39)	71.9(45)	27.5(24)	42.0(15)	95.2(16)
5	OK78305	2169.6(25)	40.4(40)	72.5(39)	25.8(33)	38.3(26)	87.8(35)
6	OK78306	2365.8(8)	46.4(9)	75.1(16)	24.8(38)	38.8(25)	99.5(4)
7	OK78307	1530.5(59)	39.0(47)	68.3(58)	24.3(43)	36.0(46)	90.2(29)
8	OK78308	2074.3(35)	41.5(34)	74.5(22)	23.8(52)	42.5(8)	95.5(12)
9	OK78309	2107.9(34)	43.4(20)	71.2(2)	27.3(26)	35.0(52)	93.0(21)
10	OK78310	2023.8(43)	38.3(52)	72.4(42)	30.7(6)	34.8(53)	82.8(47)
11	OK78311	2522.8(3)	37.6(54)	75.7(10)	31.7(4)	42.8(6)	95.0(17)
12	OK78312	2276.1(14)	42.9(25)	73.4(36)	26.0(29)	40.8(17)	90.8(27)
13	OK78313	2248.1(17)	41.6(33)	73.9(31)	25.8(32)	40.7(19)	87.7(36)
14	OK78314	2517.2(4)	42.6(26)	76.8(3)	25.7(35)	42.5(9)	100.0(2)
15	OK78315	1822.0(54)	43.1(22)	71.2(50)	26.0(30)	37.0(40)	93.3(20)
16	OK78316	2141.6(30)	42.4(29)	69.9(54)	23.8(51)	41.3(16)	81.5(51)
17	OK78317	2164.0(28)	43.6(19)	70.1(53)	24.2(45)	43.5(5)	83.5(46)
18	OK78318	1922.9(51)	41.1(37)	74.3(25)	24.7(39)	39.2(22)	96.0(11)
19	OK78319	1743.5(56)	36.6(57)	74.1(27)	27.5(23)	36.3(44)	98.3(5)
20	OK78320	1878.1(52)	37.0(56)	73.7(34)	30.0(7)	35.8(49)	97.3(9)
21	OK78321	2326.6(11)	49.7(2)	75.0(17)	23.5(54)	40.8(18)	97.1(7)
22	OK78322	2904.0(1)	47.4(4)	76.4(4)	24.0(46)	43.8(2)	95.5(13)
23	OK78323	1687.5(58)	38.1(53)	68.0(59)	26.7(27)	30.5(59)	91.5(24)
24	OK78324	1872.5(53)	39.1(46)	67.8(60)	28.7(14)	34.3(55)	92.0(23)
25	OK78325	2321.0(12)	43.9(18)	74.8(19)	31.3(5)	36.0(47)	88.0(34)
26	OK78326	2292.9(13)	46.7(8)	75.4(14)	28.5(15)	37.5(35)	91.5(25)
27	OK78327	2023.8(44)	38.8(48)	75.6(13)	28.2(20)	34.2(56)	88.8(33)
28	OK78328	2051.9(39)	41.5(36)	73.4(35)	25.0(37)	42.2(12)	91.5(26)
29	OK78329	2169.6(27)	45.4(11)	72.4(41)	23.7(52)	40.0(20)	90.7(28)
30	OK78330	2068.7(37)	42.4(28)	71.9(47)	24.0(47)	38.2(28)	85.2(44)
31	OK78331	2152.8(29)	40.8(38)	71.7(48)	24.3(44)	39.0(23)	84.5(45)
32	OK78332	2192.0(23)	42.7(27)	69.7(55)	24.0(48)	37.5(36)	80.5(53)
33	OK78333	2349.0(10)	40.4(41)	69.7(56)	25.7(34)	42.5(10)	80.5(54)
34	OK78334	2236.9(19)	38.5(49)	75.6(11)	28.8(12)	37.7(33)	86.8(41)
35	OK78335	1984.6(48)	42.2(31)	72.3(43)	25.8(31)	37.3(38)	81.7(50)
36	OK78336	2057.5(38)	40.2(42)	74.2(26)	28.3(17)	36.0(48)	86.5(43)
37	OK78337	2119.1(33)	50.5(1)	75.6(12)	23.0(56)	37.5(37)	104.8(1)
38	OK78338	2051.9(40)	49.6(3)	71.9(44)	21.0(59)	37.3(39)	80.8(52)
39	OK78339	1951.0(49)	44.3(15)	71.2(49)	24.0(49)	40.0(21)	81.8(49)
40	OK78340	2192.0(22)	44.6(14)	74.5(23)	26.3(28)	34.8(54)	94.7(18)
41	OK78341	2012.6(46)	42.9(24)	76.4(5)	20.3(60)	37.0(41)	87.0(40)
42	OK78342	2046.3(41)	46.9(7)	76.1(7)	21.2(58)	42.2(13)	87.3(39)
43	OK78343	2040.7(42)	38.5(51)	73.9(30)	29.8(8)	32.5(58)	93.5(19)
44	OK78344	1995.8(47)	42.3(30)	74.5(24)	27.8(21)	35.8(50)	98.0(6)
45	OK78345	1760.3(55)	37.4(55)	72.5(40)	29.7(9)	37.8(31)	95.2(15)
46	OK78346	2169.6(26)	43.1(21)	72.6(38)	28.7(13)	33.3(57)	92.8(22)
47	OK78347	1934.1(50)	43.1(23)	76.4(6)	28.2(19)	37.0(42)	86.8(42)
48	OK78348	2253.7(16)	39.3(45)	74.1(28)	28.8(11)	35.8(51)	95.2(14)
49	OK78349	2074.3(36)	46.0(10)	73.8(33)	24.7(40)	38.3(27)	70.3(59)
50	OK78350	2248.1(18)	41.5(35)	74.1(29)	28.3(16)	37.7(34)	89.8(31)
51	OK78351	2119.1(32)	45.3(12)	75.9(8)	28.2(18)	37.8(30)	99.7(3)
52	OK78352	1496.9(60)	39.3(44)	70.6(51)	21.5(57)	36.2(45)	87.7(37)
53	OK78353	2203.2(21)	47.0(6)	71.9(46)	23.3(55)	38.0(29)	74.3(57)
54	OK78354	2461.1(7)	44.0(17)	70.6(52)	25.2(36)	38.8(24)	69.8(60)
55	Tam W-101	2534.0(2)	38.5(50)	75.7(9)	27.3(25)	42.8(7)	82.8(48)
56	Lovrin 6	1709.9(57)	47.2(5)	69.0(57)	23.8(50)	28.8(60)	71.5(58)
57	Triumph 64	2466.7(6)	39.9(43)	79.0(1)	27.7(22)	42.2(14)	96.8(10)
58	Osage	2023.8(45)	27.7(59)	74.7(20)	32.5(3)	43.7(3)	90.2(30)
59	Vona	2124.8(31)	27.4(60)	74.6(21)	37.5(1)	44.0(1)	79.2(55)
60	Newton	2203.2(20)	30.4(58)	73.2(37)	37.2(2)	42.5(11)	87.3(38)
	Means	2128.1	41.7	73.4	26.6	38.4	89.0
	L.S.D. 0.05	244.6	3.3	1.1	2.4	4.9	4.1

Six agronomic traits are based on means of three locations.

TABLE V

QUALITY DATA FOR 54 F_5 LINES AND SIX CHECK CULTIVARS

Entry No.	Selection Number	Wheat Protein %	Flour Protein %	Flour Yield %	Specific Sediment	Mixing Time (min)	Mix Curve Height
1	OK78301	15.1(22)	13.4(23)	63.2(22)	4.7(19)	3.1(31)	28.5(15)
2	OK78302	14.6(40)	12.7(45)	64.0(17)	4.6(27)	3.3(29)	28.0(29)
3	OK78303	15.1(24)	12.9(37)	56.8(51)	4.3(49)	2.5(51)	28.0(32)
4	OK78304	13.2(60)	11.1(60)	47.0(60)	4.8(16)	3.1(32)	27.0(43)
5	OK78305	15.3(16)	13.4(24)	59.2(40)	4.0(56)	2.8(46)	29.0(11)
6	OK78306	14.4(46)	12.1(59)	62.4(25)	4.5(35)	3.5(18)	28.0(28)
7	OK78307	14.9(26)	12.7(41)	56.8(46)	4.4(38)	3.5(12)	24.0(59)
8	OK78308	16.2(5)	14.5(2)	66.4(6)	4.1(53)	2.9(42)	30.0(4)
9	OK78309	15.7(8)	14.1(4)	65.5(7)	4.5(37)	2.9(43)	32.0(1)
10	OK78310	13.6(58)	12.6(49)	59.2(41)	4.4(42)	3.3(28)	26.0(52)
11	OK78311	14.6(39)	13.2(26)	67.2(4)	4.9(12)	2.3(56)	28.5(16)
12	OK78312	14.8(30)	13.6(15)	60.8(31)	4.3(45)	3.3(23)	28.0(21)
13	OK78313	14.6(37)	13.0(32)	65.6(8)	5.2(2)	3.9(8)	26.0(49)
14	OK78314	13.3(59)	12.5(52)	57.6(45)	4.6(28)	2.8(47)	26.5(45)
15	OK78315	13.8(56)	12.8(39)	56.8(52)	4.5(36)	3.0(40)	26.0(55)
16	OK78316	15.7(9)	14.1(5)	56.8(49)	4.6(26)	3.3(27)	29.0(12)
17	OK78317	15.8(7)	12.8(38)	59.2(37)	4.5(31)	3.3(24)	28.0(22)
18	OK78318	17.2(1)	15.1(1)	59.2(35)	3.9(58)	3.0(34)	30.0(5)
19	OK78319	13.6(57)	12.4(53)	64.8(13)	4.9(10)	4.0(3)	27.0(38)
20	OK78320	13.8(54)	12.5(50)	64.8(14)	5.1(4)	4.8(1)	26.5(47)
21	OK78321	16.3(3)	13.6(18)	52.0(57)	5.0(7)	3.4(21)	27.0(42)
22	OK78322	15.2(18)	13.5(20)	63.2(21)	4.2(50)	2.3(55)	28.0(20)
23	OK78323	14.9(27)	12.6(47)	54.4(54)	4.6(25)	3.5(19)	26.0(51)
24	OK78324	14.5(44)	12.7(44)	53.6(55)	4.3(48)	3.5(17)	26.0(53)
25	OK78325	14.5(41)	13.6(17)	58.4(42)	4.4(40)	2.6(48)	28.0(24)
26	OK78326	15.2(20)	12.7(43)	63.2(23)	4.7(20)	2.0(60)	28.0(26)
27	OK78327	15.2(19)	12.3(55)	60.0(34)	4.5(32)	3.6(9)	25.0(57)
28	OK78328	15.1(23)	13.9(8)	65.6(9)	4.7(21)	3.5(15)	28.0(27)
29	OK78329	14.8(32)	13.2(28)	62.3(27)	4.4(44)	2.5(53)	28.0(33)
30	OK78330	14.9(29)	13.7(12)	60.8(33)	4.6(29)	3.6(11)	29.0(14)
31	OK78331	15.2(21)	13.4(25)	62.4(28)	4.9(14)	4.0(7)	28.0(36)
32	OK78332	14.8(33)	13.7(14)	56.0(53)	4.7(23)	3.5(20)	28.5(18)
33	OK78333	14.8(31)	13.5(21)	64.0(19)	4.7(22)	3.0(41)	31.0(2)
34	OK78334	15.6(11)	13.7(11)	67.2(3)	4.4(41)	4.5(2)	28.0(25)
35	OK78335	15.6(13)	14.1(7)	67.2(5)	4.8(17)	3.4(22)	28.0(34)
36	OK78336	14.5(45)	13.0(33)	57.6(44)	4.1(54)	3.0(38)	26.0(54)
37	OK78337	14.7(35)	13.6(19)	65.6(11)	4.4(43)	2.5(50)	28.0(30)
38	OK78338	14.5(42)	12.5(51)	60.8(32)	4.8(15)	4.0(5)	26.5(44)
39	OK78339	13.8(53)	12.2(57)	59.2(36)	4.6(30)	3.5(13)	25.0(56)
40	OK78340	14.7(34)	13.1(29)	62.4(24)	3.7(60)	2.1(57)	28.0(19)
41	OK78341	15.3(17)	13.8(10)	64.0(20)	4.1(55)	2.5(54)	28.0(35)
42	OK78342	16.3(4)	14.4(3)	61.6(30)	3.8(59)	2.5(49)	30.0(6)
43	OK78343	15.9(6)	13.1(31)	53.6(56)	4.0(57)	2.1(58)	30.0(8)
44	OK78344	15.4(14)	13.4(22)	59.2(39)	4.3(46)	2.0(59)	27.0(40)
45	OK78345	13.8(55)	13.2(27)	56.8(50)	4.2(51)	2.9(44)	28.0(31)
46	OK78346	15.6(10)	12.7(42)	47.0(59)	4.4(39)	3.0(35)	26.0(48)
47	OK78347	14.2(48)	12.3(56)	56.8(48)	4.9(11)	4.0(6)	24.0(60)
48	OK78348	14.1(49)	13.1(30)	64.0(18)	5.0(9)	3.0(39)	30.0(7)
49	OK78349	15.6(12)	12.9(36)	50.4(58)	5.0(6)	3.0(36)	27.0(41)
50	OK78350	15.0(25)	14.1(6)	65.6(10)	4.5(34)	3.0(37)	31.0(3)
51	OK78351	14.5(43)	12.6(48)	71.2(1)	4.3(47)	2.8(45)	29.0(10)
52	OK78352	15.3(15)	12.2(58)	57.6(43)	4.5(33)	3.3(25)	27.0(37)
53	OK78353	14.3(47)	12.8(40)	62.4(26)	5.1(5)	3.1(33)	26.5(46)
54	OK78354	14.9(28)	13.8(9)	64.0(16)	5.0(8)	3.5(16)	28.5(17)
55	Tam W-101	13.9(52)	12.9(35)	61.6(29)	5.3(1)	3.5(14)	27.0(39)
56	Lovrin 6	16.9(2)	13.6(16)	56.8(47)	4.6(24)	3.3(26)	28.0(23)
57	Triumph 64	14.0(50)	13.7(13)	68.8(2)	4.2(52)	2.5(52)	30.0(9)
58	Osage	14.7(36)	13.0(34)	65.6(12)	4.9(13)	3.3(30)	29.0(13)
59	Vona	14.0(51)	12.6(46)	59.2(38)	5.2(3)	4.0(4)	25.0(58)
60	Newton	14.6(38)	12.4(54)	64.0(15)	4.7(18)	3.6(10)	26.0(50)
	Means	14.9	13.1	60.7	4.6	3.2	27.7

Quality traits are based on analysis of three location grain composites.

TABLE VI

MEAN GRAIN YIELD FOR 54 F_5 LINES AND SIX CHECK CULTIVARS AT EACH OF THREE LOCATIONS

Entry No.	Sel. No.	Stillwater 2 Reps	Lahoma 2 Reps	Haskell 2 Reps	3 Location Mean & Rank
1	OK78301	2321.0	2556.4	2169.6	2349.0 (9)
2	OK78302	2808.7	2623.7	2119.1	2517.2 (5)
3	OK78303	2321.0	2405.1	2035.0	2253.7 (15)
4	OK78304	2152.8	2522.8	1850.0	2175.2 (24)
5	OK78305	2051.9	2405.1	2051.9	2169.6 (25)
6	OK78306	2236.9	2724.6	2136.0	2365.8 (8)
7	OK78307	1580.9	1580.9	1429.6	1530.5 (59)
8	OK78308	1951.0	2203.2	2068.7	2074.3 (35)
9	OK78309	1917.3	2354.6	2051.9	2107.9 (34)
10	OK78310	1782.8	2438.7	1850.0	2023.8 (43)
11	OK78311	2018.2	2808.7	2741.4	2522.8 (3)
12	OK78312	2270.5	2321.0	2236.9	2276.1 (14)
13	OK78313	2270.5	2405.1	2068.7	2248.1 (17)
14	OK78314	2489.2	2808.7	2253.7	2517.2 (4)
15	OK78315	1715.5	2068.7	1681.9	1822.0 (54)
16	OK78316	2035.1	2472.3	1917.3	2141.6 (30)
17	OK78317	2102.3	2623.7	1766.0	2164.0 (28)
18	OK78318	1866.9	2119.1	1782.8	1922.9 (51)
19	OK78319	1597.8	1665.0	1967.8	1743.5 (56)
20	OK78320	1883.7	1850.0	1900.5	1878.1 (52)
21	OK78321	2018.2	2304.1	2657.3	2326.6 (11)
22	OK78322	2892.8	2892.8	2926.4	2904.0 (1)
23	OK78323	1547.3	2018.2	1496.9	1686.5 (58)
24	OK78324	1900.5	2220.1	1496.9	1872.5 (53)
25	OK78325	2051.9	2489.2	2421.9	2321.0 (12)
26	OK78326	1917.3	2405.1	2556.4	2292.9 (13)
27	OK78327	1951.0	2337.8	1782.8	2023.8 (44)
28	OK78328	2085.5	2203.2	1866.9	2051.9 (39)
29	OK78329	1951.0	2506.0	2051.9	2169.6 (27)
30	OK78330	1951.0	2388.2	1866.9	2068.7 (37)
31	OK78331	1934.1	2405.1	2119.1	2152.8 (29)
32	OK78332	2102.3	2388.2	2085.5	2192.0 (23)
33	OK78333	2287.3	2522.8	2236.9	2349.0 (10)
34	OK78334	2119.1	2321.0	2270.5	2236.9 (19)
35	OK78335	1866.9	2119.1	1967.8	1984.6 (48)
36	OK78336	2152.8	2371.4	1648.2	2057.5 (38)
37	OK78337	2152.8	1681.9	2522.8	2119.1 (33)
38	OK78338	2102.3	1934.1	2119.1	2051.9 (40)
39	OK78339	1799.6	2253.7	1799.6	1951.0 (49)
40	OK78340	2186.4	2337.8	2051.9	2192.0 (22)
41	OK78341	2035.0	2304.1	1698.7	2012.6 (46)
42	OK78342	1951.0	2253.7	1934.1	2046.3 (41)
43	OK78343	2136.0	2068.7	1917.3	2040.7 (42)
44	OK78344	1934.1	2136.0	1917.3	1995.8 (47)
45	OK78345	1715.5	2035.0	1530.5	1760.3 (55)
46	OK78346	2102.3	2270.5	2136.0	2169.6 (26)
47	OK78347	2035.0	1984.6	1782.8	1934.1 (50)
48	OK78348	2539.6	2354.6	1866.9	2253.7 (16)
49	OK78349	1883.7	2455.5	1883.7	2074.3 (36)
50	OK78350	2186.4	2455.5	2102.3	2248.1 (18)
51	OK78351	2573.2	1665.0	2119.1	2119.1 (32)
52	OK78352	1665.0	1779.6	1025.9	1496.9 (60)
53	OK78353	2236.9	2354.6	2018.2	2203.2 (21)
54	OK78354	2640.5	2556.4	2186.4	2461.1 (7)
55	Tam W-101	2119.1	3027.3	2455.5	2534.0 (2)
56	Lovrin 6	1345.5	2085.5	1698.7	1709.9 (57)
57	Triumph 64	2354.6	2674.2	2371.4	2466.7 (6)
58	Osage	2035.0	2152.8	1883.7	2023.8 (45)
59	Vona	1866.9	2741.4	1766.0	2124.7 (31)
60	Newton	1917.3	2506.0	2186.4	2203.2 (20)
	Means	2060.3	2315.6	2008.4	2128.1
	L.S.D. 0.05	496.6	404.2	378.9	244.6
	C.V.	12.1%	8.7%	9.4%	10.1%

TABLE VII

MEAN KERNEL WEIGHT FOR 54 F_5 LINES AND SIX CHECK CULTIVARS AT EACH OF THREE LOCATIONS

Entry No.	Sel. No.	Stillwater 2 Reps	Lahoma 2 Reps	Haskell 2 Reps	3 Location Mean & Rank
1	OK78301	41.8	42.1	41.0	41.7 (32)
2	OK78302	47.9	43.5	40.4	44.0 (16)
3	OK78303	46.8	43.9	44.6	45.1 (13)
4	OK78304	42.7	43.9	35.8	40.8 (39)
5	OK78305	43.8	40.2	37.3	40.4 (40)
6	OK78306	45.5	47.0	46.8	46.4 (9)
7	OK78307	39.2	42.8	35.0	39.0 (47)
8	OK78308	39.6	44.7	40.3	41.5 (34)
9	OK78309	42.3	41.3	46.5	43.4 (20)
10	OK78310	41.8	40.6	32.6	38.3 (52)
11	OK78311	38.2	37.6	36.9	37.6 (54)
12	OK78312	41.7	42.8	44.0	42.9 (25)
13	OK78313	39.9	45.1	39.9	41.6 (33)
14	OK78314	46.9	45.0	36.0	42.6 (26)
15	OK78315	44.9	46.3	38.2	43.1 (22)
16	OK78316	44.5	43.9	38.8	42.4 (29)
17	OK78317	44.4	46.0	40.3	43.6 (19)
18	OK78318	38.1	46.1	39.1	41.1 (37)
19	OK78319	38.3	41.5	30.2	36.6 (57)
20	OK78320	40.9	41.1	28.9	37.0 (56)
21	OK78321	47.9	48.7	52.6	49.7 (2)
22	OK78322	47.8	46.5	47.9	47.4 (4)
23	OK78323	36.2	43.8	34.4	38.1 (53)
24	OK78324	39.6	42.4	35.2	39.1 (46)
25	OK78325	41.7	45.1	44.9	43.9 (18)
26	OK78326	45.7	45.5	48.8	46.7 (8)
27	OK78327	35.2	41.6	39.6	38.8 (48)
28	OK78328	43.9	41.9	38.8	41.5 (36)
29	OK78329	43.7	45.5	47.1	45.4 (11)
30	OK78330	43.5	42.9	40.9	42.4 (28)
31	OK78331	41.0	42.2	39.4	40.8 (38)
32	OK78332	39.8	44.1	44.3	42.7 (27)
33	OK78333	38.8	40.9	41.5	40.4 (41)
34	OK78334	37.3	38.8	39.4	38.5 (49)
35	OK78335	40.7	43.5	42.4	42.2 (31)
36	OK78336	41.3	39.1	40.1	40.2 (42)
37	OK78337	50.4	51.0	50.0	50.5 (1)
38	OK78338	52.4	51.9	44.5	49.6 (3)
39	OK78339	44.8	46.6	41.3	44.3 (15)
40	OK78340	45.7	45.3	42.8	44.6 (14)
41	OK78341	36.7	46.3	45.9	42.9 (24)
42	OK78342	48.8	47.1	45.0	46.9 (7)
43	OK78343	39.5	39.2	36.7	38.5 (51)
44	OK78344	46.0	40.0	40.8	42.3 (30)
45	OK78345	35.5	41.3	35.5	37.4 (55)
46	OK78346	44.2	43.1	42.1	43.1 (21)
47	OK78347	43.1	44.3	42.0	43.1 (23)
48	OK78348	41.8	40.0	36.0	39.3 (45)
49	OK78349	48.6	45.9	43.6	46.0 (10)
50	OK78350	39.5	44.1	41.0	41.5 (35)
51	OK78351	48.4	43.5	44.0	45.3 (12)
52	OK78352	36.1	46.1	35.7	39.3 (44)
53	OK78353	52.0	43.7	45.4	47.0 (6)
54	OK78354	45.4	45.6	40.9	44.0 (17)
55	Tam W-101	37.0	39.1	39.4	38.5 (50)
56	Lovrin 6	40.3	52.1	49.3	47.2 (5)
57	Triumph 64	40.3	39.7	39.7	39.9 (43)
58	Osage	26.7	29.3	27.0	27.7 (59)
59	Vona	27.2	27.6	27.3	27.4 (60)
60	Newton	30.7	31.1	29.5	30.4 (58)
	Means	41.9	43.0	40.2	41.7
	L.S.D. 0.05	7.4	3.7	5.7	3.3
	C.V.	8.8%	4.3%	7.1%	6.9%

TABLE VIII

AGRONOMIC AND QUALITY DATA FOR EIGHT ELITE LINES AND FOUR CHECK CULTIVARS

Entry No.	Selection Number	Grain Yield (kg/ha)	Kernel Weight (g/1000)	Test Weight (kg/ha)	Kernels/ Spike	Tiller Number	Plant Height (cm)	Wheat Protein %	Flour Protein %	Flour Yield %	Specific Sediment	Mixing Time (min)	Mix Curve Height
22	OK78322	2904.0(1)	47.4(4)	74.4(4)	24.0(46)	43.8(2)	95.5(13)	15.2(18)	13.5(20)	63.2(21)	4.2(50)	2.3(50)	28.0(20)
11	OK78311	2522.8(3)	37.6(54)	75.7(10)	31.7(4)	42.8(6)	95.0(17)	14.6(39)	13.2(26)	67.2(4)	4.9(12)	2.3(56)	28.5(16)
14	OK78314	2517.2(4)	42.6(27)	76.8(3)	25.7(35)	42.5(9)	100.0(2)	13.3(59)	12.5(52)	57.6(45)	4.6(28)	2.8(47)	26.5(45)
02	OK78302	2517.2(5)	44.0(16)	75.1(15)	24.5(41)	43.5(4)	97.5(8)	14.6(40)	12.7(45)	64.0(17)	4.6(27)	3.3(29)	28.0(29)
37	OK78337	2119.1(33)	50.5(1)	75.6(12)	23.0(56)	37.5(37)	104.8(1)	14.7(35)	13.6(19)	65.6(11)	4.4(43)	2.5(50)	28.0(30)
21	OK78321	2326.6(11)	49.7(2)	75.0(17)	23.5(54)	40.8(18)	97.7(7)	16.3(3)	13.6(18)	52.0(57)	5.0(7)	3.4(21)	27.0(42)
38	OK78338	2051.9(40)	49.6(3)	71.9(44)	21.0(59)	37.3(39)	80.8(52)	14.5(42)	12.5(51)	60.8(32)	4.8(15)	4.0(5)	26.5(44)
53	OK78353	2203.2(21)	47.0(6)	71.9(46)	23.3(55)	38.0(29)	74.3(57)	14.3(47)	12.8(40)	62.4(26)	5.1(5)	3.1(33)	26.5(45)
55	Tam W-101	2534.0(2)	38.5(50)	75.7(9)	27.3(25)	42.8(7)	82.8(48)	13.9(52)	12.9(35)	61.6(29)	5.3(1)	3.5(14)	27.0(39)
56	Lovrin 6	1709.9(57)	47.2(5)	69.0(57)	23.8(50)	28.8(60)	71.5(58)	16.9(2)	13.6(16)	56.8(47)	4.6(24)	3.3(26)	28.0(23)
57	Triumph 64	2466.7(6)	39.9(43)	79.0(1)	27.7(22)	42.2(14)	96.8(10)	14.0(50)	13.7(13)	68.8(2)	4.2(52)	2.5(52)	30.0(9)
60	Newton	2203.2(20)	30.4(58)	73.2(37)	37.2(2)	42.5(11)	87.3(38)	14.6(38)	12.4(54)	64.0(15)	4.7(18)	3.6(10)	26.0(50)
Means for 60 entries at 3 locations		2128.1	41.7	73.4	26.6	38.4	89.0	14.9	13.1	60.7	4.6	3.2	27.7

Six agronomic traits are based on means of three locations, six quality traits are based on analysis of three location grain composites.

APPENDIX B

FIGURES

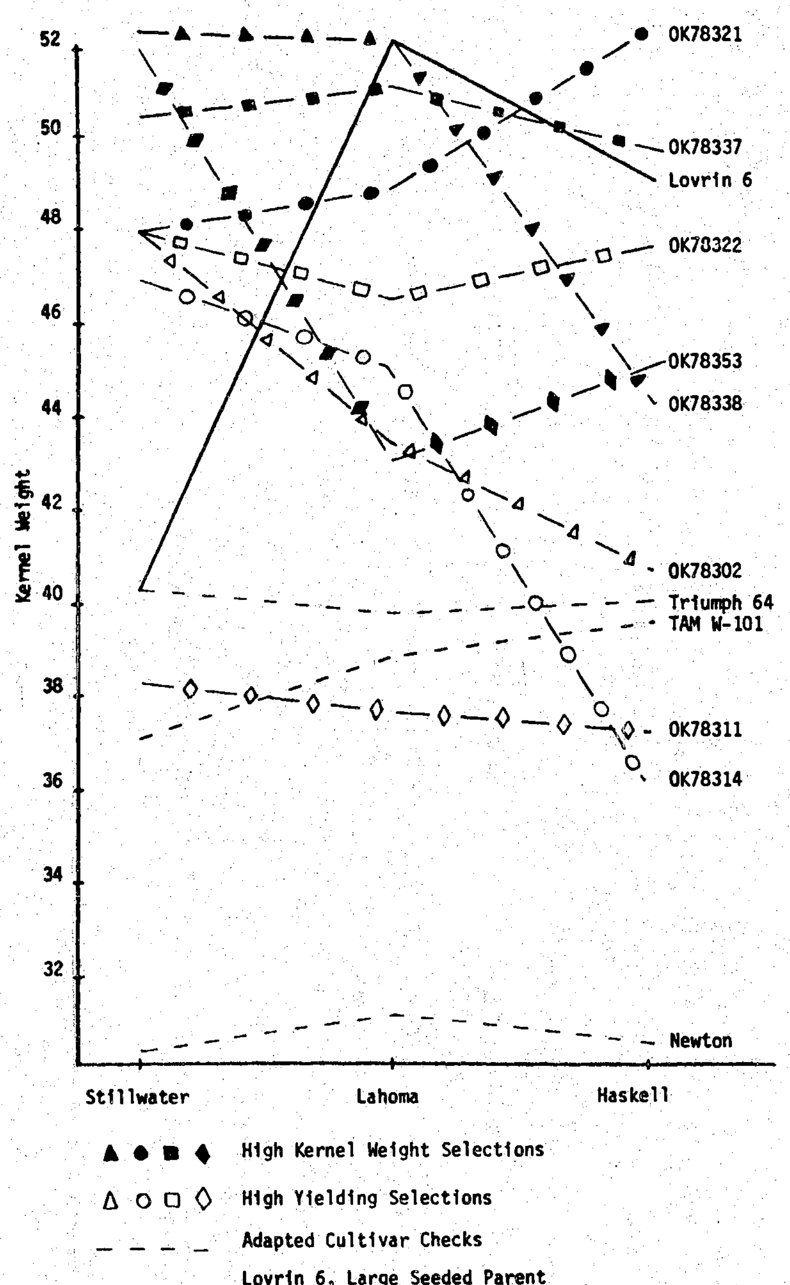

Figure 1. Kernel Weight by Environment Interaction for Eight Elite Lines and Four Check Cultivars.

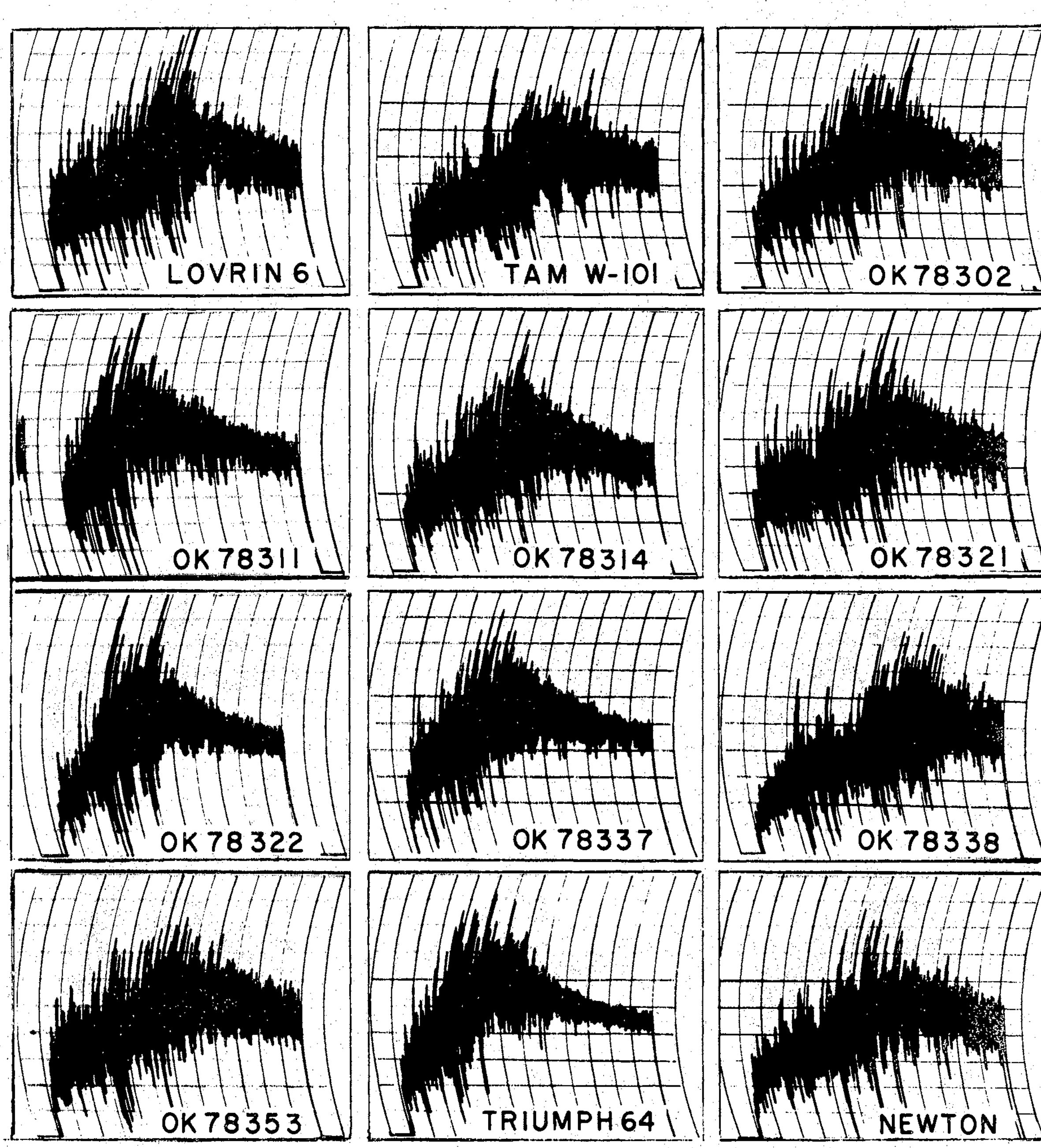

Figure 2. Mixogram Data for Eight Elite Lines and Four Check Cultivars.

VITA ²

F. Phyll Cammack

Candidate for the Degree of

Master of Science

Thesis: AGRONOMIC AND QUALITY CHARACTERISTICS OF SELECTED LARGE-SEEDED WHEAT LINES

Major Field: Agronomy

Biographical:

Personal Date: Born in Rexburg, Idaho, February 10, 1953, the son of Mr. and Mrs. Elwin F. Cammack.

Education: Graduated from Middleton High School, Middleton, Wisconsin in 1971; received the Bachelor of Science degree from Brigham Young University, Provo, Utah in 1977, with a major in Agronomy; completed requirements for the Master of Science degree at Oklahoma State University in May, 1979, with a major in Agronomy.

Professional Experience: Assistant technician, Horticulture Department, University of Wisconsin, May-August, 1975 and 1976; Research Assistant, Department of Agronomy, Oklahoma State University, Stillwater, Oklahoma, June, 1977 to June, 1979. Student member of American Society of Agronomy.