AGRONOMIC PERFORMANCE OF WHEAT, BARLEY, AND TRITICALE AS AFFECTED BY LEVELS OF NITROGEN AND PHOSPHORUS

By

ROBERT EDWARD KLEIN

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Oklahoma State University

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Thesis Approved:

Edward L. Smith
Thesis Adviser

Lavoy I. Croy

Lewis H. Edwards

D. D. Durham
Dean of the Graduate College

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TABLE OF CONTENTS

LIST OF TABLES

Table | Page

LIST OF FIGURES

Figure		Page

CHAPTER I

INTRODUCTION

Each year, the Great Plains area loses productive agricultural land to highways, roads, cities, and industry. The only way this loss of land can be offset is through increased production efficiency on the remaining land. Wheat, one of the leading crops in the Great Plains, is one of the prime candidates for a program to increase efficiency of production. Barley is an important feed crop in the Great Plains. It is another cereal crop that should be considered in a program for improving production efficiency. In an attempt to increase production, new crops are being sought and tested for possible utilization. Triticale is one of the new crops that could prove very beneficial in the search for more productive food and feed crops. However, in order to become a valuable crop, many production weaknesses in the plant will have to be corrected.

In order to increase grain and forage yields, the crop plant must be made more efficient in the use of some growth factor(s). Yield is controlled by many genes and has proven to be very difficult to manipulate in breeding programs. However, the plant breeder can study yield components and determine their relationship to yield. This type of approach promises to be rewarding. A study of the effects of nitrogen and phosphorus on these yield components and their relationship to total yield could result in an efficient method of increasing yield with more success than by working with yield *per se*.

Higher levels of applied fertilizer have been shown to increase crop yields. However, levels greater than plants can utilize effectively could result in decreased production, a reduction in quality, or in agricultural pollution problems. In addition, economic returns for the investment must be recognized in order to go to higher fertility levels. Effective use of fertilizer and crop management are essential for increased production and improved quality.

Protein content is also in need of improvement. Since wheat contributes a large portion of protein to the human diet, genetic and biochemical mechanisms are being considered for increasing protein content. Until high protein varieties are developed however, spring applications of nitrogen can be used to effectively increase protein content.

The primary objectives of this study are: 1) to investigate the response of wheat, barley and triticale to various nitrogen and phosphorus treatment combinations; and 2) to determine the relative importance and the interrelationships between yield and yield components in those varieties and the effects of nitrogen and phosphorus on these yield components.

CHAPTER II

REVIEW OF LITERATURE

Effects of Nitrogen and Phosphorus on Yield

Many studies have been conducted to investigate the effects of nitrogen and phosphorus on total grain yield in wheat and other small grain crops. Although investigations have proven the effectiveness of nitrogen and phosphorus for improving yield, less information is available on the effects of nitrogen and phosphorus on components of yield. According to Engledow and Wadham (14) and Kiesselbach and Sprague (25), the three components in the cereals responsible for total grain yield are the number of tillers per unit area, the number of kernels per head, and the average weight per kernel.

Factors such as rainfall and fallowing have been shown to influence the response of a crop species to nitrogen and phosphorus. Smika (34) concluded that in the Great Plains, nitrogen consistently increased yield on continuous wheat. With fallowing, however, yield was not always increased with nitrogen. Martin and Leonard (28) contend that soil nitrates are increased by fallowing causing a reduced response to nitrogen. Eck and Tucker (11) summarized 104 fertilizer experiments on wheat and reported that rainfall distribution was more important than total rainfall. Highest yields were obtained with a combination of nitrogen and phosphorus.

Slavik (33) reported on the effects of moisture stress at different stages of plant development. He noted a decrease in the number of fertile tillers with moisture stress during the early stages of development. He further noted a reduced number of seeds per spike or reduced seed weight from a moisture stress during spikelet formation.

In an irrigated study, Andre _et al_. (4) evaluated Inia 66 spring wheat under three nitrogen and four phosphorus levels. Although nitrogen had a much greater effect than phosphorus, the highest yield was obtained by using a combination of nitrogen and phosphorus.

Bishop and MacEachern (8) studied spring wheat and barley under rates of 45, 90 and 135 kg/ha of nitrogen and 39, 78 and 117 kg/ha of phosphorus. Yield increases in wheat were observed two of the three years and in barley one of the three years. Their results indicated that for nitrogen to result in increased yield, phosphorus and potassium must not be limiting. Chapman and Mason (9) evaluated a spring wheat under phosphorus rates of 0, 56, 112, 224, and 448 kg/ha and found no significant increase in yield due to phosphorus and in fact noted a decrease in yield at higher rates of application. Fuehring (16) found a negative response in grain yield of spring wheat to phosphorus was due to over-stimulation of tillers.

Certain production problems have been encountered with high nitrogen levels. These include lodging and delayed maturity. In an irrigation study conducted by Hojjati and Maleki (18), excessive lodging and delayed maturity of wheat due to nitrogen application were reported. However, nitrogen consistently increased grain protein. They reported no increase in yield with 50 or 100 kg/ha of nitrogen while 200 kg/ha sharply reduced yield. It was determined that the additional nitrogen was used for vegetative growth which resulted in increased lodging.

Utilizing a late spring application of nitrogen, Hucklesby et al. (20) demonstrated an increase in grain yield and protein content of winter wheat. Protein content and grain yield were positively correlated in this study. It was concluded that applications of nitrogen in late spring could result in higher yields of high protein winter wheat when lodging was not a factor.

An attempt to evaluate the effectiveness of split applications of nitrogen topdressings was carried out by Jain et al. (22). They found no advantage of splitting topdressing over a single application. They also found no difference due to soil or foliar application methods. The least efficient method tested was when all nitrogen was applied at planting time. Increased yields were obtained with each additional application of nitrogen.

Yield Components and Their Relationship to Yield

A number of studies have dealt with the action of yield components on yield in attempts to design a system whereby selection based on yield components would result in advancement of yield.

Fonseca and Patterson (15) utilizing a diallel cross of winter wheats studied the heritability of yield components and the interrelationships among the components. Heritabilities for number of spikes and kernels per spike were generally found to be higher than those for kernel weight and grain yield. They further stated that for the component of yield approach to breeding to be effective, components must not be physiologically associated, must have high heritability, and must be genetically independent. They concluded that progress may be limited due to the strong negative correlation between number of spikes and kernels per spike.

In a similar study, Hsu and Walton (19) with spring wheats determined that late-flowering plants had higher yields due to longer spikes. Spike number was very closely associated with higher yield and was the most important yield component. They concluded that for each variety there is one primary yield component responsible for changes in yield. Thus, different varieties may have the same yield potential, but the effects of the yield components are different in different varieties. Rawson (31) studied 12 wheat varieties ranging from very early to late in maturity in the glasshouse. He concluded that spike number, an important determinant of grain yield, was increased only by an extension of the growing season.

Effects of Nitrogen and Phosphorus on Yield Components

By studying the action of nitrogen and phosphorus on yield components and their relationship to total yield, a plant breeder may have a better basis for selection of parents than yield itself.

Hobbs (17) attributed a yield increase in winter wheat to the increase in the number of tillers and the number of kernels per head which resulted from the application of nitrogen in early spring. He further stated that yields were increased by nitrogen only if phosphorus was adequate. Terman et al. (39) evaluated the performance of Cheyenne hard red winter wheat at nitrogen rates of 0, 45, and 90 kg/ha and concluded that if water and other growth factors are adequate, nitrogen will effectively increase yield. In addition, nitrogen in excess of vegetative needs increased kernel protein content.

Stickler and Pauli (38) evaluated four wheat varieties under rates of 0, 25, 50, 75, and 100 pounds of nitrogen per acre for five years. Their results agreed with those of Hobbs in that the first effect of nitrogen was to increase the number of tillers. They found no significant difference in the number of seeds per head due to nitrogen, however. In addition, seed weight was decreased with the higher rates of nitrogen. They found that there was little tendency for a differential response of the varieties to nitrogen although, the varieties did on the average respond differently.

A study was conducted by Johnson _et al_. (23) with four wheat varieties differing in plant height. They found a positive association between grain yield and the number of kernels per spike. However, number of spikes appeared to be most closely associated with grain yield. These workers concluded that individual components could provide a better basis for the selection of parents and the evaluation of their progeny than yield itself. Studies by McNeal _et al_. (29) also showed that increased number of heads and an increased number of spikelets but decreased seed weight resulted from increased nitrogen application. There was no significant difference in test weight due to increased nitrogen application although there was a definite variety by fertilizer interaction associated with test weight, kernel weight, and plant height.

Physiology of Yield and Yield Components

Yield expression may be viewed in two ways as proposed by Reitz (32): 1) vigor and translocation of metabolites to the kernel; and 2) protection against interference with metabolic processes. An increase in the efficiency of either one or both of these processes will result in increased grain yield. Work with the assimilation process has shown that growth is controlled not only by the total amount of assimilates produced but also by the manner in which they are partitioned among the various parts of the plant. Bingham (7) demonstrated that metabolite storage characteristics of the kernel and the availability of photosynthates to the kernel were of similar importance in determining yield. McNeal et al. (29) proposed that the amount of topgrowth apparently regulates the amount of nutrients taken up by the plant and this is all that is available for translocation to the grain.

Because of the recent interest in physiological problems related to yield, attention has veered towards more intense study of mineral nutrition, light energy, and temperature as factors influencing growth (26).

Adams (1) studied the basis of yield component compensation. He proposed that the developmental flexibility of yield components could facilitate the maintenance of a more stable yield level if in development, variation in one component could compensate for variation in another. Resources available to individual plants are subject to severe limitations caused by inter-plant competition. In addition, intra-plant competition for resources available to the plant may lead to compensatory variation among yield components. According to Adams (1), compensation may be explained as the competition for both organic and inorganic nutrients. When reproduction is started, metabolic input to the yield component system appears to fluctuate rhymically under metabolic control or in response to major external forces. Since components of yield are initiated at different stages of plant development, a possible explanation for compensation is that the metabolic input for the formation and development of reproductive structures is relatively invariable and limiting. As the first component in the sequence uses up more or less input for either environmental or genetic causes, the next component tends to vary in a compensating manner using up the residual substrate whether it be small or large. The third component has a similar response to variation in the first two.

An alternate hypothesis is that an oscillatory variation of growth factors would lead to a limiting input for the development of the different components (1). That is, a component in phase with the general input is favored. A repressor is created by this enhancement which would be unfavorable to one or both of the other components.

Adams and Grafius (2) suggested that yield component balance among crop plants is achieved primarily through the oscillatory response of sequential components to limited resources. As environmental resources vary, there is a need in a crop plant if that plant is utilizing these resources to maximum benefit. Every variety of a seed bearing crop plant reaches a compromise in the utilization of available resources. Strong linkages would not permit the needed flexibility to respond to limited resources. According to Adams and Grafius (2), the genetic ceilings that hamper the capacity of a component to respond when resources are available should be raised by promoting recombinations of unfavorably linked genes, and increasing the flow of environmental resources throughout the period of need by the components. They further stated that the principles of balance among components should not be overlooked.

Donald (10) proposed a plant breeding scheme that involved the anatomy or physiology of a crop species. He stated that competition for light, water and nutrients is a very complex phenomonen and may involve one or more factors at a time. He concluded that improvements in yield of cereal crops could be attained by raising the proportion of grain weight in the total dry-matter production of the plant.

CHAPTER III

METHODS AND MATERIALS

The study was grown during the 1971-72 growing season on the Agronomy Research Station, Stillwater, Oklahoma. The site selected for this study consisted of a Kirkland Silt Loam soil that had weakly convex to concave relief with surface gradients of one to two percent (37). The area was uniform in soil characteristics and appeared to be desirable as a site for a nursery experiment.

The growing season was characterized by below normal precipitation. Total season rainfall was 58 mm below normal with 47 mm below normal in October and November and 67 mm below normal in March and April (5, 6). In addition, high temperatures occurred prior to heading causing some varieties to initiate heading early. Shortly after, freezing temperatures were noted which could have resulted in damage to some of the spikes. In an attempt to maintain favorable production conditions, the nursery was irrigated three times before moisture stress became critical as determined by six tensiometer probes. The nursery was irrigated on March 28, April 4, and April 14 with a total of 89 mm of water applied. Results of a soil test indicated that there were 23 kg/ha of available nitrogen, 88 kg/ha of available phosphorus and 250 kg/ha of available potassium on the test site. The soil had a ph of 5.5.

Small Grain Varieties

The material evaluated in the study consisted of three hard red winter wheat varieties, one soft red winter wheat (*Triticum aestivum* L. em. Thell), two barley varieties (*Hordeum vulgare*), and four triticale varieties (*Triticale hexaploide* Lart.). The varieties were chosen on the basis of their contrasting characters and present or potential usefulness as varieties or breeding lines. A brief description of the varieties are presented below.

'Danne' is a hard red winter wheat variety that was developed in Oklahoma (36). It is early maturing and has a wide area of adaptation. It is midtall in height. Danne is considered to be rather well balanced with regard to yield components.

'Palo Duro' is also a hard red winter wheat developed by DeKalb Ag Research Incorporated (40). Under Oklahoma conditions it is considered to be medium to medium-late in maturity. It is a semi-dwarf variety and has a high test weight. Palo Duro has a high yield potential under above average fertility and moisture conditions due to a high tillering capacity.

'Centurk' is another one of the hard red winter wheats and in Oklahoma is classed as a medium-late maturing variety (35). Centurk originated in Nebraska and was released jointly by the U. S. D. A. and eight major wheat producing states. Among some of its characters are excellent productivity, prolific tillering capacity, average to small spike and short kernel. It is midtall in plant height.

'Blueboy' wheat is a soft red winter wheat that was developed in North Carolina (30). Blueboy also differs from the other three wheat varieties in that it is awnletted while the others are all awned. The spike is large and the kernel is midlong. Blueboy has high yield potential and has shown good responses to nitrogen fertilizers in many parts of the soft red winter wheat region. Low test weight and low tillering capacity are also characteristic of Blueboy wheat. It is midtall in plant height under Oklahoma conditions.

'Will' barley is a six-rowed, facultative winter barley which exhibits a high level of winterhardiness (21). It is midseason to late in maturity and is midtall in plant height. Will was developed at the Oklahoma Agricultural Experiment Station. It is awned with high yield potential but is known for weak straw.

'Kerr' barley is another Oklahoma release that is also six-rowed, rough awned and a facultative winter barley (13). Kerr has a higher test weight, produces more forage, and has more resistance to straw breakage than Will. It is midtall in plant height and late in maturity.

'CL72' is a rather tall variety of triticale that is late in maturity, and has high test weight (12). CL72 is a spring type with fair winterhardiness. Seed of CL72 was obtained through commercial seed channels. Forage production has been described as fair in early fall and poor in late spring often due to severe winterkilling. Grain yields are good.

'T204' is also a spring type triticale with fair to poor winterhardiness but less than CL72 (12). T204 has a lower test weight and about the same height as CL72. Grain yields are lower but forage yields are about the same as CL72 unless winterkilling occurs. In this case, forage production is lower than CL72.

'Rosner' triticale is the shortest of the four triticale varieties, but is earlier in maturity than the others (24, 27). It was developed in Canada and was the first variety to be released in Canada. Rosner has shown very poor forage production and very low grain yields in Oklahoma. Again, winterhardiness is very poor.

'T385' is the only triticale studied that appeared to have sufficient winterhardiness to survive winters in Oklahoma (12). T385 is not a true winter type but is intermediate in habit. The height is the same as CL72 and T204 and test weight is high. Grain yields and forage yields of T385 have been good in Oklahoma.

The Field Layout

A split-plot design was used for this study. Nitrogen levels comprised the main-plots while the sub-plots consisted of phosphorus levels by varieties arranged factorially. Main-plots were randomized within each replication and sub-plots occurred at random within main-plots. There were four replications of each treatment. A plot consisted of four 3 m rows, 30.5 cm apart. The seeding rate was 100 kg viable seed per ha which was about 20 percent above the rate normally used in the state. The test was planted on October 2, 1971, with a tractor-mounted, four row, cone seeder.

The variety by fertilizer combinations used in the study are shown in Table I. The three nitrogen levels in the study were 60, 120, and 180 kg/ha. A preplant starter fertilizer (18-46-0) was applied to all plots at the rate of 111 kg/ha. January 12, 1972, was selected as the first topdressing date. An additional 40 kg/ha were applied to the N_1 levels and 56 kg/ha were added to the N_2 and N_3 levels. On February 23, 1972, the final topdressing was made. To the N_2 levels were added 43

TABLE I

VARIETIES BY FERTILIZER TREATMENT COMBINATIONS[1]

Wheat	
Centurk	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Palo Duro	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Danne	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Blueboy	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Barley	
Kerr	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Will	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Triticale	
T385	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
T204	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
CL72	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)
Rosner	N_1 (P_1, P_2, P_3), N_2 (P_1, P_2, P_3), N_3 (P_1, P_2, P_3)

[1]N_1 = 60 kg/ha actual Nitrogen, Split application (Planting with January topdressing)

N_2 = 120 kg/ha actual Nitrogen, Split application (Planting with January and February topdressings)

N_3 = 180 kg/ha actual Nitrogen, Split application (Planting with January and February topdressings)

P_1 = 50 kg/ha P_2O_5. At planting time.

P_2 = 75 kg/ha P_2O_5. At planting time.

P_3 = 100 kg/ha P_2O_5. At planting time.

kg/ha and 103 kg/ha were added to the N_3 levels, completing all treatments. The respective nitrogen topdressings were applied with a small hand powered fertilizer spreader utilizing the ammonium nitrate form of nitrogen.

The three phosphorus levels in the study were 50, 75, and 100 kg/ha of P_2O_5. All phosphorus treatments were completed at planting time. Previous reports of excellent responses of triticale to phosphorus stimulated interest to utilize the high levels of phosphorus.

Characters Evaluated

Each observation was recorded for each plot. The characters evaluated were: a) grain yield, b) tiller number, c) kernels per tiller, d) kernel weight, e) forage yield, f) heading date, g) plant height, and h) protein content for wheat. In addition, field notes were taken on winterkill and lodging but these traits were not analyzed statistically.

Grain Yield

This trait was determined by harvesting two 2.4 m rows which were prepared by cutting 0.3 m from each end of the two center rows of each plot. The yield of grain was recorded in grams per plot as it was removed from the thresher and was then converted to kilograms per hectare for statistical analysis. The harvested area per plot was 1.46 m^2.

Tiller Number

This was determined by counting the number of seed bearing tillers in a 30.5 cm section of row for each plot. This was expressed as number of tillers per 930 cm^2.

Kernels per Tiller

This was determined by collecting 10 heads at random from each plot, counting the number of kernels and recording the average.

Kernel Weight

This was determined by weighing a random sample of 200 kernels from each plot, and was expressed as grams/200 kernels.

Forage Yield

This was measured by clipping a 30.5 cm section of the first row of each plot. Plots were clipped on November 17, 1971, and again on March 17, 1972, with a hand sickle. The samples were placed in dryers at a temperature of 60 C for 96 hours. At the end of this period, the samples were weighed and weights were recorded as grams per plot. A total forage yield per plot was calculated and converted to kilograms per hectare prior to statistical analysis.

Maturity

Maturity of the different varieties was determined by the heading date. Heading date was measured as the number of days from March 31, 1972, to the time when approximately three fourths of the heads were emerged from the boot.

Plant Height

This was recorded on April 30, 1972, after all plots had headed and was measured as the distance in centimeters from the soil line to the tip of the spike excluding awns and was recorded as average height of the plot.

Kernel Protein

Kernel protein for wheat varieties was determined by standard Kjeldahl methods according to AACC cereal laboratory procedures (3). The determinations were made in the wheat quality laboratory, Oklahoma State University.

Winterkill

This was determined by an arbitrary visual rating scale, estimating the percent dead plants per plot.

Lodging

This was estimated by a visual rating of the percent of the plot that was not standing erect.

Statistical Analysis

The statistical analyses of variance for all data collected in the study was done on an IBM 360/65 Computer at the Oklahoma State University Computer Center. An analysis of variance was performed on each of eight traits to determine the differences among nitrogen levels, phosphorus levels, and varieties. In addition, variety by nitrogen, variety by phosphorus, and second order interactions were computed. A separate analysis was made for each crop.

CHAPTER IV

RESULTS AND DISCUSSION

Wheat

As an indication of the general productivity of the test, the mean yield of all wheat varieties over nitrogen and phosphorus levels was 3949.8 kg/ha (59.0 bu/acre). The highest yielding treatment mean was 4629.9 kg/ha (69 bu/acre) for Palo Duro at the N_1 P_3 level, while the lowest yielding treatment mean was 2861.3 kg/ha (42.8 bu/acre) for Danne at the N_2 P_3 level. Average grain and forage yields for all varieties of all crops are listed in Tables II and III.

Mean squares from the analyses of variance of the data for the four wheat varieties are presented in Table IV. Differences among varieties were highly significant for all characters. For certain traits, nitrogen levels, phosphorus levels, and/or interaction with varieties were significant. These will be discussed under appropriate headings.

Grain Yield

Differences among varieties were highly significant for grain yield. Differences among nitrogen levels were not statistically significant, nor were differences among phosphorus levels. However, a significant nitrogen by variety interaction was observed. The basis for this interaction is shown in Figure 1. Although the varieties responded

TABLE II

OVERALL RANKING FOR GRAIN YIELD

Variety	Grain Yield in kg/ha
Centurk	4291.4
Palo Duro	4089.5
Blueboy	3797.0
Danne	3621.2
Will	3295.6
Kerr	2975.4
CL72	2280.8
T385	2082.8
T204	1912.6
Rosner	1315.6

TABLE III

OVERALL RANKING FOR FORAGE YIELD

Variety	Forage Yield in kg/ha
Blueboy	2826.2
Centurk	2583.3
T385	2580.6
Kerr	2404.6
Rosner	2360.5
Will	2267.6
Palo Duro	2148.5
Danne	2108.0
CL72	1896.6
T204	1671.0

TABLE IV

MEAN SQUARES FROM ANALYSES OF VARIANCE OF DATA FOR WHEAT

Source of Variation	d.f.	Grain Yield (X 10^{-4})	Tiller Number	Kernels per Tiller	Kernel Weight	Percent Grain Protein	Forage Yield (X 10^{-4})	Heading Date	Plant Height
N Levels	2	105.00	991.13**	5.61	3.30	107.36**	22.25	5.05	75.22
Error (a)	6	60.13	68.78	5.55	0.91	5.95	18.02	2.80	76.03
Varieties	3	321.06**	5221.21**	525.33**	11.73**	17.27**	435.26**	179.19**	103.47**
P Levels	2	59.27	281.76*	0.67	0.65*	0.10	154.65**	3.86	3.34
Var X P	6	57.46	196.11*	2.18	0.32	0.32	16.28	0.61	22.50
N X Var	6	61.34*	91.34	7.35**	0.20	2.07**	6.82	1.10	10.59
N X P	4	25.36	142.94	3.79	0.18	0.58	40.55	1.89	12.53
N X Var X P	12	20.33	100.37	3.27	0.14	0.41	22.31	0.78	6.31
Error (b)	99	27.36	89.63	2.55	0.18	0.50	20.46	1.67	23.03

*Significant at the .05 level of probability

**Significant at the .01 level of probability

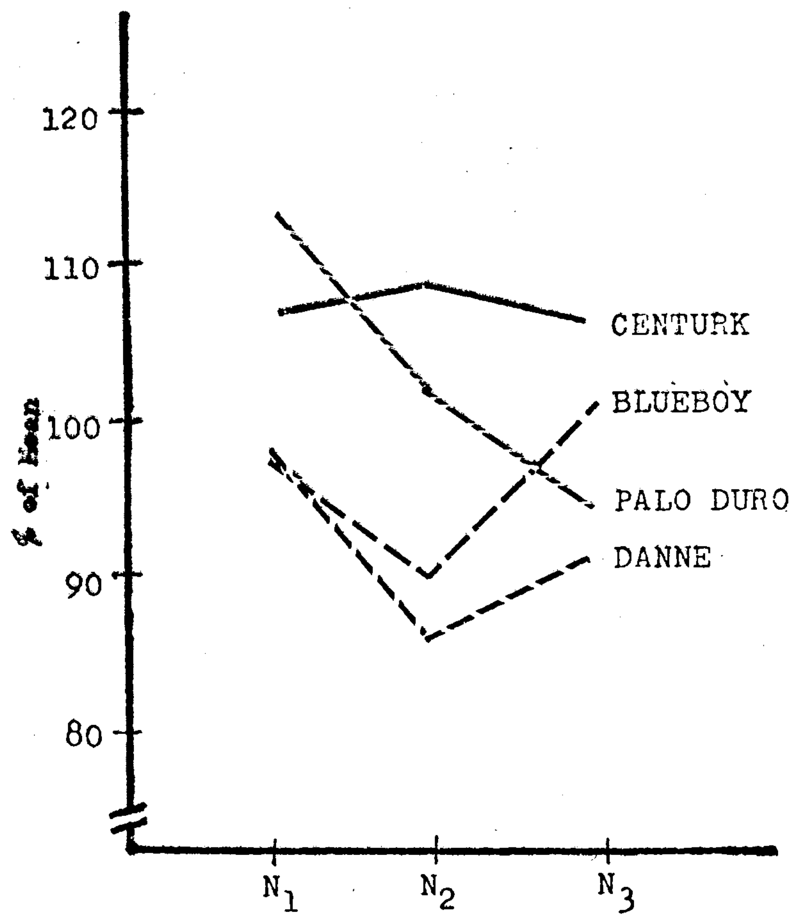

Figure 1. Grain Yield of the Four Wheat Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (3949.8 kg/ha)

differently to nitrogen levels, there was no significant difference in yield due to nitrogen. The yield of Blueboy had the greatest positive response to nitrogen.

Possible reasons for the lack of response to nitrogen or phosphorus for grain yield include high and low temperature stress in the spring months. Also, some moisture stress probably occurred in spite of irrigation treatments. High temperatures were noted in early spring and as a result, some varieties may have initiated heading earlier than usual. Soon after, freezing temperatures were noted which may have damaged some spikes. In addition, the high levels of fertilizer may have increased tiller number beyond the point of sufficient moisture to fill heads on those extra tillers. Tillers, the first component in the sequence, apparently drew heavily on available resources. As soil moisture was depleted, the other components did not have sufficient moisture to develop fully, as proposed by Adams (1). The increased number of tillers may have been in competition for sunlight. The increased lodging may have also increased competition for light by shading of some plants. Another possible factor was that the plots were fallowed the previous year and as a result, the nitrogen supplying capabilities of the soil may have been very high as contrasted to continuous wheat as pointed out by Martin and Leonard (28). The genetic potential for higher yield was present but the environmental conditions were not present for that potential to be fully expressed. Treatment means for grain yield are presented in Appendix Table VII.

Tiller Number

Mean squares for tiller number were highly significant for differences among nitrogen levels and varieties. Significant mean squares were also observed for differences among phosphorus levels and for phosphorus by variety interaction. There appeared to be a linear relationship between tillers and nitrogen levels as shown in Figure 2. High levels of nitrogen increased tiller number and agrees with the results of Hobbs (17). Apparently, sufficient soil moisture was available during the stages of tiller development, allowing more tillers to develop as nitrogen levels were increased.

Phosphorus application also resulted in an increase in number of tillers for all varieties from the P_1 to the P_2 level as shown in Figure 3. The phosphorus by variety interaction can be seen also in Figure 3, by the fact that from P_2 to P_3 the tiller number increased for Palo Duro, which exhibited the largest response to phosphorus, while decreasing for Danne, Centurk, and Blueboy. One fact that should also be considered is that Palo Duro was the highest tillering variety. Treatment means for tiller number are presented in Appendix Table VIII.

Kernels per Tiller

Mean squares for differences among varieties were highly significant for the number of kernels per tiller. In addition, a highly significant variety by nitrogen interaction was observed. As shown in Figure 4, the varieties had a differential response for kernels per tiller in different nitrogen levels. Blueboy and Centurk showed an increase in kernels per tiller from N_1 to N_2 and then a decrease from N_2 to N_3 while the response of Danne and Palo Duro was the reverse. Treatment means for kernels per tiller are presented in Appendix Table IX.

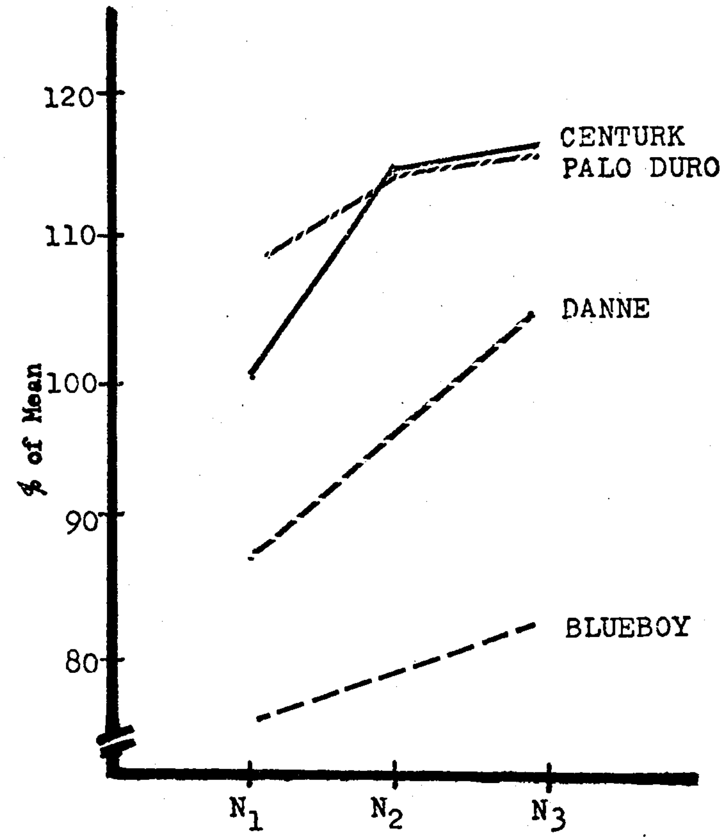

Figure 2. Tiller Number of the Four Wheat Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (76.6 Tillers)

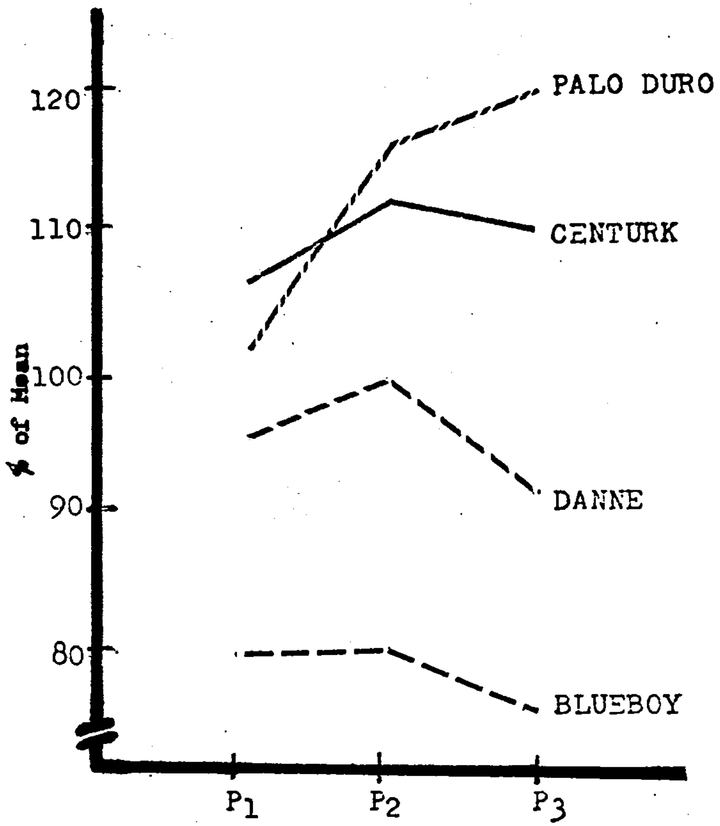

Figure 3. Tiller Number of the Four Wheat Varieties at the Three Levels of Phosphorus Expressed As Percent of Grand Mean (76.6 Tillers)

Kernel Weight

For the character kernel weight, means squares were significant for differences among varieties. There was also a significant difference among levels of phosphorus for this trait. The overall effect of phosphorus was to reduce kernel weight at the P_2 level and then remain constant at the P_3 level as shown in Figure 5. As stated earlier, phosphorus increased tiller number to the P_2 level thus resulting in more heads filled by smaller kernels. Since there was no difference in kernels per tiller due to phosphorus, the reduction would have to have occurred in the size of the kernels. Treatment means for kernel weight are presented in Appendix Table X.

Grain Protein

Mean squares for grain protein were highly significant for differences among varieties, nitrogen levels, and for the variety by nitrogen interaction. The main effect of nitrogen was to increase protein content (Figure 6). Palo Duro and Centurk showed an increased response to nitrogen application as compared to Blueboy and Danne. The magnitude of the mean squares indicate the difference among nitrogen levels was of more importance than the nitrogen by variety interaction. This tends to agree with reports of Terman et al. (39). Treatment means for protein content are presented in Appendix Table XI.

Forage Yield

Mean squares for forage yield were highly significant for differences among varieties and phosphorus levels. Yields of forage were

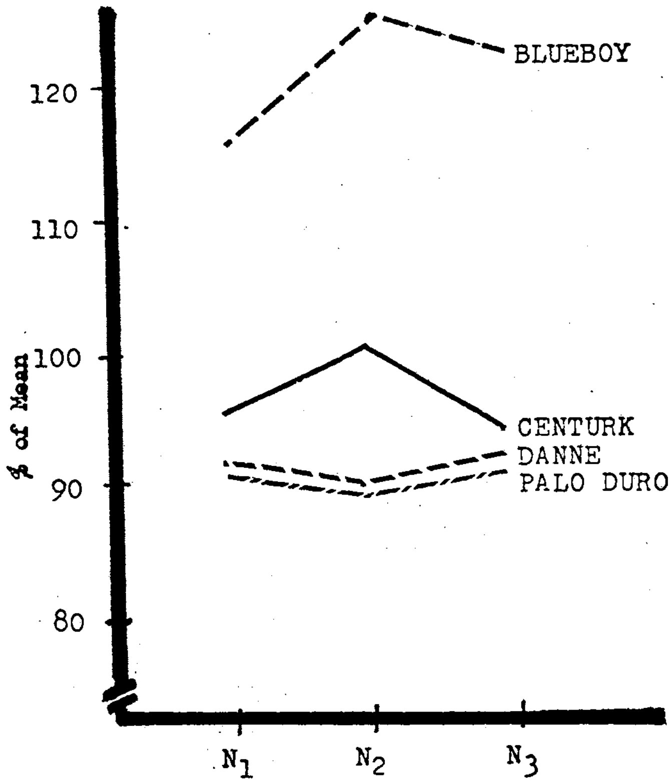

Figure 4. Kernels per Tiller of the Four Wheat Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (25.7 Kernels)

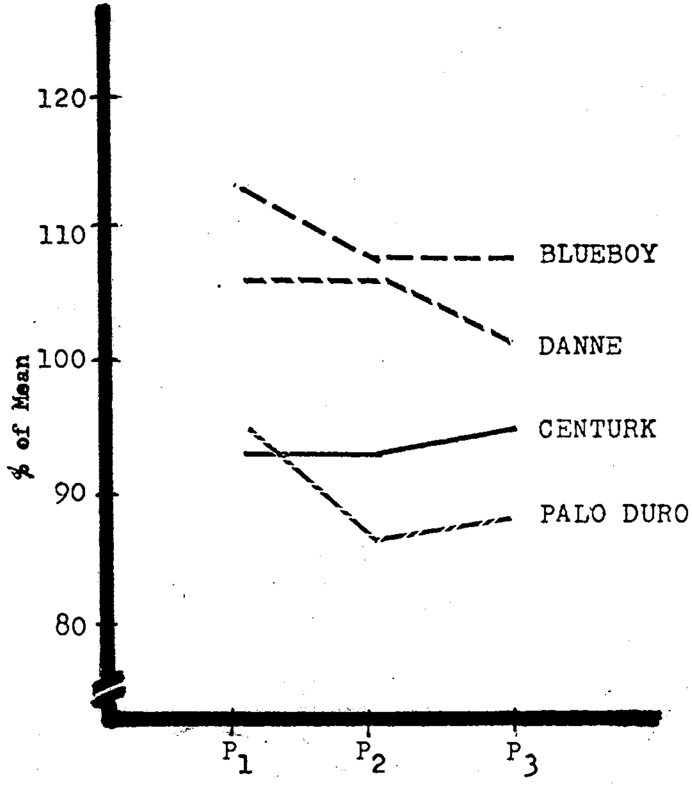

Figure 5. Kernel Weight of the Four Wheat Varieties at the Three Levels of Phosphorus Expressed As Percent of Grand Mean (6.0 Grams)

increased by additional phosphorus (Figure 7). Blueboy and Centurk produced considerably more forage than Palo Duro and Danne. Centurk had an increase in forage production with each increase of phosphorus application while the other three varieties showed no increase from P_2 to P_3. Phosphorus increased the tiller number at the P_2 level which could have contributed to the increased forage production observed at the P_2 and P_3 levels. Treatment means for forage yield are presented in Appendix Table XII.

Maturity

Mean squares for heading date are significant only for differences among varieties. Previous reports indicated that nitrogen tended to delay maturity (19). Results of this study do not agree with such reports. It is felt that perhaps the low level of nitrogen plus nitrogen supplied by the soil was sufficient to reach the threshold of delayed maturity. Therefore, no effect in maturity due to nitrogen or phosphorus treatment was noted. Average heading dates for the four varieties were: Blueboy, April 17; Danne, April 19; Centurk, April 21; and Palo Duro, April 22.

Plant Height

Mean squares for plant height were highly significant for differences among varieties. However, nitrogen and phosphorus had no effect on plant height of the four wheat varieties. Treatment means for plant height are presented in Appendix Table XIII.

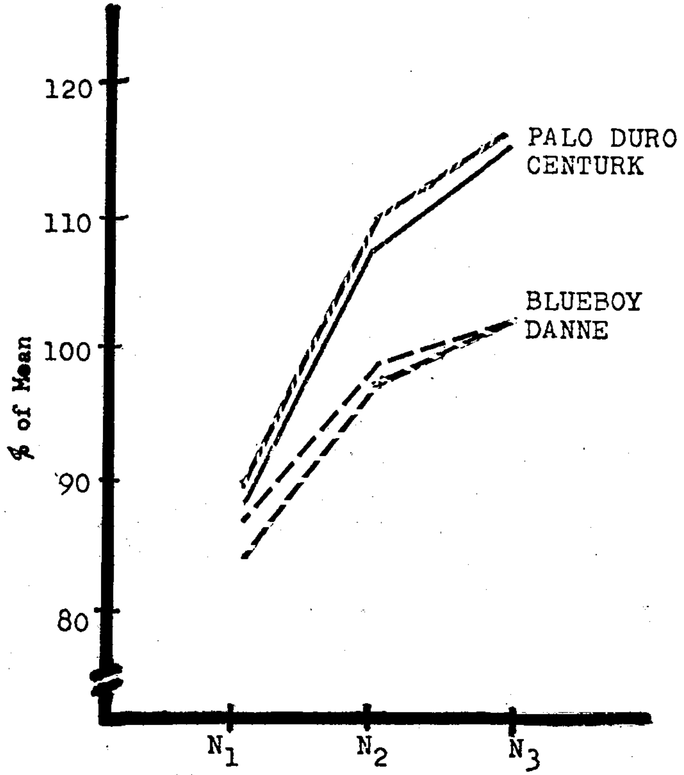

Figure 6. Percent Kernel Protein of the Four Wheat Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (13.3 Percent)

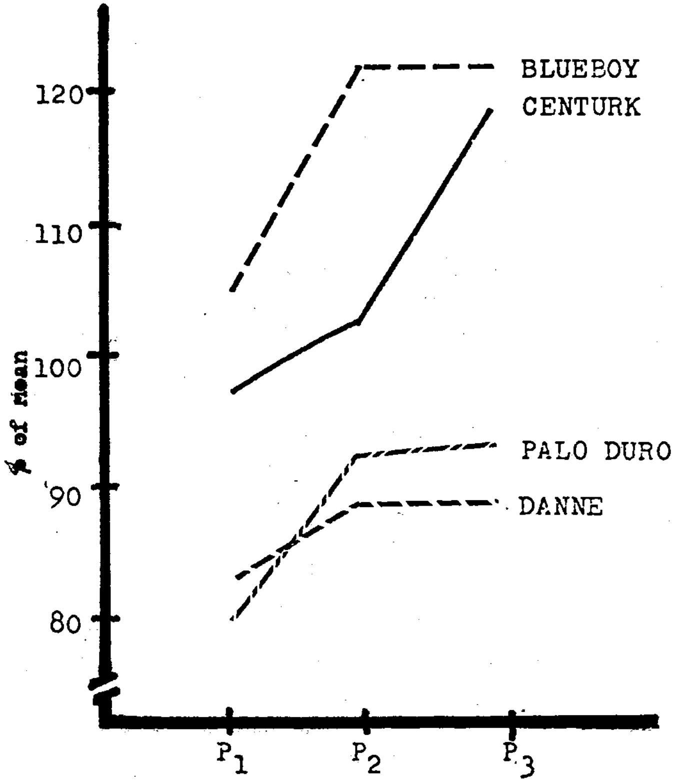

Figure 7. Forage Yield of the Four Wheat Varieties at the Three Levels of Phosphorus Expressed As Percent of Grand Mean (2416.5 kg/ha)

Lodging

Due to the fact that lodging was measured as percent by a visual estimation, an analysis of variance was not conducted. The highest yielding variety, Centurk, had the highest lodging percent. Overall, increased levels of nitrogen resulted in increased lodging. This tends to agree with work of Hojjati and Maleki (18). Treatment means for lodging are presented in Appendix Table XIV.

Yield and Yield Components

Although there were no significant differences in yield due to differences among nitrogen and phosphorus levels, there were significant differences in certain yield components. Consequently, significant changes in a yield component resulting from changes in nitrogen or phosphorus application would have to be offset by complimentary changes in one or both of the other components if yield itself were not changed significantly. The interrelationships among the yield components with regard to nitrogen and phosphorus treatments were examined for the four wheat varieties as shown in Figures 8 to 15.

For the variety Centurk, kernels per tiller seemed to be most closely associated with yield as shown in Figure 8. However, tiller number seemed to be more important than the other two components in determining yield in this variety. Yield increased from N_1 to N_2. This increase was accounted for by an increase in tiller number and kernels per tiller. At the N_3 level, a yield decrease was accompanied by a slight increase in tiller number and a decrease in both kernels per tiller and kernel weight. For phosphorus levels (Figure 9), a constant

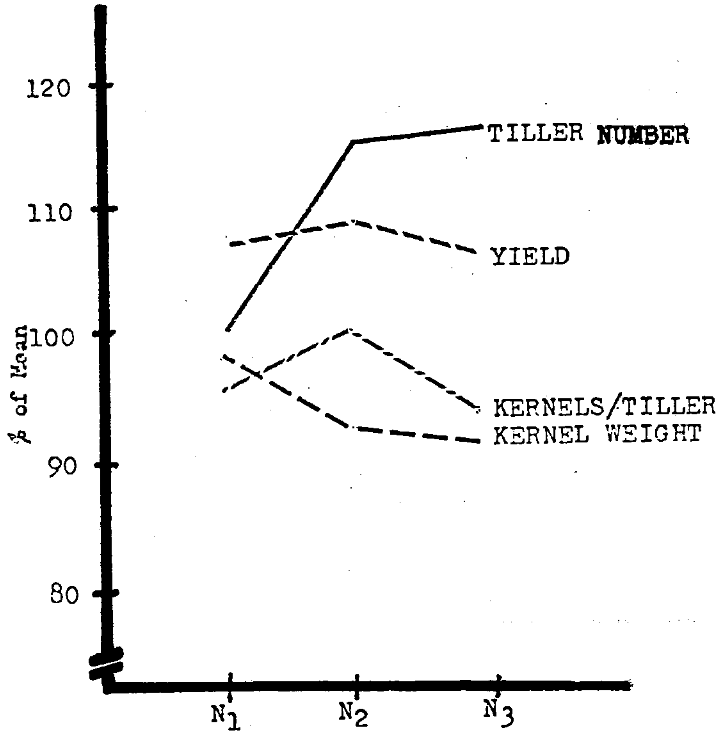

Figure 8. Grain Yield and Components of Yield of Centurk at the Three Levels of Nitrogen Expressed As Percent of Grand Mean

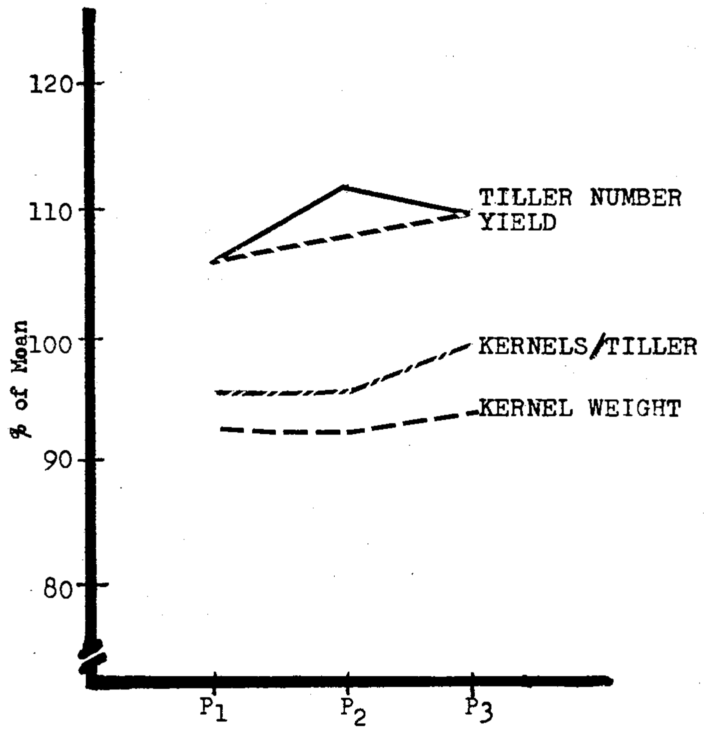

Figure 9. Grain Yield and Components of Yield of Centurk at the Three Levels of Phosphorus Expressed As Percent of Grand Mean

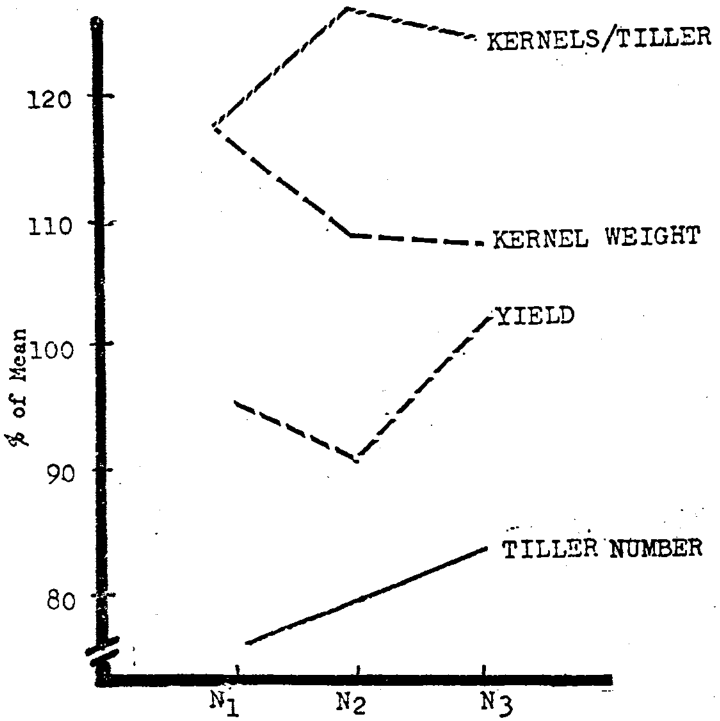

Figure 10. Grain Yield and Components of Yield of Blueboy at the Three Levels of Nitrogen Expressed As Percent of Grand Mean

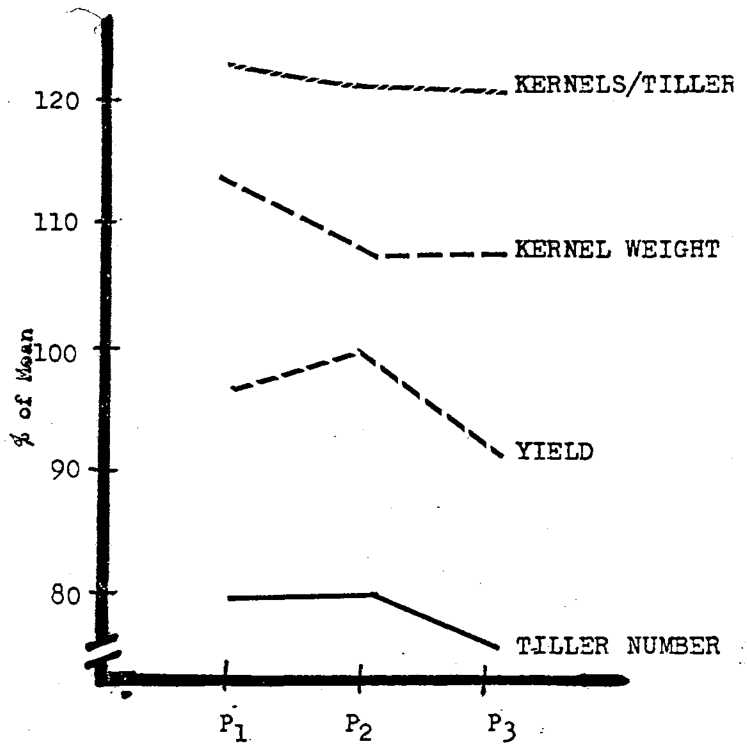

Figure 11. Grain Yield and Components of Yield of Blueboy at the Three Levels of Phosphorus Expressed As Percent of Grand Mean

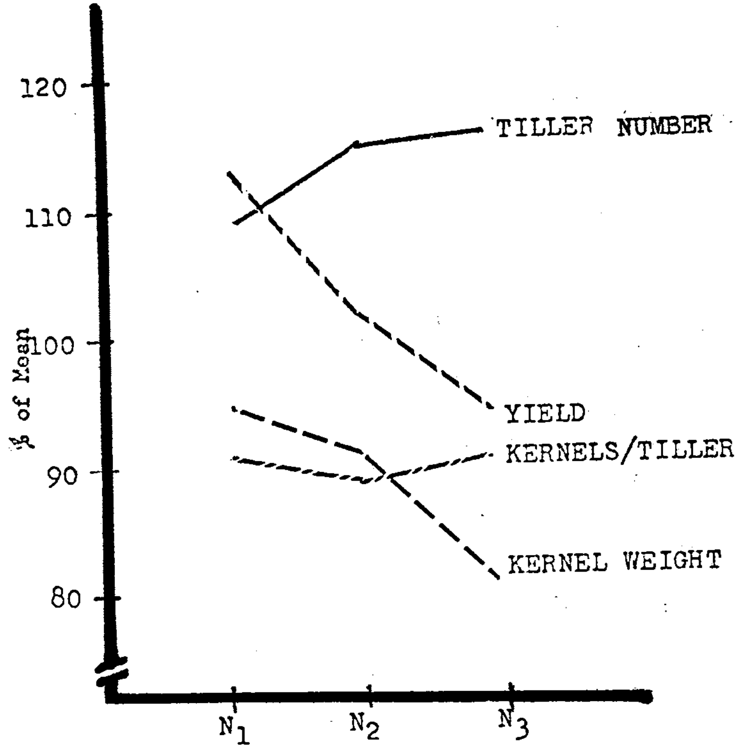

Figure 12. Grain Yield and Components of Yield of Palo Duro at the Three Levels of Nitrogen Expressed As Percent of Grand Mean

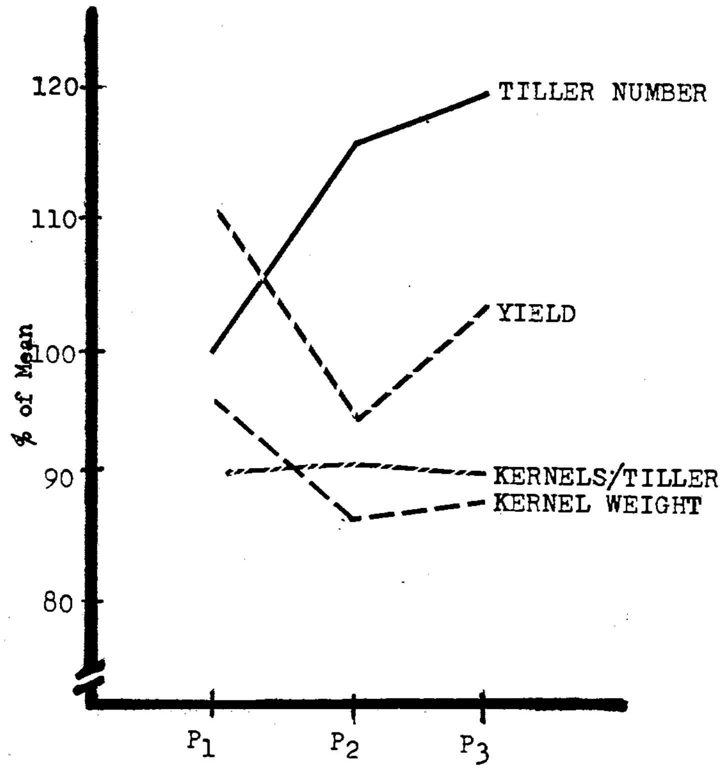

Figure 13. Grain Yield and Components of Yield of Palo Duro at the Three Levels of Phosphorus Expressed As Percent of Grand Mean

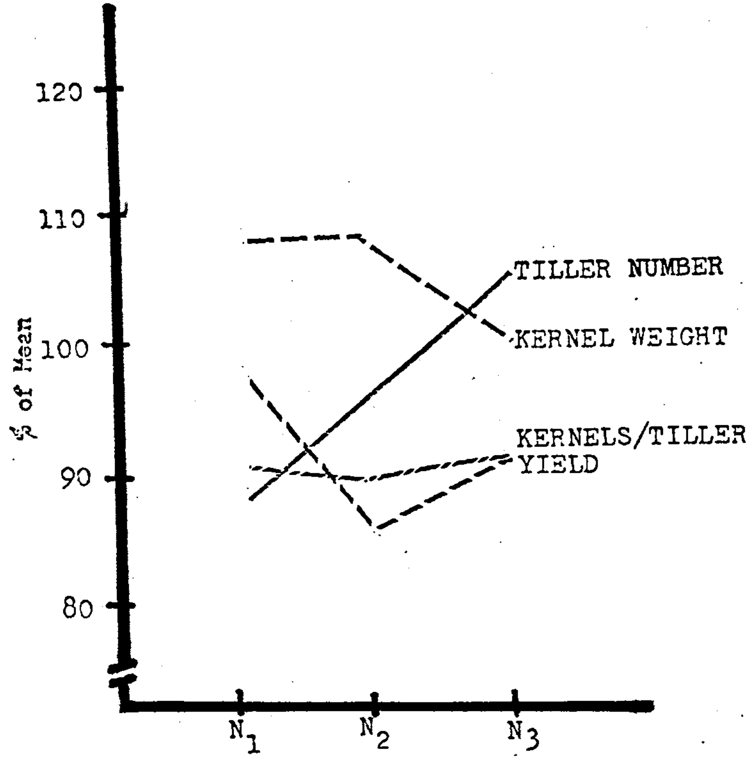

Figure 14. Grain Yield and Components of Yield of Danne at the Three Levels of Nitrogen Expressed As Percent of Grand Mean

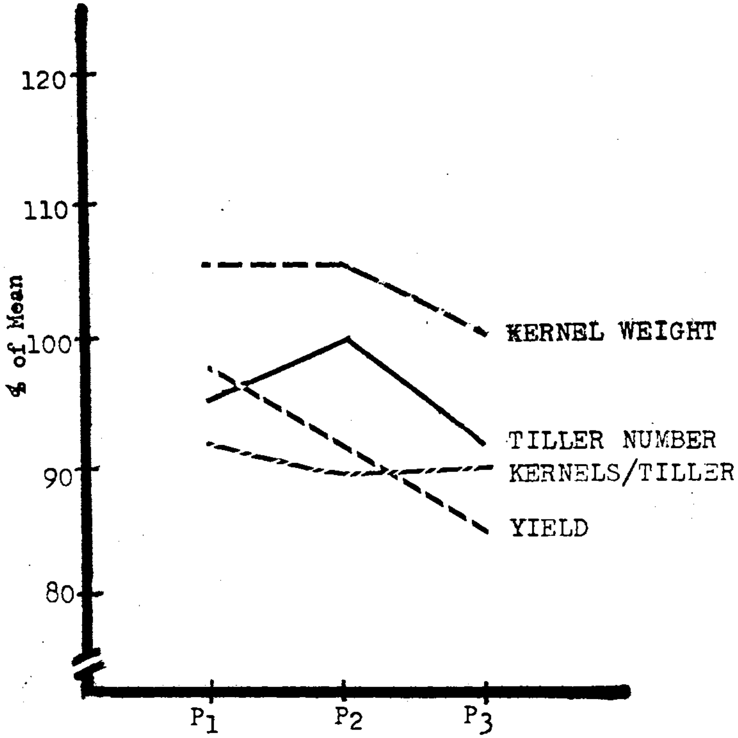

Figure 15. Grain Yield and Components of Yield of Danne at the Three Levels of Phosphorus Expressed As Percent of Grand Mean

increase in yield was noted. Tiller number increased from P_1 to P_2 and then decreased at the P_3 level. Kernel weight, as well as kernels per tiller, remained constant from P_1 to P_2 and then showed a slight increase at the P_3 level.

For the variety Blueboy, tiller number appeared to be most closely associated with yield (Figures 10 and 11). From N_1 to N_2 a decrease in yield was noted. This decrease was accompanied by an increase in tiller number and kernels per tiller. Kernel weight decreased. An increase in yield was noted from N_2 to N_3. This increase could only be accounted for by the increased tiller number. Kernels per tiller and kernel weight both decreased at the N_3 level. For phosphorus levels, grain yield increased at the P_2 level due to an increase in tiller number while kernels per tiller and kernel weight decreased. Yield was decreased at the P_3 level due to a decrease in tiller number accompanied by a slight decrease in kernels per tiller and no change in kernel weight.

For the variety Palo Duro, kernel weight appeared to be the component most closely associated with yield (Figures 12 and 13). Grain yield decreased sharply at the N_2 and N_3 levels. The only component that could account for this decrease is kernel weight. At the N_2 level, tiller number increased while kernel weight and kernels per tiller decreased. Kernel weight again decreased at the N_3 level while tiller number and kernels per tiller both increased. As with nitrogen levels, kernel weight followed yield more closely than the other two components for phosphorus levels. At the P_2 level, grain yield decreased, tiller number and kernels per tiller both increased, while kernel weight decreased. At the P_3 level, grain yield increased and was accompanied by an increase in kernel weight and tiller number, while kernels per tiller decreased slightly.

For the variety Danne, kernels per tiller appeared to be most closely associated with yield (Figures 14 and 15). In addition, kernel weight appeared to have a high positive association with grain yield. A yield decrease at the N_2 level was accompanied by an increase in tiller number and kernel weight. Kernels per tiller decreased slightly. At the N_3 level, yield increased as did kernels per tiller and tiller number. Kernel weight decreased at the N_3 level. For phosphorus levels, a steady decrease in yield was noted. At the P_2 level, tiller number increased, kernels per tiller decreased and kernel weight remained constant. At the P_3 level, tiller number decreased, as did kernel weight, while kernels per tiller increased slightly.

The results of this study tend to agree with reports of Hsu and Walton (19) who stated that for each variety there is one primary yield component responsible for increasing yield.

Barley

As an indication of the level of productivity of the two barley varieties in this test, the mean yield of the two varieties across all levels of nitrogen and phosphorus was 3235.5 kg/ha (60.5 bu/acre). The highest treatment mean was 3856.5 kg/ha (72.1 bu/acre) for Will at N_1 P_2, while the lowest was 2662.9 kg/ha (49.8 bu/acre) for Will at N_3 P_1.

Mean squares from analyses of variance of data for barley are presented in Table V. Mean squares for differences between varieties were highly significant for all characters except forage yield, plant height and maturity.

TABLE V

MEAN SQUARES FROM ANALYSES OF VARIANCE OF DATA FOR BARLEY

Source of Variation	d.f.	Grain Yield ($X 10^{-4}$)	Tiller Number	Kernels per Tiller	Kernel Weight	Forage Yield ($X 10^{-4}$)	Heading Date	Plant Height
N Levels	2	124.54*	370.50	31.33	3.70*	121.36	0.01	67.18
Error (a)	6	17.98	144.59	18.12	0.57	47.47	0.01	46.27
Varieties	1	184.51**	7875.13**	3568.72**	8.20**	33.80	0.01	6.72
P Levels	2	42.46	495.79	8.74	0.66	19.01	0.01	24.76
Var X P	2	10.92	41.29	12.97	0.12	48.60	0.01	15.26
N X Var	2	36.75	186.50	13.18	0.76	34.97	0.01	72.76*
N X P	4	12.84	355.42	15.89	0.27	18.22	0.01	23.81
N X Var X P	4	24.79	73.67	31.98*	0.44	33.44	0.01	12.56
Error (b)	45	24.72	174.35	11.85	0.40	25.16	0.01	18.75

*Significant at the .05 level of probability

**Significant at the .01 level of probability

Grain Yield

The analysis of variance indicated significant differences between varieties and among nitrogen levels for grain yield. A decrease in yield occurred with increased levels of nitrogen (Figure 16). Will yielded higher than Kerr for all nitrogen levels. Treatment means for grain yield are presented in Appendix Table XV.

Tiller Number

There was no significant difference in tiller number due to nitrogen or phosphorus. Significant differences between varieties were observed for tiller number. Kerr had the highest number of tillers, but was lower than Will in grain yield. Treatment means for tiller number are presented in Appendix Table XVI.

Kernels per Tiller

Mean squares for differences between varieties were highly significant. In addition, a significant nitrogen by variety by phosphorus interaction was observed. This second order interaction indicates that the varieties did not respond similarly to increases in nitrogen at different levels of phosphorus. This effect is shown in Figures 18 and 19. Treatment means for kernels per tiller are presented in Appendix Table XVII.

Kernel Weight

Mean squares for differences between varieties were highly significant as were differences among nitrogen levels. The effects of nitrogen

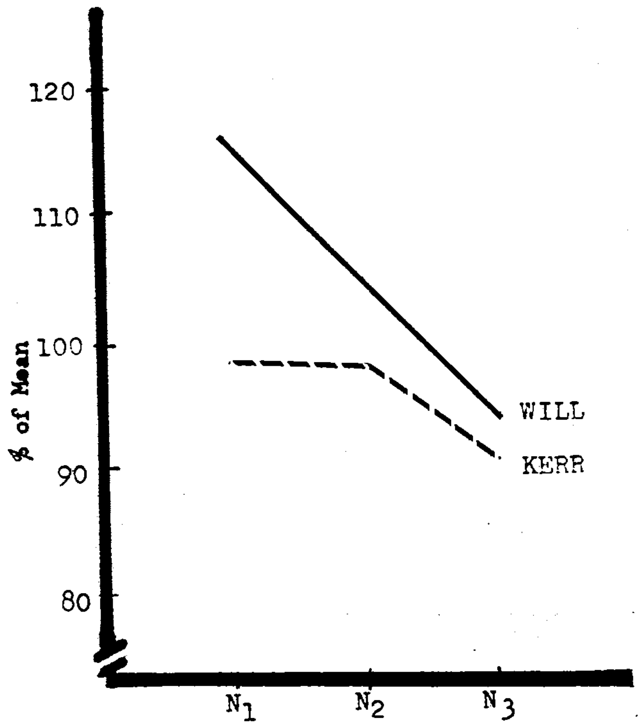

Figure 16. Grain Yield of the Two Barley Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (3135.5 kg/ha)

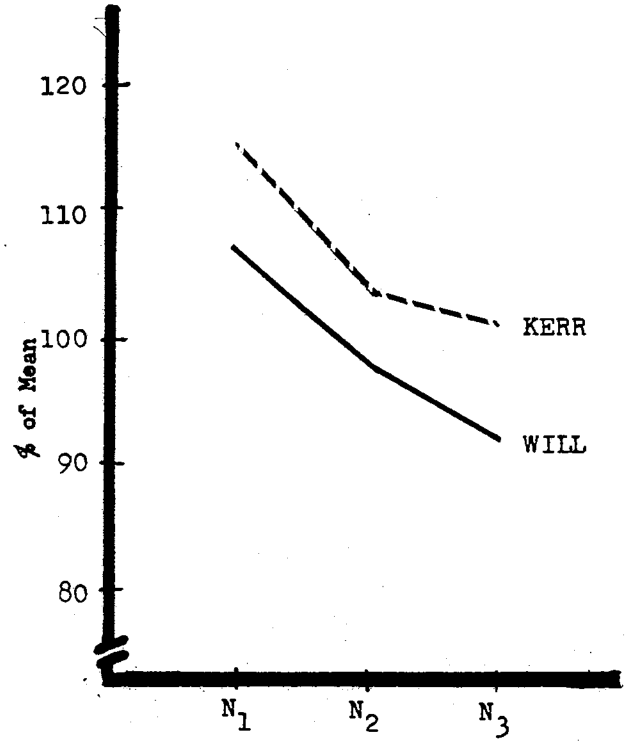

Figure 17. Kernel Weight of the Two Barley Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (5.2 Grams)

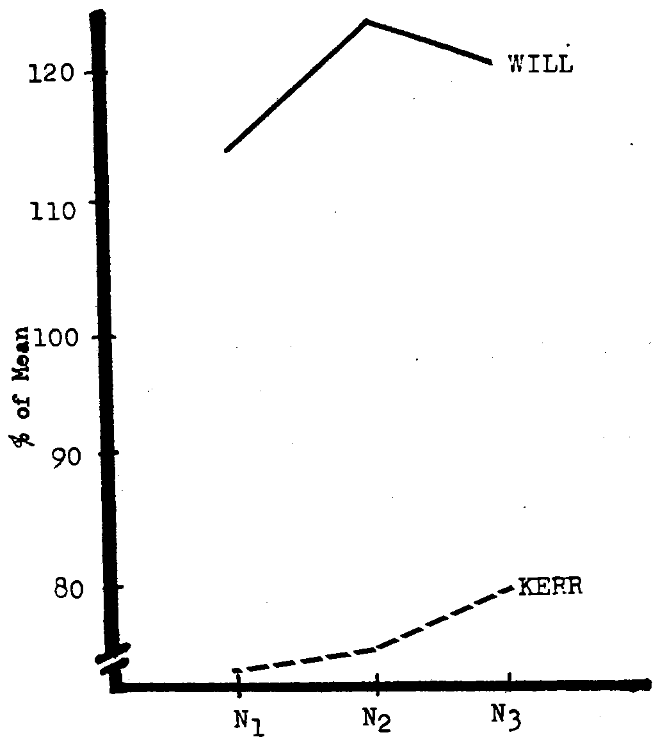

Figure 18. Kernels per Tiller of the Two Barley Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (31.0 Kernels)

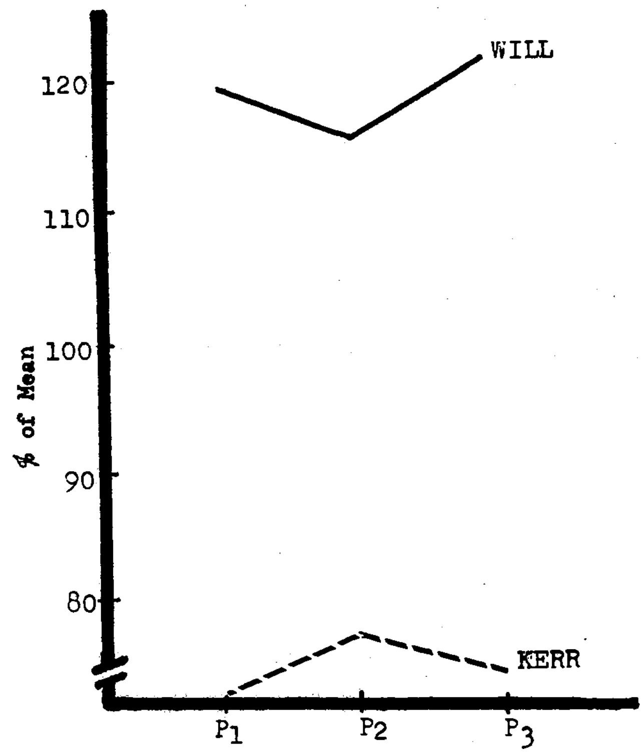

Figure 19. Kernels per Tiller of the Two Barley Varieties at the Three Levels of Phosphorus Expressed As Percent of Grand Mean (31.0 Kernels)

levels on kernel weight are shown in Figure 17. For both varieties, kernel weight decreased with increased levels of nitrogen. Treatment means for kernel weight are presented in Appendix Table XVIII.

Forage Yield

Mean squares for forage yield indicated no significant differences between varieties, among nitrogen or phosphorus levels or interactions. Treatment means for forage yield are presented in Appendix Table XIX.

Maturity

Mean squares for maturity indicated no significant differences between varieties, among nitrogen or phosphorus levels, or interactions. Averaged over all treatments, the two barley varieties headed the same day, April 17.

Plant Height

Mean squares for differences between varieties were significant as was the nitrogen by variety interaction. Will showed a slight but consistent increase in plant height with increased levels of nitrogen. Kerr decreased in plant height from N_1 to the N_2 level and then increased at the N_3 level. This interaction indicates that the varieties did not respond similarly to nitrogen with regard to this trait as shown by Figure 20. Treatment means for plant height are presented in Appendix Table XX.

Lodging

Although statistical analysis was not made, higher nitrogen levels

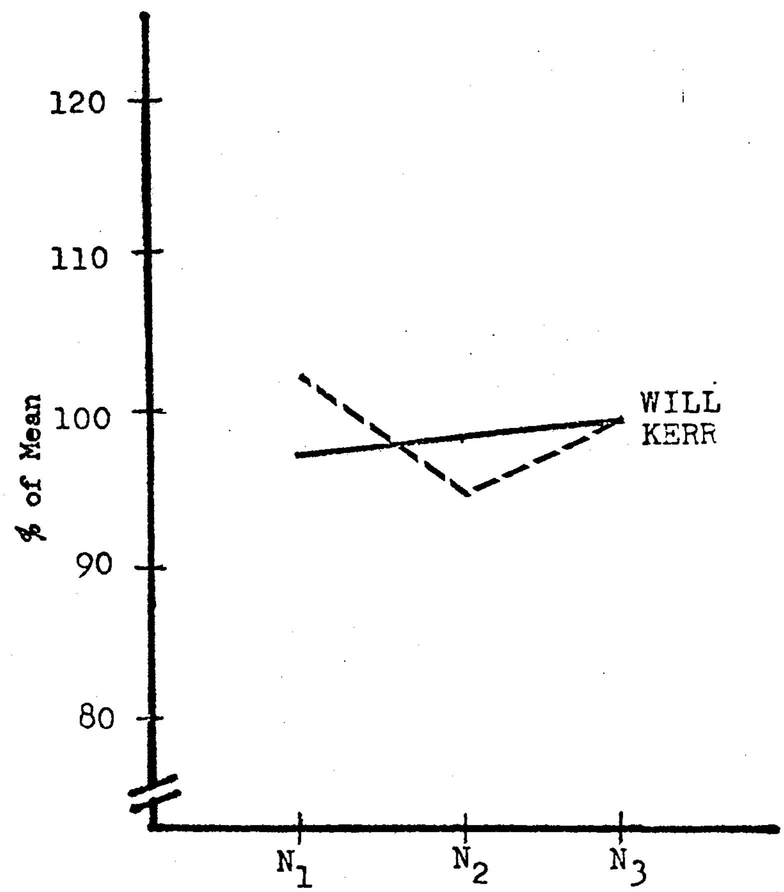

Figure 20. Plant Height of the Two Barley Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (89.4 cm)

increased lodging of the barley varieties. Will appeared to lodge more than Kerr. Treatment means for lodging are presented in Appendix Table XXI.

Triticale

As an indication of the level of productivity of the four triticale varieties in the test, the mean yield of the four varieties across all levels of nitrogen and phosphorus was 1897.9 kg/ha (29.4 bu/acre). The highest treatment mean was 2856.0 kg/ha (44.2 bu/acre) for T385 at N_1 P_3, while the lowest was 791.8 kg/ha (12.2 bu/acre) for Rosner at N_1 P_1.

The interpretation of the results of the triticale section may be limited somewhat due to severe winterkilling of three of the varieties, Rosner, T204, and CL72. Considerable recovery and regrowth was observed for CL72 and T204, while Rosner exhibited the least recovery. Differences in winter injury and regrowth no doubt affected grain yields (Table II) as well as other traits.

Mean squares for various traits of the triticale varieties are listed in Table VI. Mean squares for differences among varieties for all characters were highly significant.

Grain Yield

Significant mean squares for differences among varieties and for variety by nitrogen and variety by phosphorus interactions were observed for this trait. These interactions indicated that the four varieties of triticale did not respond similarly to nitrogen or phosphorus levels. This response is shown in Figures 21 and 22. Grain yield of CL72, the highest yielding variety, decreased slightly at the N_2 level and more

TABLE VI

MEAN SQUARES FROM ANALYSES OF VARIANCE OF DATA FOR TRITICALE

Source of Variation	d.f.	Grain Yield (X 10^{-4})	Tiller Number	Kernels per Tiller	Kernel Weight	Forage Yield (X 10^{-4})	Heading Date	Plant Height
N Levels	2	31.32	402.69*	54.67	5.96*	22.15	0.47	135.77*
Error (a)	6	38.60	43.77	30.25	0.95	49.66	2.65	14.95
Varieties	3	624.06**	5441.91**	1293.28**	7.74**	625.51**	238.91**	7764.95**
P Levels	2	55.14	16.97	26.69	0.23	54.47	0.13	82.02
Var X P	6	44.75*	25.23	13.34	0.34	15.14	0.84	49.05
N X Var	6	45.69*	92.10	25.56	0.28	8.13	1.12	92.77*
N X P	4	17.88	14.72	10.63	0.39	41.77	1.32	16.14
N X Var X P	12	10.19	52.72	20.00	0.36	12.77	1.28	15.98
Error (b)	99	20.83	45.66	18.29	0.50	18.57	1.00	36.86

*Significant at the .05 level of probability

**Significant at the .01 level of probability

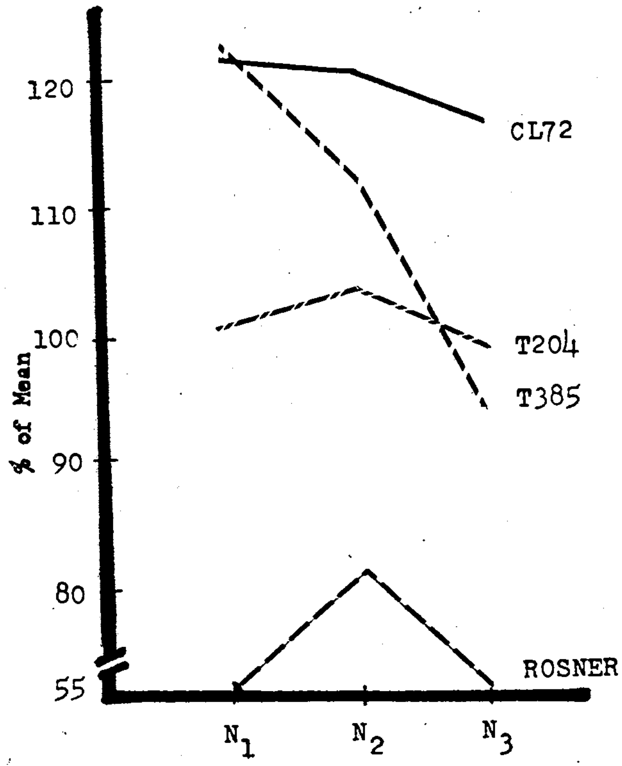

Figure 21. Grain Yield of the Four Triticale Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (1897.9 kg/ha)

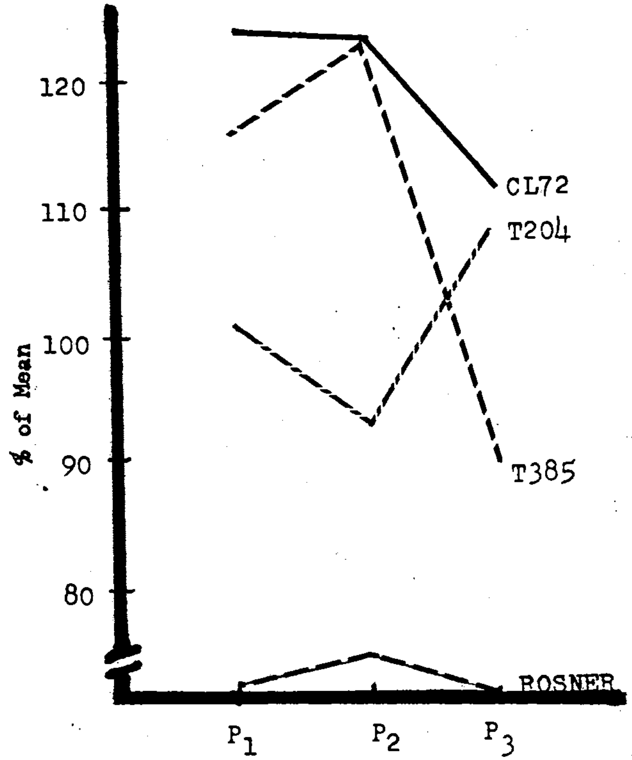

Figure 22. Grain Yield of the Four Triticale Varieties at the Three Levels of Phosphorus Expressed As Percent of Grand Mean (1897.9 kg/ha)

drastically at the N_3 level. Grain yield for T385 decreased very sharply at both the N_2 and N_3 levels. T204, apparently affected by winterkilling but to a lesser extent than Rosner, showed an increase in grain yield at N_2 and a decrease at the N_3 level. Rosner, affected very much by winterkilling had a very low yield at N_1 but increased at N_2 then decreased at N_3 again. For phosphorus levels, CL72 showed a slight decrease at the P_2 level and a more pronounced decrease at the P_3 level. The variety T385 exhibited an increase at the P_2 level, but a drastic decrease at the P_3 level. T204 showed a decrease in grain yield at the P_2 level but an increase at the P_3 level. Rosner had a slight increase in yield at the P_2 level and a slight decrease at the P_3 level. Treatment means for grain yield are presented in Appendix Table XXII.

Tiller Number

Mean squares for differences among varieties were significant as well as for differences among nitrogen levels for this trait. As shown in Figure 23, each additional level of nitrogen effectively increased the number of tillers for all varieties except Rosner. T385, the highest tillering variety, had 50.9 tillers per 930 cm^2 at the N_1 level and 28.4 at the N_3 level. Treatment means for tiller number are presented in Appendix Table XXIII.

Kernels per Tiller

Mean squares for differences among varieties were significant but no other treatment variable was significant for kernels per tiller. CL72 and T204 had the highest number of kernels per tiller with 40.5 and 40.2 respectively. T385 and Rosner had 30.2 and 29.7 kernels per tiller respectively. Treatment means for kernels per tiller are shown in Appendix Table XXIV.

Kernel Weight

Mean squares for differences among varieties were significant as were differences among nitrogen levels. The overall effect of nitrogen was to decrease kernel weight (Figure 24). Treatment means for kernel weight are presented in Appendix Table XXV.

Maturity

Mean squares for differences among varieties were highly significant but no other treatment variable was significant. The four varieties had later heading dates on the average than wheat or barley. Average heading dates for the four triticale varieties were: Rosner, April 20; T385, April 24; T204 and CL72, April 25.

Forage Yield

Mean squares for differences among varieties were highly significant for this trait. No other treatment variable was significant for differences in forage yield. Treatment means for forage yield are presented in Appendix Table XXVI.

Plant Height

Mean squares for differences among varieties were significant as were those among nitrogen levels. As shown in Figure 25, nitrogen applications tended to increase plant height of CL72, T204, and Rosner, but caused a reduction in height of T385. Treatment means for plant

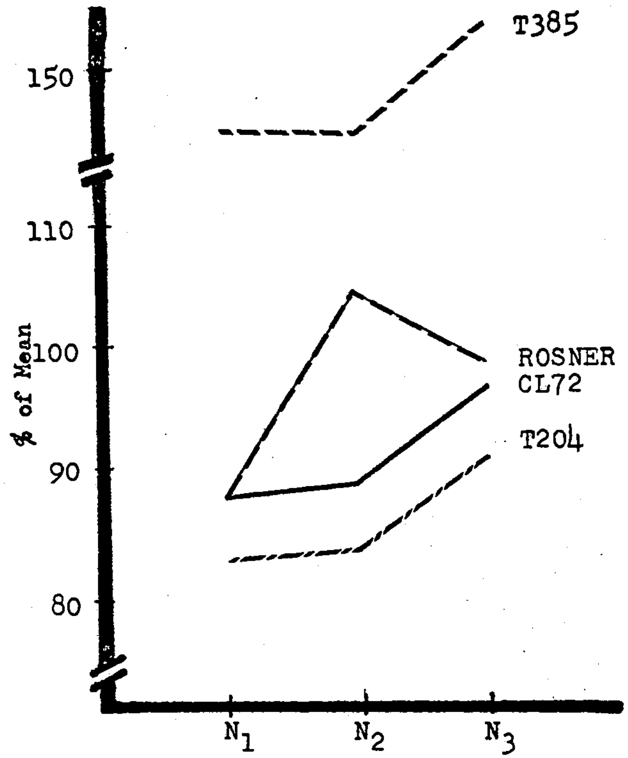

Figure 23. Tiller Number of the Four Triticale Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (34.6 Tillers)

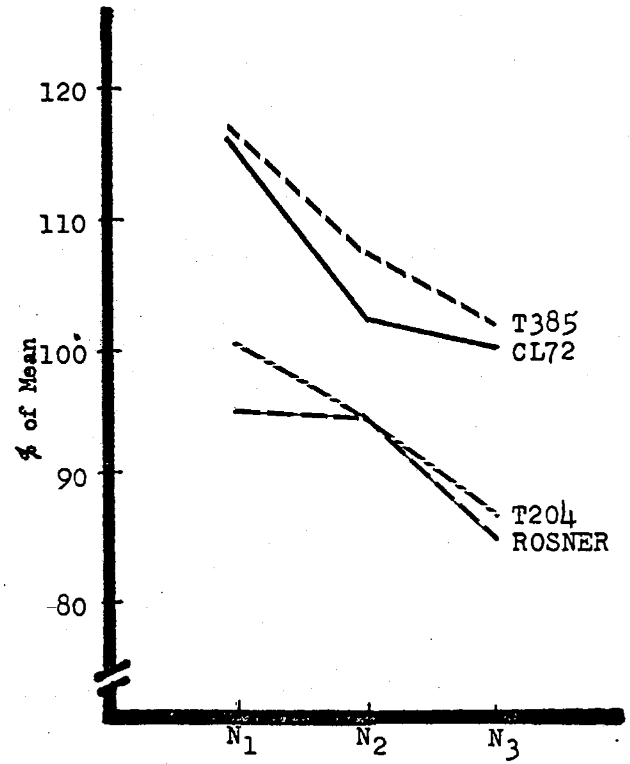

Figure 24. Kernel Weight of the Four Triticale Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (5.4 Grams)

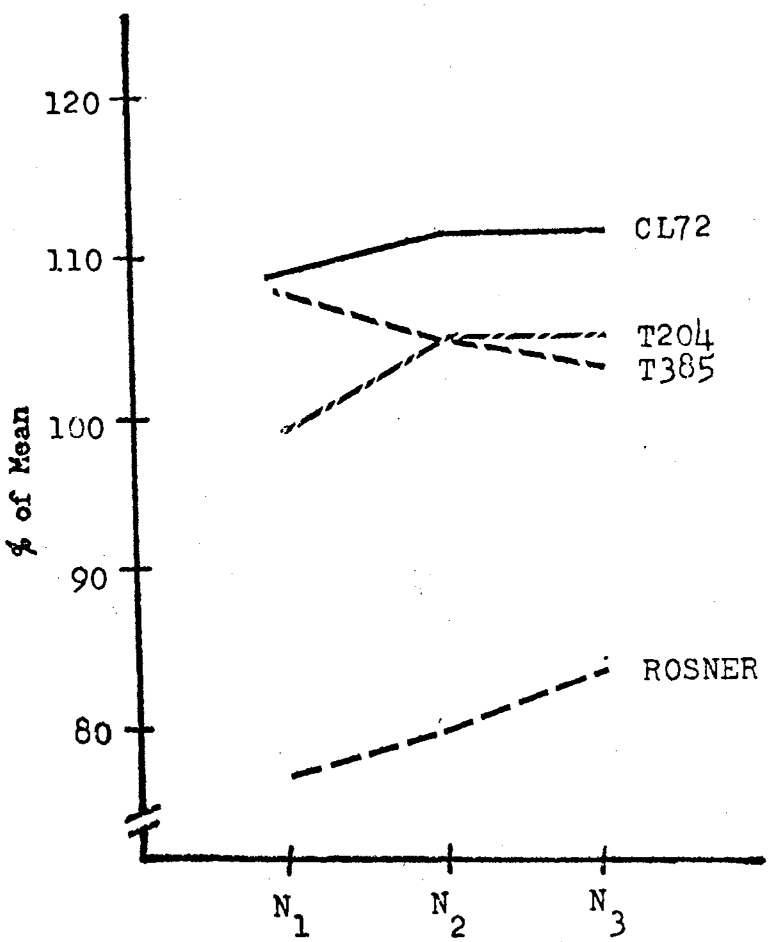

Figure 25. Plant Height of the Four Triticale Varieties at the Three Levels of Nitrogen Expressed As Percent of Grand Mean (108.4 cm)

height are presented in Appendix Table XXVII.

Lodging

Lodging did not seriously affect the triticale varieties although, on the average, higher nitrogen levels tended to increase lodging. Treatment means for lodging are presented in Appendix Table XXVIII.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study were: 1) to investigate the effects of nitrogen and phosphorus on representative varieties of wheat, barley, and triticale, and 2) to determine the relative importance and the interrelationships between yield and yield components for wheat.

The four wheat varieties, two barley varieties, and four triticale varieties were selected on the basis of their contrasting characters and their present and potential use as varieties and/or breeding lines. The study was conducted in a replicated test on the Agronomy Farm Research Station, Stillwater, Oklahoma. A split-plot design was used for the study. Nitrogen levels were main-plots while the sub-plots consisted of phosphorus levels by varieties arranged factorially. A plot consisted of four 3 m rows spaced 30.5 cm apart. Three irrigations were made in the spring to attempt to maintain high production conditions. Irrigations were made before moisture stress was evident as indicated by readings from tensiometer probes placed within the test site. Levels of nitrogen were 60, 120, and 180 kg/ha. A preplant starter fertilizer (18-46-0) was applied at the rate of 111 kg/ha. Topdressings were made in January and February with a hand-powered fertilizer spreader to complete all nitrogen levels. Phosphorus levels were 50, 75, and 100 kg/ha and were applied at planting time. The seeding rate was 100 kg/ha for all entries and the test was planted on October 2, 1971.

Characters analyzed were grain yield, tiller number, kernels per tiller, kernel weight, forage yield, heading date, and plant height. In addition, kernel protein content was measured for the wheat varieties. An analysis of variance was conducted for each character to provide information on differences among varieties, nitrogen levels, phosphorus levels, and interactions. A separate analysis was conducted for each crop.

The mean yields for each crop averaged across nitrogen and phosphorus treatments were: wheat, 3949.8 kg/ha, barley, 3235.5 kg/ha, and triticale, 1897.9 kg/ha. Mean squares for differences among varieties were highly significant for grain yield of all crops. There was no increase in grain yield due to either nitrogen or phosphorus fertilization. However, there was a significant decrease in yield of barley due to increased increments of nitrogen. There were also significant nitrogen by variety interactions for wheat and triticale. In addition, a significant variety by phosphorus interaction for grain yield was observed for triticale. It is believed that the nitrogen and phosphorus levels of the N_1 P_1 treatment in this study were adequate to achieve maximum yield under the environmental conditions experienced. Previous production reports indicated that the varieties tested have a higher genetic potential for yield than was observed in this study. Had more desirable growing conditions existed, a response to nitrogen would have been expected.

For tiller number, differences among varieties were significant. In general, tiller number of wheat and triticale varieties was increased by nitrogen application. In addition, phosphorus applications resulted in increased tiller number for the four wheat varieties. Also, a variety by phosphorus interaction was noted for the wheat varieties.

For kernels per tiller, differences among varieties were again highly significant. For the wheat varieties, a highly significant nitrogen by variety interaction was noted for kernels per tiller. In addition, a significant second order interaction of nitrogen by variety by phosphorus was noted for the two barley varieties.

For kernel weight, differences among varieties were highly significant. There was also a difference among levels of nitrogen for the triticale and barley varieties in response to this trait. In addition, a significant difference among levels of phosphorus for kernel weight was noted in the four wheat varieties. Increased levels of phosphorus and nitrogen resulted in decreased kernel weight.

For yields of forage, differences among varieties were significant for the wheat and triticale varieties, but not for the barley varieties. Mean squares for forage yield indicated highly significant differences among phosphorus levels for the wheat varieties. Wheat forage yields were increased by additional phosphorus but not with additional nitrogen.

Differences among varieties of wheat and triticale were highly significant for heading date. There was no difference between the barley varieties for this trait. Neither nitrogen nor phosphorus had any effect on heading date.

Differences among varieties of wheat and triticale were highly significant for plant height. A significant nitrogen by variety interaction was noted for the barley and triticale varieties for this trait.

Mean squares for kernel protein were highly signifcant for differences among varieties, differences among nitrogen levels, and for the nitrogen by variety interaction for the wheat varieties. The overall effect of nitrogen was to increase grain protein although the wheat varieties, on the average, tended to respond differently for this trait.

Although an analysis of variance was not conducted for lodging, treatment means indicated that each additional level of nitrogen tended to increase lodging for all varieties.

Winterkilling was observed in the triticale varieties but not in the wheat or barley varieties. Three of the triticale varieties tested had severe winterkilling, while one, T385, appeared to have sufficient winterhardiness to survive the winter in Oklahoma.

In the study of yield and yield components of the wheat varieites, tiller number of Centurk appeared to be more important than the other two components in determining yield in this variety. For the variety Blueboy, tiller number also appeared to be most closely associated with yield. For the variety Palo Duro, kernel weight appeared to be the component most closely associated with yield. Kernels per tiller appeared to be most closely associated with yield for the variety Danne. Kernel weight also appeared to have a high positive association with grain yield for Danne.

These data indicate that for each variety, there is one component more closely associated with yield than the other two. It is believed that adverse interactions among yield components may frequently occur. However, it has been shown that these interactions can be overcome by the fact that higher yield levels are being reached in small grain production in many areas around the world. It is believed that the selection of parents on the basis of individual components rather than on yield _per se_ could be a more effective method of developing superior breeding populations. Nitrogen or phosphorus fertilization for maximum response of a particular component could result in increased yield assuming other factors were not limiting. From a breeding standpoint, a cross between Blueboy (low tiller number, high kernels per tiller, and high kernel weight) and Centurk (high tiller number, intermediate in kernels per tiller, and low kernel weight) might result in high yielding progeny by favorable complementation of yield components.

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APPENDIX

TABLE VII

MEANS FOR GRAIN YIELD OF WHEAT IN kg/ha

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Centurk	4458.4	4206.2	4362.6	4060.0	4444.9	4418.0	4137.3	4246.6	4288.6
Palo Duro	4522.3	4303.7	4629.9	4379.4	3806.1	3944.0	4256.7	3174.0	3789.3
Blueboy	3644.7	3994.4	3710.3	3543.9	3743.9	3490.1	4303.7	4083.5	3658.2
Danne	3863.3	3742.2	3967.5	3886.8	3461.5	2861.3	3851.5	3691.8	3264.8
Average	4122.2	4061.6	4167.6	3967.5	3864.1	3678.3	4137.3	3799.0	3750.2

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Centurk	4342.4	4307.7	4224.2	4218.6	4299.2	4356.4	4291.4
Palo Duro	4485.3	4043.2	3740.0	4386.1	3761.2	4121.0	4089.5
Blueboy	3783.1	3592.6	4015.1	3830.8	3940.6	3619.5	3797.0
Danne	3857.7	3403.2	3602.7	3867.2	3631.8	3364.5	3621.2
Average	4117.1	3836.7	3895.5	4075.7	3908.2	3865.4	Mean 3949.8

TABLE VIII

MEANS FOR TILLERS PER 930 cm^2 FOR WHEAT

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Palo Duro	78.0	83.8	89.8	79.3	93.0	91.5	78.5	92.0	96.8
Centurk	78.8	82.3	69.5	80.0	87.5	97.3	88.0	91.0	88.8
Danne	65.5	71.3	65.5	71.8	79.3	69.5	84.3	80.8	77.3
Blueboy	61.5	56.8	57.0	53.3	64.3	63.8	69.3	64.0	56.3
Average	70.9	73.5	70.4	71.1	81.0	80.5	80.0	81.9	79.8

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Palo Duro	83.8	87.9	89.1	78.6	89.6	92.7	86.9
Centurk	76.8	88.3	89.3	82.3	86.9	85.2	84.8
Danne	67.4	73.5	80.8	73.8	77.1	70.8	73.9
Blueboy	58.4	60.4	63.2	61.3	61.7	59.0	60.7
Average	71.6	77.5	80.6	74.0	78.8	76.9	Mean 76.6

TABLE IX

MEANS FOR KERNELS PER TILLER FOR WHEAT

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Blueboy	31.3	29.0	29.7	31.2	33.4	32.3	32.6	31.1	31.3
Centurk	24.5	23.4	26.3	24.7	26.3	26.9	24.7	24.3	23.9
Danne	24.1	23.3	23.1	22.9	22.5	23.6	24.1	23.6	22.9
Palo Duro	23.1	23.5	23.2	23.5	22.6	22.7	22.7	24.0	23.6
Average	25.7	24.8	25.6	25.6	26.2	26.4	26.0	25.7	25.4

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Blueboy	30.0	32.3	31.7	31.7	31.2	31.1	31.3
Centurk	24.7	25.9	24.3	24.6	24.6	25.7	25.0
Danne	23.5	23.0	23.5	23.7	23.1	23.2	23.3
Palo Duro	23.3	23.0	23.4	23.1	23.4	23.2	23.2
Average	25.4	26.0	25.7	25.8	25.6	25.8	Mean 25.7

TABLE X

MEANS FOR 200 KERNEL WEIGHT IN GRAMS FOR WHEAT

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Blueboy	7.2	6.9	6.8	6.8	6.4	6.3	6.5	6.2	6.4
Danne	6.4	6.6	6.5	6.6	6.5	6.0	6.1	6.2	6.0
Centurk	5.9	5.9	6.1	5.4	5.6	5.7	5.6	5.5	5.5
Palo Duro	5.6	5.7	5.8	6.0	5.1	5.3	5.4	4.6	4.8
Average	6.3	6.2	6.3	6.2	5.9	5.8	5.9	5.6	5.7

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Blueboy	7.0	6.5	6.4	6.8	6.5	6.5	6.6
Danne	6.5	6.4	6.1	6.4	6.4	6.1	6.3
Centurk	5.9	5.6	5.5	5.6	5.6	5.7	5.7
Palo Duro	5.7	5.5	5.0	5.7	5.2	5.3	5.4
							Mean
Average	6.3	6.0	5.7	6.1	5.9	5.9	6.0

TABLE XI

MEANS FOR PERCENT KERNEL PROTEIN FOR WHEAT

Variety	N_1 P_1	N_1 P_2	N_1 P_3	N_2 P_1	N_2 P_2	N_2 P_3	N_3 P_1	N_3 P_2	N_3 P_3
Palo Duro	12.2	11.6	11.8	14.2	14.6	15.1	15.5	15.3	15.4
Centurk	12.1	11.0	12.1	14.3	13.8	14.3	15.4	15.7	14.9
Blueboy	11.7	11.6	11.5	13.2	13.0	13.1	13.4	13.7	13.8
Danne	11.2	11.3	11.0	12.6	13.2	13.0	13.5	13.6	13.6
Average	11.8	11.4	11.6	13.6	13.6	13.9	14.4	14.6	14.4

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Palo Duro	11.9	14.6	15.4	13.9	13.8	14.1	13.9
Centurk	11.7	14.2	15.3	14.0	13.5	13.8	13.7
Blueboy	11.6	13.1	13.6	12.8	12.8	12.8	12.8
Danne	11.2	12.9	13.6	12.4	12.7	12.5	12.6
Average	11.6	13.7	14.5	13.3	13.2	13.3	Mean 13.3

TABLE XII

MEANS FOR FORAGE YIELD OF WHEAT IN kg/ha

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Blueboy	2650.0	2522.2	3019.4	2611.1	3333.3	2811.1	2394.4	3022.2	3072.2
Centurk	2472.2	2263.9	2733.3	2102.8	2708.3	3275.0	2530.6	2513.9	2650.0
Palo Duro	1911.1	2313.9	2230.6	1761.1	2180.6	2361.1	2133.3	2244.4	2200.0
Danne	1941.7	2025.0	1975.0	1783.3	2444.4	2166.7	2327.8	1986.1	2322.2
Average	2243.8	2281.3	2489.6	2064.6	2666.7	2653.5	2346.5	2441.7	2561.1

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Blueboy	2730.6	2918.5	2829.6	2551.9	2959.3	2967.6	2826.2
Centurk	2489.8	2695.4	2564.8	2368.5	2495.4	2886.1	2583.3
Palo Duro	2151.9	2100.9	2192.6	1935.2	2246.3	2263.9	2148.5
Danne	1980.6	2131.5	2212.0	2017.6	2151.9	2154.6	2108.0
Average	2338.2	2461.6	2499.8	2218.3	2463.2	2568.1	Mean 2416.5

TABLE XIII

MEANS FOR PLANT HEIGHT IN cm FOR WHEAT

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Centurk	90.5	89.0	92.3	86.0	88.8	90.5	92.5	92.5	92.0
Palo Duro	89.5	89.8	88.0	85.8	87.8	86.5	85.5	90.5	90.0
Blueboy	89.0	87.5	85.5	87.0	89.8	86.5	86.8	90.3	87.5
Danne	87.8	85.0	86.8	86.3	83.0	84.3	88.0	86.8	89.5
Average	89.2	87.8	88.1	86.3	87.3	86.9	88.2	90.0	89.8

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Centurk	90.6	88.4	92.3	89.7	90.1	91.6	90.4
Palo Duro	89.1	86.7	88.1	86.9	89.3	88.2	88.1
Blueboy	87.3	87.8	88.2	87.6	89.2	86.5	87.8
Danne	86.5	84.5	88.7	87.3	84.9	86.8	86.4
Average	88.4	86.8	89.3	87.9	88.4	88.3	Mean 88.2

TABLE XIV

MEANS FOR PERCENT LODGING FOR WHEAT

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Centurk	23.8	7.5	20.0	21.3	32.5	31.3	40.0	60.0	26.3
Palo Duro	10.0	5.0	8.8	7.5	5.0	37.5	15.0	12.5	38.8
Danne	6.3	6.3	13.8	7.5	16.3	6.3	20.0	15.0	11.3
Blueboy	5.0	5.0	5.0	6.3	5.0	5.0	8.8	8.8	5.0
Average	11.3	5.9	11.9	10.6	14.7	20.0	20.9	24.1	20.3

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Centurk	17.1	28.3	42.1	28.3	33.3	25.8	29.2
Palo Duro	7.8	16.7	15.4	10.8	7.5	28.3	15.6
Danne	8.8	10.0	22.1	11.3	12.5	10.4	11.4
Blueboy	5.0	5.4	7.5	6.6	6.3	5.0	6.0
Average	9.7	15.1	21.8	14.3	14.9	17.4	Mean 15.5

TABLE XV

MEANS FOR GRAIN YIELD OF BARLEY IN kg/ha

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Will	3473.2	3856.5	3587.6	3177.4	3543.9	3182.4	2662.9	2846.2	3330.3
Kerr	2989.1	2785.7	3364.0	2846.2	3175.7	3108.4	2770.5	2857.9	2881.5
Average	3231.2	3321.1	3475.8	3011.8	3359.8	3145.4	2716.7	2852.1	3105.9

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Will	3639.1	3301.2	2946.5	3104.5	3415.5	3366.8	3295.6
Kerr	3046.2	3043.4	2836.6	2868.6	2939.8	3118.0	2975.4
Average	3342.7	3172.3	2891.6	2986.6	3177.6	3242.4	3135.5

TABLE XVI

MEANS FOR TILLERS PER 930 cm^2 FOR BARLEY

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Kerr	83.0	76.3	100.8	91.3	81.0	78.0	87.3	82.8	96.0
Will	53.5	57.8	67.0	68.0	63.5	62.5	75.0	64.8	76.0
Average	68.3	67.0	83.9	79.6	72.3	70.3	81.1	73.8	86.0

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Kerr	86.7	83.4	88.7	87.2	80.0	91.6	86.3
Will	59.4	64.7	71.9	65.5	62.0	68.5	65.3
Average	73.0	74.0	80.3	76.3	71.0	80.0	Mean 75.8

TABLE XVII

MEANS FOR KERNELS PER TILLER FOR BARLEY

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Will	39.7	31.6	37.7	39.2	38.9	40.1	35.3	40.6	39.4
Kerr	21.6	24.7	23.0	22.8	23.8	24.3	24.5	25.6	25.6
Average	30.6	28.1	30.4	31.0	31.3	32.2	29.9	33.0	32.5

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Will	36.3	39.4	38.4	38.1	37.0	39.1	38.0
Kerr	23.1	23.6	25.2	23.0	24.6	24.3	24.0
Average	29.7	31.5	31.8	30.5	30.8	31.7	Mean 31.0

TABLE XVIII

MEANS FOR 200 KERNEL WEIGHT IN GRAMS FOR BARLEY

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Kerr	5.7	6.0	5.7	5.7	5.3	5.2	5.4	5.5	5.1
Will	5.0	5.6	5.5	4.7	5.4	4.6	4.6	4.1	4.0
Average	5.4	5.8	5.6	5.2	5.3	4.9	5.0	4.8	4.5

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Kerr	5.8	5.4	5.3	5.6	5.6	5.3	5.5
Will	5.4	4.9	4.2	4.7	5.0	4.7	4.8
							Mean
Average	5.6	5.1	4.8	5.2	5.3	5.0	5.2

TABLE XIX

MEANS FOR FORAGE YIELD OF BARLEY IN kg/ha

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Kerr	2491.7	2161.1	2194.4	2316.7	2488.9	2605.6	2788.9	2091.7	2502.8
Will	1363.9	1919.4	2352.8	2466.7	2552.8	2591.7	2372.2	2411.1	2377.8
Average	1927.8	2040.3	2273.6	2391.7	2520.8	2598.6	2580.6	2251.4	2440.3

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Kerr	2282.4	2470.4	2461.1	2532.4	2247.2	2434.3	2404.6
Will	1878.7	2537.0	2387.0	2067.6	2294.4	2440.7	2267.6
Average	2080.6	2503.7	2424.1	2300.0	2270.8	2437.5	Mean 2336.1

TABLE XX

MEANS FOR PLANT HEIGHT IN cm FOR BARLEY

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Kerr	93.8	91.8	90.3	85.5	86.3	87.3	88.5	92.5	91.3
Will	87.8	86.0	88.0	84.0	91.0	91.3	89.8	91.0	92.0
Average	90.8	88.9	89.5	84.8	88.6	89.3	89.1	91.8	91.6

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Kerr	91.9	86.3	90.8	89.3	90.2	89.6	89.7
Will	87.5	88.8	90.9	87.2	89.3	90.7	89.1
Average	89.7	87.5	90.8	88.2	89.8	90.1	Mean 89.4

TABLE XXI

MEANS FOR PERCENT LODGING FOR BARLEY

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
Will	15.0	31.3	18.8	25.0	55.0	45.0	43.8	81.3	56.3
Kerr	13.8	10.0	18.9	11.3	13.8	22.5	33.8	37.5	45.0
Average	14.4	20.6	18.8	18.1	34.4	33.8	38.8	59.4	50.6

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
Will	21.7	41.7	60.4	27.9	55.8	40.0	38.0
Kerr	14.2	15.8	38.8	19.6	20.4	28.8	22.9
Average	17.9	28.8	49.6	23.8	38.1	34.4	Mean 32.1

TABLE XXII

MEANS FOR GRAIN YIELD OF TRITICALE IN kg/ha

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
CL72	2246.0	2377.1	2298.1	2499.9	2299.8	2091.3	2338.5	2378.8	1997.2
T385	2449.4	2671.3	1856.0	2210.7	2397.3	1792.1	1933.3	1943.4	1491.2
T204	1783.7	1790.4	2153.5	1930.0	1793.8	2108.2	2012.3	1724.9	1916.5
Rosner	791.8	1168.4	1168.4	1839.2	1677.8	1114.6	1373.5	1398.7	1307.9
Average	1817.7	2001.8	1869.0	2119.9	2042.2	1776.5	1914.4	1861.4	1678.2

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
CL72	2307.1	2297.0	2238.2	2361.4	2351.9	2128.9	2280.8
T385	2325.6	2133.4	1789.3	2197.8	2337.4	1713.1	2082.8
T204	1909.2	1944.0	1884.6	1908.7	1769.7	2059.4	1912.6
Rosner	1042.9	1543.9	1360.0	1334.8	1415.0	1197.0	1315.6
Average	1896.2	1979.5	1818.0	1950.7	1968.5	1774.6	Mean 1897.9

TABLE XXIII

MEANS FOR TILLERS PER 930 cm^2 FOR TRITICALE

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T385	52.8	53.3	46.8	48.0	51.0	53.5	60.0	50.5	56.0
Rosner	23.4	27.0	28.5	36.3	38.5	36.8	35.0	35.3	30.5
CL72	27.8	23.4	28.0	25.3	29.5	26.5	28.8	34.0	33.8
T204	19.5	25.3	23.8	23.3	19.0	28.0	27.5	27.8	30.0
Average	30.9	32.2	31.8	33.2	34.5	36.2	37.8	36.9	37.6

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
T385	50.9	50.8	55.5	53.6	51.6	52.1	52.4
Rosner	26.4	37.2	33.6	31.7	33.6	31.9	32.4
CL72	26.3	27.1	32.2	27.3	28.9	29.4	28.5
T204	22.8	23.4	28.4	23.4	24.0	27.3	24.9
Average	31.6	34.6	37.4	34.0	34.5	35.2	Mean 34.6

TABLE XXIV

MEANS FOR KERNELS PER TILLER FOR TRITICALE

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
CL72	40.1	43.6	40.1	38.5	38.2	39.6	39.0	42.6	43.0
T204	40.7	43.8	42.6	39.4	41.1	38.4	35.5	39.2	40.8
T385	32.5	32.2	30.8	29.7	31.6	30.2	29.9	28.4	26.8
Rosner	25.0	30.6	33.8	32.4	28.4	32.1	29.1	29.0	27.1
Average	34.5	37.6	36.8	35.0	34.8	35.1	33.4	34.8	34.4

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
CL72	41.3	38.8	41.5	39.2	41.5	40.9	40.5
T204	42.3	39.6	38.5	38.5	41.4	40.6	40.2
T385	31.8	30.5	28.3	30.7	30.7	29.2	30.2
Rosner	29.8	31.0	28.4	28.8	29.3	31.0	29.7
Average	36.3	35.0	34.2	34.3	35.7	35.4	Mean 35.1

TABLE XXV

MEANS FOR 200 KERNEL WEIGHT IN GRAMS FOR TRITICALE

Variety	N_1			N_2			N_3		
	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T385	6.3	6.8	5.9	5.9	6.1	5.6	5.4	5.6	5.6
CL72	5.9	6.3	6.5	6.1	5.5	5.0	5.6	5.5	5.1
T204	5.4	5.3	5.7	5.0	5.1	5.2	4.8	4.7	4.7
Rosner	5.0	5.2	5.1	5.4	5.1	4.9	4.1	4.8	5.0
Average	5.7	5.9	5.8	5.6	5.4	5.2	5.0	5.1	5.1

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
T385	6.3	5.8	5.5	5.9	6.2	5.7	5.9
CL72	6.2	5.5	5.4	5.9	5.7	5.5	5.7
T204	5.4	5.1	4.7	5.1	5.0	5.2	5.1
Rosner	5.1	5.1	4.6	4.8	5.0	5.0	4.9
Average	5.8	5.4	5.1	5.4	5.5	5.3	Mean 5.4

TABLE XXVI

MEANS FOR FORAGE YIELD OF TRITICALE IN kg/ha

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T385	2472.2	2513.9	2466.7	2580.6	2336.1	3069.4	2580.6	2875.0	2330.6
Rosner	1883.3	2477.8	2447.2	2208.3	2319.4	2750.0	2269.4	2325.0	2563.9
CL72	1800.0	2072.2	1855.6	1911.1	1597.2	1988.9	1802.8	2013.9	2027.8
T204	1352.8	1650.0	1652.8	1841.7	1836.1	1813.9	1372.2	2000.0	1519.4
Average	1877.1	2178.5	2105.6	2135.4	2022.2	2405.6	2006.3	2303.5	2110.4

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
T385	2484.3	2662.0	2595.4	2544.4	2575.0	2622.2	2580.6
Rosner	2269.4	2425.9	2386.1	2120.4	2374.1	2587.0	2360.5
CL72	1909.3	1832.4	1948.1	1838.0	1894.4	1957.4	1896.6
T204	1551.9	1830.6	1630.6	1522.2	1828.7	1622.0	1671.0
Average	2053.7	2187.7	2140.0	2006.3	2168.1	2207.2	Mean 2127.2

TABLE XXVII

MEANS FOR PLANT HEIGHT IN cm FOR TRITICALE

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
CL72	117.8	115.5	121.3	123.3	121.3	120.5	120.5	121.3	123.0
T385	115.5	120.3	113.0	114.0	114.3	113.0	115.0	112.0	109.3
T204	110.8	106.0	107.5	117.3	111.8	113.0	118.5	108.5	115.5
Rosner	83.8	84.3	82.5	90.8	84.8	84.3	91.8	90.5	90.8
Average	106.9	106.5	106.1	111.3	107.9	107.7	111.4	108.1	109.6

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
CL72	118.2	121.6	121.6	120.5	119.3	121.6	120.4
T385	116.3	113.8	112.1	114.8	115.5	111.8	114.0
T204	108.1	114.0	114.2	115.5	108.8	112.0	112.1
Rosner	83.5	86.6	91.0	88.8	86.5	85.8	87.0
Average	106.5	109.0	109.7	109.9	107.5	107.8	Mean 108.4

TABLE XXVIII

MEANS FOR PERCENT LODGING FOR TRITICALE

	N_1			N_2			N_3		
Variety	P_1	P_2	P_3	P_1	P_2	P_3	P_1	P_2	P_3
T385	3.8	5.0	6.3	5.0	5.0	5.0	8.8	7.5	6.3
CL72	5.0	5.0	3.8	5.0	7.5	6.3	6.3	6.3	6.3
T204	3.8	5.0	6.3	5.0	3.8	5.0	6.3	5.0	6.3
Rosner	3.8	5.0	5.0	5.0	5.0	5.0	6.3	3.8	5.0
Average	4.1	5.0	5.3	5.0	5.3	5.3	6.9	5.6	5.9

	N_1 Ave	N_2 Ave	N_3 Ave	P_1 Ave	P_2 Ave	P_3 Ave	Var Ave
T385	5.0	5.0	7.5	5.8	5.8	5.8	5.8
CL72	4.6	6.3	6.3	5.4	6.3	5.4	5.7
T204	5.0	4.6	5.8	5.0	4.6	5.8	5.1
Rosner	4.6	5.0	5.0	5.0	4.6	5.0	4.9
Average	4.8	5.2	6.1	5.3	5.3	5.5	Mean 5.4

VITA

Robert Edward Klein

Candidate for the Degree of

Master of Science

Thesis: AGRONOMIC PERFORMANCE OF WHEAT, BARLEY, AND TRITICALE AS AFFECTED BY LEVELS OF NITROGEN AND PHOSPHORUS

Major Field: Agronomy

Biographical:

Personal Data: Born in Butler, Oklahoma, June 16, 1947, son of Arthur and Beulah Klein.

Education: Graduated from Butler High School, Butler, Oklahoma, in 1965; received Bachelor of Science degree in Agronomy from Oklahoma State University in 1969; completed requirements for the Master of Science degree in May, 1973.

Professional Experience: Graduate Assistant, Department of Agronomy, Oklahoma State University, Stillwater, Oklahoma, October, 1971, to May, 1973.

Military Service: United States Army, January, 1970 (Rank E-1) to September, 1971 (Rank, E-5).