YIELD COMPONENTS AND MORPHOLOGICAL STRUCTURES OF WINTER WHEAT MULTIPLE CROPPED IN BERMUDAGRASS

By

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PREFACE

I am grateful to the Agronomy Department of Oklahoma State University for their financial and instructional support while attending this University. Utmost appreciation is expressed to my major advisor, Dr. Lavoy I. Croy, and the other members of my committee, Dr. Robert Reed and Dr. Lewis Edwards, for their guidance in the writing of this thesis. I am grateful to Dr. Syed H. Mohiuddin for his assistance in the statistical analysis. I also wish to express appreciation to Miss Dayna Edwards and Miss Julie Arrington for their excellent technical and laboratory assistance.

I am grateful to my parents, Mr. and Mrs. Paul Nightengale and to Mr. and Mrs. J. W. Scannell, Mrs. R. M. Scannell, and Mrs. Viola Rauh for their encouragements during my educational pursuit. Most important, I wish to express my appreciation to my wife, Joan, for her patience and understanding while attending Oklahoma State University.

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CHAPTER I

INTRODUCTION

Man's strife to solve the problem of world hunger by means of improved crop production has paralleled that of the evolution of agriculture. During the early developmental stages of farming man increased crop yields by merely planting in rows instead of broadcasting the seed. He next began to use mechanical weed control and fertilizer application in the form of manure, crop residues, and green manuring. Upon the introduction of the industrial age, crop production was increased by bringing new land into cultivation. With the advent of the chemical fertilizer industry and improved knowledge in soil fertility, crop physiology, genetics, and other sciences, great strides have been made in improved crop yields.

Man can no longer rely upon increasing the acreage of cultivated land for higher food production. He must therefore search for means of improving land use efficiency. One way of accomplishing greater efficiency in land use would be that of multiple cropping or companion cropping. This is not a new method uncommon to today's farming practices; however, it has not been exploited to the greatest extent.

When considering multiple cropping, one would prefer to reduce the competition between the different species to a minimum. A logical choice of crops would thus be one having a summer growth habit and the other a winter growth habit. Two such species which meet these requirements are bermudagrass (Cynodon spp.) and winter wheat (Triticum aestivum L.).

When sowing winter wheat in bermudagrass sod it is desirable to delay the planting of the wheat as long as possible in the fall, to reduce the competition. Because of this it is usually impractical to sow the wheat for fall and winter grazing purposes. This, however, does not eliminate the sod-seeding of winter wheat for the purposes of grain production. One would suspect that higher levels of nitrogen and higher seeding rates would be necessary in sod-seeding to maintain yields comparable to that of conventional cultural methods.

The objectives of this study were (1) to determine optimum levels of nitrogen and seeding rate for wheat sown in bermudagrass sod, (2) to study the effects of nitrogen levels and seeding rates upon the yield components and morphological plant parts of wheat.

CHAPTER II

LITERATURE REVIEW

Multiple Cropping

Multiple cropping systems are becoming common practice in today's agriculture. This type of crop management is especially adaptable to the small farming operations, which involve animal production as well as crop production. In such systems there is generally land which is under permanent pasture, consisting of either native or introduced grass species. The oversowing of these pastures, during their dormant season, with a noncompetitive crop species could feasibly increase the gross income per acre as well as improve the overall productivity of the land.

Literature on multiple cropping studies is very extensive and multiple cropping systems are presently an active area of agronomic research. Examples of some species combinations being studied are: Sorghum in ryegrass sod (32), annual ryegrass in dallisgrass--common bermudagrass sod (14), and perennial ryegrass--red and white clover mixtures undersown with winter rye (19). The majority of these studies are for forage yield and not grain yield. While there are numerous species combinations that could be made, the two most probable choices for

Oklahoma would be winter wheat and bermudagrass. These two crops are very common throughout the state and they represent a major portion of the farm income.

Advantages and Disadvantages of Sod-seeding

One advantage of sod-seeding a crop is that of reduced tillage. This not only saves labor costs but also fuel consumption and equipment wear. The second advantage of sod-seeding is the use of land at a time of the year in which it normally would not be in production. This would have the obvious effect of increasing the yearly income obtained from the land. Another important aspect of sod-sowing is the improved moisture conditions for the inter-sown species and the prevention of soil erosion. Improved soil aggregation stability and surface soil moisture have been noted under reduced tillage of wheat (9). This improved soil moisture condition has in some crops led to higher yields. Corn grown in rye sod averaged 44% higher in yield than conventionally tilled corn (36). Higher soil moisture was attributed as the factor causing these yield differences. In direct drilled wheat, yields were equal to that of conventionally tilled wheat (41). Higher available soil moisture in no-till and sod-seeded crops can be attributed to decreased evaporation from the soil and a greater ability to store moisture (6, 25). One must take into consideration that these studies were conducted on sod which had been killed by means of herbicide application.

With the seeding of winter wheat in bermudagrass, the success of obtaining yields equivalent to that of conventional tillage would be dependent upon year to year precipitation. This type of cropping system utilizes moisture the year around, thus it may offset the advantage of reduced soil evaporation in sod planting. This system of wheat culture would probably not be satisfactory for low rainfall regions or during years of drought.

While the sowing of a winter annual in the sod of a summer perennial would appear to be an ideal means of land utilization, this system is not without problems or difficulties, which must be solved with further research. Sod-seeded rye reduced the first harvest of coastal bermudagrass. This reduction in yield was intensified as the nitrogen levels increased for rye fertilization (52). This effect may be explained as a result of competition for light. Higher nitrogen application for rye increased foliage production, thus decreased the amount of light reaching the bermudagrass. Sod-seeding requires a higher degree of fertility management than does conventional seeding methods. Another disadvantage of this system is the initial decrease in bermudagrass yields, which could reduce forage production for hay or grazing. The grazing period would also be delayed until completion of small grains harvest.

Nitrogen Levels and Seeding Rates

As Stated previously soil moisture is of major significance in multiple cropping. Two factors which affect the usage of this moisture and which have a direct effect upon yield are the seeding rates and nitrogen levels. Optimum nitrogen and seeding rates have not been studied sufficiently as the results vary with precipitation and climatic conditions. In a study at Muskogee, Oklahoma, 60 pounds per acre of nitrogen and a seeding rate of 90 pounds per acre was sufficient for maximum yields of wheat sown in bermudagrass (11). A similar experiment conducted at Stillwater, Oklahoma, demonstrated that 68-102 kg/ha seeding rate was optimum for sod-sown wheat. The optimum levels of nitrogen and seeding rate would be expected to increase during years of high precipitation and decrease in the years of lower rainfall.

Yield Components

Yield in cereal crops has generally been considered as an expression of many factors of which each make a contribution. The environment has a drastic effect upon yield, and yet it is the least controllable factor. Genetic and physiological characters, which the plant possess, are the second most important factors that determine the yield of a crop. There are three major characters which contribute significantly to yield in cereal crops. These are number of fertile tillers per plant, number of kernels per spike, and the kernel weight (17). These three factors are collectively referred to as the yield components.

Contribution to Yield

While all three of the components of yield are important, the percentage contribution to yield is not divided equally among each component. McNeal, et al. (34) showed by simple correlation coefficients that grain yield was more closely related to fertile tillers per 4.9 meters than with kernels per head or kernel weight. In the wheat varieties Lemhi and Thatcher it was determined that heads per plant and kernels per head were more closely associated with yield per plant than was kernel weight (35). Johnson, et al. (23) compared the yield components of high yielding short varieties of winter wheat to the lower yielding tall varieties. The high yielding varieties were found to produce more kernels per spike, while kernel weight and spike number were less than other varieties. While the latter data does not agree with the literature previously cited, these discrepancies can be attributed to the variation between varieties and plant types (20).

In the future yield components may become important in the selection for high yielding varieties. However, many studies presently show that at maximum yield levels, substantial increases in any one yield component usually cause a decrease in one or both of the other components (18, 43).

The Effects of Nitrogen and Seeding Rate

Nitrogen is an essential constituent of plant proteins and is necessary for the normal growth and development of the plant. Different levels of available soil nitrogen would obviously have a significant effect upon yield and yield components. Khadr and Kassem (27) applied nitrogen to wheat at rates of 20, 40, and 60 kg/ha. The respective rates increased the yield by 93, 185, and 197%. Fertile tiller numbers were increased by 36, 71, and 83% as compared to a zero nitrogen control. While it is true that increasing nitrogen levels in the soil results in increased yields, there is a level at which yield can no longer be increased by higher nitrogen rates. This point of saturation depends upon many factors such as moisture, population density, and most important, the variety of wheat. Johnson, et al. (23) determined that yield increased with increased nitrogen up to about 90 kg/ha for Lancer winter wheat and 112.5 kg/ha for C.I. 14016. While the ultimate effect of nitrogen addition is upon yield, the direct effect may be to increase the number of tillers and tillering efficiency (1, 21, 40). The other two components are usually secondary in response to nitrogen and in some cases may respond negatively towards nitrogen application. Syme (47), in a study using high yielding wheats, found that increases in nitrogen levels and in seeding rates resulted in higher ear populations and a decrease in the number of grains per ear.

Yield components are not only affected by nitrogen but also by seeding rate. Alhagi (1) found that increasing seeding rates from 68 to 136 kg/ha increased the tillers/m^2 of wheat sown in bermudagrass sod. Quinlan and Sagar (40) determined that doubling the seeding rate in spring wheat decreased the number of fertile tillers per plant but did not decrease yield. Bengtsson (4) concluded that increased seeding rates decreased tillering per plant; however, yield was increased due to more ears per unit area. Briggs (7) measured the effect of seeding rate in different varieties of wheat. He determined that rate of seeding had no effect upon seed weight or test weight. The effect of seeding rate, thus appears to be upon the tillering capacity of the plant.

Morphological Plant Parts and Yield

Yield in cereal crops can be characterized as economic yield and biological yield. Both types are the ultimate result of photosynthesis which has occurred throughout the life cycle of the plant (37). Those morphological characters above the flag leaf node are the most important in the fulfillment of the photosynthetic requirement for the developing grain. Simpson (45), in a study containing 120 varieties of wheat, found high positive correlation coefficients between grain weight and the photosynthetic area above the flag leaf node. Yap and Harvey (53) determined that head surface, peduncle surface, and flag leaf area were all strongly associated with grain yield in barley.

Spike and Flag Leaf Contribution

The contribution of each character is altered with the different phases of the reproductive stage. However, when evaluating the total photosynthetic contribution to grain yield the spike and the flag leaf are the most important structures (2, 26, 50). The importance of these two structures can be exemplified by means of shading experiments. Light is very critical during the heading stages and even slight restrictions for short periods reduces yield (39). Saghir, et al. (42) shaded the various parts of wheat and barley to determine their importance in grain yield. Shading the spike proved to be the most effective treatment in yield reduction, while shading the lower leaves proved to have the least significance in lowering the yield. The results of these experiments are not unexpected since the flag leaf and the spike are in the most effective position for light absorption during the rapid grain filling stages. In addition these two plant parts have shorter distances than other parts for the translocation of photosynthate to the grain.

There have been many studies which attempt to measure the actual percentage contribution to grain weight by the spike and flag leaf. The results of these undertakings are as varied as the number of varieties of wheat and the techniques for studying photosynthesis. Thorne (49), reported that CO_2 fixed by the wheat ear accounted for 17-30% of the grain weight. However, more than this was lost by spike respiration so that the flag leaf made the greatest contribution of 110-120%. Evans and Rawson (13), published data which is in disagreement with Thorne's estimations of spike respiration. They determined that photosynthesis by the grain up until ripening amounted to 33-42% of the total ear photosynthesis. This amount of contribution by the grain was sufficient to nearly balance the loss of CO_2 by dark respiration. Their estimation of the contribution to grain weight by the ear was 33% in the variety Sonora and 20% in Gabo, while in some awned varieties spike contributions were as high as 76%. While the measurements of spike photosynthesis have large variations, a general estimate of 10-44% would be a good mean percentage contribution (30).

Importance of Awns

One characteristic of the wheat spike is the presence or absence of awns. This particular component has been studied extensively and is very important in spike photosynthesis. Awned varieties are generally superior to awnless varieties (38). The improved yield is consistently attributed to an increase in kernel weight (38, 15). Another important aspect of awned versus awnless varieties is that the higher yields associated with the awned wheat show the greatest significance under drought conditions (3). In a study conducted by Evans, et al. (12), drought increased the proportion of assimilate contributed by ear photosynthesis to grain filling. An assimilate contribution of 13-24% occurred in awnless wheat varieties while 34-43% was observed in awned lines. In an attempt to explain the advantages of awns various researchers have concluded that the primary asset of awns is an increase in net photosynthesis (29, 22, 48).

Flag Leaf Area and Duration

The flag leaf is another essential component in supplying photosynthate to the developing grain. This being the uppermost leaf it is ideally located for light reception. In addition it is the last leaf to remain green prior to grain maturity. Many studies have been undertaken to determine means of improving its photosynthetic efficiency and light absorption. Berdahl, Rasmusson, and Moss (5), from experiments involving large and small leaf lines of barley, postulated that large leaves favor higher kernel weight and small leaf lines paralleled increased culm production. Not only is leaf size important, but the orientation or angle appears to have significance in improved light absorption. Lupton (33) suggested that the selecting of erect leaves in wheat could be a means of yield improvement. The breeding of narrow, small, upright leaves in wheat could result in an improved canopy architecture. This would have the effect of increased light absorption and thus a higher photosynthetic rate per plant.

Another active area of flag leaf research is the leaf duration, the period of time which the flag leaf remains green. Duration expressed as leaf area duration has been positively correlated with yield (16). Welbank, et al. (51) found that wheat varieties had grain yields proportional to their leaf area duration. Increasing the duration of the flag leaf would have the obvious effect of increasing the flow of photosynthate to the grain at a most critical time of plant development. These results present the possibility of selective breeding for duration as a means of improving yields.

Selection is not the only means for increasing leaf area duration. Khalifa (28) observed an increase in leaf area duration with early nitrogen applications. Thus with a combination of a breeding program as well as fertility trials, improved flag leaf photosynthesis through increased duration could feasibly be obtained.

Research in the physiological aspects of yield has opened many avenues for yield improvement. This is presently an active area of research; however, more studies of this type must be simulated before significant advances in yield of cereal crops can be expected.

CHAPTER III

MATERIALS AND METHODS

1974-75 Study

The study was conducted at the Oklahoma State University Agronomy Research Station at Stillwater, Oklahoma. The location of the study was on a Kirkland silt loam soil, in a lowland area, which was frequently subject to moist conditions.

The experimental design was a completely randomized block, with three replications of treatments. The treatments were arranged factorially, with seeding rate and nitrogen levels being the two factors involved.

'Danne' hard red winter wheat was intersown in Midland bermudagrass sod on October 1, 1974. This was accomplished with a 2.8 m International drill, having a 25.4 cm row spacing. The plot sizes were 2.8 m wide and 12.2 m long. A 7.6 m border alley-way was left between replications. The seeding rates were 67, 101, and 135 kg/ha. Fertilizer application at seeding time consisted of 112 kg/ha of 18-46-0. Ammonium nitrate was top-dressed on April 4, 1975 at rates of 34, 67, 101, and 135 kg/ha of actual nitrogen.

Measurement of Plant Characters

Upon grain maturity one 0.61 m row was sampled randomly from each plot. These samples were then used for fertile tiller count, number of kernels per spike, peduncle area, chaff weight, and micro-kjeldahl nitrogen determination.

In counting the number of tillers, only those bearing spikes were counted. All characters measured were based upon ten randomly chosen tillers.

To obtain measurements of the peduncles, the culms were excised above the uppermost node and at the base of the first joint of the rachis. The length of the individual peduncles were measured. The diameter was measured by laying the ten peduncles adjacent to each other and measuring the width ten centimeters from the base of the peduncles.

The spikes were threshed on a rub-board hand thresher and total weights of individual samples were taken. The chaff was separated from the grain by means of an air flow seed cleaner. Grain weight was taken after the cleaning process. Chaff weight was calculated by subtracting the grain weight from the total weight. Total numbers of seed per sample were counted and then averaged to estimate the number of kernels per spike.

A sample (0.2 gm) of whole seed was weighed for micro-kjeldahl nitrogen determination. This analysis was conducted by the Oklahoma State University Soil and Water

Analysis Laboratory. Percent nitrogen was converted to percent grain protein by multiplying the conversion factor 5.7 by the nitrogen percentage.

The field plots were harvested for total grain yield on June 19, 1975. These samples were also used for 200 kernel weight.

<u>1975-76 Study</u>

The location of the 1975-76 experiment was relocated due to wet and weedy conditions at the previous site. This study was conducted on an elevated area with a moderate sloping, terraced terrain.

The experiment was a randomized block design with a factorial arrangement of treatments. There were four replications of treatments with the plot sizes being the same as the previous year.

'Triumph' hard red winter wheat was sown in Midland bermudagrass sod on October 17, 1975 according to the method of the previous season. Seeding rates of 67, 101, 135, and 168 kg/ha were used. Due to mechanical errors 336 kg/ha of 0-46-0 was applied at seeding time. However, no deterimental effects were noted upon germination.

The field plots were top-dressed with ammonium nitrate on February 10, 1976. Levels of actual nitrogen applied were 34, 67, 101, and 135 kg/ha.

Measurement of Plant Characters

Samples for flag leaf area measurements were taken on May 18, 1976. Fifteen flag leaves were randomly sampled from each plot and packed in ice until they could be transferred to a freezer. At a later date these samples were thawed in water to allow full turgidity to return to the leaves. Ten leaves were randomly chosen from each sample and the individual leaf areas were measured with an automatic leaf area scanner. The area of the ten leaves per sample were averaged for an estimate of leaf area per plot.

Two 0.31 m row samples per plot were taken on June 6, 1976 for tiller counts. The tiller number, 200 kernel weight, chaff weight, number of kernels per spike, peduncle area, and micro-kjeldahl nitrogen samples were taken from these samples in the same manner as the previous season.

Total plot harvest for grain yield was taken on June 25, 1976 using a Gleaner combine.

CHAPTER IV

RESULTS AND DISCUSSION 1974-75

Grain Yield

The overall mean of grain yield was 693.3 kg/ha (10.3 bu/a). The highest average yield was 1037.5 kg/ha (15.4 bu/a) obtained at the 101 kg/ha nitrogen level and the 135 kg/ha seeding rate (Table III, Appendix). The lowest mean grain yield of 294.9 kg/ha (4.4 bu/a) occurred with the 135 kg/ha nitrogen level and 67 kg/ha seeding rate.

The cause for such low grain yield values may be attributed to two sources. The primary cause was probably due to a high weed population which occurred throughout the study area. Dock (Rumex spp.) and various Trifolium species were the major species contributing to this weed population. While the clovers were competitive with the wheat as under-story vegetation, the dock was equal in height to the wheat and thus could have been highly competitive for both nutrients and light. A second factor which would have resulted in a negative effect upon grain yield was the excessive moisture which accumulated at various times during the fall. The field plot area was located in a low lying area where run-off water from higher surrounding land accumulated. This resulted in some of the plots being temporarily flooded. Some death losses did occur during these periods of high moisture.

Nitrogen was highly significant in its effect upon grain yield. As the nitrogen rates increased, grain yields decreased. There was no significant difference between the 34, 67, and 101 kg/ha nitrogen rates. However, with the 135 kg/ha rate a significant decrease in yield occurred (Figure 1). These results suggest that the lowest nitrogen level supplied enough nitrogen for the yield levels obtained. With the 135 kg/ha rate excessive nitrogen could have caused large amounts of vegetative growth, resulting in lower yields. Dougherty (10) noted a 7% decrease in the yield of spring wheat with nitrogen application and high seeding rates. He attributed these results to increased water stress. Similarly, Scott (44), using high seeding rates reduced the number of grains set per spike. Singh, et al. (46), noted an increase in the depletion of stored soil moisture with high nitrogen application.

Seeding rate was not significant in its effect upon grain yield. There was evidence of a nitrogen by seeding rate interaction which had significance at the 0.07 level of probability.

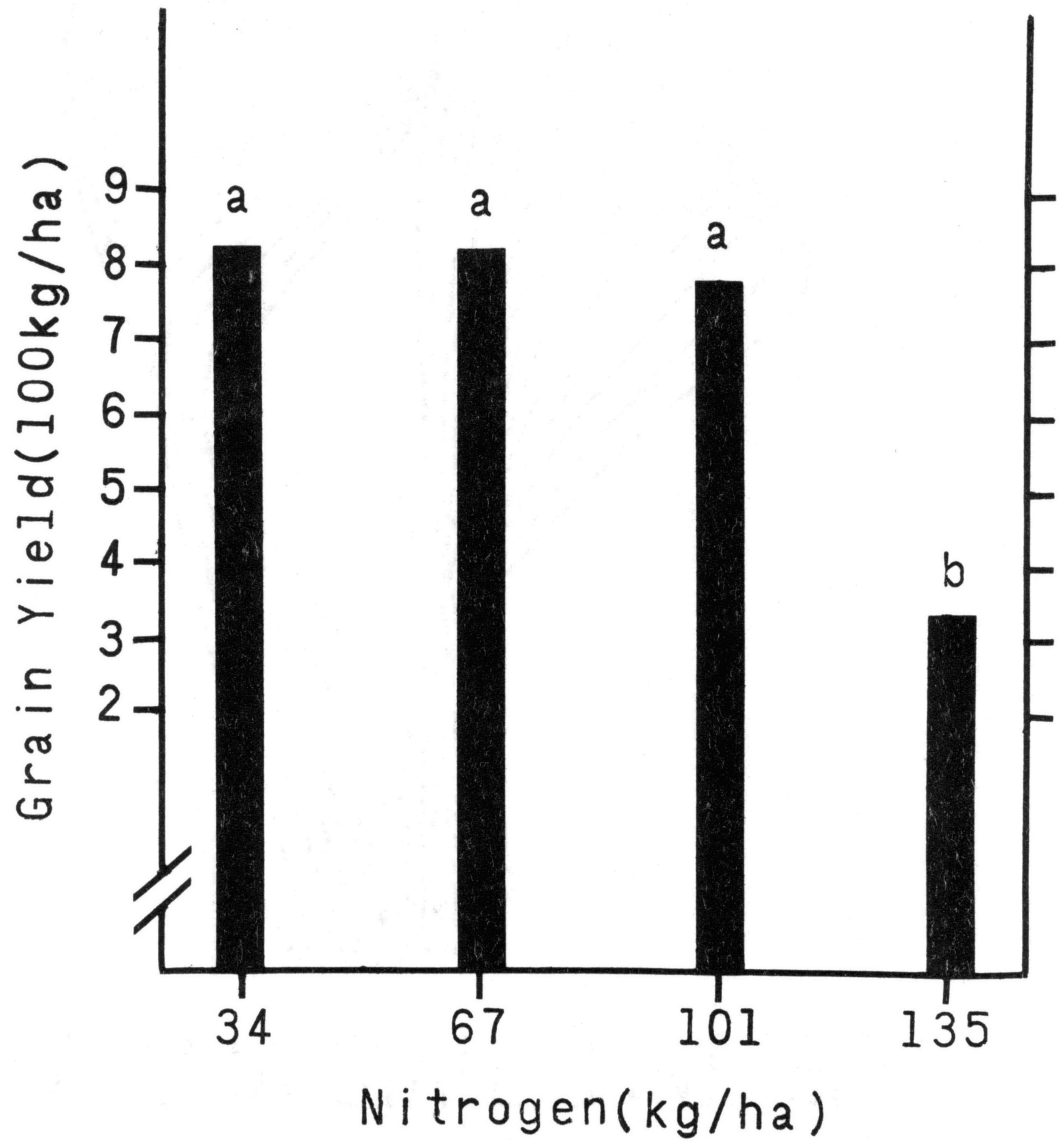

Figure 1. Grain Yield as Affected by Nitrogen Levels (1974-75). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

Percent Grain Protein

The overall mean of percent protein of the grain was 11.6%. A protein value of 10.6% was the lowest mean which occurred at the 34 kg/ha nitrogen level and the 135 kg/ha seeding rate. The highest mean of 12.7% protein occurred at the 135 kg/ha nitrogen level and seeding rate. There was no difference between the 34, 67, and the 101 kg/ha nitrogen levels. The 135 kg/ha rate of nitrogen did significantly increase the percent grain protein as compared to the 34 and 67 kg/ha rates. There was no significant difference between the 135 and the 101 kg/ha rate (Figure 2). Johnson, et al. (24) also noted an increase in protein as nitrogen application was increased.

Seeding rate and nitrogen by seeding rate interaction were not significant at the 0.05 level of probability.

Yield Components and Other Plant Characters

Kernel weight was not significantly affected by nitrogen levels. However, seeding rate exhibited a high degree of significance (probability = 0.01) in its effect upon the kernel weight. As the seeding rate increased the kernel weight decreased (Figure 3). There was a significant (probability = 0.02) nitrogen by seeding rate interaction. However, the simple effect of seeding rate was greater than the effect of the interaction (Table IX, Appendix).

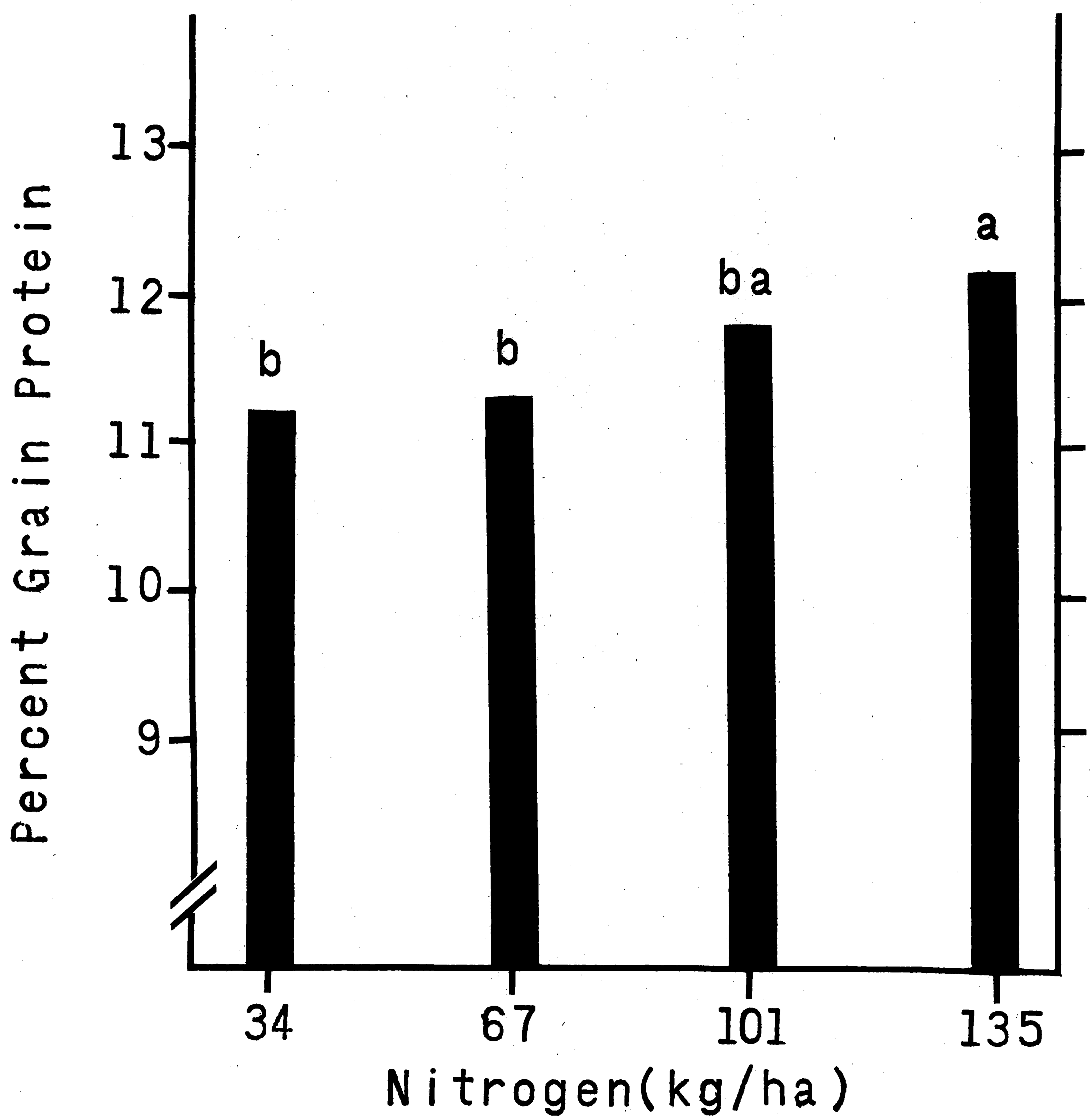

Figure 2. Percent Grain Protein as Affected by Nitrogen Levels (1974-75). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

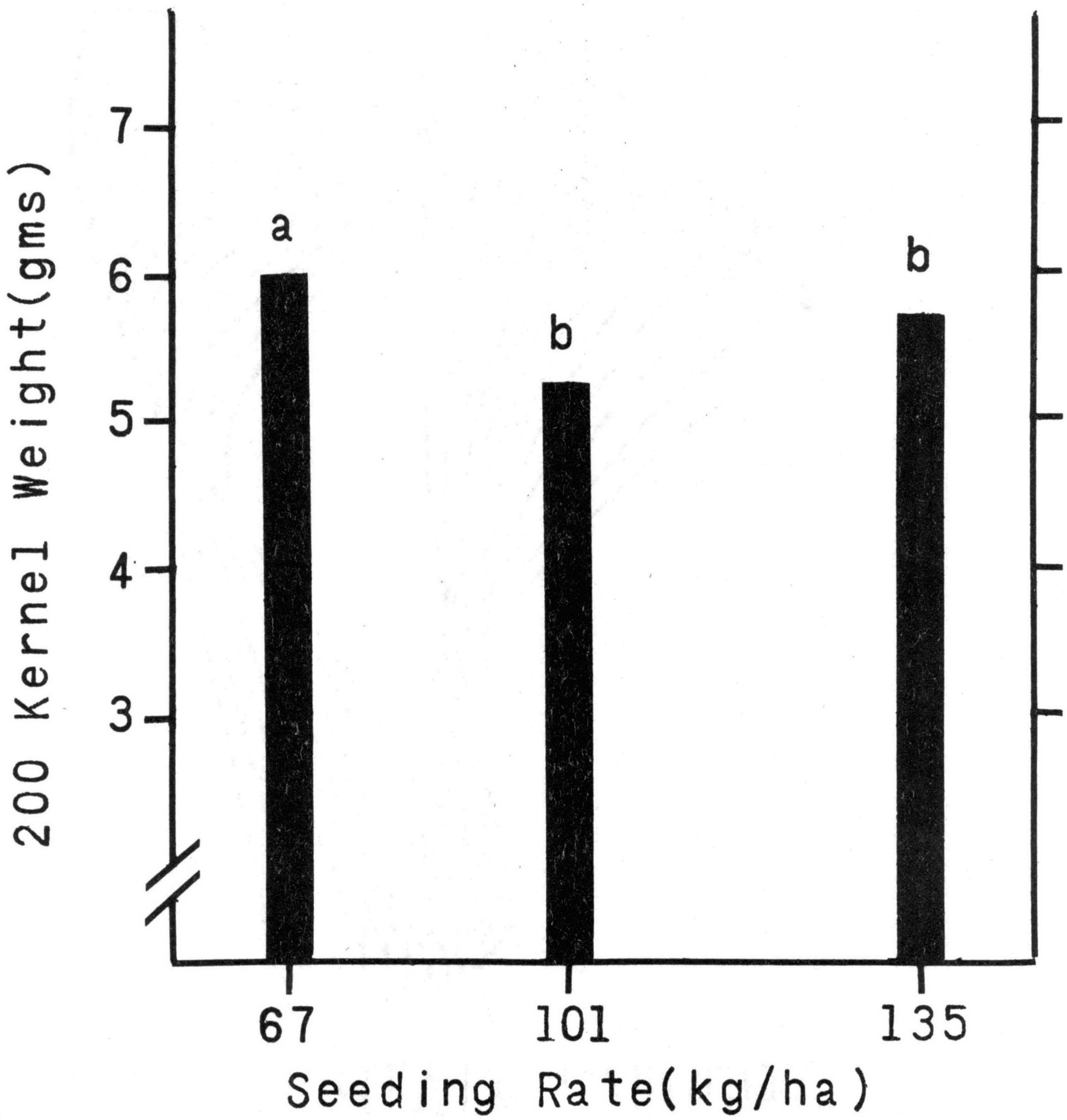

Figure 3. Kernel Weight as Affected by Seeding Rates (1974-75). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

Nitrogen treatments were significantly different (probability = 0.06) in their effect upon the number of kernels/spike. The number of kernels/spike increased as the nitrogen levels increased. Alhagi (1) found similar effects of nitrogen upon this yield component. No significant differences were shown between the 34, 67, and the 101 kg/ha rates. The 135 kg/ha rate was associated with significantly more kernels/spike than the 34 and 67 kg/ha rates of nitrogen. There was no difference in the number of kernels/spike between the 135 and 101 kg/ha nitrogen rates (Figure 4). Seeding rate and nitrogen by seeding rate were not significant.

No significant differences appeared in the F test, for tillers/m as affected by nitrogen and seeding rates.

Increased seeding rates proved to have an adverse effect upon chaff weight. No differences existed in chaff weight between the 67 and 101 kg/ha rate. The 135 kg/ha rate significantly (probability = 0.004) decreased the chaff weight (Figure 5). It is believed that as the plant population increased a higher level of competition resulted. The individual plants compensated for this high level of competition at the expense of chaff weight and kernel weight.

The last character evaluated, peduncle area, was not significantly affected by nitrogen levels and seeding rates.

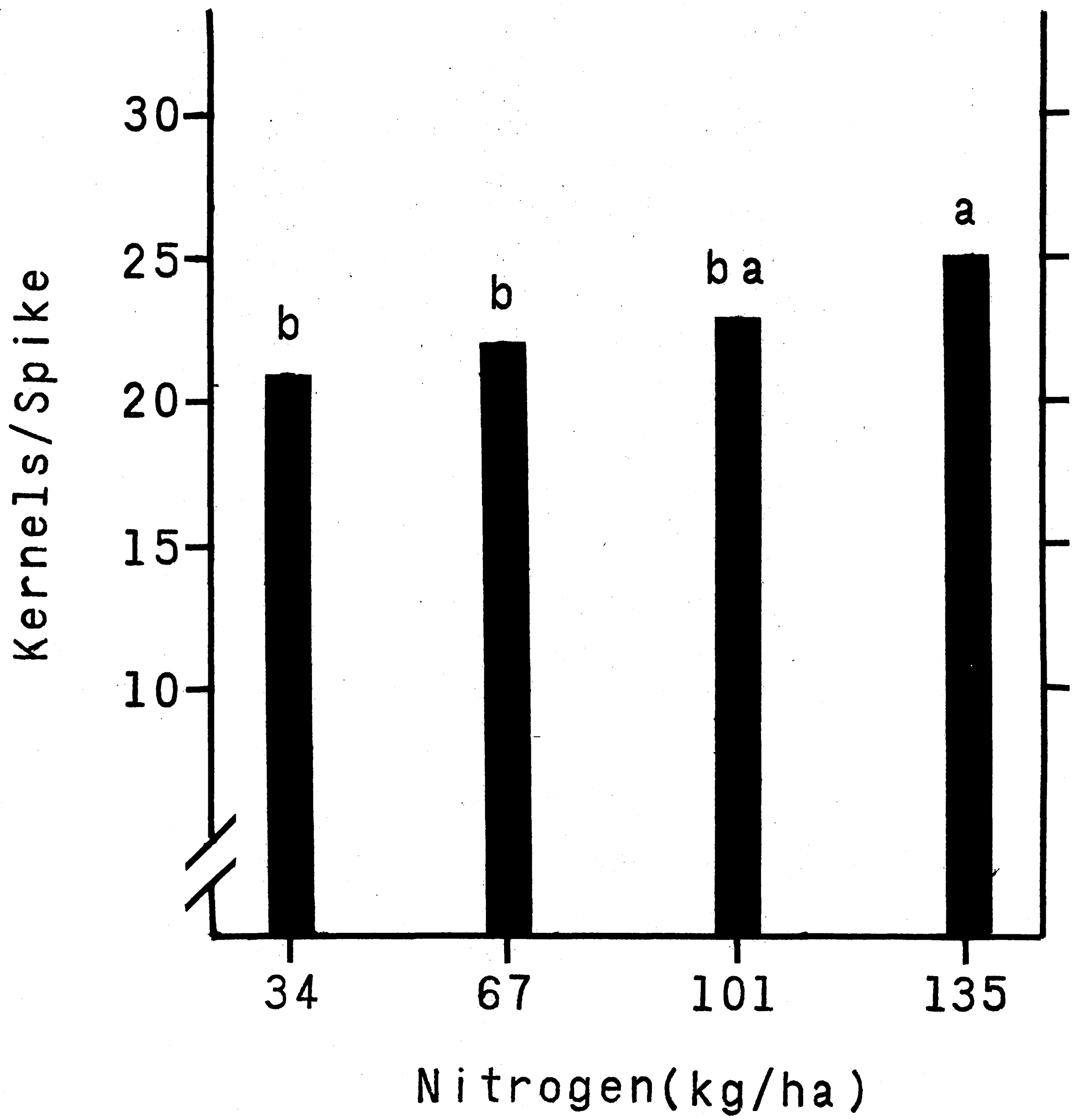

Figure 4. Kernels Per Spike as Affected by Nitrogen Levels (1974-75). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

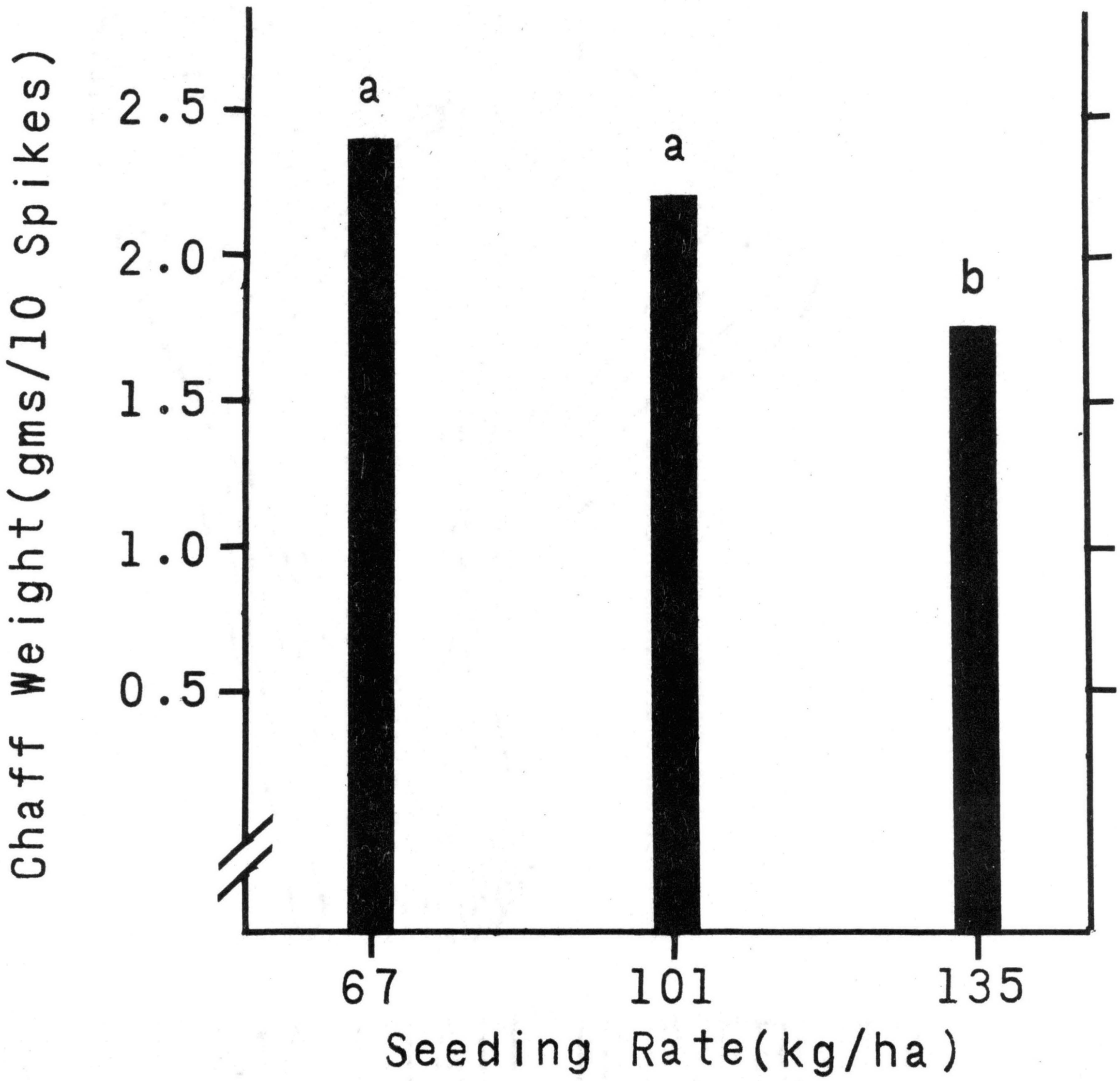

Figure 5. Chaff Weight as Affected by Seeding Rates (1974-75). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

Simple Correlation Coefficients

Correlation coefficients were determined for the various plant characters and grain yield (Table I). None of the characters evaluated significantly correlated with grain yield. Because of this, it is difficult to determine which character contributed the most to yield. The unusually low grain yields may have been caused by numerous factors which masked the effects of the yield components in their contribution to yield. This could have hidden any correlation between yield and the other plant characters.

Peduncle area and number of kernels/spike had highly significant correlations with each other (Figure 6) ($r = 0.637$). It is believed that peduncle area did not have an effect upon the number of kernels/spike. Since the number of kernels are determined before the peduncles become functional in photosynthesis. The positive response seen between these two factors was probably due to an unknown factor which positively affected the peduncles as well as the number of kernels/spike.

TABLE I

SIMPLE CORRELATION COEFFICIENTS OF GRAIN YIELD, PERCENT GRAIN PROTEIN, AND OTHER PLANT CHARACTERS (1974-75)

Plant Characters	Grain Protein	Chaff Weight	Kernel Weight	Kernels/ Spike	Tillers/m	Peduncle Area
Grain Yield	-0.123	-0.201	-0.113	-0.169	0.267	-0.225
Grain Protein		0.375*	-0.225	0.357	0.144	0.393*
Chaff Weight			-0.021	0.667**	0.001	0.727**
Kernel Weight				0.179	-0.468**	-0.052
Kernels/Spike					-0.097	0.637**
Tillers/m						0.190
Peduncle Area						

*Significance at 0.05 level probability.

**Significance at 0.01 level probability.

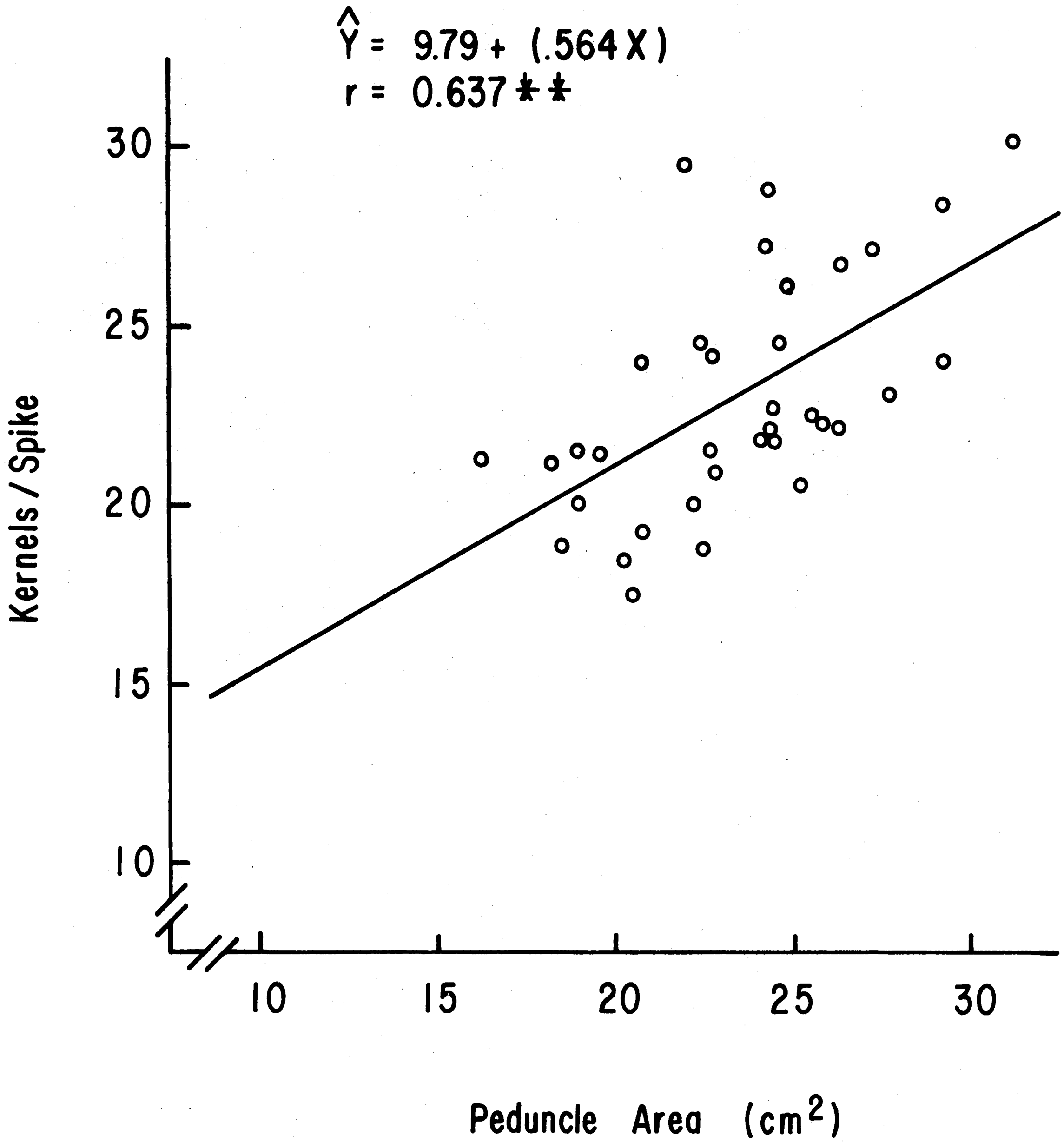

Figure 6. Peduncle Area and Its Simple Correlation with Kernels Per Spike (1974-75).
**Significant at the 0.01 level of probability.

CHAPTER V

RESULTS AND DISCUSSION 1975-76

Grain Yield

The growing season of 1975-76 was an abnormally dry year. Unseasonably dry weather occurred in the fall and it persisted until early spring. The grain yields were higher than the previous year. The mean grain yield was 1130.1 kg/ha (16.8 bu/a), while the maximum and minimum yields were 2093.4 kg/ha (31.1 bu/a) and 557.1 kg/ha (8.3 bu/a), respectively. The maximum grain yield occurred at the 101 kg/ha nitrogen level and the 135 kg/ha seeding rate. The minimum grain yield occurred at the 135 kg/ha nitrogen level and the 67 kg/ha seeding rate.

No significant differences in grain yield were observed with different nitrogen rates. This season's precipitation was below normal, which may account for the lack of response to nitrogen treatments.

Increasing the seeding rates caused highly significant differences in grain yield. As the seeding rate increased, grain yield increased. Differences in yield occurred between the 67 kg/ha and 101 kg/ha seeding rates.

Beyond the 101 kg/ha rate no significant differences were present, although there were increases in grain yield (Figure 7).

Percent Grain Protein

A high degree of significance existed with grain protein as affected by nitrogen. As with the previous year, increased nitrogen application generally resulted in higher percent grain protein. There was a decline in the protein for the 101 kg/ha nitrogen rate averaged over the seeding rates to 10.1%. The reason for such low grain protein at this level of nitrogen is not known. Protein values of 10.8, 9.4, and 8.2% occurred at the first three seeding rates, respectively. A percent grain protein of 12.2% occurred at the highest seeding rate. If one excludes this treatment there is no significant difference beyond the 67 kg/ha nigrogen rate (Figure 8). The lowest mean protein value was 9.3%, which occurred at the 34 kg/ha nitrogen level. The highest mean protein content (14.2%) occurred at the 135 kg/ha nitrogen level.

Seeding rate was not significant in its effect upon grain protein.

Yield Components and Other Plant Characters

A high degree of significance was observed with the effects of nitrogen upon kernel weight. A significant decrease in kernel weight occurred with the application of

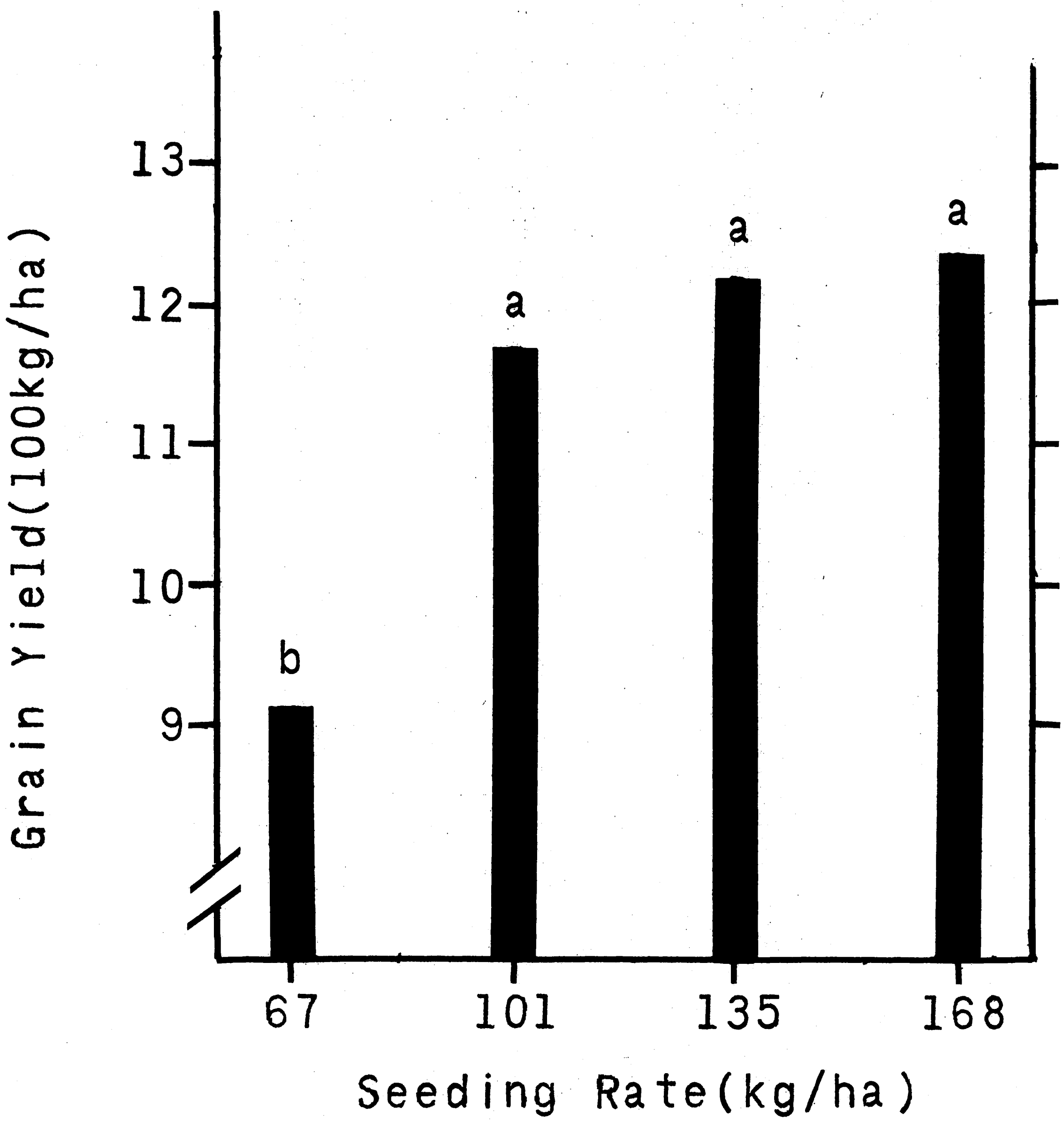

Figure 7. Grain Yield as Affected by Seeding Rates (1975-76). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

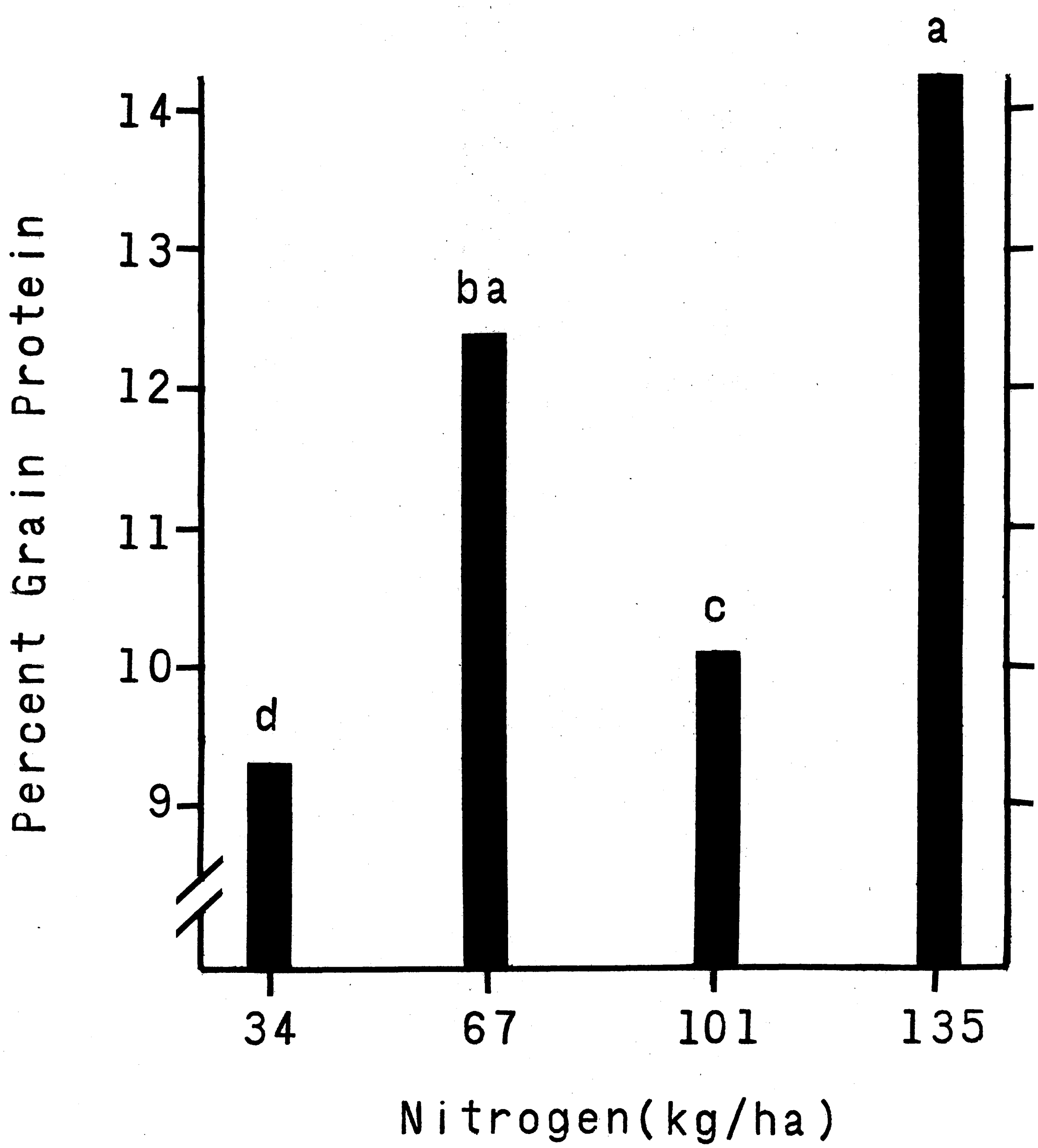

Figure 8. Percent Grain Protein as Affected by Nitrogen Levels (1975-76). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

nitrogen at 67 kg/ha. No further decreases in kernel weight were seen at the 101 and 135 kg/ha nitrogen levels (Figure 9).

The numbers of kernels/spike were significantly increased as higher nitrogen rates were applied. As can be noted from Figure 10, a gradual increase in the number of kernels/spike occurred at all levels of nitrogen. These results explain why a decrease in kernel weight occurred with increased nitrogen levels. The additional nitrogen was being utilized by the wheat plant for increased spikelet production. This resulted in the transport of photosynthate to more sink sites with each site receiving less carbohydrates at the higher levels of nitrogen, which then had the effect of decreasing the kernel weight. Langer and Liew (31) noted that grain weight responded less to nitrogen treatment than grain numbers. Yield was controlled by the transport of carbohydrates, which was dependent upon the number of sites available for grain filling.

Nitrogen was not significant in its effect upon tillers/m; however, seeding rate was highly significant in its effect upon tillers/m. As the seeding rate was increased from 67 to 101 kg/ha, an increase in tiller number resulted (Figure 11). Further increases in seeding rate was not effective in increasing tillers/m.

Nitrogen and seeding rate had no significant effect upon chaff weight and peduncle area.

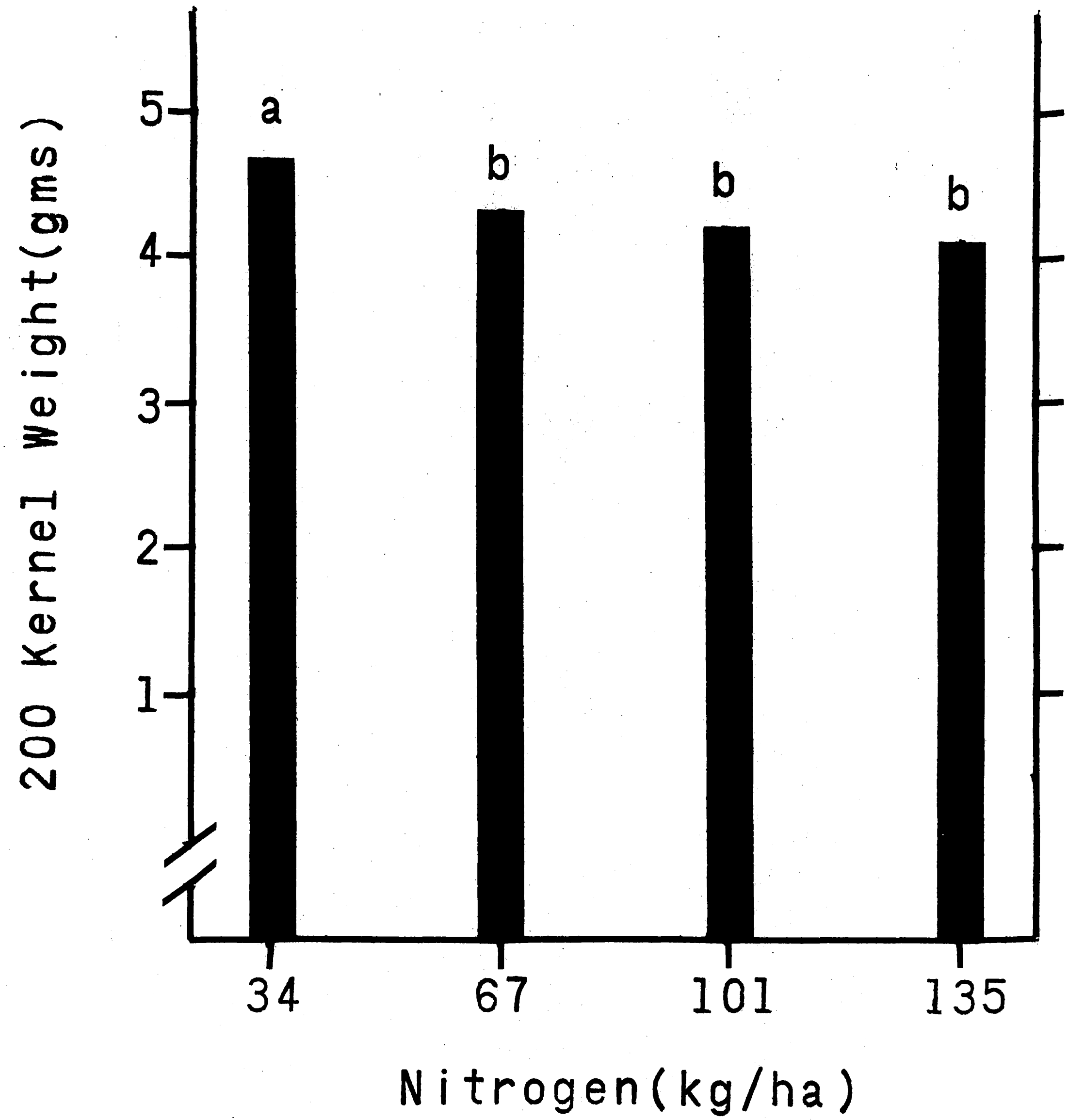

Figure 9. Kernel Weight as Affected by Nitrogen Levels (1975-76). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

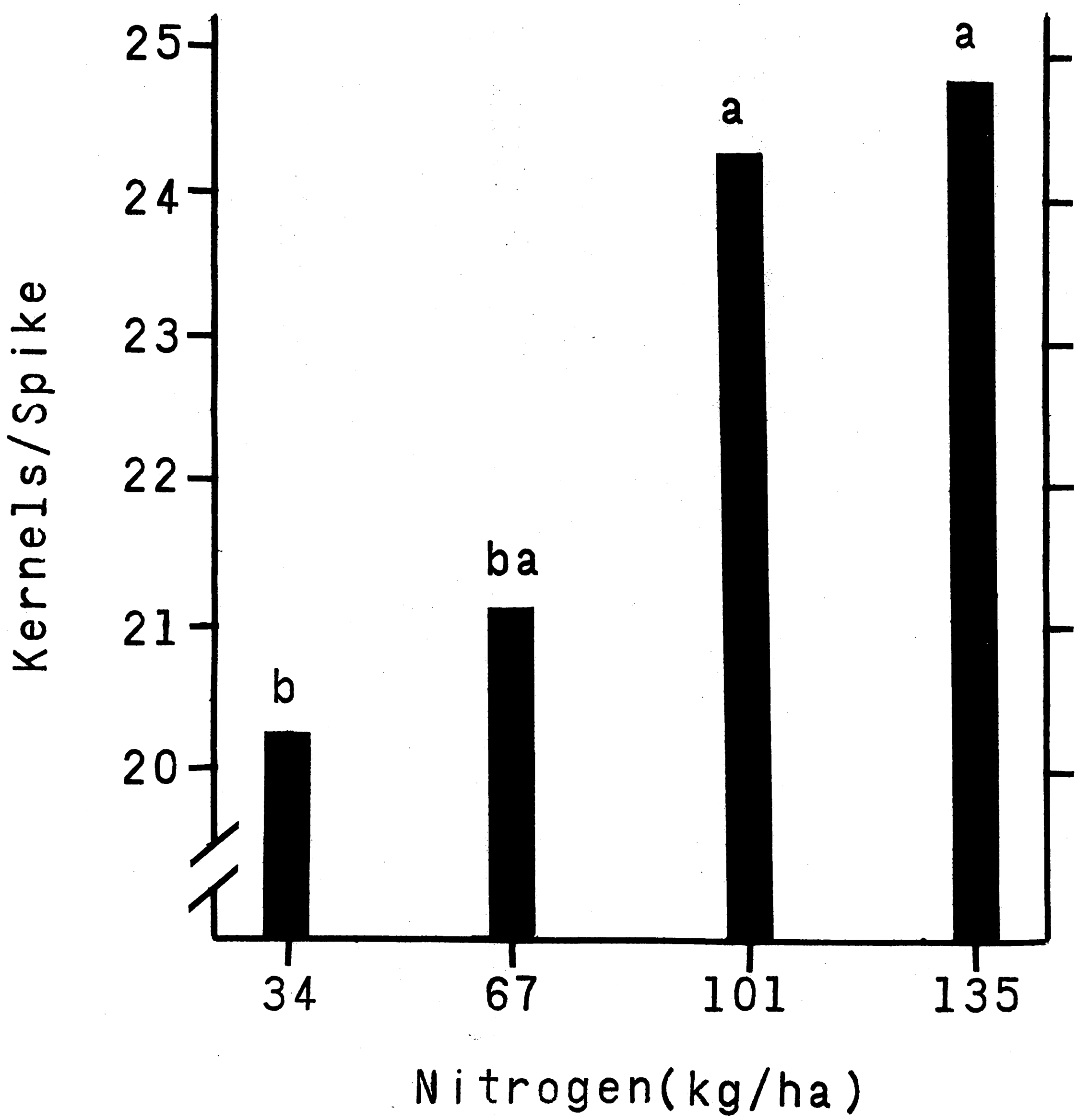

Figure 10. Kernels Per Spike as Affected by Nitrogen Levels (1975-76). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

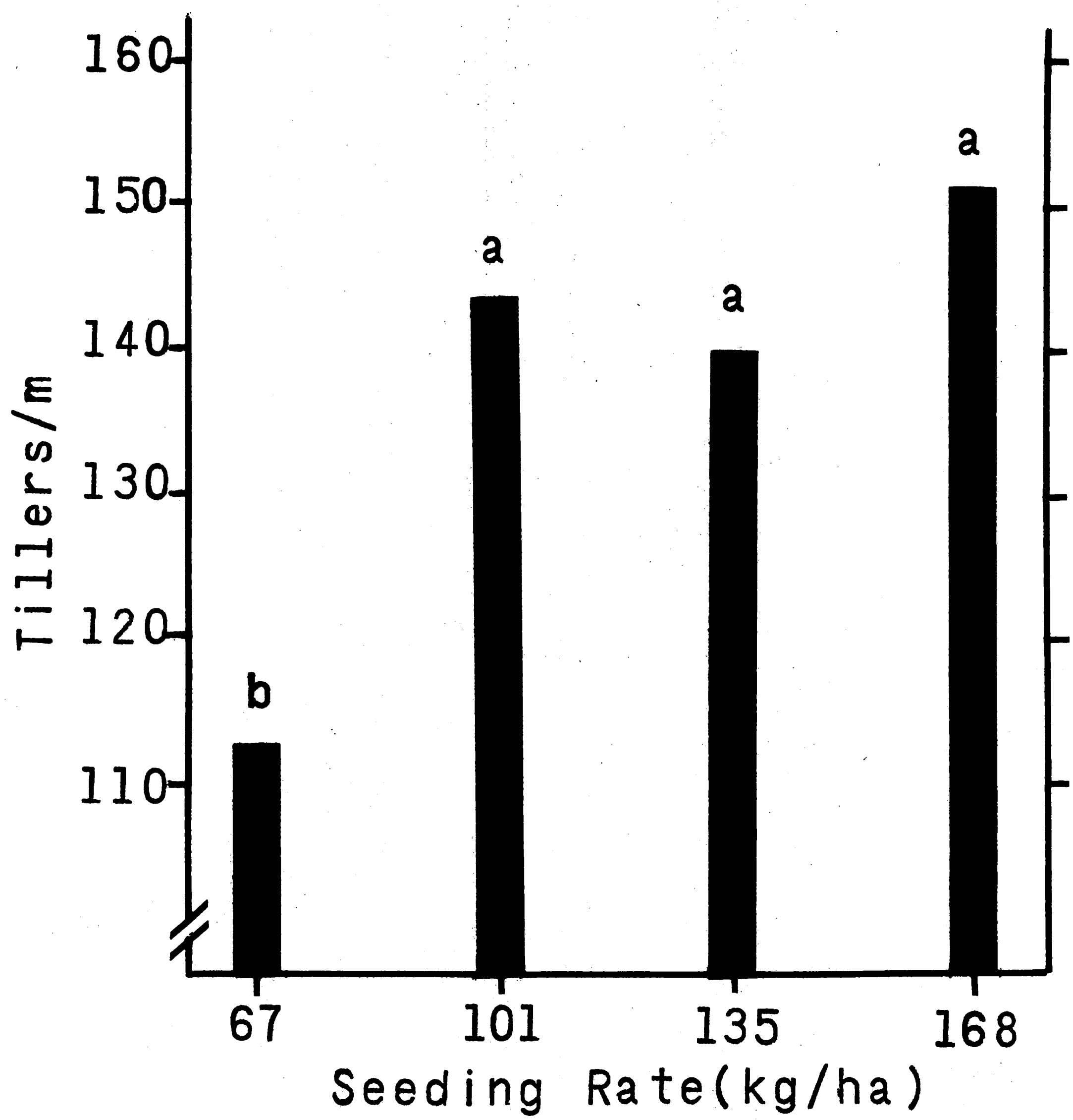

Figure 11. Tiller Number as Affected by Seeding Rates (1975-76). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

Flag leaf area was not significantly affected by nitrogen applications. Increasing the seeding rate from 67 to 101 kg/ha resulted in a significant decrease in flag leaf area (Figure 12). Further increases in seeding rate did not significantly decrease flag leaf area, although a general decline in area was observed.

Simple Correlation Coefficients

Simple correlation coefficients were computed between the various plant characters and grain yield (Table II). Tillers/m was the only character which was significant in its correlation with grain yield. This correlation was highly significant (probability = 0.01), with a coefficient value of 0.474 (Figure 13).

Kernel weight was significant in its correlation with percent grain protein. A correlation coefficient of -0.444 existed between these two characters (Figure 14).

Only peduncle area significantly correlated with kernel weight. The significance was at the 0.01 level of probability with a correlation coefficient of 0.421 (Figure 15).

The number of kernels/spike had significant correlation coefficients with peduncle area (0.692), (Figure 16).

From these simple correlation coefficients it can be concluded that the major source of yield for the 1975-76 season was tillers/m. All of the other characters were secondary in their importance as yield components. These

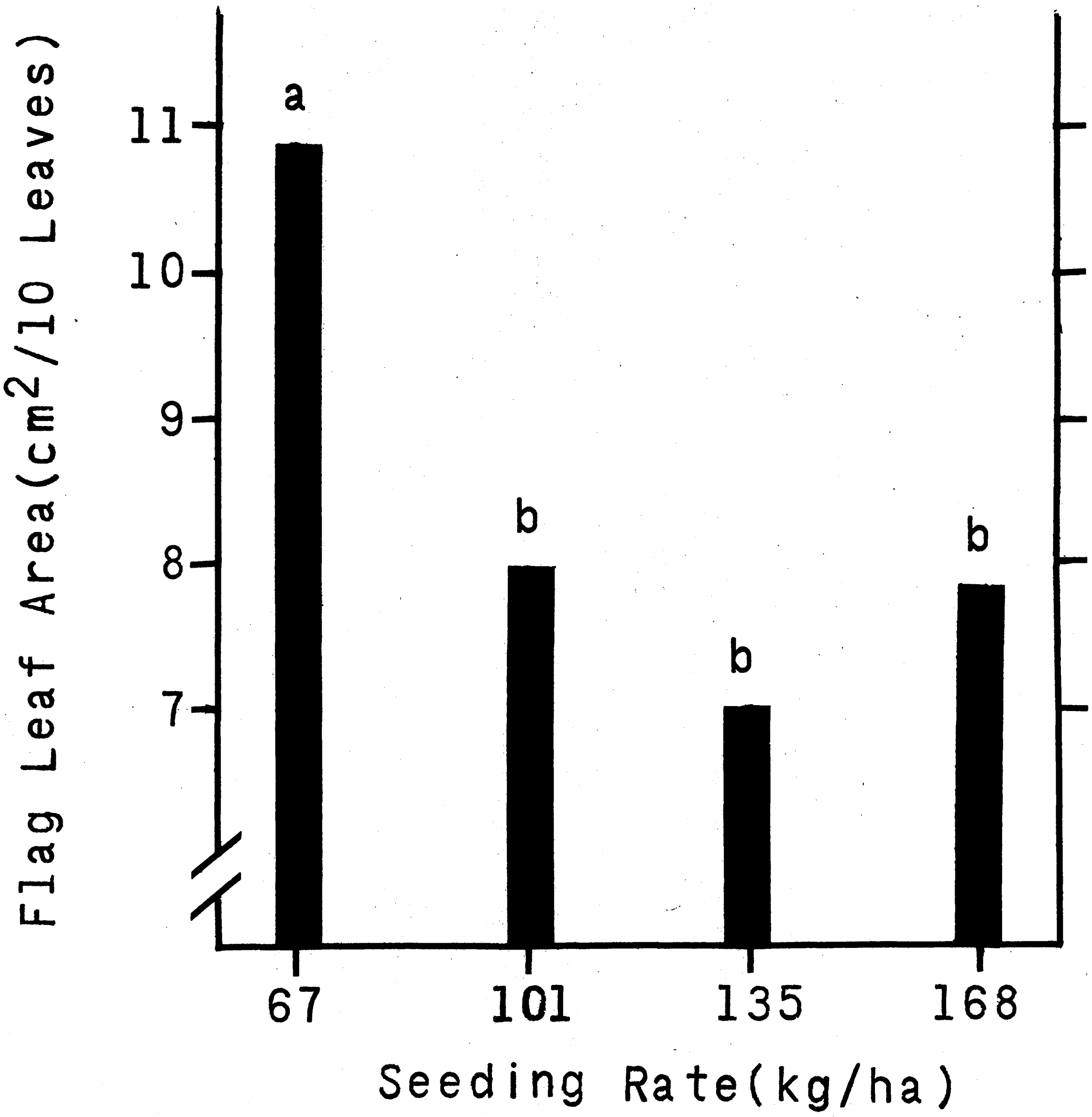

Figure 12. Flag Leaf Area as Affected by Seeding Rates (1975-76). (Treatments with the same letter are not significantly different at the 0.05 level of probability.)

TABLE II

SIMPLE CORRELATION COEFFICIENTS FOR GRAIN YIELD, PERCENT GRAIN PROTEIN, AND OTHER PLANT CHARACTERS (1975-76)

Plant Characters	Grain Protein	Chaff Weight	Kernel Weight	Kernel/ Spike	Tillers/m	Peduncle Area	Flag Leaf Area
Grain Yield	-0.029	0.089	0.155	-0.105	0.474**	0.125	-0.193
Grain Protein		-0.004	-0.444**	-0.041	0.242*	-0.136	0.214
Chaff Weight			0.231	0.656**	-0.101	0.524**	0.121
Kernel Weight				0.165	-0.117	0.421**	0.042
Kernels/Spike					-0.373**	0.692**	0.251*
Tillers/m						-0.222	-0.202
Peduncle Area							0.228
Flag Leaf Area							

*Significance at the 0.05 level of probability.

**Significance at the 0.01 level of probability.

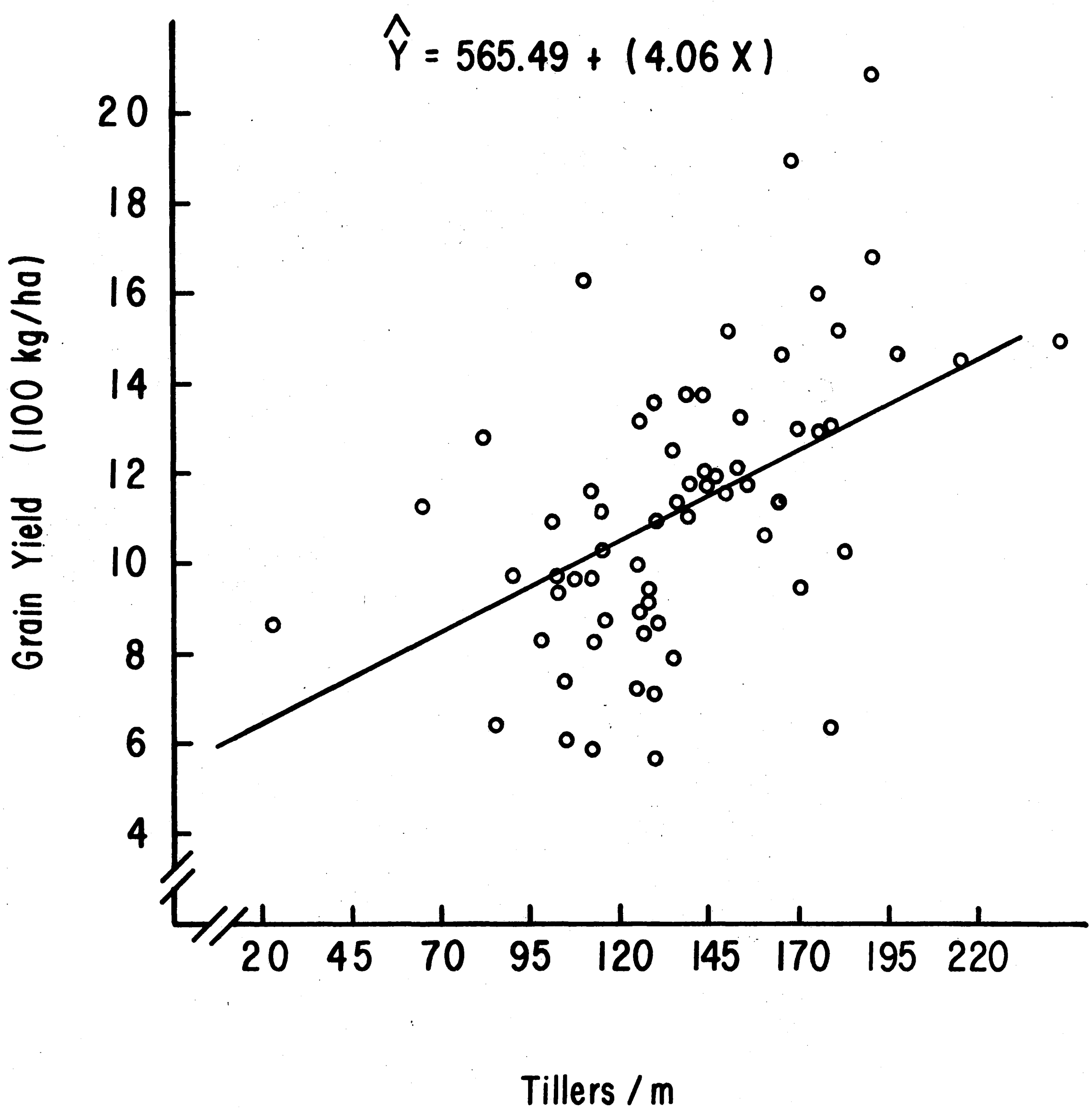

Figure 13. Tiller Number and Its Simple Correlation with Grain Yield (1975-76).
**Significant at the 0.01 level of probability.

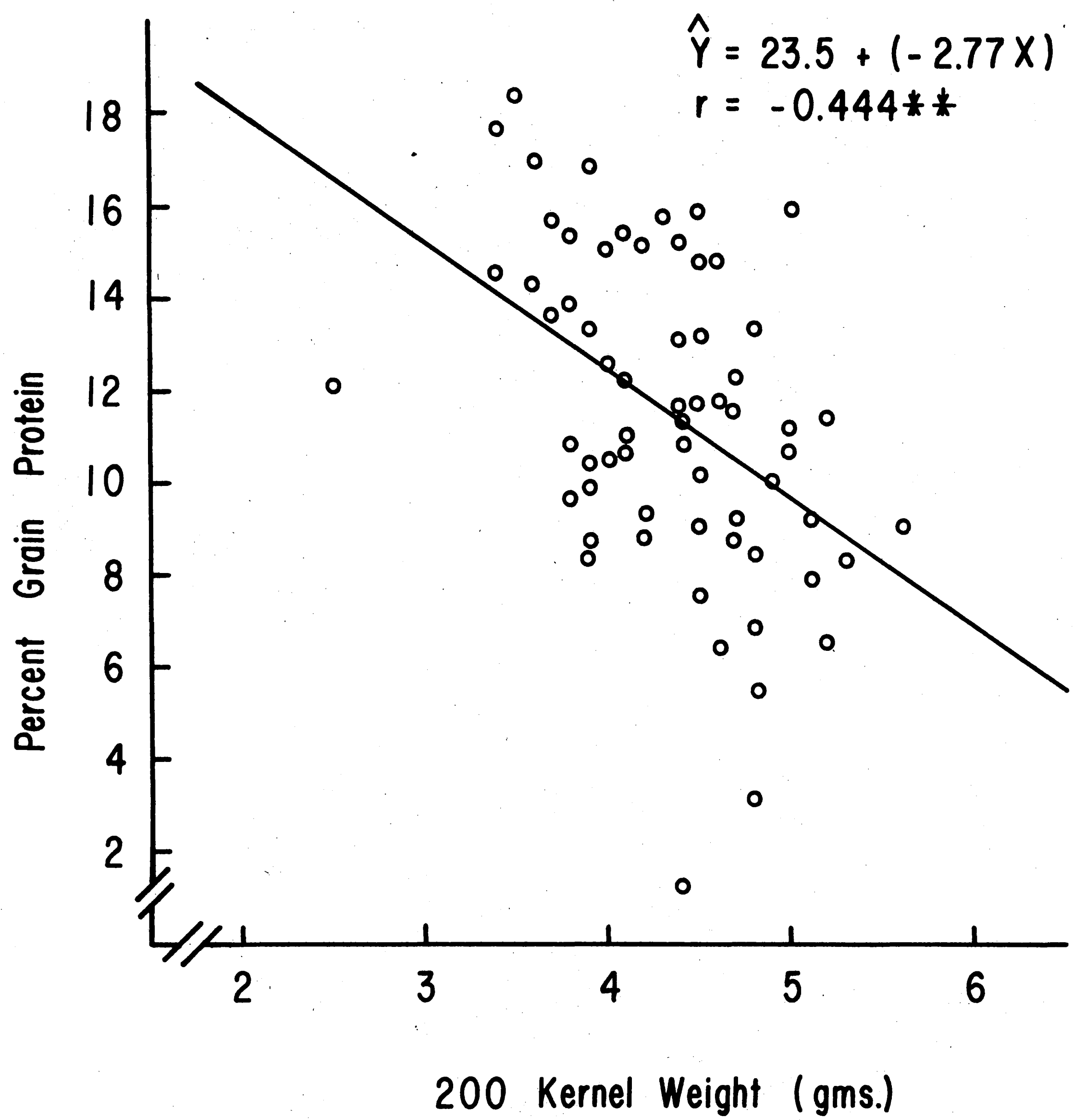

Figure 14. Kernel Weight and Its Simple Correlation with Percent Grain Protein (1975-76).
**Significant at the 0.01 level of probability.

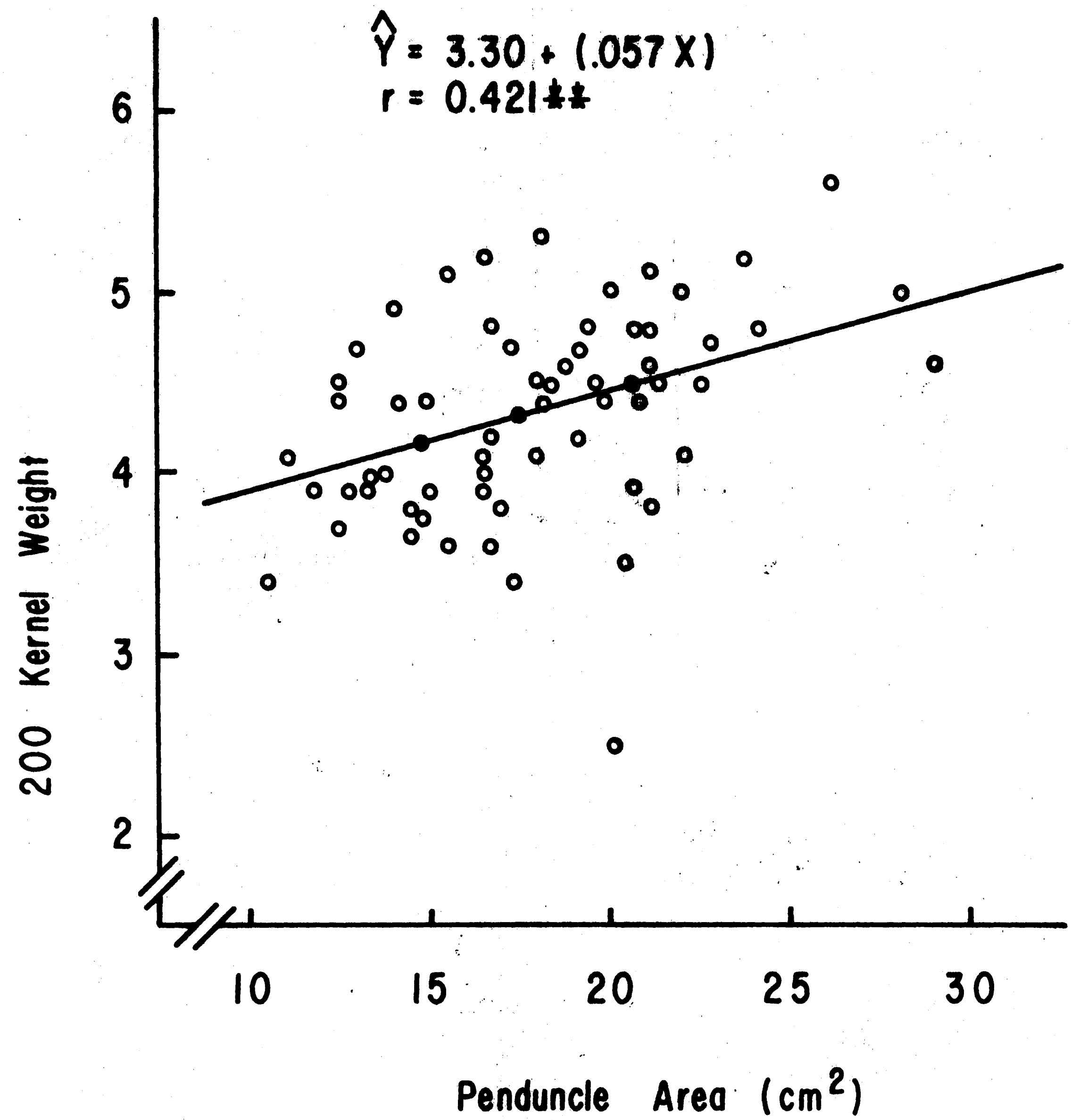

Figure 15. Peduncle Area and Its Simple Correlation with Kernel Weight (1975-76).
**Significant at the 0.01 level of probability.

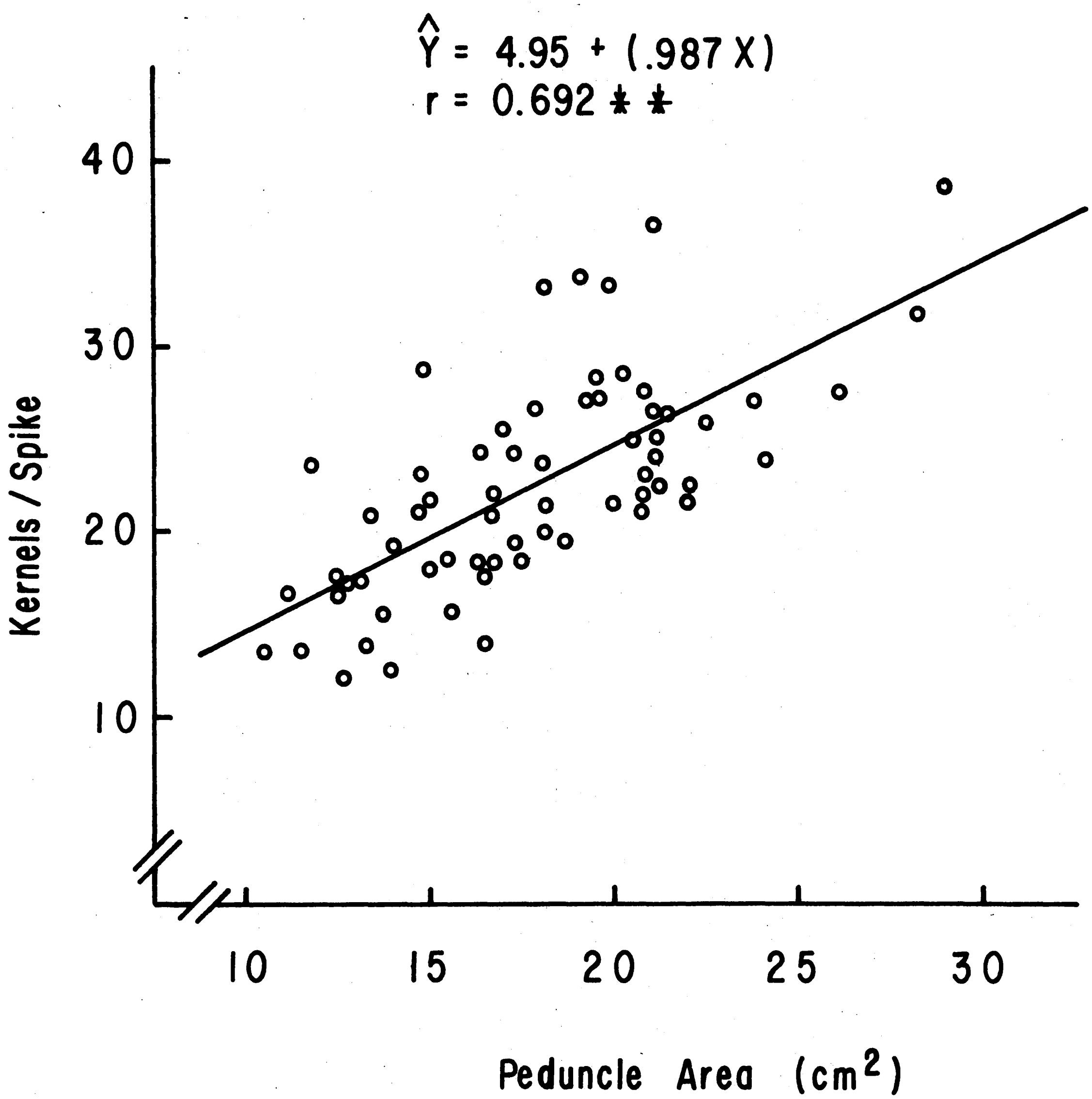

Figure 16. Peduncle Area and Its Simple Correlation with Kernels Per Spike (1975-76).
**Significant at the 0.01 level of probability.

results are in agreement with McNeal and others (34, 35) who made similar conclusions.

Peduncle area, flag leaf area, and the chaff weight collectively are the major constituents of the photosymthetic area which contribute to grain development. All of these characters were positively related to the number of kernels/spike. As discussed previously, this is believed to be the result of increased assimilate flow which would be available for the development of more kernels/spike. Kernel weight was also increased as photosynthetic areas were increased. This relationship, however, was only evident in the positive correlation with peduncle area.

Another point of interest was that tillers/m was negatively correlated with the number of kernels/spike and positively correlated to percent grain protein. This was believed to be a response which resulted from increased competition from the higher plant population.

CHAPTER VI

SUMMARY AND CONCLUSIONS

A two year multiple cropping study was conducted on the Oklahoma State University Agronomy Research Station. The purpose of this study was to determine optimum nitrogen fertilization and seeding rates for winter wheat sown in bermudagrass sod. The yield components and other plant characters were also studied to determine their responses to the various nitrogen and seeding rate treatments.

Grain yield for the 1974-75 season was altered only by increased levels of nitrogen fertilization. Maximum yields were obtained with nitrogen rates between 34 and 101 kg/ha. Higher application rates drastically reduced grain yields.

Nitrogen did not significantly affect grain yield for the 1975-76 season. This may be the result of an unusually dry growing season which could have reduced the availability and uptake of the nitrogen. Increased seeding rates were favorable for higher yields. The optimum seeding rates for maximum yields were between 101 and 168 kg/ha.

There were no significant correlations between grain yield and the yield components or other characters evaluated for the 1974-75 season. However, for the 1975-76 season the number of tillers/m was significant in its correlation with grain yield. It was believed that this character was the major components of grain yield for this season.

Percent grain protein was affected by nitrogen fertilizer for both years of the study. As nitrogen levels increased there was a general trend for the percent grain protein to also increase. Maximum protein content for both years were reached at the 135 kg/ha nitrogen levels.

The three yield components; kernel weight, number of kernels/spike, and number of tillers/m had varied responses to nitrogen and seeding rates. For the 1974-75 season kernel weight was significantly decreased with increased seeding rates. A significant nitrogen x seeding rate interaction occurred. Nitrogen had a significant affect upon kernel weight for the 1975-76 season. As nitrogen fertilization increased kernel weight decreased.

The number of kernels/spike was increased in both years by increasing nitrogen application.

The number of tillers/m showed no response to nitrogen and seeding rate in 1974-75. However, in 1975-76 seeding rate had a significant effect upon the tiller/m. With higher seeding rates the number of tillers/m increased.

The practice of sod sowing winter wheat in bermudagrass is a feasible means of using idle acres of pasture during the winter months for central Oklahoma. However, the growth and yield responses may vary extensively from season to season depending upon yearly precipitation and soil moisture status.

LITERATURE CITED

1. Alhagi, M. A. 1975. Effects of nitrogen, planting date, and seeding rate on the yield components of winter wheat sown in bermudagrass sod. M.S. thesis, Okla. State Univ., Stillwater, Okla.

2. Apel, P., C. O. Lehman, and A. Friedrick. 1973. Relationship between flag leaf area, photosynthetic rate and grain yield per ear in spring wheat. Field Crops Abst. 28:594.

3. Atkins, I. M. and M. J. Norris. 1955. The influence of awns on yield and certain morphological characters of wheat. Agron. J. 47:218-220.

4. Bengtsson, A. 1974. Row spacing and sowing rate for spring wheat and barley. Field Crop Abst. 27:12.

5. Berdahl, J. D., D. C. Rasmusson, and D. N. Moss. 1972. Effects of leaf area on photosynthetic rate, light penetration, and grain yield in barley. Crop Sci. 12:177-180.

6. Blevins, R. L., D. Cook, S. H. Phillips, and R. E. Phillips. 1971. Influence of no-tillage on soil moisture. Agron. J. 63:593-596.

7. Briggs, K. G. 1975. Effects of seeding rate and row spacing on agronomic characters of Glenlea, Pitic 62, and Neepawa wheats. Can. J. Plant Sci. 55: 363-367.

8. Carr, D. J. and I. F. Wardlaw. 1965. The supply of photosynthetic assimilate to the grain from the flag leaf and ear of wheat. Aust. J. Biol. Sci. 18:711-719.

9. Davidson, J. M. and P. W. Santelmann. 1973. An evaluation of various tillage systems for wheat. Okla. Agri. Exp. Sta. B-711.

10. Dougherty, C. T., W. R. Scott, and R. H. M. Langer. 1975. Effects of sowing rate, irrigation, and nitrogen on the components of yield of spring sown semidwarf and standard New Zealand wheat. New Zealand J. Agr. Res. 18:197-201.

11. Elder, W. C. and B. B. Tucker. 1968. Overseeding small grains in bermudagrass sod for grain production. Okla. Agr. Exp. Sta. 592.

12. Evans, L. T., J. Bingham, P. Jackson, and J. Sutherland. 1972. Effects of awns and drought on the supply of photosynthate and its distribution within wheat ears. Ann. App. Biol. 70:67-76.

13. Evans, L. T. and H. M. Rawson. 1970. Photosynthesis and respiration by the flag leaf and components of the ear during grain development in wheat. Aust. J. Biol. Sci. 23:245-254.

14. Evers, G. W. and E. F. Eastin. 1974. Sod seeding of annual ryegrass. Amer. Soc. of Agron. Abst. p. 83.

15. Faris, D. G. 1974. Yield development in four isogenic barley lines differing in awn length. Can. J. Plant Sci. 54:315-322.

16. Fischer, R. A. and G. D. Kohn. 1966. The relationship of grain yield to vegetative growth and post-flowering leaf area in the wheat crop under conditions of limited soil moisture. Aust. J. Agri. Res. 17:281-295.

17. Fonseca, S. and F. L. Patterson. 1968. Yield components heritabilities and interrelationships in winter wheat (Triticum aestivum L.). Crop Sci. 8:614-617.

18. Grafius, J. E. and L. B. Okoli. 1974. Dimensional balance among yield components and maximum yield in an 8x8 diallel of barley. Crop Sci. 14:353-355.

19. Gromadinski, A. 1975. Effects of autumn or spring sowing on the yields of some plants undersown as catch crops with rye grown for grain. Nowe Rolnictwo 23:20-21. Herb. Abst. 45:142.

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

21. Ishag, H. M. and M. B. Taha. 1974. Production and survival of tillers of wheat and their contribution to yield. J. Agri. Sci. 83:117-124.

22. Johnson, R. R., C. M. Willmer, and D. N. Moss. 1975. Role of awns in photosynthesis, respiration, and transpiration of barley spikes. Crop. Sci. 15: 217-221.

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

24. Johnson, F. A., A. F. Dreier, and P. H. Grobouski. 1973. Yield and protein response to nitrogen fertilizer of two winter wheat varieties differing in inherent protein content of their grain. Agron. J. 65:259-263.

25. Jurencak. J. 1974. The effect of minimum soil cultivation with continuous cultivation of winter wheat on the structural condition of chernozem. Rostlinna' V'yroba 20(1/2):43-52. Field Crop Abst. 28:591.

26. Kaul, R. 1974. Potential net photosynthesis in flag leaves of severely drought stressed wheat cultivars and its relationship to grain yield. Can. J. Plant Sci. 54:811-815.

27. Khadr, F. H. and A. A. Kassem. 1970. Response of wheat yeild and components to nitrogen fertilization. Alexandria J. of Agri. Res. 18:245-251. Field Crop Abst. 26:165.

28. Khalifa, M. A. 1973. Effects of nitrogen on leaf area index, leaf area duration, net assimilation rate and yield of wheat. Agron. J. 65:253-256.

29. Kjack, J. L. and R. E. Witters. 1974. Physiological activity of awns in isolines of Atlas barley. Crop. Sci. 14:243-247.

30. Kriedemann, P. 1966. The photosynthetic activity of the wheat ear. Ann. Bot. N.S. 30:349-363.

31. Langer, R. H. M. and F. K. Y. Liew. 1973. Effects of varying nitrogen supply at different stages of the reproductive phase on spikelet and grain production and on grain nitrogen in wheat. Aust. J. Agri. Res. 24:647-656.

32. Lundy, H. W., G. M. Prine, and W. K. Robertson. 1975. No-tillage planting in Bahia grass of Italian ryegrass sod. Proc. soil and Crop. Sci. Soc. of Florida 33:30.

33. Lupton, F. G. H. 1972. Further experiments on photosynthesis and translocation in wheat. Ann. Appl. Biol. 71:69-79.

34. McNeal, F. H., E. P. Smith, and M. A. Berg. 1974. Plant height, grain yield, and yield component relationships in spring wheat. Agron. J. 66: 575-578.

35. McNeal, F. H. 1960. Yield components in Limhi x Thatcher wheat cross. Agron. J. 52:348-349.

36. Moschler, W. W., G. M. Shear, D. L. Hallock, R. D. Sears, and G. D. Jones. 1967. Winter cover crops for sod-planted corn: Their selection and management. Agron. J. 59:547-551.

37. Nass, H. G. 1973. Determination of characters for yield selection in spring wheat. Can. J. Plant Sci. 53:755-762.

38. Patterson, F. L., L. E. Compton, R. M. Caldwell, and F. J. Schafer. 1962. Effects of awns on yield, test weight, and kernel weight of soft red winter wheat. Crop Sci. 2:199-200.

39. Pendeton, J. W. and R. O. Weibel. 1965. Shading studies on winter wheat. Agron. J. 57:292-293.

40. Quinlan, J. D. and G. R. Sagar. 1965. Grain yield in two contrasting varieties of spring wheat. Ann. Bot. N.S. 29:683-697.

41. Reeves, T. G. and A. Ellington. 1974. Direct drilling experiments with wheat. Aust. J. Exp. Agri. and Animal Husb. 14:237-240.

42. Saghir, A. R., A. R. Khau, and W. W. Worzella. 1968. Effects of plant parts on the grain yield, kernel weight, and plant height in wheat and barley. Agron. J. 60:95-97.

43. Schlehuber, A. M. and B. B. Tucker. 1967. Wheat Culture in Wheat and Wheat Improvement. Amer. Soc. Agron. Monograph no. 13.

44. Scott, W. R., C. T. Dougherty, and R. H. M. Langer. 1975. An analysis of a wheat yield depression caused by high sowing rates with reference to the pattern of grain set within the ear. New Zealand J. Agri. Res. 18:209-214.

45. Simpson, G. M. 1968. Association between grain yield per plant and photosynthetic area above the flag leaf node in wheat. Can. J. Plant Sci. 48:253-260.

46. Singh, R., Y. Singh, S. S. Prihar, and P. Sing. 1975. Effects of nitrogen fertilization on yield and water use efficiency of dry land wheat as affected by stored water and rainfall. Agron. J. 67:599-603.

47. Syme, J. R. 1972. Features of high yielding wheats grown at two seed rates and two nitrogen levels. Aust. J. Exp. Agri. and Animal Husb. 12:165-170.

48. Teare, I. D., J. W. Sij, R. P. Waldren, and S. M. Goltz. 1972. Comparative data on the rate of photosynthesis, respiration, and transpiration of different organs in awned and awnless isogenic lines of wheat. Can. J. Plant Sci. 52:965-971.

49. Thorne, G. N. 1965. Photosynthesis of ears and flag leaves of wheat and barley. Ann. Bot. N.S. 29:317-329.

50. Voldeng, H. D. and G. M. Simpson. 1967. The relationship between photosynthetic area and grain yield per plant in wheat. Can. J. Plant Sci. 47:359-365.

51. Welbank, P. J., S. A. W. French, and K. J. Witts. 1966. Dependence of yields of wheat varieties on their leaf area duration. Ann. Bot. N.S. 30:291-299.

52. Welch, L. F., S. R. Wilkinson, and G. A. Hillsman. 1967. Rye seeded for grain in coastal bermudagrass. Agron. J. 59:467-471.

53. Yap, T. C. and B. L. Harvey. 1972. Relations between grain yield and photosynthetic parts above the flag leaf node in barley. Can. J. Plant Sci. 52:241-246.

APPENDIXES

TABLE III

MEAN VALUES OF GRAIN YIELD, AND THE YIELD COMPONENTS AT THE VARIOUS LEVELS OF NITROGEN AND SEEDING RATES (1974-75)

Nitrogen Level	Seeding Rate (kg/ha)	Grain Yield (kg/ha)	200 Kernel Weight (Gms)	Number of Kernels/ Spike	Number of Tillers/m
34	67	773.5	6.3	22.9	117.4
34	101	952.3	4.1	20.7	144.2
34	135	757.8	6.0	19.9	102.3
67	67	1002.5	5.6	23.5	92.8
67	101	563.3	5.5	22.4	130.2
67	135	902.6	5.9	20.6	99.3
101	67	911.5	5.7	27.0	91.2
101	101	393.5	5.8	21.8	86.9
101	135	1037.5	5.7	20.0	122.3
135	67	294.9	6.5	23.7	82.0
135	101	387.6	5.6	26.1	85.3
135	135	342.9	5.3	25.7	125.6
LSD 0.05		420.21	1.03	5.09	43.8

TABLE IV

MEAN VALUES OF PERCENT GRAIN PROTEIN, CHAFF WEIGHT, AND PEDUNCLE AREA AT THE VARIOUS LEVELS OF NITROGEN AND SEEDING RATES (1974-75)

Nitrogen Level (kg/ha)	Seeding Rate (kg/ha)	Percent Grain Protein	Chaff Weight (gms)	Peduncle Area (Cm^2)
34	67	11.6	2.6	24.2
34	101	11.4	2.1	21.5
34	135	10.6	1.7	19.2
67	67	11.6	2.2	26.6
67	101	11.6	2.4	23.3
67	135	10.7	1.7	19.8
101	67	12.2	2.3	23.6
101	101	11.7	2.0	24.7
101	135	11.6	1.8	22.7
135	67	12.1	2.4	24.6
135	101	11.9	2.4	25.5
135	135	12.7	2.1	26.2
LSD 0.05		1.35	0.61	6.50

TABLE V

MEAN VALUES OF GRAIN YIELD, AND THE YIELD COMPONENTS AT THE VARIOUS SEEDING RATES AVERAGED OVER NITROGEN LEVELS (1974-75)

Seeding Rate (kg/ha)	Grain Yield (kg/ha)	200 Kernel Weight (gms)	Number of Kernels/Spike	Number of Tillers/m
67	745.6	6.0	24.3	96.1
101	574.2	5.2	22.7	111.8
135	760.2	5.7	21.6	112.5
LSD 0.05	210.1	0.52	2.55	21.9

TABLE VI

MEAN VALUES OF PERCENT GRAIN PROTEIN, CHAFF WEIGHT, AND PEDUNCLE AREA, AT THE VARIOUS SEEDING RATES, AVERAGED OVER NITROGEN LEVELS (1974-75)

Seeding Rate (kg/ha)	Percent Grain Protein	Chaff Weight (gms)	Peduncle Area (Cm^2)
67	11.9	2.4	23.7
101	11.7	2.2	23.7
135	11.4	1.8	22.0
LSD 0.05	0.67	0.31	3.25

TABLE VII

MEAN VALUES OF GRAIN YIELD, AND THE YIELD COMPONENTS AT THE VARIOUS NITROGEN LEVELS AVERAGED OVER SEEDING RATES (1974-75)

Nitrogen Level (kg/ha)	Grain Yield (kg/ha)	200 Kernel Weight (gms)	Number of Kernel/Spike	Number of Tillers/m
34	827.9	5.5	21.1	121.6
67	822.8	5.7	22.2	107.5
101	780.8	5.8	22.9	100.3
135	341.8	5.8	25.1	97.7
LSD 0.05	242.6	0.60	2.94	25.3

TABLE VIII

MEAN VALUES OF PERCENT GRAIN PROTEIN, CHAFF WEIGHT, AND PEDUNCLE AREA, AT THE VARIOUS NITROGEN LEVELS, AVERAGED OVER SEEDING RATE (1974-75)

Nitrogen Level (kg/ha)	Percent Grain Protein	Chaff Weight (gms)	Peduncle Area (Cm^2)
34	11.2	2.1	21.6
67	11.3	2.1	21.9
101	11.8	2.1	23.6
135	12.2	2.3	25.4
LSD 0.05	0.78	0.35	3.75

TABLE IX

MEAN SQUARES FROM ANALYSIS OF VARIANCE OF DATA FOR GRAIN YIELD AND THE YIELD COMPONENTS (1974-75)

Source	DF	Grain Yield	200 Kernel Weight	Number of Kernels/ Spike	Number of Tillers/m
REP	2	67808.674	0.263611	1.73528	65.02083
NITR	3	498304.881**	0.210648	25.98741*	96.04398
SDRATE	2	128383.237	1.996944**	22.28778	97.64583
NITR x SDRATE	6	140537.951	1.216204*	11.97519	137.46065
REP x NITR	6	71303.644	0.332870	5.90602	41.50232
REP x SDRATE	4	53296.839	0.610694	6.04069	19.47917
REP x NITR x SDRATE	12	59483.784	0.310509	11.61921	86.71065
ERROR	22	61582.483	0.371187	9.04679	62.15720
CORRECTED TOTAL	35	116724.023	0.589040	11.33968	80.16250

*Significance at the 0.05 level of probability.

**Significance at the 0.01 level of probability.

TABLE X

MEAN SQUARES FROM ANALYSIS OF DATA FOR PERCENT GRAIN PROTEIN, CHAFF WEIGHT, AND PEDUNCLE AREA (1974-75)

Source	DF	Grain Protein	Chaff Weight	Peduncle Area
REP	2	1.110833	0.0452778	14.235278
NITR	3	1.898519*	0.1432407	28.268889
SDRATE	2	0.655833	0.9786111**	12.661944
NITR x SDRATE	6	0.608796	0.0949074	7.296389
REP x NITR	6	0.722685	0.1182407	15.547500
REP x SDRATE	4	0.192917	0.2673611	17.407361
REP x NITR x SDRATE	12	0.732546	0.0903241	13.426250
ERROR	22	0.631742	0.1301263	14.728611
CORRECTED TOTAL	35	0.765143	0.1688492	14.468825

*Significance at 0.05 level of probability.

**Significance at 0.01 level of probability.

TABLE XI

MEAN VALUES OF GRAIN YIELD, AND THE YIELD COMPONENTS, AT THE VARIOUS LEVELS OF NITROGEN AND SEEDING RATES (1975-76)

Nitrogen Level (kg/ha)	Seeding Rate (kg/ha)	Grain Yield (kg/ha)	200 Kernel Weight (gms)	Number of Kernels/Spike	Number of Tillers/M
34	67	1165.0	4.7	22.3	121.0
34	101	1097.3	4.6	20.5	141.3
34	135	1105.9	4.6	18.8	152.8
34	168	1240.9	4.8	19.5	176.7
67	67	894.8	4.3	22.7	113.4
67	101	1038.6	4.2	18.5	160.0
67	135	1169.2	4.5	24.7	117.4
67	168	1363.4	4.2	18.6	170.8
101	67	878.0	3.8	26.5	119.0
101	101	1321.1	4.5	24.4	131.2
101	135	1464.6	4.3	21.3	150.8
101	168	1176.1	4.5	25.1	131.2
135	67	709.2	4.2	29.0	115.7
135	101	1206.4	4.3	29.9	155.1
135	135	1119.4	3.9	22.6	137.7
135	168	1131.2	3.9	22.7	131.2
LSD 0.05		409.8	0.67	7.73	43.6

TABLE XII

MEAN VALUES OF PERCENT GRAIN PROTEIN, CHAFF WEIGHT, PEDUNCLE AREA, AND FLAG LEAF AREA AT THE VARIOUS LEVELS OF NITROGEN AND SEEDING RATES (1975-76)

Nitrogen Level (kg/ha)	Seeding Rate (kg/ha)	Percent Grain Protein	Chaff Weight (gms)	Peduncle Area (Cm^2)	Flag Leaf Area
34	67	8.9	1.6	18.7	10.3
34	101	8.7	1.5	15.9	5.3
34	135	8.1	1.8	16.6	6.5
34	168	11.4	1.8	16.3	6.6
67	67	12.3	1.9	19.1	10.4
67	101	13.3	1.5	15.9	10.8
67	135	10.4	1.9	18.8	5.8
67	168	13.7	2.0	15.3	9.5
101	67	10.8	1.9	17.7	11.3
101	101	9.4	1.8	20.7	8.9
101	135	8.2	1.3	18.2	7.5
101	168	12.2	2.0	19.0	7.8
135	67	12.9	2.3	20.1	11.5
135	101	14.6	2.3	19.2	7.0
135	135	14.4	1.6	18.7	8.4
135	168	14.7	2.4	16.3	7.5
LSD 0.05		4.28	0.99	5.58	4.94

TABLE XIII

MEAN VALUES OF GRAIN YIELD, AND THE YIELD COMPONENTS, AT THE VARIOUS SEEDING RATES AVERAGED OVER NITROGEN LEVELS (1975-76)

Seeding Rate (kg/ha)	Grain Yield (kg/ha)	200 Kernel Weight (gms)	Number of Kernels/Spike	Number of Tillers/m^2
67	911.7	4.3	25.1	117.4
101	1165.9	4.4	22.1	146.9
135	1214.8	4.3	21.8	139.7
168	1227.9	4.3	21.4	152.5
LSD 0.05	204.9	0.33	3.87	21.8

TABLE XIV

MEAN VALUES OF PERCENT GRAIN PROTEIN, CHAFF WEIGHT, PEDUNCLE AREA, AND FLAG LEAF AREA, AT THE VARIOUS SEEDING RATES AVERAGED OVER NITROGEN LEVELS (1975-76)

Seeding Rate	Percent Grain Protein	Chaff Weight (gms)	Peduncle Area (Cm^2)	Flag Leaf Area (Cm^2)
67	11.2	1.9	18.9	10.9
101	11.5	1.8	17.9	8.0
135	10.3	1.6	18.1	7.0
168	13.0	2.1	16.7	7.8
LSD 0.05	2.14	0.50	2.79	2.47

TABLE XV

MEAN VALUES OF GRAIN YIELD, AND THE YIELD COMPONENTS AT THE VARIOUS NITROGEN LEVELS, AVERAGED OVER SEEDING RATES (1975-76)

Nitrogen Level (kg/ha)	Grain Yield (kg/ha)	200 Kernel Weight (gms)	Number of Kernels/Spike	Number of Tillers/m
34	1152.3	4.7	20.3	147.9
67	1116.5	4.3	21.1	140.3
101	1210.0	4.3	24.3	133.1
135	1041.5	4.1	24.8	134.8
LSD 0.05	204.9	0.33	3.87	21.8

TABLE XVI

MEAN VALUES OF PERCENT GRAIN PROTEIN, CHAFF WEIGHT, PEDUNCLE AREA, AND FLAG LEAF AREA, AT THE VARIOUS NITROGEN LEVELS, AVERAGED OVER SEEDING RATES(1975-76)

Nitrogen Level (kg/ha)	Percent Grain Protein	Chaff Weight (gms)	Peduncle Area (Cm^2)	Flag Leaf Area (Cm^2)
34	9.3	1.7	16.9	7.2
67	12.4	1.8	17.2	9.1
101	10.1	1.8	18.9	8.9
135	14.2	2.1	18.6	8.6
LSD 0.05	2.14	0.50	2.79	2.47

TABLE XVII

MEAN SQUARE FROM ANALYSIS OF VARIANCE OF DATA FOR GRAIN YIELD AND THE YIELD COMPONENTS (1975-76)

Source	DF	Grain Yield	200 Kernel Weight	Number of Kernels/ Spike	Number of Tillers/m
REP	3	149432.45	1.537917	82.943906	133.9688
NITR	3	79445.24	0.948750**	82.789323*	67.1875
SDRATE	3	350394.06**	0.061250	45.466823	355.9479**
NITR x SDRATE	9	93180.91	0.224722	19.035712	109.1840
REP x NITR	9	123749.45	0.170278	44.404446	88.8715
REP x SDRATE	9	105070.52	0.126667	25.030295	50.4792
REP x NITR x SDRATE	27	61713.49	0.264398	25.959369	98.9375
ERROR	45	82792.09	0.218028	29.462573	87.2326
CORRECTED TOTAL	63	100033.13	0.309167	33.821228	104.4355

*Significance at 0.05 level of probability.

**Significance at 0.01 level of probability.

TABLE XVIII

MEAN SQUARES FROM ANALYSIS OF DATA FOR PERCENT GRAIN PROTEIN, CHAFF WEIGHT, PEDUNCLE AREA, AND FLAG LEAF AREA (1975-76)

Source	DF	Grain Protein	Chaff Weight	Peduncle Area	Flag Leaf Area
REP	3	7.94021	0.943490	65.20307	5.32104
NITR	3	78.45938**	0.628906	15.52891	12.05854
SDRATE	3	20.16354	0.558073	12.59849	45.50604*
NITR x SDRATE	9	3.79896	0.256545	8.66168	7.81729
REP x NITR	9	11.22896	0.523073	29.27571	17.27674
REP x SDRATE	9	12.88868	0.473351	21.22585	7.42590
REP x NITR x SDRATE	27	7.02095	0.480156	8.74775	11.84567
ERROR	45	9.03610	0.487379	15.34896	12.04793
CORRECTED TOTAL	63	12.07150	0.486228	16.64524	12.71697

*Significance at 0.05 level of probability.

**Significance at 0.01 level of probability.

VITA

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