MORPHOLOGICAL STRUCTURES ABOVE THE FLAG LEAF NODE IN RELATION TO TILLER AND GRAIN YIELD IN WINTER WHEAT

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CHAPTER I

INTRODUCTION

Wheat is one of the most important cereal crops. It is the principal source of food for human beings in most parts of the world. It is grown almost everywhere for that purpose, and is also used as feed for animals either as grain or as forage.

Having a knowledge of the relationship of the yield and plant morphological structures above the flag leaf node of winter wheat (*Triticum aestivum* L.) can be of assistance to plant breeders in making selections to achieve higher yield. Characters such as flag leaf, spike, peduncle, and flag leaf sheath have been considered as principle sources of carbohydrate for grain, but selections for these characters have not always led to yield increase, since there are biological limitations and compensation mechanisms which operate among these organs.

There are many reports which support the importance of the structure above the flag leaf node in contributing photosynthate to the developing grains of wheat (18, 9, 11, 19). Estimates of this contribution range between 60 and 80%, depending upon the methods used.

Most of the carbohydrate in cereal grain--especially wheat--comes from photosynthesis after anthesis (flowering). The carbohydrate formed before spike emergence and stored in the shoot or root contributes very little to the grain yield (38). The evidence is based on the fact that shoot and root do not lose much of their dry weight while the grain is filling. According to Rawson et al. (39), loss of carbohydrate from the stem of wheat after spike emergence could account for about 2.7 to 12.21% of the final grain weight.

The major sources of carbohydrate for grain are the flag leaf, spike, peduncle, and flag leaf sheath. Photosynthate from the penultimate leaf and those below is utilized mainly in the basal parts of the plant. The amount of photosynthate of each plant part contributing to grain yield depends on the variety used, and in particular on the presence or absence of awns. The contribution of awns to grain yield has been mentioned by most researchers. The awns have a more pronounced effect on yield in stress conditions.

The primary objectives of this research were to find the relationship between morphological structures above the flag leaf node and yield per tiller, and the relationships of morphological structures with yield per plot and yield components.

CHAPTER II

LITERATURE REVIEW

The contribution of various organs in the wheat plant during the spike filling period for many years has been a subject of study. There are many reports which support the importance of the organs above the flag leaf in their contribution to the developing grains of wheat. The spike, peduncle, flag leaf, and flag leaf sheath contribute most of the photosynthesis to the grain, while that part of the stem which is below the flag leaf node apparently contribute only a small percentage of the carbohydrate of the final grain weight. Some estimates of the contribution of grain dry weight from photosynthesis above the flag leaf node are 85% (3), 75% (16), 60% (39), 85% (51), and 83% (7). The contribution of each organ above the flag leaf node individually has been studied by several researchers. They have indicated that the relative contribution of each green organ to the final grain weight depends on its rate of photosynthesis and on the fraction of the photosynthate produced in each organ which is found in the grain at maturity. Some estimates of the contribution of grain dry weight from each organ are: spike, 10%, flag leaf and its sheath, 58%, second leaf (penultimate) and its sheath, 32% (22). Lupton (26) found another estimate; he reported the spike 23%, flag leaf and its sheath, 74%, and second leaf and its sheath, 3%. This difference in results depends on the method used, genotype, and environment. In recent years, many reports support the association of morphological characters with grain yield.

Voldeng et al. (53) studied the relative contribution to grain dry weight of the various photosynthetic structures above the flag leaf. As a result of either moderate or severe shading, they found that the spike and flag leaf contributed the major portion of photosynthate to the grain weight. They also found a close relationship between grain yield and flag leaf area in all of the seven lines studied; all of the correlation coefficients were greater than 0.70 (.71 - .81). They also indicated that spike area and the total area above the flag leaf node were more highly correlated with grain yield than was the flag leaf area.

Simpson (42), working with 120 wheats (short, medium, and tall), supported the concept that the photosynthetic area above the flag leaf node is an important determinant of dry matter production in wheat grain. He further indicated that on a per plant basis, the correlation coefficients between weight of grain and the variables, flag leaf area, head area, and total photosynthetic area above the flag leaf node were 0.84, 0.90, and 0.92, respectively. He also found a very high positive correlation (0.91) between weight of grain per plant and number of kernels per plant.

Puckridge (38) used a field assimilation chamber to measure the carbon dioxide uptake of wheat plants in the field before and after defoliation. He reported that at anthesis (flowering) and ten days later, only the top three leaves were effective in photosynthesis. Removal of the two leaves (penultimate and antipenultimate) below the flag leaf reduced photosynthesis of the community by 25 to 28%, and further removal of the flag leaf reduced the community photosynthesis by an additional 24 to 30%. The estimated contribution of the spike depended on the technique of measurement and varied from 7 to 15%.

Walpole et al. (54) in a field experiment obtained results which supported the work of Puckridge. They studied the effects on grain development by the removal of half of the flag leaf, the entire leaf, and all of the leaves from selected main shoots of a field crop of winter wheat. They found that all of the defoliation treatment reduced final grain yield, but the extent of the reduction increased with severity of the defoliation, and the reduction was due largely to the decrease in the weight of the individual grain, although the number of grains per spike were also depressed slightly.

Hsu et al. (18), by using five cultivars of spring wheat and the ten possible crosses among these five cultivars, studied and compared them with the parental strain in a controlled experiment. They reported that the structures above the flag leaf node, the length of leaf sheath and the flag leaf breadth were associated with yield. They also indicated that the number of spikes per plant made the most important contribution to yield, followed by the number of kernels per spike.

Briggs (5) in a detailed study, obtained similar results and indicated that in programs aimed at increasing yield, selection for increased spike length, flag leaf sheath area, and flag leaf lamina area and decreased peduncle length would appear desirable. These results compare with those of McNeal et al. (30), whose results suggest that the flag leaf by itself is not a very good index to plant performance. Chowdhry et al. (9) did not agree with Hsu's results. In a field study on four wheat cultivars and their four possible crosses, they found that flag leaf sheath length was positively related to plant height, grain yield, and its components in almost all of the population, but little or no such relation occurred with flag leaf lamina length and width in most cases. Nass (32) in an experiment for determining characters for yield selection, found that morphological characters influenced plot yield indirectly in that flag leaf width and total photosynthetic area above the flag leaf node were associated with yield per head.

One of the interesting and active areas of flag leaf research has to do with leaf area duration, LAD or D (length of time the leaf area is functional). Several workers have indicated that there is an association between active photosynthesis area after anthesis and high yield (7, 48). Welbank (55) found that wheat cultivars had grain yields proportional to their leaf area duration. Fischer et al. (17) supported Welbank's results and also found a positive relationship between yield and leaf area duration. Spiertz et al. (44), by studying spring wheat to find the relation between leaf and D, suggested that by accurate measurement of morphological parts above the flag leaf from separate parts of the culm, the D value of the flag leaf and peduncle were closely correlated with the grain yield. Increasing the duration of flag leaf photosynthesis would have an obvious effect on increasing the flow of carbohydrate to grains during the grain filling period. Pinthus and Shalom (37) conducted an experiment to find whether duration or rate of dry matter accumulation has a relationship with grain yield. They concluded that the differences in grain weight between varieties used is a result of differences in the rate rather than in the duration of dry matter accumulation in grains of high yielding and low yielding varieties.

A number of methods have been used for estimating the contribution made by cereal spike photosynthesis to grain yield. Takeda and Murata (47) reported that shading the spike decreased grain dry weight by 18% in one experiment, and by 20 to 26% in another experiment, but Allison (1) did not agree with Takeda and said that photosynthesis of the spike contributed very little because the surface area of the spike is only about 2% of that of the rest of the plant. He indicated that shading of the spike decreased grain weight by less than 4%. The results are supported by Thorne (51), who showed that CO_2 fixed by the wheat spike accounted for 17 to 30% of the grain weight. However, she indicated that more than this was lost by spike respiration, so she concluded that the flag leaf made the greatest contribution to grain weight. Evans and Rawson (13) reported data which are different from that of Thorne's estimation of spike respiration. They found that photosynthesis by the grain until maturity is equivalent to 33 to 42% of the total spike photosynthesis of the wheat plant, so this amount of contribution by the grain was enough to balance the loss of CO_2 by dark respiration. They indicated that in the period of grain development, the contribution made by spike photosynthesis to grain yield was 33% and 20%, respectively, in the awnless cultivars, whereas in some awned cultivars of wheat, spike contribution was as high as 76%. These results support those of earlier workers. Kriedemann (25) reported that the contribution of spike (wheat) photosynthesis to yield of wheat depended on technique and on environmental conditions. He estimated that 10 to 44% of grain carbohydrate came from the spike. Saghir et al. (40) studied shading treatments on the spike of wheat and barley. They reported that the spike was found to be the most critical plant part affecting the grain development of wheat and barley. By shading the spike they found shriveled grains at maturity and there was a reduction of 59.7% in grain weight compared to the control. Olugbemi et al. (33) in an experiment by infra-red gas analysis in a controlled environment, measured the net photosynthetic rates of spikes. They found that the rate of net photosynthesis of the spikes of two awned wheat lines were two to three times greater than those of their isogenic awnless counterparts. In another experiment in a greenhouse with detached shoots, Olugbemi et al. (34) found that the contribution of the spike photosynthesis to gross photosynthesis was determined by using CO_2. They found that the spike of the awnless line contributed about 10% of the total photosynthesis, and the awns increased this to 18%.

Numerous workers have reported the importance of awns in wheat and barley because under certain climatic conditions, awned varieties outyield awnless varieties (42). The presence of awns can significantly increase the photosynthetic rate of the spike. Sutherland et al. (45) showed that awns contributed considerably to grain filling, especially under drought conditions. They also suggested that the contribution of awns to grain dry wheat might be remarkably different in dwarf than in tall varieties if the photosynthetic rates of the canopies of dwarf varieties were less than in tall cultivars.

Evans et al. (12) studied the effect of awns and drought on the supply and distribution of photosynthat within wheat spikes. By using two closely related lines--awned and awnless--they supported Atkins' result and indicated that drought had different effects on spike and leaf photosynthesis, and that drought increased the proportion of carbohydrate contributed by spike photosynthesis to grain filling from 13 to 24% in the awnless spikes and from 34 to 43% in the awned spikes. Olugbemi et al. (34) do not agree with the results of Evans et al. (12). Studying isogenic lines of winter wheat in the field, they found that the awns did not increase the net photosynthesis of the complete canopy, but decreased the photosynthesis of other organs such as flag leaf, peduncle, and flag leaf sheath. So they did not find any difference between the awned and awnless lines in their NCE (net carbon dioxide exchange) under irrigated conditions.

The importance of peduncle and flag leaf sheath have been mentioned by several workers. The flag leaf sheath which wraps and supports the lower parts of the stem can be as photosynthetically active as the flag leaf blade. Thorne (51) and Chowdry et al. (9) studied the relationship of yield in wheat to some selected morphological characters under field conditions. They found a positive relationship between flag leaf sheath length and grain yield in one variety (SP_{342}), grains per spike in a second variety (MexiPak 65). Yap and Harvey (56) studied the relation between yield and morphological parts above the flag leaf node in barley. They found a positive association between yield and peduncle surface, and indicated that of the three traits, flag leaf area, head area, and peduncle surface, head area showed the most association, peduncle second, and flag leaf area the least association with the grain yield.

Yield Components

Yield of cereal is affected by genetics and environmental factors. Each makes a considerable contribution to yield during vegetative and reproductive phases. The environment has an extreme effect on yield, and so far it is the least controllable factor. The second and the most important factors are genetic and physiological characters which the plant possesses. As early as 1923, Engledow and Wadham (11) attempted to divide yield into its component parts. Characters such as the number of plants per unit area, number of fertile spikes per plant, number of grains per spike, and weight per grain were considered as the units from which high yield might be developed. Selection for these factors did not, however, invariably lead to the yield increases which were expected, because biological limitations and compensation mechanisms operate among the yield components. All components of yield are important, but the percentage of contribution to yield is not divided equally among each component. McNeal (27) showed that in the wheat cultivars Thatcher and Lemi, spikes per plant and kernels per head were more closely associated with yield per plant than was kernel weight. McNeal et al. (30) indicated that in wheat varieties, grain yield was more closely related to fertile tiller per area than with kernels per spike or kernel weight. Hsu and Walton (18) by studying spring wheat, reported that spike number per plant was the most important component in determining yield per plant on spring wheat. Scott et al. (41) showed by simple correlation coefficients that grain yield was more closely related to grain number per unit area, and they suggested that for achieving these, the grain numbers per spikelet should be increased perhaps by reducing tiller mortality.

Yield components in the future may become an important character in the selection for achieving higher yield varieties. But most of the studies so far have shown that at maximum yield levels, increases in one yield component usually cause a decrease in one or both of the other components.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted on the wheat architecture performance nursery grown at Stillwater, Oklahoma, during the 1979-1980 crop year. The nursery contained winter wheat cultivars developed by various programs in the United States and other countries around the world (Table I).

The growing season at Stillwater was characterized by above average precipitation (Table II), with the precipitation during the growing season (October 1979 to June 1980) being 237.2 mm above average.

The experiment contained thirty cultivars: eighteen subheading cultivars originated in the United States, and twelve were from seven different countries. The cultivars were planted in a randomized complete block design with four replications on October 17, 1979. The experiment received a preplant application of 123 Kg/ha N as NH_4NO_3 and top dressing of 123 Kg/ha N as NH_4NO_3 on February 28, 1980. Each cultivar was planted in a plot in four rows 304.8 cm long and 30.48 cm between rows.

Characteristics Evaluated

Data were collected on yield per plot, yield per tiller, tiller number, number of seeds per each spike, flag leaf length, flag leaf width, flag leaf sheath length, and flag leaf area (flag leaf length

TABLE I

ENTRY NUMBER, NAME, AND ORIGIN OF WHEAT VARIETIES

Entry No.	Cultivar	Origin
1	Turkey	USA - Kansas
2	Triumph 64	USA - Oklahoma
3	Scout 66	USA - Nebraska
4	Bezostaia 1	USSR
5	Burgas 2	Bulgaria
6	Priboy	USSR
7	Osage	USA - Oklahoma
8	Tam W-101	USA - Texas
9	Vona	USA - Colorado
10	Sadovo 1	Bulgaria
11	Lovrin 6	Romania
12	F23-71	Romania
13	Newton	USA - Kansas
14	Payne	USA - Oklahoma
15	Sturdy	USA - Texas
16	Partizanka	Yugoslavia
17	NR31-74	Austria
18	NR391-76	Austria
19	Tam W-105	USA - Texas
20	Tam W-103	USA - Texas
21	Plainsman V	USA - Kansas
22	Blueboy	USA - North Carolina
23	Hart	USA - Missouri
24	Arthur 71	USA - Indiana
25	TX71A562-6	USA - Texas
26	OK754615	USA - Oklahoma
27	OK78002	USA - Oklahoma
28	Hackiman Komugi	Japan
29	GK Protein	Hungary
30	Stephens (SWW)	USA - Washington

TABLE II

RAINFALL RECEIVED AND DEVIATION FROM NORMAL BY MONTH FOR CROP YEAR 1979-80 AT STILLWATER, OKLAHOMA

		Rainfall (mm)		
Year	Month	Received	Average	Deviation from Average
1979	July	104.39	89.66	14.73
	August	82.29	81.53	.76
	September	33.27	101.85	-68.56
	October	35.56	70.61	-35.05
	November	67.81	46.99	20.82
	December	48.23	34.04	14.19
1980	January	45.47	29.46	16.01
	February	15.49	34.29	-18.80
	March	73.15	47.24	25.91
	April	136.14	72.64	63.50
	May	166.37	117.35	49.02
	June	209.30	107.69	101.61
	TOTAL	1017.47	833.35	184.12

x flag leaf width). Peduncle length, peduncle diameter and weight of kernels per spike also were determined. Yield per tiller was determined on the weight of the threshed and cleaned grain harvested from each 1.49 m^{-2} of the plot and was expressed in grams per plot. Tiller count was based on the number of fertile tillers in a 30 cm length row. Two observations were made at random from two central rows, where plot yield was obtained; the average of two measurements was used in this experiment.

Twelve tillers were chosen at random from border rows of each plot (six tillers from each row); each tiller was tagged by number on each tag (from 1 to 12).

Flag leaf length and flag leaf width (taken at the widest point perpendicular to length measurement) of the twelve tillers were measured in the field when the tillers were green (about twelve days after anthesis). These characteristics were recorded as flag leaf length and flag leaf width, respectively.

After maturity, these tillers were harvested (5 cm above ground) and the following measurements were made in the laboratory. Peduncle length was measured as the length from auricle to the base of the spike. Peduncle diameter was measured by putting the peduncle on a ruler. These measurements were expressed as peduncle length and peduncle diameter, respectively. Flag leaf sheath length was measured. The measurement was based on the length from flag leaf node to auricle, and expressed as flag leaf sheath length.

Spikes of twelve tillers were threshed individually by using a hand "thresh board," and grains were separated from the chaff by blowing. The grains of each spike were counted and weighed, and were recorded as seeds/spike and weight/spike (tiller yield), respectively.

Grain protein was determined by a "UDY" colorimetric method of protein determination (samples were obtained from tiller yield).

Statistical Analyses

Statistical analyses were carried out on the yield/plot and yield/tiller, and photosynthetic structures above the flag leaf node. Flag leaf length, width, leaf area, peduncle length and diameter, flag leaf sheath length, seeds/spike, weight/spike, number of tiller, and protein % analyses were made. Analysis of variance for each character was performed on 30 cultivars. Simple correlations were computed for each character with each of the other characters. Simple correlations were computed for the whole population (1440 tillers) and for each cultivar in four replications individually. The coefficient (r_{xy}) of the simple correlation between two variables, x and y, was determined by the variance component correlation.

The correlation coefficient was calculated for determining the possible correlation coefficient between photosynthetic structure, yield components and yield per plot.

CHAPTER IV

RESULTS AND DISCUSSION

Results of the analysis of variance for yield per plot, photosynthetic structures above the flag leaf note, and yield components are presented in Tables III, IV, and V, respectively; the means of data are shown in Appendix Tables VIII, IX, and X. The varieties grown in this study were significantly different in yield and other characteristics.

There were highly significant differences among cultivars for flag leaf length, flag leaf width, flag leaf sheath length, peduncle length, peduncle diameter, and flag leaf area.

Analysis of variance of yield components (Table V) also showed highly significant differences for three yield components (kernel weight, tillers per unit area, and seeds per spike).

Simple correlation analysis was computed for thirty cultivars (Table VII) and for each cultivar between structures above the flag leaf node and yield per tiller. The correlation among yield components, yield per plot, and structures above flag leaf node was also computed (Table VII).

Grain Yield

The overall mean of grain yield for 30 cultivars was 3177 Kg/ha (47.2 bu/A). Hart was highest in the yield with 3825 kg/ha (56.8

TABLE III

MEAN SQUARE FOR FLAG LEAF AND OTHER CHARACTERS OF 30 WINTER WHEAT VARIETIES

Source	Degree of Freedom	Flag Leaf Length	Flag Leaf Width	Flag Leaf Sheath Length	Flag Leaf Area
Rep.	3	1305	26.2	2038	178137
Var.	29	14033**	79.4**	20365**	708942**
Rep. x Var.	87	1015.9	7.52	1289	553942.2

* ** Significant at the 5% and 1% level of probability, respectively.

TABLE IV

MEAN SQUARE FOR PEDUNCLE LENGTH AND OTHER CHARACTERS OF 30 WINTER WHEAT VARIETIES

Source	Degree of Freedom	Peduncle Length	Peduncle Diameter	Weight/ Spike	% Protein
Rep.	3	12048	80	0.4	0.375
Var.	29	52121**	4.93**	2.43**	4.45**
Rep. x Var.	87	2417	1.78	0.1304	0.31

* ** Significant at the 5% and 1% levels of probability, respectively.

TABLE V

MEAN SQUARE FOR YIELD, YIELD COMPONENTS, AND OTHER CHARACTERS OF 30 WINTER WHEAT VARIETIES

Source	Degree of Freedom	Yield	Tillers	Seed Weight	Seeds per Spike
Rep.	3	2365.23	15.50	0.0018	123.4
Var.	29	36246.9**	356.95**	0.0164**	2593**
Rep. x Var.	87	1638.7	40.26	0.00071	54.54

** Significant at the 5% and 1% level of probability.

bu/A) and ranked sixth in tiller number, twentieth in seeds/spike, and eleventh in seed weight. Stephen was lowest in yield with 1326 kg/ha (56.8 bu/A) and ranked sixth in tiller number, seventh in seeds/spike, and twenty-ninth in seed weight. TAM W-103 had the highest tiller number and ranked twenty-eighth in yield. F23-71 had the highest number of seeds/spike, and ranked twenty-sixth in yield. Lovring had the highest seed weight, and ranked twenty-third in yield per plot. The yield of the Hart variety may be as a result of a good combination of yield components; in addition it ranked sixth in tiller number.

The correlation coefficients of yield vs. other characteristics are presented in Table VI. The grain yield per plot of four replications for each cultivar are represented in the Appendix (Table X). Significant correlation between grain yield per plot and seed weight ($r = 0.24$), and grain yield and tiller yield ($r = 0.29$) was observed.

Yield Components

Yield per plot was positively correlated with tillers per area in this study, but correlation was not statistically significant. Some workers have found a negative correlation between grain yield and tiller count. Spike number is one of the yield components which is affected by environmental conditions occurring during early developmental stages (Thorne, 50). So high yielding varieties could produce many tillers because of favorable environmental conditions of the early developmental stages or high yielding varieties have the genetic potential of producing many tillers.

TABLE VI

CORRELATION COEFFICIENT OF GRAIN YIELD, YIELD COMPONENTS, AND PHOTOSYNTHETIC STRUCTURES OF 30 WINTER WHEAT VARIETIES

	1	2	3	4	5	6	7	8	9	10	11	12
1. Flag leaf length		0.29	0.07	0.09	0.07	0.03	0.06	0.79	0.06	0.10	0.08	0.16
2. Flag leaf width			-0.23*	0.28	0.10	0.18	-0.01	0.81**	0.20	0.11	0.06	0.10
3. Flag leaf sheath length				0.37**	0.58**	0.27	0.03	-0.10	-0.20	0.07	0.07	0.25*
4. Tiller yield (weight/spike)					0.32	0.67**	0.26*	0.24*	0.07	-0.07	0.29*	-0.24*
5. Peduncle length						0.32*	0.07	0.10	0.07	0.05	0.03	-0.16
6. Seeds/spike							0.10	0.14	-0.02	0.00	0.14	-0.17
7. Peduncle diameter								-0.02	0.24*	-0.00	0.05	-0.05
8. Leaf area									0.16	0.14	0.11	0.17
9. Seed weight										-0.08	0.24*	-0.11
10. Tillers											0.14	0.23*
11. Grain yield												0.15
12. Protein												0

*, ** Significant at 5% and 1% levels of probability, respectively (87 degrees of freedom).

Seed weight is affected by environmental conditions after pollination, and might be a factor of high yielding varieties. According to the results of this study (Appendix Tables XVII, X), the highest top four varieties in seed weight, entries 11, 10, 24, and 4 ranked 23rd, 13th, 27th, and 20th in yield per plot. The significant correlation of yield and seed weight under this experiment emphasizes the importance of improving this yield component in favor of yield increases.

Photosynthetic Components and Tiller Yield

The simple correlation coefficient between weight per spike (tiller yield) and structures above flag leaf node, flag leaf area, and seeds/spike are reported in Table VII. Flag leaf area was computed as flag leaf length times flag leaf width. Flag leaf length had a positive and highly significant correlation with flag leaf width and flag leaf areas, r = 0.48 and 0.91, respectively. Flag leaf length had a positive significant correlation with tiller yield and seeds/spike, r = 0.12, and 0.10, respectively, but the correlations were not high.

The correlation coefficient between flag leaf width with tiller yield and seeds/spike were 4 = 0.19 and 0.22, respectively, which were higher than the correlations of flag leaf length with tiller yield and seeds/spike (Figure 1). Flag leaf width had a positive significant correlation with flag leaf sheath, r = 017, and peduncle diameter, r = 0.24.

Flag leaf area had positive and significant correlation with tiller yield and seeds per spike, which were intermediate compared to

TABLE VII

SIMPLE CORRELATION COEFFICIENT TILLER FOR YIELD AND SOME OTHER CHARACTERS FOR 30 VARIETIES

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.48**	0.11**	0.12**	0.09**	0.10**	0.11**	0.91**
2. Flag leaf width			0.17**	0.19**	0.07**	0.22**	0.17**	0.78**
3. Flag leaf sheath length				0.22**	-0.15**	0.30**	0.24**	0.16**
4. Tiller yield					0.04	0.77**	0.37**	0.17**
5. Peduncle length						-0.04	0.07*	0.09**
6. Seeds/spike							0.38**	0.18**
7. Peduncle diameter								0.16**
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

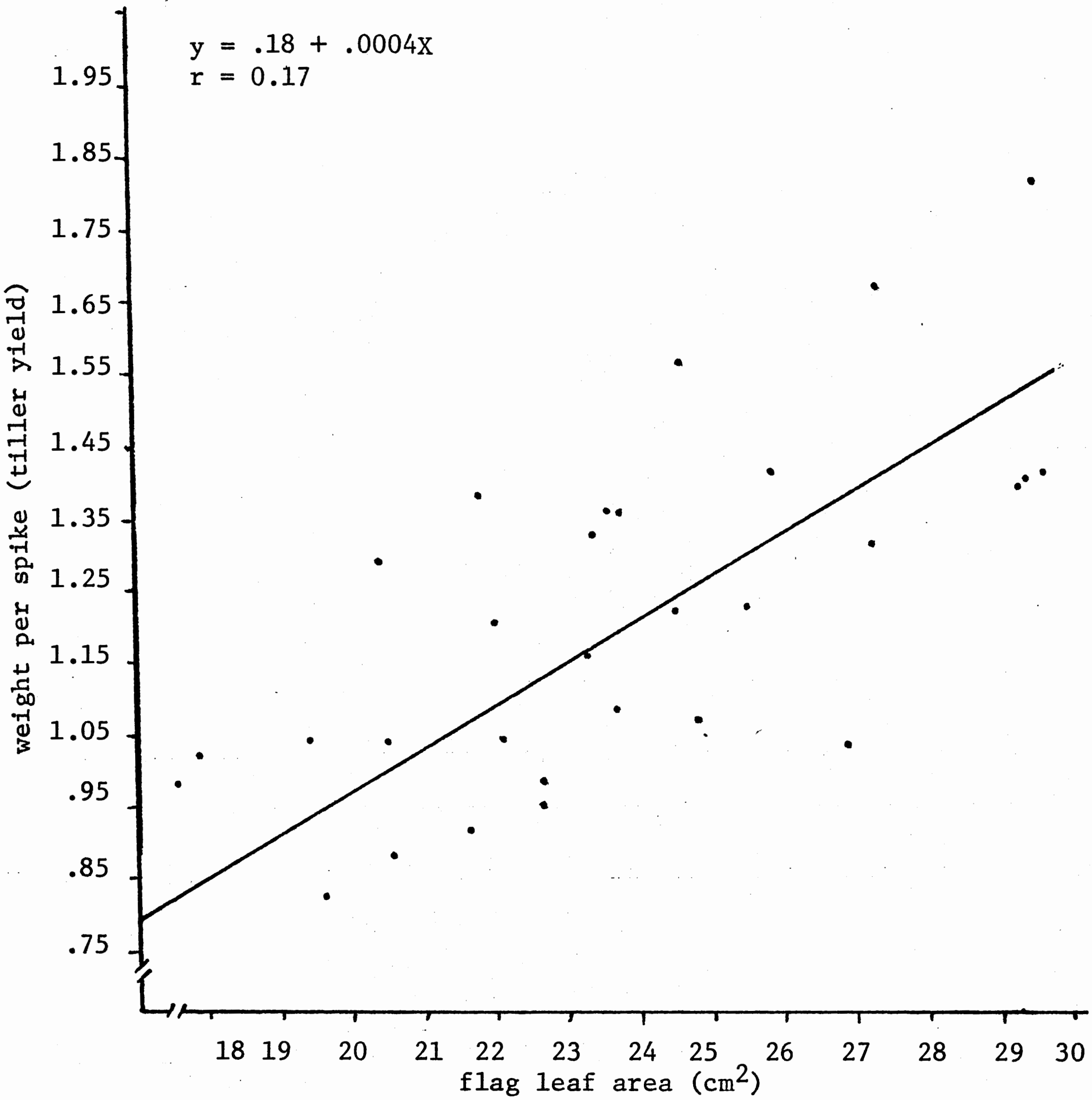

Figure 1. Regression of Tiller Yield on Flag Leaf Area

flag leaf length and flag leaf width. The results of this study from a significant standpoint are supported by Simpson (42), indicating that the variables, tiller yield and seeds per spike were significantly correlated with flag leaf area, but this correlation was not high (Figure 1). Because of lower correlation, it may be said that flag leaf length, width, or flag leaf area along cannot be a good criterion in plant presentation (Figures 1 and 2). McNeal et al. (28) agree that flag leaf area by itself appears not to be a good index to plant performance, and he indicated that other plant parts must be more influential in determining grain yield.

Flag leaf sheath length has positive and significant correlation with tiller yield and seeds per spike, r = 0.22 and 0.30, respectively (Table VII). Flag leaf sheath and peduncle length have negative and significant correlation, r = -0.15. Here, also, the correlations between yield per tiller and flag leaf sheath length were not high, but they are significant (because of high degrees of freedom). Flag leaf sheath was positively and significantly correlated with peduncle diameter and leaf area, r = 0.24 and 0.16. The highest correlation coefficient was found between weight per spike (tiller yield) and seeds per spike, r = 0.77.

Peduncle length had nonsignificant positive correlation with tiller yield, and negative correlation with seeds per spike. In the seed-setting time, the peduncle was not fully developed, thus it might compete for photosynthate with seeds. Briggs and Aytenifsu (6) found a negative correlation between peduncle length and yield per plant. Other workers have found different results for peduncle and grain yield. Yap and Harvey (56) found a positive correlation between

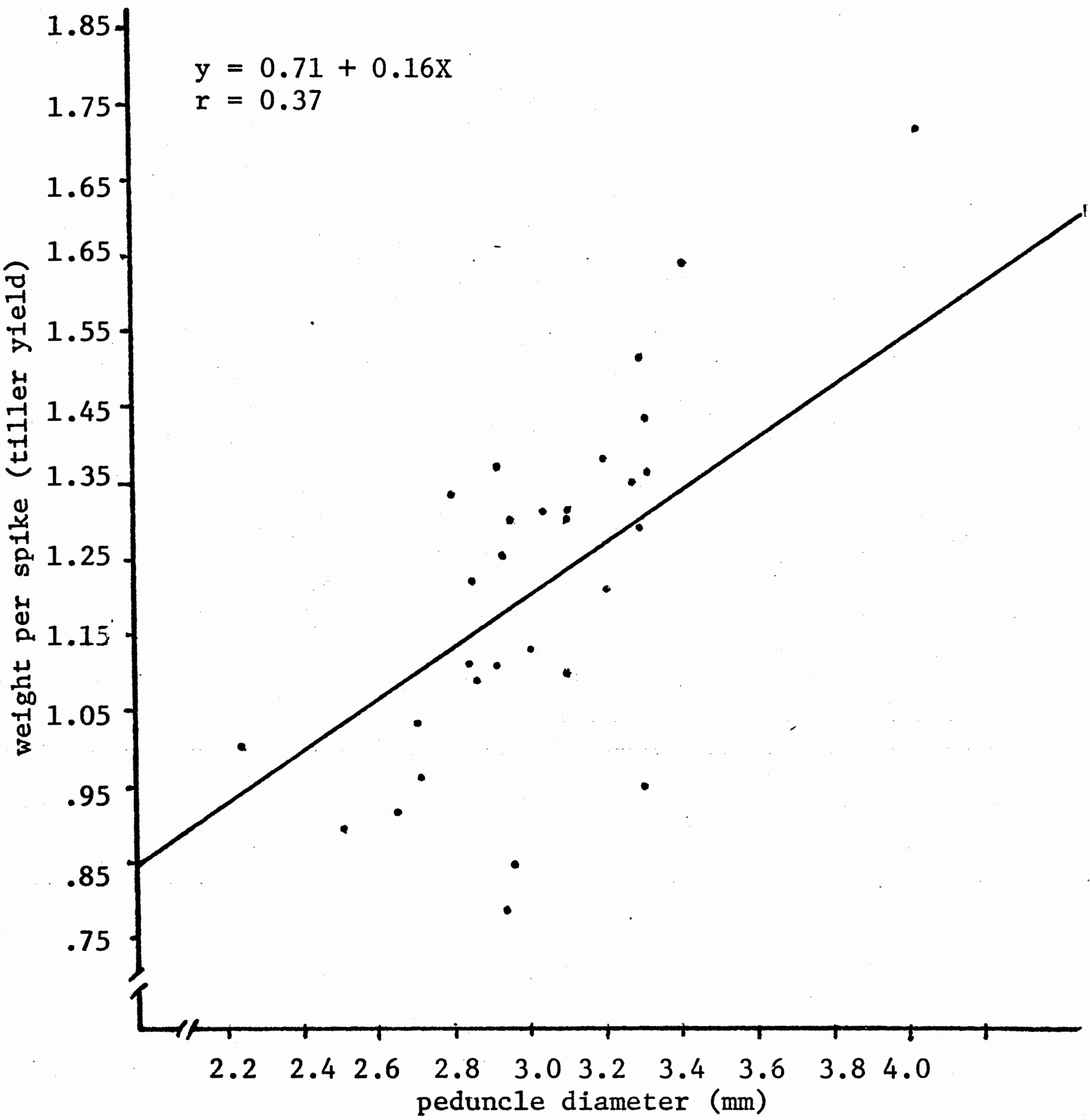

Figure 2. Regression of Tiller Yield on Peduncle Diameter

peduncle and grain yield, and indicated that the relative importance of the structure was quite stable and the peduncle was second in importance with yield association after the head area.

Peduncle had the highest correlation with tiller yield and seeds per spike, r = 0.37 and 0.38 (Figure 2). These higher correlations may be overestimating because of some error in measurement of peduncle diameter, but increasing the peduncle diameter may result in a stronger stem and may also give a greater vascular capacity, allowing greater water and nutrient movement and also because of very low correlation of peduncle length with tiller yield and negative association of peduncle length and seeds per spike. Distance of translocation of assimilation from the source (photosynthesizing structures) to sink (grains) may be a limiting factor to grain yield. By increasing the diameter of the peduncle and decreasing the length, the capacity of translocation, especially in the first period of reproductive growth (grain setting), may increase the overall efficiency of the translocation process.

Because of lower correlation between tiller yield and structures above the flag leaf node when data for varieties are pooled, correlations were made within each variety, across the four replications, to determine possible relationships between structures above the flag leaf node and tiller yield.

Simple correlation between tiller yield and structure above the flag leaf node was carried out for each individual cultivar, and the results are as follows (Appendix Tables XI to XL).

The Hart variety ranked #1 in respect to yield per plot. The structures above the flag leaf node did not have any significant correlation with tiller yield. Tiller yield was highly and positively correlated with the number of kernels per spike (Appendix Table XI). It is possible that the grains of this variety received more carbohydrates from the head than did other varieties (Hsu, 18). The results of Yap et al. (56) showed that among the structures above the flag leaf node, the head area showed the most association with grain yield.

Vona ranked #2 in yield per plot. The coefficients of relationship were different from the previous variety. Yield per tiller had high and positive significant correlation with flag leaf sheath length, peduncle diameter, and flag leaf area, r = 0.67, 0.36, and 0.29, respectively (Appendix Table XII). Seeds per spike had positive and highly significant correlations with flag leaf sheath, peduncle diameter, r = 0.53 and 0.32. The results agree with the results of Chowdhry et al. (9), especially for flag leaf sheath. Tiller yield had a nonsignificant negative correlation with peduncle length, indicating a limitation which is caused by distance from the source to the sink. Briggs et al. (6) found highly significant negative correlation between these two variables.

The Sturdy variety, which ranked #3 in grain yield, tiller yield had significant correlations with flag leaf length and flag leaf area, r = 0.35 and 0.34, respectively. The results of Simpson (42) agreed with these results, indicating that flag leaf is correlated with yield per tiller and yield per plant, and is also correlated with seeds per spike.

TAM-105 ranked #4 in yield per plot, showing results different from the previous varieties. Tiller yield and seeds/spike had positive significant correlation with peduncle diameter, r = 0.55 and 0.56, respectively. Although the correlation of tiller yield with flag leaf width and flag leaf area were significant, they were very low.

Paritzanka ranked #5 in yield per plot. There was no high correlation between tiller yield and structures above the flag leaf node, except for yield per tiller and flag leaf sheath length, which was not high, but was significant. In this variety, the importance of head photosynthesis is obvious (Appendix Table XV).

The Burgas variety ranked #6 in yield per plot. Grain of this variety, like Vona, apparently received most of its carbohydrate from flag leaf sheath, r = 0.48 (Appendix Table XVI). In addition, tiller yield and seeds per spike were positively and significantly associated with peduncle diameter, r = 0.38 and 0.37, respectively.

The remaining varieties showed results similar to the above varieties. In some varieties there was a significant association between tiller yield and sheath or other structures. There were also some varieties like NR391-76 (Appendix Table XIV), which ranked #14 in yield per plot. In this variety, tiller yield had positive significant correlations with flag leaf length, flag leaf width, flag leaf area, flag leaf sheath length, and peduncle diameter, r = 0.46, 0.55, and 0.50, respectively. Tiller yield and seeds per spike were highly associated. A summarization can be generalized as follows:

Flag leaf length had significant positive correlation with tiller yield in these varieties: Sturdy, NR391-76, Priboy, and Bezostaia 1. Flag leaf width was positively and significantly correlated with tiller yield in these varieties: TAM-105, NR391-76, Osage, Sadovo, GKProtein, Newton, and Bezostaia 1.

Flag leaf sheath had significant positive correlation with tiller yield in the varieties Vona, Partizanka, Burgas 2, NR391-76, TAM W-101, OK754615, OK78002, Sadovo, Plainsman, GK Protein, Priboy, TX71A562-6, Bezostaia 1, Triumph 64, NR31-74, Oovrin 6, Hackiman, Scout 66, TAM W-103, and Stephens.

Flag leaf area was positively and significantly correlated with tiller yield in varieties Vona, Sturdy, TAM W-105, NR391-76, Sadova, GK Protein, Priboy, Newton, Bezostaia, and Lovrin. There were negative significant correlations between leaf area and tiller yield in varieties Scout 66 and F23-71.

Peduncle length showed positive significant correlation with tiller yield in varieties Bezostaia 1, NR31-74, Scout 66, Turkey, and Stephens. There were negative significant correlations between peduncle length and tiller yield in varieties Triumph 64, Lovrin 6, and Hackiman Komugi 1.

Peduncle diameter had significant positive correlations with tiller yield in varieties Vona, TAM W-105, Burgas 2, NR391-76, TAM W-101, OK754615, OK78002, Blueboy, Savodo 1, Plainsman V, Priboy, TX71A562-6, Newton, Bezostaia 1, Triumph 64, NR31-74, Lovrin 6, Hackiman Komug 1, Scout 66, F23-71, TAM W-103.

The correlation coefficients for each variety are reported in the Appendix. There were some common features among varieties. First, whenever yield per tiller was significantly associated with a variable, seeds per spike also showed significant association with that variable or variables. There was also such a relationship for flag leaf length, flag leaf width, and flag leaf area. It became obvious that varieties showed different results, and the results are supported by different previous workers.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study were to determine the relationships between morphological structures above the flag leaf node and yield per tiller, and to determine relationships of the morphological structures with yield and the yield components and relative importance of three yield components. The experiment was conducted on the winter wheat architecture performance nursery grown at Stillwater, Oklahoma, during the 1979-80 crop year. The cultivars were planted in a complete randomized block design with four replications. Each variety was planted in a plot in four rows 304.8 cm long and spaced 30.48 cm between rows. The characters evaluated were grain yield per plot, tiller number, seeds/spike, flag leaf length, flag leaf width, flag leaf sheath, peduncle length, peduncle diameter, leaf area, seed weight, tiller yield, and percent protein. Statistical analyses were conducted on 30 varieties.

An analysis of variance indicated that there were significant differences due to varieties for all characters evaluated. All of the characters were significantly different due to varieties at the 1% level of probability. Duncan multiple range test was used for comparison of the means. There was no significant difference among the 15 top yielding varieties for yield at the 5% Duncan multiple range test. The Hart variety produced the highest yield with 3826 Kg/ha

(56.8 bu/a). This variety ranked #6 in tiller number, #12 in seeds/spike, and #11 in kernel weight.

The data indicated that among yield components, only kernel weight had a significant correlation with yield. Kernel weight was the most important yield component in terms of its influence on grain yield. Tiller number and seeds/spike were second and third, respectively.

Yield was positively and significantly correlated with seeds/spike, Yield was positively correlated with flag leaf length, flag leaf width, flag leaf sheath length, peduncle length, peduncle diameter, and protein percentage, but none of these correlations was statistically significant. Yield was positively correlated with tiller yield (weight/spike).

Tiller yield was significantly correlated with structures above the flag leaf node. The importance of their contribution to grain yield or tiller yield were in order of peduncle diameter, flag leaf sheath, leaf area, flag leaf width, and flag leaf length.

Because of the lower correlation of cultivars for tiller yield and structures, the correlation coefficients between tiller yield and structures for each variety were completed. The results indicated different correlations, and each variety showed different results. In some varieties, tiller yield had a significant correlation with flag leaf length, and other varieties showed high positive correlation with flag leaf sheath. Each variety showed its own results, thus this result indicates that in programs aimed to increase yield, selection for increased structures above the flag leaf node cannot be generalized, but depends upon the variety with regard to selection for increased yield.

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APPENDIX

TABLES

TABLE VIII

MEANS OF YIELD COMPONENTS AND SOME OTHER CHARACTERS FOR THIRTY WINTER WHEAT VARIETIES

Variety	No. of Tillers/ 30 cm	No. of Seeds per Spike	% Grain Protein	Seed Weight gr	Weight/ Spike gr
Turkey	62.00	32.31	15.65	0.0283	0.92
Triumph 64	68.75	26.62	14.92	0.0380	1.01
Scout 66	67.50	27.29	14.97	0.0329	0.90
Bezostaia 1	46.25	33.75	15.27	0.0406	1.37
Burgas 2	43.00	38.48	15.15	0.0354	1.35
Priboy	54.75	32.73	14.57	0.0393	1.28
Osage	62.25	32.54	15.12	0.0338	1.10
TAM W-101	61.00	26.25	15.42	0.0395	1.04
Vona	66.25	39.10	13.92	0.0321	1.10
Sadevo 1	43.75	31.77	13.27	0.0433	1.36
Lovrin 6	42.00	27.54	15.05	0.0483	1.29
F23-71	44.00	52.98	14.62	0.030	1.62
Newton	54.25	44.23	14.85	0.0257	1.13
Payne	56.50	38.52	15.17	0.0288	1.11
Sturdy	46.00	37.89	15.22	0.0348	1.31
Partizanka	47.75	37.14	14.25	0.0353	1.31
NR31-74	48.00	40.94	13.30	0.029	1.19
NR391-76	37.75	48.77	13.10	0.0384	1.78
TAM W-105	65.75	34.98	14.37	0.0314	1.09
TAM W-103	70.25	34.98	13.45	0.0310	0.80
Plainsman V	55.75	31.10	16.97	0.0310	0.96
Blueboy	51.25	42.54	14.60	0.0321	1.36
Hart	62.25	33.23	14.95	0.0357	1.18
Arthur 71	54.50	20.62	16.67	0.0415	0.85
TX71A562-6	57.25	46.52	13.80	0.0269	1.25
OK754615	58.00	39.37	13.37	0.0335	1.32
OK78002	51.00	37.68	12.75	0.0360	1.29
Hackiman	40.25	47.92	15.30	0.0318	1.52
GK Protein	43.00	34.72	15.77	0.0364	1.27
Stephens	46.50	41.75	16.50	0.0226	0.94
LSD 0.05	8.91	10.37	0.77	0.22	0.14
LSD 0.01	11.81	13.75	1.03	0.31	0.14

TABLE IX

MEANS OF PHOTOSYNTHETIC STRUCTURES OF THIRTY WINTER WHEAT VARIETIES

Variety	Flag Leaf Length cm	Flag Leaf Width cm	Flag Leaf Area cm	Peduncle Length cm	Peduncle Diameter mm	Flag Leaf Sheath Lng cm
Turkey	16.5	1.34	22.45	18.70	2.67	22.48
Triumph 64	15.9	1.20	19.29	21.53	2.27	16.84
Scout 66	17.2	1.23	21.48	22.73	2.52	17.78
Bezostaia 1	17.3	1.46	25.39	17.62	3.35	18.76
Burgas	17.9	1.60	28.81	13.58	3.35	16.20
Priboy	17.4	1.43	25.21	16.55	3.29	18.43
Osage	16.2	1.27	20.68	22.46	3.10	19.12
RAM W-101	16.1	1.50	24.50	18.30	2.73	13.74
Vona	14.18	1.43	20.32	18.14	2.85	13.46
Sadovo 1	19.16	1.51	29.06	18.37	3.22	17.41
Lovrin 6	19.38	1.59	30.83	10.14	3.08	17.71
F23-71	17.6	1.52	30.94	16.48	3.37	18.10
Newton	15.8	1.43	26.94	17.57	3.00	16.45
Payne	13.7	1.24	22.97	14.16	2.91	14.93
Sturdy	17.1	1.35	23.26	13.60	3.04	15.23
Partizanka	18.8	1.36	25.97	16.28	3.10	17.55
NR31-74	18.1	1.38	25.09	18.90	3.22	17.52
NR391-76	18.7	1.53	29.22	16.34	4.00	19.98
TAM 105	15.2	1.41	21.89	19.22	2.87	14.40
TAM W-103	14.1	1.37	19.48	16.58	2.93	12.65
Plainsman V	14.1	1.23	17.56	15.34	2.71	14.54
Blueboy	17.4	1.67	28.93	18.68	2.92	18.03
Hart	18.00	1.34	24.16	14.42	2.94	16.87
Arthur 71	15.0	1.34	20.45	21.66	2.96	16.79
TX71A562-6	14.8	1.35	20.21	13.32	2.93	16.92
OK754615	16.0	1.44	23.28	16.98	2.83	14.74
OK78002	15.8	1.45	23.08	17.20	2.95	17.35
Hackiman Komugi	18.6	1.68	31.48	14.57	3.31	17.35
GK Protein	18.3	1.45	26.78	15.37	3.35	15.66
Stephens (SWW)	13.7	1.63	22.41	17.74	3.27	17.98
LSD .05	4.48	0.38	10.46	6.90	1.87	4.47
LSD .01	5.93	0.51	15.72	9.19	2.40	7.06

TABLE X

RANK AND MEANS OF GRAIN YIELD FOR THIRTY WINTER WHEAT VARIETIES

Variety	Entry No.	Mean	Bu/Ac	Rank	Kg/ha
Turkey	1	257.5	25.8	29	1738.3
Triumph 64	2	455.00	45.5	21	3065.6
Scout	3	366.95	37.5	25	2519.8
Bezostaia 1	4	472.50	47.3	20	3186.8
Burgas 2	5	550.00	55.0	6	3705.6
Priboy	6	498.75	47.9	17	3213.8
Osage	7	516.25	51.6	12	3476.6
RAM W-101	8	546.25	54.6	7	3678.7
Vona	9	566.25	56.6	2	3813.5
Sadovo 1	10	511.25	51.1	13	3442.9
Lovrin 6	11	425.00	48.5	23	2863.4
F23-71	12	368.75	36.9	26	2688.3
Newton	13	476.25	47.6	19	3207.1
Payne	14	538.75	53.9	10	3631.5
Sturdy	15	557.50	55.8	3	3759.5
Partizanka	16	552.50	55.3	5	3725.8
NR31-74	17	448.75	44.9	22	3025.2
NR391-76	18	508.75	50.9	14	3429.4
TAM W-105	19	555.00	55.5	4	3739.3
TAM W-103	20	311.25	31.1	28	2095.4
Plainsman V	21	508.75	50.9	15	3429.4
Blueboy	22	530.00	53.0	11	3570.9
Hart	23	568.75	56.9	1	3833.6
Arthur 71	24	363.75	36.4	27	2452.4
TX71A562-6	25	491.25	49.1	18	3308.1
OK754615	26	543.75	54.4	8	3665.2
OK78002	27	542.20	54.3	9	3685.5
Hackiman Komugi	28	420.00	42.0	24	2829.8
GK Proteini	29	508.75	50.9	16	3429.4
Stephens (SWW)	30	196.25	19.6	30	1320.5

LSD .05		56.88			
LSD .01		70.37			

TABLE XI

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR THE CULTIVAR HART

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.40**	0.1	-0.05	0.40**	-0.24	0.11	0.93**
2. Flag leaf width			0.05	0.23	0.32*	0.09	-0.04	0.70**
3. Flag leaf sheath length				0.26	-0.18	0.41**	0.03	0.04
4. Tiller yield					-0.04	0.78**	0.09	0.06
5. Peduncle length						-0.35*	-0.04	0.40**
6. Seeds/spike							0.17	-0.14
7. Peduncle diameter								0.08
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR VONA

	1	2	3	4	5	6	7	8
1. Flag leaf length.		0.48**	0.23	0.23	0.23	0.33*	0.21	0.87**
2. Flag leaf width			0.24	0.26	0.01	0.36	0.18	0.84
3. Flag leaf sheath length				0.67**	-0.16	0.53**	0.31*	0.28*
4. Tiller yield					-0.20	0.84**	0.36*	0.29*
5. Peduncle length						--.02	-0.14	0.13
6. Seeds/spike							0.32*	0.39*
7. Peduncle diameter								0.22
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XIII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR STURDY

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.31*	0.015	0.35*	0.19	0.34*	0.06	0.85**
2. Flag leaf width			0.09	0.22	0.33*	0.30*	0.11	0.76**
3. Flag leaf sheath length				0.08	-0.43**	0.04	-0.27	-0.02
4. Tiller yield					-0.03	0.92**	0.24	0.34*
5. Peduncle length						-0.05	-0.06	0.29*
6. Seeds/spike							0.19	0.38**
7. Peduncle diameter								0.11
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XIV

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR TAM W-105

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.57**	0.40**	0.25	0.12	0.19	0.26	0.93**
2. Flag leaf width			0.19	0.28*	0.25	0.21	0.32*	0.82**
3. Flag leaf sheath length				0.19	0.18	0.34*	0.42**	0.36*
4. Tiller yield					0.27	0.79**	0.55**	0.29*
5. Peduncle length						0.19	0.35*	0.17
6. Seeds/spike							0.56**	0.21
7. Peduncle diameter								0.33*
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XV

SIMPLE CORRELATION COEFFICIENT FORTILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR PARTIZANIA

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.63**	0.23	0.07	0.14	0.05	0.17	0.94**
2. Flag leaf width			0.18	0.16	0.04	0.04	0.05	0.85**
3. Flag leaf sheath length				0.28*	0.19	0.24	0.45**	0.24
4. Tiller yield					0.14	0.94**	0.27	0.10
5. Peduncle length						0.02	0.15	0.11
6. Seeds/spike							0.25	0.03
7. Peduncle diameter								0.14
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XVI

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR BURGAS 2

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.34*	0.23	-0.20	-0.03	-0.32	-0.08	0.93**
2. Flag leaf width			0.30*	0.17	-0.09	0.14	0.33	0.66**
3. Flag leaf sheath length				0.48**	-0.14	0.49**	0.22	0.31*
4. Tiller yield					-0.10	0.72**	0.38**	-0.09
5. Peduncle length						-0.09	-0.001	-0.5
6. Seeds/spike							0.37**	-0.19
7. Peduncle diameter								-0.08
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XVII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR TAM W-101

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.60**	-0.08	0.003	-0.06	-0.02	-0.044	0.93**
2. Flag leaf width			0.04	0.20	-0.10	0.16	0.20	0.84**
3. Flag leaf sheath length				0.65**	0.11	0.68**	0.35	-0.02
4. Tiller yield					-0.22	0.91**	0.37**	-0.09
5. Peduncle length						-0.28**	0.007	-0.06
6. Seeds/spike							0.34*	0.06
7. Peduncle diameter								0.07
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XVIII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR OK754615

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.45*	0.16	0.16	0.05	0.31*	0.21	0.93**
2. Flag leaf width			0.26	0.14	0.01	0.28*	0.24	0.73**
3. Flag leaf sheath length				0.29*	-0.47**	0.54**	0.53**	0.21
4. Tiller yield					0.06	0.75**	0.32*	0.16
5. Peduncle length						-0.25	-0.05	0.04
6. Seeds/spike							0.55**	0.33*
7. Peduncle diameter								0.24
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XIX

SIMPLE CORRELATION COEFFICIENT FORTILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR OK78002

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.38**	-0.31*	0.03	0.23	0.05	-0.18	0.92**
2. Flag leaf width			-0.13	-0.24	-0.02	-0.22	-0.30*	0.70**
3. Flag leaf sheath length				0.30*	-0.29*	0.32	0.44**	-0.29*
4. Tiller yield					0.15	0.82**	0.50**	0.10
5. Peduncle length						-0.05	-0.07	0.17
6. Seeds/spike							0.42**	-0.14
7. Peduncle diameter								-0.26
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XX

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR PAYNE

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.48**	0.15	-0.02	0.17	0.13	0.34*	0.93**
2. Flag leaf width			0.41**	0.26	-0.01	0.46**	0.31*	0.77**
3. Flag leaf sheath length				0.11	0.34*	0.16	0.23	0.28*
4. Tiller yield					-0.08	0.82**	0.24	0.10
5. Peduncle length						0.16	0.25	0.13
6. Seeds/spike							0.39**	0.28*
7. Peduncle diameter								0.37**
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXI

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR BLUEBOY

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.16	-0.31	0.14	-0.26	0.09	0.12	0.84**
2. Flag leaf width			0.11	0.04	0.07	-0.5	0.11	0.68**
3. Flag leaf sheath length				0.21	-0.08	0.26	0.11	-0.28*
4. Tiller yield					0.03	0.72**	0.33*	0.15
5. Peduncle length						0.02	0.15	-0.23
6. Seeds/spike							0.36*	0.06
7. Peduncle diameter								0.16
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR OSAGE

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.54**	-0.05	0.14	0.28*	0.25	-0.05	0.93**
2. Flag leaf width			0.15	0.34*	0.22	0.51**	0.23	0.81**
3. Flag leaf sheath length				0.11	0.04	0.34*	0.37*	0.04
4. Tiller yield					0.26	0.86**	0.27	0.24
5. Peduncle length						0.17	0.38**	0.28*
6. Seeds/spike							0.390**	0.39**
7. Peduncle diameter								0.08
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXIII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR SADOVO 1

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.57**	0.38**	0.22	0.02	0.06	0.21	0.91**
2. Flag leaf width			0.27	0.39**	0.15	0.43**	0.28*	0.85**
3. Flag leaf sheath length				0.47**	0.11	0.38**	0.44**	0.36**
4. Tiller yield					0.08	0.88**	0.48**	0.30*
5. Peduncle length						0.14	0.22	0.09
6. Seeds/spike							0.55**	0.22
7. Peduncle diameter								0.25
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXIV

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR NR391-76

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.76**	0.27	0.46**	0.12	0.39**	0.40**	0.96**
2. Flag leaf width			0.32*	0.63**	0.19	0.62**	0.40**	0.90**
3. Flag leaf sheath length				0.43**	0.23	0.34*	0.10	0.23
4. Tiller yield					0.23	0.92**	0.59**	0.55**
5. Peduncle length						0.16	0.06	0.15
6. Seeds/spike							0.55**	0.51**
7. Peduncle diameter								0.42**
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXV

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR PLAINSMAN V

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.53**	0.19	-0.001	-0.13	-0.10	0.02	0.93**
2. Flag leaf width			0.41**	0.19	-0.04	0.19	0.24	0.80**
3. Flag leaf sheath length				0.30*	0.001	0.26	0.12	0.33*
4. Tiller yield					0.06	0.89**	0.59**	0.09
5. Peduncle length						0.23	0.15	-0.11
6. Seeds/spike							0.57**	0.03
7. Peduncle diameter								0.13
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXVI

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR GK PROTEIN

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.67**	0.39**	0.22	0.04	0.26	0.10	0.92**
2. Flag leaf width			0.61**	0.53**	-0.02	0.38**	0.20	0.90**
3. Flag leaf sheath length				0.83**	-0.05	0.77**	0.31*	0.53**
4. Tiller yield					-0.18	0.81**	0.18	0.40**
5. Peduncle length						-0.14	0.26	0.02
6. Seeds/spike							0.18	0.04
7. Peduncle diameter								0.15
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXVII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR PRIBOY

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.68**	0.52**	0.46**	0.21	0.22	0.46**	0.96**
2. Flag leaf width			0.62**	0.25	0.12	0.26	0.53**	0.85**
3. Flag leaf sheath length				0.29*	-0.34*	0.45**	0.26	0.61**
4. Tiller yield					-0.12	0.75**	0.29*	0.42**
5. Peduncle length						-0.40**	0.24	0.19
6. Seeds/spike							0.20	0.25
7. Peduncle diameter								0.52**
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXVIII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR TX71A562-6

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.58**	-0.08	0.23	-0.14	0.16	0.13	0.93**
2. Flag leaf width			0.28*	0.14	-0.13	0.26	0.32*	0.84**
3. Flag leaf sheath length				0.31*	-0.18	0.59**	0.38**	0.05
4. Tiller yield					-0.02	0.76**	0.53**	0.20
5. Peduncle length						0.10	-0.07	-0.15
6. Seeds/spike							0.53**	0.21
7. Peduncle diameter								0.22
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXIX

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR NEWTON

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.55**	0.15	0.24	0.61**	0.16	0.14	0.94**
2. Flag leaf width			0.56**	0.33*	0.16	0.56**	0.36*	0.79**
3. Flag leaf sheath length				0.13	-0.34*	0.41**	0.35*	0.31*
4. Tiller yield					0.09	0.51**	0.30*	0.29*
5. Peduncle length						-0.18	-0.08	0.50**
6. Seeds/spike							0.43**	0.32*
7. Peduncle diameter								0.23
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXX

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR BEZOSTAIA 1

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.57**	0.45**	0.46**	0.23	0.49**	0.27	0.93**
2. Flag leaf width			0.40**	0.48**	0.06	0.44**	0.27	0.81**
3. Flag leaf sheath length				0.47**	0.06	0.50**	0.31*	0.47**
4. Tiller yield					0.34*	0.90**	0.50**	0.53**
5. Peduncle length						0.25	0.34*	0.19
6. Seeds/spike							0.48**	0.52**
7. Peduncle diameter								0.29*
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXI

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR TRIUMPH 64

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.54**	0.37**	-0.001	0.17	0.07	0.003	0.88**
2. Flag leaf width			0.43**	0.08	0.22	0.15	0.07	0.86**
3. Flag leaf sheath length				0.49**	0.001	0.51**	0.28*	0.44**
4. Tiller yield					-0.31*	0.94**	0.40**	0.01
5. Peduncle length						0.37**	-0.23	0.22
6. Seeds/spike							0.40**	0.10
7. Peduncle diameter								0.04
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR NR31-74

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.61**	0.03	0.10	-0.04	0.20	0.36*	0.94**
2. Flag leaf width			0.08	-0.02	-0.18	0.03	0.18	0.84**
3. Flag leaf sheath length				0.47**	-0.12	0.61**	0.58**	0.21
4. Tiller yield					0.31*	0.91**	0.60**	0.06
5. Peduncle length						0.21	0.19	0.10
6. Seeds/spike							0.64**	0.13
7. Peduncle diameter								0.32*
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXIII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR LOVRIN 6

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.12	0.52**	0.21	-0.05	0.22	-0.13	0.79**
2. Flag leaf width			0.27	0.26	-0.14	0.24	0.18	0.70**
3. Flag leaf sheath length				0.35*	-0.42**	0.12	0.31*	0.55**
4. Tiller yield					-0.46**	0.37**	0.47**	0.31
5. Peduncle length						-0.15	-0.26	-0.12
6. Seeds/spike							0.19	0.30*
7. Peduncle diameter								0.10
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXIV

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR HACKIMAN

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.51**	0.16	0.05	0.12	0.05	0.22	0.91**
2. Flag leaf width			0.22	0.26	-0.10	0.25	0.26	0.81**
3. Flag leaf sheath length				0.62**	-0.37**	0.61**	0.63**	0.21
4. Tiller yield					-0.34*	0.89**	0.38**	0.16
5. Peduncle length						-0.49**	-0.13	0.04
6. Seeds/spike							0.37**	0.15
7. Peduncle diameter								0.28*
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXV

SIMPLE CORRELATION COEFFICIENT FORTILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR SCOUT 66

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.38**	-0.19	-0.24	-0.29*	-0.24	-0.21	0.87**
2. Flag leaf width			-0.22	-0.27	-0.23	0.13	-0.30*	0.73**
3. Flag leaf sheath length				0.32*	0.10	0.67**	0.45**	-0.27
4. Tiller yield					0.58**	0.69**	0.49**	-0.30*
5. Peduncle length						0.36	0.38**	-0.33*
6. Seeds/spike							0.58**	-0.34*
7. Peduncle diameter								-0.33*
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXVI

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR F23-71

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.11	-0.04	0.06	0.06	0.02	0.006	0.81**
2. Flag leaf width			-0.05	0.05	0.55**	0.06	0.03	0.66**
3. Flag leaf sheath length				0.05	-0.55**	0.08	0.02	0.006
4. Tiller yield					0.05	0.82**	0.49**	-0.68**
5. Peduncle length						0.006	0.25	0.03
6. Seeds/spike							0.50**	0.05
7. Peduncle diameter								-0.6
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXVII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR ARTHUR 71

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.64**	0.36*	-0.11	0.09	-0.10	0.02	0.95**
2. Flag leaf width			0.24	0.19	0.18	0.06	0.14	0.83**
3. Flag leaf sheath length				0.06	0.28*	0.02	0.34*	0.30*
4. Tiller yield					0.10	0.68**	0.18	-0.03
5. Peduncle length						-0.14	0.36	0.12
6. Seeds/spike							0.10	-0.06
7. Peduncle diameter								0.05
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXVIII

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR TAM W-103

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.55**	0.15	-0.01	-0.10	0.06	0.20	0.92**
2. Flag leaf width			0.03	0.003	0.13	-0.10	0.12	0.82**
3. Flag leaf sheath length				0.76**	-0.10	0.78**	0.44**	0.11
4. Tiller yield					-0.14	0.87**	0.50**	-0.03
5. Peduncle length						-0.20	0.04	0.004
6. Seeds/spike							0.58**	-0.11
7. Peduncle diameter								0.17
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XXXIX

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR TURKEY

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.58**	-0.09	0.23	0.30*	0.13	0.11	0.92**
2. Flag leaf width			0.07	0.26	0.37**	0.18	0.25	0.84**
3. Flag leaf sheath length				0.08	-0.11	0.005	0.32*	0.02
4. Tiller yield					0.40**	0.84**	0.20	0.25
5. Peduncle length						0.39**	0.14	0.36
6. Seeds/spike							0.25	0.15
7. Peduncle diameter								0.21
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

TABLE XL

SIMPLE CORRELATION COEFFICIENT FOR TILLER YIELD AND SOME OTHER CHARACTERS FOR CULTIVAR STEPHENS

	1	2	3	4	5	6	7	8
1. Flag leaf length		0.08	-0.18	-0.24	-0.17	0.06	0.002	0.83**
2. Flag leaf width			0.31*	0.20	0.10	0.47**	0.12	0.61**
3. Flag leaf sheath length				0.33*	-0.14	0.69**	0.34*	0.02
4. Tiller yield					0.52**	0.56**	0.24	-0.08
5. Peduncle length						-0.03	-0.23	-0.07
6. Seeds/spike							0.42**	0.30*
7. Peduncle diameter								0.06
8. Leaf area								

* ** Significant values for simple correlation coefficient are 0.28 and 0.36 at 5% and 1% levels of probability, respectively (44 degrees of freedom).

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VITA

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Master of Science

Thesis: MORPHOGOLICAL STRUCTURES ABOVE THE FLAG LEAF NODE IN RELATION TO TILLER AND GRAIN YIELD IN WINTER WHEAT

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