



**Physical Properties and Laboratory  
Scale Extraction Rate of  
Oklahoma Hard Winter Wheat  
1999 Cultivar Trials in Agricultural Ex-  
periment Stations**



Oklahoma Agricultural Experiment Station • Division of Agricultural Sciences and Natural Resources

FAPC P-991

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**T**he physical properties and laboratory scale flour extraction for Hard Winter wheat varieties grown at Oklahoma State University Experiment Stations in 1999 were analyzed. Twenty cultivars grown in fourteen locations representing six agricultural districts showed a protein content range of 9.3 to 15.7 percent (12 percent moisture basis, mb). The highest and lowest average protein contents were observed in samples from Goodwell irrigated management (14.9 percent, 12 percent mb) and Frederick (10.6 percent, 12 percent mb), respectively. Six of fourteen cultivars showed all values (100 percent distribution, across location) of protein content in the range of 11 to less than 14 percent. Those cultivars were 2163, Big Dawg, Dominator, Champ, Tam 302 and Tomahawk. The other varieties had about 70 percent distribution of protein content in the same range. Test weight frequency distributions across locations of values equal to or greater than 58 lb/bu showed 2174 (79 percent), Big Dawg, Ogallala, and Tonkawa (72 percent each) as the first and second (tie) places, respectively. Average single kernel weight distributions with values equal to or greater than 28 mg were observed for Big Dawg (93 percent) and all cultivars in Elk City yielded 28 mg or greater values. Extraction rates ranking of cultivars varied within each location of the agricultural districts. Overall, the top ranking cultivars were Ogallala in the Panhandle, Big Dawg in the Central and North Central Districts (except for Alva), and AgSeco 7853 in the West Central. In the Southwest agricultural districts, Coronado consistently ranked higher extraction rates compared to the other cultivars.

## INTRODUCTION

This report describes key physical properties of Hard Red Winter wheat cultivars planted in Oklahoma Experimental Stations during the crop year 1999. Since environmental condition during the growing season plays a significant role influencing the quality of wheat, it is of interest to describe the variation of key wheat quality parameters

### Key Symbols:



≤, less or equal to  
≥, greater or equal to  
<, less than  
>, greater than  
+, plus.

of the top twenty cultivars grown throughout different regions in the state. The record of this information is valuable to the wheat industry since it will give a historical track record that can complement agronomical data already available through other sources (Krenzer et al, 2000) and protein content from previous years (Brusewitz and Stephens, 1979).

## METHODOLOGY

Twenty cultivars of Hard Winter wheat were grown by Eugene Krenzer, Ph.D., Extension Specialist, Department of Plant and Soil Sciences, in fourteen locations corresponding to six agricultural districts based on the Oklahoma Agricultural Statistics Service. The cultivars were planted in a randomized complete block design with four replicates in Oklahoma State University Experiment Station plots. Each subplot consisted of five 3.0 m long rows spaced 0.23 m apart. A small plot combine was used to harvest each plot and a sub-sample, number 10 can of about gallon size, was saved. The sub-samples were cleaned twice and the test weight analyzed using AACC method 55-10 (AACC 1995) in a standard quart apparatus. A composite sample was obtained by blending the four replicates per block and used for subsequent analysis.

There were 280 samples collected and stored in a freezer at 8°F for 16 to 24 hours. Protein content was determined by near infrared (NIR) transmittance in a whole grain analyzer (ZX-800 Zeltex Inc., Hagerstown, MD). Selected samples showing protein values higher than 13 percent were analyzed by the Dumas method using a combustion nitrogen analyzer Model MacroN (Foss Heraeus, Elementar) and Kjeldahl AACC method 46-13. These methods confirmed the high protein values obtained with NIR. High protein values were attributed to differences in fertilization levels used. Physical analysis to estimate grain uniformity (average single kernel weight, diameter and hardness) were performed using a Single Kernel Characterization System (SKCS Model 4100, Perten Inst.,



Springfield, IL), which analyzes a three hundred kernel sample size. Kernel size distribution was completed using 200g samples in a Ro-Tap (W.S. Tyler Inc., Mentor, OH) equipped with Tyler sieves No. 7 (2.82 mm) and No. 9 (2.00 mm). After one minute of sifting, kernels on the sieves were weighed and reported as a percentage. Kernels on U.S. sieve No. 7 were considered large size; kernels on top of sieve No. 9 were considered medium; and those kernels sifting through sieve No. 9 were labeled small. Flour extraction was measured using AACC method 12-10A and milled on a Brabender Quadrumat Sr. mill (C. W. Brabender Inst., Hackensack, NJ). Extraction rates were calculated against total products on an "as is" moisture basis.

## RESULTS

### Percent Protein

The average protein content of all the cultivars tested was less than 12% (12% mb), averaged across locations with a range of 9.3 to 15.7% (Table 1a, b). When averaged across cultivars, wheat samples from Goodwell irrigated management had the highest average protein content (14.9% on a 12% mb) (Table 2). The location with the lowest average protein content was Frederick with 10.6% and a range of 9.3 to 11.4% (Table 2). These results show the potential protein that the cultivars can produce. The average protein content of the same cultivars grown commercially can vary widely. Differences can be accounted for by management practices, including fertilizer application among other factors.

### Test Weight

Cultivars 2174, Agseco 7853, Big-Dawg, Ogallala and Tonkawa had an average test weight of 59+ lb/bu, while Tam 302 and Tomahawk averaged <55 lb/bu, across locations (Table 1a, b). Among the locations that gave test weight >59 lb/bu were Goodwell under both dry land and irrigated management, Gage, Altus, and Elk City while Lamont and Lahoma had the lowest (<55 lb/bu), averaged across cultivars (Table 2).

### Average Single Kernel Weight

When cultivar values were averaged across locations, Big Dawg had the highest single kernel weight at 33.4 mg, while 2163 and Ogallala had 23.6 mg (Table 1a, b). Cultivars that showed  $\geq 28$  mg target value were 2174, Agseco 7853, Chisholm, Coronado, Custer, Lockett and Tonkawa (Table 1a, b). When single kernel weight was averaged across cultivars, samples from Elk City had the highest at 32.5 mg while Lamont had the lowest at 21.3 mg (Table 3). Among the locations that showed  $\geq 28$  mg were Alva, Cherokee, Frederick and Goodwell dryland, Gage and Marshall (Table 3).

### Average Single Kernel Diameter

Big Dawg had the largest average single kernel diameter (2.4 mm), while Betty and 2174 (cv) gave the lowest average diameter at 1.9 mm (Table 1a, b). Cultivars that measured  $\geq 2.2$  mm (target value) were 2174, Agseco 7853, Lockett and Tonkawa, while the rest of the cultivars had an average kernel diameter of  $\leq 2.2$  mm. Wheat samples from Elk City, taken from 20 cultivars, showed the highest

average single kernel diameter (2.3 mm) among the locations, whereas Lamont showed the lowest (1.8 mm, Table 2). All the other locations had average single kernel diameter between 1.9 to 2.2 mm.

### Average Kernel Hardness

Jagger and Betty were among the highest hardness kernel textured cultivars with an average hardness index >77 while Heyne was the softest with a hardness index of 56 (Table 1a, b). Cultivars that had  $\geq 65$  kernel hardness averaged across locations were 2137, 2163, 2174, Big Dawg, Coronado, Custer, Dominator, Karl 92, Lockett, Ogallala, Oro Blanco, Tam 302, Tomahawk and Tonkawa. Wheat samples from Frederick had the lowest hardness index of 57, which is slightly lower than the target of minimum hardness 60. All the other locations ranged from 61 to 77 average hardness index values (Table 2).

### Average Kernel Size

Large kernel size is defined as kernels that stay on a No. 7 mesh (Tyler No. 7 screen, 2.82 mm) opening while medium kernel size is retained on a No. 9 mesh (Tyler No. 9 screen 2.00 mm) opening. Large kernel size is desirable because it generally produces higher flour extraction. Uniform kernel size (low standard deviation) is also desirable.

Big Dawg (cv) produced the highest proportion of large kernel size at 80% while Ogallala had only 39% (Table 1a, b). Cultivars with >60% large kernel size were 2174, Agseco 7853, Coronado, Custer, Lockett, Tam 302 and Tonkawa, averaged across locations. Locations that produced  $\geq 70\%$  large kernel size were Alva, Elk City and Frederick (Table 2).

### Percent Distribution Average Across Cultivars and Locations

#### Percent Protein

##### Distribution comparison by cultivar across locations

(Fig. 1- 20, Panel A). The protein content of the cultivars 2163, Big Dawg, Dominator, Champ, Tam 302 and Tomahawk showed all values (100% distribution) in the range of 11 to 14+% protein. The rest of the cultivars, 14 out of 20, had about 70% distribution in the same range. This means that 70% of the samples had a protein content of 11% or higher.

##### Distribution comparison by location, across cultivars

**Distribution comparison by location, across cultivars** (Fig. 21- 34, Panel A). The protein content of the samples from Altus, Alva, Cherokee, Elk City, Goodwell dryland, Goodwell irrigated, Haskell, Lahoma, Lamont, and Marshall were distributed within the range of 11 to 14+% protein. Only the Frederick location gave protein content less than 11%.

The protein values reported here were used for comparative purposes only. These samples were grown at OSU Agricultural Experiment Stations with optimum fertilizer application and in the absence of grazing practices. The results illustrate the relative potential of the cultivars for seed protein content.

### **Average Test Weight**

Test weight values of the same cultivars tested in Oklahoma Agricultural Stations were reported earlier by Krenzer. Test weight values of 58 (lb/bu) or higher are a target quality characteristic. Test weight values are used as an estimate of flour yield potential. In most recent years, higher wheat test weight lots produce higher flour extraction; but there are exceptions to this observation and this is checked with every new crop. Extraction rates are of special interest to the milling industry.

### **Average across locations**

(Fig. 1- 20, Panel B). Cultivars with test weights  $\geq 58$  lb/bu at  $\geq 50$  frequency distribution were 2137 (50%), Coronado (50%), Chisholm (57%), Custer (57%), Karl 92 (58%), Agseco 7853 (64%), Ogallala (72%), Tonkawa (72%), Big Dawg (72%) and 2174 (79%).

### **Average across cultivars**

(Fig. 21- 34, Panel B). Locations with  $\geq 50\%$  frequency distribution of test weight at 58 lb/bu or more were Apache (60%), Alva (65%), Altus (80%), Goodwell irrigated (80%), Elk City (95%), Gage (95%) and Goodwell dryland (100%), while the rest of the locations have 50% or less.

### **Average Single Kernel Weight**

The quality target for average single kernel weight is 28 mg or higher.

### **Average across locations**

(Fig. 1- 20, Panel C). Big Dawg showed the highest percent distribution (93%) of average single kernel weight at  $\geq 28$  mg or more. Other cultivars that showed  $\geq 50\%$  distribution for this quality target ( $\geq 28$  mg) were Coronado (50%), Heyne (50%), 2137 (57%), 2174 (57%), Agseco 7853 (57%), Chisholm (57%), Custer (64%), Lockett (64%) and Tonkawa (72%).

### **Average across cultivars**

(Fig. 21- 34, Panel C). All samples from Elk City had an average single kernel test weight  $\geq 28$  mg, while all samples from Lamont had  $\leq 28$  mg. Other cultivars with  $\geq 50$  percent distribution of  $\geq 28$  mg average single kernel weight were Frederick (50%), Marshall (50%), Alva (60%), Gage (65%), Cherokee (70%) and Goodwell dryland (80%).

### **Average Single Kernel Diameter**

The desired value for average single kernel diameter is 2.2 mm or higher.

### **Average across locations**

(Fig. 1- 20, Panel D). All samples from cultivars 2163, Betty, Jagger and Oro Blanco had a single kernel diameter of  $< 2.2$  mm. Cultivars that gave  $\geq 50\%$  distribution of kernel diameter at  $\geq 2.2$  mm were Coronado (50%), Lockett (50%), Agseco 7853 (57%), 2137 (71%), 2174 (71%) and Big Dawg (93%).

### **Average across locations**

(Fig. 21- 34, Panel D). All cultivars (100%) grown at Lamont measured  $< 2.2$  mm, while kernel diameters of  $\geq 2.2$  mm were observed in Cherokee and Goodwell dryland (50%) and Elk City (70%).

### **Extraction Rate by Agricultural District**

Extraction rate, also referred to as flour yield, was ranked within each location and assessed as a relative comparison among cultivars and locations.

In the Panhandle area (Table 3), Ogallala (cv) produced the highest extraction rate in Gage (65.2%) and Goodwell dryland (65.7%); it also ranked third in Goodwell irrigated (66.6%). Tonkawa (cv) produced the lowest extraction rate ( $< 62\%$ ) and ranked the lowest among the cultivars.

In the North Central agricultural district (Table 4), Big Dawg (cv) ranked first in Lahoma (62.4%) and Lamont (62.9%), but ranked fourth in Cherokee (64.4%), and among the lowest (57.5%) in Alva. Tonkawa and Custer ranked the lowest among all the cultivars in all the locations tested.

In the West Central agricultural district (Table 5), Agseco 7853 (cv) yielded the highest extraction rate (65.4%), while Tonkawa (cv) yielded the lowest (59.9%).

In the East Central agricultural district (Table 5), Big Dawg (cv) yielded the highest extraction rate (62.3%), while Custer (cv) produced the lowest (54.5%).

In the Central agricultural district (Table 6), Tomahawk (cv) ranked second in both Chickasha (62.3%) and Marshall (63.8%) locations. Tonkawa (cv) produced the lowest extraction rate followed by Custer (cv).

In the Southwest agricultural district (Table 7), Coronado (cv) consistently ranked among the highest ( $> 64\%$ ) out of the cultivars sampled in all the areas, while Jagger (cv) constantly ranked lower ( $< 61\%$ ).

### **CITED REFERENCES**

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**Table 1a. Summary of Physical Characteristics by Cultivar**

Hard Winter Wheat			Averages Across 14 Locations						
Cultivar	Protein % 12% m.b.	Test Weight (lb-bu)	Single Kernel Characteristics			Kernel Size (%)			
			Avg Weight (mg)	Avg Diameter (mm)	Average Hardness	Large	Medium	Small	
2137	Average <sup>2</sup>	12.3 ± 1.4	57.8 ± 2.5	28.0 ± 3.5	2.1 ± 0.2	67.9 ± 4.6	57.6 ± 12.1	41.0 ± 11.0	0.6 ± 0.4
	Range	10.2 - 14.8	51.9 - 61.3	22.0 - 34.5	1.8 - 2.4	60.9 - 75.4	27.1 - 76.6	22.8 - 72.2	0.1 - 1.7
2163	Average	12.6 ± 1.1	55.3 ± 2.7	23.6 ± 3.0	1.9 ± 0.1	70.1 ± 5.5	46.5 ± 11.8	53.2 ± 11.2	1.3 ± 0.9
	Range	10.5 - 14.5	49.0 - 59.1	18.1 - 30.0	1.6 - 2.1	58.8 - 79.8	17.5 - 64.8	34.8 - 80.3	0.4 - 3.9
2174	Average	12.9 ± 1.3	59.2 ± 2.8	29.0 ± 2.9	2.3 ± 0.2	78.4 ± 7.5	69.4 ± 12.0	29.9 ± 11.7	0.7 ± 0.7
	Range	10.6 - 15.3	52.0 - 62.3	22.3 - 33.4	1.9 - 2.6	63.3 - 87.6	44.1 - 96.9	13.0 - 54.0	0.0 - 2.5
Agseco	Average	13.0 ± 1.3	59.0 ± 2.7	30.2 ± 4.4	2.2 ± 0.2	61.5 ± 7.3	68.6 ± 17.0	30.8 ± 16.8	0.5 ± 0.4
	Range	10.5 - 15.2	53.7 - 63.3	23.9 - 38.2	1.9 - 2.5	50.2 - 73.0	37.9 - 96.3	13.5 - 61.0	0.0 - 1.3
betty	Average	12.2 ± 1.6	57.2 ± 2.9	24.1 ± 3.2	1.9 ± 0.2	77.9 ± 6.7	46.4 ± 11.4	53.2 ± 10.4	1.4 ± 2.2
	Range	9.8 - 15.4	51.4 - 61.0	19.6 - 28.9	1.7 - 2.2	66.3 - 89.6	28.7 - 66.0	33.5 - 70.6	0.1 - 8.6
big dawg	Average	12.9 ± 1.2	59.0 ± 2.4	33.4 ± 3.0	2.5 ± 0.1	73.4 ± 7.7	80.2 ± 7.0	19.5 ± 6.7	0.3 ± 0.3
	Range	11.2 - 14.8	53.5 - 62.0	26.7 - 38.0	2.2 - 2.7	58.1 - 88.2	63.4 - 87.9	12.0 - 35.3	0.0 - 1.3
clomp	Average	12.8 ± 1.2	57.5 ± 2.9	26.8 ± 4.8	2.0 ± 0.2	63.2 ± 8.2	54.5 ± 13.9	44.6 ± 13.4	0.9 ± 0.9
	Range	11.2 - 15.1	49.9 - 59.8	21.2 - 34.0	1.7 - 2.3	47.4 - 72.0	34.3 - 73.6	26.3 - 65.1	0.2 - 3.4
chisholm	Average	12.2 ± 1.0	59.3 ± 2.7	28.2 ± 3.8	2.1 ± 0.2	64.2 ± 5.7	54.7 ± 15.0	44.4 ± 14.2	0.9 ± 1.2
	Range	10.6 - 14.3	52.0 - 61.8	22.3 - 33.6	1.8 - 2.3	52.8 - 71.4	33.6 - 80.9	19.1 - 64.9	0.0 - 4.9
coronado	Average	13.0 ± 1.0	56.9 ± 3.4	28.2 ± 4.0	2.2 ± 0.2	70.8 ± 5.9	65.9 ± 12.2	33.5 ± 11.9	0.7 ± 0.6
	Range	10.9 - 14.3	49.9 - 61.4	19.5 - 33.5	1.7 - 2.4	61.0 - 80.3	41.7 - 83.1	16.6 - 59.3	0.1 - 2.1
custer	Average	12.5 ± 1.1	58.0 ± 3.3	29.1 ± 3.9	2.2 ± 0.2	71.9 ± 6.6	61.8 ± 13.5	37.5 ± 13.2	0.7 ± 0.5
	Range	10.6 - 14.0	50.5 - 61.8	22.8 - 35.0	1.8 - 2.5	58.8 - 79.4	36.8 - 77.3	22.4 - 60.8	0.2 - 1.8

<sup>2</sup> - Average ± standard deviation.  
1 mb = moisture basis

**Table 1b. Summary of Physical Characteristics by Cultivar**

Hard Winter Wheat			Averages Across 14 Locations						
Cultivar	Protein % 12% m.b.	Test Weight (lb-bu)	Single Kernel Characteristics			Kernel Size (%)			
			Avg Weight (mg)	Avg Diameter (mm)	Average Hardness	Large	Medium	Small	
Dominator	Average <sup>2</sup>	13.0 ± 1.3	58.4 ± 2.7	26.9 ± 3.9	2.0 ± 0.2	65.7 ± 7.9	43.0 ± 13.4	55.7 ± 12.5	1.4 ± 1.5
	Range	11.1 - 15.5	51.9 - 61.9	21.6 - 35.6	1.8 - 2.4	46.7 - 78.8	22.9 - 63.1	36.5 - 76.3	0.2 - 6.1
Hayne	Average	12.2 ± 1.4	57.6 ± 2.8	27.4 ± 4.0	2.1 ± 0.2	56.9 ± 6.6	54.7 ± 11.9	44.3 ± 11.2	1.1 ± 1.0
	Range	9.3 - 14.8	52.7 - 61.8	20.6 - 33.6	1.7 - 2.3	45.5 - 69.3	37.8 - 77.9	22.0 - 58.6	0.1 - 3.6
Jagger	Average	12.9 ± 1.5	56.3 ± 3.2	25.0 ± 3.7	2.0 ± 0.2	77.0 ± 6.2	46.3 ± 15.8	53.3 ± 15.0	1.5 ± 1.2
	Range	10.5 - 15.3	46.5 - 61.1	19.0 - 29.3	1.7 - 2.2	64.8 - 87.6	21.8 - 88.4	30.9 - 75.4	0.2 - 3.6
Karl92	Average	12.9 ± 1.5	58.4 ± 2.1	27.4 ± 3.3	2.1 ± 0.2	65.9 ± 7.1	50.4 ± 13.1	46.7 ± 12.7	0.9 ± 0.9
	Range	10.2 - 15.7	53.7 - 62.0	22.0 - 34.6	1.8 - 2.4	51.7 - 75.0	28.4 - 70.6	28.8 - 67.9	0.0 - 3.7
Lockett	Average	12.8 ± 1.4	57.2 ± 2.8	30.4 ± 4.9	2.2 ± 0.2	66.2 ± 9.3	65.7 ± 12.5	33.8 ± 12.1	0.6 ± 0.5
	Range	10.7 - 14.8	53.0 - 61.5	24.2 - 38.3	1.9 - 2.5	44.1 - 78.6	42.6 - 89.0	13.7 - 55.3	0.1 - 2.0
Ogalala	Average	13.0 ± 1.4	59.0 ± 2.5	23.8 ± 2.5	1.9 ± 0.1	74.5 ± 6.2	39.4 ± 10.0	59.1 ± 9.5	1.6 ± 1.2
	Range	10.2 - 15.2	52.8 - 62.6	19.0 - 29.5	1.7 - 2.2	65.8 - 83.8	20.0 - 59.4	40.2 - 77.4	0.5 - 4.4
oro blanco	Average	12.0 ± 1.4	57.3 ± 3.4	24.1 ± 3.4	1.9 ± 0.2	60.7 ± 6.3	40.0 ± 11.9	57.4 ± 11.2	1.9 ± 1.3
	Range	9.9 - 13.9	49.0 - 61.5	17.7 - 28.9	1.6 - 2.1	57.4 - 78.2	27.1 - 59.4	36.5 - 71.5	0.3 - 4.8
TAM302	Average	13.0 ± 1.2	54.6 ± 3.7	26.9 ± 4.7	2.0 ± 0.2	74.0 ± 9.4	60.3 ± 13.0	39.1 ± 12.5	0.6 ± 0.6
	Range	11.3 - 15.2	47.2 - 59.2	19.6 - 35.8	1.7 - 2.5	46.9 - 81.3	42.6 - 84.6	15.2 - 58.2	0.2 - 2.5
Tomahawk	Average	13.2 ± 1.3	55.8 ± 3.8	26.5 ± 3.8	2.1 ± 0.2	72.5 ± 6.0	59.2 ± 15.7	40.1 ± 15.5	0.7 ± 0.5
	Range	11.2 - 15.1	48.7 - 60.5	19.8 - 33.8	1.7 - 2.4	57.7 - 80.2	32.5 - 82.9	16.6 - 66.7	0.3 - 2.2
Toskawa	Average	13.1 ± 1.1	59.2 ± 2.4	30.4 ± 4.0	2.2 ± 0.2	72.4 ± 6.3	68.3 ± 12.3	31.2 ± 11.8	0.6 ± 0.6
	Range	10.3 - 14.8	53.8 - 62.0	21.4 - 36.6	1.8 - 2.5	56.2 - 81.4	43.8 - 84.0	16.1 - 54.2	0.0 - 2.0

<sup>2</sup> - Average ± standard deviation.  
1 mb = moisture basis

**Table 2. Summary of Physical Characteristics by Location**

Hard Winter Wheat			Averages Across 20 Cultivars						
Locations	Protein % (12% mb)	Test Weight lbbu	Single Kernel Characteristics			Kernel Size (%)			
			Ave. Weight (mg)	Ave. Diameter (mm)	Average Hardness	Large	Medium	Small	
Arkus	Average <sup>1</sup>	14.0 ± 0.5	59.4 ± 1.5	24.8 ± 3.0	2.0 ± 0.2	73.3 ± 8.0	40.5 ± 15.3	58.6 ± 14.0	0.3 ± 0.5
	Range	13.1 - 14.7	55.6 - 61.7	20.4 - 30.5	1.7 - 2.3	57.2 - 83.7	17.6 - 68.2	31.3 - 80.3	0.3 - 2.6
Aho	Average	13.1 ± 0.5	68.4 ± 1.6	29.3 ± 3.6	2.2 ± 0.2	73.8 ± 6.7	60.4 ± 11.8	30.3 ± 11.6	0.4 ± 0.3
	Range	12.1 - 13.8	55.3 - 80.4	23.7 - 35	1.9 - 2.5	60.0 - 85.1	41.4 - 86.3	13.5 - 67.7	0.0 - 1.0
Apache	Average	11.9 ± 0.7	58.6 ± 1.6	27.3 ± 4.5	2.1 ± 0.3	72.4 ± 7.2	55.3 ± 20.5	43.9 ± 19.8	0.8 ± 0.9
	Range	10.5 - 13.0	55.8 - 61.0	20.5 - 37.2	1.8 - 2.7	54.7 - 87.8	21.8 - 86.9	13.0 - 75.4	0.0 - 3.2
Cherokee	Average	12.2 ± 0.5	57.2 ± 1.6	30.6 ± 4.0	2.2 ± 0.2	61.8 ± 7.7	62.7 ± 11.9	36.7 ± 11.6	0.5 ± 0.4
	Range	11.2 - 13.0	54.2 - 59.2	25.0 - 39.0	1.9 - 2.7	47.4 - 72.7	41.0 - 83.8	15.9 - 57.7	0.2 - 1.8
Chizasha	Average	11.5 ± 0.9	55.6 ± 1.7	23.5 ± 3.3	1.9 ± 0.2	78.2 ± 5.7	41.1 ± 13	55.9 ± 11.5	2.9 ± 2.1
	Range	9.8 - 13.0	52.6 - 58.6	19.6 - 34.7	1.7 - 2.8	63.9 - 86.4	24.2 - 80.6	19.3 - 69.6	0.1 - 8.8
Elk City	Average	12.3 ± 0.8	60.8 ± 1.1	32.5 ± 2.6	2.3 ± 0.1	72.3 ± 6.8	72.7 ± 10.5	27.0 ± 10.4	0.4 ± 0.2
	Range	11.1 - 13.4	57.8 - 62.6	28.9 - 38.3	2.1 - 2.5	56.8 - 81.9	50.7 - 86.1	13.7 - 40.2	0.0 - 0.7
Frederick	Average	10.6 ± 0.5	55.2 ± 1.3	28.0 ± 3.7	2.2 ± 0.2	67.3 ± 7.5	68.1 ± 11.2	31.4 ± 10.9	0.5 ± 0.3
	Range	9.3 - 11.4	53.4 - 58.4	22.3 - 34.1	1.8 - 2.5	44.1 - 89.7	49.0 - 84.6	15.2 - 50.3	0.2 - 1.3
Goodwell	Average	13.2 ± 0.6	61.2 ± 1.1	30.8 ± 3.5	2.2 ± 0.2	77.1 ± 6.0	57.1 ± 15.9	42.3 ± 15.8	0.7 ± 0.4
	Range	12.2 - 14.4	58.3 - 63.3	22.4 - 35.6	1.9 - 2.6	68.2 - 88.2	24.0 - 85.2	14.5 - 74.5	0.2 - 1.5
Jagger	Average	14.9 ± 0.5	59.3 ± 1.2	27.7 ± 2.8	2.1 ± 0.1	84.7 ± 7.2	68.7 ± 15.3	40.7 ± 15.1	0.6 ± 0.3
	Range	13.8 - 16.7	56.5 - 61.1	23.0 - 33.2	1.9 - 2.4	59.6 - 76.5	37.1 - 85.8	14.2 - 62.1	0.2 - 1.5
Jagge	Average	11.3 ± 0.8	60.2 ± 1.2	29.4 ± 3.7	2.1 ± 0.2	63.3 ± 7.1	66.6 ± 9.7	32.8 ± 9.4	0.7 ± 0.3
	Range	9.9 - 12.7	57.4 - 61.8	22.7 - 35.9	1.8 - 2.5	50.6 - 77.8	42.2 - 81.5	16.5 - 56.5	0.1 - 1.3
Hackell	Average	12.1 ± 0.4	55.8 ± 2.0	25.8 ± 2.8	2.1 ± 0.2	74.9 ± 4.8	47.3 ± 12.2	52.0 ± 12.0	0.8 ± 0.6
	Range	11.1 - 12.7	51.3 - 58.7	22.0 - 31.7	1.8 - 2.5	64.5 - 80.2	30.3 - 80.6	19.2 - 68.6	0.1 - 3.0
Lahoma	Average	14.1 ± 0.5	64.7 ± 2.0	25.2 ± 3.4	2.0 ± 0.2	69.3 ± 6.0	52.3 ± 15.8	46.8 ± 15.4	0.8 ± 0.9
	Range	12.8 - 15.2	47.2 - 59.5	19.6 - 32.3	1.7 - 2.4	59.7 - 81.7	28.5 - 87.9	12.0 - 68.1	0.0 - 3.4
Lamont	Average	13.3 ± 0.4	51.3 ± 1.9	21.3 ± 2.3	1.8 ± 0.1	66.8 ± 5.8	43.3 ± 8.6	54.4 ± 7.9	2.4 ± 0.9
	Range	12.7 - 13.9	48.3 - 53.9	17.7 - 26.7	1.6 - 2.2	57.8 - 78.4	29.3 - 83.4	35.3 - 67.6	1.3 - 3.9
Marshall	Average	13.7 ± 0.5	58.3 ± 1.7	29.3 ± 3.6	2.1 ± 0.2	70.4 ± 7.5	56.4 ± 10.5	42.9 ± 10	0.7 ± 0.5
	Range	12.7 - 14.6	53.5 - 60.0	21.8 - 35.2	1.8 - 2.5	55.9 - 81.6	36.4 - 73.9	25.8 - 61.8	0.1 - 1.8

<sup>1</sup> - Average ± standard deviation.  
<sup>1</sup> mb = moisture basis

**Table 3. Flour Extraction Yield (%)**

Panhandle Agricultural District									
Location	Gage		Goodwell Dryland			Goodwell Irrigated			
	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>
2137	57.6	11	66	63.5	9	69.1	66.9	1	70.9
2163	60.1	10	67	62.2	12	69.3	63.2	12	69.9
2174	63.9	3	69	64.4	8	69.5	64.7	6	69.7
Agreco 7853	63.6	6	69	65.6	2	70.2	66.0	5	70.4
Big Dawg	62.1	9	68	64.9	5	69.9	64.5	9	69.6
Chisholm	62.5	8	68	62.7	11	68.6	65.3	6	70.0
Coronado	63.8	5	69	65.2	4	70.0	66.9	1	70.9
Custer	57.5	12	66	62.9	10	68.7	63.7	11	69.2
Jagger	64.7	2	70	65.2	3	70.0	64.1	10	69.4
Karl 92	63.0	7	69	64.5	7	69.6	65.3	6	70.0
Ogallala	65.2	1	70	65.7	1	70.3	66.6	3	70.8
Tomahawk	63.8	4	69	64.6	6	69.7	66.6	3	70.8
Torkana	55.4	13	65	60.2	13	67.2	61.6	13	68.0

<sup>1</sup> - Cultivars were ranked based on extraction rate (%) by Quadrant Mill.  
<sup>2</sup> - Calculated extraction rate (%).

**Table 4. Flour Extraction Yield (%)**

North Central Agricultural District												
Location	Aho		Cherokee			Lahoma			Lamont			
	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>			
2137	57.7	10	65.8	62.7	10	68.8	61.8	6	68.1	54.9	10	64.3
2163	59.1	8	66.6	62.4	11	68.4	58.7	12	66.4	54.3	11	63.9
2174	57.9	9	65.9	61.8	12	68.0	62.6	9	68.5	57.3	8	65.8
Agreco 7853	61.0	3	67.6	66.9	1	70.9	59.5	5	66.6	61.1	3	67.7
Big Dawg	57.5	11	65.7	64.4	4	69.5	62.4	1	68.5	62.9	1	68.7
Chisholm	63.5	1	69.0	64.3	5	69.5	60.9	8	67.6	59.5	6	65.3
Coronado	59.7	7	66.9	64.7	3	69.7	56.8	3	65.2	57.8	7	65.8
Custer	56.2	13	65.0	62.9	9	68.7	55.5	11	64.6	53.0	13	63.2
Jagger	61.0	3	67.7	63.4	7	69.0	58.2	10	66.1	53.4	12	63.4
Karl 92	60.5	5	67.4	65.2	2	70.0	64.6	4	69.7	62.3	2	68.4
Ogallala	60.9	6	67.0	64.0	6	69.3	61.7	7	68.0	58.7	4	66.4
Tomahawk	61.9	2	68.2	63.4	7	69.0	61.9	2	68.2	58.7	5	66.4
Torkana	58.5	12	65.1	60.5	13	67.4	58.4	13	66.2	58.8	9	65.3

<sup>1</sup> - Cultivars were ranked based on flour yield (%) by Quadrant Mill.  
<sup>2</sup> - Calculated flour yield (%).

**Table 5. Flour Extraction Yield (%)**

West Central Agricultural District				East Central Agricultural District			
Location	Elk City			Location	Haskell		
Cultivar	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Cultivar	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>
2137	62.1	10	68.3	2137	59.3	7	66.7
2163	63.2	9	68.9	2163	65.1	12	64.4
2174	61.2	12	67.8	2174	61.2	3	67.8
Agseco 7853	65.4	1	70.1	Agseco 7853	58.5	9	66.3
Big Dawg	63.3	8	68.9	Big Dawg	62.3	1	68.4
Chisholm	63.3	7	68.9	Chisholm	56.1	11	64.9
Coronado	64.2	4	69.4	Coronado	60.2	5	67.2
Custer	61.4	11	67.9	Custer	54.5	13	64.0
Jagger	63.7	5	69.2	Jagger	58.6	8	66.3
Karl 02	65.0	2	69.9	Karl 02	62.2	2	68.3
Ogallala	63.7	5	69.2	Ogallala	61.1	4	67.7
Tomahawk	64.9	3	69.8	Tomahawk	59.6	6	66.9
Torkawa	59.9	13	67.0	Torkawa	57.9	10	65.9

<sup>1</sup>. Cultivars were ranked based on extraction rate (%) by Quadrant Mill.  
<sup>2</sup>. Calculated extraction rate (%).

**Table 6. Flour Extraction Yield (%)**

Central Agricultural District						
Location	Chickasha			Marshall		
Cultivar	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>
2137	59.8	6	67.0	60.4	9	67.3
2163	54.2	12	63.9	61.1	6	67.7
2174	59.6	9	66.3	60.6	8	67.4
Agseco 7853	60.3	5	67.3	63.8	2	69.2
Big Dawg	63.0	1	68.8	62.6	4	68.5
Chisholm	59.4	8	66.8	60.7	7	67.5
Coronado	61.5	3	67.9	59.6	10	66.9
Custer	56.8	11	65.4	55.2	13	64.4
Jagger	58.3	10	66.1	59.2	11	66.7
Karl 02	60.7	4	67.5	64.1	1	69.4
Ogallala	59.5	7	66.8	62.0	5	68.2
Tomahawk	62.3	2	68.4	63.8	2	69.2
Torkawa	52.4	13	62.9	58.9	12	66.5

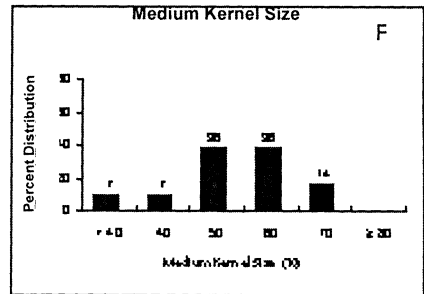
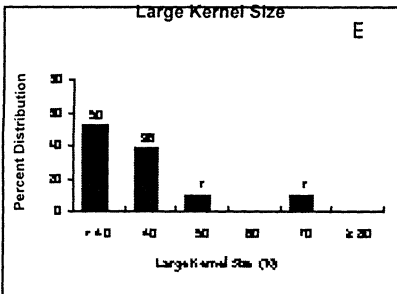
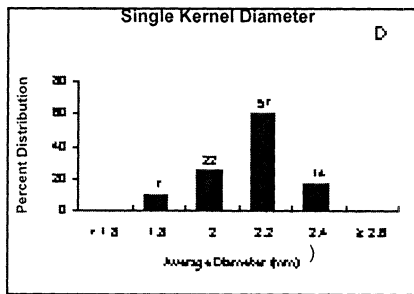
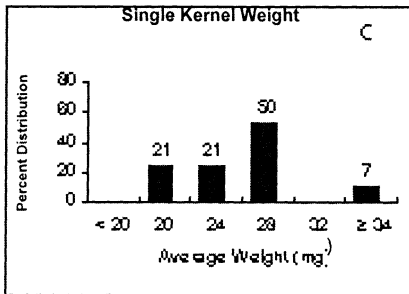
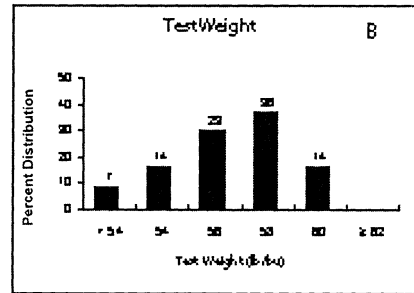
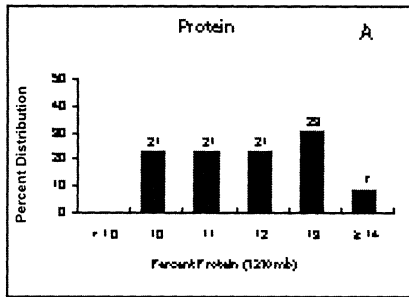
<sup>1</sup>. Cultivars were ranked based on extraction rate (%) by Quadrant Mill.  
<sup>2</sup>. Calculated extraction rate (%).

**Table 7. Flour Extraction Yield (%)**

Southwest Agricultural District									
Location	Altus			Apache			Frogertk		
Cultivar	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>	Quadrant Mill Extraction (%)	Rank <sup>1</sup>	Buhler Mill Extraction (%) <sup>2</sup>
2137	61.2	10	67.8	61.5	7	67.9	59.1	13	66.6
2163	58.7	13	66.4	60.4	8	67.3	60.2	10	67.2
2174	61.7	9	68.0	59.3	10	66.7	61.1	8	67.7
Agseco 7853	62.1	8	68.3	63.9	4	69.3	62.3	6	68.4
Big Dawg	63.3	4	69.9	64.6	3	69.6	65.4	1	70.1
Chisholm	64.5	1	69.6	63.0	5	68.8	64.3	4	69.5
Coronado	64.3	2	69.5	64.7	2	69.7	65.2	2	70.0
Custer	59.0	12	66.6	60.1	9	67.1	61.7	7	68.0
Jagger	60.6	11	67.4	59.0	11	66.6	59.2	12	66.7
Karl 02	64.2	3	69.4	57.0	13	66.5	62.3	5	68.4
Ogallala	63.3	5	68.9	62.7	6	68.6	59.7	11	67.0
Tomahawk	62.3	7	68.4	64.9	1	69.8	64.3	3	69.5
Torkawa	63.0	6	68.8	57.2	12	65.6	60.9	9	67.6

<sup>1</sup>. Cultivars were ranked based on extraction rate (%) by Quadrant Mill.  
<sup>2</sup>. Calculated extraction rate (%).

**Figure 1.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar 2137 Across 14 Locations**



**Figure 2.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar 2163 Across 14 Locations**

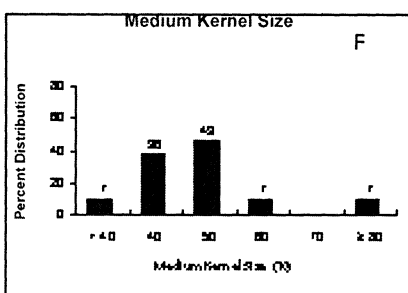
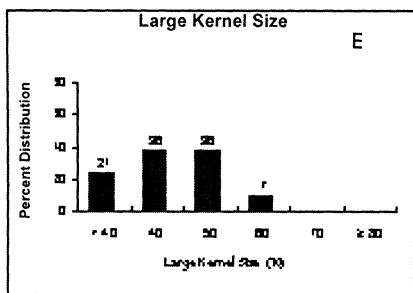
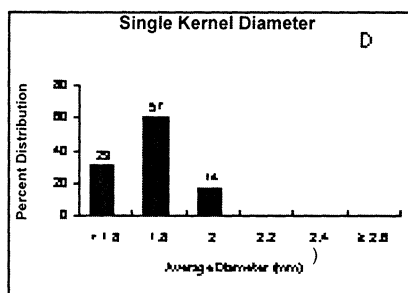
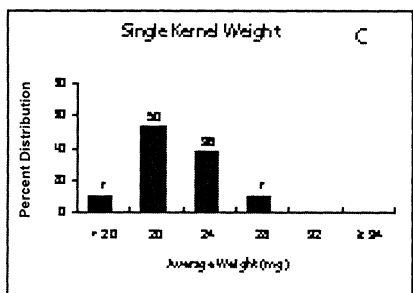
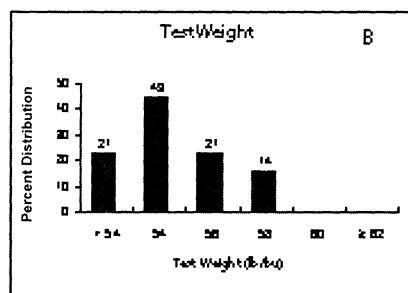
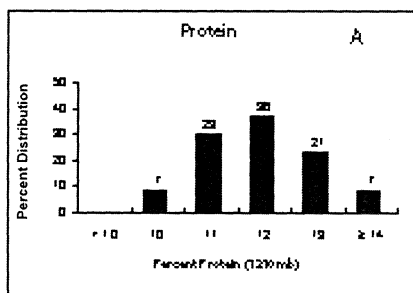






Figure 3.  
Percent Distribution of Protein and Physical Characteristics of Cultivar 2174 Across 14 Locations

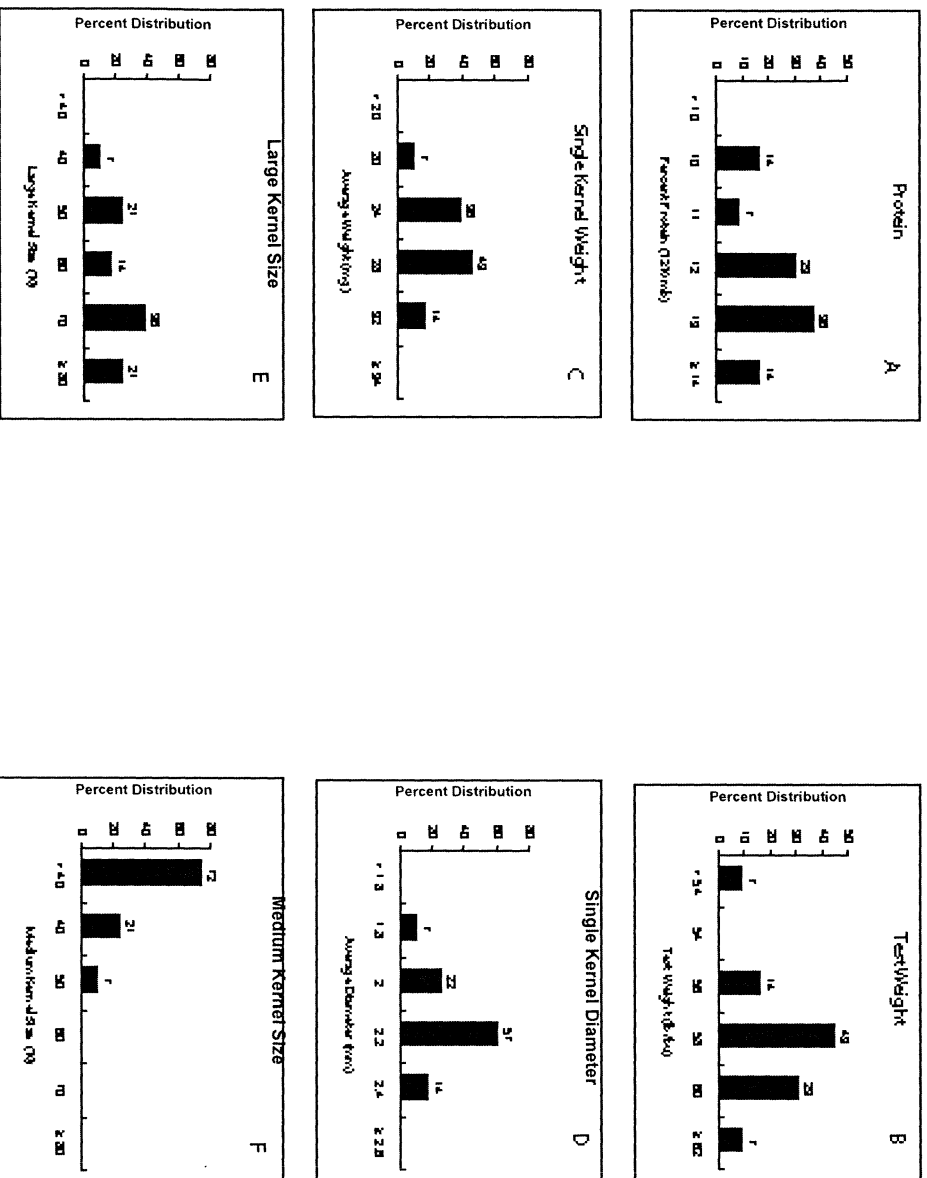
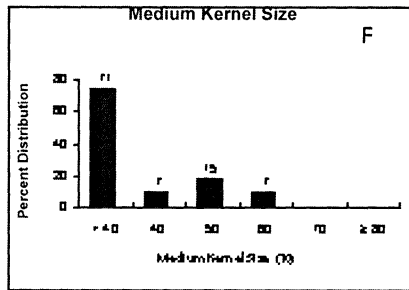
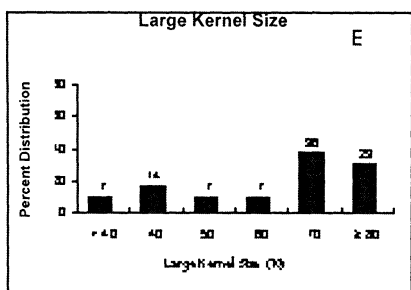
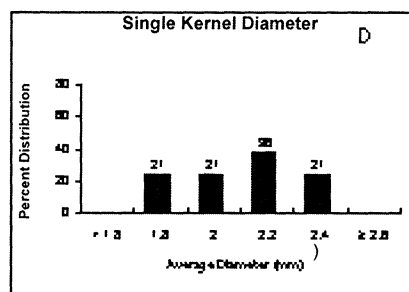
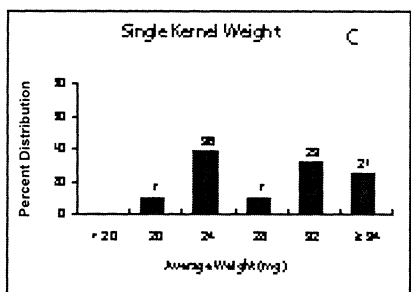
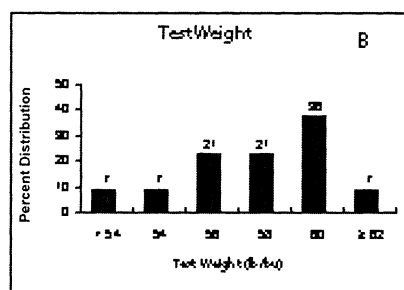
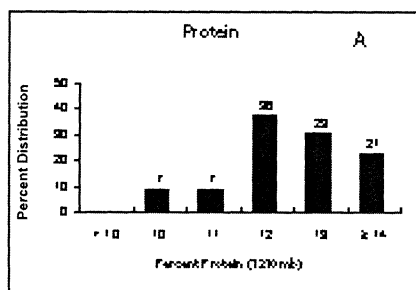
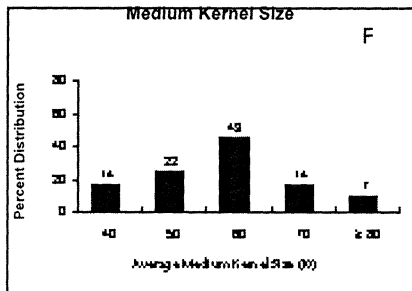
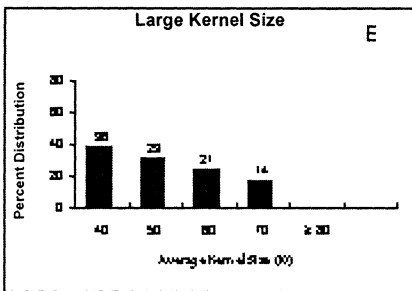
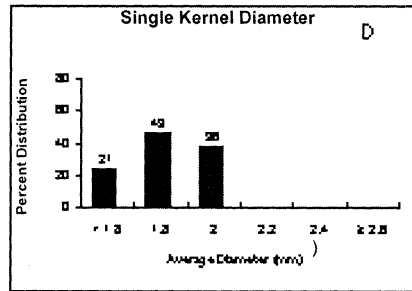
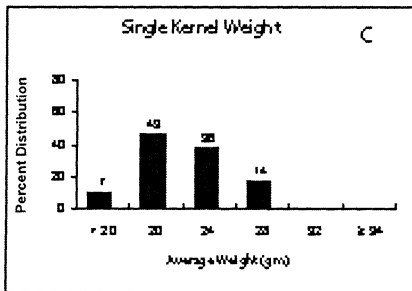
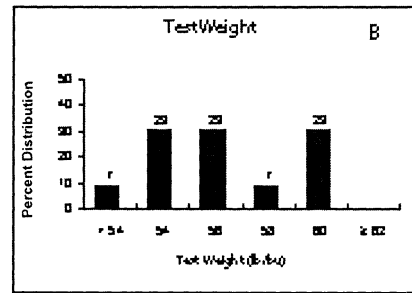
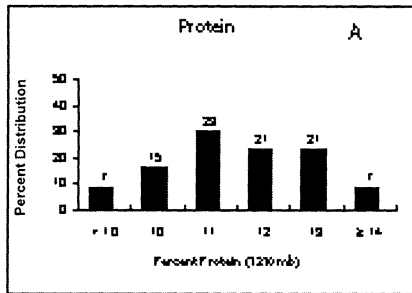


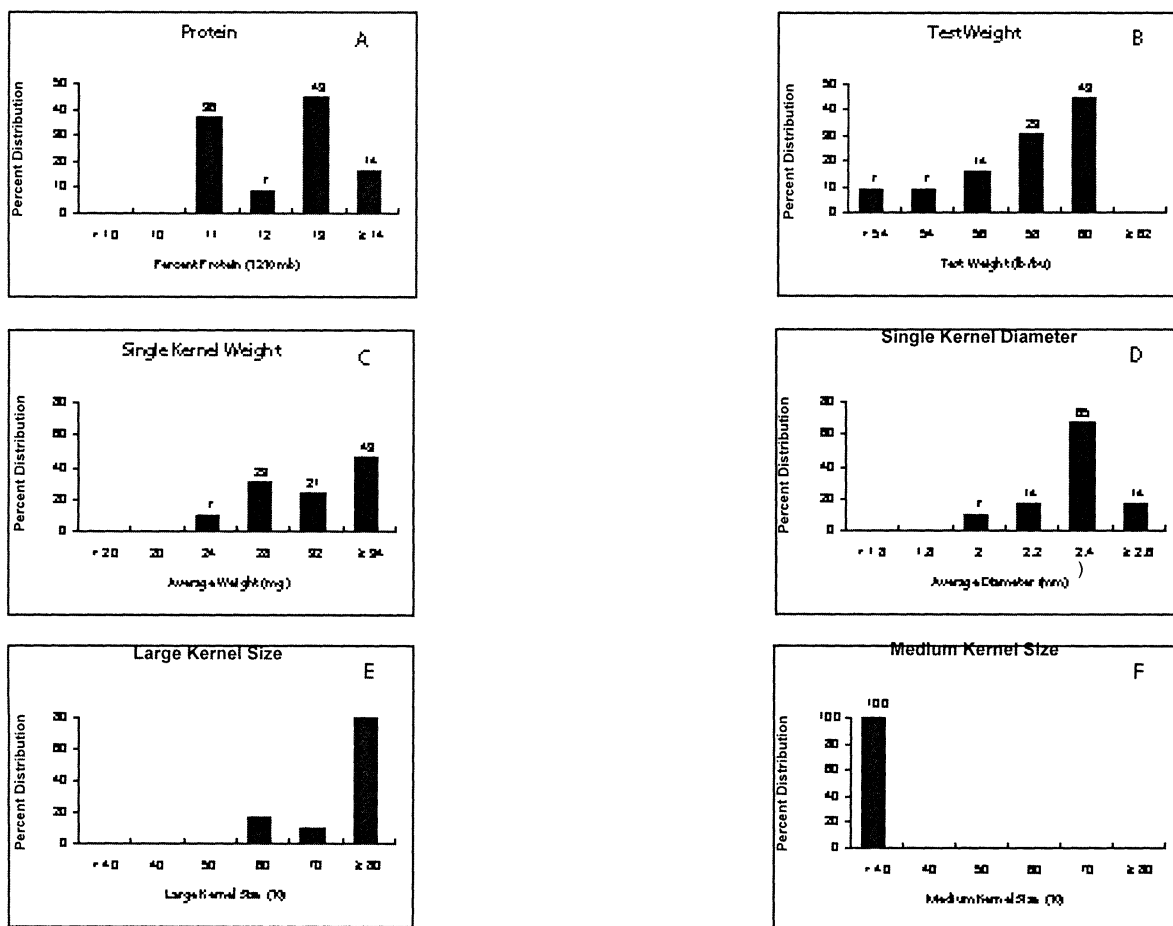
Figure 4.  
Percent Distribution of Protein and Physical Characteristics of Cultivar 7853 Across 14 Locations



**Figure 5.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Betty Across 14 Locations**



**Figure 6.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Big Dawg Across 14 Locations**



**Figure 7.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Champ Across 14 Locations**

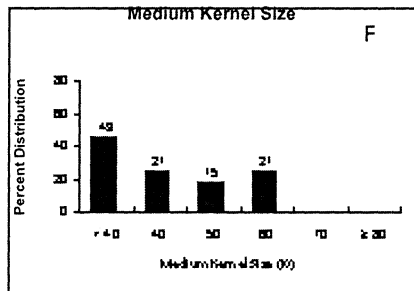
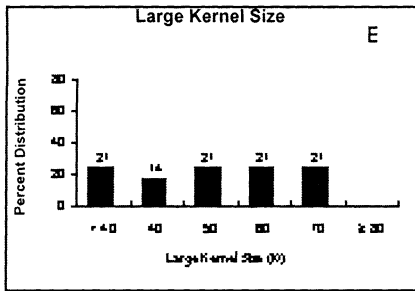
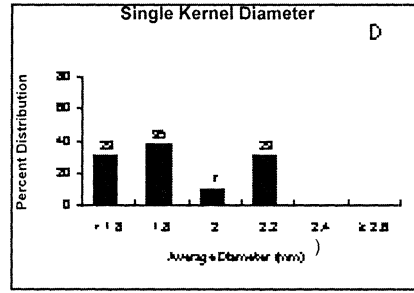
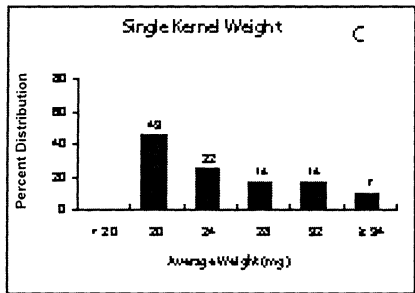
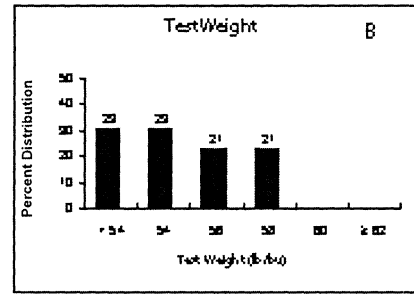
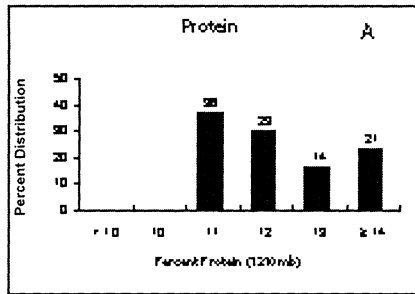
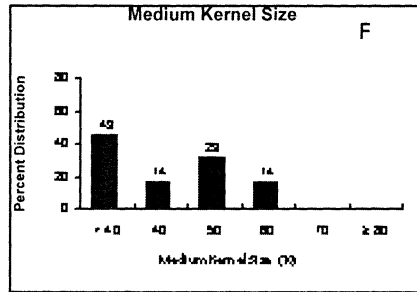
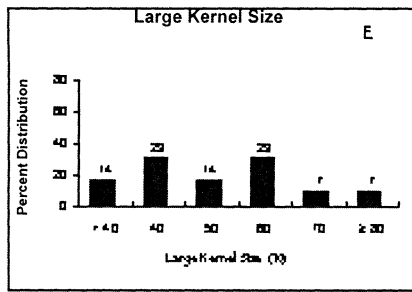
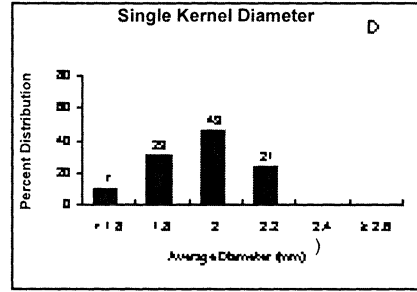
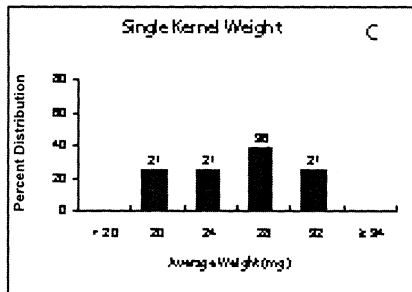
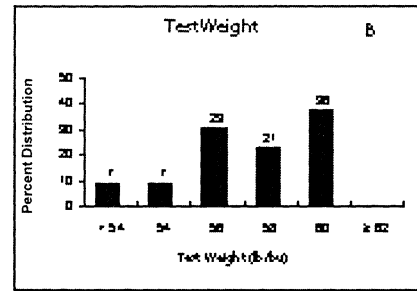
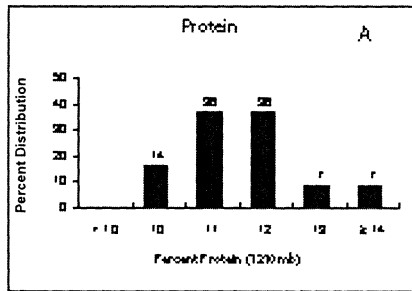
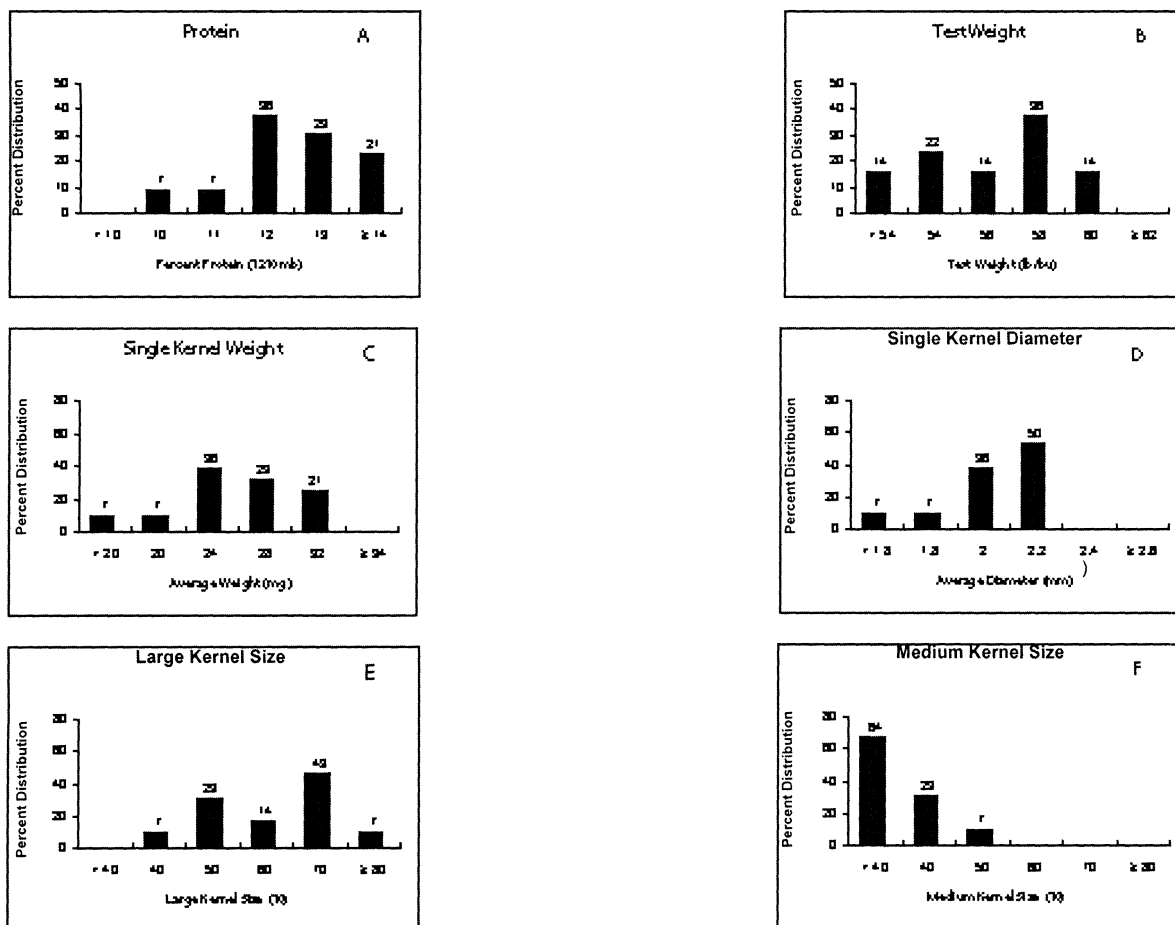


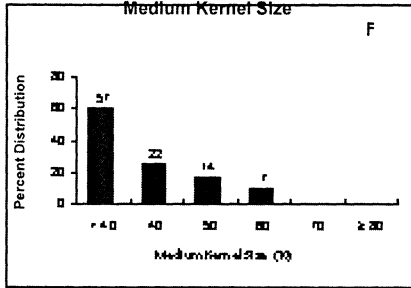
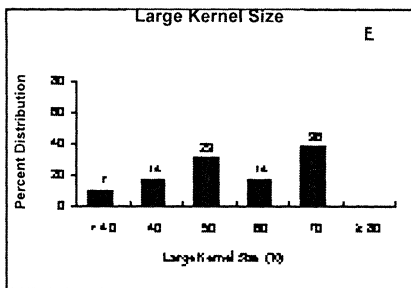
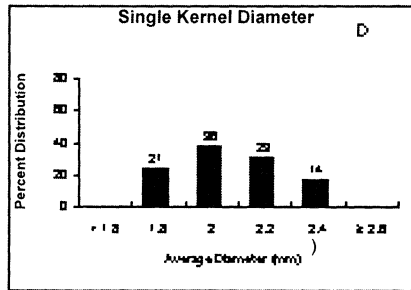
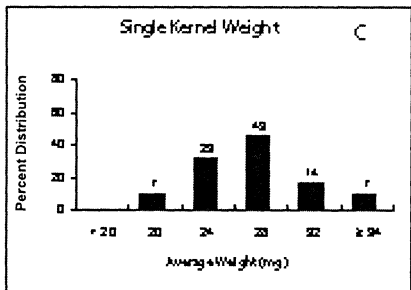
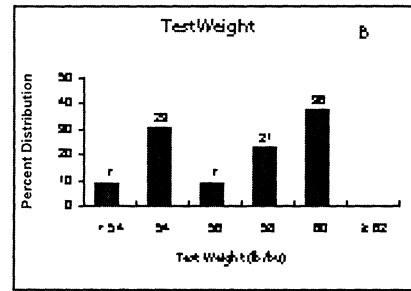
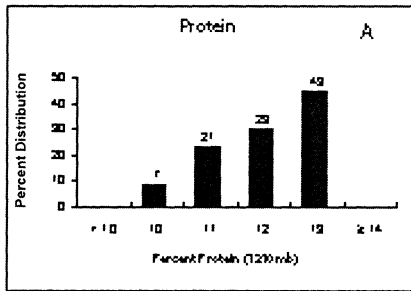
Figure 8.  
Percent Distribution of Protein and Physical Characteristics of Cultivar Chisholm Across 14 Locations



**Figure 9.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Coronado Across 14 Locations**



**Figure 10.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Custer Across 14 Locations**





**Figure 11.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Dominator Across 14 Locations**

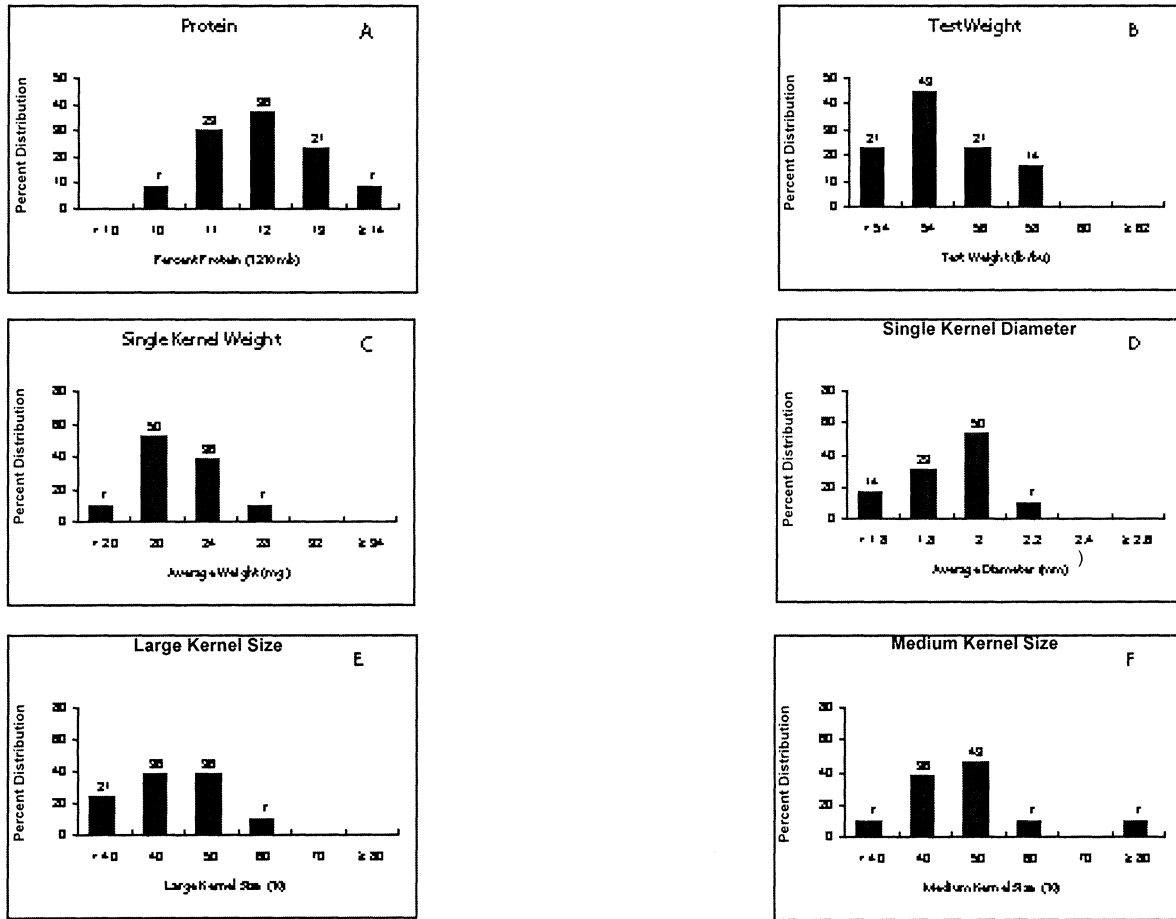
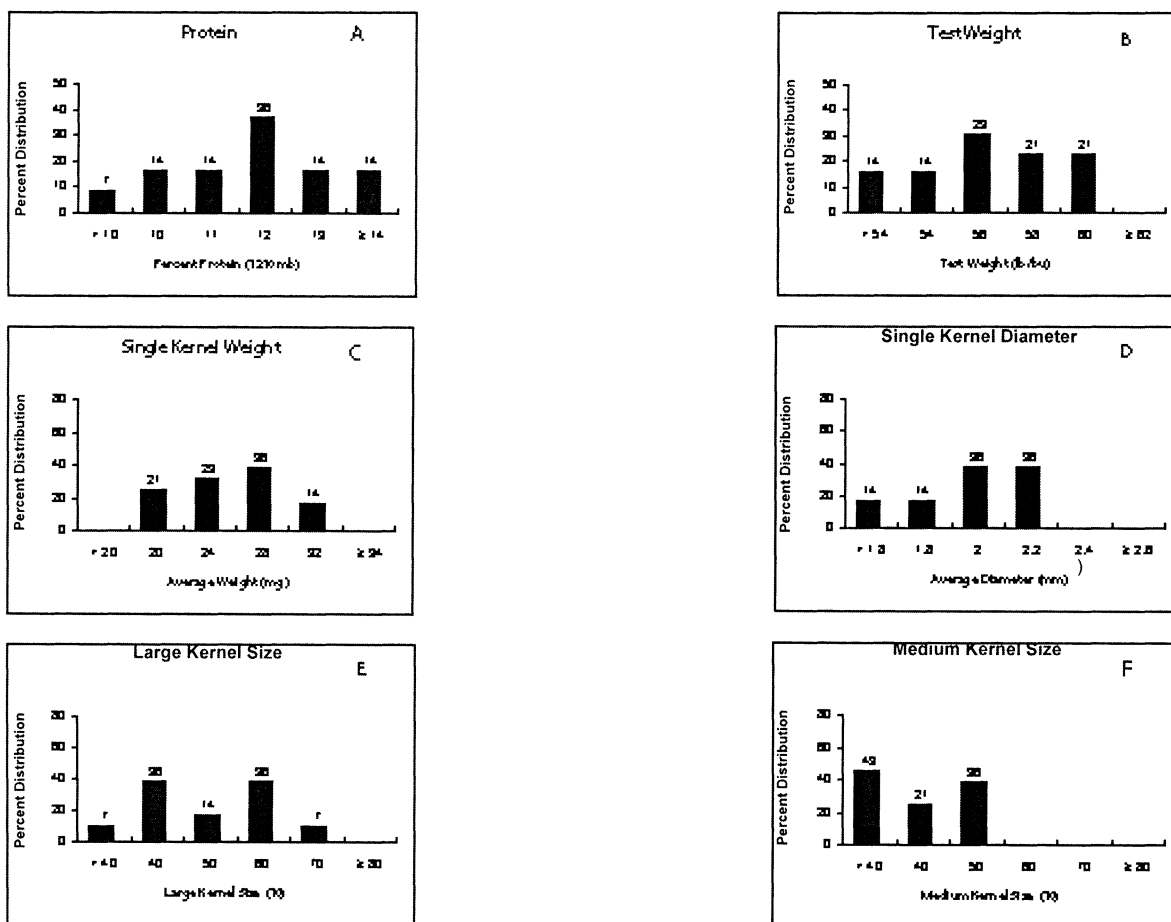
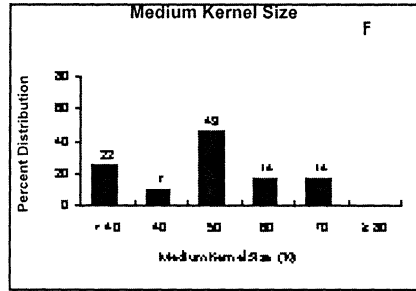
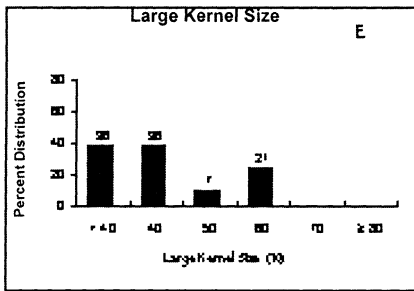
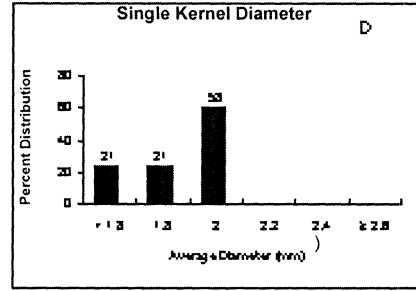
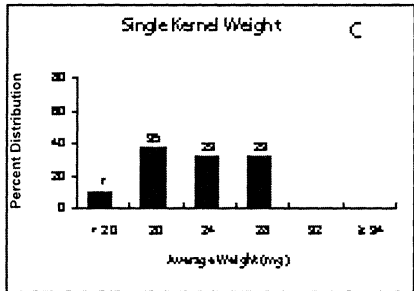
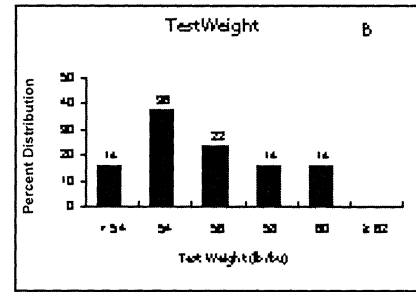
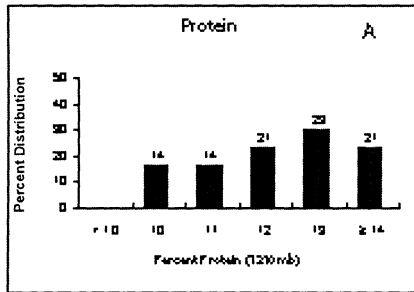


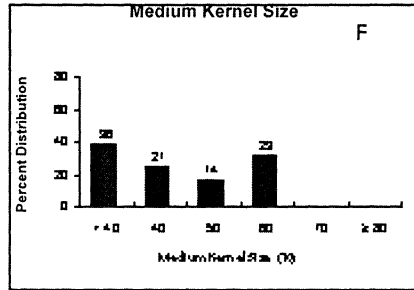
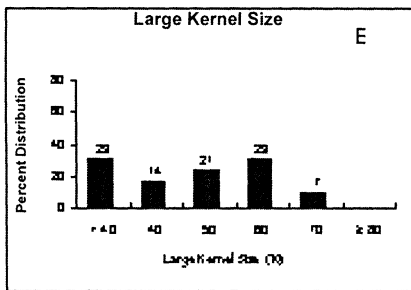
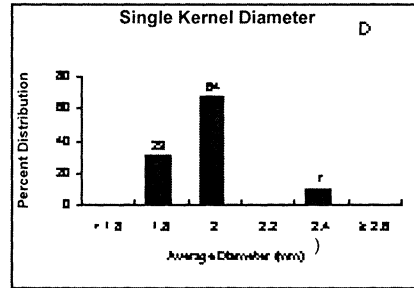
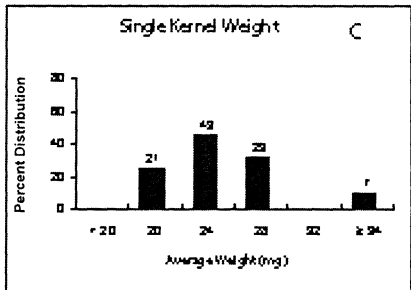
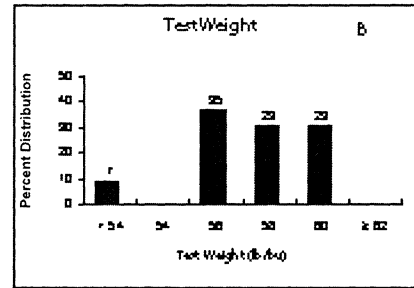
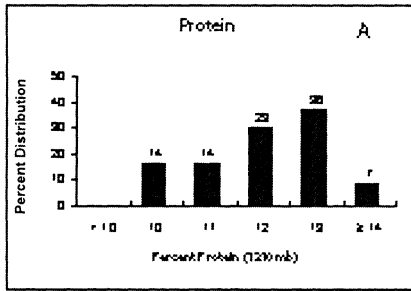
Figure 12.  
Percent Distribution of Protein and Physical Characteristics of Cultivar Heyne Across 14 Locations



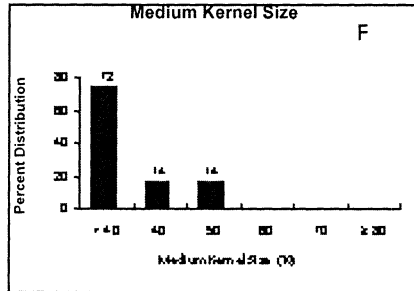
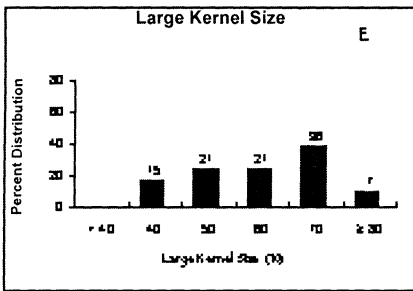
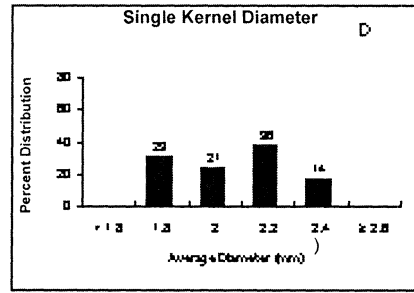
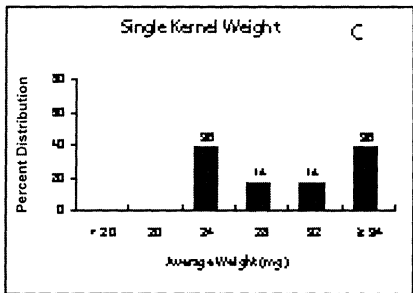
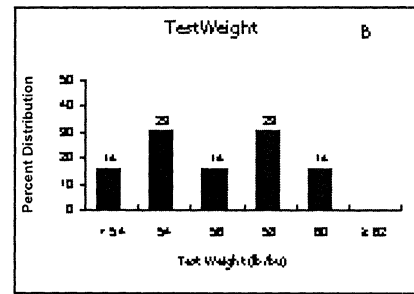
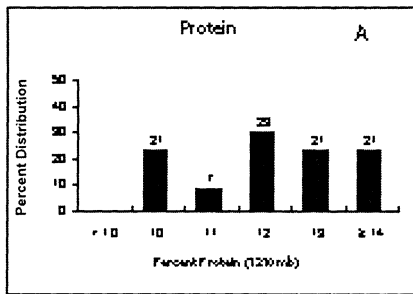
**Figure 13.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Jagger Across 14 Locations**



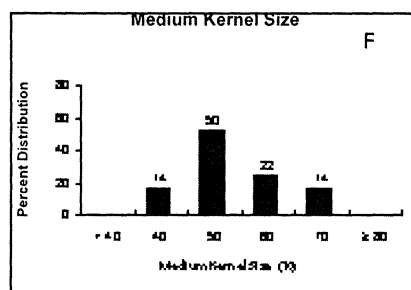
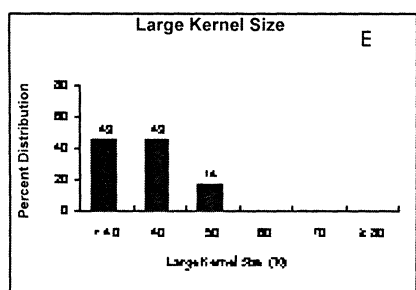
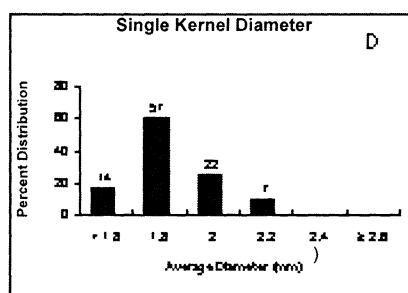
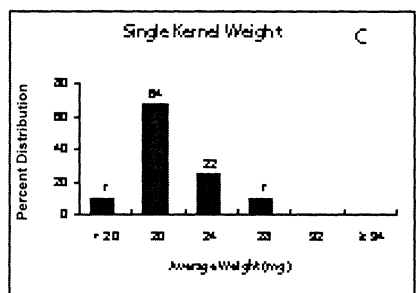
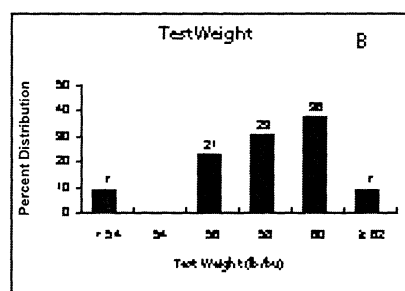
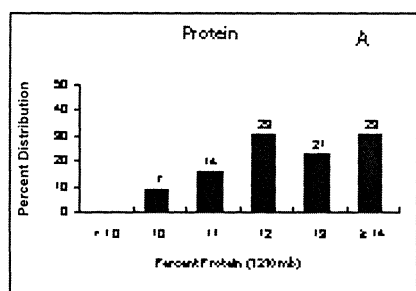
**Figure 14.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Karl Across 14 Locations**



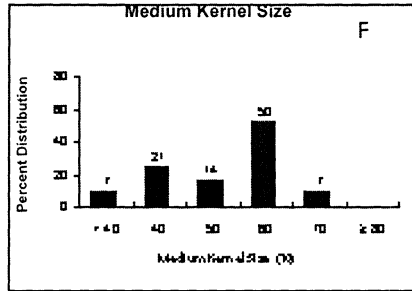
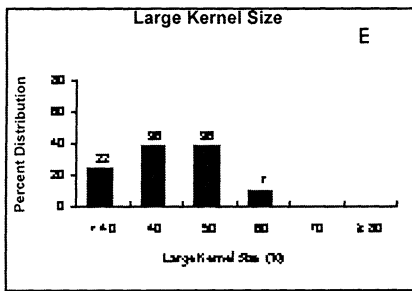
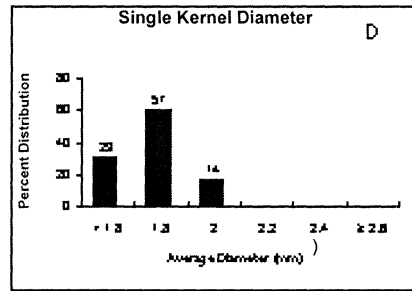
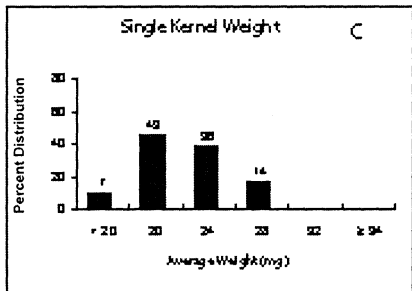
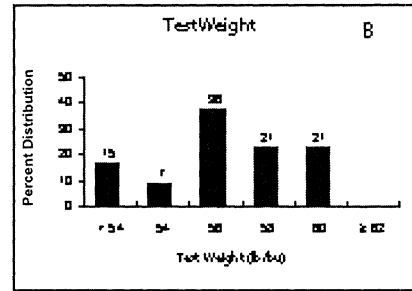
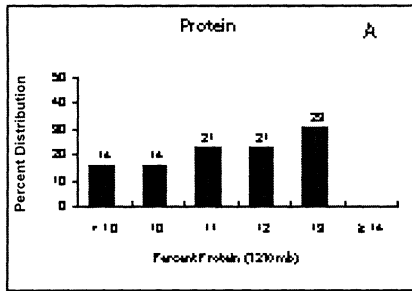
**Figure 15.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Lockett Across 14 Locations**



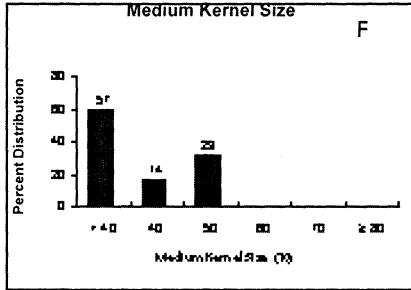
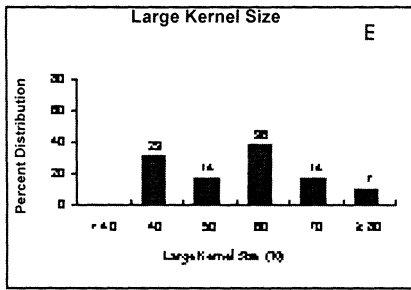
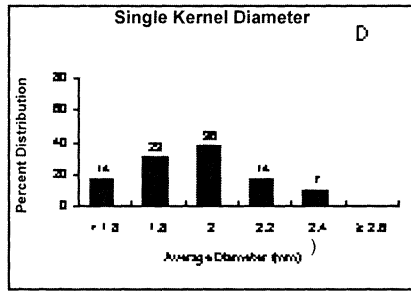
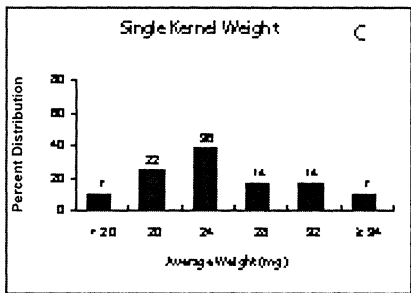
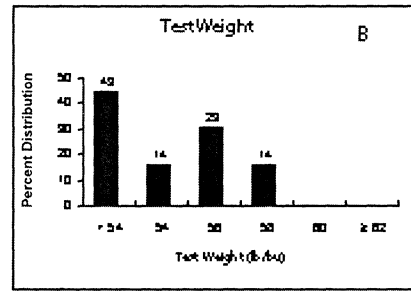
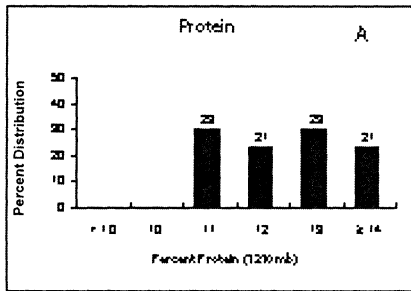
**Figure 16.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Ogallala Across 14 Locations**



**Figure 17.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Oro Blanco Across 14 Locations**

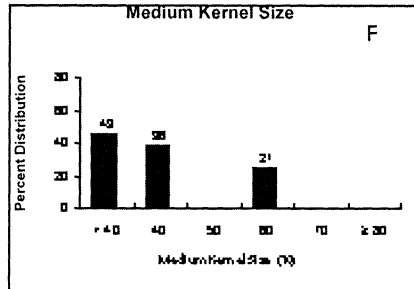
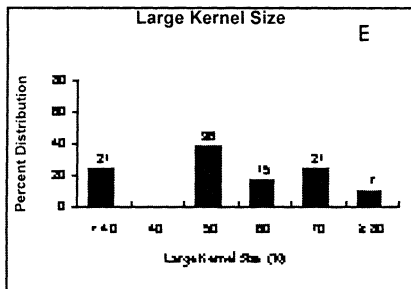
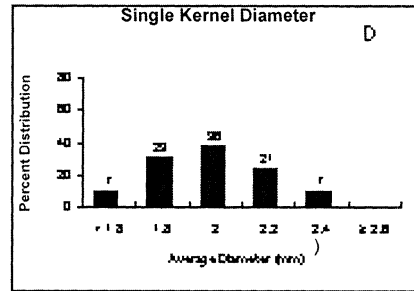
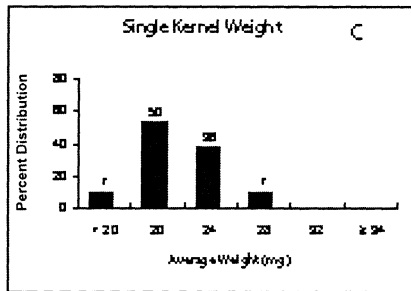
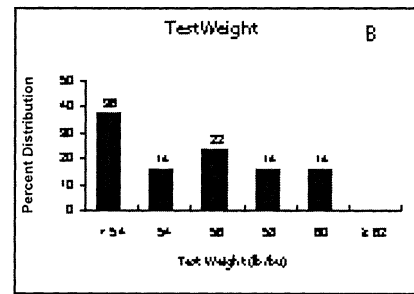
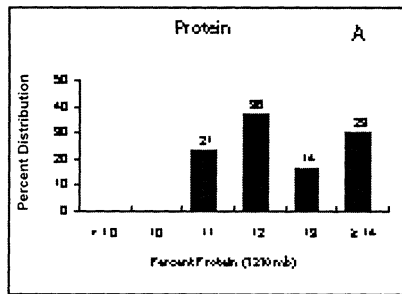


**Figure 18.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Tam 302 Across 14 Locations**

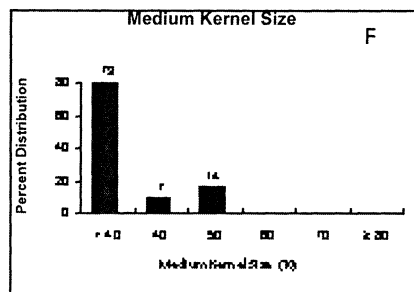
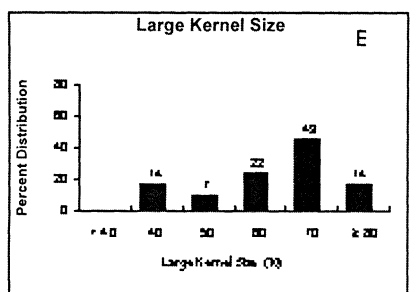
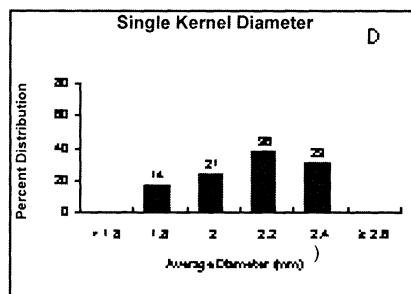
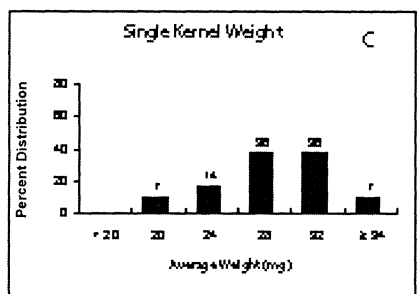
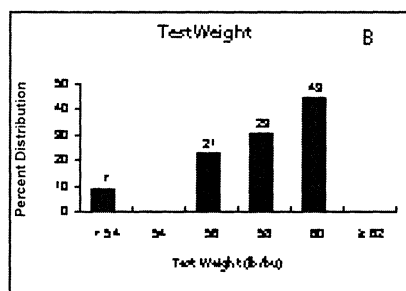
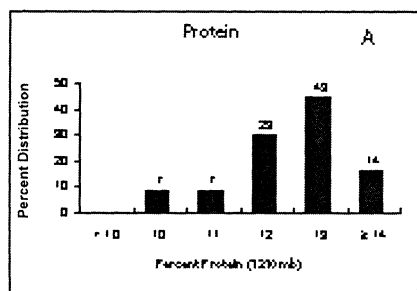




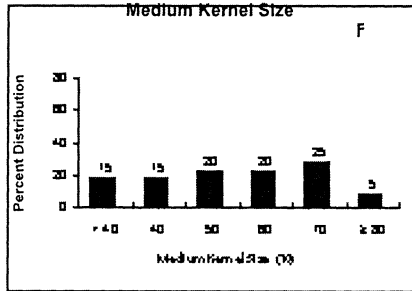
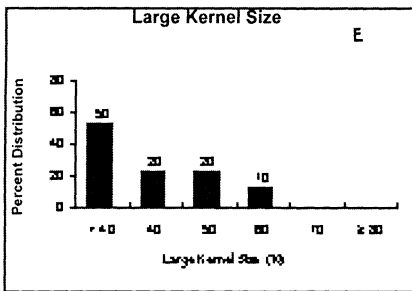
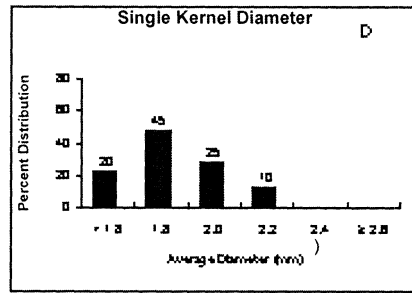
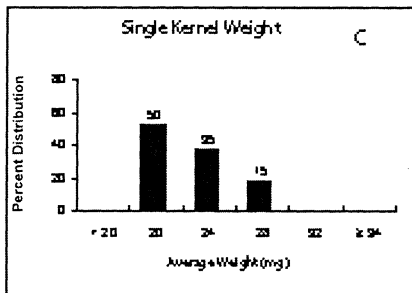
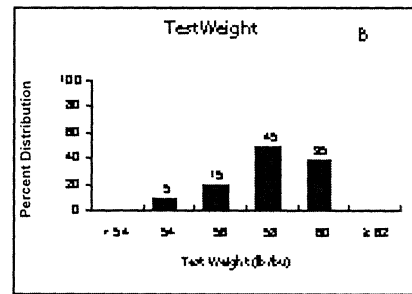
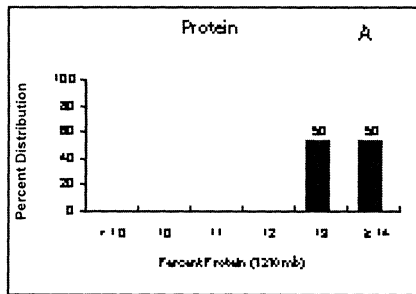
**Figure 19.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Tomahawk Across 14 Locations**



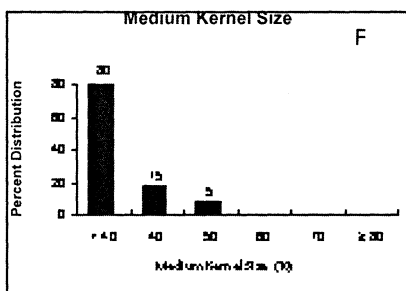
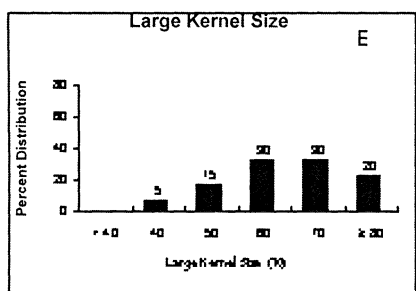
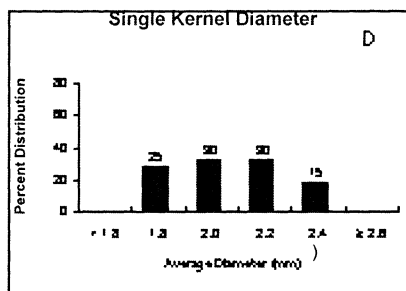
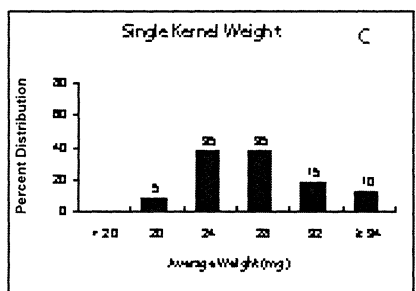
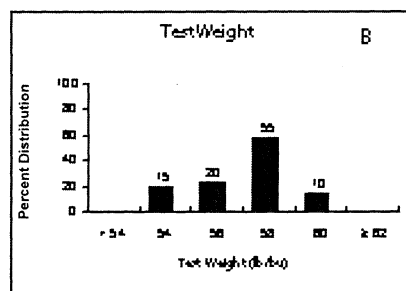
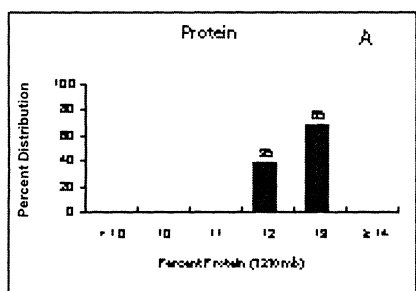
**Figure 20.**  
**Percent Distribution of Protein and Physical Characteristics of Cultivar Tonkawa Across 14 Locations**



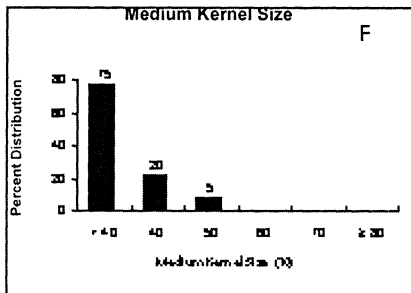
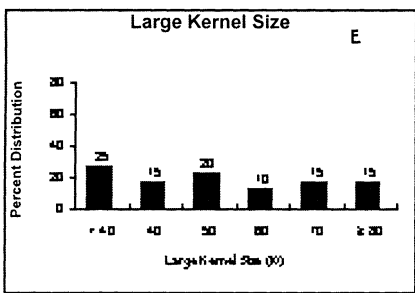
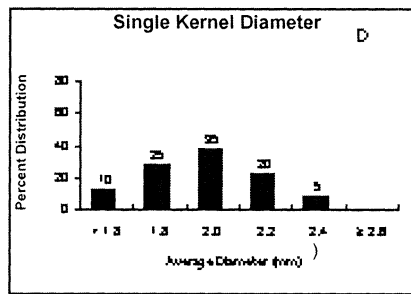
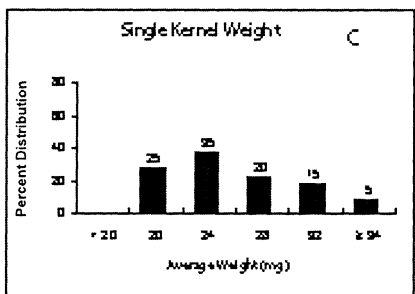
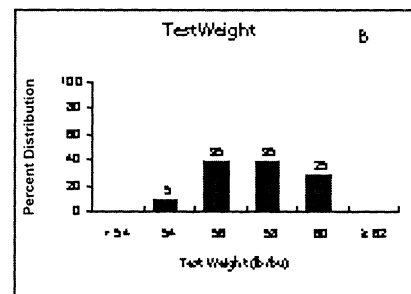
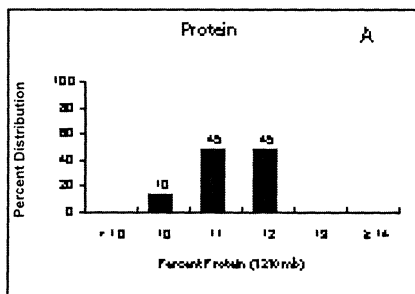
**Figure 21.**  
**Percent Distribution of Protein and Physical Characteristics at the Altus Location Across 20 Cultivars**



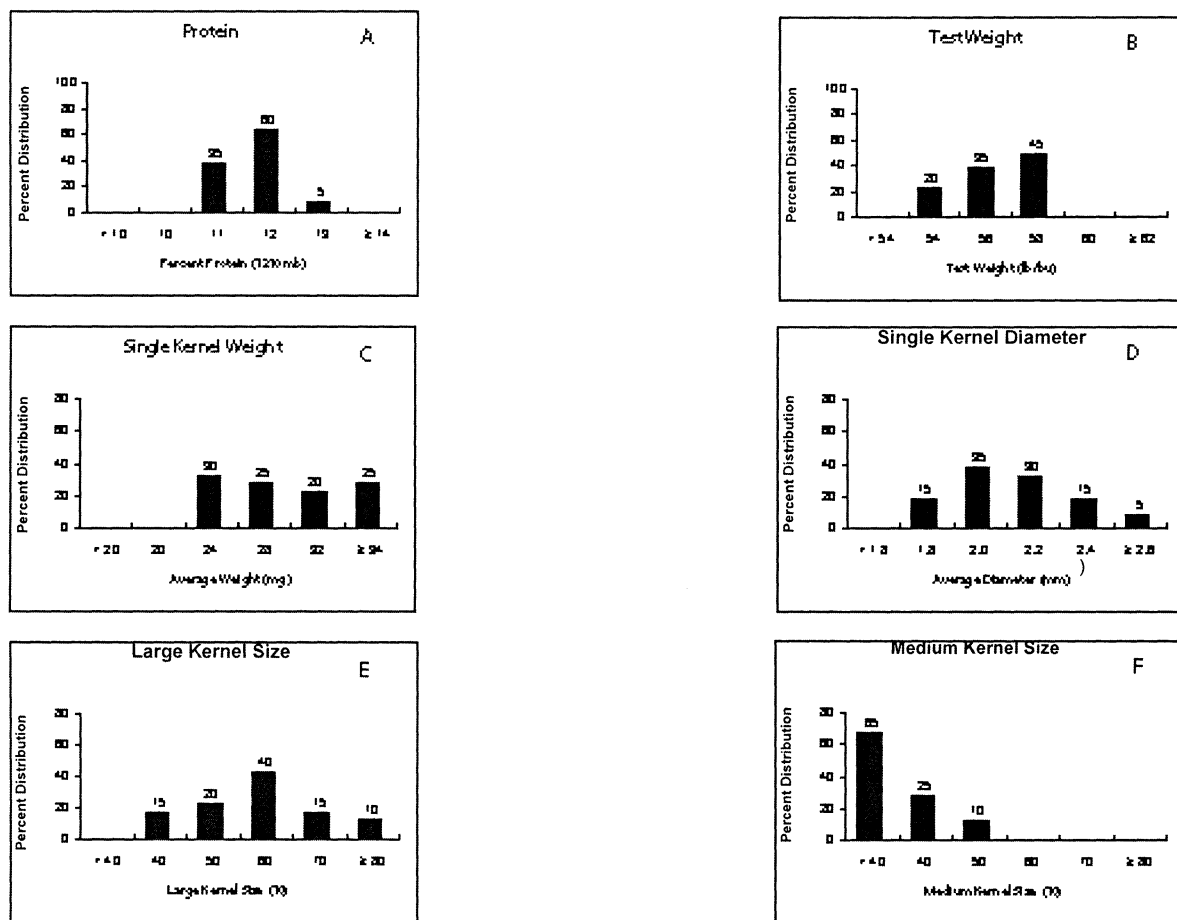
**Figure 22.**  
**Percent Distribution of Protein and Physical Characteristics at the Alva Location Across 20 Cultivars**



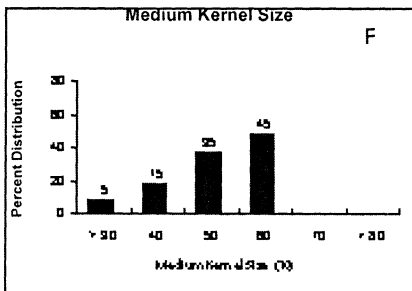
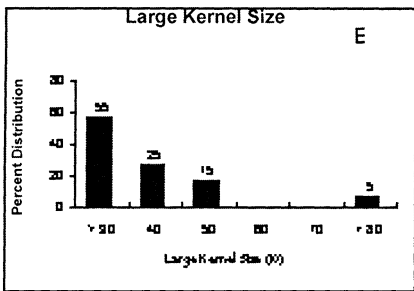
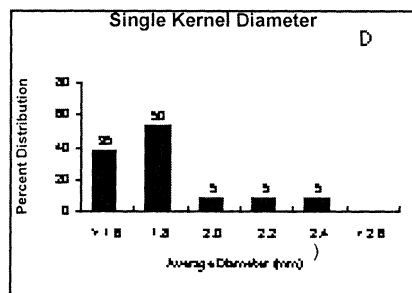
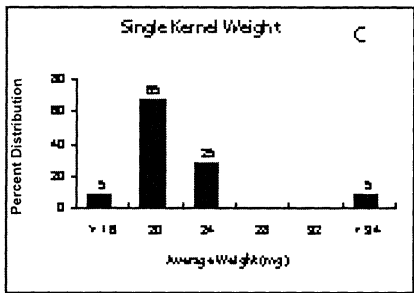
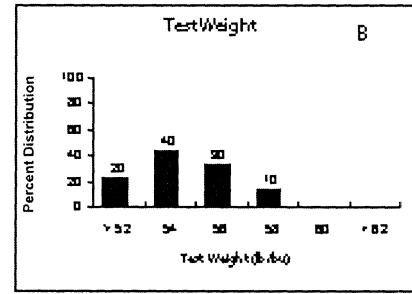
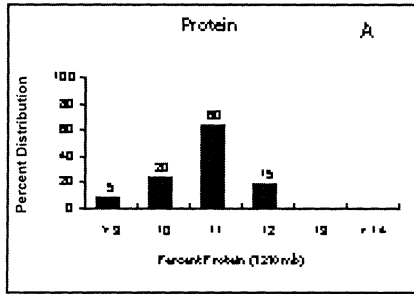
**Figure 23.**  
**Percent Distribution of Protein and Physical Characteristics at the Apache Location Across 20 Cultivars**



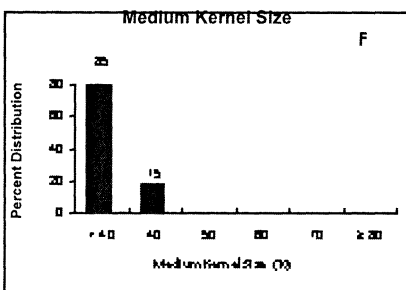
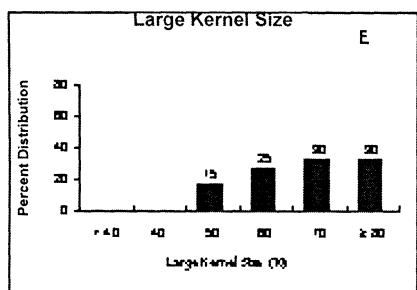
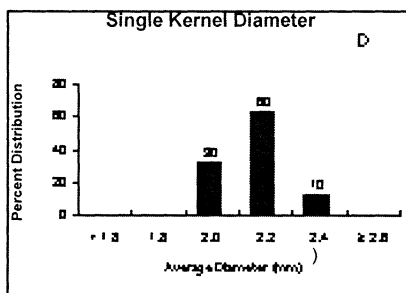
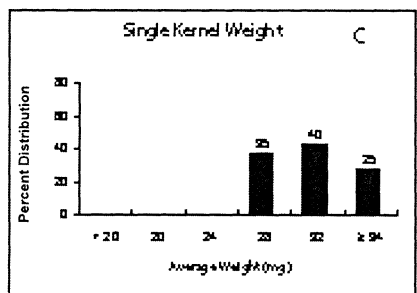
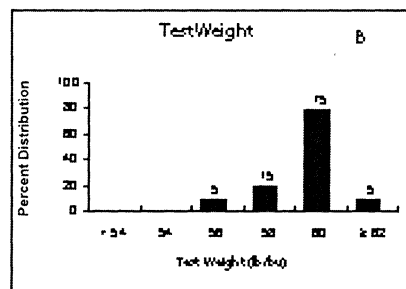
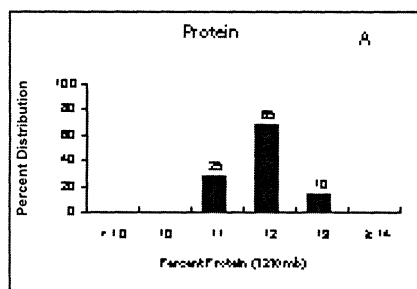
**Figure 24.**  
**Percent Distribution of Protein and Physical Characteristics at the Cherokee Location Across 20 Cultivars**



**Figure 25.**  
**Percent Distribution of Protein and Physical Characteristics at the Chickasha Location Across 20 Cultivars**

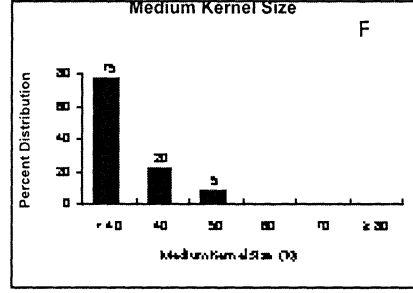
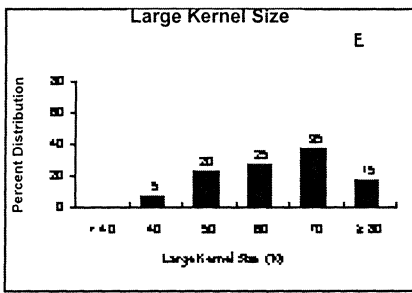
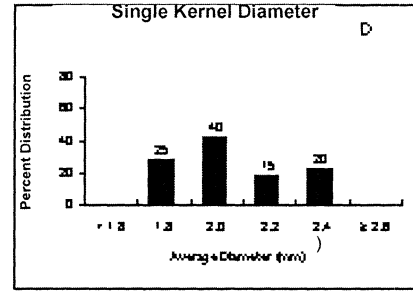
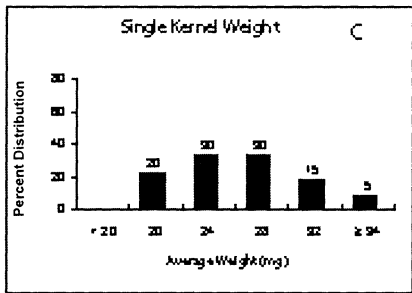
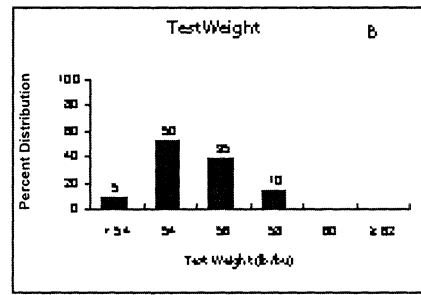
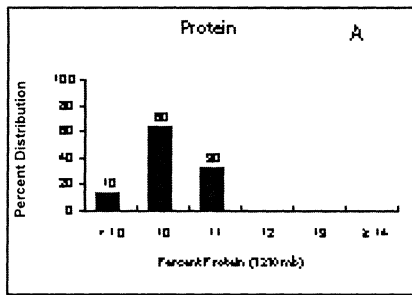


**Figure 26.**  
**Percent Distribution of Protein and Physical Characteristics at the Elk City Location Across 20 Cultivars**

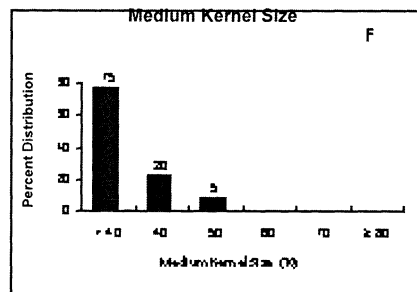
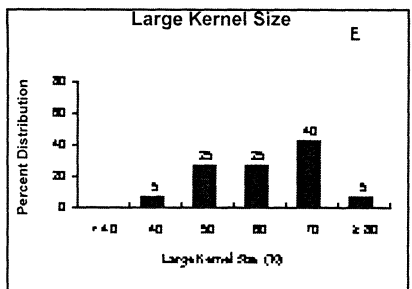
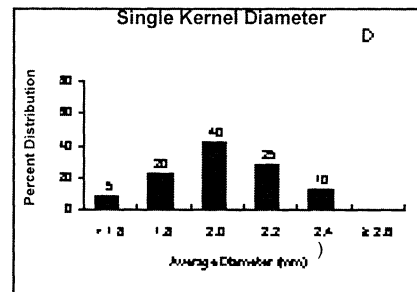
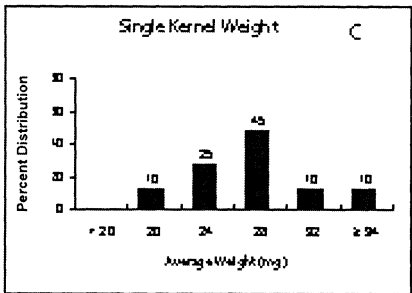
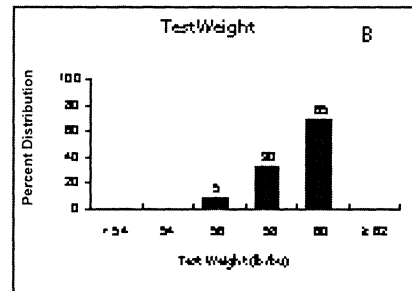
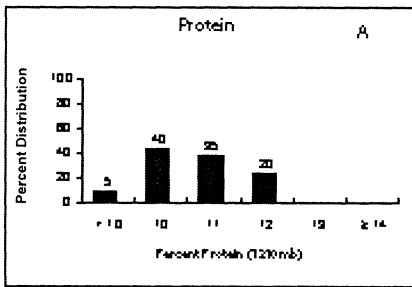




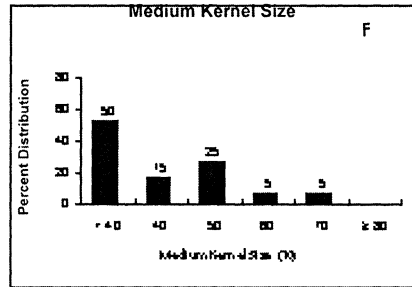
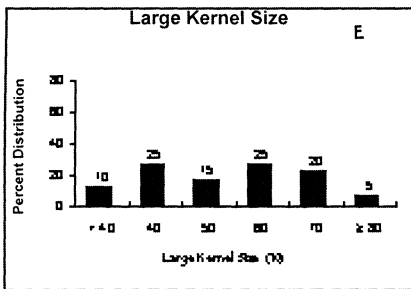
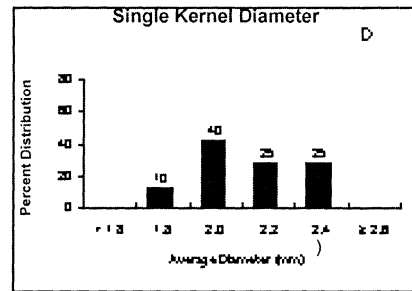
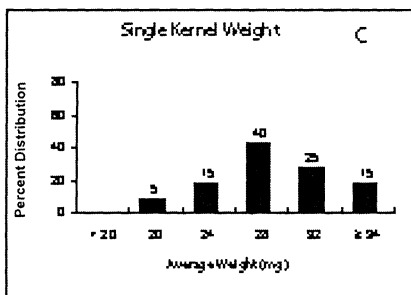
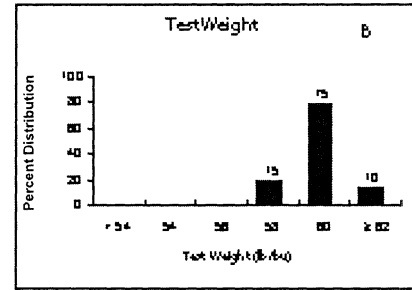
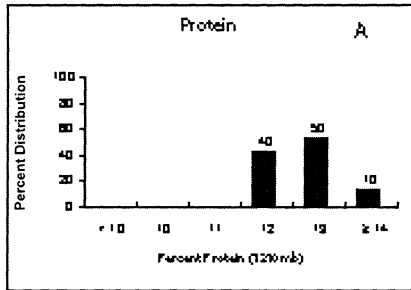
**Figure 27.**  
**Percent Distribution of Protein and Physical Characteristics at the Frederick Location Across 20 Cultivars**



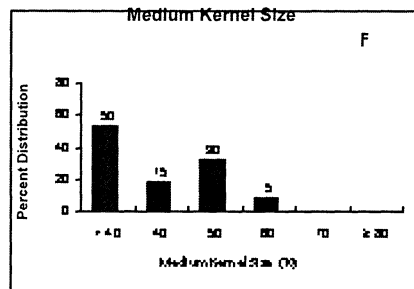
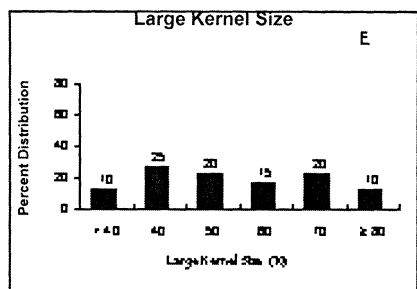
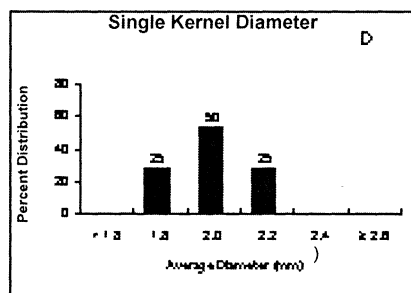
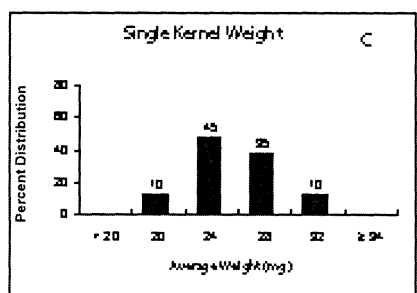
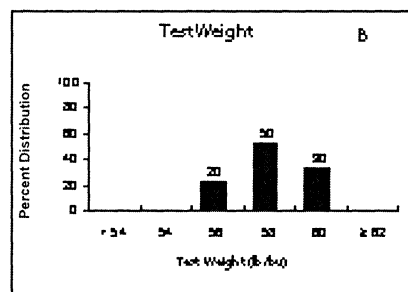
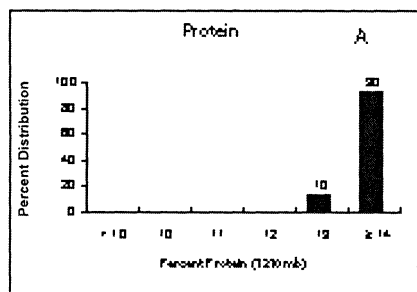
**Figure 28.**  
**Percent Distribution of Protein and Physical Characteristics at the Gage Location Across 20 Cultivars**



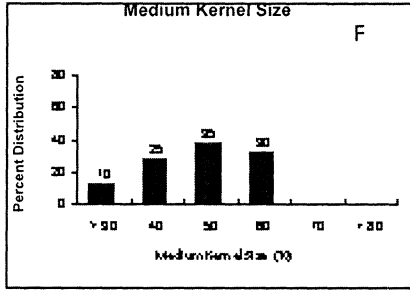
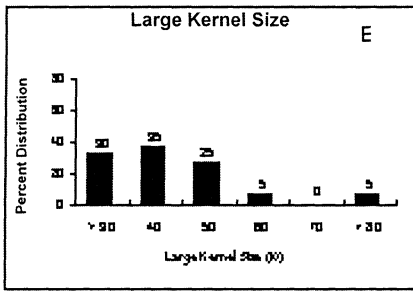
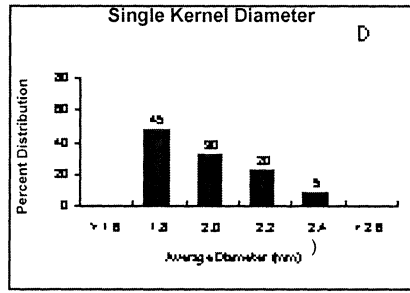
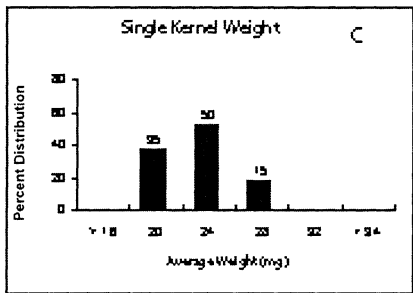
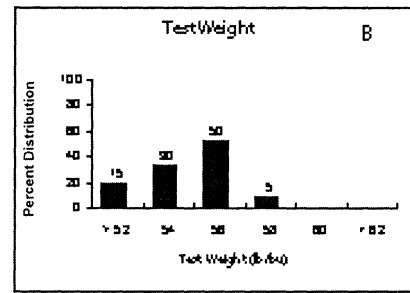
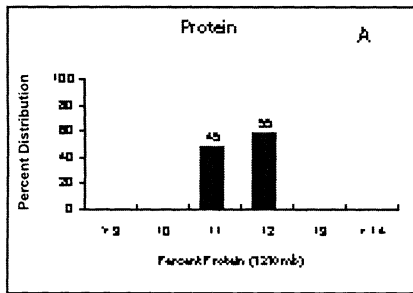
**Figure 29.**  
**Percent Distribution of Protein and Physical Characteristics at the Goodwell, Dryland Location Across 20 Cultivars**



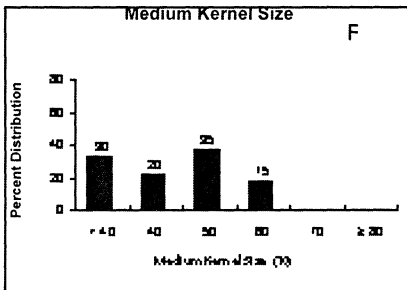
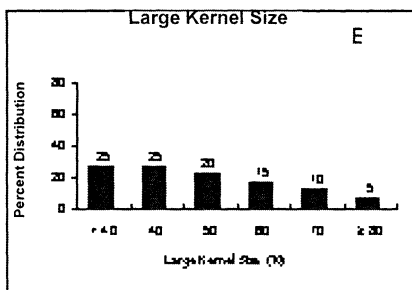
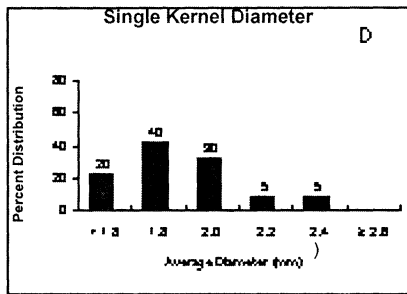
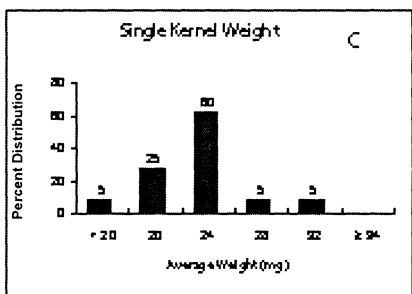
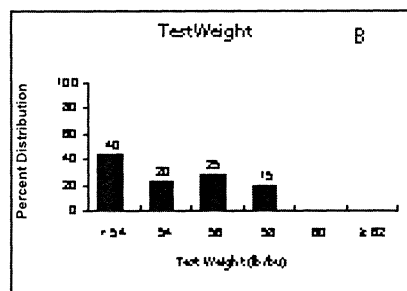
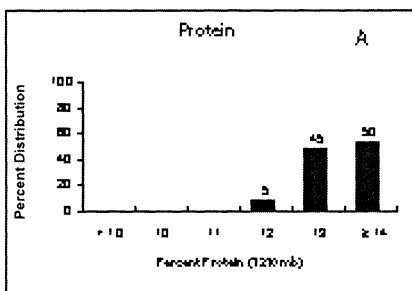
**Figure 30.**  
**Percent Distribution of Protein and Physical Characteristics at the Goodwell, Irrigated Location Across 20 Cultivars**



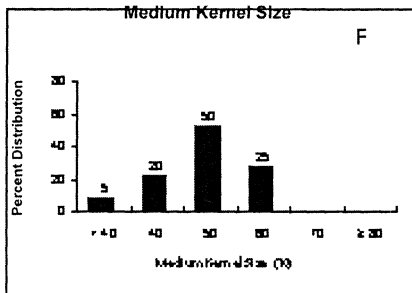
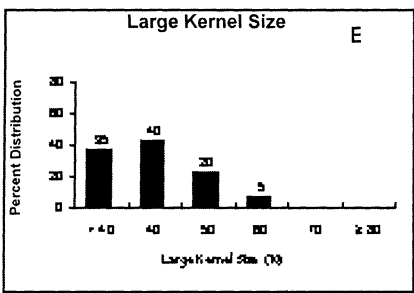
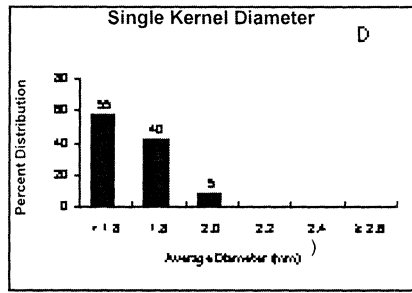
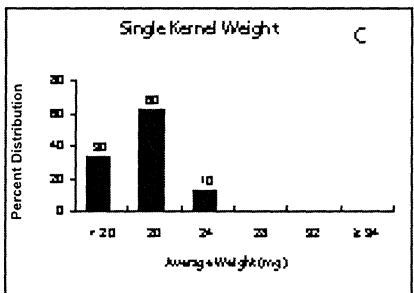
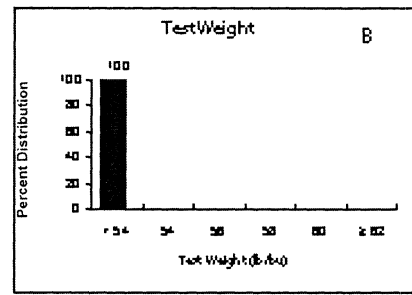
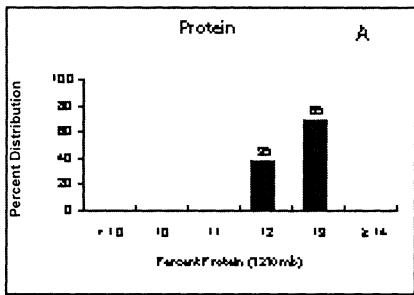
**Figure 31.**  
**Percent Distribution of Protein and Physical Characteristics at the Haskell Location Across 20 Cultivars**



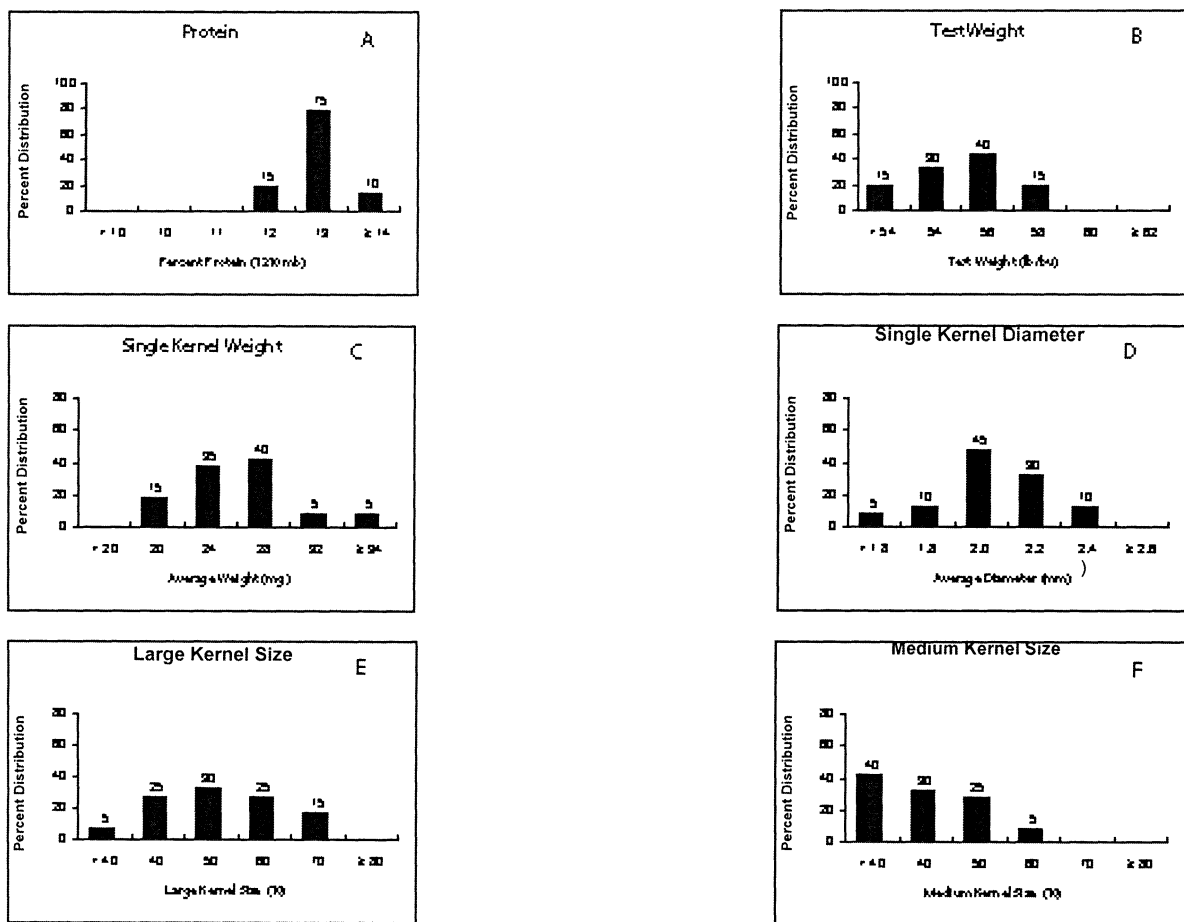
**Figure 32.**  
**Percent Distribution of Protein and Physical Characteristics at the Lahoma Location Across 20 Cultivars**



**Figure 33.**  
**Percent Distribution of Protein and Physical Characteristics at the Lamont Location Across 20 Cultivars**



**Figure 34.**  
**Percent Distribution of Protein and Physical Characteristics at the Marshall Location Across 20 Cultivars**



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