# A COMPARISON OF YIELD AND RELATED AGRONOMIC CHARACTERS BETWEEN RELATED AWNLESS AND BEARDED WINTER WHEAT SEGREGATES

by

VERNE CLIFFORD FINKNER

B. S., Colorado State College
of Agriculture and Mechanical Arts, 1947

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## INTRODUCTION

For many years interest in yielding ability of awnless and bearded wheats has been shown by both breeder and producer. Yielding ability is a variable and complex character depending upon both environmental conditions and heritable factors for its expression. It is therefore a difficult problem to collect data which can be used as conclusive evidence as a basis of comparison of yielding ability.

In 1939 and 1940, at the Kansas Agricultural Experiment Station, crosses were made between Chiefkan and Tenmarq, Comanche, and Cheyenne to transfer the high test weight character of Chiefkan to the other three varieties. As Chiefkan has poor baking quality and is an awnless variety, plans were made to study the inheritance of baking quality and the effect of awns on the segregates of these crosses. The results obtained from the awn effect study are presented in this paper.

## REVIEW OF LITERATURE

### Inheritance of Awns

Biffen (1905) is given credit for making the first genetical study of awns. He interpreted his results on a single factor basis. Awnlessness was dominant in the $F_1$ and the $F_2$ segregated three awnless to one bearded. Spillman (1902) observed that the $F_2$ generation segregated three awnless to one bearded. Gaines (1926), in a Marquis x Turkey cross, obtained a ratio of two and one-half awnless to one bearded. Percival (1912) divided the $F_2$ into three classes; awnless, intermediate, and bearded and obtained a one awnless-two intermediate-one bearded ratio. Gaines (1917) and Gaines and Singleton (1926) interpreted their work on a 1:2:1 basis according to the breeding behavior of the $F_2$. Clark and Quisenberry (1929) interpreted a one factor difference for awns in a Marquis x Kota cross. Stewart (1931) and Stewart and Dalley (1932) explained awn behavior in a cross of Sevier x Dicklow on a single factor basis obtaining 1:2:1 in the $F_2$. The same results were obtained by Stewart (1931) in a Ridit x Federation-Sevier segregate cross.

Howard and Howard (1912) observed a single factor difference was not adequate to explain awn behavior in their crosses. If they grouped all bearded plants together they got fifteen bearded to one awnless. They concluded a two factor paid difference explained the behavior of awns, and the bearded condition was dominant. Stewart (1926) classified awns into four classes and explained his results as two factors located on the same chromosome with 35 percent crossing over. Stewart and Judd (1931) carried a cross of Hard Federation x Kota through the $F_5$ and found only four true breeding classes. They explained their results on basis of two factor pair difference with independent inheritance.

Clark (1924) classified awns into five classes all of which would breed true. He interpreted the results as due to at least two dominant factors for awnlessness, and bearded plants represented by at least one double recessive factor. He classified the true breeding classes as (1) awnless, (2) apically awnletted, (3) awnletted, (4) short awned and (5) awned or bearded. Clark and Hooker (1926) in a cross of class one wheat with a class three wheat obtained results which they interpreted on basis of one primary and one secondary factor pair.

Stewart and Tingey (1928), in a cross of Marquis x Federation, interpreted the $F_2$ results on a single factor pair difference. Transgressive segregation occurred in the $F_3$ indicating a more complex inheritance.

Clark, Quisenberry, and Powers (1933), in a cross between a class five wheat with a class one wheat, obtained a good fit to a 1:8:4:2:1 phenotypic ratio. They interpreted their results as two major factors giving seven genotypic groups and five phenotypic groups. Quisenberry and Clark (1933), in a cross between a class one wheat and class three wheat, and another cross between a class five wheat and class three wheat, could explain their results on the basis of two major genetic factor pairs.

Stewart (1932), in a cross of Federation x Sevier, concluded a two factor difference with Sevier having both factors and Federation having neither. He was doubtful of which condition was dominant because the $F_1$ was intermediate between both parents. Clark, Florell, and Hooker (1928), in crosses between Bobs, Hard Federation, and Propo wheats, found if they grouped classes one and two against three, four, and five they obtained a close fit to a 9:7 ratio. They interpreted their results on two major and one minor genetic factor pairs.

Watkins and Ellerton (1940) have done the most critical work on awn inheritance. They classified wheats as bearded, tipped 1, tipped 2, half awned, hooded, awnless, and hooded awnless. They established the following genes: $B_1$ reduces awns to only a few awn tips and are classified as tipped 1, $b_1^a$ forms a multiple allelomorphic series with $B_1$ and $b_1$ giving half awned types. $B_2$ is the gene for tipped 2. There may be another multiple allelomorph with $B_2$ and $b_2$. The gene for bearded is $b_1$. The gene $H_d$ reduces the length of the awns and makes them curved and twisted near the base.

Sears (1944), in nullisomic analysis of wheat plants, partly confirmed Watkins and Ellerton's work and has added additional information. He located gene $H_d$ on chromosome VIII, gene $B_2$ on chromosome X with its dominant allele $b_1$, and found factors on chromosomes II and XX that are of the opposite type to the other known awn genes in that they promote awn development rather than inhibit it.

Gericke (1923) grew Sonora wheat in tap water and some other in soil. Some of the wheats in tap water produced awns but none of the wheats in the soil produced awns. He interpreted his results due to environmental differences only.

## Awn Effect on Kernel and Test Weight

Schmidt and Percival, in 1898, as reviewed by Clark (1928), observed that awns are important for normal grain and the amount of importance is in direct relation to the size of the awn. Perlitius, as reviewed by Clark (1928), using bearded, clipped beard, and awnless plants found that the awn has an important influence on the volume and weight of the kernel. Vasilyev (1897) lowered the weight of kernels by as much as nine percent by clipping off the beards.

Grantham (1922) found kernel weight to be less in the awnless varieties on both fertilized and unfertilized ground. The awnless varieties were more seriously affected by lack of fertilizer than the bearded.

Hayes, Aamodt, and Stevenson (1927), in a study of winter and spring varieties, showed that the bearded strains excelled in plumpness of grain. Goulden and Neatby (1929) observed that bearded plants produced plumper grain but found no significant difference in weight of 500 kernels. Stevens (1930) found bearded plants produced plumper kernels and more grams of kernels per plant.

Gemmell (1933) used Kanred wheat and clipped the awns at three different periods of time. In every case the bearded plants produced higher test weight seed than the clipped plants. The difference between the bearded and clipped plants was less the later the elipping. Rosenquist (1936) eliminated clipping damage by comparing kernels produced by the eame heterozygous plant. Kernels from the bearded florete of the $F_1$ plant were about 1.4 percent heavier than those from awnless florets in the eame spike. Kernels from intermediately bearded $F_2$ spikes were 3.2 percent heavier than those from the awnless and fully bearded were 4.9 percent heavier than the awnless.

Lamb (1937) studied segregating rows from a bulk population of eight segregating populatione. Out of many rows studied only in eix oases were the bearded significantly higher in weight of 1,000 kernels. When an average of all means was taken, the bearded led by 0.4 grams per 1,000 kernels or 1.41 percent. Bayles and Suneson (1940) showed a composite of bearded plants wae superior to that from a composite of awnless or awnletted plants in both kernel weight and pounde per bushel regardless of environment. They found thie to be true in both a study of spring and winter wheats. Their conclusions were based on results from the $F_3$ through the $F_7$ generations.

Miller et al. (1944) studied seven varieties of bearded red winter wheate by removing all awns, removing half of the awne, and normal plants. The beards were removed at four different growth periods. Total and partial deawning decreaeed the weight of the grain, total deawning decreaeing it twice ae much ae partial deawning. Greatest decrease wae obtained by earliest deawning. The same results were observed for grams of kernele per head, weight of 1,000 kernels and number of grains per head.

## Awn Effect on Yield

Hickman (1888) compared bearded and awnless varieties grown in Ohio as to yield. In 1886 bearded varieties outyielded awnless while in 1887 and 1888 the reverse was true. The differences in each case were very slight. Grantham (1917) observed bearded varieties were higher yielders because of superior tillering habit. Grantham (1918) found in twenty-six tests, including 1,986 varieties and strains, that bearded wheats outyielded the awnless varieties both with and without application of fertilizer. The reduction of yield of the bearded wheats when not fertilized was 30 percent while that of the awnless was 41 percent.

Clark, Florell, and Hooker (1928) observed a decrease in yield, in a segregating cross, with an increase of the length and number of awns. They contributed the difference to more shattering in the bearded plants and if shattering did not occur the bearded plants were higher yielding. Clark and Quisenberry (1929) found awnletted plants averaged higher in yield than bearded plants in the $F_2$. In the $F_3$ a significant difference was found between the awnletted and bearded plants which could not be accounted for by difference in shattering.

Goulden and Neatby (1929) found bearded plants yielded significantly more than awnless plants. Stevens (1930) found bearded plants yielded significantly more than awnless plants under Kansas conditions.

Clark, Quisenberry, and Powers (1933) found no important relation between the degree of awnedness and yield in segregates of a Hope x Hard Federation cross. Aamodt and Torrie (1934), using 29 segregating $F_3$ lines of Reward x Caesium, found no significant relationship between awns and yield. The same results were secured from two years' data of Marquillo x Marquis-Kanred progeny. Lamb (1937), in a study of a bulk of eight segregating populations in three seasons, indicated no significant increase in yield due to awns.

Gommell (1933) found that bearded plants outyielded plants with clipped beards, the difference being less as the crop approached maturity. When the awns were removed from spikelets on one side of the spike and not on the other, the bearded side still outyielded the clipped side.

Bayles and Suneson (1940), in tests of composite bearded and composite awnless segregates of winter wheat, found no significant difference in yield. In a similar test of spring wheats the bearded wheats significantly outyielded the awnless in two of the four years tested. $F_3$ through $F_7$ seed was used for testing and separations were made to obtain true breeding awnless and bearded segregates.

Miller et al. (1944) found deawning of heads caused a decrease in yield and that 50 to 80 percent of the decrease in yield is caused by decreased kernel weight. The rest of the decrease was due to less kernels produced by the deawned heads.

## Other Awn Effects

Gaines and Singleton (1926) found the average ripe date of the bearded, intermediate, and awnless was approximately the same. Goulden and Neatby (1929) found awnless plants were significantly later heading than bearded plants.

Gaines and Singleton (1926) found that bearded $F_3$ plants were more resistant to bunt, but little or no linkage existed. Clark, Quisenberry and Powers (1933) found no important relation between the degree of awnedness and resistance or susceptibility to bunt. Goulden and Neatby (1929) found awnless plants to be significantly more susceptible to black chaff.

Gaines (1926) found no linkage between awns and winter habit. Aamodt (1923) found no correlation winter or spring growth habits and presence or absence of awns.

Grantham (1917) thought that bearded wheats were superior in tiller habit and had a more flexible straw. Lamb (1937) found no significant difference in length of straw and did not believe that awns could possibly influence the tillering habit of plants.

Perlitius, as reviewed by Clark (1928), found awned plants produced seeds which had an increase in starch content. Clark and Quisenberry (1929) showed that bearded plants produced seeds significantly higher in crude protein content than the awnletted. Miller et al. (1944) found that awns did not produce an increase in percentage of ash of the grain. Clark (1928) found no correlation between awns and kernel texture when texture was measured as chalky, soft, intermediate, hard or vitreous.

## Physiological Functions of Awns

Perlitius, as reviewed by Clark (1928), found that awns were important for transpiration. Heads with awns removed transpired only half as much water as normal bearded heads. Vasilyev (1898) found that clipping beards diminishes the transpiration of the head between 60 and 63 percent. Gauch and Miller (1940) found deawned heads transpired 38.9 percent less than bearded heads. The curves of transpiration rate paralleled each other throughout the experiment. The beards transpire only 1 to 5 percent of the total amount of water lost from the plant by transpiration.

Lamb (1937) thought that beards played a role in removing from the translocation system of the plant, at filling time, substances (possibly silicates) which otherwise might interfere with the rapid movement of materials into the grain. Miller et al. (1944) found deawning increased the ash content of the glumes. In more than two-thirds of the cases the weight of the rachises was increased by deawning and the amount of ash in the rachis was also increased.

## MATERIALS AND METHODS

### Sister Plant Comparisons of Selfed Hybrid Wheat Segregates

In 1939 and 1940 three bearded winter wheat varieties, Tenmarq, Comanche, and Cheyenne were crossed to an awnletted winter wheat variety, Chiefkan, to transfer the high test weight of Chiefkan to the other three varieties. Tenmarq is mid-season, mid-tall, and has good quality. Cheyenne is late season, short to mid-tall, and has average quality. Comanche is early, short strawed, and has high quality. Chiefkan is midseason, mid-tall, high test weight, but has poor quality.

The $F_1$ plants were grown in the greenhouse in 1939-40 and the $F_2$ seed was space planted about two inches apart in the field in the fall of 1940 in plant rows. Awnless and bearded $F_2$ plant counts were taken to determine the gene difference of the parents for awns, and other agronomic data were taken in the $F_2$. The $F_3$ seed was thickly sown in plant rows in the fall of 1942. Seed from all $F_3$ plant rows that were breeding true for awn type was bulked within each row and used for comparison data the following year. From the $F_3$ segregating plant rows heterozygous heads were selected for planting the following season, fall of 1942. In the summer of 1943 selections of true breeding bearded and awnless $F_5$ seed were made for planting and testing the following year. Thus, in the summer of 1944 they had for comparison, $F_5$ bearded and awnless plants that were sisters in the $F_3$. This procedure was continued and in 1947 comparisons were made between bearded and awnless $F_7$ plants that were sisters in the $F_5$. This procedure has been described in more detail by Atkins and Mangelsdorf (1942).

Since there was no basis of pairing bearded and awnless rows in the $F_4$, the experimental design was a randomized block. Three replications were planted but only two were used in the analysis. In the $F_5$ and the $F_6$ the sister pairs were planted side by side in the first replication and the paired data technique was used in analysis of that replication. The second and third replications were randomized without regard to sister pairs and were analyzed in a randomized block. In the $F_7$ the sister pairs were kept together in all three replications in a split plot design. Randomization was somewhat restricted in all designs as the awnless row was always between two bearded rows.

The plots in all years were single eight-foot rows with one foot between rows. Planting was done with a small nursery spout drill and the seeding rate was measured by volume to approximate a planting rate of six pecks per acre. Harvesting was done by hand and threshing in a nursery rod row thresher. The seed was weighed in grams to determine yield and test weight was taken on standard test weight equipment using the pint or half-pint kettle or unit measure weights. Weight of 500 kernels was obtained by the average of three sampled weighings of 500 kernels. Kernels were counted by using a seed counter containing 500 holes. All broken kernels were removed and replaced by whole kernels before the weight was taken.

## Sister Plant Comparisons of Backcrossed Wheat Segregates

$F_1$ plants obtained from the original crosses made in the greenhouse 1938-39 were backcrossed to each parent in 1940. From this first backcross sister bearded and awnless plants were selected for testing. An outline of the yearly procedure is given below:

1938-39 The original crosses were made and seed space planted in the field in the fall of 1939.

1940 The $F_1$ plants from the original crosses were backcrossed to each parent and the seed space planted.

1941 All plants which were bearded or awnless were discarded. Some of the $F_1$ plants from the first backcross which were heterozygous were backcrossed the second time to each parent. The rest of the seed was replanted in order to secure true breeding bearded and awnless plants the next year.

1942 Plants breeding true for awn type were planted in plant rows. $F_1$ plants from the second backcross that were heterozygous for awn type were again backcrossed to each parent. Some of the plants heterozygous for awn type were replanted in order to secure true breeding bearded and awnless plants from the second backcross the next year.

1943 Plant rows were harvested and planted in four eight-foot rows for testing in 1944. Plants breeding true for awn type from the second backcross were planted in plant rows. Heterozygous plants from the third backcross were either replanted or backcrossed to each parent for the fourth time.

1944 Data were taken on true breeding bearded and awnless plants from the first backcross and seed replanted. Plant rows from the second backcross were replanted for testing in 1945. Plants breeding true for awn type from the third backcross were planted in plant rows. Heterozygous plants from the fourth backcross were either replanted or backcrossed to each parent for the fifth time.

1945 Data were taken on true breeding bearded and awnless plants from the second backcross and on true breeding bearded and awnless plants from the first backcross. Seed from both was replanted. Plant rows from the third backcross were replanted for testing in 1946. Plants breeding true for awn type from the fourth backcross were planted in plant rows. Heterozygous plants from the fifth backcross were either replanted or backcrossed to each parent for the sixth time.

This same procedure was followed and in 1947 data were available on plants that had been backcrossed to each parent four times and selfed twice, plants that had been backcrossed to each parent three times and selfed three times, plants that had been backcrossed to each parent twice and selfed four times, and plants that had been backcrossed once and selfed five times.

Since backcrossing a heterozygote to a homozygous parent obtains the same rate of homozygosity as if self-fertilization is employed, the 1944 $BC_1$ data should give comparable results to the 1943 $F_3$ sister plant selection data. The 1945 backcross data should give results comparable to the 1944 $F_5$ sister plant selection data, the 1946 backcross data should be comparable to the

1946 $F_6$ sister plant selection data, and the 1947 backcross data should be comparable to the 1947 $F_7$ sister plant selection data.

The statistical design for the backcross experiment was a split plot. Plots were split on the basis of awnless and bearded and also on recurrent parents. A plot consisted of four eight-foot rows with one foot between rows. The two center rows were used for the analysis. The method of planting, harvesting, and threshing procedures were the same as described for the sister plant selection project.

## Natural Selection of Related Hybrid Wheat Segregates

Bulks of each of the three crosses were planted to determine the influence of awns on natural selection. Random samples of seed from the previous generation were planted. Head counts were taken each year. The awnless and awned tipped heads were counted together to avoid error in classification.

From the remainder of the $F_2$ seed the large kernels were separated out and replanted. This was to determine if mechanical separation would change the rate of natural selection or be an aid in selecting plants for high test weight and large kernels. Each year the progeny of the large kernels was again separated for kernel size and the larger kernels replanted. Comparisons were made between the natural bulks and the large seeded bulks in regard to yield, test weight, and kernel weight.

## EXPERIMENTAL DATA AND RESULTS

The $F_1$ and $F_2$ generations of the three crosses were grown in 1941. From $F_2$ data there apparently is only one major factor difference for awn character between Chiefkan and the other three varieties. Plant counts were made by grouping awnless and heterozygous plants together to avoid error of classification. The counts and Chi-square values are given in Table 1.

Table 1. Numbers of bearded and awnless plus heterozygous plants in the $F_2$ generation of the crosses indicated, with expected numbers under the 3:1 hypothesis, and the values of Chi-square.

| Cross | Total plants obs. | Bearded Number plants Obs. | Bearded Number plants Exp. | Awnless and heterozygous Number plants Obs. | Awnless and heterozygous Number plants Exp. | Chi-square value | P |
|---|---|---|---|---|---|---|---|
| Chiefkan x Tenmarq | 708 | 186 | 177 | 522 | 531 | 0.6101 | 0.50 |
| Chiefkan x Comanche | 1190 | 275 | 297.5 | 915 | 892.5 | 2.2689 | 0.15 |
| Chiefkan x Cheyenne | 922 | 249 | 230.5 | 673 | 691.5 | 1.9797 | 0.20 |

The plumpness and high test weight of Chiefkan apparently is influenced by several factors which are recessive. Only a few samples in the $F_2$ were as good as Chiefkan.

Plants of the $F_1$ and parents were space planted three inches apart in the field and 50 plants of each cross were studied in detail. The summarized data obtained are given in Table 2.

The Tenmarq and Cheyenne crosses were taller than the tallest parent. The $F_1$'s had fewer tillers per plant but heads that were equal to or exceeding the parents in weight. Tenmarq and Comanche have large heads but the $F_1$ crosses did not have as many kernels per head as either of these two parents but more than Chiefkan. Cheyenne and Chiefkan have small heads, and in the cross between these two varieties the $F_1$ had more kernels per head than either parent. A larger kernel was produced on the $F_1$ plants as shown by the weight of 500 kernels. The test weight of each cross was intermediate between that of the parents indicating that the inheritance of this character may be complicated.

Table 2. Averages of 50 $F_1$ space planted plants obtained from the crosses indicated and averages of 50 parental plants.

| Cross or parent | Height inches | Tillers with heads | Grams grain Plant | Grams grain Head | Kernels per head | Test weight lbs/bu. | Weight 500 kernels grams |
|---|---|---|---|---|---|---|---|
| Tenmarq x Chiefkan | 40.9 | 8.6 | 7.63 | 0.92 | 28.5 | 59.7 | 15.70 |
| Tenmarq | 36.9 | 9.4 | 6.26 | 0.87 | 31.1 | 56.2 | 13.10 |
| Comanche x Chiefkan | 40.1 | 7.9 | 6.42 | 0.88 | 26.6 | 60.1 | 16.12 |
| Comanche | 37.3 | 9.8 | 7.48 | 0.90 | 30.1 | 57.8 | 14.46 |
| Cheyenne x Chiefkan | 41.4 | 9.0 | 7.21 | 0.88 | 28.1 | 59.6 | 15.37 |
| Cheyenne | 39.1 | 10.9 | 6.80 | 0.69 | 25.8 | 58.6 | 12.72 |
| Chiefkan | 40.5 | 11.1 | 7.81 | 0.83 | 25.7 | 61.5 | 14.94 |

RESULTS FROM THE TENMARQ X CHIEFKAN SEGREGATES

In 1942 a random sample of the progeny of $F_2$ bearded, awnless, and heterozygous plants was planted for increase. In 1943 progeny of 25 true breeding awnless and 25 true breeding bearded lines was selected at random for detailed study. The summarized data obtained on these lines are shown in Table 3. The average date of heading and average height of plants did not show enough difference between the bearded and awnless plants to justify statistical analysis. The analysis of variance summaries for yield and test weight are shown in Table 4. In analyses made throughout this report all possible interactions were first tested for significance; if they were found to be non-significant they were then pooled with the error factor when possible. In all cases the F-ratio is the larger estimated variance divided by the smaller estimated variance. Probabilities are given at the closest 50, 25, 10, 5, 2.5, 1, or 0.5 percent levels.

The analysis in Table 4 indicates that in the $F_4$ generation the bearded segregates were higher yielding and had a higher test weight than did the awnless segregates.

In the heterozygous $F_3$ progeny rows heads were selected that were homozygous for beards and awnlessness for increase in 1943 and for testing in the $F_5$ in 1944. Table 5 gives the summarized $F_5$ data. Again the average difference between bearded and awnless lines in date of first head and plant height was not great enough to be of practical significance. Test weight data given in Table 5 are estimated test weights and were not analyzed.

Table 3. Plot averages of agronomic data for three replications of bearded and awnless $F_4$ segregates from a Tenmarq x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test weight/170cc | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 19 | 24 | 36 | 39 | 29.5 | 28.2 | 27.8 | 26.5 |
| 21 | 22 | 37 | 37 | 27.0 | 21.9 | 28.1 | 27.2 |
| 21 | 24 | 38 | 38 | 23.6 | 28.3 | 27.9 | 26.9 |
| 20 | 22 | 38 | 39 | 26.7 | 21.0 | 27.7 | 27.0 |
| 22 | 23 | 39 | 39 | 25.8 | 24.4 | 28.0 | 26.7 |
| 22 | 24 | 40 | 39 | 25.1 | 19.8 | 27.3 | 26.7 |
| 22 | 23 | 41 | 42 | 30.1 | 31.2 | 27.7 | 26.4 |
| 22 | 24 | 38 | 40 | 21.6 | 27.5 | 27.5 | 27.2 |
| 22 | 19 | 42 | 38 | 31.0 | 25.4 | 27.4 | 25.8 |
| 24 | 23 | 40 | 39 | 30.3 | 20.5 | 27.0 | 27.1 |
| 21 | 24 | 40 | 40 | 30.6 | 28.3 | 27.2 | 27.2 |
| 21 | 22 | 39 | 40 | 30.5 | 29.3 | 27.8 | 26.9 |
| 20 | 18 | 37 | 38 | 31.5 | 28.7 | 28.2 | 27.4 |
| 20 | 20 | 40 | 41 | 31.5 | 30.7 | 27.7 | 26.5 |
| 22 | 23 | 40 | 39 | 30.5 | 30.1 | 27.3 | 27.2 |
| 22 | 22 | 40 | 41 | 28.3 | 27.6 | 27.0 | 26.0 |
| 24 | 21 | 42 | 39 | 26.7 | 21.2 | 27.6 | 26.3 |
| 22 | 22 | 38 | 37 | 28.8 | 24.1 | 27.8 | 26.7 |
| 22 | 20 | 38 | 38 | 29.1 | 22.1 | 27.1 | 26.7 |
| 20 | 22 | 38 | 38 | 24.9 | 21.7 | 27.5 | 26.2 |
| 22 | 22 | 38 | 40 | 24.4 | 20.3 | 27.4 | 25.8 |
| 20 | 22 | 39 | 39 | 24.4 | 19.8 | 26.4 | 26.8 |
| 21 | 23 | 39 | 36 | 23.4 | 20.2 | 27.4 | 25.8 |
| 22 | 22 | 39 | 38 | 23.3 | 21.3 | 28.2 | 25.6 |
| 23 | 26 | 37 | 39 | 22.9 | 20.7 | 27.8 | 26.3 |
| Averages | | | | | | | |
| 21.48 | 22.28 | 38.80 | 38.92 | 27.26 | 24.57 | 27.55 | 26.6 |
| Parent averages | | | | | | | |
| 20.33 | 22.00 | 37.33 | 40.00 | 25.13 | 27.00 | 26.28 | 27.70 |

Table 4. Analysis of variance of yield and test weight data summarized in table 3 for the $F_4$ bearded and awnless Tenmarq x Chiefkan segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 6,384 | 13.98 | 0.005 |
| Between replications | 1 | 4,058 | 8.89 | 0.005 |
| Error | 97 | 456.40 | | |
| | | Test weight | | |
| Between awns | 1 | 28.30 | 98.40 | 0.005 |
| Between replications | 1 | 0.0484 | 5.94 | 0.50 |
| Error | 97 | 0.2876 | | |

Table 5. A summary of agronomic data comparisons between bearded and awnless $F_5$ segregates that were sister pairs in the $F_3$ from a Tenmarq x Chiefkan cross.

| First headed |  | Height in inches |  | Yield bus./A. |  | Test wt. lbs/bu. |  |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 27 | 28 | 39 | 39 | 26.7 | 20.6 | 58.5 | 57.3 |
| 29 | 29 | 37 | 39 | 21.1 | 21.3 | 57.8 | 57.5 |
| 27 | 27 | 38 | 36 | 29.3 | 22.9 | 59.7 | 57.8 |
| 28 | 29 | 37 | 36 | 23.5 | 22.3 | 59.5 | 57.3 |
| 28 | 28 | 37 | 37 | 23.7 | 19.7 | 59.3 | 57.3 |
| 27 | 29 | 38 | 38 | 29.4 | 23.2 | 59.7 | 58.0 |
| 27 | 28 | 38 | 39 | 27.1 | 25.6 | 59.3 | 58.2 |
| 28 | 26 | 37 | 38 | 23.2 | 26.9 | 58.3 | 58.3 |
| 27 | 28 | 37 | 37 | 24.9 | 23.9 | 57.5 | 57.2 |
| 29 | 28 | 38 | 35 | 21.7 | 18.5 | 59.0 | 56.8 |
| 28 | 27 | 36 | 35 | 21.9 | 20.5 | 58.2 | 56.0 |
| 25 | 27 | 35 | 37 | 25.5 | 25.0 | 58.3 | 58.3 |
| 29 | 29 | 37 | 36 | 16.7 | 18.9 | 58.3 | 57.3 |
| 27 | 27 | 37 | 37 | 25.1 | 21.5 | 58.5 | 56.7 |
| 28 | 28 | 36 | 35 | 23.6 | 15.3 | 58.5 | 57.8 |
| 25 | 26 | 37 | 36 | 31.2 | 24.7 | 60.0 | 58.8 |
| 26 | 26 | 37 | 37 | 36.1 | 28.0 | 59.8 | 59.0 |
| 27 | 28 | 38 | 37 | 21.4 | 19.1 | 58.2 | 58.8 |
| 27 | 26 | 39 | 37 | 22.6 | 24.1 | 57.5 | 57.7 |
| 26 | 26 | 37 | 37 | 28.3 | 24.0 | 59.7 | 58.2 |
| 28 | 27 | 38 | 37 | 21.1 | 20.1 | 58.0 | 57.2 |
| 29 | 29 | 37 | 38 | 26.1 | 24.9 | 58.5 | 57.7 |
| 26 | 26 | 36 | 38 | 29.2 | 29.5 | 59.2 | 58.7 |
| 29 | 29 | 38 | 39 | 23.1 | 19.1 | 56.8 | 55.3 |
| Averages |  |  |  |  |  |  |  |
| 27.38 | 27.54 | 37.25 | 37.08 | 25.10 | 22.48 | 58.67 | 57.63 |
| Parent averages |  |  |  |  |  |  |  |
| 27.50 | 27.00 | 36.00 | 37.75 | 24.54 | 24.45 | 56.45 | 59.25 |

Table 6. Analysis of variance of yield data summarized in table 5 for bearded and awnless Tenmarq x Chiefkan $F_5$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| Between awns | 1 | 2,960 | 5.11 | 0.025 |
| Between replications | 1 | 931.3 | 1.61 | 0.10 |
| Error | 93 | 579.0 | | |

The yield data were analyzed on 24 plots of plants which were sister pairs in the $F_3$. The paired data method of analysis gave results which indicated the bearded plants were higher yielding than the awnless plants, the probability at the 0.025 level. In group comparisons of the same 24 segregates in two randomized replications the same results were indicated. The analysis of variance summary table for the yield data of the $F_5$ is given in Table 6.

Due to lack of personnel, this part of the experiment was discontinued for the year 1945. In 1946 $F_6$ segregates that were sister pairs in the $F_4$ and were homozygous for beards and awnlessness were compared for yield and test weight. The paired data technique used on 29 plots of plants indicated that in the $F_6$ generation the bearded lines were higher yielding than the awnless lines, the probability being 0.05. In group comparisons of the same 29 segregates in two randomized replications the same results were indicated with the probability at the 0.005 level. The bearded lines were also indicated as being higher in test weight than the awnless lines. The analysis of variance summaries for yield and test weight are presented in Table 8 and the summarized data are presented in Table 7. There was not enough difference between the average date of first head and plant height of the bearded and awnless lines to be of practical importance.

In 1947 $F_7$ segregates that were sister pairs in the $F_5$ and were homozygous for beards and awnlessness were compared. This year the experimental design was changed from the randomized block to the split plot. The summarized $F_7$ data are given in Table 9. The average date of first heading and plant height was again nearly the same for both bearded and awnless segregates. The analysis of variance summaries for yield and for test weight are presented in Table 10.

The analysis presented in Table 10 fails to indicate a difference between the bearded and awnless segregates for either yield or test weight.

The summarized backcross data are given in Table 11. The analysis of variance summaries for yield, test weight, and weight of 500 kernels are presented in Table 12 for the segregates that have been backcrossed to their recurrent parent once.

Table 12 indicates no difference between recurrent parents in regard to yield, but indicates that the progeny from bearded segregates from both series of backcrosses is higher yielding than the progeny from the awnless segregates. When Chiefkan is used as the recurrent parent the test weight is higher than when Tenmarq is used as shown by the test weight analysis. The analysis of weight of 500 kernels fails to indicate differences between recurrent parents or between bearded or awnless segregates in regard to weight of 500 kernels.

The analysis of variance summaries for the yield, the test weight, and for the weight of 500 kernels for the second backcross and the first backcross advanced one generation by selfing are given in Table 13.

The yield analysis of Table 13 indicates that the awn reaction is not constant for yield and that its effect depends

Table 7. A summary of agronomic data comparisons between bearded and awnless $F_6$ segregates that were sister pairs in the $F_4$ from a Tenmarq x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 7 | 10 | 41 | 42 | 33.1 | 30.7 | 61.5 | 60.0 |
| 8 | 8 | 41 | 41 | 34.7 | 20.6 | 60.5 | 57.5 |
| 11 | 11 | 39 | 40 | 26.3 | 29.9 | 61.0 | 59.5 |
| 8 | 7 | 41 | 39 | 29.2 | 27.1 | 62.0 | 59.5 |
| 8 | 10 | 40 | 41 | 30.0 | 28.9 | 61.0 | 61.0 |
| 8 | 8 | 41 | 42 | 40.3 | 31.7 | 61.5 | 60.0 |
| 6 | 8 | 40 | 42 | 37.5 | 37.5 | 62.5 | 61.0 |
| 7 | 8 | 41 | 43 | 33.6 | 26.4 | 62.0 | 59.0 |
| 8 | 7 | 41 | 42 | 27.7 | 37.2 | 60.5 | 61.0 |
| 4 | 6 | 40 | 40 | 42.9 | 35.1 | 61.0 | 59.0 |
| 9 | 11 | 41 | 42 | 36.3 | 25.7 | 60.5 | 57.0 |
| 12 | 11 | 41 | 42 | 38.3 | 35.7 | 60.5 | 59.0 |
| 5 | 7 | 41 | 40 | 40.3 | 33.3 | 61.0 | 59.5 |
| 8 | 7 | 40 | 39 | 35.3 | 39.8 | 61.0 | 59.5 |
| 7 | 9 | 40 | 41 | 36.3 | 28.1 | 62.0 | 60.0 |
| 6 | 10 | 40 | 41 | 31.8 | 30.9 | 61.0 | 60.5 |
| 4 | 6 | 40 | 39 | 34.1 | 23.9 | 60.0 | 57.5 |
| 5 | 7 | 41 | 40 | 38.3 | 27.7 | 61.5 | 58.0 |
| 6 | 9 | 41 | 41 | 34.4 | 23.9 | 61.0 | 57.5 |
| 8 | 7 | 41 | 40 | 30.0 | 23.3 | 60.0 | 58.5 |
| 8 | 7 | 42 | 40 | 36.0 | 26.6 | 61.5 | 59.5 |
| 8 | 9 | 41 | 41 | 27.7 | 34.7 | 60.0 | 59.5 |
| 9 | 7 | 40 | 40 | 37.1 | 34.3 | 63.5 | 60.5 |
| 9 | 6 | 41 | 41 | 42.0 | 33.9 | 60.0 | 59.0 |
| 7 | 4 | 41 | 40 | 36.3 | 32.8 | 59.5 | 59.5 |
| 4 | 5 | 41 | 40 | 26.5 | 32.3 | 60.5 | 59.5 |
| 6 | 7 | 41 | 40 | 35.7 | 42.5 | 61.5 | 60.0 |
| 6 | 5 | 40 | 39 | 36.7 | 38.5 | 61.0 | 59.5 |
| 8 | 7 | 40 | 40 | 30.4 | 31.5 | 58.5 | 57.5 |
| 4 | 6 | 39 | 39 | 36.3 | 31.7 | 61.0 | 61.5 |
| Averages | | | | | | | |
| 7.13 | 7.67 | 40.57 | 40.57 | 34.50 | 31.21 | 60.97 | 59.35 |
| Parent averages | | | | | | | |
| 8.50 | 7.50 | 39.33 | 40.50 | 31.75 | 34.30 | 59.50 | 61.50 |

Table 8. Analysis of variance of yield and test weight data summarized in table 7 for bearded and awnless Tenmarq x Chiefkan $F_6$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 29,484 | 9.70 | 0.005 |
| Between replications | 1 | 46,060 | 15.11 | 0.005 |
| Error | 115 | 3,040.6 | | |
| | | Test weight | | |
| Between awns | 1 | 39 | 34.27 | 0.005 |
| Error | 56 | 1.14 | | |

Table 9. A summary of agronomic data comparisons between bearded and awnless $F_7$ segregates that were sister pairs in the $F_5$ from a Tenmarq x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 19 | 20 | 42 | 42 | 30.3 | 25.5 | 60.5 | 58.5 |
| 21 | 21 | 40 | 39 | 19.5 | 28.0 | 59.5 | 59.0 |
| 21 | 21 | 40 | 41 | 26.9 | 27.9 | 59.0 | 59.0 |
| 22 | 21 | 39 | 39 | 23.7 | 27.8 | 59.0 | 59.0 |
| 21 | 20 | 39 | 40 | 22.7 | 29.1 | 59.0 | 59.5 |
| 20 | 20 | 42 | 42 | 33.9 | 27.7 | 61.0 | 60.0 |
| 22 | 22 | 40 | 40 | 26.8 | 28.7 | 60.0 | 59.0 |
| 21 | 21 | 42 | 42 | 34.8 | 26.0 | 60.5 | 60.0 |
| 17 | 18 | 44 | 44 | 31.1 | 31.2 | 61.0 | 60.0 |
| 22 | 22 | 44 | 43 | 34.7 | 33.1 | 60.0 | 60.5 |
| 18 | 18 | 37 | 37 | 24.3 | 23.1 | 57.0 | 57.0 |
| 23 | 24 | 39 | 37 | 26.7 | 22.8 | 60.0 | 58.5 |
| 22 | 21 | 37 | 37 | 28.7 | 24.5 | 60.5 | 60.0 |
| 21 | 21 | 37 | 38 | 29.2 | 30.5 | 60.0 | 59.0 |
| 20 | 20 | 38 | 37 | 25.1 | 25.2 | 59.5 | 59.0 |
| 21 | 21 | 41 | 41 | 23.6 | 26.4 | 60.5 | 60.0 |
| 22 | 22 | 40 | 39 | 22.7 | 24.1 | 58.0 | 58.5 |
| 22 | 21 | 38 | 39 | 20.7 | 26.1 | 58.0 | 59.0 |
| 22 | 21 | 41 | 39 | 25.4 | 28.6 | 58.0 | 58.5 |
| 21 | 21 | 41 | 41 | 34.6 | 31.9 | 61.0 | 60.5 |
| 21 | 21 | 39 | 39 | 34.1 | 29.7 | 61.0 | 61.0 |
| 21 | 21 | 40 | 39 | 36.7 | 32.2 | 61.5 | 60.0 |
| 22 | 23 | 40 | 40 | 23.9 | 26.9 | 56.5 | 58.0 |
| 17 | 17 | 40 | 41 | 32.3 | 23.5 | 58.5 | 59.0 |
| 21 | 21 | 37 | 37 | 15.4 | 17.8 | 55.0 | 56.5 |
| 21 | 21 | 40 | 41 | 30.4 | 29.2 | 58.5 | 60.5 |
| 18 | 18 | 39 | 39 | 34.3 | 30.9 | 59.0 | 60.0 |
| 21 | 21 | 41 | 41 | 28.2 | 31.1 | 60.0 | 60.5 |
| 19 | 19 | 38 | 39 | 27.5 | 23.8 | 57.0 | 56.0 |
| 18 | 18 | 38 | 38 | 26.2 | 32.5 | 56.0 | 57.0 |
| Averages | | | | | | | |
| 20.57 | 20.53 | 39.77 | 39.70 | 27.81 | 27.56 | 59.17 | 59.00 |
| Parent averages | | | | | | | |
| 21.50 | 21.50 | 39.17 | 40.83 | 26.03 | 27.63 | 58.00 | 59.00 |

Table 10. Analysis of variance of yield and test weight data summarized in table 9 for bearded and awnless Tenmarq x Chiefkan $F_7$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between lines | 29 | 2,406.1 | 4.8817 | 0.005 |
| Between replications | 2 | 11,224 | 22.772 | 0.005 |
| Error a | 58 | 492.88 | | |
| Between awns | 1 | 5 | 10.31 | 0.50 |
| Awns x lines | 29 | 652.00 | 12.647 | 0.005 |
| Error b | 58 | 51.552 | | |
| | | Test weight | | |
| Between lines | 29 | 3.79 | 7.85 | 0.005 |
| Between awns | 1 | 0.0663 | 7.28 | 0.25 |
| Error | 29 | 0.483 | | |

Table 11. Agronomic data comparisons between bearded and awnless segregates that were obtained from backcrossing one to four times to the recurrent parent.

| Year | First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | | Wt. 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| | | | | | Tenmarq x $Chiefkan_2$ | | | | | |
| 1944 | 26 | 26 | 38 | 38 | 29.5 | 26.6 | 60.6 | 58.7 | 14.49 | 13.45 |
| 1945 | 29 | 30 | 44 | 44 | 15.8 | 16.5 | 51.0 | 50.5 | 10.36 | 9.59 |
| 1946 | 5 | 6 | 41 | 40 | 39.7 | 32.7 | 60.3 | 59.4 | 17.02 | 15.90 |
| 1947 | 21 | 22 | 39 | 39 | 21.7 | 22.9 | 60.0 | 60.0 | 14.00 | 13.57 |
| | | | | | Tenmarq x $Chiefkan_3$ | | | | | |
| 1945 | 29 | 30 | 45 | 44 | 19.9 | 14.3 | 54.0 | 50.5 | 10.70 | 9.74 |
| 1946 | 7 | 7 | 40. | 41 | 38.8 | 32.2 | 60.6 | 60.0 | 16.61 | 15.43 |
| 1947 | 21 | 22 | 38 | 39 | 19.7 | 22.9 | 59.5 | 60.0 | 13.38 | 13.57 |
| | | | | | Tenmarq x $Chiefkan_4$ | | | | | |
| 1946 | 5 | 6 | 40 | 40 | 36.7 | 31.9 | 61.5 | 60.3 | 16.96 | 16.27 |
| 1947 | 21 | 21 | 38 | 37 | 23.1 | 27.1 | 59.0 | 60.0 | 13.76 | 13.54 |
| | | | | | Tenmarq x $Chiefkan_5$ | | | | | |
| 1947 | 21 | 21 | 38 | 38 | 23.1 | 23.2 | 59.5 | 60.0 | 13.13 | 13.40 |
| | | | | | Chiefkan x $Tenmarq_2$ | | | | | |
| 1944 | 26 | 27 | 37 | 36 | 28.4 | 22.1 | 60.0 | 57.3 | 14.46 | 12.96 |
| 1945 | 29 | 30 | 44 | 44 | 15.6 | 16.1 | 50.0 | 51.5 | 9.99 | 10.48 |
| 1946 | 7 | 8 | 40 | 41 | 32.6 | 34.3 | 60.0 | 59.2 | 16.66 | 15.52 |
| 1947 | 21 | 22 | 37 | 37 | 21.7 | 22.9 | 60.0 | 60.0 | 14.00 | 13.67 |

Table 11. (concl.)

| Year | First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | | Wt. 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| | | | | | Chiefkan x $Tenmarq_5$ | | | | | |
| 1945 | 29 | 30 | 45 | 44 | 14.8 | 12.5 | 48.5 | 46.5 | 9.94 | 8.96 |
| 1946 | 6 | 7 | 41 | 41 | 37.1 | 33.3 | 59.6 | 58.7 | 17.16 | 16.53 |
| 1947 | 21 | 21 | 35 | 36 | 24.5 | 25.6 | 60.0 | 60.5 | 15.21 | 15.41 |
| | | | | | Chiefkan x $Tenmarq_4$ | | | | | |
| 1946 | 7 | 7 | 41 | 42 | 35.1 | 32.0 | 60.0 | 58.0 | 16.87 | 15.34 |
| 1947 | 21 | 21 | 37 | 35 | 26.0 | 22.9 | 60.0 | 60.0 | 14.82 | 14.06 |
| | | | | | Chiefkan x $Tenmarq_5$ | | | | | |
| 1947 | 22 | 21 | 37 | 38 | 24.6 | 26.5 | 60.0 | 59.5 | 14.77 | 14.15 |
| | | | | | Parents | | | | | |
| 1944 | 27 | 26 | 37 | 38 | 25.2 | 25.3 | 56.8 | 59.5 | 12.54 | 12.83 |
| 1945 | 29 | 29 | 45 | 44 | 14.8 | 14.6 | 50.0 | 49.5 | 9.72 | 9.81 |
| 1946 | 7 | 7 | 39 | 41 | 33.5 | 35.6 | 58.7 | 60.3 | 15.75 | 15.88 |
| 1947 | 22 | 21 | 36 | 37 | 23.0 | 22.1 | 59.0 | 60.0 | 14.49 | 13.22 |

Table 12. Analysis of variance of yield, test weight and weight of 500 kernels data obtained in 1944 and summarized in table 11 for bearded and awnless backcross segregates of a Tenmarq x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 2,352 | 10.74 | 0.10 |
| Between replications | 2 | 347.5 | 1.59 | 0.50 |
| Error a | 2 | 219.0 | | |
| Between awns | 1 | 6,257 | 7.88 | 0.025 |
| Error b | 5 | 793.6 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 2.803 | 800.9 | 0.005 |
| Between replications | 2 | 0.120 | 34.29 | 0.025 |
| Error a | 2 | 0.0035 | | |
| Between awns | 1 | 15.87 | 75.57 | 0.005 |
| Error b | 5 | 0.21 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 0.0676 | 1.278 | 0.50 |
| Between awns | 1 | 1.61 | 30.489 | 0.10 |
| Error | 1 | 0.0529 | | |

Table 13. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1945, and summarized in table 11 for bearded and awnless backcross segregates of a Tenmarq x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 2,147 | 1.37 | 0.50 |
| Between replications | 2 | 736 | 4.01 | 0.25 |
| Error a | 2 | 2,950 | | |
| Between backcrosses | 1 | 210 | 3.62 | 0.50 |
| Error b | 5 | 761.2 | | |
| Between awns | 1 | 1,683 | 1.82 | 0.50 |
| Awns x backcrosses | 1 | 3,060 | 10.78 | 0.01 |
| Error c | 10 | 283.8 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 11.28 | 1.00 | 0.50 |
| Between backcrosses | 1 | 1.531 | 7.37 | 0.25 |
| Error a | 1 | 11.28 | | |
| Between awns | 1 | 2.53 | 1.35 | 0.50 |
| Awns x recurrent parents | 1 | 1.53 | 49.08 | 0.25 |
| Awns x backcrosses | 1 | 3.41 | 109.17 | 0.05 |
| Error b | 1 | 0.0312 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 0.13 | 4.08 | 0.25 |
| Between backcrosses | 1 | 0.1458 | 3.64 | 0.25 |
| Error a | 1 | 0.5305 | | |
| Between awns | 1 | 0.616 | 2.49 | 0.25 |
| Error b | 3 | 0.2472 | | |

upon the number of backcrosses. By examining the 1945 data given in Table 11 it is seen that there is no difference between the bearded and awnless segregates which have been backcrossed and selfed once. In the segregates that have been backcrossed the second time, the bearded segregates are higher yielding than the awnless segregates. The analysis indicates that there is no difference in yield caused by other factors. The test weight analysis indicates the same awn effect as did the yield analysis; in the segregates that have been backcrossed the second time, the bearded segregates have the higher test weight. The analysis of the weight of 500 kernels fails to indicate any difference between the bearded and awnless segregates in regard to weight of 500 kernels.

The analysis of variance summaries for the yield, the test weight, and for the weight of 500 kernels for the third backcross and lines from the first and second backcross that had been advanced another generation by selfing are presented in Table 14.

The yield analysis in Table 14 indicates that segregates having Chiefkan as the recurrent parent are higher yielding than those having Tenmarq as the recurrent parent. There is no consistent awn effect on yield indicated, but that the bearded segregates yield more than the awnless segregates if Chiefkan is used as the recurrent parent is indicated. The test weight analysis indicates that the bearded segregates are consistently higher in test weight than are the awnless segregates. The weight of 500 kernels analysis indicates that the bearded segregates are

Table 14. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1946, and summarized in table 11 for bearded and awnless backcross segregates of a Tenmarq x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 1,444 | 20.9275 | 0.05 |
| Between replications | 2 | 244 | 3.5362 | 0.25 |
| Error a | 2 | 69 | | |
| Between backcrosses | 2 | 609 | 1.09 | 0.25 |
| Error b | 10 | 557.2 | | |
| Between awns | 1 | 14,003 | 3.03 | 0.50 |
| Awns x recurrent parents | 1 | 4,626 | 4.2557 | 0.05 |
| Error c | 14 | 1,087 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 3.61 | 5.3382 | 0.25 |
| Between backcrosses | 2 | 0.07 | 9.71 | 0.10 |
| Error a | 2 | 0.68 | | |
| Between awns | 1 | 3.41 | 33.1068 | 0.005 |
| Error b | 5 | 0.103 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 0.00100 | 538.30 | 0.025 |
| Between backcrosses | 2 | 0.02486 | 21.65 | 0.05 |
| Error a | 2 | 0.5383 | | |
| Between awns | 1 | 3.297 | 58.2 | 0.005 |
| Error b | 5 | 0.05663 | | |

consistently higher in this respect than are the awnless segregates. It also indicates that segregates from the second backcross have a higher weight per 500 kernels than the segregates from the first backcross.

The analysis of variance summariss for the yield, the test weight, and for the weight of 500 kernels for the fourth backcross and segregates from the first, second, and third backcross that have been advanced another generation by selfing are presented in Table 15.

The yield analysis in Table 15 indicates that the effect of awns on yield depends upon the recurrent parent used and the number of backcrosses to that parent. There is no consistent awn effect on yield indicated. The test weight analysis indicates no difference in test weight between the bearded and awnless segregates. The weight of 500 kernels analysis indicates no difference between the bearded and awnless segregates in this respect, but does indicate a difference between recurrent parents. When Tenmarq is used as a recurrent parent the weight of 500 kernels is greater than when Chiefkan is used as the recurrent parent.

The differences between the bearded and awnless segregates in regard to date of first heading and plant height were not large enough to be of practical value and were not analyzed statistically.

The natural selection procedure was carried out as described earlier and the data obtained are given in Table 16. The large seed plantings were compared with the normal seed plantings for yield, test weight, and weight of 500 kernels. The planting rates

Table 15. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1947, and summarized in table 11 for bearded and awnless backcross segregates of a Tenmarq x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 4,740 | 5.3507 | 0.25 |
| Between replications | 2 | 11,731 | 13.2703 | 0.10 |
| Error a | 2 | 884 | | |
| Between backcrosses | 3 | 784.7 | 1.09 | 0.25 |
| Error b | 15 | 722.3 | | |
| Between awns | 1 | 2,745 | 3.81 | 0.10 |
| Awns x recurrent parents x backcrosses | 7 | 720 | 2.41 | 0.05 |
| Error c | 16 | 292.5 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 0.0625 | 3.67 | 0.50 |
| Between backcrosses | 3 | 0.0625 | 3.67 | 0.25 |
| Error a | 3 | 0.2292 | | |
| Between awns | 1 | 0.2375 | 2.18 | 0.10 |
| Error b | 7 | 0.1089 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 4.2326 | 9.95 | 0.05 |
| Between backcrosses | 3 | 0.2028 | 2.10 | 0.25 |
| Error a | 3 | 0.4256 | | |
| Between awns | 1 | 0.0760 | 1.06 | 0.25 |
| Error b | 7 | 0.0803 | | |

Table 16. Comparison of agronomic data between normal bulk populations and a mechanically screened bulk population from the $F_2$ through the $F_7$ generation of a Tenmarq x Chiefkan cross.

| Generation | Number of heads | | | | Yield bus./A. | | Test weight lbs. | | Weight 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Normal seed | | Large seed | | | | | | | |
| | Awnless + heterozygous | Bearded | Awnless + heterozygous | Bearded | Normal | Large | Normal | Large | Normal | Large |
| $F_2$ | 980 | 379 | Not taken | | 18.1 | 27.3 | 53.0 | 52.5 | 10.41 | 10.32 |
| $F_3$ | 804 | 587 | 652 | 716 | 28.0 | 30.4 | 59.5 | 59.5 | 14.77 | 15.18 |
| $F_4$ | 726 | 972 | 608 | 1,091 | 26.7 | 31.1 | 59.2 | 59.0 | 13.91 | 14.14 |
| $F_5$ | 751 | 899 | 540 | 783 | 12.5 | 16.2 | 50.0 | 51.0 | 9.90 | 10.25 |
| $F_6$ | 526 | 978 | 292 | 1,446 | 31.5 | 34.6 | 58.9 | 59.3 | 15.54 | 15.94 |
| $F_7$ | 561 | 1,029 | 186 | 1,420 | 23.6 | 23.6 | 59.5 | 59.5 | 14.08 | 14.89 |

were equal volume and not of equal numbers or weight. It would have been more desirable if the planting rates had been of equal numbers. The analysis of variance summaries for yield, test weight, and weight of 500 kernels are presented in Table 17.

The analysis in Table 17 indicates that the larger kernels produce larger yields than do the normal kernels, that there is no difference in test weight between the progeny of the larger kernels and the normal kernels, and that the larger kernels tend to produce heavier kernels than the normal kernels produce as shown by the higher weight of 500 kernels.

The expected numbers were computed on head counts in three ways to determine if the observed deviated from them or not. The expected numbers were first computed on basis of the theorical rate of homozygosity reached when plants are selfed. The expected numbers were than corrected on the basis of the first head count. This procedure would account for the possibility of obtaining a sample that was not normal the first year, i.e., a sample that contained many more heads of one type or the other due to no cause other than sampling error. The third method was to compute the expected numbers on the basis of the observed number from each previous generation. All of these methods assume the same rate of homozygosity and any deviation from that rate is due to natural selection. Because of the difficulty of accurate classification of the awnless and heterozygous heads, they were grouped into one group and the bearded into another group. This procedure of grouping will not change the results any because there is only a one factor difference between bearded

Table 17. Analysis of variance summary of yield, test weight and weight of 500 kernels between a normal bulk population and a large seeded bulk population.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between years | 5 | 87.114 | 18.77 | 0.005 |
| Between seed size | 1 | 43.32 | 9.33 | 0.025 |
| Error | 5 | 4.642 | | |
| | | Test weight | | |
| Between years | 5 | 32.4928 | 237.45 | 0.005 |
| Between seed size | 1 | 00.04080 | 3.35 | 0.50 |
| Error | 5 | 0.13684 | | |
| | | Weight of 500 kernels | | |
| Between years | 5 | 11.8803 | 279.01 | 0.005 |
| Between seed size | 1 | 0.3710 | 8.71 | 0.025 |
| Error | 5 | 0.04258 | | |

and awnlessness in the varieties involved. The results are presented in Table 18.

The Chi-square values in the first part of Table 18 indicate that there was always an excess of bearded plants in both the normal and screened populations. When the expected numbers were computed from the observed numbers for the first head counts as shown in the second part of Table 18, the same results are indicated for the normal population. A good fit is obtained in the $F_5$ of the large seed bulk as indicated by the Chi-square value of 0.80. In each other generation there was again an excess of bearded plants as shown by the observed and expected numbers and the Chi-square values obtained. When the expected numbers were computed from the observed numbers of the previous generation as shown in the third part of Table 18, the normal bulk population had an excess of bearded plants in the $F_2$, the $F_3$, the $F_4$, and the $F_6$ generations. In the $F_5$ there was an excess of the awnless plants and in the $F_7$ a good fit of the observed numbers was obtained as shown by the Chi-square value of 0.50. The same results are indicated for the large seeded bulks with a Chi-square value in the $F_7$ being only 0.10.

Table 18. Chi-square values and probabilities of observed bearded and awnless plus heterozygous head counts from segregating normal and screened bulk populations in a Tenmarq x Chiefkan cross.

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| On basis of theorical rate of homozygosity | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1359 | 980 | 1019 | 5.97 | 0.05 |
| | B | 25.00 | | 379 | 340 | | |
| $F_3$ Normal | A+H | 62.50 | 1391 | 804 | 869 | 12.96 | 0.01 |
| | B | 37.50 | | 587 | 522 | | |
| $F_3$ Large | A+H | 62.50 | 1368 | 652 | 855 | 128.00 | 0.01 |
| | B | 37.50 | | 716 | 513 | | |
| $F_4$ Normal | A+H | 56.25 | 1698 | 726 | 955 | 124.00 | 0.01 |
| | B | 43.75 | | 972 | 743 | | |
| $F_4$ Large | A+H | 56.25 | 1699 | 608 | 956 | 290.00 | 0.01 |
| | B | 43.75 | | 1031 | 743 | | |
| $F_5$ Normal | A+H | 53.12 | 1650 | 751 | 877 | 38.64 | 0.01 |
| | B | 46.87 | | 899 | 773 | | |
| $F_5$ Large | A+H | 53.12 | 1323 | 540 | 702 | 80.64 | 0.01 |
| | B | 46.87 | | 783 | 620 | | |
| $F_6$ Normal | A+H | 51.56 | 1504 | 526 | 775 | 165.05 | 0.01 |
| | B | 48.44 | | 978 | 729 | | |
| $F_6$ Large | A+H | 51.56 | 1738 | 292 | 896 | 840.00 | 0.01 |
| | B | 48.44 | | 1446 | 842 | | |
| $F_7$ Normal | A+H | 50.78 | 1590 | 561 | 807 | 152.00 | 0.01 |
| | B | 49.22 | | 1029 | 783 | | |
| $F_7$ Large | A+H | 50.78 | 1606 | 186 | 816 | 988.00 | 0.01 |
| | B | 49.22 | | 1420 | 790 | | |
| On basis of theorical rate of homozygosity after correction of first head count | | | | | | | |
| $F_2$ Normal | A+H | 72.11 | 1359 | 980 | 980 | | |
| | B | 27.89 | | 379 | 379 | | |
| $F_3$ Normal | A+H | 60.10 | 1391 | 804 | 836 | 3.07 | 0.05 |
| | B | 39.90 | | 587 | 555 | | |

Table 18. (cont.)

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| $F_3$ Large | A+H | 47.66 | 1368 | 652 | 652 | | |
| | B | 52.34 | | 716 | 716 | | |
| $F_4$ Normal | A+H | 54.09 | 1698 | 726 | 918 | 87.42 | 0.01 |
| | B | 45.92 | | 972 | 780 | | |
| $F_4$ Large | A+H | 42.89 | 1699 | 608 | 729 | 35.17 | 0.01 |
| | B | 57.10 | | 1031 | 970 | | |
| $F_5$ Normal | A+H | 51.08 | 1650 | 751 | 843 | 20.53 | 0.01 |
| | B | 48.92 | | 899 | 807 | | |
| $F_5$ Large | A+H | 40.51 | 1323 | 540 | 536 | 0.05 | 0.80 |
| | B | 59.49 | | 893 | 787 | | |
| $F_6$ Normal | A+H | 49.57 | 1504 | 526 | 746 | 128.73 | 0.01 |
| | B | 50.42 | | 978 | 758 | | |
| $F_6$ Large | A+H | 39.31 | 1738 | 292 | 683 | 369.00 | 0.01 |
| | B | 60.68 | | 1446 | 1055 | | |
| $F_7$ Normal | A+H | 48.82 | 1590 | 561 | 776 | 116.00 | 0.01 |
| | B | 51.17 | | 1039 | 814 | | |
| $F_7$ Large | A+H | 38.72 | 1606 | 186 | 622 | 499.00 | 0.01 |
| | B | 61.28 | | 1420 | 984 | | |
| On basis of theorical rate of homozygosity after correcting for each previous generation | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1359 | 980 | 1019 | 5.97 | 0.05 |
| | B | 25.00 | | 379 | 540 | | |
| $F_3$ Normal | A+H | 60.10 | 1391 | 804 | 836 | 3.07 | 0.05 |
| | B | 39.90 | | 587 | 555 | | |
| $F_3$ Large | A+H | 62.50 | 1368 | 652 | 855 | 128.00 | 0.01 |
| | B | 37.50 | | 716 | 513 | | |
| $F_4$ Normal | A+H | 52.02 | 1698 | 726 | 883 | 58.16 | 0.01 |
| | B | 47.98 | | 972 | 815 | | |
| $F_4$ Large | A+H | 42.89 | 1699 | 608 | 729 | 35.17 | 0.01 |
| | B | 57.11 | | 1031 | 970 | | |

Table 18. (concl.)

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| $F_5$ Normal | A+H | 40.39 | 1650 | 751 | 666 | 18.18 | 0.01 |
| | B | 59.61 | | 899 | 984 | | |
| $F_5$ Large | A+H | 33.82 | 1323 | 540 | 447 | 29.22 | 0.01 |
| | B | 66.18 | | 783 | 876 | | |
| $F_6$ Normal | A+H | 52.88 | 1504 | 526 | 795 | 193.00 | 0.01 |
| | B | 47.12 | | 978 | 709 | | |
| $F_6$ Large | A+H | 29.62 | 1738 | 292 | 689 | 379.00 | 0.01 |
| | B | 60.38 | | 1446 | 1049 | | |
| $F_7$ Normal | A+H | 34.44 | 1590 | 561 | 548 | 0.47 | 0.50 |
| | B | 65.56 | | 1029 | 1042 | | |
| $F_7$ Large | A+H | 16.55 | 1606 | 186 | 266 | 2.89 | 0.10 |
| | B | 83.46 | | 1420 | 1340 | | |

# RESULTS FROM THE COMANCHE X CHIEFKAN SEGREGATES

The procedure used with the Comanche x Chiefkan segregates was the same as described for the Tenmarq x Chiefkan segregates. The summarized data from the $F_4$ generation of bearded and awnless progenies are presented in Table 19. The average date of first heading and the average plant height did not differ enough to be of practical significance. The analysis of variance summaries for yield and test weight are presented in Table 20.

The yield analysis in Table 19 indicates that the bearded segregates are higher yielding than the awnless segregates in the $F_4$ generation. The test weight analysis indicates that the bearded segregates were also higher in test weight than were the awnless segregates in this generation.

The summarized data for the $F_5$ generation are presented in Table 21. Test weights were not taken in this year and only estimated test weights are presented in Table 21. These estimated test weights were not analyzed. The average date of first heading and the average plant height again showed little difference between the bearded and the awnless segregates. The analysis of variance summary for yield is presented in Table 22.

The paired data analysis was used on 25 pairs of bearded and awnless segregates. These segregates were sister plants in the $F_3$. The results from this analysis indicated that the bearded lines were higher yielding than the awnless lines with the probability at the 0.025 level. The same 25 pairs placed in two replications in a randomized block and analyzed as shown

Table 19. A summary of agronomic data comparisons between bearded and awnless $F_4$ segregates from a Comanche x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test weight/17cc | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 17 | 19 | 37 | 34 | 30.2 | 19.1 | 27.9 | 25.4 |
| 19 | 17 | 37 | 35 | 20.2 | 21.6 | 28.2 | 27.2 |
| 18 | 19 | 36 | 34 | 25.1 | 20.2 | 26.1 | 28.1 |
| 20 | 20 | 38 | 36 | 29.4 | 20.3 | 28.3 | 27.3 |
| 19 | 19 | 34 | 36 | 26.9 | 19.9 | 27.6 | 26.7 |
| 21 | 18 | 37 | 36 | 27.9 | 21.9 | 27.4 | 27.0 |
| 19 | 20 | 38 | 37 | 32.5 | 22.3 | 27.1 | 27.2 |
| 21 | 20 | 37 | 35 | 26.3 | 22.5 | 27.7 | 26.6 |
| 19 | 18 | 37 | 36 | 26.9 | 23.3 | 27.9 | 26.7 |
| 21 | 19 | 38 | 36 | 27.3 | 27.1 | 28.3 | 26.8 |
| 22 | 20 | 38 | 37 | 26.2 | 19.4 | 28.0 | 27.8 |
| 19 | 21 | 38 | 37 | 30.8 | 20.0 | 27.7 | 27.3 |
| 20 | 21 | 37 | 37 | 28.7 | 26.3 | 27.6 | 27.1 |
| 17 | 21 | 37 | 38 | 28.8 | 27.9 | 28.0 | 26.3 |
| 19 | 20 | 34 | 38 | 24.7 | 19.9 | 28.1 | 27.2 |
| 20 | 18 | 36 | 33 | 20.0 | 16.6 | 28.0 | 27.0 |
| 21 | 17 | 38 | 34 | 27.0 | 18.1 | 27.2 | 27.2 |
| 18 | 22 | 35 | 36 | 25.1 | 13.9 | 27.8 | 26.9 |
| 20 | 22 | 36 | 37 | 27.1 | 22.1 | 28.4 | 27.4 |
| 20 | 19 | 37 | 36 | 22.2 | 19.5 | 27.7 | 26.8 |
| 23 | 21 | 38 | 38 | 30.0 | 21.5 | 27.5 | 27.1 |
| 22 | 23 | 38 | 38 | 22.7 | 22.5 | 27.1 | 26.2 |
| 19 | 17 | 37 | 38 | 24.0 | 27.1 | 27.6 | 26.4 |
| 19 | 18 | 38 | 38 | 26.4 | 19.5 | 27.6 | 26.1 |
| 23 | 23 | 39 | 37 | 25.9 | 23.9 | 26.8 | 26.7 |
| Averages | | | | | | | |
| 19.84 | 19.68 | 37.00 | 36.28 | 26.49 | 21.46 | 27.66 | 26.90 |
| Parent averages | | | | | | | |
| 17.83 | 22.67 | 33.83 | 39.00 | 24.33 | 23.20 | 26.83 | 27.50 |

Table 20. Analysis of variance of yield and test weight data summarized in table 19 for bearded and awnless Comanche x Chiefkan $F_4$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 15,006 | 25.1 | 0.001 |
| Between replications | 1 | 204.49 | 2.92 | 0.50 |
| Error | 97 | 597.7 | | |
| | | Test weight | | |
| Between awns | 1 | 20.20 | 70.8 | 0.005 |
| Between replications | 1 | 0.01 | 28.52 | 0.25 |
| Error | 97 | 0.2852 | | |

Table 21. A summary of agronomic data comparisons between bearded and awnleas $F_5$ segregates that were sister pairs in the $F_3$ from a Comanche x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 25 | 26 | 37 | 39 | 31.0 | 25.4 | 58.2 | 57.5 |
| 25 | 27 | 38 | 40 | 26.9 | 28.0 | 59.3 | 58.5 |
| 27 | 27 | 38 | 39 | 27.2 | 27.7 | 59.0 | 57.8 |
| 26 | 28 | 38 | 40 | 26.6 | 19.4 | 57.7 | 57.3 |
| 27 | 27 | 38 | 40 | 24.6 | 30.1 | 57.5 | 57.3 |
| 24 | 26 | 36 | 39 | 29.7 | 26.7 | 59.7 | 59.0 |
| 27 | 26 | 38 | 37 | 32.4 | 21.1 | 58.8 | 57.3 |
| 26 | 26 | 39 | 37 | 27.6 | 27.5 | 58.3 | 58.0 |
| 26 | 27 | 38 | 38 | 31.0 | 24.7 | 60.2 | 58.5 |
| 25 | 24 | 37 | 37 | 31.9 | 31.1 | 59.0 | 58.7 |
| 26 | 28 | 41 | 42 | 26.4 | 25.9 | 59.7 | 58.3 |
| 27 | 26 | 39 | 38 | 34.5 | 27.0 | 59.8 | 58.8 |
| 26 | 25 | 41 | 40 | 30.9 | 25.1 | 61.0 | 59.8 |
| 26 | 26 | 39 | 38 | 30.5 | 27.5 | 59.3 | 58.0 |
| 25 | 24 | 38 | 36 | 29.7 | 27.9 | 59.0 | 58.2 |
| 26 | 27 | 38 | 39 | 23.2 | 19.7 | 59.8 | 56.0 |
| 27 | 27 | 40 | 38 | 28.7 | 57.0 | 60.8 | 58.7 |
| 26 | 26 | 39 | 39 | 28.3 | 25.1 | 59.8 | 58.2 |
| 30 | 27 | 41 | 39 | 28.5 | 28.3 | 60.0 | 58.2 |
| 28 | 25 | 38 | 38 | 27.6 | 26.3 | 58.0 | 59.3 |
| 25 | 25 | 37 | 36 | 27.7 | 26.1 | 58.5 | 58.5 |
| 25 | 25 | 37 | 38 | 27.5 | 31.7 | 60.3 | 59.7 |
| 29 | 28 | 41 | 39 | 28.2 | 22.3 | 60.3 | 58.2 |
| 26 | 26 | 39 | 39 | 24.1 | 25.1 | 59.5 | 60.0 |
| 26 | 29 | 38 | 37 | 28.9 | 20.5 | 60.3 | 58.7 |
| Averages | | | | | | | |
| 26.24 | 26.32 | 38.52 | 38.48 | 28.54 | 25.89 | 59.35 | 58.34 |
| Parent averages | | | | | | | |
| 25.17 | 26.33 | 37.67 | 39.83 | 32.45 | 30.65 | 57.65 | 58.92 |

Table 22. Analysis of variance of yield data summarized in table 21 for bearded and awnless Comanche x Chiefkan $F_5$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| Between awns | 1 | 4,529 | 10.7 | 0.005 |
| Between replications | 1 | 5.29 | 79.8 | 0.10 |
| Error | 97 | 422.4 | | |

in Table 22 indicated the same results with the probability at the 0.005 level.

The summarized data for the $F_6$ generation are presented in Table 23. The average date of first heading and the average plant height were again very similar for the bearded and awnless segregates. The analysis of variance summaries for the yield and the test weight are presented in Table 24. The test weights were not taken on each replication but were taken on the composits seed from all three of the plots.

The paired data analysis computed on the 30 bearded and awnless segregates that were sisters in the $F_4$ indicated that the bearded lines were higher yielding than their sister awnless lines, the probability being at the 0.05 level. Table 24 analysis of yield summary computed on the same 30 segregates from two randomized blocks indicates the same results but at a probability level of 0.005. The analysis summary for the test weights indicates that the bearded lines have a heavier test weight than their sister awnless lines.

The statistical design for the $F_7$ comparison data was the split plot. The summarized data are presented in Table 25. The average height of plants and the average date of first heading were again nearly the same for both the bearded and the awnless segregates. The analysis of variance summaries for the yield and the test weight are presented in Table 26.

The yield analysis of Table 26 indicates that the bearded lines are higher yielding than their sister awnless lines. The test weight analysis of Table 26 indicates a difference in test

Table 23. A summary of agronomic data comparisons between bearded and awnless $F_6$ segregates that were sister pairs in the $F_4$ from a Comanche x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 3 | 4 | 37 | 37 | 32.7 | 25.2 | 60.0 | 60.0 |
| 4 | 6 | 38 | 37 | 29.5 | 33.1 | 61.5 | 62.1 |
| 3 | 4 | 39 | 39 | 48.3 | 33.1 | 62.5 | 61.5 |
| 6 | 5 | 38 | 38 | 30.7 | 28.6 | 63.0 | 62.0 |
| 6 | 7 | 39 | 38 | 36.5 | 35.2 | 63.0 | 62.0 |
| 3 | 3 | 38 | 38 | 37.1 | 35.9 | 63.5 | 62.5 |
| 3 | 2 | 36 | 37 | 34.4 | 33.7 | 62.5 | 63.0 |
| 8 | 4 | 37 | 37 | 33.3 | 30.5 | 62.0 | 61.5 |
| 6 | 6 | 38 | 38 | 33.9 | 31.1 | 61.5 | 61.0 |
| 5 | 5 | 38 | 38 | 36.9 | 37.3 | 63.5 | 64.5 |
| 4 | 4 | 38 | 39 | 36.5 | 36.5 | 64.0 | 63.0 |
| 6 | 7 | 38 | 38 | 42.8 | 29.9 | 62.0 | 61.5 |
| 6 | 6 | 38 | 37 | 35.1 | 32.5 | 63.0 | 62.0 |
| 6 | 6 | 39 | 37 | 38.3 | 38.6 | 63.5 | 62.0 |
| 1 | 1 | 38 | 37 | 33.2 | 37.8 | 64.0 | 63.0 |
| 1 | 2 | 38 | 38 | 43.6 | 39.2 | 63.0 | 62.0 |
| 2 | 1 | 38 | 37 | 39.2 | 33.5 | 63.5 | 61.5 |
| 2 | 3 | 39 | 38 | 43.5 | 34.4 | 63.5 | 62.0 |
| 2 | 3 | 38 | 38 | 37.0 | 37.9 | 62.5 | 61.0 |
| 1 | 2 | 38 | 39 | 40.2 | 30.5 | 62.5 | 61.5 |
| 7 | 9 | 40 | 40 | 35.9 | 37.3 | 62.5 | 62.0 |
| 7 | 4 | 40 | 38 | 36.3 | 35.3 | 62.5 | 63.0 |
| 2 | 5 | 38 | 39 | 35.7 | 33.9 | 63.0 | 62.0 |
| 8 | 8 | 40 | 40 | 33.2 | 28.1 | 62.0 | 61.5 |
| 5 | 4 | 40 | 38 | 31.1 | 34.5 | 61.0 | 61.5 |
| 3 | 6 | 37 | 38 | 38.7 | 34.1 | 64.5 | 62.5 |
| 2 | 6 | 37 | 38 | 42.6 | 27.9 | 62.5 | 61.5 |
| 4 | 3 | 37 | 38 | 37.4 | 33.3 | 62.0 | 62.5 |
| 6 | 8 | 38 | 40 | 32.7 | 28.5 | 62.0 | 61.0 |
| 4 | 4 | 38 | 37 | 32.2 | 39.1 | 61.5 | 61.0 |
| Averages | | | | | | | |
| 4.2 | 4.6 | 38.17 | 38.03 | 36.62 | 33.55 | 62.63 | 61.92 |
| Parent averages | | | | | | | |
| 2.5 | 6.5 | 37.17 | 39.67 | 36.60 | 38.20 | 61.50 | 62.50 |

Table 24. Analysis of variance of yield and test weight data summarized in table 22 for bearded and awnless Comanche x Chiefkan $F_6$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 6,675 | 8.48 | 0.005 |
| Between replications | 1 | 1,519 | 1.93 | 0.25 |
| Error | 117 | 786.8 | | |
| | | Test weight | | |
| Between awns | 1 | 7 | 8.286 | 0.005 |
| Error | 58 | 0.8448 | | |

Table 25. A summary of sgronomic data comparisons between bearded and awnless $F_7$ segregates that were sister pairs in the $F_5$ from a Comanche x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 18 | 18 | 35 | 35 | 32.7 | 28.3 | 60.5 | 60.0 |
| 18 | 18 | 34 | 33 | 24.5 | 21.8 | 60.0 | 60.0 |
| 17 | 17 | 38 | 37 | 33.1 | 25.7 | 61.0 | 59.5 |
| 17 | 17 | 37 | 36 | 32.9 | 30.1 | 60.5 | 60.5 |
| 18 | 19 | 37 | 39 | 30.0 | 27.8 | 61.0 | 60.5 |
| 19 | 19 | 39 | 37 | 31.1 | 33.5 | 60.5 | 59.0 |
| 21 | 21 | 40 | 40 | 38.9 | 29.3 | 60.5 | 60.5 |
| 19 | 19 | 38 | 38 | 34.8 | 31.9 | 60.5 | 60.0 |
| 20 | 20 | 37 | 38 | 26.3 | 28.0 | 60.0 | 60.0 |
| 21 | 21 | 39 | 40 | 27.1 | 29.9 | 58.0 | 59.0 |
| 21 | 20 | 39 | 41 | 35.9 | 36.9 | 59.0 | 58.5 |
| 22 | 22 | 41 | 42 | 32.7 | 32.4 | 59.0 | 59.5 |
| 21 | 20 | 41 | 41 | 34.7 | 37.0 | 59.0 | 59.0 |
| 16 | 16 | 41 | 40 | 35.3 | 34.8 | 60.0 | 58.5 |
| 17 | 17 | 40 | 39 | 33.3 | 31.6 | 60.0 | 59.5 |
| 17 | 18 | 38 | 37 | 32.7 | 33.1 | 60.0 | 60.5 |
| 17 | 17 | 40 | 39 | 33.2 | 28.1 | 60.0 | 60.0 |
| 23 | 23 | 42 | 44 | 29.5 | 33.4 | 59.5 | 59.0 |
| 21 | 21 | 38 | 37 | 29.4 | 22.7 | 61.0 | 59.0 |
| 20 | 20 | 40 | 41 | 34.9 | 30.0 | 59.0 | 58.0 |
| 22 | 22 | 41 | 42 | 29.3 | 30.3 | 60.0 | 60.0 |
| 20 | 17 | 40 | 37 | 34.5 | 31.3 | 62.0 | 60.0 |
| 21 | 20 | 39 | 39 | 28.9 | 28.9 | 62.0 | 61.0 |
| 21 | 21 | 40 | 40 | 33.9 | 33.9 | 62.0 | 60.5 |
| 19 | 20 | 39 | 40 | 33.4 | 32.9 | 59.5 | 59.5 |
| 19 | 18 | 39 | 37 | 30.9 | 29.9 | 62.0 | 61.0 |
| 20 | 19 | 40 | 39 | 27.1 | 31.2 | 59.5 | 59.5 |
| 18 | 18 | 37 | 36 | 28.3 | 30.8 | 60.0 | 59.5 |
| 21 | 22 | 41 | 41 | 31.9 | 28.2 | 61.5 | 60.0 |
| 22 | 22 | 42 | 42 | 26.5 | 30.9 | 62.0 | 60.5 |
| Averages | | | | | | | |
| 19.53 | 19.40 | 39.07 | 38.90 | 31.59 | 30.49 | 60.32 | 59.73 |
| Parent averages | | | | | | | |
| 17.83 | 21.83 | 38.17 | 41.67 | 31.40 | 30.74 | 59.25 | 59.75 |

Table 26. Analysis of variance of yield and test weight data summarized in table 25 for bearded and awnless Comanche x Chiefkan $F_7$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between lines | 29 | 1,269.7 | 2.0569 | 0.01 |
| Between replications | 2 | 23,798 | 38.552 | 0.005 |
| Error a | 58 | 617.29 | | |
| Between awns | 1 | 1,378 | 2.948 | 0.10 |
| Awns x lines | 29 | 467.45 | 1.5689 | 0.05 |
| Error b | 58 | 297.95 | | |
| | | Test weight | | |
| Between lines | 29 | 0.6897 | 1.67 | 0.10 |
| Between awns | 1 | 3.0 | 7.25 | 0.01 |
| Error | 29 | 0.4138 | | |

weight between the bearded and awnless segregates, the bearded lines having the higher test weight in the $F_7$ generation. The test weights were again taken on bulked seed from the three plots.

The backcross procedure was also the same as described before. The summarized data for the backcrosses of Comanche x Chiefkan segregates to their recurrent parents are given in Table 27. The analysis of variance summary for the yield, the test weight and the weight of 500 kernels are presented in Table 28. All weights of 500 kernels were taken on composite samples of the bulked three plots from the three replications.

Table 28 yield analysis indicates that the difference between bearded and awnless segregates from the first backcross is not consistent, but depends upon the variety used as the recurrent parent. If Chiefkan is used as the recurrent parent the bearded segregates are higher yielding than the awnless segregates. If Comanche is used as the recurrent parent, no difference between the yield of the bearded and awnless segregates is indicated. The test weight analysis of Table 28 indicates that the awn effect on test weight depends upon using Chiefkan as the recurrent parent. When Chiefkan is used as the recurrent parent the bearded segregates have a higher test weight than the awnless segregates. The analysis of variance for the weight of 500 kernels fails to indicate any difference between the bearded and awnless segregates in this respect.

The analysis of variance summaries for the yield, the test weight and the weight of 500 kernels for the second backcross and

Table 27. Agronomic data comparisons between bearded and awnless segregates that were obtained from backcrossing one to four times to the recurrent parent.

| Year | First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs./bu. | | Wt. 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| | | | | | Chiefkan x Comanche$_2$ | | | | | |
| 1944 | 25 | 25 | 39 | 39 | 31.6 | 30.9 | 58.8 | 56.5 | 13.20 | 12.28 |
| 1945 | 26 | 26 | 43 | 43 | 26.5 | 20.1 | 56.6 | 54.0 | 11.14 | 10.36 |
| 1946 | 2 | 3 | 38 | 39 | 31.8 | 36.9 | 59.5 | 58.8 | 16.73 | 16.03 |
| 1947 | 18 | 18 | 39 | 39 | 32.1 | 26.6 | 61.0 | 59.5 | 14.58 | 13.23 |
| | | | | | Chiefkan x Comanche$_3$ | | | | | |
| 1945 | 26 | 27 | 43 | 42 | 23.6 | 21.8 | 53.0 | 48.5 | 11.59 | 10.40 |
| 1946 | 2 | 2 | 38 | 37 | 38.2 | 35.2 | 59.1 | 57.7 | 17.40 | 15.86 |
| 1947 | 18 | 18 | 38 | 38 | 33.7 | 31.0 | 60.0 | 59.5 | 14.15 | 13.75 |
| | | | | | Chiefkan x Comanche$_4$ | | | | | |
| 1946 | 2 | 2 | 38 | 38 | 40.0 | 33.9 | 58.6 | 57.2 | 16.82 | 15.61 |
| 1947 | 18 | 18 | 40 | 38 | 34.0 | 33.5 | 60.0 | 58.5 | 13.63 | 12.93 |
| | | | | | Chiefkan x Comanche$_5$ | | | | | |
| 1947 | 19 | 18 | 42 | 39 | 34.3 | 34.3 | 60.0 | 59.0 | 13.60 | 12.75 |
| | | | | | Comanche x Chiefkan$_2$ | | | | | |
| 1944 | 26 | 26 | 40 | 40 | 34.9 | 24.8 | 60.3 | 56.8 | 14.25 | 11.51 |
| 1945 | 29 | 30 | 44 | 42 | 24.2 | 14.7 | 55.0 | 51.0 | 11.02 | 9.52 |
| 1946 | 5 | 7 | 40 | 39 | 33.9 | 30.9 | 60.7 | 59.2 | 17.27 | 14.75 |
| 1947 | 22 | 22 | 42 | 44 | 31.0 | 28.5 | 60.5 | 59.5 | 13.84 | 12.28 |

Table 27. (concl.)

| Year | First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs./bu. | | Wt. 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| Comanche x $Chiefkan_3$ | | | | | | | | | | |
| 1945 | 29 | 30 | 44 | 43 | 18.9 | 14.6 | 52.5 | 50.5 | 9.91 | 9.23 |
| 1946 | 6 | 6 | 39 | 40 | 35.6 | 33.6 | 60.8 | 59.8 | 16.69 | 15.28 |
| 1947 | 22 | 22 | 41 | 41 | 28.6 | 27.4 | 60.5 | 60.0 | 13.16 | 12.95 |
| Comanche x $Chiefkan_4$ | | | | | | | | | | |
| 1946 | 6 | 6 | 40 | 40 | 35.9 | 32.4 | 61.0 | 60.7 | 17.32 | 16.09 |
| 1947 | 21 | 22 | 40 | 39 | 24.9 | 27.0 | 60.0 | 60.5 | 13.32 | 13.38 |
| Comanche x $Chiefkan_5$ | | | | | | | | | | |
| 1947 | 22 | 22 | 43 | 40 | 22.3 | 22.8 | 60.0 | 60.0 | 12.53 | 12.28 |
| Parents | | | | | | | | | | |
| 1944 | 25 | 26 | 38 | 41 | 33.2 | 29.8 | 58.0 | 59.4 | 13.14 | 12.36 |
| 1945 | 26 | 29 | 43 | 45 | 25.4 | 20.1 | 54.0 | 54.5 | 11.90 | 10.30 |
| 1946 | 2 | 7 | 38 | 40 | 35.8 | 34.1 | 59.1 | 61.2 | 17.39 | 16.23 |
| 1947 | 18 | 21 | 41 | 39 | 34.0 | 22.7 | 60.0 | 60.0 | 14.33 | 13.17 |

Table 28. Analysis of variance of yield, test weight and weight of 500 kernels data obtained in 1944 and summarized in table 27 for bearded and awnless backcross segregates of a Comanche x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 574 | 2.4741 | 0.25 |
| Between replications | 2 | 1,171 | 5.0496 | 0.10 |
| Error a | 2 | 232 | | |
| Between awns | 1 | 8,694 | 1.3213 | 0.50 |
| Awns x recurrent parents | 1 | 6,580 | 30.8558 | 0.005 |
| Error b | 4 | 213.25 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 2.707 | 10.03 | 0.10 |
| Between replications | 2 | 0.0035 | 77.14 | 0.01 |
| Error a | 2 | 0.27 | | |
| Between awns | 1 | 24.94 | 21.86 | 0.25 |
| Awns x recurrent parents | 1 | 1.141 | 11.07 | 0.025 |
| Error b | 4 | 0.1032 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 0.0196 | 42.25 | 0.10 |
| Between awns | 1 | 3.3489 | 4.0441 | 0.25 |
| Error | 1 | 0.8281 | | |

the first backcross advanced one generation by selfing are presented in Table 29.

The yield analysis in Table 29 indicates that the bearded segregates are consistently higher yielding than are the awnless backcross segregates. The test weight analysis indicates the same results for test weight. It also indicates that the segregates that have been backcrossed only once are higher in test weight than the segregates that have been backcrossed the second time. The analysis summary for weight of 500 kernels indicates that the bearded segregates are higher in weight of 500 kernels than are the awnless segregates.

The analysis of variance summaries for the yield, the test weight, and the weight of 500 kernels data for the third backcross and the first and second backcrosses advanced a generation by selfing are presented in Table 30. The yield analysis of this table indicates that there is no consistent awn effect on yield, but that its effect depends upon the variety used as the recurrent parent and the number of backcrosses made. The test weight analysis indicates that the bearded segregates are consistently higher in test weight than the awnless segregates. It is interesting to note that the table also indicates that there is significantly less variation among the number of backcrosses than there is in the estimation of the population variation. This is probably due to sampling error. The analysis of the weight of 500 kernels indicates that the bearded segregates produce heavier kernels than the awnless segregates.

Table 29. Analysie of variance of yield, teet weight and weight of 500 kernele data, obtained in 1945, and eummarized in table 27 for bearded and awnlese backcrose eegregatee of a Comanche x Chiefkan croes.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 14,504 | 12.7005 | 0.10 |
| Between replicatione | 2 | 2,217 | 1.9413 | 0.50 |
| Error a | 2 | 1,142 | | |
| Between backoroesee | 1 | 1,568 | 1.69 | 0.50 |
| Error b | 5 | 2,648 | | |
| Between awne | 1 | 18,040 | 9.43 | 0.01 |
| Error c | 11 | 1,914 | | |
| | | Teet weight | | |
| Between recurrent parents | 1 | 0.7813 | 25.04 | 0.10 |
| Between baokcrossee | 1 | 5.2813 | 169.3 | 0.05 |
| Error a | 1 | 0.0312 | | |
| Between awne | 1 | 19.5313 | 23.03 | 0.025 |
| Error b | 3 | 0.848 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parente | 1 | 1.8145 | 4.06 | 0.25 |
| Between backcrosses | 1 | 0.1035 | 4.31 | 0.25 |
| Error a | 1 | 0.4465 | | |
| Between awns | 1 | 2.1528 | 29.94 | 0.01 |
| Error b | 3 | 0.0719 | | |

Table 30. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1946, and summarized in table 27 for bearded and awnless backcross segregates of a Comanche x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between reourrent parents | 1 | 4,738 | 2.0909 | 0.25 |
| Between replications | 2 | 9,251 | 4.0825 | 0.25 |
| Error a | 2 | 2,266 | | |
| Between backcrosses | 2 | 4,068 | 1.55 | 0.25 |
| Error b | 10 | 1,313 | | |
| Between awns | 1 | 3,906 | 1.81 | 0.25 |
| Awns x recurrent parents x backcrosses | 5 | 2,155 | 3.33 | 0.05 |
| Error c | 12 | 647 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 10.64 | 9.1724 | 0.10 |
| Between backorosses | 2 | 0.045 | 25.78 | 0.05 |
| Error a | 2 | 1.16 | | |
| Between awns | 1 | 3.31 | 35.5913 | 0.005 |
| Error b | 6 | 0.093 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 0.09187 | 3.82 | 0.50 |
| Between backcrosses | 2 | 0.07076 | 4.95 | 0.25 |
| Error a | 2 | 0.35055 | | |
| Between awns | 1 | 6.17767 | 33.91 | 0.005 |
| Error b | 5 | 0.18218 | | |

The analyeis of variance eummariee for the yield, the test weight and the weight of 500 kernels for the fourth baokcroee and the first, eeoond, and third backcrossee advanced another generation by selfing are preeented in Table 31. The yield analysie indieatee that when Comanohe is used as the recurrent parent higher yields are obtained than when Chiefkan is used ae the reourrent parent. This analysis also indieates that when Comanche is used as a reeurrent parent three or four times, higher yielde are obtained than when Chiefkan is used ae the recurrent parent, or when less baokcrosses to Comanche are used. This analysie fails to indicate any difference between the bearded and awnlese eegregates in regard to yield. The test weight analyeie indieates that the bearded eegregatee are higher in teet weight than the awnleee eegregates. The weight of 500 kernele analyeis indicates that the bearded segregates have a higher weight of 500 kernels than the awnlese segregates.

The natural eeleetion procedure for the Comanohe x Chiefkan bulks wae the same ae deeoribed for the Tenmarq x Chiefkan bulks. The summarized data obtained are presented in Table 32. The analyeis of variance summaries for the yield, the test weight, and the weight of 500 kernels between the normal bulks and the large seeded bulks are preeented in Table 33. The yield analysis of Table 33 fails to indioate any differenee in yield between the progeny of the large eeede and that of the normal eeeds. The test weight analyeis indioatos the test weights between the normal and large seed bulks could be the same. The weight of 500 kernels analyeis indioates that the larger kernels produce

Table 31. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1947, and summarized in Table 27 for bearded and awnless backcross segregates of a Comanche x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 41,184 | 126.92 | 0.01 |
| Between replications | 2 | 3,455 | 10.65 | 0.10 |
| Error a | 2 | 324.5 | | |
| Between backcrosses | 3 | 678.3 | 2.56 | 0.25 |
| Backcrosses x recurrent parents | 3 | 8,072 | 4.655 | 0.025 |
| Error b | 12 | 1,734 | | |
| Between awns | 1 | 1,825 | 2.02 | 0.10 |
| Error c | 23 | 903.4 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 0.7656 | 2.88 | 0.25 |
| Between backcrosses | 3 | 0.1406 | 1.89 | 0.50 |
| Error a | 3 | 0.2656 | | |
| Between awns | 1 | 1.8906 | 7.63 | 0.025 |
| Error b | 7 | 0.2477 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 1.4884 | 7.15 | 0.10 |
| Between backcrosses | 3 | 0.4422 | 2.12 | 0.25 |
| Error a | 3 | 0.2081 | | |
| Between awns | 1 | 1.7292 | 10.62 | 0.01 |
| Error b | 7 | 0.1629 | | |

Table 32. Comparison of agronomic data between normal bulk populations and a mechanically screened bulk population from the $F_2$ through the $F_7$ generation of a Comanche x Chiefkan cross.

| | Number of heads | | | | Yield | | Test weight | | Weight 500 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Normal seed | | Large seed | | bus./A. | | lbs. | | kernels/grams | |
| Generation | Awnless + heterozygous | Bearded | Awnless + heterozygous | Bearded | Normal | Large | Normal | Large | Normal | Large |
| $F_2$ | 1299 | 481 | Not taken | | 25.3 | 30.7 | 54.0 | 54.0 | 11.57 | 11.50 |
| $F_3$ | 1038 | 611 | 744 | 996 | 27.4 | 31.2 | 60.0 | 60.0 | 15.29 | 15.63 |
| $F_4$ | 1109 | 1063 | 529 | 1500 | 34.2 | 34.3 | 59.4 | 59.7 | 13.44 | 13.88 |
| $F_5$ | 1055 | 1047 | 641 | 1524 | 24.1 | 23.1 | 52.0 | 54.0 | 10.50 | 11.24 |
| $F_6$ | 1105 | 1424 | 345 | 2085 | 38.3 | 36.9 | 59.7 | 60.6 | 16.96 | 18.22 |
| $F_7$ | 690 | 1249 | 217 | 1685 | 30.4 | 31.7 | 60.5 | 61.0 | 14.57 | 15.75 |

Table 33. Analysis of variance summary of yield, test weight and weight of 500 kernels between a normal bulk population and a large seeded bulk population.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between years | 5 | 47.9873 | 12.95 | 0.025 |
| Between seed size | 1 | 5.6034 | 1.51 | 0.25 |
| Error | 5 | 3.7053 | | |
| | | Test weight | | |
| Between years | 5 | 24.3298 | 84.82 | 0.005 |
| Between seed size | 1 | 1.1408 | 3.98 | 0.10 |
| Error | 5 | 0.28684 | | |
| | | Weight of 500 kernels | | |
| Between years | 5 | 12.9366 | 98.02 | 0.005 |
| Between seed size | 1 | 1.2610 | 9.55 | 0.025 |
| Error | 5 | 0.13198 | | |

heavier kernels than the normal bulked seed produces.

The head counts and the Chi-square values are presented in Table 34. One part of this table indicates that there is an excess of bearded plants in each generation of both the normal and the screened bulk populations. The second part of the table indicates that when the expected numbers are computed from the observed numbers in the first head count, that only in the $F_3$ and in the $F_5$ generations do the observed numbers fit the expected numbers in the normal bulks. In the large seeded bulks there is still an excess of bearded heads in each generation. When the expected numbers are computed on the observed number of the previous generation, as shown in the third part of Table 34, the observed numbers fit the expected numbers in the $F_3$ and the $F_5$ generations of the normal bulk. In the rest of the normal bulk generations and in all of the large seeded bulk generations there is an excess of the bearded plants as shown by the observed and expected numbers and the Chi-square values.

Table 34. Chi-square values and probabilities of observed bearded and awnless plus heterozygous head counts from segregating normal and screened bulk populations in a Comanche x Chiefkan cross.

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| On basis of theorical rate of homozygosity | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1780 | 1299 | 1335 | 3.88 | 0.05 |
| | B | 25.00 | | 481 | 445 | | |
| $F_3$ Normal | A+H | 62.50 | 1649 | 1038 | 1031 | 0.84 | 0.40 |
| | B | 37.50 | | 611 | 618 | | |
| $F_3$ Large | A+H | 62.50 | 1740 | 744 | 1088 | 290.00 | 0.01 |
| | B | 37.50 | | 996 | 652 | | |
| $F_4$ Normal | A+H | 56.25 | 2172 | 1109 | 1222 | 23.89 | 0.01 |
| | B | 43.75 | | 1063 | 950 | | |
| $F_4$ Large | A+H | 56.25 | 2029 | 529 | 1141 | 750.00 | 0.01 |
| | B | 43.75 | | 1500 | 888 | | |
| $F_5$ Normal | A+H | 53.12 | 2102 | 1055 | 1117 | 7.34 | 0.01 |
| | B | 46.87 | | 1047 | 985 | | |
| $F_5$ Large | A+H | 53.12 | 2165 | 641 | 1150 | 480.50 | 0.01 |
| | B | 46.87 | | 1524 | 1015 | | |
| $F_6$ Normal | A+H | 51.56 | 2529 | 1105 | 1304 | 62.70 | 0.01 |
| | B | 48.44 | | 1424 | 1225 | | |
| $F_6$ Large | A+H | 51.56 | 2439 | 354 | 1258 | 1341.00 | 0.01 |
| | B | 48.44 | | 2085 | 1181 | | |
| $F_7$ Normal | A+H | 50.78 | 1939 | 690 | 985 | 179.60 | 0.01 |
| | B | 49.22 | | 1249 | 954 | | |
| $F_7$ Large | A+H | 50.78 | 1902 | 217 | 966 | 1180.00 | 0.01 |
| | B | 49.22 | | 1685 | 936 | | |
| On basis of theorical rate of homozygosity after correction of first head count | | | | | | | |
| $F_2$ Normal | A+H | 72.98 | 1780 | 1299 | 1299 | | |
| | B | 27.02 | | 481 | 481 | | |

Table 34. (cont.)

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| $F_3$ Normal | A+H | 60.82 | 1649 | 1038 | 1003 | 3.12 | 0.08 |
| | B | 39.18 | | 611 | 646 | | |
| $F_3$ Large | A+H | 42.76 | 1740 | 744 | 744 | | |
| | B | 57.24 | | 996 | 996 | | |
| $F_4$ Normal | A+H | 54.73 | 2172 | 1109 | 1189 | 11.89 | 0.01 |
| | B | 42.26 | | 1063 | 983 | | |
| $F_4$ Large | A+H | 38.49 | 2029 | 529 | 781 | 132.20 | 0.01 |
| | B | 61.52 | | 1500 | 1248 | | |
| $F_5$ Normal | A+H | 51.69 | 2102 | 1055 | 1087 | 1.95 | 0.20 |
| | B | 48.30 | | 1047 | 1015 | | |
| $F_5$ Large | A+H | 36.35 | 2165 | 641 | 787 | 42.55 | 0.01 |
| | B | 63.65 | | 1524 | 1378 | | |
| $F_6$ Normal | A+H | 50.17 | 2529 | 1105 | 1269 | 42.54 | 0.01 |
| | B | 49.82 | | 1424 | 1260 | | |
| $F_6$ Large | A+H | 35.29 | 2439 | 354 | 861 | 461.45 | 0.01 |
| | B | 64.72 | | 2085 | 1578 | | |
| $F_7$ Normal | A+H | 49.41 | 1939 | 690 | 958 | 148.19 | 0.01 |
| | B | 50.58 | | 1249 | 981 | | |
| $F_7$ Large | A+H | 34.75 | 1902 | 217 | 661 | 459.09 | 0.01 |
| | B | 65.25 | | 1685 | 1241 | | |
| On basis of theorical rate of homozygosity after correcting for each previous generation | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1780 | 1299 | 1335 | 3.88 | 0.05 |
| | B | 25.00 | | 481 | 445 | | |
| $F_3$ Normal | A+H | 60.82 | 1649 | 1038 | 1003 | 3.12 | 0.08 |
| | B | 39.18 | | 611 | 646 | | |
| $F_3$ Large | A+H | 62.50 | 1740 | 744 | 1008 | 290.00 | 0.01 |
| | B | 37.50 | | 996 | 652 | | |
| $F_4$ Normal | A+H | 56.66 | 2172 | 1109 | 1231 | 27.99 | 0.01 |
| | B | 43.35 | | 1063 | 941 | | |

Table 34. (concl.)

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| $F_4$ Large | A+H | 38.49 | 2029 | 529 | 781 | 132.20 | 0.01 |
| | B | 61.52 | | 1500 | 1248 | | |
| $F_5$ Normal | A+H | 48.23 | 2102 | 1055 | 1014 | 3.20 | 0.07 |
| | B | 51.78 | | 1047 | 1088 | | |
| $F_5$ Large | A+H | 36.35 | 2165 | 641 | 787 | 42.55 | 0.01 |
| | B | 63.65 | | 1524 | 1378 | | |
| $F_6$ Normal | A+H | 48.72 | 2529 | 1105 | 1232 | 25.53 | 0.01 |
| | B | 51.29 | | 1424 | 1297 | | |
| $F_6$ Large | A+H | 28.74 | 2439 | 354 | 701 | 241.05 | 0.01 |
| | B | 71.26 | | 2085 | 1738 | | |
| $F_7$ Normal | A+H | 43.03 | 1939 | 690 | 834 | 43.62 | 0.01 |
| | B | 56.97 | | 1249 | 1105 | | |
| $F_7$ Large | A+H | 13.85 | 1902 | 217 | 263 | 9.34 | 0.01 |
| | B | 86.15 | | 1685 | 1639 | | |

## RESULTS FROM THE CHEYENNE X CHIEFKAN SEGREGATES

The procedures used with the Cheyenne x Chiefkan segregates were the same as described for the Tenmarq x Chiefkan segregates. The summarized data for the progeny of bearded and awnless plant selections selected at random from $F_2$ plants are presented in Table 35. The analysis of variance summaries for the yield and the test weight are presented in Table 36. In all generations of this cross there was not enough difference between the bearded and the awnless segregates date of first heading and plant height to be of practical importance and were not analyzed statistically.

The yield analysis as given in Table 36 indicates that in the $F_4$ generation the bearded segregates are higher yielding than the awnless segregates. The test weight analysis indicates the same results for test weight.

The summarized data for the $F_5$ generation are presented in Table 37. Actual test weights were not taken in this year but the estimated test weights are given in Table 37. These estimated test weight data were not analyzed. The analysis of variance for the $F_5$ yield data is presented in Table 38.

The paired data analysis was used on 25 pairs of bearded and awnless segregates in the $F_5$ that were sister pairs in the $F_3$. The results indicated that the bearded lines were higher yielding than the awnless segregates, the probability at the 0.01 level. The same 25 pairs placed in a randomized block and analyzed as shown in Table 38 indicated that there is no

Table 35. Plot averages of agronomic data for three replications of bearded and awnless $F_4$ segregates from a Cheyenne x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test weight/17cc | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 24 | 24 | 40 | 37 | 28.1 | 28.7 | 26.7 | 26.1 |
| 23 | 22 | 39 | 40 | 25.9 | 23.2 | 27.5 | 26.6 |
| 24 | 25 | 38 | 37 | 29.1 | 21.3 | 26.6 | 26.2 |
| 22 | 23 | 35 | 36 | 26.9 | 21.8 | 26.9 | 27.2 |
| 23 | 22 | 37 | 36 | 23.4 | 24.7 | 26.9 | 26.1 |
| 22 | 22 | 38 | 37 | 30.5 | 24.4 | 27.3 | 26.6 |
| 22 | 24 | 38 | 37 | 24.7 | 21.2 | 27.6 | 26.8 |
| 24 | 24 | 37 | 36 | 22.3 | 22.7 | 27.1 | 26.4 |
| 22 | 25 | 39 | 37 | 24.9 | 22.5 | 27.0 | 26.8 |
| 22 | 24 | 37 | 38 | 26.5 | 22.2 | 28.0 | 26.2 |
| 22 | 24 | 36 | 39 | 22.0 | 27.0 | 26.8 | 26.7 |
| 23 | 24 | 40 | 38 | 29.7 | 22.7 | 27.5 | 26.7 |
| 24 | 25 | 38 | 38 | 27.3 | 35.5 | 27.8 | 26.3 |
| 22 | 23 | 38 | 39 | 22.0 | 24.0 | 27.0 | 26.4 |
| 21 | 24 | 38 | 38 | 21.8 | 21.3 | 26.6 | 26.2 |
| 23 | 24 | 36 | 38 | 20.7 | 18.7 | 26.8 | 26.5 |
| 22 | 24 | 41 | 39 | 29.3 | 20.6 | 26.7 | 26.3 |
| 24 | 24 | 39 | 38 | 24.5 | 24.9 | 27.1 | 26.4 |
| 24 | 23 | 38 | 39 | 27.4 | 26.3 | 27.1 | 26.5 |
| 24 | 27 | 40 | 41 | 33.0 | 25.2 | 27.0 | 26.2 |
| 24 | 23 | 38 | 40 | 22.7 | 21.6 | 26.8 | 25.5 |
| 22 | 24 | 38 | 39 | 24.7 | 20.1 | 27.3 | 25.9 |
| 23 | 24 | 39 | 40 | 30.3 | 22.5 | 26.9 | 26.5 |
| 24 | 25 | 40 | 39 | 26.8 | 24.8 | 27.7 | 26.7 |
| 25 | 23 | 40 | 40 | 27.5 | 23.8 | 27.0 | 26.6 |
| Averages | | | | | | | |
| 23.00 | 23.84 | 38.28 | 38.24 | 26.08 | 23.67 | 27.11 | 26.42 |
| Parent averages | | | | | | | |
| 23.18 | 22.00 | 36.18 | 39.67 | 27.15 | 25.30 | 27.15 | 26.80 |

Table 36. Analysis of variance of yield and test weight data summarized in table 35 for the $F_4$ bearded and awnless segregates of the Cheyenne x Chiefkan.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 5,126 | 10.85 | 0.005 |
| Between replications | 1 | 1,076 | 2.28 | 0.10 |
| Error | 97 | 472.4 | | |
| | | Test weight | | |
| Between awns | 1 | 11.42 | 54.64 | 0.005 |
| Between replications | 1 | 0.14 | 1.49 | 0.50 |
| Error | 97 | 0.209 | | |

Table 37. A summary of agronomic data comparisons between bearded and awnless $F_5$ segregates that were sister pairs in the $F_3$ from the Cheyenne x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 29 | 30 | 39 | 41 | 24.1 | 27.9 | 59.5 | 58.5 |
| 29 | 29 | 41 | 39 | 26.4 | 19.2 | 57.8 | 55.8 |
| 30 | 30 | 39 | 39 | 19.9 | 25.3 | 58.2 | 58.2 |
| 30 | 28 | 40 | 41 | 23.7 | 21.1 | 58.5 | 57.2 |
| 28 | 28 | 40 | 41 | 26.9 | 24.3 | 59.2 | 58.7 |
| 29 | 29 | 40 | 40 | 22.3 | 25.9 | 58.3 | 58.8 |
| 28 | 29 | 39 | 38 | 27.9 | 24.7 | 59.3 | 58.2 |
| 26 | 26 | 38 | 39 | 23.6 | 24.1 | 59.3 | 58.2 |
| 28 | 29 | 40 | 41 | 29.3 | 24.1 | 60.2 | 58.3 |
| 28 | 26 | 39 | 38 | 26.7 | 27.6 | 60.2 | 59.8 |
| 29 | 29 | 41 | 40 | 26.1 | 22.9 | 59.0 | 58.2 |
| 27 | 27 | 42 | 40 | 30.4 | 28.1 | 61.0 | 59.8 |
| 28 | 28 | 40 | 40 | 29.0 | 27.9 | 59.7 | 59.5 |
| 28 | 29 | 40 | 40 | 28.1 | 30.5 | 60.0 | 59.8 |
| 27 | 28 | 42 | 40 | 31.5 | 22.0 | 60.8 | 59.5 |
| 29 | 29 | 41 | 43 | 27.0 | 25.7 | 60.0 | 59.2 |
| 28 | 28 | 41 | 40 | 23.0 | 24.5 | 58.5 | 58.5 |
| 28 | 28 | 40 | 40 | 23.9 | 25.7 | 59.0 | 58.0 |
| 29 | 28 | 40 | 38 | 29.6 | 26.6 | 60.7 | 59.2 |
| 28 | 28 | 40 | 39 | 30.3 | 22.5 | 59.2 | 57.0 |
| 28 | 29 | 41 | 40 | 24.3 | 17.1 | 57.5 | 56.2 |
| 29 | 29 | 40 | 41 | 24.3 | 20.8 | 58.3 | 59.0 |
| 28 | 28 | 42 | 41 | 26.3 | 24.8 | 58.0 | 57.7 |
| 29 | 29 | 40 | 39 | 25.7 | 23.1 | 57.0 | 57.0 |
| 30 | 30 | 40 | 40 | 25.8 | 24.8 | 57.5 | 57.5 |
| Averages | | | | | | | |
| 28.40 | 28.44 | 40.20 | 39.92 | 26.24 | 24.45 | 59.07 | 58.31 |
| Parent averages | | | | | | | |
| 29.00 | 26.65 | 39.83 | 39.83 | 26.30 | 27.75 | 57.05 | 59.40 |

Table 38. Analysis of variance of yield data summarized in table 37 for bearded and awnless segregates from Cheyenne x Chiefkan.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 306.25 | 1.25 | 0.50 |
| Between replications | 1 | 114.49 | 3.33 | 0.50 |
| Error | 97 | 381.48 | | |

difference between the yields of the bearded segregates and the yield of the awnless segregates.

The summarized data for the $F_6$ generation are presented in Table 39. The analysis of variance summaries for the yield and the test weight are presented in Table 40.

The paired data analysis was oomputed on 30 bearded and awnless segregates that were sister pairs in the $F_4$ and the results indicated that there was no difference between the bearded and the awnless segregatee in yield in the $F_6$, the probability being 0.50. The analysis of variance of the yield data as shown in Table 40 indioates that the awnless segregates are higher yielding than the bearded segregatee with a probability of 0.05. The test weight analyeis indicates that the bearded and awnless segregates do not differ in thie respeot.

The statistioal design for the $F_7$ oomparison data was the eplit plot. The summarized data are presented in Table 41. The analysis of variance eummaries for yield and teat weight are presented in Table 42.

The yield analysie presented in Table 42 indioates the difference in the yield of the bearded and awnlees plants in the $F_7$ generation depende upon the replication. The bearded segregatee were the higher yielders under the oonditions of the third replication. The test weight analyeis indioates that the bearded eegregates produce seed which has a higher test weight than that produced by the awnless segregates.

The baokoroes procedures for the Cheyenne x Chiefkan segregates were the same as described earlier for the other crosses.

Table 39. A summary of agronomic data comparisons between bearded and awnless $F_6$ segregates that were sister pairs in the $F_4$ from a Cheyenne x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 12 | 13 | 42 | 41 | 32.5 | 28.1 | 60.5 | 60.0 |
| 11 | 11 | 42 | 41 | 25.7 | 29.3 | 61.0 | 59.5 |
| 12 | 11 | 40 | 42 | 33.7 | 32.7 | 61.0 | 61.0 |
| 7 | 7 | 37 | 39 | 25.9 | 32.1 | 60.5 | 60.0 |
| 7 | 8 | 41 | 42 | 31.3 | 39.3 | 61.0 | 62.0 |
| 9 | 9 | 41 | 41 | 31.9 | 34.8 | 60.5 | 60.0 |
| 9 | 8 | 41 | 40 | 31.5 | 36.1 | 60.0 | 61.0 |
| 8 | 7 | 42 | 43 | 33.3 | 36.3 | 61.0 | 61.0 |
| 10 | 12 | 42 | 42 | 33.6 | 28.9 | 60.5 | 60.0 |
| 10 | 12 | 42 | 40 | 31.2 | 25.6 | 60.5 | 60.0 |
| 11 | 9 | 41 | 41 | 27.4 | 34.1 | 59.5 | 60.0 |
| 9 | 10 | 41 | 42 | 28.5 | 31.8 | 60.0 | 60.0 |
| 11 | 7 | 41 | 40 | 29.0 | 29.4 | 60.0 | 58.5 |
| 7 | 9 | 42 | 40 | 20.9 | 28.3 | 59.0 | 60.0 |
| 7 | 9 | 41 | 40 | 25.1 | 27.1 | 61.0 | 60.0 |
| 7 | 8 | 41 | 42 | 17.6 | 30.7 | 59.0 | 60.0 |
| 10 | 11 | 42 | 42 | 34.2 | 33.8 | 61.5 | 60.5 |
| 8 | 10 | 41 | 40 | 33.4 | 28.3 | 60.5 | 60.5 |
| 10 | 11 | 39 | 40 | 31.8 | 30.8 | 60.0 | 60.0 |
| 7 | 7 | 42 | 42 | 43.7 | 35.4 | 62.5 | 61.5 |
| 8 | 7 | 42 | 42 | 31.7 | 37.0 | 61.0 | 61.0 |
| 9 | 8 | 40 | 40 | 30.3 | 33.2 | 60.5 | 60.0 |
| 8 | 6 | 40 | 41 | 33.3 | 40.9 | 61.0 | 60.5 |
| 8 | 9 | 41 | 42 | 38.2 | 36.1 | 60.0 | 61.0 |
| 9 | 9 | 42 | 43 | 29.8 | 37.7 | 61.0 | 61.0 |
| 11 | 11 | 42 | 40 | 29.3 | 26.5 | 59.5 | 60.0 |
| 12 | 12 | 41 | 40 | 28.3 | 28.5 | 60.5 | 60.0 |
| 10 | 10 | 42 | 41 | 30.7 | 29.1 | 61.0 | 60.0 |
| 7 | 9 | 41 | 41 | 27.8 | 31.5 | 59.5 | 59.5 |
| 8 | 7 | 43 | 42 | 34.8 | 32.6 | 61.0 | 60.0 |
| Averages | | | | | | | |
| 9.07 | 9.23 | 41.17 | 41.07 | 30.55 | 32.20 | 60.48 | 60.28 |
| Parent averages | | | | | | | |
| 10.83 | 7.17 | 39.17 | 41.67 | 28.25 | 35.15 | 58.75 | 62.25 |

Table 40. Analysis of variance of yield and test weight data summarized in table 39 for bearded and awnless $F_6$ Cheyenne x Chiefkan segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between awns | 1 | 3,413 | 3.86 | 0.05 |
| Between replications | 1 | 1,141 | 1.29 | 0.25 |
| Error | 117 | 884 | | |
| | | Test weight | | |
| Between awns | 1 | 1.00 | 2.00 | 0.25 |
| Error | 58 | 0.50 | | |

Table 41. A summary of agronomic data comparisons between bearded and awnless $F_7$ segregates that were sister pairs in the $F_5$ from a Cheyenne x Chiefkan cross.

| First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | |
|---|---|---|---|---|---|---|---|
| Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| 23 | 24 | 46 | 45 | 31.7 | 34.0 | 60.0 | 60.5 |
| 24 | 25 | 46 | 44 | 26.8 | 23.0 | 59.5 | 58.5 |
| 21 | 22 | 43 | 42 | 35.3 | 35.1 | 60.0 | 60.0 |
| 22 | 21 | 42 | 43 | 36.3 | 31.9 | 61.0 | 60.5 |
| 21 | 22 | 44 | 45 | 34.4 | 35.6 | 61.0 | 60.5 |
| 22 | 21 | 47 | 46 | 36.3 | 29.9 | 61.5 | 61.0 |
| 21 | 21 | 45 | 46 | 30.7 | 31.0 | 61.0 | 60.5 |
| 23 | 23 | 47 | 47 | 30.0 | 26.9 | 60.5 | 60.0 |
| 21 | 21 | 44 | 42 | 34.8 | 36.0 | 60.0 | 60.0 |
| 25 | 24 | 45 | 44 | 38.4 | 31.9 | 61.5 | 61.0 |
| 24 | 23 | 47 | 47 | 38.5 | 34.5 | 60.0 | 60.0 |
| 22 | 22 | 48 | 48 | 36.5 | 36.1 | 60.5 | 60.0 |
| 21 | 23 | 48 | 46 | 40.0 | 30.7 | 60.5 | 59.5 |
| 22 | 23 | 44 | 43 | 33.5 | 30.5 | 60.0 | 60.0 |
| 22 | 22 | 45 | 44 | 32.6 | 31.3 | 60.0 | 59.0 |
| 21 | 22 | 44 | 44 | 24.9 | 26.9 | 60.0 | 58.0 |
| 23 | 23 | 45 | 44 | 26.6 | 27.9 | 60.0 | 59.0 |
| 22 | 22 | 46 | 45 | 30.7 | 25.1 | 60.0 | 58.5 |
| 22 | 23 | 44 | 43 | 30.1 | 34.3 | 59.5 | 59.5 |
| 26 | 25 | 45 | 44 | 33.2 | 29.0 | 60.0 | 59.5 |
| 22 | 22 | 43 | 45 | 37.0 | 30.7 | 59.5 | 59.0 |
| 23 | 23 | 45 | 45 | 42.3 | 45.1 | 60.5 | 60.5 |
| 25 | 23 | 46 | 47 | 39.9 | 35.5 | 59.5 | 60.0 |
| 24 | 22 | 47 | 47 | 30.8 | 26.2 | 58.5 | 58.0 |
| 21 | 21 | 48 | 48 | 34.7 | 29.3 | 60.5 | 60.0 |
| 21 | 21 | 47 | 47 | 30.5 | 26.1 | 59.5 | 59.5* |
| 21 | 21 | 45 | 46 | 36.8 | 36.2 | 61.0 | 60.0 |
| 21 | 21 | 46 | 48 | 39.3 | 38.7 | 60.5 | 60.0 |
| 22 | 21 | 46 | 45 | 31.6 | 38.1 | 60.0 | 59.5 |
| 25 | 21 | 43 | 43 | 29.3 | 33.1 | 59.0 | 60.0 |
| Averages | | | | | | | |
| 22.43 | 22.27 | 45.37 | 45.10 | 33.78 | 32.02 | 60.17 | 59.73 |
| Parent averages | | | | | | | |
| 22.33 | 22.00 | 43.00 | 45.33 | 35.60 | 27.20 | 59.75 | 60.00 |

* One entry in original data was supplied by missing plot technique.

Table 42. Analysis of variance of yield and test weight data summarized in table 41 for bearded and awnless Cheyenne x Chiefkan $F_7$ segregates.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between lines | 29 | 2,416.8 | 7.8834 | 0.005 |
| Between replications | 2 | 1,946.5 | 6.3493 | 0.005 |
| Error a | 58 | 306.57 | | |
| Between awns | 1 | 2,276 | 1.94 | 0.25 |
| Awns x replications | 2 | 1,176 | 3.2913 | 0.05 |
| Awns x lines | 29 | 623.62 | 1.7453 | 0.05 |
| Error b | 56 | 357.31 | | |
| | | Test weight | | |
| Between lines | 29 | 1.3793 | 4.29 | 0.005 |
| Between awns | 1 | 5.0 | 15.56 | 0.005 |
| Error | 28* | 0.321 | | |

* One entry in original data was supplied by missing plot technique.

The summarized data for the backcrosses are presented in Table 43. The analysis of variance summaries for the yield, the test weight and the weight of 500 kernels for the first backcross are presented in Table 44. All weights of 500 kernels were taken on composite samples of all replications as were the test weights after the first backcross.

The analysis in Table 44 indicates that the bearded segregates were consistently higher yielding than the awnless segregates in crosses using either Cheyenne or Chiefkan as the recurrent parent. It also indicates that when Chiefkan is used as the recurrent parent higher yields are obtained than when Cheyenne is used as the recurrent parent. The test weight analysis indicates that the awn effect on test weight is not consistent, but that the bearded segregates have the higher test weight when the recurrent parent is Cheyenne. No difference in test weight is indicated between the bearded and awnless segregates when Chiefkan is used as the recurrent parent. This analysis also indicates that the segregates obtained when Chiefkan is used as the recurrent parent are higher in test weight than those obtained by using Cheyenne as the recurrent parent. The weight of 500 kernels analysis indicates that segregates obtained from one backcross to Chiefkan have a higher weight of 500 kernels than those backcrossed once to Cheyenne. This analysis fails to indicate any difference between the bearded and awnless segregates in regard to weight of 500 kernels.

The analysis of variance summaries for the yield, the test weight, and the weight of 500 kernels for the second backcross

Table 43. Agronomic data comparisons between bearded and awnless segregates that were obtained from backcrossing one to four times to the recurrent parent.

| Year | First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | | Wt. 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| | | | | | Chiefkan x $Cheyenne_2$ | | | | | |
| 1944 | 28 | 30 | 42 | 40 | 27.5 | 19.6 | 56.1 | 51.8 | 10.67 | 9.52 |
| 1945 | 30 | 31 | 43 | 44 | 18.2 | 14.4 | 53.5 | 52.5 | 9.84 | 9.98 |
| 1946 | 10 | 10 | 39 | 41 | 31.0 | 28.7 | 59.8 | 58.3 | 16.42 | 14.07 |
| 1947 | 23 | 24 | 44 | 45 | 29.6 | 28.6 | 59.5 | 58.5 | 13.13 | 12.20 |
| | | | | | Chiefkan x $Cheyenne_3$ | | | | | |
| 1945 | 32 | 32 | 43 | 43 | 19.9 | 13.4 | 54.5 | 52.5 | 10.21 | 10.23 |
| 1946 | 9 | 9 | 39 | 40 | 33.1 | 33.0 | 59.1 | 58.3 | 15.89 | 15.17 |
| 1947 | 22 | 23 | 43 | 44 | 34.3 | 31.8 | 59.5 | 59.5 | 13.10 | 13.13 |
| | | | | | Chiefkan x $Cheyenne_4$ | | | | | |
| 1946 | 10 | 10 | 37 | 38 | 31.1 | 29.7 | 58.8 | 57.9 | 16.37 | 15.02 |
| 1947 | 23 | 23 | 43 | 44 | 39.0 | 33.9 | 60.5 | 59.0 | 13.10 | 13.13 |
| | | | | | Chiefkan x $Cheyenne_5$ | | | | | |
| 1947 | 24 | 24 | 43 | 41 | 38.0 | 33.4 | 60.0 | 59.5 | 13.83 | 13.20 |
| | | | | | Cheyenne x $Chiefkan_2$ | | | | | |
| 1944 | 26 | 27 | 41 | 40 | 36.7 | 30.7 | 60.4 | 58.6 | 13.21 | 12.41 |
| 1945 | 30 | 29 | 44 | 44 | 16.1 | 14.7 | 54.5 | 54.0 | 10.16 | 10.32 |
| 1946 | 7 | 7 | 39 | 40 | 35.4 | 33.6 | 60.7 | 60.3 | 17.21 | 16.53 |
| 1947 | 22 | 23 | 46 | 47 | 38.6 | 32.4 | 60.0 | 60.0 | 13.68 | 13.00 |

Table 43. (concl.)

| Year | First headed | | Height in inches | | Yield bus./A. | | Test wt. lbs/bu. | | Wt. 500 kernels/grams | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless | Bearded | Awnless |
| | | | | | Cheyenne x $Chiefkan_3$ | | | | | |
| 1945 | 30 | 30 | 44 | 45 | 16.2 | 15.9 | 56.0 | 54.0 | 10.49 | 10.14 |
| 1946 | 6 | 7 | 39 | 40 | 32.8 | 35.0 | 60.6 | 60.3 | 17.16 | 16.89 |
| 1947 | 21 | 22 | 45 | 47 | 33.1 | 33.7 | 61.0 | 61.0 | 13.60 | 14.28 |
| | | | | | Cheyenne x $Chiefkan_4$ | | | | | |
| 1946 | 7 | 7 | 40 | 40 | 35.3 | 32.0 | 61.7 | 60.8 | 17.61 | 16.73 |
| 1947 | 21 | 22 | 47 | 47 | 35.7 | 34.3 | 61.0 | 61.0 | 13.75 | 13.49 |
| | | | | | Cheyenne x $Chiefkan_5$ | | | | | |
| 1947 | 21 | 21 | 46 | 46 | 30.7 | 31.5 | 60.5 | 60.5 | 13.33 | 13.27 |
| | | | | | Parents | | | | | |
| 1944 | 29 | 26 | 40 | 41 | 28.1 | 29.8 | 55.3 | 59.4 | 10.20 | 12.36 |
| 1945 | 32 | 29 | 42 | 43 | 20.1 | 18.1 | 54.5 | 54.0 | 10.36 | 9.95 |
| 1946 | 11 | 7 | 39 | 39 | 35.2 | 33.3 | 58.5 | 60.4 | 16.03 | 16.30 |
| 1947 | 23 | 22 | 42 | 46 | 32.3 | 31.9 | 60.5 | 61.0 | 14.03 | 13.37 |

Table 44. Analysis of variance of yield, test weight and weight of 500 kernels data obtained in 1944 and summarized in table 43 for bearded and awnless backcross segregates of Cheyenne x Chiefkan crosses.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 31,009 | 17.54 | 0.05 |
| Between replications | 2 | 170.5 | 10.37 | 0.10 |
| Error a | 2 | 1,767 | | |
| Between awns | 1 | 14,422 | 12.17 | 0.025 |
| Error b | 5 | 1,185 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 92.4 | 142 | 0.01 |
| Between replications | 2 | 00.1 | 6.5 | 0.10 |
| Error a | 2 | 0.65 | | |
| Between awns | 1 | 27.3 | 6.06 | 0.25 |
| Awns x recurrent parents | 1 | 4.5 | 60 | 0.005 |
| Error b | 4 | 0.075 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 7.3712 | 240 | 0.05 |
| Between awns | 1 | 0.9506 | 30.96 | 0.10 |
| Error | 1 | 0.0307 | | |

and the first backcross advanced one generation by selfing are presented in Table 45.

The yield analysis of Table 45 indicates that the awn effect on yield is not consistent, but depends upon the variety used as the recurrent parent. When Cheyenne is used as the recurrent parent the bearded segregates are higher yielding than the awnless segregates. There is no difference indicated when Chiefkan is used as the recurrent parent. The test weight analysis indicates that the awn effect on test weight is consistent and that the bearded plants are higher in test weight than the awnless segregates. This analysis also indicates that the segregates from the second backcross to Chiefkan are higher in test weight than the segregates from the second backcross to Cheyenne. The weight of 500 kernels analysis fails to indicate any difference between the bearded and awnless segregates in regard to weight of 500 kernels.

The analysis of variance summaries for the third backcross and the first and second backcrosses advanced another generation by selfing for yield, the test weight and the weight of 500 kernels are presented in Table 46. The yield analysis indicates that there is no difference in yield between the bearded and awnless segregates. The test weight analysis indicates that the bearded segregates are consistently higher in test weight than the awnless segregates. This analysis also indicates that the segregates obtained from the third backcross to Chiefkan are higher in test weight than those obtained from the third backcross to Cheyenne. The weight of 500 kernels analysis indicates

Table 45. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1945, and summarized in table 43 for bearded and awnless backcross segregates of a Cheyenne x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 376 | 1.13 | 0.50 |
| Between replications | 2 | 4,257 | 9.99 | 0.10 |
| Error a | 2 | 426 | | |
| Between backcrosses | 1 | 99 | 1.15 | 0.50 |
| Error b | 5 | 114 | | |
| Between awns | 1 | 5,133 | 1.92 | 0.50 |
| Awns x backcrosses | 1 | 163 | 1.70 | 0.50 |
| Awns x recurrent parent | 1 | 2,668 | 9.64 | 0.01 |
| Error c | 9 | 277 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 3.7813 | 121 | 0.05 |
| Between backcrosses | 1 | 0.7813 | 25.04 | 0.10 |
| Error a | 1 | 0.0312 | | |
| Between awns | 1 | 3.7813 | 13.45 | 0.05 |
| Error b | 3 | 0.8437 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 0.09031 | 3.27 | 0.50 |
| Between backcrosses | 1 | 0.07411 | 2.68 | 0.50 |
| Error a | 1 | 0.02762 | | |
| Between awns | 1 | 0.00011 | 2543.6 | 0.025 |
| Error b | 3 | 0.2798 | | |

Table 46. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1946, and summarized in table 43 for bearded and awnless backcross segregates of a Cheyenne x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 7,685 | 8.44 | 0.10 |
| Between replications | 2 | 2,509 | 2.76 | 0.25 |
| Error a | 2 | 910.5 | | |
| Between backcrosses | 2 | 750 | 1.28 | 0.50 |
| Error b | 10 | 961 | | |
| Between awns | 1 | 1,089 | 1.64 | 0.25 |
| Error c | 17 | 665.94 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 12.41 | 21.21 | 0.05 |
| Between backcrosses | 2 | 0.06 | 9.75 | 0.10 |
| Error a | 2 | 0.585 | | |
| Between awns | 1 | 1.92 | 25.03 | 0.005 |
| Error b | 6 | 0.0767 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 7.038 | 1059.00 | 0.005 |
| Between backcrosses | 2 | 0.14203 | 21.39 | 0.05 |
| Error a | 2 | 0.00664 | | |
| Between awns | 1 | 3.2552 | 12.23 | 0.025 |
| Error b | 5 | 0.26627 | | |

that the bearded plante are consistently higher in weight of 500 kernels than the awnless segregates. This analysis also indicates that the weight of 500 kernels is greater when Chiefkan is used as the recurrent parent than when Cheyenne is used.

The analysis of variance summaries for the fourth backcrosses and the first, second and third backcrosses advanced another generation by selfing, for the yield, the test weight and the weight of 500 kernels are presented in Table 47. The yield analysis indicates that the bearded segregates are higher yielding than the awnless segregates regardless of the recurrent parent used. This analysis also indicates that the higher yielding recurrent parent depends upon the number of backcrosses used. The first backcross using Chiefkan as the recurrent parent gave the highest yields. In the second and third backcrosses there was no difference indicated between the yields of the recurrent parents used. In the fourth backcross the higher yields were obtained when Cheyenne was used as the recurrent parent. The test weight analysis indicates there is no difference between the test weights of the bearded and awnless segregates. This analysis also indicates that when Chiefkan is used as the recurrent parent higher test weights are obtained than when Cheyenne is used as the recurrent parent. The weight of 500 kernels analysis indicates that there is no difference between the bearded and awnless segregates in weight of 500 kernels.

Table 47. Analysis of variance of yield, test weight and weight of 500 kernels data, obtained in 1947, and summarized in table 43 for bearded and awnless backcross segregates of a Tenmarq x Chiefkan cross.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between recurrent parents | 1 | 37 | 38.0 | 0.10 |
| Between replications | 2 | 3,960 | 2.82 | 0.25 |
| Error a | 2 | 1,406 | | |
| Between backcrosses | 3 | 2,504 | 2.58 | 0.25 |
| Recurrent parent x backcross | 3 | 6,458 | 8.57 | 0.005 |
| Error b | 12 | 753.8 | | |
| Between awns | 1 | 7,105 | 6.46 | 0.025 |
| Error c | 23 | 1,099 | | |
| | | Test weight | | |
| Between recurrent parents | 1 | 6.8906 | 37.8 | 0.01 |
| Between backcrosses | 3 | 1,3073 | 7.17 | 0.10 |
| Error a | 3 | 0.18231 | | |
| Between awns | 1 | 0.39058 | 2.78 | 0.25 |
| Error b | 7 | 0.14063 | | |
| | | Weight of 500 kernels | | |
| Between recurrent parents | 1 | 1.3865 | 3.67 | 0.25 |
| Between backcrosses | 3 | 0.5285 | 1.40 | 0.50 |
| Error a | 3 | 0.3777 | | |
| Between awns | 1 | 0.0734 | 3.57 | 0.50 |
| Error b | 7 | 0.2617 | | |

The natural selection procedure for the Cheyenne x Chiefkan bulks was the same as described for the other crosses. The summarized data obtained from this cross are given in Table 48. The large seed progenies were compared with the normal for yield, test weight and weight of 500 kernels. The analysis of variance summaries are presented in Table 49. The yield analysis of Table 49 indicates there was no difference between the yields obtained by planting large kernels compared with that obtained by planting of normal kernels. The analysis of the test weight indicates there was less difference between the test weights of the large and small kernels progenies than there was in the estimation of the population variation. The weight of 500 kernels analysis indicates that the large kernels produce kernels that are heavier than those produced by the normal kernels as shown by the weight of 500 kernels.

The head counts and the Chi-square values are presented in Table 50. The first part of this table indicates that in the $F_2$ and the $F_5$ generations of the normal bulk the deviations of the observed numbers from the expected numbers could be explained by chance. In all other generations of the normal bulk and in all generations of the screened bulk there was an excess of the bearded heads. When the expected numbers were computed from the observed numbers of the first head counts as shown in part two of Table 50, the same results were obtained. When the expected numbers were computed from the observed numbers of each previous generation as are shown in the third part of this table, the normal bulk had an excess of bearded heads in the $F_3$,

Table 48. Comparison of agronomic data between normal bulk populations and a mechanically screened bulk population from the $F_2$ through the $F_7$ generation of a Cheyenne x Chiefkan cross.

| Generation | Number of heads: Normal seed: Awnless + heterozygous | Number of heads: Normal seed: Bearded | Number of heads: Large seed: Awnless + heterozygous | Number of heads: Large seed: Bearded | Yield bus./A.: Normal | Yield bus./A.: Large | Test weight lbs.: Normal | Test weight lbs.: Large | Weight 500 kernels/grams: Normal | Weight 500 kernels/grams: Large |
|---|---|---|---|---|---|---|---|---|---|---|
| $F_2$ | 1156 | 388 | Not taken | | 30.7 | Lost | 57.5 | 55.5 | 11.93 | 12.26 |
| $F_3$ | 979 | 705 | 740 | 1013 | 30.9 | 31.3 | 60.0 | 60.0 | 14.31 | 14.68 |
| $F_4$ | 1119 | 1116 | 496 | 1532 | 28.8 | 29.6 | 57.0 | 58.8 | 11.32 | 11.99 |
| $F_5$ | 806 | 778 | 340 | 1088 | 17.2 | 20.3 | 55.0 | 55.5 | 10.55 | 10.86 |
| $F_6$ | 391 | 884 | 197 | 1540 | 36.1 | 35.0 | 59.6 | 59.7 | 17.09 | 15.88 |
| $F_7$ | 794 | 1506 | 147 | 2070 | 34.4 | 35.0 | 61.0 | 60.5 | 13.33 | 14.41 |

Table 49. Analysis of variance summaries of yield, test weight and weight of 500 kernels between a normal bulk population and a large seeded bulk population.

| Factors | D/F | Estimated variance | F-value | Probability |
|---|---|---|---|---|
| | | Yield | | |
| Between years | 4 | 90.3625 | 79.72 | 0.005 |
| Between seed size | 1 | 1.521 | 1.34 | 0.25 |
| Error | 4 | 1.1335 | | |
| | | Test weight | | |
| Between years | 5 | 9.3628 | 12.08 | 0.025 |
| Between seed size | 1 | 0.0008 | 968.55 | 0.025 |
| Error | 5 | 0.7748 | | |
| | | Weight of 500 kernels | | |
| Between years | 5 | 9.3106 | 145.39 | 0.005 |
| Between seed size | 1 | 1.2097 | 18.89 | 0.01 |
| Error | 5 | 0.06404 | | |

Table 50. Chi-square values and probabilities of observed bearded and awnless plus heterozygous head counts from segregating normal and screened bulk populations in a Cheyenne x Chiefkan cross.

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| On basis of theorical rate of homozygosity | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1544 | 1156 | 1158 | 0.001 | 0.98 |
| | B | 25.00 | | 388 | 386 | | |
| $F_3$ Normal | A+H | 62.50 | 1684 | 979 | 1052 | 13.50 | 0.01 |
| | B | 37.50 | | 705 | 632 | | |
| $F_3$ Large | A+H | 62.50 | 1735 | 740 | 1096 | 308.54 | 0.01 |
| | B | 37.50 | | 1013 | 657 | | |
| $F_4$ Normal | A+H | 56.25 | 2235 | 1119 | 1256 | 34.12 | 0.01 |
| | B | 43.75 | | 1116 | 979 | | |
| $F_4$ Large | A+H | 56.25 | 2028 | 496 | 1141 | 833.63 | 0.01 |
| | B | 43.75 | | 1532 | 887 | | |
| $F_5$ Normal | A+H | 53.12 | 1584 | 806 | 841 | 3.12 | 0.08 |
| | B | 46.87 | | 778 | 743 | | |
| $F_5$ Large | A+H | 53.12 | 1428 | 340 | 759 | 493.73 | 0.01 |
| | B | 46.87 | | 1088 | 669 | | |
| $F_6$ Normal | A+H | 51.56 | 1275 | 391 | 657 | 222.19 | 0.01 |
| | B | 48.44 | | 884 | 618 | | |
| $F_6$ Large | A+H | 51.56 | 1737 | 197 | 896 | 1126.30 | 0.01 |
| | B | 48.44 | | 1540 | 841 | | |
| $F_7$ Normal | A+H | 50.78 | 2300 | 794 | 1168 | 243.33 | 0.01 |
| | B | 49.22 | | 1506 | 1132 | | |
| $F_7$ Large | A+H | 50.78 | 2217 | 147 | 1126 | 1729.70 | 0.01 |
| | B | 49.22 | | 2070 | 1091 | | |
| On basis of theorical rate of homozygosity after correction of first head count | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1544 | 1156 | 1158 | 0.001 | 0.98 |
| | B | 25.00 | | 388 | 386 | | |
| $F_3$ Normal | A+H | 62.50 | 1684 | 979 | 1052 | 13.50 | 0.01 |
| | B | 37.50 | | 705 | 632 | | |

Table 50. (cont.)

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| $F_3$ Large | A+H | 62.50 | 1753 | 740 | 1096 | 308.54 | 0.01 |
| | B | 37.50 | | 1013 | 657 | | |
| $F_4$ Normal | A+H | 56.25 | 2235 | 1119 | 1256 | 34.12 | 0.01 |
| | B | 43.75 | | 1116 | 979 | | |
| $F_4$ Large | A+H | 37.99 | 2028 | 496 | 770 | 157.18 | 0.01 |
| | B | 62.01 | | 1532 | 1258 | | |
| $F_5$ Normal | A+H | 53.12 | 1584 | 806 | 841 | 3.12 | 0.08 |
| | B | 46.87 | | 778 | 743 | | |
| $F_5$ Large | A+H | 35.88 | 1428 | 340 | 512 | 90.08 | 0.01 |
| | B | 64.12 | | 1088 | 916 | | |
| $F_6$ Normal | A+H | 51.66 | 1275 | 391 | 657 | 222.19 | 0.01 |
| | B | 48.44 | | 884 | 618 | | |
| $F_6$ Large | A+H | 34.82 | 1737 | 197 | 605 | 422.20 | 0.01 |
| | B | 65.17 | | 1540 | 1132 | | |
| $F_7$ Normal | A+H | 50.78 | 2300 | 794 | 1168 | 243.33 | 0.01 |
| | B | 49.22 | | 1506 | 1132 | | |
| $F_7$ Large | A+H | 34.29 | 2217 | 147 | 760 | 752.34 | 0.01 |
| | B | 65.70 | | 2070 | 1457 | | |
| On basis of theorical rate of homozygosity after correcting for each previous generation | | | | | | | |
| $F_2$ Normal | A+H | 75.00 | 1544 | 1156 | 1158 | 0.001 | 0.98 |
| | B | 25.00 | | 388 | 386 | | |
| $F_3$ Normal | A+H | 62.50 | 1684 | 979 | 1052 | 13.50 | 0.01 |
| | B | 37.50 | | 705 | 632 | | |
| $F_3$ Large | A+H | 62.50 | 1753 | 740 | 1096 | 308.54 | 0.01 |
| | B | 37.50 | | 1013 | 657 | | |
| $F_4$ Normal | A+H | 52.32 | 2235 | 1119 | 1169 | 4.48 | 0.03 |
| | B | 47.67 | | 1116 | 1066 | | |
| $F_4$ Large | A+H | 37.99 | 2028 | 496 | 770 | 157.18 | 0.01 |
| | B | 62.01 | | 1532 | 1258 | | |

Table 50. (concl.)

| Generation and kind | | Expected percent | Total no. observed | Observed number | Expected number | Chi-square | P |
|---|---|---|---|---|---|---|---|
| $F_5$ Normal | A+H | 47.28 | 1584 | 806 | 749 | 8.23 | 0.01 |
| | B | 52.71 | | 778 | 835 | | |
| $F_5$ Large | A+H | 23.10 | 1428 | 340 | 330 | 0.39 | 0.50 |
| | B | 76.90 | | 1088 | 1098 | | |
| $F_6$ Normal | A+H | 49.39 | 1275 | 391 | 630 | 179.22 | 0.01 |
| | B | 50.62 | | 884 | 645 | | |
| $F_6$ Large | A+H | 23.11 | 1737 | 197 | 401 | 134.93 | 0.01 |
| | B | 76.89 | | 1540 | 1336 | | |
| $F_7$ Normal | A+H | 30.20 | 2300 | 794 | 695 | 20.21 | 0.01 |
| | B | 69.79 | | 1506 | 1605 | | |
| $F_7$ Large | A+H | 11.16 | 2217 | 147 | 247 | 45.56 | 0.01 |
| | B | 88.13 | | 2070 | 1970 | | |

the $F_4$ and the $F_6$ generations. In the $F_5$ and the $F_7$ generations of the normal bulk there was an excess of the awnless plus heterozygous heads indicated. In the screened bulks there was an excess of the bearded heads in each generation except the $F_5$ in which the deviation of the observed from the expected could be accounted for by chance alone.

## DISCUSSION OF RESULTS

Throughout the analysis of the data presented the probability of 0.05 or less was used as an indication of a difference existing between the characters being studied. If the differences between the bearded and awnless plants are due to awns, results from all of the crosses should be comparable to each other for any one generation. From the analysis of variance tables presented it can be seen that in the $F_4$ generation of all three of the crosses, the bearded segregates were higher yielding and had a higher test weight than the awnless segregates. The probability in all cases was at most 0.005.

In the $F_5$ the bearded plants were higher yielding than the awnless plants in the Tenmarq and Comanche x Chiefkan crosses. This was true for both statistical designs and the probabilities were 0.025 or less in all cases. In the Cheyenne x Chiefkan cross the paired data indicated that the bearded plants were higher yielding than the awnless plants, but the randomized block design failed to indicate any difference. Since the plots used for comparisons were sister plants in the $F_3$, the paired data technique should give the more reliable results.

In the $F_6$ generation the bearded segregates were again higher yielding than the awnless segregates for the Tenmarq and Comanche crosses. When the Cheyenne cross comparison was made by the paired data design there was no difference indicated, but when the randomized block design was used the awnless plants were higher yielding than the bearded plants. The paired data technique should have given the more reliable results.

In the $F_6$ generation a higher test weight was indicated for the bearded segregates in both the Tenmarq and Comanche crosses. No difference was indicated in the Cheyenne cross.

In the $F_7$ generation no difference was indicated between the bearded and awnless plants in regard to yield in the Tenmarq and Cheyenne crosses. The Comanche cross still showed the bearded segregates to be the higher yielding. The Comanche and Cheyenne crosses showed the bearded plants to be higher in test weight, but the actual difference was very slight. The Tenmarq crosses failed to show a difference between the awnless and bearded plants in test weight.

The backcross data are more difficult to draw conclusions from because, in most cases, the degrees of freedom are too few to show any differences except extreme differences. However, the first backcross, which should be comparable to the selfed $F_4$ data, indicated that the bearded plants were higher yielding in all of the crosses. In the Comanche backcross the interaction of awns x recurrent parent was significant and therefore had to be used in the "F" ratio with awns. A consistent awn effect could not easily be shown here when both factors have only one degree of freedom each. However, the results compare favorably with the $F_4$ sister plant selection results. The same difficulty is encountered in trying to draw conclusions from the test weight data, but the bearded plants seem to be superior to their sister awnless segregates after they have been backcrossed to the parents once. No difference was indicated in the weight of 500 kernels between the bearded and their sister awnless segregates.

In the second backcross the bearded plants were again superior to the awnless plants if the significant interactions are not used as the error terms. The same is true for the test weights. No difference was indicated between the weight of 500 kernels in the Tenmarq and Cheyenne crosses between the bearded and awnless segregates, but in the Comanche cross the bearded plants had a higher weight of 500 kernels than did the awnless plants. The yield and test weight results compare favorably with the results obtained in the $F_5$ of the selfing method.

In the third backcross the bearded segregates yielded higher than the awnless segregates in the Tenmarq and Comanche crosses if the interactions are not used as the error terms. No difference is indicated in the Cheyenne cross. In all of the crosses the test weight is higher on the bearded segregates than on the awnless segregates. This agrees with the $F_6$ selfed plant data except in regard to the test weight of the Cheyenne cross. In all crosses the weight of 500 kernels was higher in the bearded segregates than it was in their sister awnless segregates.

In the fourth backcross no difference is indicated in the yield of the bearded and awnless segregates from the crosses of Tenmarq or Comanche. The bearded plants seemed to be higher yielding than the awnless plants in the Cheyenne cross. The bearded plants in the Comanche cross have a higher test weight than the awnless plants. No difference is indicated between the bearded and awnless plants in regard to test weight in the other crosses. These conclusions do not agree entirely with those from the $F_7$ selfed progeny data. However, examination of the probabilities indicate closer agreement than the conclusions suggest. The weight of 500 kernels was greater when produced by the bearded plants in the Comanche cross but not in the other two crosses.

While the results from the Tenmarq and Comanche crosses were very similar, the Cheyenne cross did not follow the same pattern. This would not be expected if the results were due to awns alone. There is also a definite trend in all of the crosses for the yield and test weight of the awnless segregates to equal those of the bearded segregates as they become more closely related in advance generations. If the difference in the early generations was due to the awns alone that difference should continue through all generations and be constant for all generations. It is evident then that the behavior of these crosses cannot be explained on presence or absence of the awns alone. There must be some genetic diversity in these crosses that is so closely related to the awn expression that its own expression depends and/or interacts with the awn expression.

The behavior of these results might be explained if some of the genes influencing yield are located on the same chromosome which contains the factor for awn expression. The double dominant yield genes may control the same yield character with or without the presence of awns. Heterozygous pairs of yield genes may be able to equal the effect of the dominant yield genes if the awns are present, but not equal the effect of the dominant yield genes if the awns are absent.

For illustration, it can be assumed that there are several of these yield genes on the same chromosome which contains the factor for awn expression. Chiefkan has the double dominant yield genes and Tenmarq and Comanche have the double recessive alleles to these yield genes. Cheyenne contains the same yield genes but some are double recessive and some are double dominant. From crosses involving Chiefkan with any of the other three varieties one would expect the bearded segregates to be higher yielding in the early generations than the awnless segregates because one or more of these yield genes would be heterozygous. As soon as the homozygosity was nearly 100 percent one would expect the awnless segregates to be equal in yield to the bearded segregates. The degree of homozygosity is expected to reach approximately 100 percent sometime between the sixth and ninth generations, depending upon the number of factors involved. The data indicate that Tenmarq and Cheyenne crosses have reached this degree of homozygosity by the seventh generation. The Comanche cross has not yet reached this point, but Comanche is a higher yielding variety than either of the other three so it can be assumed that it was heterozygous for more yield factors than the other crosses. It should reach this degree of homozygosity in the next two generations.

If other conditions were more desirable for the awnless plants than for the bearded plants in any one year, one could expect the awnless plants to outyield the bearded segregates. This could also be expected if in some of the bearded parents some double recessive yield genes were so closely linked to the gene for bearded and the dominant gene linked closely to the gene for awnlessness that little crossing over occurred.

If such an explanation were plausible one could expect the backcross program to give the following results if the recurrent parents are equal in yielding ability to start with.

1. Backcrossing to Chiefkan should give higher yields than backcrossing to the bearded parent.

2. Bearded segregates obtained from backcrossing to the bearded parent should always be higher yielding than the awnless segregates.

3. Bearded segregates obtained from backcrossing to the awnless parent should be higher yielding than the awnless segregates until the awnless segregates are homozygous dominant for the yield genes and then the yield should be equal.

The statistical design used for this study was such that it was expected to obtain more efficient results for differences between the degree of awnness at the expense of the results for the recurrent parents. However, backcross data from the Cheyenne and Tenmarq backcrosses agree very well with the above requisites. The Comanche backcross data do not agree with the first requisite, but it is a higher yielding variety to start with so it might be expected that backcrossing to Comanche would give higher yields than backcrossing to Chiefkan.

The number of observed bearded and awnless heads from bulk plantings deviated markedly from the expected in favor of the bearded plants. This first occurred in the $F_2$ generation of the Tenmarq and Comanche crosses, but not until the $F_3$ generation of the Cheyenne crosses. It is very interesting to note that in the

$F_5$ generation the awnless plants gained back considerably in the bearded-awnless head ratio. It was unfortunate that the selfed plant comparisons were discontinued that year, but the backcross data indicated no increase yield of the awnless plants over the bearded plants.

When the bearded and awnless $F_2$ seed was space planted no differences were noted between the number of tillers, the number of heads per plant, or the number of seeds per head. This would indicate that the bearded plants are better competitors than the awnless plants when they are thick sown together. Probably this is due to more tillers produced rather than to more seeds per head, or to actual killing out of very young awnless seedlings by the more vigorous bearded seedlings. Future experiments will have to be conducted to determine the causes.

Large kernels separated out from a normal bulk population increased the rate of natural selection of the bearded over the awnless. This probably is because the bearded plants produce larger seeds, therefore, when the largest seeds are separated out and replanted, most of them will produce bearded plants. To obtain better information regarding size of seed, the small kernels should be separated out and replanted also.

The progeny of the large kernels produced higher yields than the progeny of the normal kernels in the Tenmarq cross. No difference was indicated in test weight between the progeny of the large seeds and the progeny of the normal seed. The weight of 500 kernels was greater for the large seed progeny than it was for the normal seed progeny in all three of the crosses. Any differences in yield, test weight or weight of 500 kernels could be explained by the presence of a larger number of bearded plants in the progeny of the large seed.

# SUMMARY

In 1938-39 at Manhattan, Kansas an awnless winter wheat variety, Chiefkan, was crossed with three bearded winter wheat varieties, Tenmarq, Comanche and Cheyenne. $F_2$ data indicated the awnless variety differed from the bearded varieties by only one factor pair for the expression of the awn character. A study was made in the later generation of the awn effect upon data of first heading, plant height, yield, test weight, and kernel weight of segregates from these crosses.

The method of study was to isolate isogenic lines that were completely homozygous for all genes except the pair involved with awns. This was done by both selfing of heterozygous tip-awned plants and by backcrosses of the heterozygous tip-awned plants, using both parents as the recurrent parent. The data presented in this thesis are the results obtained from the $F_4$ through the $F_7$ generations of selfing and the first through the fourth backcrosses.

The results indicated that in early generations the bearded segregates are superior to the awnless segregates in yield, test weight and kernel weight. As the bearded and awnless lines become more closely related the superiority of the bearded lines becomes less pronounced and may completely disappear. The differences observed in these characters are not due exclusively to the awn gene, but rather to other genes associated with but separable from it.

There was no difference of practical significance observed between the bearded and awnless lines in regard to date of first heading and plant height.

Normal bulk hybrid populations from each of the crosses were carried through the $F_7$ generation to determine if there was natural selectivity of awn type. The number of observed bearded and awnless heads deviated markedly from the expected in favor of the bearded. In the $F_5$ generation, however, the reverse was indicated.

The largest kernels were screened from the normal $F_2$ bulk hybrid populations for each cross. These kernels were carried in bulk through the $F_7$ generation the largest seeds being separated each generation. The separation of the largest kernels increased the rate of natural selection in favor of the bearded heads. As in the normal bulks, the natural selection in the $F_5$ of the screened bulk was in favor of the awnless heads.

The normal and large seeded bulks were compared through the $F_7$ for yield, test weight and kernel weight. No differences were indicated that could not be explained on the basis of the greater number of bearded plants in the large seeded bulks.

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