A STUDY OF SOME AWN CHARACTERS OF SMOOTH AWNS BARLEYS

THESIS FOR THE DEGREE OF M. S.

C. Roy Adair

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A STUDY OF SOME AWN CHARACTERS OF SMOOTH-AWN BARLEYS

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A STUDY OF SOME AWN CHARACTERS OF SMOOTH AWN BARLEYS

Thesis

Respectfully submitted in partial fulfillment
for the degree of Master of Science
at
Michigan State College of Agriculture
and Applied Science

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TABLE OF CONTENTS

INTRODUCTION

Comparisons made at the Michigan Agricultural Experiment Station in 1928 and reported in Michigan Agricultural Experiment Station Special Bulletin No. 191 indicated that there were pronounced differences in the smoothness of awn of "smooth awn" varieties of barley (10). This condition raised a question as to the possibility of obtaining six-row or two-row strains with awns of still greater smoothness.

In 1929 a problem was outlined with the idea of obtaining some information on the inherited and seasonal variations in the degree of smoothness which might be found in the smooth awn barley strains then grown on the Station plats. The earlier work at the Station on smoothness of awn had shown that smoothness is not a simple quantitative character. With this in mind five factors were studied: length of awn, length of barbed area, ratio of length of awn to length of barbed area, and the number of barbs in areas one centimeter long taken at two different places on the awn.

The main objects of the problem were as follows:

1. To determine whether it is as reliable to use strain averages as to use individual head averages in the calculation of results.

2. To determine whether there are significant inherited and seasonal differences between the degrees of smoothness of awn or the lengths of awn of the six-row strains and those of the two-row strains.

3. To determine whether there are significant inherited and seasonal differences among the degrees of smoothness of awn or among the lengths of awn of the six-row strains; of the two-row strains.

4. To determine whether there are significant inherited and seasonal differences in the degrees of smoothness of awn or in the lengths of awn of a group of two-row strains, all of which come from the same cross.

5. To compare Michigan Black Barbless, Spartan, and Michigan-Two-Row with some of the extremely smooth and the extremely rough strains.

6. To determine whether there are significant differences among the variabilities of the different factors studied.

7. To determine the degrees of relationship existing among some of the factors studied.

The literature bearing upon the different phases of this problem will be reviewed before discussing this problem as outlined.

REVIEW OF LITERATURE

Harlan and Hayes (4): Crosses were made between Lion and rough awned varieties. They determined that a high yielding, smooth awned variety, of any head type desired, may be produced by crossing and selection.

Harlan (5): The term "smooth awn" may be confused with awnless or hooded. Smooth awn barley was first described by Koerarieke, Europe, in 1882. Robert Regel, Russia, worked on smooth awn barley in 1909. The United States Department of Agriculture and the Minnesota Agricultural Experiment Station started a cooperative project on smooth awn barley in 1909. An importation of smooth awn barley was made from North Africa, in December 1911, and crosses were made between this smooth awn barley and common rough awn varieties. Smooth awn was found to be recessive to rough awn. This author had no conception of the number of factors concerned so could not say whether teeth can be entirely removed or not. He stated, however, that Hordeum lieorrhynchum (smooth awn types) importations have yielded as well as other importations, and smooth awn progeny have yielded very well in nurseries, but the absence of smooth awn commercial varieties in Asia and southern Europe where they have been known for a long time indicates a weakness of some sort. Indications are that

smooth awn varieties that give satisfactory yields may be obtained.

Harlan and Pope (6): The smooth awned character of Lion is undoubtedly linked with undesirable characters, but this linkage is not absolute, as it has been found that crossing over will occur. When back-crossing is practiced the chromosome carrying the smooth awn factor will cross over with the chromosome carrying rough awn factor and desirable characters, so there would be a maximum chance of smooth awn becoming linked with desirable characters.

Hayes and Wilcox (7): The work done by these authors showed that the smooth awn barley overcomes the undesirable characters of the rough awn, awnless, and hooded varieties. The awn is an important physiological organ and the lack of it in the awnless and hooded varieties causes them to be low in yield. The rough awn of the "rough awn" varieties makes them very disagreeable to handle. The smooth awn varieties are not disagreeable to handle and they do not have the physiological limitations of the awnless and hooded varieties.

Vavilon (12): This author worked on the origin of smooth awn barleys and he believed that they are the result of natural crosses between two rough awn barleys of different types. Types of rough awn parents necessary to get smooth

awn progeny are: slender awn with triangular, wide-apart, acicular teeth arranged in close spiral (group nutans colchicum and n. precocius), and broad awn with large closely set teeth, disposed in loose spiral and occuring also along the external median line of the awn (coeleste and nudoficiens groups). He believed smooth awn is dependent upon five or six factors.

Colin and Trouard-Riolle (1): Crossed white, rough-awn Albert and smooth-awn black barley. Some of F_1 heads had smooth awns only, others had smooth awns and rough awns and some others were smooth for half their length and rough for the remainder. Only the rough awned heads showed any signs of Mendelian segregation in F_2.

Hor (9): This author worked on the interrelation of the following genetic factors in barley: black glume (B), rough awn (R), long rachilla hair (L). The arrangement is BRL, the distance between B and R being greater than the distance between R and L. Crossover value between B and L is 44.04±4.74%, between B and R is 41.48±5.45% and between R and L is 34.5±2.89%.

Griffee (3): Svanhals, a two-row, rough awn, white glume, Helminthosporium sativum resistant variety, was crossed with Lion, a six-row, smooth awn, black glume, H. sativum susceptible variety. The F_1 was rough; F_2 rough and partially or almost entirely smooth. The results gave indication of a two factor difference, RR and SS. R produces

rough, S is hypostatic to R and in absence of R produces intermediate type, rr ss produces smooth awn of the Lion type. There is quite a variability in the placing of the barbs on awns of pure lines, which indicates the presence of other factors. In the F_2 he obtained twelve rough, three intermediate, and one smooth. Rough and smooth awn factors are independent of two and six-row, and black and white glume. One of the three factors that produces resistance to H. sativum is linked with rough.

Hayes (8): The first series of crosses made by Dr. H. V. Harlan between Lion and rough awned varieties failed in Minnesota because of susceptibility to spot blotch (H. sativum). A second series of crosses was made and the problem of spot blotch resistance was taken into consideration. The factors for rough awn and resistance are linked but some crossing over occured so it was possible to obtain six-row, smooth awn, white glume, resistant varieties. Velvet (Minn. No. 447), Comfort (Minn. No. 451), and Glabron (Minn. No. 445) are the three best varieties obtained from this series.

Sigfusson (11): Crosses were made between Chinese, a rough awn short rachilla hair variety, and Lion, a smooth awn, long rachilla hair variety. Rough awn was found to be due to two complementary factors, R and S; R being more important than S, but both necessary to produce roughness

of the Chinese type. There was some linkage between r and L, the factor for long rachilla hair.

Rather, Down, Brown, Clark (10) P.18-19: Photomicrographs showed differences to exist in the degree of smoothness among several of the commercial "smooth awn" varieties. Spartan and Michigan Black Barbless were the smoothest of the varieties under observation.

SOURCE OF MATERIAL

Three commercial varieties, Michigan Black Barbless, Spartan, and Michigan Two-Row, and some 222 strains coming from crosses made in 1924 between the smooth awn and the rough awn or hooded varieties in the nursery at that time are the material used in this thesis.

The three varieties were used for comparison purposes and are some of the parents of the smooth awn strains. Michigan Black Barbless is a six-row, smooth awn variety that was selected from Lion (C.I.No.923); Spartan is a two-row, smooth awn variety and is a selection from a cross between Michigan Black Barbless and Michigan Two-Row; Michigan Two-Row is a two-row, rough awn variety. There were 76 six-row smooth awn strains coming from five crosses and 144 two-row smooth awn strains coming from twelve crosses. These 222 strains had been selected for four years

until they were breeding true for apparent morphological characters. During this period of selection the smooth awn segregates had been saved and the rough awn segregates discarded. The smoothness had been judged by pulling the awn back and forth between the thumb and forefinger.

METHODS

Ten heads were collected in the field from each of the 222 strains and the three varieties and placed in an envelope. Four awns were taken from each head and the following measurements and counts were made: length of awn recorded in millimeters; distance the barbs extend down from the tip of the awn, recorded in millimeters; number of barbs in an area one centimeter long starting .5 mm from tip of awn (called "first count" in this thesis); and number of barbs in an area one centimeter long starting 25 mm from tip of awn (called "second count" in this thesis). A fifth factor, the awn-barbed area ratio, was obtained by dividing the length of awn by the length of the barbed area.

Three different methods were used during the course of this problem in making the counts and measurements. Early in 1929 a bifocal microscope was used but it proved unsatisfactory as it consumed too much time. A change

was then made to a stereoptican. The awn was placed on a graduated slide and the image projected on a screen with the stereoptican. The awn was thus magnified so that it was possible to count the barbs. This method was found very impractical in that it took two men to operate the madhine and make the reading, so a projection microscope was obtained to use on the 1930 material. The magnified image of the awn was projedted down on the table, thus making it possible for one man to operate the instrument and make the counts.

COMPUTATIONS

The results obtained from the two and six row strains were computed separately. Two types of averages were obtained: those for the individual heads from the four awns of each head; and those for the strain from the averages of the ten heads of each strain. The average values of all of the factors studied, together with their standard deviations and coefficients of variability, were obtained for 1929 and 1930.

Differences between the different factors were obtained by the formula:

$$A \pm P.E._A \pm B \pm P.E._B = \text{Difference} \pm \text{P.E.diff.}$$

$$\text{P.E.diff} = \left((P.E._A)^2 + (P.E._B)^2\right)^{1/2}$$

Differences were assumed to be significant when the quotient of the difference divided by the probable error of the difference was 3.2 or greater.

Correlation coefficients were calculated by the diagonal method used by the Farm Crops Department of Michigan State College which is a modification of the method given by Crum and Patton (2).

The limits of significance of r as used in this thesis are:

slight - r greater than .3 and greater than six times its probable error.

marked - r greater than .5 and greater than six times its probable error.

strong - r^2 greater than .5 and greater than six times its probable error.

RESULTS

The data given in Table 1 were obtained by using the average values of each individual head. This table gives the mean, standard deviation, and coefficient of variability with the respective probable errors of each of the five factors studied for the six-row and two-row types of 1929 and 1930. Table 2 contains similar data as Table 1, except that the values were obtained by using the strain averages instead of each individual head.

Table 3 gives a comparison of the mean values of each of the factors obtained from individual head averages

with those from strain averages. The differences in the values of the means obtained by the two methods are shown to be very slight and in no case is the difference significant.

Table 4 gives a comparison of the values of the coefficients of variability of each of the factors as obtained from individual head averages with those from strain averages. The differences in the values of the coefficients of variability are large in all cases, the differences being significant for all factors in all of the groups except awn-barbed area ratio and first count six-row 1929 and lengths of barbed area six-row 1930.

Table 5 gives a comparison of the means of the five factors for the two-row with those for the six-row strains. The two-row strains have longer awns and longer barbed area than the six-row strains for both years. There was no significant difference between the awn-barbed area ratios in 1929, but in 1930 this value was significantly higher in the two-row strains, showing that they had smoother awns than the six-row strains for that year. The six-row strains had a significantly higher "first count" both years. The six-row strains had higher "second count" than the two-row strains both years, but the differences could not be considered significant. These counts show that the six-row strains had a greater number of barbs per unit area than the

two-row strains.

Table 6 gives a comparison of the values of the means of the five factors of the 1929 crop with those of the 1930 crop, for both two-row and six-row strains. The length of awn was significantly greater in 1930 than in 1929 in both the six-row and two-row strains. The length of barbed area was greater in 1929 than in 1930, the difference being significant in the two-row strains, but not in the six-row strains. The awn-barbed area ratio was significantly larger in 1930 than in 1929 in both groups. The "first count" and "second count" were significantly higher in 1929 than in 1930 in both groups. This shows the awns to be smoother in 1930 than in 1929.

Table 7 gives a comparison of the values of the coefficient of variability of the five factors for the two-row with those for the six-row strains for the two years, 1929 and 1930. In 1929 all of the factors were significantly more variable in the six-row than in the two-row varieties, except length of barbed area, which was significantly more variable in the two-row than in the six-row strains for that year. In 1930 the two-row strains were more variable than the six-row strains. This difference was not significant for length of awn but it was for all the other factors.

Table 8 gives a comparison of the values of the coefficients of variability of the five factors in 1929 with those in 1930 for the two groups. The length of awn was significantly more variable in 1929 than in 1930. The length of barbed area was slightly more variable in 1929 than in 1930 in the six-row strains. The length of barbed area was significantly more variable in 1930 than in 1929 in the two-row strains. The awn-barbed area ratio in the six-row strains was significantly more variable in 1929 than in 1930. In the two-row strains the awn-barbed area ratio was more variable in 1930 than in 1929, but the difference was not significant. The "first count" of the six-row strains was significantly more variable in 1929 than in 1930. The "first count" of the two-row strains was more variable in 1930 than in 1929, but the difference was not significant. The "second count" of the six-row varieties was more variable in 1929 than in 1930 but the difference was not significant. The "second count" of the two-row varieties was significantly more variable in 1930 than in 1929. This table shows that the six-row strains were more variable in 1929 than in 1930, and that the two-row strains except for the length of awn, was more variable in 1930.

Whether significant inherited and seasonal differences exist in the degree of smoothness or in the length of awn of

two-row strains was determined from a group of 37 strains, all of which came from the same cross. The mean, standard deviation, and coefficient of variability of four factors were calculated. The several factors of the individual strains for 1929 were compared with the same factors for 1930. Comparisons were made between the values of the mean and the values of the coefficient of variability in all cases. These results are shown in Tables 9 to 16.

Table 9 gives the comparison between the values of the mean of the length of awn for 1929 and those for 1930. Thirty-one of the strains had significantly longer awns in 1930 than in 1929; four were longer in 1930, but not significantly so; and two were longer in 1929 than they were in 1930, but these differences were not significant.

Table 10 gives the comparison between the values of the coefficient of variability of the length of awn for 1929 and those for 1930. Seven of the strains were more variable in 1930 than in 1929, but none of these differences were significant. Thirty of the strains were more variable in 1929 than in 1930, but in only five cases were the differences significant.

Table 11 gives the comparison between the values of the mean of the length of barbed area for 1929 and those for 1930. Seventeen of the strains had longer barbed areas in 1930 than in 1929, but only six of these differences were

significant. Twenty of the strains had longer barbed areas in 1929 than in 1930, but only eight of these differences were significant.

Table 12 gives the comparison between the values of the coefficient of variability of the length of barbed area for 1929 and those for 1930. Twenty-two of the strains were more variable in 1930 than in 1929, but in only two cases were the differences significant. Fifteen of the strains were more variable in 1929 than in 1930, but in only two cases were the results significant.

Table 13 gives the comparison between the values of the mean of the "first count" for 1929 and those for 1930. In 13 strains the value for the "first count" was higher in 1930 than in 1929 but in only five cases were these differences significant. In 24 strains the value for the "first count" was greater in 1929 than in 1930; 11 of these strains had significant differences.

Table 14 gives the comparison between the values of the coefficient of variability of the "first count" for 1929 and those for 1930. Fourteen of the strains were more variable in 1930 than in 1929; four of these differences were significant. Twenty-three of the strains were more variable in 1929 than in 1930; four of these differences being significant.

Table 15 gives the comparison between the values of the mean of the "second count" for 1929 and those for 1930. Twenty-two of the strains had larger "second counts" in 1930 than in 1929; nine of these differences were significant. Fifteen of the strains had larger "second counts" in 1929 than in 1930; eight of these differences being significant.

Table 16 gives the comparison between the values of the coefficient of variability of the "second count" for 1929 and those for 1930. Eighteen of the strains were more variable in 1930 than in 1929, but only four of these differences were significant. Nineteen of the strains were more variable in 1929 than in 1930, but only two of these differences were significant.

The possibility of selecting for extreme types of smoothness within these smooth awn segregates was determined by calculating the mean, standard deviation and coefficient of variability, for each of four factors measured, for four of the strains and the three varieties Spartan, Michigan Black Barbless and Michigan Two Row. The four strains used were strains number 70516, 71502, 710206 and 728612. The first two strains are extremely smooth, smooth awn strains, and the latter two are extremely rough, smooth awn strains. The values of these constants together with the probable error of each, for these four factors are reported in Table

17. The values of the constants of these four factors, and the probable errors of each, of the seven varieties and strains, are reported in Table 17. The mean values of length of barbed area and "second count" are shown graphically in Figure 1. Plates 1, 2, 3 and 4 are photomicrographs of the awns of these four strains. Spartan, Michigan Two-Row, strains 70516, 71502 and 710206 are two-row; Michigan Black Barbless and strain 728612 are six row. Strains 70516 and 71502 both have significantly shorter awns and barbed areas, and significantly fewer number of barbs than Spartan. Strain 710206 has significantly shorter awns, significantly longer barbed area and a significantly greater number of barbs than Spartan. Strain 728612 has significantly longer awns and barbed area, and a significantly greater number of barbs than Michigan Black Barbless. Michigan Two-Row, which is a rough awn variety, has significantly longer barbed area than any of these smooth awn varieties and strains, and significantly greater number of barbs than any of these except strain number 728612.

Table 18 shows the differences in variability among the five factors for the six-row strains in 1929. Named in order from the least variable to the most variable they are: length of awn, "first count", length of barbed area, awn-barbed area ratio, "second count". These differences are all significant except the difference between "first count" and

length of barbed area.

Table 19 shows the differences in variability among the five factors for the six-row strains in 1930. Named in order from the least variable to the most variable they are: length of awn, "first count", awn-barbed area ratio, length of barbed area, "second count". The differences were all significant. The order of variability was the same for the two years except awn-barbed area ratio and length of barbed area were reversed.

Table 20 shows the differences in variability among the five factors for the two-row strains in 1929. Named in order from the least variable to the most variable they are: length of awn, "first count", awn-barbed area ratio, length of barbed area, "second count". These differences are all significant between the various factors except the difference between awn-barbed area ratio and length of barbed area.

Table 21 shows the differences in variability among the five factors for the two-row strains in 1930. Named in order from the least variable to the most variable they are: length of awn, "first count", awn-barbed area ratio, length of barbed area, "second count". These differences are all significant. The coefficients of variability of the five factors in the two-row group are in the same order for the two years, and are in the same order that they are in the

six-row strains except for the one difference in the six-row in 1929 which was noted above.

The correlations that were computed to show the relationships between the different factors studied, are reported in Tables 22, 23, 24, and 25.

Table 22 contains a report of the correlations that were computed for both the six-row and two-row groups for the two years. The correlations reported in this table were obtained by using the averages of each individual head. There was a very slight degree of association in all cases between length of awn and length of barbed area, and in 1930 in both the six-row and two-row groups, there was a slight positive correlation between these two factors. There was no correlation between the factors, length of awn and "second count", except in the two-row group for 1930 there was a slight positive correlation between these two factors. There was a strong positive correlation between length of barbed area and "second count" in all cases. There was a strong negative correlation between "first count" and awn-barbed area ratio in 1929, and a marked correlation between these two factors in 1930. There was a strong negative correlation between "second count" and awn-barbed area ratio in all the groups. The latter three correlations show that the greater the number of barbs the longer the barbed area.

The same group of correlations were computed using the averages of the strains, instead of each individual head average. This group of correlations is shown in Table 23. The results obtained by this method give very similar results to those obtained by using the averages of each individual head. Comparisons are made between the results obtained by these two methods, these comparisons being shown in Table 24. Only one case shows a significant difference between the results. This case involves the correlations between "first count" and awn-barbed area ratio for the two-row group in 1929; this difference is 6.83 times the probable error of the difference, although there is a marked negative correlation in both cases.

Correlations were computed between the factors, length of awn, length of barbed area, awn-barbed area ratio, "first count", and "second count" for 1929 with the same factors for 1930. These are reported in Table 25. There were marked positive correlations between length of barbed areas, between awn-barbed area ratio, between second counts, in both the six-row and two-row groups and first counts in the six-row group. The other correlation values are not statistically significant.

DISCUSSION

In making comparisons between the results obtained by using the individual head averages and by using the averages of the strains the values of the means of all the factors were the same from both methods of calculation, except that the coefficients of variability of all factors obtained by using the individual head averages were higher than the values of this constant obtained by using the strain averages. This is to be expected as some of the strains are quite heterozygous, but the extremes are averaged in to obtain the strain average so that the spread of the population is very much less than when each head is used to obtain these constants.

The results of this experiment show considerable differences between the values of the factors for 1929 when compared with the corresponding values for 1930. A possible explanation is the general difference in the two seasons. The year 1929 was a very poor year for barley and the plots used in 1929 were very low in fertility. As a result the yields were so low in 1929 that only enough of each strain was harvested to obtain seed for the 1930 planting.

Differences in all the factors studied were found to exist between the six-row and the two-row groups. These differences, while due to differences in inheritance, are

modified by seasonal conditions. The two-row strains had significantly longer awns than the six-row strains, but this difference was not so great in 1930 when better growing conditions prevailed. The six-row strains had the shorter barbed area both years but this difference was less in 1930. There was no difference in the awn-barbed area ratio in 1929, but in 1930 this factor was significantly larger for the two-row group than it was in the six-row group. The "first count" was significantly less for the two-row than it was for the six-row both years, but the difference was greater in 1930 than it was in 1929. The "second count" was less for the two-row strains both years but the differences were not significant either year. These results show that the two-row strains have longer and smoother awns than the six-row strains, but that the differences vary with seasonal conditions.

The length of awn in 1930 was significantly greater than in 1929 in both the six-row and two-row groups but the coefficient of variability was low both years. This shows that there are differences due to seasonal conditions and that differences due to inheritance were slight. The awn-barbed area ratio was greater and the number of barbs was lower in 1930 than in 1929. The coefficients of variability in these 12 dases were high showing that there were differances in smoothness of awn which were caused by

differences in inheritance and by differences in seasonal conditions.

A group of the two-row type strains were used to make comparisons between the values of four factors studied in 1929 with their corresponding factors in 1930. The results of this study correspond very closely to the results obtained by comparing the entire population of 1929 with that of 1930.

A comparison was made between Michigan Black Barbless and Spartan which are smooth awn varieties and Michigan Two-Row which is a rough awn variety with two extremely rough awn strains and two extremely smooth awn strains. The results of these comparisons show that all of the strains are much smoother than Michigan Two-Row, but that there are wide differences between strains that are "smooth awn" selections from smooth awn x rough awn crosses. These comparisons also show that it is possible to obtain strains that are smoother than the present commercial smooth awn varieties.

In making comparisons among the different factors to determine the amount of variability it was found that they rank in the following order: length of awn, "first count", awn-barbed area ratio, length of barbed area, and "second count", named in order from the least variable to the most variable. All of the strains have a number of

barbs near the tip but there is a wide variation between strains in the distance they extend down the awn, which fact is brought out by the results.

The results of the correlation studies show that smooth awn is not associated with length of awn, and that the long awned strains are as likely to be smooth as are the short awned strains. There is a very close association, however, between the length of the barbed area and the number of barbs "second count". Some strains had very few barbs per unit area but they extended quite far down the awn which tends to lower this correlation. This fact also tends to make the correlation between awn-barbed area ratio and "first count" lower than the correlation between awn-barbed area ratio and "second count". The relatively high negative correlation between awn-barbed area ratio with both "first count" and "second count" show that, if the barb counts are high, a large portion of the awn will be barbed.

The inter-annual correlations of all of the factors for both six-row and two-row strains were positive and significant, except for length of awn and "first count" in the two-row group and length of awn in the six-row group. The high positive correlation between length of barbed areas between awn-barbed area ratios, between "first counts" and between "second counts" show that these factors are

quite constant within a strain and not so dependent upon the environment as length of awn.

SUMMARY

1. It is as reliable to use the strain averages as the individual head averages in computing the mean of any one of the factors, but the individual head averages should be used to obtain the coefficient of variability.

2. There are significant differences in smoothness of awn and length of awn due to inherited and seasonal differences. The two-row group had longer and smoother awns than the six-row group both years. Both of the groups had longer and smoother awns in 1930 than in 1929.

3. There are significant differences in degree of smoothness and length of awn among the strains in the six-row group which are due to inherited and seasonal differences.

4. There are significant differences in degree of smoothness and length of awn among the strains in the two-row group which are due to inherited and seasonal differences.

5. There are significant differences in length of awn among a group of two-row strains due to inherited and seasonal differences. There also were significant dif-

ferences in smoothness of awn among some of these strains due to seasonal and inherited differences, but the numbers used were probably too small to bring out all of the differences.

6. There are "smooth awn" strains that are smoother and "smooth awn" strains that are rougher than Michigan Black Barbless and Spartan.

7. Length of awn was the least variable factor studied, followed in order by "first count", awn-barbed area ratio, length of barbed area, and "second count". This shows that all of the strains had a number of barbs near the tip, but there was a wide range of variation in the distance they extended down the awn.

8. There was a strong correlation between number of barbs and length of barbed area, and between number of barbs and awn-barbed-area ratio. The correlation between length of awn and length of barbed area and between length of awn and number of barbs was very low in all cases. In making selections smooth awn strains could be selected by determining the distance the barbs extended down the awn. There is a strong degree of association between this factor and number of barbs, so the awn would be relatively smooth if the barbs did not extend over more than a third of the awn. All of the factors for smoothness of awn for one year showed a high degree of association with the same

factor for the next year. This shows that these factors were quite constant within a strain and so inherited.

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Table 1. The means, standard deviations, and coefficients of variability with their Probable Errors of the five factors studied, using the averages of each individual head for the two-row and six-row types in 1929 and 1930.

	Mean	Standard Deviation	Coefficient of Var.
Length of awn			
six-row, 1929	111.23±.38	14.81±.27	13.31±.25
six-row, 1930	125.75±.29	11.97±.21	9.52±.16
two-row, 1929	132.41±.30	15.70±.21	11.86±.16
two-row, 1930	140.83±.24	13.50±.17	9.59±.12
Length of barbed area			
six-row, 1929	48.33±.40	15.46±.28	31.99±.64
six-row, 1930	47.61±.35	14.42±.25	30.29±.57
two-row, 1929	58.13±.38	20.54±.27	35.14±.52
two-row, 1930	53.39±.42	23.44±.29	43.89±.65
Awn-barbed area ratio			
six-row, 1929	2.57±.03	1.01±.02	39.16±.81
six-row, 1930	2.84±.02	.71±.01	24.94±.46
two-row, 1929	2.54±.02	.85±.01	33.39±.49
two-row, 1930	3.08±.02	1.09±.01	35.47±.50
First count			
six-row, 1929	68.59±.55	21.61±.39	31.51±.63
six-row, 1930	66.40±.37	15.08±.26	22.72±.41
two-row, 1929	64.25±.32	16.91±.22	26.33±.37
two-row, 1930	60.39±.29	16.30±.20	27.00±.36
Second count			
six-row, 1929	35.57±.48	18.58±.33	52.25±.18
six-row, 1930	32.24±.37	15.33±.27	47.53±.99
two-row, 1929	33.96±.30	15.77±.21	46.44±.74
two-row, 1930	30.97±.32	17.91±.22	57.84±.80

Table 2. Same determinations as in Table 1, except computed from averages of each strain.

	Mean	Standard Deviation	Coefficient of Variability
Length of awn			
six-row, 1929	111.59±.88	11.50±.63	10.14±.46
six-row, 1930	125.81±.70	9.14±.50	7.26±.39
two-row, 1929	131.88±.63	11.26±.45	8.54±.34
two-row, 1930	140.74±.63	11.26±.45	8.00±.22
Length of barbed area			
six-row, 1929	48.21±.98	12.76±.69	26.46±1.54
six-row, 1930	47.76±.97	12.64±.69	26.46±1.54
two-row, 1929	58.50±.95	16.95±.67	25.49±1.07
two-row, 1930	53.43±1.13	20.21±.80	37.82±1.70
Awn-barbed area ratio			
six-row, 1929	2.51±.07	.86±.05	34.39±2.08
six-row, 1930	2.80±.04	.57±.03	20.16±1.14
two-row, 1929	2.46±.04	.66±.03	26.81±1.13
two-row, 1930	2.99±.05	.92±.04	30.86±1.33
First count			
six-row, 1929	68.15±1.43	18.66±1.01	27.38±1.60
six-row, 1930	65.75±.95	12.35±.67	18.78±1.06
two-row, 1929	64.16±.79	14.03±.56	21.87±0.91
two-row, 1930	60.22±.75	13.30±.53	22.08±0.92
Second count			
six-row, 1929	35.03±1.16	15.11±.82	43.13±2.74
six-row, 1930	31.59±.90	11.70±.64	37.03±2.39
two-row, 1929	33.81±.65	11.67±.46	34.52±1.52
two-row, 1930	30.98±.83	14.80±.59	47.77±1.08

Table 3. Comparison between the value of the means reported in Table 1 and the corresponding value reported in Table 2.

	Individual head	Strain	Difference	Difference / P.E.of Diff.
Length of awn				
six-row, 1929	111.23±.38	111.59±.88	.36±.96	0.4
six-row, 1930	125.75±.29	125.81±.70	.06±.76	0.1
two-row, 1929	132.41±.30	131.88±.63	.53±.70	0.8
two-row, 1930	140.83±.24	140.74±.63	.09±.67	0.1
Length of barbed area				
six-row, 1929	48.33±.40	48.21±.98	.12±1.06	0.1
six-row, 1930	47.61±.35	47.76±.97	.15±1.03	0.2
two-row, 1929	58.13±.38	58.40±.95	.37±1.02	0.4
two-row, 1930	53.39±.42	53.43±1.13	.04±1.21	0.0
Awn-barbed area ratio				
six-row, 1929	2.57±.03	2.51±.07	.06±.08	0.8
six-row, 1930	2.89±.02	2.80±.04	.09±.04	2.3
two-row, 1929	2.54±.02	2.46±.04	.08±.04	2.0
two-row, 1930	3.08±.02	2.99±.05	.09±.05	1.8
First count				
six-row, 1929	68.59±.55	68.15±1.43	.44±1.53	0.3
six-row, 1930	66.40±.37	65.75±.95	.65±1.02	0.6
two-row, 1929	64.25±.32	64.16±.79	.09±.85	0.0
two-row, 1930	60.39±.29	60.22±.75	.17±.80	0.0
Second count				
six-row, 1929	35.57±.48	35.03±1.16	.54±1.26	0.4
six-row, 1930	32.24±.37	31.59±.90	.65±.97	0.7
two-row, 1929	33.96±.30	33.81±.65	.15±.72	0.2
two-row, 1930	30.97±.32	30.98±.83	.01±.89	0.0

Table 4. Comparison of the values of the coefficients of variability reported in Table 1, and the corresponding values reported in Table 2.

	Individual head	Strain	Difference	Difference / P.E.of Diff.
Length of awn				
six-row, 1929	13.31±.25	10.14±.46	3.17±.52	6.1
six-row, 1930	9.52±.16	7.26±.39	2.26±.42	5.4
two-row, 1929	11.86±.16	8.54±.34	3.32±.38	8.7
two-row, 1930	9.59±.12	8.00±.22	1.59±.25	6.4
Length of barbed area				
six-row, 1929	31.99±.64	26.46±1.54	5.53±1.67	3.3
six-row, 1930	30.29±.57	26.46±1.54	3.83±1.64	2.3
two-row, 1929	35.14±.52	26.49±1.07	8.65±1.19	7.3
two-row, 1930	43.89±.65	37.82±1.70	6.07±1.82	3.3
Awn-barbed area ratio				
six-row, 1929	39.16±.81	34.39±2.08	4.77±2.23	2.1
six-row, 1930	24.94±.46	20.16±1.14	4.78±1.23	3.9
two-row, 1929	33.39±.49	26.81±1.13	6.58±1.23	5.3
two-row, 1930	35.47±.50	30.86±1.33	4.61±1.42	3.2
First count				
six-row, 1929	31.51±.63	27.38±1.60	4.13±1.72	2.4
six-row, 1930	22.72±.41	18.78±1.06	3.94±1.14	3.5
two-row, 1929	26.33±.37	21.87±.91	4.46±.98	4.6
two-row, 1930	27.00±.36	22.08±.92	4.92±.99	5.0
Second count				
six-row, 1929	52.25±1.18	43.13±2.74	9.12±2.98	3.1
six-row, 1930	47.53±.99	37.03±2.39	10.50±2.59	4.1
two-row, 1929	46.44±.74	34.52±1.52	11.92±1.69	7.1
two-row, 1930	57.84±.80	47.77±1.08	10.07±1.34	7.5

Table 5. Comparison between the value of the means of the five factors studied for the six-row group, and the corresponding means of the two-row group.

		Six-row	Two-row	Difference	Difference / P.E.Diff.
Length of awn	1929	111.23±.38	132.41±.30	-21.18±.48	44.1
Length of awn	1930	125.75±.29	140.83±.24	-15.08±.38	39.7
Length of barbed area	1929	48.33±.40	58.13±.38	- 9.80±.55	17.8
Length of barbed area	1930	47.61±.35	53.39±.42	- 5.78±.55	10.5
Awn-barbed area ratio	1929	2.57±.03	2.54±.02	.03±.04	0.8
Awn-barbed area ratio	1930	2.84±.02	3.08±.02	- .24±.03	8.0
First count	1929	68.59±.55	64.25±.32	4.34±.64	6.8
First count	1930	66.40±.37	60.39±.29	6.01±.47	12.8
Second count	1929	35.57±.48	33.96±.30	1.61±.57	2.8
Second count	1930	32.24±.37	30.97±.32	1.27±.49	2.6

Six-row largest

\- Six-row smallest

Table 6. Comparison between the value of the means of the five factors studied for 1929 and the corresponding means in 1930.

	1929	1930	Difference	Difference / P.E.Diff.
Length of awn				
Six-row	111.23±.38	125.75±.29	-14.52±.48	30.3
Two-row	132.41±.30	140.83±.24	- 8.42±.38	22.2
Length of barbed area				
Six-row	48.33±.40	47.61±.35	.72±.53	1.4
Two-row	58.13±.38	53.39±.42	4.74±.57	8.3
Awn-barbed area ratio				
Six-row	2.57±.03	2.84±.02	- .27±.04	6.8
Two-row	2.54±.02	3.08±.02	- .54±.03	18.0
First count				
Six-row	68.59±.55	66.40±.37	2.19±.66	3.3
Two-row	64.25±.32	60.39±.29	3.86±.43	9.0
Second count				
Six-row	35.57±.48	32.24±.37	3.33±.61	5.5
Two-row	33.96±.30	30.97±.32	2.99±.44	6.8

- 1929 smallest

Table 7. Comparison between the values of coefficients of variability of the five factors studied for the six-row group and the corresponding values for the two-row group.

		Six-row	Two-row	Difference	Difference / P.E.Diff.
Length of awn	1929	13.31±.25	11.86±.16	1.45±.30	4.8
Length of awn	1930	9.52±.16	9.59±.12	- .07±.20	0.4
Length of barbed area	1929	31.99±.64	35.14±.52	-3.15±.82	3.8
Length of barbed area	1930	30.29±.57	43.89±.65	-13.60±.86	15.8
Awn-barbed area ratio	1929	39.16±.81	33.39±.49	5.77±.95	6.1
Awn-barbed area ratio	1930	24.94±.46	35.47±.50	-10.53±.68	15.5
First count	1929	31.51±.63	26.33±.37	5.18±.73	7.1
First count	1930	22.72±.41	27.00±.36	-4.28±.55	7.8
Second count	1929	52.25±1.18	46.44±.74	5.81±1.39	4.2
Second count	1930	47.53±.99	57.84±.80	-10.31±1.27	8.1

- Six-row smallest

Table 8. Comparison between the values of the coefficients of variability of the five factors studied in 1929 and the corresponding values for 1930.

	1929	1930	Difference	Difference / P.E.Diff.
Length of awn				
six-row	13.31±.25	9.52±.16	3.79±.30	12.6
two-row	11.86±.16	9.59±.12	2.27±.20	11.4
Length of barbed area				
six-row	31.99±.64	30.29±.57	1.60±.86	2.0
two-row	35.14±.52	43.89±.65	-8.75±.83	10.5
Awn-barbed area ratio				
six-row	39.16±.81	24.94±.46	14.22±.93	15.3
two-row	33.39±.49	35.47±.50	-1.98±.70	2.8
First count				
six-row	31.51±.63	22.72±.41	8.79±.75	11.7
two-row	26.33±.37	27.00±.36	- .67±.52	1.3
Second count				
six-row	52.25±1.18	47.53±.99	4.72±1.54	3.0
two-row	46.44±.74	57.84±.80	-11.40±1.09	10.5

- 1929 smallest

Table 9. Mean lengths of awn, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E.Diff.
152.03±1.68	152.98±2.62	.95±3.11	.3
130.48±2.85	142.93±.78	12.45±2.95	4.2
118.08±2.38	127.23±1.36	9.15±2.74	3.3
118.90±1.92	134.48±1.45	15.58±2.40	6.5
124.39±1.68	139.35±2.01	14.96±2.62	5.7
127.25±2.12	136.80±.80	9.55±2.27	4.2
119.38±2.12	137.48±1.77	18.10±2.76	6.6
120.08±1.60	146.23±1.68	26.15±2.32	11.3
124.77±3.38	158.80±2.08	34.03±3.97	8.6
111.48±3.30	134.55±4.31	23.07±5.43	4.3
130.31±2.25	163.10±2.31	32.79±3.22	10.2
123.39±4.03	141.00±6.67	17.61±7.79	2.3
135.95±3.14	150.00±1.59	14.05±3.52	4.0
145.10±2.60	149.98±1.55	4.88±3.03	1.6
134.40±4.37	150.08±2.20	15.68±4.89	3.2
143.09±2.19	152.60±1.58	9.51±2.70	3.5
127.05±2.57	146.80±2.27	19.75±3.43	5.8
147.38±3.15	146.15±1.82	- 1.23±3.64	.3
139.05±3.34	152.08±3.40	13.03±4.77	2.7
136.09±3.02	150.85±1.86	14.76±3.54	4.2
152.73±1.68	157.70±1.46	4.97±2.23	2.2
133.42±4.70	161.08±3.04	27.66±5.60	4.9
130.38±3.58	158.25±2.79	27.87±4.54	6.1
144.50±2.45	141.03±1.72	- 3.47±2.99	1.2
138.77±3.23	155.60±2.38	16.83±4.01	4.2
137.47±2.96	157.43±1.44	19.96±3.29	6.1
146.15±2.71	166.75±1.78	20.60±3.24	6.4
123.34±2.89	149.18±2.11	25.84±3.54	7.3
124.85±2.18	152.50±3.23	27.65±3.90	7.1
124.18±3.06	148.55±2.09	24.37±3.71	6.6
126.35±2.93	165.75±1.30	39.40±3.20	12.3
118.14±3.23	139.90±1.94	21.76±3.77	5.8
125.00±2.78	154.50±1.79	29.50±3.31	8.9
134.45±2.56	161.33±1.11	26.88±2.79	9.6
136.36±2.55	162.33±1.78	25.97±3.11	8.4
120.00±1.80	140.95±3.05	20.95±3.54	5.9
127.95±2.17	145.13±1.05	17.18±2.41	7.1

1930 largest

- 1930 smallest

Table 10. Coefficients of variability of the length of awn, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E.Diff.
5.18±.78	8.04±1.22	2.86±1.44	2.0
10.21±1.55	2.55±.38	-7.66±1.60	4.8
9.45±1.44	4.99±.76	-4.46±1.63	2.7
7.20±1.15	5.07±.76	-2.13±1.38	1.5
5.28±.95	6.77±1.03	1.49±1.40	1.1
7.40±1.17	2.74±.41	-4.66±1.24	3.8
8.31±1.27	6.04±.91	-2.27±1.56	1.5
6.23±.94	5.37±.81	- .86±1.24	.7
12.04±1.94	6.16±.93	-5.88±2.15	2.7
13.17±2.13	17.22±2.67	4.05±3.42	1.2
7.68±1.23	6.65±1.00	-1.03±1.59	.7
14.52±2.23	21.02±3.30	6.50±3.98	1.6
10.82±1.65	4.95±.75	-5.87±1.81	3.2
8.41±1.27	4.85±.73	-3.56±1.47	2.4
13.63±2.34	6.88±1.04	-6.75±2.56	2.6
6.42±1.08	4.85±.73	-1.57±1.30	1.2
9.49±1.43	7.24±1.09	-2.25±1.80	1.3
10.03±1.53	5.84±.88	-4.19±1.77	2.4
8.74±1.70	10.84±1.60	2.10±2.33	.9
9.29±1.57	5.74±.87	-3.55±1.80	2.0
5.17±.78	4.33±.67	- .84±1.03	.8
12.78±1.51	8.85±1.33	-3.93±2.01	2.0
12.88±1.98	8.27±1.25	-4.61±2.34	2.0
7.95±1.20	5.73±.86	-2.22±1.48	1.5
10.34±1.66	7.17±1.08	-3.17±1.98	1.6
9.04±1.52	4.28±.65	-4.76±1.65	2.9
8.71±1.31	5.01±.76	-3.70±1.51	2.5
9.84±1.67	6.63±1.00	-3.21±1.94	1.7
8.18±1.25	9.86±1.5	.68±1.95	.4
11.56±1.77	6.58±.99	-4.98±2.03	2.5
10.88±1.66	3.67±.55	-7.21±1.75	4.1
12.83±1.97	6.50±.98	-6.33±2.20	2.9
10.43±1.78	5.42±.82	-5.01±1.96	2.6
8.91±1.34	3.22±.48	-5.69±1.42	4.0
8.31±1.32	5.15±.78	-3.16±1.53	2.1
6.68±1.06	10.13±1.54	3.45±1.87	1.8
7.94±1.20	3.38±.51	-4.56±1.30	3.5

1930 largest

- 1930 smallest

Table 11. Mean lengths of barbed area, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E. Diff.
42.25±1.39	42.05±1.31	- .20±1.91	.1
71.95±4.04	69.73±7.02	- 2.22±8.10	.3
55.83±1.74	38.75±.75	-17.08±1.89	9.0
45.88±1.76	38.63±1.43	- 7.25±2.27	3.2
50.97±2.33	54.25±4.21	3.28±4.81	.7
57.33±3.19	69.20±3.68	11.87±4.87	2.4
53.60±1.71	32.70±.88	-20.90±1.92	10.9
51.95-.58	40.60±1.33	-11.35±1.45	7.8
44.86-2.02	50.25±1.32	5.39±2.41	2.2
57.45-1.79	64.73±3.65	7.28±4.07	1.8
57.39-1.30	47.58±.96	- 9.81±1.62	6.1
59.31-3.50	69.26±5.67	9.95±2.11	4.7
59.90±3.02	83.33±3.33	23.43±4.50	5.2
104.40±3.57	91.15±2.81	-13.25±4.54	2.9
66.97±1.94	86.45±1.58	19.48±2.50	7.8
85.19±3.49	82.33±2.82	- 2.86±4.49	.6
81.35±3.55	80.15±2.00	- 1.20±4.08	.3
89.55±5.63	82.80±5.76	- 6.75±8.05	.8
62.67±4.19	70.68±4.88	8.01±6.43	1.2
76.13±2.90	91.48±3.47	15.35±4.52	3.4
94.48±2.99	106.45±4.54	11.97±5.44	2.2
66.79±5.35	78.00±6.58	11.21±8.48	1.3
65.35±3.84	74.40±6.11	9.05±7.22	1.3
42.63±1.11	42.25±3.43	- .38±3.60	.1
46.56±2.69	50.60±1.13	4.04±2.92	1.4
78.16±8.21	73.38±6.75	- 4.78±10.63	.5
43.88±2.86	33.18±1.27	-10.70±3.31	3.4
55.28±2.95	38.50±2.33	-16.78±3.76	4.5
63.68±1.11	60.55±2.28	- 3.13±2.54	1.2
54.18±3.71	49.98±3.35	- 4.20±5.00	.8
90.87±4.61	112.20±2.98	21.33±5.49	3.9
80.85±4.38	89.05±1.97	8.20±4.80	1.7
49.74±1.82	68.05±2.87	18.31±3.40	5.4
63.53±4.68	63.9±6.86	.37±8.31	.0
76.47±6.11	57.03±7.02	-19.44±9.31	2.1
46.53±2.54	38.85±.94	- 7.68±2.71	2.8
58.38±1.93	37.73±1.34	-20.65±2.35	8.8

1930 largest

- 1930 smallest

Table 12. Coefficient of variability, 1929 and 1930, of length of barbed area of a group of two-row strains.

1929	1930	Difference	Difference / P.E. Diff.
15.77±2.44	14.64±2.27	- 1.13±3.33	.3
26.32±4.24	47.22±8.56	20.90±9.55	2.2
14.65±2.26	9.05±1.39	- 5.60±2.65	2.1
17.08±2.78	17.48±2.72	.40±3.89	.1
17.94±3.34	36.42±6.18	18.48±7.03	2.6
24.75±4.17	24.94±3.99	.19±5.77	.0
14.98±2.30	11.27±1.72	- 3.71±2.87	1.3
6.16±.93	15.32±2.36	9.16±2.54	3.6
20.03±3.31	12.31±1.88	.28±3.81	.1
13.85±2.24	26.45±4.26	12.60±4.81	2.6
10.05±1.61	9.50±1.45	- .55±2.17	.2
26.27±4.44	36.40±6.17	10.13±7.60	1.3
23.63±3.75	18.76±6.93	- 4.87±7.89	.6
16.03±2.48	12.40±1.90	- 3.63±3.12	1.2
12.15±2.08	13.52±2.07	1.37±2.94	.5
17.18±2.98	16.08±2.49	- 1.10±3.88	.2
20.43±3.21	11.68±1.79	- 8.75±3.68	2.4
29.46±4.81	32.62±5.41	3.16±7.24	.4
24.26±4.99	32.35±5.36	8.09±7.32	1.1
15.97±2.76	17.79±2.76	1.82±3.90	.5
14.83±2.28	19.99±3.13	5.16±3.87	1.3
29.10±6.12	39.55±6.83	10.45±9.17	1.1
27.56±4.45	38.52±6.62	10.96±7.98	1.4
12.24±1.87	38.08±6.52	25.84±6.78	3.8
25.68±4.34	10.49±1.60	-15.19±4.62	3.3
44.06±8.75	43.12±7.44	- .94±11.49	.1
30.55±5.02	18.01±2.80	-12.54±5.75	2.2
22.35±4.10	28.35±4.59	6.00±6.15	1.0
8.17±1.25	17.66±4.36	9.49±4.54	2.1
32.12±5.32	31.42±5.18	- .70±7.42	.1
23.78±3.78	12.46±1.91	-11.32±4.24	2.7
25.39±4.07	10.39±1.58	-15.00±4.37	3.4
17.19±2.67	19.80±3.10	2.61±4.09	.6
35.12±5.91	50.35±9.32	15.23±11.04	1.4
35.59±6.31	57.70±11.23	22.11±12.88	1.7
24.23±4.08	11.30±1.73	-12.93±4.43	2.9
15.47±2.39	16.70±2.59	1.23±3.53	.4

1930 largest

- 1930 smallest

Table 13. Values of mean of first count, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E. Diff.
51.05±3.41	66.80±.92	15.75±3.53	4.5
92.35±2.02	81.30±1.50	-11.05±2.52	4.4
85.43±2.41	66.20±5.03	-19.23±5.57	3.5
72.88±3.61	58.50±1.88	-14.58±4.07	3.5
80.07±5.01	72.35±1.80	- 7.72±5.32	1.5
80.72±3.78	77.00±1.83	- 3.72±4.20	.9
78.55±6.42	63.55±1.45	-15.00±6.57	2.3
76.15±2.22	59.50±1.20	-16.65±2.52	6.6
40.22±2.69	69.95±1.19	29.73±2.94	10.1
79.61±2.35	71.00±1.97	- 8.61±3.07	2.8
72.56±2.64	69.70±2.45	- 2.86±3.60	.8
73.22±2.76	65.00±3.15	- 8.22±4.19	2.0
69.95±1.51	67.10±1.16	- 2.85±1.90	1.5
76.70±.99	80.25±1.29	3.55±1.63	2.2
62.40±2.53	65.80±1.46	3.40±2.92	1.2
66.06±1.28	64.45±.90	- 1.61±1.56	1.0
72.37±.80	74.65±.72	2.28±1.08	2.1
76.25±1.43	70.70±3.01	- 5.55±3.33	1.7
71.95±2.44	80.90±2.28	8.95±3.34	2.7
57.71±1.12	78.25±1.00	20.54±1.50	13.7
77.15±1.48	73.15±.84	- 4.00±1.70	2.4
72.67±6.72	66.60±3.77	- 6.07±7.71	.8
75.45±2.43	76.15±1.94	- .30±3.11	.1
34.80±1.38	51.00±2.00	16.20±2.43	6.7
46.64±2.17	54.20±1.96	7.56±2.92	2.6
63.08±3.43	75.95±2.45	12.87±4.22	3.1
54.22±2.40	55.25±1.90	1.03±3.06	.3
54.44±1.94	24.35±1.71	-30.09±2.58	11.7
62.60±2.28	42.15±2.43	-20.45±3.30	6.2
56.85±2.44	37.20±2.77	-19.65±3.69	5.3
72.48±1.66	81.20±1.40	8.72±2.17	4.0
73.00±1.38	76.05±2.79	3.05±3.11	1.0
55.25±4.88	53.85±1.75	- 1.40±5.18	.3
89.65±2.32	61.35±4.01	-28.30±4.63	6.1
81.31±3.73	62.15±4.75	-19.16±6.04	3.2
74.03±5.42	37.15±1.94	-36.88±5.76	6.4
64.15±3.47	41.90±3.17	-22.25±4.70	4.7

1930 largest

- 1930 smallest

Table 14. Coefficient of variability of first count, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E. Diff.
21.24±5.15	6.43±.98	-24.81±5.24	4.7
10.25±1.57	29.16±4.76	18.91±5.01	3.8
13.20±2.02	37.46±6.39	24.26±6.67	3.6
22.05±3.66	15.04±2.31	- 7.01±4.33	1.6
24.54±4.67	11.68±1.79	-12.86±5.00	2.6
20.67±3.42	11.12±1.70	- 9.55±3.82	2.5
38.38±6.59	10.67±1.62	-27.71±6.78	4.1
13.66±2.12	9.48±1.40	- 4.18±2.54	1.7
29.79±5.14	7.96±1.20	-21.83±5.28	4.1
13.10±2.11	13.02±1.99	- .08±2.90	.0
16.18±2.64	16.45±2.55	.27±3.67	.0
16.75±2.74	21.55±3.57	4.80±4.50	1.1
10.12±1.54	8.31±1.26	- 1.81±1.99	.9
6.08±.92	7.52±1.13	1.44±1.46	1.0
16.99±2.94	10.38±1.58	- 6.61±3.34	2.0
7.96±1.34	6.54±.99	- 1.42±1.67	.9
5.21±.79	4.52±.68	- .69±1.04	.7
8.79±1.33	19.94±3.12	11.15±3.39	3.3
12.31±2.35	13.24±2.03	.93±3.11	.3
8.16±1.38	5.97± .90	- 2.19±1.65	1.3
8.97±1.37	5.36± .81	- 3.61±1.59	2.3
33.59±7.24	26.52±4.27	- 7.07±8.41	.8
15.13±2.33	11.97±3.47	- 3.16±4.18	.8
18.58±2.90	18.39±2.87	- .19±4.08	.1
20.67±3.42	17.00±2.64	- 3.67±4.32	.9
22.80±4.04	15.11±2.33	- 7.69±4.66	1.7
20.76±3.26	16.12±2.49	- 4.64±4.10	1.1
14.96±2.58	32.91±5.47	17.95±6.04	2.0
17.11±2.67	27.08±4.36	9.97±5.11	2.0
20.10±3.15	34.88±5.86	14.78±6.65	2.2
10.71±1.63	8.07±1.22	- 2.64±2.04	1.3
8.84±1.33	17.22±2.67	8.38±2.98	2.8
41.38±7.23	15.28±2.36	-26.10±7.61	3.4
12.12±1.86	30.61±5.02	18.49±5.35	3.5
20.40±3.37	35.87±6.07	15.47±6.94	2.2
32.73±5.49	24.49±3.91	- 8.24±6.74	1.2
25.34±4.06	35.44±5.98	10.10±7.23	1.4

1930 largest

\- 1930 smallest

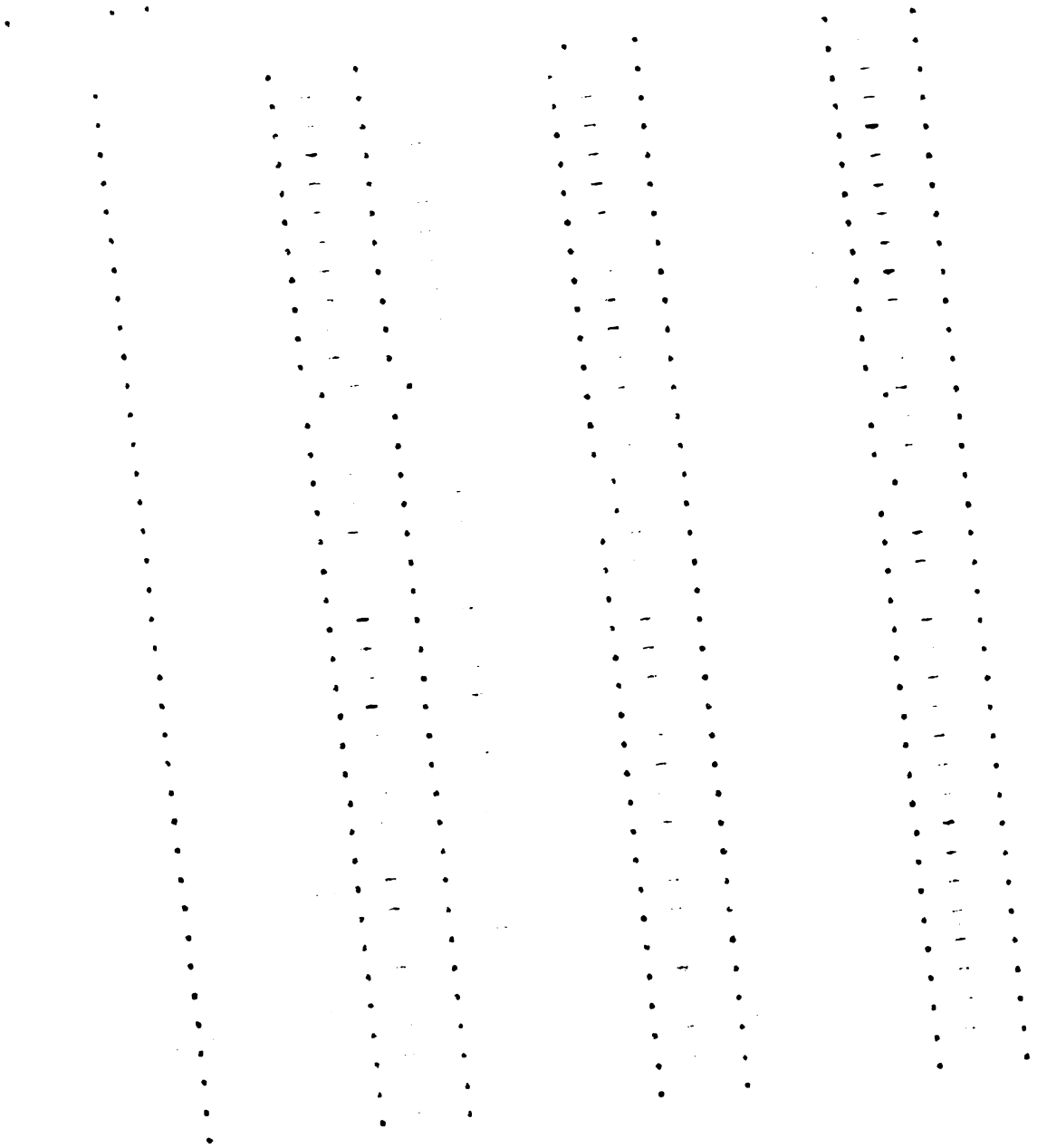


Table 15. Values of mean of second count, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E.Diff.
21.95±1.89	29.70±2.17	7.75±2.88	2.7
57.10±.85	53.57±3.22	- 3.53±3.33	1.1
39.80±1.62	25.55±2.23	-14.25±2.76	5.2
33.17±3.37	24.05±1.53	- 9.12±3.70	2.5
40.56±3.02	39.25±3.75	- 1.31±4.81	2.7
44.14±3.94	51.85±3.95	7.71±5.58	1.4
39.85±1.87	17.20±1.88	-22.65±2.65	8.6
35.50±1.37	21.45±2.24	-14.05±2.63	5.3
20.42±1.93	39.60±2.13	19.18±2.88	6.7
47.67±1.56	40.89±2.18	- 6.78±2.68	2.5
39.78±1.83	41.55±2.37	1.77±2.99	.6
44.33±3.04	42.22±4.60	- 2.11±5.51	.4
35.95±2.16	50.25±1.70	14.30±2.75	5.2
48.00±1.29	51.30±1.39	3.30±1.89	1.8
38.23±2.32	45.70±1.19	7.47±2.61	2.9
44.44±1.10	50.10±.89	5.66±1.70	3.3
48.10±.92	53.25±.92	5.15±1.30	4.0
44.57±3.10	51.30±3.30	6.73±4.53-	1.5
42.88±3.26	50.8±4.08	7.92±5.22	1.5
40.29±.72	59.45±1.51	19.16±1.67	11.5
49.15±1.73	59.10±1.55	9.95±2.32	4.3
43.17±6.48	46.70±4.05	3.53±7.64	.5
48.40±2.99	52.30±.95	3.90±3.14	1.2
18.55±1.32	32.50±1.85	13.95±2.27	6.2
29.26±2.58	34.45±1.34	5.19±2.91	1.8
35.53±4.59	41.10±4.40	5.57±6.36	.9
20.58±2.67	12.15±1.63	- 8.43±3.13	2.7
33.06±1.03	13.70±2.05	-19.36±2.29	8.5
36.45±2.07	26.95±1.63	- 9.50±2.64	3.6
29.20±2.99	19.50±2.71	- 9.70±4.04	2.4
47.28±5.28	62.35±1.64	15.07±5.53	2.7
46.60±2.28	56.70±1.51	10.10±2.73	3.7
23.35±1.69	31.25±1.64	7.90±2.36	3.4
16.43±4.38	36.45±5.22	20.02±6.81	2.9
54.95±3.92	31.40±4.62	-23.55±6.06	3.9
37.11±4.47	15.90±1.06	-21.21±4.59	4.6
34.90±2.10	14.40±1.23	-20.50±2.43	8.4

1930 largest

- 1930 smallest

Table 16. Coefficient of variability of second count, 1929 and 1930, of a group of two-row strains.

1929	1930	Difference	Difference / P.E. Diff.
40.39±7.01	34.30±5.75	- 6.09±9.07	.7
6.94±1.05	29.16±4.76	22.22±4.88	4.6
19.06±2.97	42.60±7.50	23.54±8.07	2.9
45.17±8.51	29.81±4.87	-15.36±9.80	1.6
29.03±5.65	44.74±7.98	15.71±9.78	1.6
41.26±7.59	35.68±6.03	- 5.58±9.69	.6
22.03±3.48	51.37±9.58	29.34±10.19	2.9
18.05±2.80	48.99±8.98	30.94±9.41	3.3
42.03±7.77	25.27±4.05	-16.76±8.76	1.9
14.59±2.27	22.74±3.60	8.15±4.26	1.9
20.45±3.42	26.74±4.30	6.29±5.49	1.2
30.21±5.22	48.51±9.35	18.30±12.04	1.5
28.14±4.57	15.85±2.45	-12.29±5.18	2.4
12.62±1.93	12.68±1.94	.06±2.74	.0
25.48±4.56	12.20±1.87	-13.28±4.93	2.7
10.41±1.77	8.33±1.26	- 2.08±2.17	1.0
8.97±1.35	7.91±1.19	- 1.06±1.80	.6
32.63±5.42	30.14±4.94	- 2.49±7.33	.3
27.65±5.38	37.63±6.43	9.98±8.38	1.2
5.26±.89	11.91±1.82	6.65±2.03	3.3
16.49±2.55	12.26±1.87	- 4.23±3.16	1.3
54.54±13.41	40.67±7.07	-13.87±15.16	.9
28.49±4.63	8.50±1.29	-19.99±4.81	4.2
33.34±5.56	26.62±4.29	- 6.72±7.02	1.0
39.28±7.14	18.19±2.83	-21.09±7.68	2.8
54.11±11.49	50.23±9.29	3.88±14.78	.3
60.90±12.99	62.98±12.72	2.08±18.18	.1
13.08±2.23	70.04±14.85	56.96±15.02	3.8
26.68±4.29	28.41±4.61	1.53±6.30	.2
48.07±8.76	65.22±13.38	17.15±15.99	1.1
52.34±9.82	15.50±2.39	-36.84±10.11	3.6
22.92±3.63	12.49±1.91	-10.43±4.10	2.5
33.93±5.67	24.62±3.93	- 9.31±6.90	1.4
37.71±6.45	67.11±13.95	39.40±15.37	1.9
31.74±5.52	68.91±14.51	37.17±15.52	2.4
53.56±10.38	36.66±6.22	-16.90±12.10	1.4
28.24±4.58	40.15±6.96	-11.91±8.33	1.4

1930 largest

- 1930 smallest

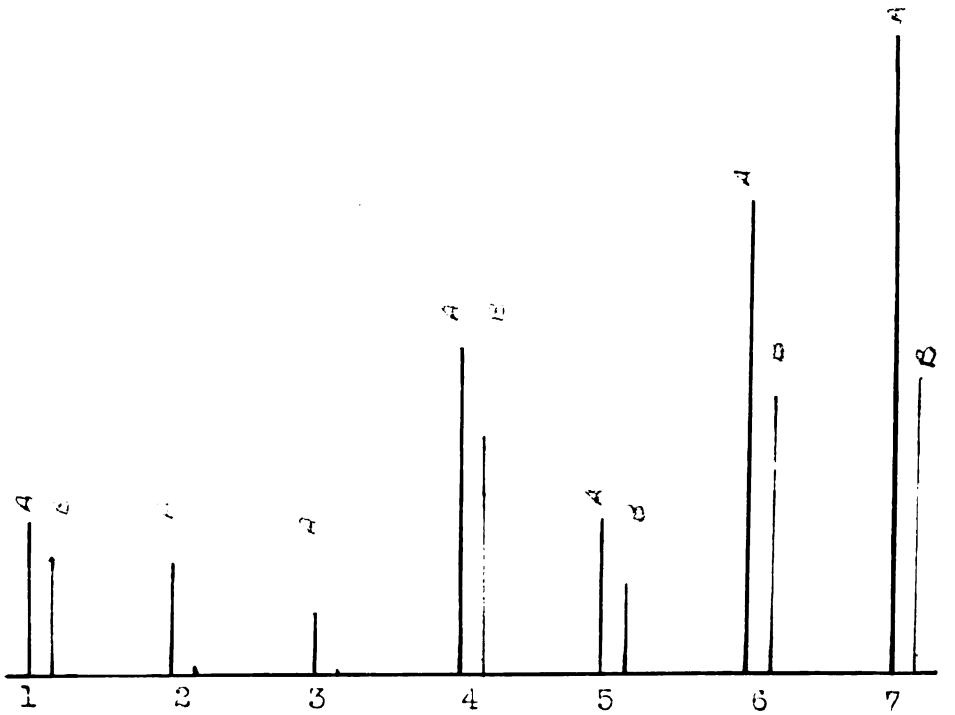
Table 17: Values of the Four Factors Studied for Spartan, Michigan Black Barbless, 0437, 0466, 0573, 0843, Michigan Two-row, for 1930

	Spartan	Mich. B.B.	70516	71502	710206	728612	Mich. Two-row
Length of awn							
Mean	152.98 ±2.62	127.44 ±.99	119.95 ±1.57	133.73 ±1.90	132.95 ±1.13	163.8 ±2.29	166.99 ±1.47
Standard Deviation	12.30 ±1.85	6.21 ±.70	7.35 ±1.11	8.92 ±1.35	5.30 ±.80	10.74 ±1.62	9.76 ±1.04
Coefficient of Variability	8.04 ±1.22	4.88 ±.55	6.13 ±.92	6.67 ±1.01	3.98 ±.60	6.56 ±.99	5.84 ±.62
Length of barbed area							
Mean	42.05 ±1.31	42.88 ±1.01	30.00 ±.86	17.03 ±1.13	83.23 ±1.19	124.73 ±2.21	166.99 ±1.47
Standard Deviation	6.16 ±.93	6.33 ±.71	4.02 ±.61	5.28 ±.80	5.60 ±.84	10.36 ±1.56	9.76 ±1.04
Coefficient of Variability	14.64 ±2.27	14.75 ±1.69	13.41 ±2.06	31.02 ±5.10	6.73 ±1.02	8.31 ±1.25	5.84 ±.62
First Count							
Mean	66.80 ±.92	71.33 ±1.69	26.40 ±1.29	16.55 ±1.42	77.90 ±1.15	86.80 ±1.43	90.50 ±.82
Standard Deviation	4.30 ±.65	10.63 ±1.20	6.06 ±.91	6.64 ±1.00	5.37 ±.81	6.72 ±1.01	5.41 ±.58

Table 17 Continued

	Spartan	Mich. B.B.	70516	71502	710206	728612	Mich. Two-row
Coefficient of Variability	6.43 ±.98	14.91 ±1.71	22.95 ±3.64	40.12 ±6.95	6.90 ±1.04	7.74 ±1.17	5.98 ±.64
Second Count Mean	29.70 ±2.17	25.08 ±1.84	6.35 ±.97	0.60 ±.25	59.60 ±1.21	69.40 ±1.06	76.43 ±.58
Standard Deviation	10.19 ±1.54	11.60 ±1.30	4.56 ±.69	1.15 ±.17	5.66 ±.85	4.99 ±.75	3.87 ±.41
Coefficient of Variability	34.30 ±5.75	46.24 ±6.21	71.79 ±15.43	191.65 ±114.41	9.50 ±1.43	7.19 ±1.08	5.06 ±.54

Figure 1. Length of barbed area and "second count" of the varieties and strains reported in Table 17.

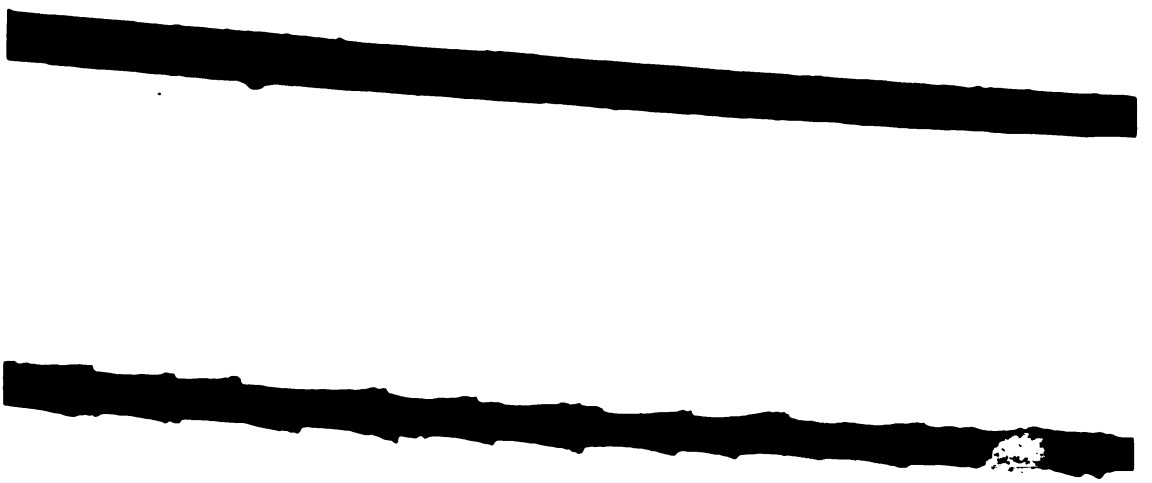


1. Spartan - 1930
2. 70516 - 1930
3. 71502 - 1930
4. 710206 - 1930
5. Michigan Black Barbless - 1930
6. 728612 - 1930
7. Michigan Two Row - 1930

A _____ Length of barbed area

B ———— Second count

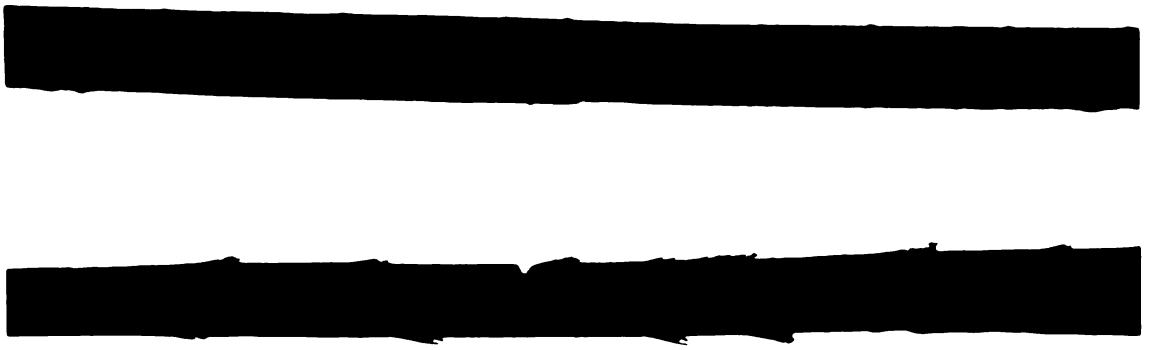
Plate 1.



First count strain 70516 (upper).

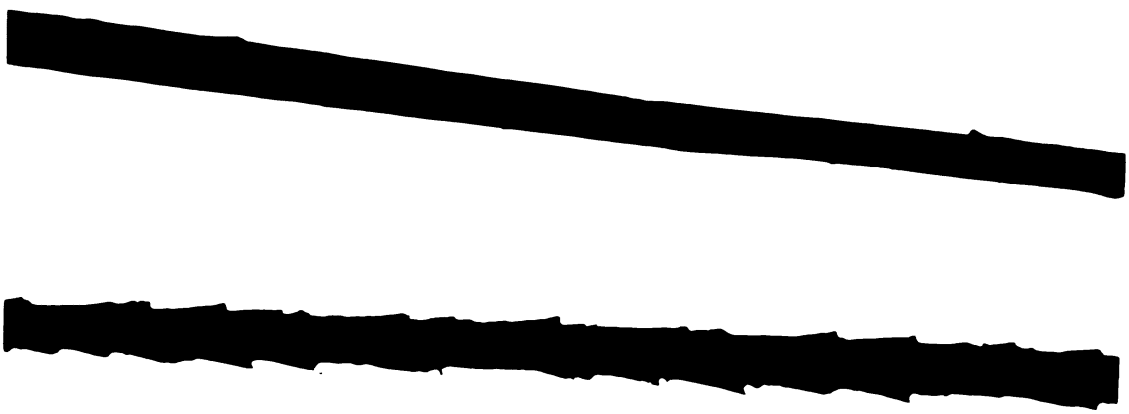
Strain 710206 (lower).

Plate 2.



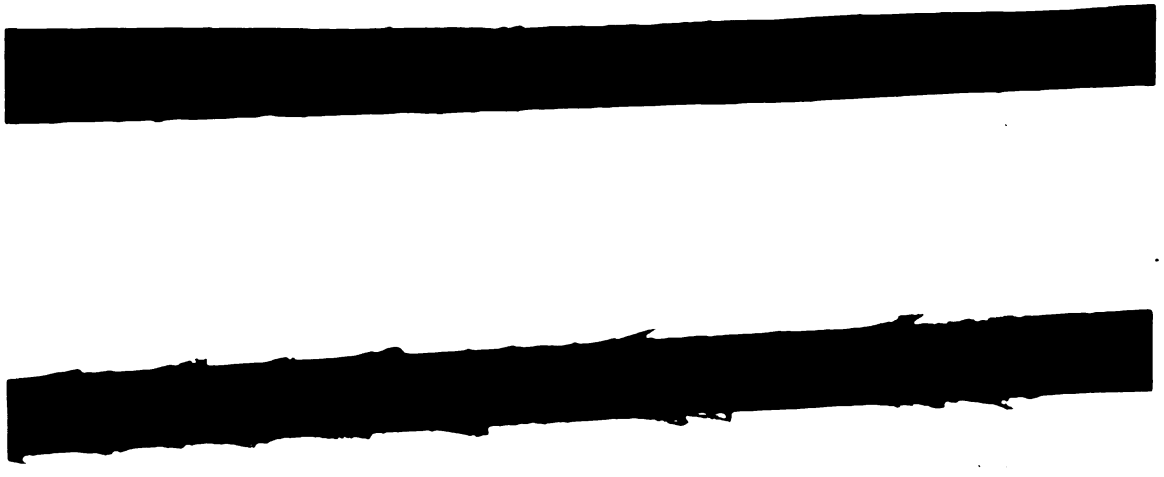
Second count strain 70516 (upper), and
strain 710206 (lower).

Plate 3.



First count strain 71502 (upper), and
strain 728612 (lower).

Plate 4.



Second count strain 71502 (upper), and
strain 728612 (lower).

Table 18. Differences in variability of the five factors studied for the six-row strains in 1929.

			Difference	Difference / P.E.Diff.
Length of awn	13.31±.25			
Length of barbed area		31.99±.64	-18.68±.69	27.0
Awn-barbed area ratio		39.16±.81	-25.85±.85	30.4
First count		31.51±.63	-18.20±.68	26.8
Second count		52.25±1.18	-38.94±1.21	32.2
Length of barbed area	31.99±.64			
Awn-barbed area ratio		39.16±.81	- 7.17±1.03	7.0
First count		31.51±.63	.48±.90	.5
Second count		52.25±1.18	-20.26±1.34	15.1
Awn-barbed area ratio	39.16±.81			
First count		31.51±.63	7.65±1.03	7.4
Second count		52.25±1.18	-13.09±1.43	9.2
First count	31.51±.63			
Second count		52.25±1.18	-20.74±1.34	15.5

\- First column smallest

Table 19. Differences in variability of the five factors studied for the six-row strains, 1930.

			Difference	Difference / P.E.Diff.
Length of awn	9.52±.16			
Length of barbed area		30.29±.57	-20.77±.59	35.2
Awn-barbed area ratio		24.94±.46	-15.42±.49	31.5
First count		22.72±.41	-13.20±.44	30.0
Second count		47.53±.99	-38.01±1.00	38.0
Length of barbed area	30.29±.57			
Awn-barbed area ratio		24.94±.46	5.35±.73	7.3
First count		22.72±.41	7.57±.70	10.8
Second count		47.53±.99	-17.24±1.14	15.1
Awn-barbed area ratio	24.94±.46			
First count		22.72±.41	2.22±.62	3.6
Second count		47.53±.99	-22.59±1.09	20.7
First count	22.72±.41			
Second count		47.53±.99	-24.81±1.07	23.2

\- First column smallest

Table 20. Differences in variability in the five factors studied for the two-row strains, 1929.

			Difference	Difference / P.E. Diff.
Length of awn	11.86±.16			
Length of barbed area		35.14±.52	-23.28±.54	41.1
Awn-barbed area ratio		33.39±.49	-21.53±.52	41.4
First count		26.33±.37	-14.47±.40	38.2
Second count		46.44±.74	-34.58±.76	45.5
Length of barbed area	35.14±.52			
Awn-barbed area ratio		33.39±.49	1.75±.71	2.5
First count		26.33±.37	8.81±.64	13.8
Second count		46.44±.74	-11.30±.90	12.6
Awn-barbed area ratio	33.39±.49			
First count		26.33±.37	7.06±.61	11.6
Second count		46.44±.74	-13.05±.89	14.7
First count	26.33±.37			
Second count		46.44±.74	-20.11±.83	24.2

- First column smallest

Table 21. Differences in variability in the five factors studied for the two-row strains, 1930.

			Difference	Difference / P.E.Diff.
Length of awn	9.59±.12			
Length of barbed area		43.89±.65	-34.30±.66	52.0
Awn-barbed area ratio		35.47±.50	-25.88±.41	63.1
First count		27.00±.36	-17.41±.38	45.8
Second count		57.84±.80	-48.25±.81	59.6
Length of barbed area	43.89±.65			
Awn-barbed area ratio		35.47±.50	- 8.42±.82	10.3
First count		27.00±.36	16.89±.74	22.8
Second count		57.84±.80	-13.95±1.03	13.5
Awn-barbed area ratio	35.47±.50			
First count		27.00±.36	+ 8.47±.62	13.7
Second count		57.84±.80	-22.37±.94	23.8
First count	27.00±.36			
Second count		57.84±.80	-30.84±.88	35.1

\- First column smallest

Table 22. Correlations between the factors studied for both two-row and six-row groups for 1929 and 1930, computed from the averages of each head.

X	Y	r	$\frac{r}{P.E.}$
Six-row 1929			
Length of awn	Length barbed area	$.23 \pm .04$	5.8
Length of awn	Second count	$.05 \pm .04$	1.3
Length barbed area	Second count	$.76 \pm .02$	38.0
First Count	Awn-barbed area ratio	$-.75 \pm .02$	37.5
Second Count	Awn-barbed area ratio	$-.79 \pm .01$	79.0
Six-row 1930			
Length of awn	Length barbed area	$.36 \pm .03$	12.0
Length of awn	Second Count	$.18 \pm .04$	4.5
Length barbed area	Second Count	$.78 \pm .01$	78.0
First Count	Awn-barbed area ratio	$-.63 \pm .02$	31.5
Second Count	Awn-barbed area ratio	$-.80 \pm .01$	80.0
Two-row 1929			
Length of awn	Length of barbed area	$.26 \pm .02$	13.0
Length of awn	Second Count	$.01 \pm .02$	.5
Length barbed area	Second Count	$.73 \pm .01$	73.0
First count	Awn-barbed area ratio	$-.98 \pm .001$	980.0
Second count	Awn-barbed area ratio	$-.77 \pm .01$	77.0
Two-row 1930			
Length of awn	Length of barbed area	$.41 \pm .02$	20.5
Length of awn	Second Count	$.31 \pm .02$	15.5
Length barbed area	Second Count	$.85 \pm .01$	85.0
First Count	Awn-barbed area ratio	$-.59 \pm .02$	29.5
Second Count	Awn-barbed area ratio	$-.84 \pm .01$	84.0

Table 23. Correlations, between the factors studied, both two-row and six-row groups for 1929 and 1930, computed from the averages of each strain.

X	Y	r	$\frac{r}{P.E.}$
Six-row 1929			
Length of awn	Length barbed area	$.07 \pm .11$	.6
Length of awn	Second count	$.29 \pm .10$	2.9
Length of barbed area	Second count	$.76 \pm .05$	15.2
First count	Awn-barbed area ratio	$-.75 \pm .05$	15.0
Second count	Awn-barbed area ratio	$-.85 \pm .03$	28.3
Six-row 1930			
Length of awn	Length of barbed area	$.50 \pm .09$	5.6
Length of awn	Second count	$.30 \pm .10$	3.0
Length barbed area	Second count	$.81 \pm .04$	20.8
First count	Awn-barbed area ratio	$-.65 \pm .07$	9.3
Second count	Awn-barbed area ratio	$-.82 \pm .04$	20.5
Two-row 1929			
Length of awn	Length barbed area	$.24 \pm .08$	3.0
Length of awn	Second count	$-.11 \pm .07$	1.6
Length of barbed area	Second count	$.73 \pm .04$	18.3
First count	Awn-barbed area ratio	$-.57 \pm .06$	9.5
Second count	Awn-barbed area ratio	$-.79 \pm .03$	26.3
Two-row 1930			
Length of awn	Length of barbed area	$.50 \pm .05$	10.0
Length of awn	Second count	$.36 \pm .07$	5.1
Length of barbed area	Second count	$.88 \pm .02$	44.0
First count	Awn-barbed area ratio	$-.63 \pm .05$	12.6
Second count	Awn-barbed area ratio	$-.89 \pm .02$	44.5

Table 24. Comparison between the correlation coefficients obtained from individual head averages and the corresponding values obtained by using strain averages.

X	Y	Individual heads	Strain averages	Difference
Six-row 1929				
Length of awn	Length barbed area	$.23 \pm .04$	$.07 \pm .11$	$.16 \pm .12$
Length of awn	Second count	$.05 \pm .04$	$.29 \pm .10$	$.24 \pm .11$
Length barbed areas	Second count	$.76 \pm .02$	$.76 \pm .05$	$.00 \pm .05$
First count	Awn-barbed area ratio	$-.75 \pm .02$	$-.75 \pm .05$	$.00 \pm .05$
Second count	Awn-barbed area ratio	$-.79 \pm .01$	$-.85 \pm .03$	$.06 \pm .03$
Six-row 1930				
Length of awn	Length barbed area	$.36 \pm .03$	$.50 \pm .09$	$.14 \pm .10$
Length of awn	Second count	$.18 \pm .04$	$.30 \pm .10$	$.12 \pm .11$
Length barbed areas	Second count	$.78 \pm .01$	$.81 \pm .04$	$.03 \pm .04$
First count	Awn-barbed area ratio	$-.63 \pm .02$	$-.65 \pm .07$	$.02 \pm .07$
Second count	Awn-barbed area ratio	$-.80 \pm .01$	$-.82 \pm .04$	$.02 \pm .04$
Two-row 1929				
Length of awn	Length barbed area	$.26 \pm .02$	$.24 \pm .08$	$.02 \pm .08$
Length of awn	Second count	$.01 \pm .02$	$-.11 \pm .07$	$.12 \pm .07$
Length barbed areas	Second count	$.73 \pm .01$	$.73 \pm .04$	$.00 \pm .04$
First count	Awn-barbed area ratio	$-.98 \pm .00$	$-.57 \pm .06$	$.41 \pm .06$
Second count	Awn-barbed area ratio	$-.77 \pm .01$	$-.79 \pm .03$	$.02 \pm .03$
Two-row 1930				
Length of awn	Length barbed area	$.41 \pm .02$	$.50 \pm .05$	$.09 \pm .05$
Length of awn	Second count	$.31 \pm .02$	$.36 \pm .07$	$.05 \pm .07$
Length barbed areas	Second count	$.85 \pm .01$	$.88 \pm .02$	$.03 \pm .02$
First count	Awn-barbed area ratio	$-.59 \pm .02$	$-.63 \pm .05$	$.04 \pm .04$
Second count	Awn-barbed area ratio	$-.84 \pm .01$	$-.89 \pm .02$	$.05 \pm .02$

Table 25. Inter-annual correlations of each of the factors studied, both six-row and two-row groups, using the average of the strain.

X		Y		r Six-row	r Two-row
Length of awn	1929	Length of awn	1930	.34±.10	.15±.11
Length of barbed area	1929	Length of barbed area	1930	.72±.05	.69±.06
Awn-barbed area ratio	1929	Awn-barbed area ratio	1930	.70±.04	.63±.03
First count	1929	First count	1930	.67±.06	.43±.09
Second count	1929	Second count	1930	.64±.07	.51±.08

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