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INHERITANCE IN A WHEAT CROSS OF RIDIT x UTAC

A Thesis
Submitted to the Department of Agronomy
Utah State Agricultural College

In Partial Fulfillment
of the
Requirements for the Degree of
Master of Science

By

C. Leland Dalley

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The writer wishes to express his appreciation to Dr. George Stewart, under whose direction this investigation was conducted.

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INHERITANCE IN A WHEAT CROSS OF RIDIT X UTAC

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TABLE OF CONTENTS

Page

INHERITANCE IN A WHEAT CROSS OF RIDIT x UTAC

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INTRODUCTION

Present-day plant breeding, on the foundation made many years ago, has achieved important scientific and economic results. By means of introductions and selections, superior strains such as Turkey and Kanred have been obtained. Through hybridization new combinations of characters result, combining desirable characters of different plant types in a single individual. In this program, wheat hybridization has occupied a worthy place.

Each year a number of wheat crosses are made at the Utah Experiment Station, the main purpose of which is to develop superior strains of wheat. Such an economic program is aided and hastened by studies in genetic behavior.

This paper reports such a genetic study of the inheritance of awns, spike density, and kernel color in a cross between Ridit and Utac wheat varieties.

REVIEW OF LITERATURE

Awns; Saunders (9) was perhaps the first to make written mention of the nature of awn inheritance in wheat. He did not definitely make counts of the various segregating groups, but he noted that the first-generation cross between awned and awnless wheats was partly awned and that a large proportion of the second generation was awnless.

Biffen (1) was the first to point out that he thought the awnless condition of a wheat spike is dominant in the F_1 generation, resulting in a 3:1 ratio of awnless and awned plants, respectively, in the F_2 generation. When the segregating F_3 progenies were observed, a 1:2:1 ratio resulted.

Clark (2) found a complicated condition in the inheritance of awns in a cross between Kota and Hard Federation. He first thought two factors were involved, but later decided there were more, as the segregation was very complex.

Stewart (11), in his cross between Sevier and Federation, obtained four true-breeding classes of awns: (1) fully awned like the Sevier parent, (2) awnless similar to the Federation parent, (3) and (4) intermediate classes. The two parental classes were much more numerous than the intermediate classes. The data obtained was explained on the theory that there were two factors for awns located in the same chromosome and that there was a crossing over of about 35 per cent.

Clark (3) studied the inheritance of awns in a cross between Marquis and Hard Federation. He grouped the material into the three classes: (1) awnless, (2) apically awned, and (3) awned. In the second generation the numbers in combined classes 1 and 2 compared with class 3 were close to a 3:1 ratio. Class 1 in comparison with classes 2 and 3 combined was close to a 1:15 ratio. In the F_3 generation classes 1 and 3 bred true. A two-factor interpretatión of the results was made on the basis of a primary (Aa) and a secondary (Bb) factor pair.

Jones (7) found proof for two independently inherited factors for awns in rice. From a cross between a fully awned variety and an entirely awnless variety, the F_1 was intermediate. He obtained the data from the F_2 and F_3 plants and concluded that either of the two factors alone produced an intermediate condition and that the two together produced fully developed awns.

Stewart and Heywood (13), in a cross between Federation and a hybrid of Dicklow by Sevier (III C-18), which were awnless and awned respectively, report nine genotype classes for awns into which the F_3 progenies were arranged.

There were 4 true-breeding awn classes and 5 segregating classes. The ratio of 1:2:2:4:1:2:1:2:1, with an extremely good fit, was explained on a two-factor basis with independent segregation.

Gaines (5), in a cross between Marquis and Turkey wheats, reports that the F_1 plants were all intermediate for awns, having short awns on the upper part of the spike. Both awnless and awned plants were produced in the F_2 generation. Thirty-three awned F_2 plants produced only awned segregates in the F_3. The awnless F_2 plants produced 35 homozygous awnless families and 92 heterozygous ones. The genetic segregation of the F_2 families, as shown by the performance of the F_3 was 35 awnless : 92 heterozygous : 33 (+6) awned. The expected monohybrid ratio of the same population was 41:83:41. Since the awned recessives all bred true, the unit factor theory is the most logical explanation. He further states that the awned F_3 families were somewhat more resistant to bunt than the awnless ones and indicates that there is little if any linkage between awns and resistance.

Spike Density: Biffin (1) and Spillman (10) were among the first plant breeders to study spike density. The former was perhaps the first to make measurements of spike density. They report 1:2:1 ratios for dense, intermediate, and lax spikes, indicating a single-factor difference.

The work of Gaines (4) shows, likewise, a simple 1:2:1 ratio, while Wilson's (15) results show a segregation of 3 dense to 1 lax, indicating dominance for dense heads.

Stewart (11) in his cross between Federation and Sevier, states that F_2 plants, as tested by the F_3, gave a ratio of 1:2:1 of dense, intermediate, and lax spikes. This is notable in that one parent is lax and the other intermediate. Both the dense and lax groups of families proved homozygous and the intermediates all segregated. He further states that one major factor and one or more minor factors are involved in the inheritance of spike density in the case of this cross.

Stewart (12) also observed a similar inheritance in a Kanred x Sevier cross.

The results of Stewart and Heywood (13), in a cross between Federation and a hybrid of Sevier x Dicklow, showed a clear cut division between mean coefficients of variability of homozygous dense and lax progenies of the F_3. As a result of measurement the mean coefficients of variability for the spike density of parental rows were 9.81 per cent and 10.59 per cent, and for the homozygous lax progenies it was 9.56 per cent, and for the homozygous dense progenies 10.70 per cent. The heterozygous rows showed a mean of 40.91 per cent. A ratio of 1;2;1 was obtained, indicating a one-factor difference in the parents.

Hayes and Harlan (6) explained their results with barley in some crosses by a one-factor difference, in others by a two- or by a three-factor difference.

Parker (8) in his paper emphasized the fact that the problem of inheritance of the character denseness and laxness in the wheat spike is much more complicated than was previously imagined. He emphasized the importance of measuring internode length ofr determining density rather than by using "eye classification".

Grain Color: Biffin (1) reported that red kernel color was dominant to white in the F_1 generation and segregated in a 3;1 ratio of red and white in the F_2.

Gaines (4), Clark (2), and other investigators report the same relationship.

Clark (3) states that Nilsson-Ehle first reported ratios of 15:1 and 63:1 of red and white grain, respectively, in the F_2 segregates, calling for a two-factor difference in the one case and a three-factor difference in the other.

Clark (2), in a cross between Kota and Hard Federation, states that the kernel color in the F_2 segregated in a 15:1 ratio of red and white plants. In the F_3 generation the white strains bred true and the red strains bred true or segregated in a 15:1 or a 3:1 ratio of red and white kerneled plants.

Stewart and Tingey (14), in a cross between Marquis and Federation, report a ratio of 15:1. In the F_3 there were 4 groups of progenies: (1) true-breeding for red grain, (2) segregating 15 red : 1 white, (3) segregating 3 red : 1 white, and (4) true-breeding for white grain. The ratio was 7:4:4:1.

Stewart (12), in his Kanred x Sevier cross, obtained a ratio closely approximating 37:8:12:6:1 for kernel color. There were 37 true-breeding for red grain, 8 segregating 63 red : 1 white, 12 segregating 15 red : 1 white, 6 segregating 3 red : 1 white, and 1 true-breeding for white grain out of every 64 plants. The theory of a three-factor difference gave a very close fit to his observed numbers.

PARENTAL MATERIAL

RIDIT

Ridit is the result of crosses made in order to develop a variety of wheat resistant to bunt or stinking smut and which also had high yielding ability and good quality. This variety was developed by Gaines at the Washington Agricultural Experiment Station from a cross between Turkey and Florence. The cross was made in 1915 and a selection made in 1919 from this cross resulted in the variety Ridit. It was first distributed for commercial growing in Washington in 1923 and since that time has spread rapidly.

The outstanding characteristics of Ridit are: (1) resistance to bunt smut, (2) resistance to shattering, (3) good yield, and (4) good milling qualities. Under Washington conditions the variety may be grown without fear of smut infection. It is especially adapted to eastern Washington and to the panhandle of Idaho where the winters are rather mild, thus indicating that it probably should not be grown where there is danger of severe winter killing.

UTAC

Utac is a production of the Utah Experiment Station. Its name is a combined abbreviation of "Utah A. C.". In 1918 and 1919, Stewart made a survey of the wheat fields of Utah and found an unknown variety growing in Sevier Valley, Utah, to which the name Sevier was given. It was the main variety grown in that district because of its ability to hold the grain firmly in the chaff and to fill the grain properly even when it lodged. The variety was tested at the Central farm at Logan and was found to be a good yielder when it did not lodge. Another variety, Dicklow, of Utah origin, was also being tested at the station and was found to be resistant to lodging, due to its stiff straw. In 1919 a cross between Dicklow and Sevier was made in an effort to unite the good qualities of each. The result was that in 1926 one of the strains, which had the pedigree number F-68, proved to be superior in standing ability and in yield. In 1928 there was enough grain to seed on two farms in Cache Valley and two in Sevier Valley. The new variety of wheat, "Utac", yielded 74.4 bushels an acre in Sevier County that year and stood erect, while on the same farm Sevier yielded 50 bushels and, as usual, was lodged.

The outstanding quality of Utac is its ability to stand erect on land where older varieties, such as Sevier, lodged to such an extent as to reduce the yield and cause trouble in harvesting. Moreover, shattering of the grain does not occur in Sevier as the close-fitting glumes hold the grain firmly against ordinary conditions. The grain is white, a very good quality from the standpoint of market demand in the Great Basin region.

The contrasted characters studied in this cross and noted in Table 1 are awns, spike density, and grain color.

Table 1 — Contrasted characters in the parents, Ridit and Utac.

Parental Variety	Awns	Spike Density	Grain Color
Ridit	Short apical Awns 2	Lax	Red
Utac	Fully awned Awns 4	Dense	White

EXPERIMENTAL PROCEDURE

The cross between Ridit and Utac was made in 1927 at Newton, Utah, a few miles northwest of Logan. The F_1 plants were about a foot apart each way. Several F_1 plants were harvested. One was chosen to continue with and about 400 kernels from it were seeded in the fall of 1928 in rows one foot apart and spaced 3 or 4 inches in the row. The data taken on the F_2 plants consisted of spike density, grain color, awn classes, and culm length.

In the fall of 1929 an F_3 progeny row was seeded with grain from each F_2 plant. As each F_2 plant seeded one F_3 progeny row, it was possible to use the breeding behavior of the F_3 progenies as the basis for classifying the F_2 plants. The rows were again 1 foot apart and the kernels spaced 2 or 3 inches apart in the row, making, usually, from 40 to 60 kernels to the row. After each tenth progeny the two parental varieties, Ridit and Utac, were sown side by side, spaced and seeded at the same time and in the same manner as were the progeny rows. Such a procedure made it possible to study progeny characters in connection with parental characters. In all there were 78 parental rows, 398 progeny rows.

During July the plants from each row were pulled, bundled together, properly tagged, and taken to the laboratory for study and collection of data.

Data were taken on awns, on spike density, and on grain color. After this was done, it was possible to arrive at the genetic constitution of the F_2 plants by the breeding behavior of the F_3 progenies. The mean data for the F_3 progenies were used as the basis of all classifications reported.

Plants were classified as to awn behavior by observation. Spike density was obtained by measuring 10 internodes on a leading spike of each plant, the measurement being taken along the middle part of the rachis, usually beginning about the third spikelet internode from the base of the spike, so as to avoid the variation in internode length which occurs both at the base and at the apex. To get grain color one head from each plant was threshed. The segregation was clear cut and could be determined immediately by inspection.

The data were so taken and recorded that all data from each plant could be readily traced to that plant and to the row from which it came. No theory of inheritance was advanced until all data were taken, recorded, and calculated.

EXPERIMENTAL RESULTS AND THEIR INTERPRETATION

Classifications and calculations were made of the data previously assembled and recorded in the laboratory. The progeny rows were classified into segregating and true-breeding groups for awns, for spike density, and for grain color. The mean spike density of each progeny and also its coefficient of variability were obtained.

INHERITANCE OF AWNS

The awns of the F_1 plants were of intermediate length, although they resembled more closely the apically awned parent. Both parental types and a group of intermediates were recovered in the F_2. The group of intermediates all segregated in the F_3.

The awn data of the F_3 generation showed segregation into three classes; (1) awnless, or rather awn-tipped, like the Ridit parent, (2) intermediate, and (3) fully awned like the Utac parent. These were designated as awns 2, 3, 4, respectively. The plants classified as belonging to awns 2 had short apical awns limited to the upper part of the spike; in awns class 3 the awns extended farther down the spike than awns 2 and were considerably longer and coarser. In awns class 4 the major portion of the spike was covered with long awns, enough longer than awns 3 to be easily distinguished from them. In the fully-awned group, the lax spikes had longer awns than the dense ones.

According to the recorded F_3 data there are 100 homozygous awnless, 193 heterozygous segregating for awns 2, 3, and 4, and 105 homozygous fully awned progenies. This is a close approximation of a 1:2:1 ratio.

The three awn-classes may be designated as follows:

Awns 4 - - - - - - - - - - - - AA
Awns 3 - - - - - - - - - - - - Aa
Awns 2 - - - - - - - - - - - - aa

Table 2 gives the three awn classes based on their genotypic differences, their expected ratio, and expected breeding behavior on the basis that there is a difference of one factor.

Table 3 shows the observed and calculated numbers of families and the closeness of fit of the expected to the observed on the basis of a one factor difference. From the table it is seen that X^2 = .51 and P = .7994 which is a very good fit, interpreted to mean that in 80 chances out of 100 a worse fit might occur from chance alone.

Table 2 — Three awn-class genotypes, their breeding behavior and expected ratio on the basis of a one-factor difference.

Awn Class	Expected Proportions	Genotype	Expected Breeding Behavior
4	1	AA	Breeding true for awns 4
3	2	Aa	Segregating for awns 2, 3, and 4
2	1	aa	Breeding true for awns 2

Table 3 — Goodness of fit of 3 awn genotype classes of F_3 progenies when compared with a 1:2:1 ratio which would be expected theoretically with a one-factor difference.

Progeny Group	Observed Value (O)	Calculated Value (C)	O - C	$(O - C)^2$	$\frac{(O - C)^2}{C}$
Homozygous Awns 2	100	99.5	- .50	2.50	.0251
Heterozygous Awns 2,3,4,	193	199.0	+6.00	36.00	.1809
Homozygous Awns 4	105	99.5	-5.50	30.25	.3040

X^2 = 0.5100 P = 0.7994

SPIKE DENSITY

The spike-density inheritance was determined by means of the breeding behavior of the F_3. The first forty plants from each bundle were taken at random. Ten rachis internodes were carefully measured on a leading spike of each plant. Later, after all necessary data in the laboratory had been tabulated, the mean spike density and the coefficient of variability (C.V.) of each parent row and each progeny row were calculated.

Table 4 was used to determine whether the F_3 progenies were segregating. Each progeny was placed in the table according to its mean spike density and according to its coefficient of variability. This table proves there are

Table 4 — The F_3 progenies grouped according to mean spike density classes and coefficient of variability (C.V.) classes, giving three groups, two classes with low C.V. and one class with high C.V.

Length of 10 internodes (millimeters)															C. V.
18	21	24	27	30	33	36	39	42	45	48	51	54	57	60	Classes %
										1	1				2.00
1										3	6	13	5	2	4.00
5	8	4	1						1	9	23	19	6	2	6.00
8	28	15	3							2	5	2			8.00
	14	8	1							1	1				10.00
	3	1										1			12.00
	2														14.00
															16.00
															18.00
															20.00
															22.00
					1		1								24.00
				L	3	1	2								26.00
			1	2	2	3	2	1							28.00
				3	4	7	1	1							30.00
			2	13	10	11	4	2	2						32.00
			4	7	14	11	3	1							34.00
		1	1	12	21	4									36.00
			2	5	17	7	1	1							38.00
				1	2	3									40.00
															42.00
				1											44.00

three distinct groups, one with dense spikes and the other with lax spikes, but both with low coefficients of variability; and a third group with a high coefficient of variability. The first two are regarded as homozygous true-breeding forms and the latter as segregating. All of the segregating progenies have coefficients of variability sufficiently high to make them clearly as heterozygous.

As a means of comparing the progenies with the parental types, Table 5 was prepared. The spike-density classes of the means of Ridit and Utac parental rows and the mean of F_3 progenies is arranged according to coefficient of variability classes into five groups as follows; (1) Ridit, (2) Utac, (3) homozygous dense, (4) heterozygous, and (5) homozygous lax. Spike density classes, according to the length of 10 rachis internodes in millimeters, are shown at the tops of the table. On the extreme right are found the coefficient of variability classes (C.V.).

The coefficients of variability of the Ridit parent rows has a mean of 4.83 per cent with a range from 3.7 to 6.6 per cent. The coefficients of variability of the Utac rows has a mean of 10.6 per cent with a range from 7.7 to 14.25 per cent.

The F_3 progeny was regarded as homozygous when its coefficients of variability had about the same range as those of the parental rows. For the homozygous dense progenies the mean was 8.39 per cent with a range of from 4.3 to 14 per cent. In the homozygous lax group the mean was 5.75 per cent with a range of from 2.9 to 11.9 per cent. The coefficient of variability mean for the heterozygous group was 33.65 per cent with a range of from 23.0 to 45.1 per cent. Heterozygosity was very evident. There is a marked gap between the most variable progeny classed as homozygous dense (C.V. = 14 per cent) and the least variable progeny classed as heterozygous (C.V. = 24 per cent). With this measure, homozygosity and heterozygosity are clear cut.

Table 5 — Mean spike density and coefficient of variability (C.V.) classes of Ridit and Utac wheats, and of three groups of F_3 hybrid progenies: (1) those homozygous for dense spikes, (2) those heterozygous for spike density, and (3) those homozygous for lax spikes.

Parent or Progeny	Spike-density classes															Total	C.V. Classes
	18	21	24	27	30	33	36	39	42	45	48	51	54	57	60		
Ridit									4	19						23	4.00
									2	14						16	6.00
Total or Mean									6	33						39	4.83
Utac			2	2												4	8.00
			11	6												17	10.00
			9	6												15	12.00
			3													3	14.00
Total or Mean			25	14												39	10.60
Homozygous Dense	1															1	4.00
	5	8	4	1												18	6.00
	2	28	15	3												48	8.00
		14	8	1												23	10.00
		3	1													4	12.00
		2														2	14.00
Total or Mean	8	55	28	5												96	8.39
Heterozygous						1		1								2	24.00
					1	3	1	2								7	26.00
				1	2	2	3	2	1							11	28.00
					3	4	7	1	1							16	30.00
				2	13	10	11	4	2	2						44	32.00
				4	7	14	11	3	1							40	34.00
			1	1	12	21	4									39	36.00
				2	5	17	7	1	1							33	38.00
					1	2	3									6	40.00
																	42.00
					1											1	44.00
Total or Mean			1	10	45	74	47	14	6	2						199	33.85
Homozygous Lax											1	1				2	2.00
											3	6	13	5	2	29	4.00
										1	9	23	19	6	2	59	6.00
											2	5	2			9	8.00
											1	1				2	10.00
													1			1	12.00
Total or Mean										1	16	36	35	11	4	103	5.75

64569

Only a few of the homozygous progenies showed less variability than 4 or greater than 10 per cent, as contrasted with the heterozygous group in which most of the progenies range between 28 and 38 per cent.

In order to present the data of the range of densities of the parents and of the F_3 progenies in a summarized fashion, Table 6 was prepared. The table gives the range of mean spike densities and the mean of mean spike densities of the Ridit and the Utac parent rows and of the three groups of F_3 progenies, together with the range of the coefficients of variability (C.V.) and the mean of mean coefficients of variability for the five groups. The mean of the mean spike densities of the Ridit parent was 44.5 millimeters with a coefficient of variability mean of 4.83 per cent, as contrasted with a mean spike density of 52.1 and a mean coefficient of variability of 5.75 for the lax progeny. It is seen from the table that the lax progeny had a much greater range than the Ridit parent, 46.2 - 60.8 as compared with 42.6 - 46.1.

The mean of the mean spike densities of the Utac parent was 25.2 millimeters, with a mean coefficient of variability of 10.60 per cent, as compared with a mean spike density of 22.0 and a mean coefficient of variability of 8.39.

The table proves that there are three definite groups of F_3 progeny when classified according to spike density, and that transgressive segregation is in both directions, toward greater denseness and laxness, but particularly in the direction of greater laxness.

In order to show that transgressive segregation in spike density actually occurred between the dense parent and dense progeny and the lax parent and lax progeny, Table 7 is given. The probable error was computed by the deviation from the mean method (56). The table gives the difference in mean spike density between the Ridit parent and the homozygous lax progeny and the probable error of the difference, also the difference in mean spike density between the

5

Table 6 — The range of mean spike densities and the mean of mean spike densities of Ridit and Utac rows and of three groups of F_3 families, together with the range of the coefficients of variability (C.V.) and the mean of the mean coefficients variability for the parents and for the F_3 families.

Strain	Spike Density Range	Mean Spike Density (mm.)	C. V. Range	C.V. of Mean Spike Densities
Ridit parent	42.6 - 46.1	44.5	3.7 - 6.6	4.83
Utac parent	23.1 - 26.7	25.2	7.7 -14.25	10.60
Homozygous Dense	18.1 - 27.6	22.0	4.3 -14.0	8.39
Heterozygous	23.6 - 43.7	33.4	23.0 -45.1	33.65
Homozygous Lax	46.2 - 60.8	52.1	2.9 -11.9	5.75

Table 7 — Showing the difference in mean spike density in the parents and lax and dense progenies; also the probable error of the difference.

Strain	Number of Plants	Difference of Mean Spike Density	P. E. of the Difference	Difference / P. E.	
Ridit x Lax F_3		7.6	± .314	26	7684
Utac x Dense F_3		3.2	± .323	10	5421

U

Utac parent and the dense progeny and the probable error of the difference.

$$\begin{array}{lrl} \text{Lax Progeny ——} & 52.1 & \pm .210 \\ \text{Ridit ————} & \underline{44.5} & \pm \underline{.234} \\ & 7.6 & \pm .314 \end{array} \qquad \begin{array}{lrl} \text{Utac ————} & 25.2 & \pm .296 \\ \text{Dense Progeny ——} & \underline{22.0} & \pm \underline{.130} \\ & 3.2 & \pm .323 \end{array}$$

It is seen that in the case of Ridit and the lax progeny that the difference is about 26 times the probable error, while with the dense groups the difference is 10 times the probable error. The probable error in relation to the difference indicates conclusively that transgressive segregation in spike density actually occurred.

A count of the number of families in each group shows that there are 96 homozygous dense, 199 heterozygous, and 103 homozygous lax, which immediately suggests a ratio of 1:2:1 as a logical theory to explain the results. Table 8 shows the closeness of fit when the calculated are compared with the observed numbers on the basis of a one-factor difference. From the table it is seen that $p = .90$, which indicates that the theory of a one-factor difference is probably correct.

Table 8 — Goodness of fit of three groups of F_3 progenies for spike density compared with a 1:2:1 ratio.

Progeny group	Observed Value (O)	Calculated Value (C)	O - C	$(O - C)^2$	$\frac{(O - C)^2}{C}$
Homozygous dense	96	99.5	- 3.5	12.25	.123
Heterozygous	199	199.0			
Homozygous lax	103	99.5	- 3.5	12.25	.123

$\chi^2 = .246$ $p = .903$

SOIL HETEROGENEITY:

Harris (5a) states that, "unless special precautions are taken irregularities in the field may have greater influence upon the results of an experiment than the factors in crop production which the investigator is seeking to compare."

Heterogeneity may be considered as a condition whereby one small plot has the capacity to produce a larger or smaller crop than an adjacent plot under as nearly the same conditions as possible. This condition of the soil is least at the surface and greatest at a depth of about four feet. The surface layer of a soil might be apparently uniform in a field while the underlying layers might differ greatly from one part of the field to another, hence the inadequacy of personal judgment concerning the uniformity in physical characters in fields for experimental work.

The Harris method of measuring soil heterogeneity uses the coefficient of correlation - r - as an index to soil heterogeneity. The correlation between the contiguous parents systematically distributed in this cross was
56 measured by this statistical constant (56). Uniform distribution of parental rows was brought about by planting single rows of each parent variety side by side after every tenth F_3 progeny row. All the parental rows received the same cultural treatment.

Harris advanced the theory that variability producing a positive, significant correlation is due to soil heterogeneity, as variability of soil became greater the correlation increased. According to this theory heterogeneity was not especially noticeable in this field since the coefficient of correlation for spike density gave an r of + .218 ± .103. The coefficient of correlation - r - is only a trifle more than double the probable error. The amount to which total variability in mean internode length is dependent upon soil heterogeneity can be determined by the formula $V = 100(1-\sqrt{1-r2})$, when V = variation in percentage. The variation is found to be between 6 and 7 per cent.

Because of the low soil heterogeneity, this field, with respect to spike density, may be regarded as a very suitable location for experimental plot trials.

KERNEL COLOR

In the F_1, all plants had red kernels. In the F_2, 371 plants had red kernels and 29 white. This proportion suggests a 15 red : 1 white ratio. In 1930 every F_3 plant in all the progenies were classified as to kernel color. On the basis of this F_3 breeding behavior, the decision was made as to proper classification of the F_2 plants with respect to genotype for grain color. The progenies grown from the plants with white kernels bred true in the F_3 while the remaining plants behaved in the following manner: (1) 168 were true-breeding for red grain, (2) 101 were segregating 15 red : 1 white, and (3) 99 were segregating 3 red :1white. This preliminary grouping indicated the likelihood of a two-factor difference for grain color. On the basis of two factors the calculated expectancy in the F_3 for each 16 plants is as follows:

True-breeding red grain - - - - - - - -	7
Segregating 15 red : 1 white - - - -	4
Segregating 3 red : 1 white - - - - -	4
True-breeding white grain - - - - - - -	1
	16

When the calculated expectancy was compared with the observed numbers in the two segregating groups, the variation was found to be very narrow, while in the other two groups the data showed an excess of true-breeding white families and a deficiency of true-breeding red families.

Table 9 shows the goodness of fit for the color of grain when the calculated numbers in each class are compared with the observed on the basis of a two-factor difference between the two parents. P = .7349 which is a good fit. This means that by chance alone a worse fit might be expected 73 out of 100 cases.

Table 9 — Closeness of fit of four groups as to grain color on a two-factor difference (7:4:4:1 ratio)

Progeny group	Observed Value (O)	Calculated Value (C)	O - C	$(O - C)^2$	$\frac{(O - C)^2}{C}$
Homozygous Red grain	168	174.125	- 6.125	37.5156	.2155
Segregating 15 red : 1 white	101	99.500	+ 1.500	2.2500	.0226
Segregating 3 red : 1 white	99	99.500	- .500	.2500	.0025
Homozygous white grain	30	24.875	+ 5.125	26.2650	1.0518

$X^2 = 1.2924$ $P = .7349$

SUMMARY

This paper reports data from a cross of Ridit x Utac. Ridit, developed at the Washington Experiment Station from a cross made in 1915 between Turkey and Florence, is resistant to bunt smut. Utac is a production of the Utah Experiment Station, the result of a cross made in 1919 between Dicklow and Sevier. The outstanding quality of this variety is its ability to stand erect where older varieties lodged to such an extent as to reduce the yield. Ridit is awnless, with lax spikes and red grain. Utac is awned and has dense spikes and white grain.

The F_1 plants, spaced about one foot apart each way, were harvested and grain from them seeded 3 or 4 inches apart in rows 1 foot apart. The F_1 generation from this cross was intermediate for awns and spike density, but the kernel color was red like that of the Ridit parent.

The F_2 plants were harvested and studied from the standpoint of awn classes, spike density, and grain color. An F_3 progeny row was seeded with grain of each F_2 plant. These rows were spaced 1 foot apart and the kernels, from 40 to 50 in each row, were spaced 3 or 4 inches apart in the row. There were 39 paired plantings of the two parents seeded at the same time and in the same manner after each 10 progeny rows.

The parents and F_3 progeny were harvested and taken to the laboratory for study. The data were obtained by observation for awn classes and kernel color, and by measurement of 10 rachis internodes for spike density.

There were three classes of awns in the F_3 progenies; (1) a homozygous awn-tipped group, (2) a heterozygous group, and (3) a homozygous fully awned group. Both parental types were recovered in the homozygous F_3 progenies. On the basis of a one-factor difference, $P = .80$ ~~per cent~~.

There were three spike-density groups in the F_3 progenies; (1) homozygous dense, (2) heterozygous, and (3) homozygous lax. Both parental types were recovered in the true-breeding progenies. P = .90 ~~per cent.~~

The coefficient of variability mean was more than three times as large as any of the other coefficient of variability groups, indicating that heterozygosity is very evident.

In the two homozygous groups there were found spikes considerably more compact than the spikes of the Utac parent, and all of the lax progenies, with the exception of two, were more lax than the most lax of the Ridit parent. Transgressive segregation is very pronounced.

The data taken on awns and spike density indicate a one-factor difference in each case; with grain color a two-factor difference explained the data satisfactorily. On the basis of a two-factor difference, P = .73 ~~per cent.~~

A correlation study was made between the spike density of the Ridit and Utac parents relative to soil heterogeneity. The correlation gave a positive r of .22 ± .10, indicating that soil heterogeneity was not measurably noticeable in this field with respect to spike density.

No suggestions of correlations were found between awns, spike density, and grain color in the Ridit x Utac cross.

BIBLIOGRAPHY

1. Biffin, R.H. 1905 — Mendel's Laws of Inheritance of wheat breeding.
Journal Agri. Sci., Vol. 1;4-48

2. Clark, J. A., Florell, V. H., Hooker, J. R. 1924 — Inheritance in Kota x Hard Federation Crosses.
Journal Agricultural Research, Vol. 29;1-47.

3. Clark, J. A., Hooker, J. R. 1924 — Segregation and correlated inheritance in Marquis and Hard Federation crosses, with factors for yield and quality of spring wheat in Montana
U.S.D.A. Dept. Bul. 1403

4. Gaines, E. F. 1917 — Inheritance in wheat, barley, and oat hybrids.
Wash. Agr. Exp. Sta., Bul. 135

5. Gaines, E. F. 1925 — Genetics of Marquis x Turkey wheat in respect to bunt resistance, winter habit, and awnlessness.
Jour. Agr. Res. Vol. 32;165-181

5a. Harris, J.A. 1920 — Practical universality of field heterogeneity as a factor influencing plot yields.
Jour. Agr. Res., Vol. 19;279-314

5b. Hayes, H. K., Garber, R. J. — Breeding Crop Plants, pp. 81-82 and 43-44
Macmillan, N.Y., 1927

6. Hayes, H. K., Harlan, H.V. 1920 — The inheritance of the length of internodes in the rachis of the barley spikes.
U. S. D. A., Dept. Bul. 869.

7. Jones, J. W. 1927 — Inheritance of awnedness in rice.
Jour. Amer. Soc. Agr., Vol. 20;830-839

8. Parker, W. H. 1914 — Lax and dense eared wheats.
Jour. Agr. Sci. (England), Vol. 6;371-386

9. Saunders, W.H. 1905 — Results of experiments in the cross-breeding of cereals and peas.
Canada Exp. Farm Report., pp. 6269.

10. Spillman, W.J. 1909 — The hybrid wheats.
Washington Agr. Exp. Sta., Bul. 89.

11. Stewart, Geo. 1926 — Correlated inheritance in wheats.
Jour. Agr. Res., Vol. 33;1163-1192

12. Stewart, Geo. 1928 — Correlated inheritance in Kanred x Sevier varieties of wheat.
Jour. Agr. Res., Vol. 36;873-896.

13. Stewart, George Correlated inheritance in a cross between Federation and
Heywood, D. C. a hybrid of Sevier x Dicklow.
1929 Jour. Agr. Res., Vol. 39:367-392.

14. Stewart, George Transgressive and normal segregation in a cross of Marquis
Tingey, D. C. x Federation wheats.
1928 Jour. Amer. Soc. Agr., Vol. 20:620-634

15. Wilson, J. H. Hybridization of cereals.
1908 Jour. Agr. Sci., Vol. 2:68-88.