A study of the correlation of the characters of barley
by John Edward Hodgskiss

A THESIS Presented For the Degree of Master of Science
Montana State University

Abstract:
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Montana State College,

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A STUDY OF THE CORRELATION OF THE CHARACTERS OF BARLEY.

This study is made for the purpose of finding whether correlations are present in various characters of barley and also for the study of correlation in general. Until recently practically nothing has been done along this line, especially with barley. However, we find some attention has been paid to the correlation of nitrogen content, mealiness, color of grain and paleae, length and thickness of internodes, fineness of hull, average weight per kernel, and length of head. Most of this was done before the modern statistical method was introduced.

Correlation, according to Doctor De Vries[1], is the name given to regular coincidences of apparently independent characters and marks. As E. Davenport[2] defines it, correlation refers to that interrelation between seperate characters by which they tend, in some degree, to move together. By studying the insignificant characters of a plant, a way may be shown in which they may indicate an increase or decrease in the qualities of a more valuable or commercial character or an indication of the yield. A character which may be easily seen or mèasured may give an indication of the value of a character which can not be easily examined. Correlations may be further valuable in that they may enable judgment to be passed on the probable character of the product while the plants are still young. This is especially true of biennial, like sugar beets, and perennial plants like fruit trees. It will also aid in the origination of new hybrid varieties by the physiological manifestations between the predominant and heterozygate. The relation between these characters is indicated by the coefficient of correlation in this method.

Two classifications of correlations have been brought forth. Doctor Webber[3] divides correlations into environmental, morphological, physiological, and coherital. Environmental, as the name implies, deals with correlations affected by environment, as fertility of soil compared to growth of plant. Morphological correlations are those where a variation in one character is the very cause of variations in another, as with the increase in size of the germ in corn there is an increase in the oil content. Physiological correlations are explanable by well recognized physiological principles, as excess of leaf production in tobacco is correlated with lack of seed production. A coherital character is defined as those related to and dependent upon each other in such a way that they are inherited together. The other classification proposed is that by Doctor East [4]. Here, correlations are classified as somatic and gametic. The somatic combines the environmental and morphological correlations of Webber, and the gametic consists of coherital and physiological correlations. The writer prefers the classification of Webber and deals with the physiological correlations in this work.

Barley is one of the most prominent cereals in the United States. At the present time, it ranks fourth in production and its increase has been almost phenominal. It has been grown from the earliest times and was most prominent until the introduction of oats when its production and importance decreased. In 1866, 11,283,807 bushels of barley were produced, at which time it ranked sixth among the cereals; but in 1912, by outstripping buckwheat and rye, barley rose to fourth place with the production of 223,824,000 bushels. Twenty times as much was produced in 1912 as in 1866, thus making a much larger gain than any other cereal. Wheat, its closest rival, gained ten times in production within the same period.

For all practical purposes, barley may be classified into six-rowed and two-rowed types. It may also be classified according to color of grain and into brewing and malting barleys. Some have suggested classifying it as to the percentage of protein content. We have two distinct types of six-rowed. They are the round six-rowed, (Hordeum helastichon) in which the spikelets appear as if radiately arranged upon the rachis giving the head a round form, as in the Utah Winter and the square six-rowed, which is commonly called four-rowed (Hordeum vulgare). The head assumes a square form and is sometimes known as the Manchurian type, which comprises ninety-five percent of the six-rowed barleys grown in the United States. Two types of two-rowed barley are cultivated in the United States. One has a long slender head which bends over or nods when ripe. Chevalier barley is a typical example and incidentally is the type used in this study. Fully ninety percent of the two-rowed barley grown in the United States is of this type and is typical of the Hordeum distichon group. The other type has broad, short, erect heads with awns sometimes spreading. A good example is the Primus variety. From these types, sub-types might be made. The two awnless types are the hooded and the new hybrid awnless variety, Arlington awnless, both of the Hordeum vulgare group. Three types of hulless barley are (1) six-rowed bearded hulless, (2) two-rowed bearded hulless, and (3) six-rowed hooded hulless.

The variety of barley used in this study is the New Zealand two-rowed Chevalier barley. This barley belongs to the two-rowed type, known as the Hordeum distichon which has a long slender head bending over when ripe. Seed was obtained from the Montana State College Experiment Station and was planted on the college experiment farm in Bozeman, Montana, on May 18th, 1912, in rows twelve inches apart and individual seeds six inches apart in the rows. On May 28th, the plants came up. They were irrigated July 18th, and ten days later headed out. On September 27th, they were pulled up and labeled according to the number of row and situation in row. Each plant was tied separately and all the plants in the same row were tied in a bundle. The bundles were hung up in the college granary with heads hanging down until used.

Three hundred and seven plants consisting of 4,609 culms were examined. The individual plant is taken as a unit and not the individual culm as is done by some investigators. However, each culm was examined separately and recorded accordingly. All measurements were made in centimeters and all weights in grams.

The following data were obtained:

1. Number of culms recorded consisted of the number of culms examined exclusive of the green culms which were so green as not to be of any economical value.

2. The length of culm was measured from the base of the culm to the apex of the spike.

3. The length of head was measured from the first basal spikelet to the tip of the last spikelet.

4. The number of kernels per culm included all kernels produced, those missing being calculated.

5. The rudimentary spikelets consisted of those only at the base of the head.

6. The number of spikelets consisted of all spikelets, whether rudimentary or otherwise. In the case of this type of barley, there is only one kernel for each spikelet. Thus, the only difference between the number of kernels and the number of spikelets is that the number of rudimentary spikelets is added to the number of kernels to give

the number of spikelets.

7. The average weight per kernel was obtained by dividing the total weight of kernels present by the total number of kernels per plant exclusive of those missing.

8. Total weight of kernels per plant was obtained by adding to the result of the total weight of kernels present, the result obtained from multiplying the weight per kernel by the number of kernels missing.

9. The weight of kernels per culm was obtained by dividing the corrected total weight by the number of culms examined.

In all of the above calculations, whole numbers were used entirely, except in the case of rudimentary spikelets and average weight per kernel in the final averaged result. For these two cases, it is carried out to the third decimal place. When the additional number is above five, one was added to the preceding number, but if it was below five, it was discarded and nothing added to the preceding number. This same rule was applied in all calculations in the correlation tables. All determinations are carried accurately to the third decimal place, using the fourth number in the same way as above.

From the above nine characters studied, a number of the most important correlations were studied for the purpose of determining if there are any relations between certain characters of the barley plant.

The following points were considered:

1. The correlations between the number of culms per plant as subject and the following characters as relative: the length of culm, number of kernels per culm, weight per kernel, total weight of kernels per plant, weight of kernels per culm and average number of rudimentary spikelets per culm. As the number of culms per plant increases is there an increase or decrease in the length of culm, number of kernels, weight per kernel, total weight of kernels or yield, weight of kernels per culm or yield per culm, and number of rudimentary spikelets?

2. The correlations between the length of culm as subject and the following characters as relative: number of spikelets per culm, average weight per kernel, number of rudimentary spikelets per culm, total weight of kernels per plant, average weight of kernels per culm, length of head, and number of kernels per culm. That is, do the number of spikelets increase or decrease, do the kernels become smaller or larger, do the number of rudimentary spikelets increase or decrease, does the yield per plant increase, does the yield per culm increase, do the heads become longer or shorter, and does the number of kernels per culm increase with the increase in the length of culm?

3. The correlation of the length of head as subject and the following relative characters: number of rudimentary spikelets, average weight per kernel, number of kernels and total weight of kernel. In other words, does the length of head give an indication of the number of rudimentary spikelets, of the individual weight per kernel of the numbers of kernels per culm or of the yield of the plant.?

4. The correlation of the subjective character, number of kernels, and the relative characters, average weight per kernel, number of rudimentary spikelets per culm and the total weight of kernels per plant, the largest kernels, the largest number of rudimentary spikelets, and largest yield present where there is a larger number of kernels?

5. The correlation between the average weight per kernel as subject and the average weight of kernels per culm and the total weight of kernels per plant as relative were next considered. Are the larger kernels from the heaviest yielding culms and from the heaviest yielding plants?

6. The correlation of the number of rudimentary spikelets per culm as subject was determined with the total weight of kernels per plant as the relative. Does the number of rudimentary spikelets give an indication as to the yield of the plant?

Due to the lack of work done on barley by the modern statistical method, references will be made to work done on wheat and oats by the most prominent plant breeders. Comparison between their work and the writers will be made as the discussion of the correlations are taken up. References are made to work done with oats by Leighty[5], Waldron[6], Love[7], and Humbert[8], and with wheat by Waldron[6], Roberts[9] and Meyers[10].

Leighty used 500 Sixty Day oat plants composed of 1974 culms. The work was done in Ithaca, New York. Waldron did his work in North Dakota on measurements of 1,000 oat culms and on wheat. Love at Ithaca, New York, in studying the large and small grain question, worked with different varieties and sowed hand picked seed. Roberts of Manhattan, Kansas, worked with various strains of wheat. Meyers studied the "Effect of Fertility upon Variation and Correlation in Wheat." Dawson's Golden Chaff Wheat was grown on soils of different degrees of fertility. These soils were sand, ordinary garden soil without treatment, and the same garden soil with eighty tons of manure and nine hundred pounds of acid phosphate per acre. Humbert worked with two lines of wheat designated as Line A and Line B. Eight hundred and twenty-five culms were used in Line A and four hundred and six culms in Line B. This work was done at Cornell and has not been published, but has been mentioned by Leighty.

Correlation Data.

In answer to the question whether there is a longer culm found with the larger number of culms, Table No. 1 is given. The correlation 0.182 ± 0.037, shows the relation between the number of culms per plant and the length of culm. This correlation is not very high and it can only be said that tall plants are more liable to be present where the greatest amount of tillering occurs. A great dependence can not be put on this correlation as the coefficient of variability, 38.830 ± 1.205, is high as well as the standard deviation, 7.038 ± 0.192, of the number of culms. The standard deviation of the length of culm is still higher with 8.886 $\pm$ 0.242, but the variability coefficient is low, being 9.448 $\pm$ 0.257. Roberts in studying wheat found a correlation of 0.2810, but the difference between this correlation and the writers may be due to the fact that Roberts used wheat while barley is dealt with in this paper.

TABLE NO. 1, Correlation between number of culms per plant and length of culm.

($r = 0.182 \pm 0.037$)

Number of culms per plant	Length of culm in centimeters.																				
	53 55	56 58	59 61	62 64	65 67	68 70	71 73	74 76	77 79	80 82	83 85	86 88	89 91	92 94	95 97	98 100	101 103	104 106	107 109	110 112	Totals
1-3									2						2						4
4-6								1				1		1		3					6
7-9									1	1	2	4	2	2	1	2	1				16
10-12	1					1	1	1		3	2	1	3	5	5	3	5	3	3	1	38
13-15				1		1	1	1	1	3	2	4	2	6	7	7	5	5		1	47
16-18								1	3	3	4	7	6	6	8	7	13	5	1		64
19-21								2			1	3	7	8	4	13	9	4			51
22-24											4		4	4	4	4		4			24
25-27							1		1	1	2		5	1	3	6	5	3	1		29
28-30											1	1	1	1	4	1		3			12
31-33											1			1	1			3			6
34-36												1	1	1	1	1			1		6
37-39															1	1			1		3
40-42																					0
43-45																1					1
Totals	1	0	0	1	0	2	3	6	8	11	19	22	31	36	41	49	38	30	7	2	307

In Table No. 2, the correlation between the number of culms per plant and the number of kernels per culm is 0.102 ± 0.038, which is rather low. Nothing definite can be drawn from this, further than the fact that a large number of kernels is just as apt to be found on a plant with few or many culms. The standard deviation of the number of culms is 2.404 ± 0.065 and the coefficient of variability is 8.146 ± 0.222. Both are rather low. The correlation is more dependable in this case than in Table No. 1, as the standard deviation and coefficient of variability is lower for number of kernels than for length of culm, but still on account of it being high for the number of culms, the correlation can not be much relied upon. Roberts found a correlation of 0.1805 and arrives at the same conclusion as the writers. Leighty, working with oats, finds a correlation of 0.4226 ± 0.0248 and concludes that as the number of culms increase, the number of kernels borne by each culm increases. The difference in the cereal used may be due to the different results again.

TABLE NO. 2. Correlation between number of culms per plant and number of kernels per culm.
(r = 0.102 ± 0.038)

Number of culms per plant	Number of kernels per culm: 22	23	24	25	26	27	28	29	30	31	32	33	34	35	Totals
															4
1-3				1			3								4
4-6							1		2		1	2			6
7-9			1	2	1		4	3	2	2	1				16
10-12	1			3	2	3	5	4	5	7	5	2	1		38
13-15	2		3	1	1	4	3	5	11	8	6	3			47
16-18		1	2	3		1	7	8	14	16	7	3	1	1	64
19-21			1	1	2	4	2	12	12	9	7	1			51
22-24		1		1	3	1	2	2	5	4	3	2			24
25-27			1	1	1		1		9	12	2	2			29
28-30						2		3	1	2	3		1		12
31-33			1		1		1			3					6
34-36					1			1	1	2	1				6
37-39								1	1	1					3
40-42															0
43-45						1									1
Totals	3	2	9	13	12	16	29	39	63	66	36	15	3	1	307

A correlation of -0.157 ± 0.038 is shown in Table No. 3, where the number of culms per plant is correlated with the average number of rudimentary spikelets per culm. This indicates that the larger number of rudimentary spikelets is more often found on the plants which tiller least. The standard deviation for the number of rudimentary spikelets is 0.310 ± 0.009, which is low. The coefficient of variability is 24.031 ± 0.69, which is a little high. The variability of the two characters discussed is rather high so no great dependence can be placed on the above correlation.

TABLE NO. 3. Correlation between number of culms per plant and number of rudimentary spikelets per culm.
($r = -0.157 \pm 0.038$).

	Number of Rudimentary spikelets per culm.																		
	.35 .44	.45 .54	.55 .64	.65 .74	.75 .84	.85 .94	.95 104	1.05 1.14	1.15 1.24	1.25 1.34	1.35 1.44	1.45 1.54	1.55 1.64	1.65 1.74	1.75 1.84	1.85 1.94	1.95 2.04	2.05 2.14	Totals
Number of culms per plant.																			
~~1~~-3							1							1					2
4-6							4							2					6
7-9	1			1			2	2	2			1	3	2	1	1			16
10-12			1	1		2	1	3	4	1	12	3	3	1	4	1	1		38
13-15	1			1		3	1	2	5	5	7	6	2	5	2	5	1	1	47
16-18			1		3	5	1	12	6	10	8	6	4	1	4	1	2		64
19-21			1	2	2	7	7	4	4	8	5	5	1	4	1				51
22-24			1			2	2	3	6	5	3	2							24
25-27			1			3	2	5	5	6	1	2	2		1	1			29
28-30						1	2	2		1	1	3	1		1				12
31-33								1	2	2			1						6
34-36				1				2		1	2								6
37-39							1	1				1							3
40-42																			0
43-45									1										1
Totals	2	0	5	6	5	23	24	37	35	39	39	29	17	16	14	9	4	1	305

Again, a correlation of -0.164 ± 0.037 is recorded in Table No. 4, in which the number of culms per plant is correlated with the average weight per kernel. It is here shown that the larger kernels are more often on the plants with the least tillering. The standard deviation of the average weight per kernel is 0.005 ± 0.000, and the variability coefficient is 13.158 ± 0.364. Both of these are fairly low so more dependence can be placed in this than any correlation so far discussed. Leighty found a very low correlation of 0.0003 ± 0.0302 in this case and believes that large kernels are obtained about equally from plants with many or few culms. Meyers found in the wheat sown on ordinary soil a correlation of 0.013 ± 0.032 and on the sandy soil 0.301 ± 0.027. On sandy soils, a great deal of variability occurs and this correlation can not be depended upon. From these results, it may be concluded that the number of culms has little or nothing to do with the size of kernels.

TABLE NO. 4, Correlation between number of culms per plant and average weight per kernel.
(r =-0.164 ± 0.037).

Number of culms per plant	Weight per kernel in grams. .022 .024	.025 .027	.028 .030	.031 .033	.034 .036	.037 .039	.040 .042	.043 .045	.046 .048	.049 .051	.052 .054	.055 .057	Totals
1-3						2		1		1			4
4-6	1		3			1		1					6
7-9			1	2	3	2	4		2	2			16
10-12	1		2	3	7	8	6	5	4	1		1	38
13-15		2	1	3	8	10	10	6	2	3	1	1	47
16-18		1	3	10	10	21	12	4	3				64
19-21		3	1	6	11	13	11	5	1				51
22-24			2	3	5	9	2	1	2				24
25-27		1	2	3	8	4	9	2					29
28-30				3	5	2	2						12
31-33			2		2		2						6
34-36			2	2		1	1						6
37-39					1	2							3
40-42													0
43-35					1								1
Totals	2	7	19	35	61	75	59	25	14	7	1	2	307

A rather high correlation exists between the number of culms per plant and total weight of kernels. Table No. 5 shows this to be 0.823 $\pm$ 0.012. On account of the high standard deviation of 7.230 $\pm$ 0.197 and coefficient variability of 43.348 $\pm$ 1.384 in the total weight of kernels and 7.038 $\pm$ 0.192 and 38.830 $\pm$ 1.205 respectively of the number of culms, a great dependence can not be put upon the absolute truth of this correlation. However, the correlation is so high that no other conclusion can be drawn but that a larger number of culms will give a larger yield per plant. Leighty likewise finds a high correlation of 0.8496 $\pm$ 0.0084 and arrived at the same conclusion.

TABLE NO. 5. Correlation between number of culms per plant and total weight of kernels per plant.
(r = 0.832 ± 0.012)

Number of culms per plant	Total weight of kernels in grams.														
	1 3	4 6	7 9	10 12	13 15	16 18	19 21	22 24	25 27	28 30	31 33	34 36	27 39	40 42	Totals
1-3	3	1													4
4-6	5	1													6
7-9		8	5	1	2										16
10-12	1	3	9	14	8	3									38
13-15		1	5	14	15	11	1								47
16-18			1	7	22	19	10	5							64
19-21			1	2	10	12	14	9	2	1					51
22-24				1	2	4	4	5	7	1					24
25-27					1	1	7	7	8	2	3				29
28-30					2				5	3	2				12
31-33					1			2	1			2			6
34-36						1			2	1	1		1		6
37-39												1	1	1	3
40-42															0
43-45									1						1
Totals	9	14	21	39	63	51	36	28	26	8	6	3	2	1	307

Table No. 6, shows a correlation of -0.111 ± 0.038 between the number of culms per plant and weight of kernels per culm. From this, it may be concluded that there is generally a smaller yield per culm in plants with a large number of culms. This correlation is not high and is not altogether dependable. The standard deviation for weight of kernels per culm is 0.200 ± 0.005 which is low and the coefficient of variability is 17.953 ± 0.505, being fairly low. But the number of culms is not very uniform and thus makes the correlation somewhat less valuable. Leighty found a correlation of 0.4005 ± 0.0253 with oats and Roberts, 0.8345 with wheat. Both, therefore, believe that there is a larger yield per culm with the increase in the number of culms. The three correlations given vary widely. What so great a difference is due to is a question. Two probable reasons are the differences in crop used and the different conditions under which the plants were grown as to fertility and cultivation.

Due to the fact that there is both a large standard deviation and coefficient of variability, no great dependence can be put on these correlations as this character varies a great deal. Not much uniformity exists. Only one positive fact can be drawn; with the larger number of culms, there is a larger yield. This is what is desired. Tillering is a character that should be improved. The slight disadvantages shown by the correlations are offset by the slight advantages in the other correlations.

TABLE NO. 6. Correlation between number of culms per plant and weight of kernels per culm.
(r =-0.111± 0.038).

	Weight of kernels per culm in grams.												
Number of culms per plant.	.63 .72	.73 .82	.83 .92	.93 1.02	1.03 1.12	1.13 1.22	1.23 1.32	1.33 1.42	1.43 1.52	1.53 1.62	1.63 1.72	1.73 1.82	Totals
1-3			1		1		1	1					4
4-6	1		2	1		1	1						6
7-9			5	2	1	4	1		1	2			16
10-12	2	1	4	2	10	5	5	3	5	1			38
13-15	2	1	3	5	14	7	5	4	1	3	1	1	47
16-18	2	3	4	7	11	19	10	7	1				64
19-21	3		5	7	8	18	5	4	1				51
22-24	2		2	4	4	7	4			1			24
25-27	1		4	3	9	5	7						29
28-30			1	2	4	3	2						12
31-33		1	2	1			2						6
34-36		1	2	1		1	1						6
37-39				1		2							3
40-42													0
43-45				1									1
Totals	13	7	35	37	62	72	44	19	9	7	1	1	307

In Table No. 7, the length of culm is correlated with the length of head. The correlation found was 0.269 ± 0.036. This indicates that a longer head is found on the taller plants. Although the correlation is not high, it may be termed as fairly high and positive enough to be helpful in selection. Both the coefficients of variability are low, being 9.448 ± 0.257 and 9.136 ± 0.249 for the length of culm and head respectively. However, the standard deviation is high for the former character being 8.886 ± 0.242 and fairly low for the latter, being 1.027 ± 0.028. The correlation can be depended upon as nearly true. Roberts found a slightly higher correlation of 0.2922.

TABLE NO. 7, Correlation between length of culm and length of head.
(r = 0.269 ± 0.036)

Length of culm in centimeters.	Length of head in centimeters: 7	8	9	10	11	12	13	14	Totals
53-55	1								1
56-58									0
59-61									0
62-64	1								1
65-67									0
68-70			1		1				2
71-73			1		2				3
74-76			1	1	3	1			6
77-79		1	1		2	3	1		8
80-82			1	3	4	2	1		11
83-85				4	3	11	1		19
86-88			1	5	6	9	1		22
89-91			1	7	10	12	1		31
92-94			2	7	13	11	3		36
95-97			2	5	14	17	2	1	41
98-100			1	6	21	18	3		49
101-103			1	4	12	20	1		38
104-106			1	3	13	11	2		30
107-109					3	4			7
110-112							2		2
Totals	2	1	14	45	107	119	18	1	307

Table No. 8 shows a correlation of 0.216 ± 0.037 to exist between the length of culm and number of kernels per culm. This is a fair indication that there are a larger number of kernels on the taller plants. Roberts finds a much higher correlation existing. He obtained 0.6684, which indicates that the relation is a great deal more positive than that of the writers. The constants are somewhat low, especially as to the variability coefficient, but the standard deviation is somewhat high in both cases, especially with the length of culm, being 8.886 ± 0.242, and fairly low in the other character, 2.404 ± 0.065. On the whole, both characters are fairly uniform.

TABLE NO. 8. Correlation between length of culm and number of kernels.
(r = 0.216 $\pm$ 0.037)

Length of culm in centimeters	Number of kernels per culm: 22	23	24	25	26	27	28	29	30	31	32	33	34	35	Totals
53-55	1														1
56-58															0
59-61															0
62-64	1														1
65-67															0
68-70				1					1						2
71-73			1						2						3
74-76				1			2	1	2						6
77-79				2			1		1	2	1	1			8
80-82				3			2	2	1	1	2				11
83-85			1	1		1	2	2	3	3	3	3			19
86-88			1			3	3	5	5	3	1	1			22
89-91		1		1	2		6	6	5	6	3	1			31
92-94		1	2	2	2	2	2	5	8	6	4	1	1		36
95-97			1		1	2	6	7	6	10	4	2	2		41
98-100					5	4	1	7	14	10	5	3			49
101-103			2	2	1	2	1	1	9	11	8	1			38
104-106	1		1		1	2	2	2	5	11	3	2			30
107-109								1	1	3	1			1	7
110-112							1				1				2
Totals	3	2	9	13	12	16	29	39	63	66	36	15	3	1	307

A low correlation of -0.077 ± 0.038 exists in Table No. 9, where the average length of culm is correlated with the average number of rudimentary spikelets per culm. Three hundred and five plants are used in studying the rudimentary spikelets, because two of the plants did not have any. With the standard deviation of length of culm high and the coefficient of variability of rudimentary spikelets fairly high, the correlation cannot be depended upon as the true one to any degree. The greater number of rudimentary spikelets is just as apt to be on tall plants as on shorter and probably will occur more often on the taller plants.

TABLE NO. 9. Correlation between length of culm and average number of rudimentary spikelets per culm. (r = 0.077 ± 0.038).

Length of culm in c entimeters.	.35-.44	.45-.54	.55-.64	.65-.74	.75-.84	.85-.94	.95-1.04	1.05-1.14	1.15-1.24	1.25-1.34	1.35-1.44	1.45-1.54	1.55-1.64	1.65-1.74	1.75-1.84	1.85-1.94	1.95-2.04	2.05-2114	Totals
	Number of rudimentary spikelets per culm.																		
53-55												1							1
56-58																			0
59-61																			0
62-64														1					1
65-67																			0
68-70						1					1								2
71-73								1					1		1				3
74-76							1			1	2	1		1					6
77-79									2		2	1		1	1				7
80-82						1	1	1	1	1	3	1	1				1		11
83-85						2	2	2	1	4		2	2		2	2			19
86-88				1	1	3	3	3	2	3		3	2		1				22
89-91			1	1	1	2		2	8	5	4	1	2	1	2		1		31
92-94			1	2	1	3	2	5	5	5	4	2	1	2	2			1	36
95-97						4	2	6	1	6	7	7	4	2		1			40
98-100	1		1	2	1	3	9	4	5	4	4	3	1	5	2	3	1		49
101-103			1			2	2	5	5	3	9	5	3			2	1		38
104-106	1		1		1	1	2	5	3	6	3	2		3	2				30
107-109						1		3	2	1									7
110-112															1	1			2
Totals	2	0	5	6	5	23	24	37	35	39	39	29	17	16	14	9	4	1	305

In Table No. 10, the length of culm is correlated with the number of spikelets. The correlation found was 0.210 ± 0.037, which might be termed a little lower than a fair correlation. The greater number of spikelets is liable to be on the taller plants. Not a very high standard deviation exists in the number of spikelets. It is 2.454 ± 0.067 and the coefficient of variability is 8.004 ± 0.218, which is rather low. The correlation can not be depended upon a great deal.

TABLE NO. 10. Correlation between length of culm and number of spikelets.
(r = 0.210 ± 0.037).

Length of culm in centimeters.	Number of spikelets per culm														Totals
	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
53-55	1														1
56-58															0
59-61															0
62-64	1														1
65-67															0
68-70				1					1						2
71-73				1					2						3
74-76				1			2	1	2						6
77-79			2					1	1	1	1	1	1		8
80-82				2	1		1	3	1	1		2			11
83-85				2			2	3	1	5	3	3			19
86-88			1		1	2	1	5	5	5	1	1			22
89-91		1		1	2	3	9	3	7	4	1				31
92-94			2	2	3	2	2	3	10	3	4	4	1		36
95-97			1		1	3	3	7	3	8	11	2	2		41
98-100					4	5		8	9	11	7	5			49
101-103				3	1	1	2	1	7	12	8	3			38
104-106	1		1	1	1	3	3	2	10	5	3				30
107-109								1	1	2	2			1	7
110-112								1				1			2
Totals	3	1	7	14	14	19	25	39	60	57	41	22	4	1	307

A very low correlation of 0.029 ± 0.038 exists between the length of culm and average weight per kernel as shown in Table No. 11. This correlation indicates that the larger kernel is found indiscriminately on the taller or shorter plant, or probably slightly more on the taller plant. The constants are all low, except the standard deviation of length of culm which is somewhat high, but this alone would not cause the correlation to vary much from its present relation. A great deal of discussion and work has been carried on as to the two characters mentioned. Leighty finds a correlation of 0.2188 ± 0.0287, Waldron with oats, -0.404 ± 0.017, and with winter wheat, 0.160 ± 0.084; Love, 0.278 ± 0.033; Meyers on sandy soil, 0.509 ± 0.022 and on ordinary soil, 0.480 ± 0.025, and Humbert in Line A, 0.522 ± 0.016, and in Line B, 0.506 ± 0.025. Thus it will be seen a great variation in results occur, from Waldron with -0.404 ± 0.017 to Humbert with $0.552 \pm$

0.016. Waldron believes the larger kernels are found on the shorter plants and Humbert, together with the other writers mentioned, believes the larger kernels are found on the taller plants. For such a large difference, there should be some reason, but nothing definite is yet known. More work is necessary before any positive reason can be assigned for about a 95% difference which occurs in the above case.

TABLE NO. 11. Correlation between length of culm and average weight per kernel.
($r = 0.029 \pm 0.038$).

	Average weight per kernel in grams.												
	.022 .024	.025 .027	.028 .030	.031 .033	.034 .036	.037 .039	.040 .042	.043 .045	.046 .048	.049 .051	.052 .054	.055 .057	Totals
53-55			1										1
56-58													0
59-61													0
62-64				1									1
65-67													0
68-70				1	1								2
71-73				1		1	1						3
74-76		1				1	3	1					6
77-79				1	1	4		1	1				8
80-82				1	5	1	3	1					11
83-85			1	3	1	4	4	3	2	1			19
86-88		1	3	5	4	4	2		2	1			22
89-91			2	5	4	8	6	2	3	1			31
92-94	1	2	4	4	7	10	4	2			1	1	36
95-97		2	2	1	9	10	10	2	2	2		1	41
98-100	1	1	2	7	13	10	10	1	3	1			49
101-103			1	2	11	9	8	5	1	1			38
104-106			3	3	3	10	5	6					30
107-109					2	2	3						7
110-112						1		1					2
Totals	2	7	19	35	61	75	59	25	14	7	1	2	307

In Table No. 12, a correlation of 0.241 ± 0.036 is found to exist between length of culm and total weight of kernels per plant. This is a fair correlation indicating that a higher yield would be obtained from the taller plants. The constants of the total weight of kernels is high and the correlation here found is liable to vary a great deal. Leighty finds a fairly high correlation of 0.6886 ± 0.0159 existing, while Love finds a fair correlation of 0.294 ± 0.032, which somewhat coincides with the result of the writer. Leighty and Love both conclude that the taller plants give the better yield.

TABLE NO. 12. Correlation between length of culm and total weight of kernels per plant.
(r = 0.241 ± 0.036)

Length of culm in centimeters.	Total weight of kernels per plant in gms 1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39	40-42	Totals
53-55			1												1
56-58															0
59-61															0
62-64		1													1
65-67															0
68-70		1	1												2
71-73				1	1		1								3
74-76		1		1	2	2									6
77-79	1	2	1		2		1		1						8
80-82		2	2	1	2	3		1							11
83-85			2	3	4	4	1	2		2		1			19
86-88	1	1	2	5	8	3		1	1						22
89-91		1	3	2	7	5	3	4	5		1				31
92-94	2	2	4	5	5	6	3	5	3				1		36
95-97	2			8	5	7	5	5	6		2		1		41
98-100	3	2	1	3	11	9	8	4	3	2	2	1			49
101-103		1	3	4	8	6	9	4	1	1	1				38
104-106				4	6	5	5	2	6	1		1			30
107-109				2	1	1				2				1	7
110-112			1		1										2
Totals	9	14	21	39	63	51	36	28	26	8	6	3	2	1	307

A correlation of 0.147 $\pm$ 0.038 is found between the length of culm and the average weight of kernels per culm in Table No. 13. This is somewhat low and the constants are not very high, indicating that the characters are somewhat uniform. The conclusion is that no marked relation exists between the two characters, but it may be said it is a little better than even that the greater yield per culm would be on the taller plants. Leighty concludes this correlation to be very divided when he finds the high correlation of 0.842 $\pm$ 0.0088 and the same may be said of Humbert, who finds in Line A. a correlation of 0.685 $\pm$ 0.012, andin Line B. 0.682 $\pm$ 0.018. No very high correlations are found to exist between the length of culm and the other characters. The most disputed point is whether the largest kernels are found on the tallest plant and all take exception to Waldron who believes the tallest plant has the largest kernels as a rule. No negative correlations are recorded with the length of culm and as a result it may be said that there would be no mistake in selecting the tallest plant for the purpose of improving barley.

TABLE NO. 13. Correlation between length of culm and weight of kernels per culm.

(r = 0.147 ± 0.038).

Length of culm in centimeters.	Weight of kernels per culm in grams.												
	.63	.73	.93	.93	1.03	1.13	1.23	1.33	1.43	1.53	1.63	1.73	
	.72	.82	.92	1.02	1.12	1.22	1.32	1.42	1.52	1.62	1.72	1.82	Totals
53-55	1												1
56-58													0
59-61													0
62-64	1												1
65-67													0
68-70			1	1									2
71-73			1		2								3
74-76	1				1	1	3						6
77-79			2		1	2	2	1					8
80-82			2	2	4	1	1	1					11
83-85	1		1	1	5	3	5		1	2			19
86-88	2		3	7	3	4	1	1		1			22
89-91	1	1		8	6	7	4	2	1	1			31
92-94	2	3	7	2	7	10		2	2		1		36
95-97	1	2	1	5	9	10	7	2	2	1		1	41
98-100	2		8	7	10	11	7	2	1	1			49
101-103	1		4	3	5	13	7	3	1	1			38
104-106		1	5	1	6	8	4	4	1				30
107-109					2	2	3						7
110-112					1			1					2
Totals	13	7	35	37	62	72	44	19	9	7	1	1	307

A high correlation of 0.739 ± 0.017 is found between the length of head and the number of kernels. This is shown in Table No. 14. The longer head will have the larger number of kernels. The standard deviation and coefficient of variability as a whole are rather low and the correlation obtained is rather positive in its results.

TABLE NO. 14. Correlation between length of head and number of kernels per culm.

(r = 0.739 ± 0.017).

Length of head in centimeters.	Number of kernels per culm. 22	23	24	25	26	27	28	29	30	31	32	33	34	35	Totals
7	2														2
8				1											1
9	1	2	3	4	1	2	1								14
10			6	5	2	5	12	11	3	1					45
11				3	9	5	7	23	37	23					107
12						4	8	5	23	39	29	8	2	1	119
13							1			3	6	7	1		18
14											1				1
Totals	3	2	9	13	12	16	29	39	63	66	36	15	3	1	307

In Table No. 15, the correlation between the length of head and the number of rudimentary spikelets per culm is shown. The correlation of 0.301 ± 0.035 may be termed a fair positive one and indicates that as the number of rudimentary spikelets increases the length of head increases to a rather fair extent. Being that the constants are not exceedingly high and in two cases somewhat low, the correlation will not vary much from the one given.

TABLE NO. 15. Correlation between length of head and number of rudimentary spikelets per culm.

(r = 0.301 ± 0.035).

Length of head in centimeters	Number of rudimentary spikelets per culm.																		Totals.
	.35 .44	.45 .54	.55 .64	.65 .74	.75 .84	.85 .94	.95 1.04	1.05 1.14	1.15 1.24	1.25 1.34	1.35 1.44	1.45 1.54	1.55 1.64	1.65 1.74	1.75 1.84	1.85 1.94	1.95 2.04	2.05 2.14	
7																			
8												1		1					2
9			1	2		2		1	3	1		1		1	1	1			14
10			3	2	2	3	7	8	5	7	4	2	1			1	1		44
11	1		1	1	3	14	10	19	10	18	11	7	4	4	3		1		107
12	1			1		4	5	11	15	12	22	17	11	7	6	5	2		119
13							2		2	1	2	1	1	3	4	1		1	18
14																1			1
Totals	2	0	5	6	5	23	24	37	35	39	39	29	17	16	14	9	4	1	305

A correlation of 0.386 $\pm$ 0.033 is found between length of head and average weight per kernel as shown in Table No. 16. The constants are all rather low for both the characters. The largest kernels come from the longest heads, which is somewhat contrary to Waldron's findings, as he obtained -0.511 $\pm$ 0.015 and concluded that the largest kernels came from the shortest heads. Crop differences and different degrees of fertility may here again affect the difference in results.

TABLE NO. 16. Correlation between length of head and average weight per kernel.

(r = 0.386 ± 0.033).

in centimeters.	Average weight per kernel in grams.												
	.022 .024	.025 .027	.028 .030	.031 .033	.034 .036	.037 .039	.041 .042	.043 .045	.046 .048	.049 .051	.052 .054	.055 .057	Totals
7			1	1									2
8						1							1
9	1	2	3	2	4	1	1						14
10		2	4	11	15	5	3	4		1			45
11		1	8	8	27	27	29	5	1	1			107
12		2	2	11	15	36	24	14	10	4		1	119
13	1		1	2		5	2	2	3	1	1		18
14												1	1
Total	2	7	19	35,	61	75	59	25	14	7	1	2	307

A low correlation of 0.096 ± 0.038 exists between the length of head and total weight of kernels. This is shown in Table No. 17. A high standard deviation and coefficient of variability exists in the latter character. Thus, not much weight can be put on the correlation given, as to its value. A large yield is a little more apt to occur where the larger heads are found. As indicated in the above discussion as to the length of head, the longest head is not so valuable as one might suppose as to its yielding capacity from a scientific point of view. However, it is shown positively that the number of kernels increases with the length and this is very valuable from a seedsman's point of view. Also the weight per kernel is greater on the longer head. A long head is found to be desirable, especially for the securing of a larger number of kernels and a larger size.

TABLE NO. 17. Correlation between length of head and total weight of kernels per plant.

(r = 0.096 ± 0.038).

		Total weight of kernels per plant in grams														
		1 3	4 6	7 9	10 12	13 15	16 18	19 21	22 24	25 27	28 30	31 33	34 36	37 39	40 42	Totals
Length of head in centimeters.	7		1	1												2
	8	1														1
	9	1	3	1	4	4				1						14
	10	2	2	7	8	7	6	4	5	2		1	1			45
	11	1	1	5	11	15	23	17	8	16	4	2	2	1	1	107
	12	1	7	3	12	36	16	15	15	6	4	3		1		119
	13	3		4	4	1	5			1						18
	14						1									1
	Totals	9	14	21	39	63	51	36	28	26	8	6	3	2	1	307

A small negative correlation is recorded in Table No. 18, where the number of kernels per culm is correlated with the number of rudimentary spikelets. The correlation of -0.017 ± 0.039 indicates that the two characters are more or less independent of each other. As a whole, the constants are not high and the varieties from the correlation given would be small. The same number of rudimentary spikelets will appear on the heads having few or many kernels.

TABLE NO. 18. Correlation between number of kernels per culm and number of rudimentary spikelets per culm.

(r = -0.017 ± 0.039).

Number of kernels per culm	Number of rudimentary spikelets per culm.																		
	.35 .44	.45 .54	.55 .64	.65 .74	.75 .84	.85 .94	.95 1.04	1.05 1.14	1.15 1.24	1.25 1.34	1.35 1.44	1.45 1.54	1.55 1.64	1.65 1.74	1.75 1.84	1.85 1.94	1.95 2.04	2.05 2.14	Totals.
22									1			1		1					3
23									1			1							2
24						2		1	1	1		1			1	2			9
25						1		1	3	2		2		1	1		1		12
26			1				1	1		2	3		1	2	1				12
27				1			2	4	2	2	1	1	1			2			16
28			1	1	2		2	2	1	1	5	1	4	2	4		2		28
29	1			2	1	7	5	3	3	8	3	3		2	1				39
30	1		2	2	2	10	3	11	5	5	6	8	3	2	1	1	1		63
31			1				6	12	11	12	11	5	3	1	3	1			66
32						3	3	2	5	3	9	2	3	2	1	2		1	36
33							2		1	3	1	2	2	2	1	1			15
34												2		1					3
35									1										1
Totals.	2		5	6	5	23	24	37	35	39	39	29	17	16	14	9	4	1	305

A great deal of interest has been manifested in the relation between the number of kernels and the average weight per kernel. Table No. 19 shows a correlation of 0.239 ± 0.036 to exist between these two characters. The constants are rather low and this correlation can be depended upon to be nearly correct. A 24% correlation is not very high, but it is high enough to give a fair estimate that with the larger number of kernels there would generally be larger kernels present. Waldron found the contrary to be true with a correlation of -0.595 ± 0.013 with oats and 0.115 ± 0.031 with winter wheat. Leighty and Love obtained 0.1226 ± 0.0297 and 0.251 ± 0.033 respectively, while Humbert in Line A found 0.300 ± 0.021 and in Line B 0.418 ± 0.027 to exist. These writers believe the larger kernels to be present where the larger number of kernels appear.

TABLE NO. 19. Correlation between number of kernels per culm and average weight per kernel.

(r = 0.239 ± 0.036).

Number of kernels per culm.	Average weight per kernel in grams. .022-.024	.025-.027	.028-.030	.031-.033	.034-.036	.037-.039	.040-.042	.043-.045	.046-.048	.049-.051	.052-.054	.055-.057	Totals
22			1	1		1							3
23			1	1									2
24		1	3		2		2	1					9
25		1	2		6	2	2						13
26			2	2	6	1				1			12
27		2		1	6	3	1	2				1	16
28	1			5	3	7	7	3	2	1			29
29			3	7	9	10	6	2	1	1			39
30		1	4	6	7	21	16	5	3				63
31		1	2	4	13	19	13	7	5	2			66
32	1			5	7	7	8	4	2	1		1	36
33		1	1	2	1	4	3.	1		1	1		15
34				1			1		1				3
35					1								1
Totals	2	7.	19	35	61	75	59	25	14	7	1	2	307

In Table No. 20, the correlation between the number of kernels and the total weight of kernels per plant is given. The correlation is 0.278 ± 0.036. This is not as high as might be expected when it is generally thought a large yield is directly based upon the number of kernels, but from a scientific point of view in thie case, a close relationship is not found. However, this may be due to the high variability coefficient of the total weight which is 43.348 ± 1.384. It is believed by the writer that with a larger number of kernels there will be a higher yield. The large correlation of 0.985 ± 0.001 found by Love still furthers this opinion.

A large number of kernels per culm is a profitable character to seek after. Although the correlations found are not high, the percentage is high enough to indicate the value of this character such that it will be taken into consideration in the selecting of plants for improvement.

TABLE NO. 20. Correlation between number of kernels per culm and total weight of kernels per plant.

(r = 0.278 ± 0.036).

Number of kernels per culm.	Total weight of kernels per plant in grams: 1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39	40-42	Totals.
22		1	1	1											3
23				1	1										2
24			2	4	2			1							9
25	1	4	2	2	2	1	1								13
26			1	2	5	1	2		1						12
27			2	4	4	1	2	1	2						16
28	3	4	4	3	5	5	1	2	2						29
29		2	1	6	6	10	5	4	2	1	1	1			39
30	2	2	2	6	16	10	8	5	6	3	2			1	63
31		1	2	4	12	11	12	7	8	3	2	2	2		66
32	1		2	3	7	6	4	7	4	1	1				36
33	2		2	3	2	4		1	1						15
34					1	1	1								3
35						1									1
Totals	9	14	21	39	63	51	36	28	26	8	6	3	2	1	307

Table No. 21 shows a correlation of 0.165 $\pm$ 0.037 for the average weight per kernel and the total weight of kernels per plant. This correlation is due to vary, because the constants for the total weight is very high. This correlation indicates that the chances are a little more than even that the larger kernels will give a larger yield. Love finds a higher correlation of 0.327 $\pm$ 0.031 and concludes that a greater yield is produced from the largest kernels.

TABLE NO. 21. Correlation between average weight per kernel and total weight of kernels per plant.

(r = 0.165 ± 0.037).

Average weight per kernel in grams.	Total weight of kernels per plant in grams														
	1 3	4 6	7 9	10 12	13 15	16 18	19 21	22 24	25 27	28 30	31 33	34 36	37 39	40 42	Totals
.022-.024	2														2
.025-.027			3	2	1	1									7
.028-.030	3	1	2	4	3	3	1		2						19
.031-.033		2	4	4	13	6		2	2	1	1				35
.034-.036		5	2	10	6	10	14	5	8			1			61
.037-.039	3	2	2	9	18	13	10	5	8	2			2	1	75
.040-.042		2	5	4	10	9	7	9	4	3	4	2			59
.043-.045		2	1	2	6	4	2	4	1	2	1				25
.046-.048			2	2	2	2	2	3	1						14
.049-.051	1			1	3	2									7
.052-.054				1											1
.055-.057					1	1									2
Totals	9	14	21	39	63	51	36	28	26	8	6	3	2	1	307

A very large correlation is found to exist in Table No. 22, where the average weight per kernel is correlated with the average weight of kernels per culm. The correlation found is 0.889 ± 0.008. As none of the constants can be termed high, the correlation found can be depended upon to be rather representative. This correlation gives positive assertion that a higher yield per culm exists with the presence of large kernels.

A large kernel is a very desirable character as it indicates a higher yield per plant and especially a higher yield per culm. In other correlations discussed in this paper, a large kernel gives an indication that an improvement occurs. Large kernels should always be used in improving a variety of barley.

TABLE NO. 22. Correlation between average weight per kernel and weight of kernels per culm.

(r = 0.889 ± 0.008).

Average weight per kernel in grams.	Weight of kernels per culm in grams.												
	.63-.72	.73-.82	.83-.92	.93-1.02	1.03-1.12	1.13-1.22	1.23-1.32	1.33-1.42	1.43-1.52	1.53-1.62	1.63-1.72	1.73-1.82	Totals
.022-.024	2												2
.025-.027	4	2	1										7
.028-.030	6	4	8	1									19
.031-.033	1	1	11	16	6								35
.034-.036			13	16	23	9							61
.037-.039			2	3	23	40	7						75
.040-.042				1	9	20	26	3					59
.043-.045					1	3	8	11	2				25
.046-.048							2	4	5	3			14
.049-.051							1	1	1	4			7
.052-.054											1		1
.055-.-57									1			1	2
Totals	13	7	35	37	62	72	44	19	9	7	1	1	307

Table No. 23 is produced to show the relationship between the number of rudimentary spikelets and the total weight of kernels per plant. A correlation of -0.134 ± 0.038 is found. Most of the constants are somewhat high, causing the characters to vary a great deal and thus cause a variation in the correlation. The presence of rudimentary spikelets gives an indication of the yield. If there are a large number, a smaller yield is expected. Rudimentary spikelets is an undesirable character and generally gives negative results. By this insignificant character a high or low yield may be predicted to a fair degree.

TABLE NO. 23. Correlation between number of rudimentary spikelets and total weight of kernels per plant.

(r =-0.134 ± 0.038).

Number of rudimentary spikelets per culm.	Total weight of kernels per plant in grams: 1-3	4-6	7-9	10-12	13-15	16-18	19-21	22-24	25-27	28-30	31-33	34-36	37-39	40-42	Totals
35-44		1				1									2
45-54															0
55-64				1	1		1	1	1						5
65-74	1	1	1		1		1				1				6
75-84					2	3									5
85-94		1	1	2	3	7	2	4	1	1	1				23
95-104	4	3		1	5	3	3	1	2		1	1			24
105-114			2	2	7	6	9	1	6	2		1		1	37
115-124		1	4	6	4	4	2	7	6			1			35
125-134		1		5	7	7	4	7	5	3					39
135-144			5	7	9	7	4	3	1	1	1		1		39
145-154		1	1	4	9	4	4	1	2	1	1		1		29
155-164		1	2	4	2	2	3	2			1				17
165-174	2	3		2	4	2	2		1						16
175-184			3	3	4	1	1	1	1						14
185-194			1	2	3	3									9
195-204		1	1		2										4
205-214						1									1
Totals	7	14	21	39	63	51	36	28	26	8	6	3	2	1	305

Correlations obtained in this work by Leighty, Waldron, Love, Roberts, Meyers and Humbert are presented in a tabular form in Table No. 24. These correlations are used in this paper.

Table No. 25 is produced to give the means, standard deviation, and the coefficient of variability of the character or variates obtained in this study.

TABLE NO. 24.

Summary of Correlations Dealt with in This Study.

	Subject.	Relative.	Correlation Coefficient.
		Original data on Barley.	
1.	Number of culms per plant	Length of culm	0.182 ± 0.037
2.	Number of culms per plant	Number of kernels per culm	0.102 ± 0.038
3.	" " " " "	Number of rudimentary spikelets per culm.	-0.157 ± 0.038
4.	" " " " "	Average weight per kernel.	-0.164 ± 0.037
5.	" " " " "	Total weight of kernels per plant.	0.823 ± 0.012
6.	" " " " "	Average weight of kernels per culm	-0.111 ± 0.038
7.	Length of culm.	Length of head.	0.269 ± 0.036
8.	Length of culm.	Number of kernels per culm	0.216 ± 0.037
9.	" " "	Number of rudimentary spikelets per culm.	0.077 ± 0.038
10.	" " "	Number of spikelets per culm	0.210 ± 0.037
11.	" " "	Average weight per kernel.	0.029 ± 0.038
12.	" " "	Total weight of kernels per plant.	0.241 ± 0.036
13.	" " "	Average weight of kernels per culm.	0.147 ± 0.038
14.	Length of head.	Number of kernels per culm	0.739 ± 0.017
15.	Length of head.	Number of rudimentary spikelets per culm.	0.301 ± 0.035

TABLE NO. 24. Continued.

Subject.	Relative.	Correlation Coefficient
	Original data on Barley.	
Length of head.	Average weight per kernel	0.386 ± 0.033
" " "	Total weight of kernels per plant	0.096 ± 0.038
Number of kernels per culm.	Number of rudimentary spikelets per culm.	-0.017 ± 0.039
" " " " "	Average weight per kernel.	0.239 ± 0.036
" " " " "	Total weight of kernels per plant.	0.278 ± 0.036
Average weight per kernel	Total weight of kernels per plant.	0.165 ± 0.037
" " " "	Average weight of kernels per culm.	0.889 ± 0.008
Number of rudimentary spikelets.	Total weight of kernels per plant.	-0.134 ± 0.038

TABLE NO. 24. (Continued).

Subject.	Relative	Correlation Coefficient.
Data obtained by C. E. Leighty with oats.		
Number of culms per plant	Total weight of kernels per pl	0.8496 ± 0.0084
" " " " "	Average weight of kernels per culm.	0.4005 ± 0.0253
" " " " "	Average weight per kernel.	0.0003 ± 0.0302
" " " " "	Number of kernels per culm.	0.4226 ± 0.0248
Length of culm.	Total weight of kernels per plant.	0.6886 ± 0.0159
" " "	Average weight of kernels per culm	0.8424 ± 0.0088
" " "	Average weight per kernel.	0.2188 ± 0.0287
Number of kernels per culm.	Average weight per kernel.	0.1226 ± 0.0297
ts)	Data obtained by L. R. Waldron with oats and wheat.	
Average weight per kernel	Number of kernels per culm.	-0.595 ± 0.013
" " " "	Length of head.	-0.511 ± 0.015
" " " "	Length of culm	-0.404 ± 0.017
ter Wheat.		
Average weight per kernel	Number of kernels per culm	-0.115 ± 0.031
" " " "	Length of culm.	0.160 ± 0.034

TABLE NO. 24. (Continued).

Subject.	Relative	Correlation Coefficient
Data obtained by H. H. Love with oats.		
1. Length of culm	Total weight of kernels per plant	0.294 ± 0.032
2. Length of culm	Average weight per kernel	0.278 ± 0.033
3. Number of kernels per culm.	Total weight of kernels per plant.	0.985 ± 0.001
4. Number of kernels per culm.	Average weight per kernel	0.251 ± 0.033
5. Total weight of kernels per plant.	Average weight per kernel.	0.327 ± 0.031
Data obtained by H. F. Roberts with wheat.		
1. Number of culms per plant.	Weight of kernels per culm	0.8345
2. " " " " plant.	Length of culm	0.2810
3. " " " " "	Number of kernels per culm.	0.1805
4. Length of culm.	" " " " "	0.6684
5. " " "	Length of head.	0.2922
Data obtained by C. H. Meyers with wheat.		
1. Sand. Number of culms per plant.	Average weight per kernel	0.301 ± 0.027
2. Ordinary. " " " per plant.	" " " "	0.013 ± 0.032
3. Sand. Length of culm.	" " " "	0.509 ± 0.022
4. Ordinary. " " "	" " " "	0.480 ± 0.025

TABLE NO. 24. (Continued).

Subject.	Relative	Correlation Coefficient.
Data obtained by E. P. Humbert with oats.		
1. Line A. Length of culm.	Average weight per kernel	0.552 ± 0.016
2. Line B. " " "	" " " "	0.506 ± 0.025
3. Line A. " " "	Average weight of kernels per culm.	0.685 ± 0.012
4. Line B. " " "	Average weight of kernels per culm.	0.682 ± 0.018
5. Line A. Number " kernels per culm.	Average weight per kernel.	0.300 ± 0.021
6. Line B. Number of kerbels per culm.	" " " "	0.418 ± 0.027

TABLE NO. 25.

Summary of Constants Obtained with Barley.

Characters.	Mean.	Standard Deviation.	Coefficient of variability.
ber of culms per plant	18.125 ± 0.271	-7.038 ± 0.192	38.830 ± 1.205
gth of culm.	94.056 ± 0.342	-8.886 ± 0.242	9.448 ± 0.257
ber of kernels per culm	29.511 ± 0.092	2.404 ± 0.065	8.146 ± 0.222
erage weight per kernel	.038 ± 0.000	0.005 ± 0.000	13.158 ± 0.364
ngth of head	11.241 ± 0.040	1.027 ± 0.028	9.136 ± 0.249
mber of rudimentary spikelets per culm.	1.290 ± 0.012	0.310 ± 0.009	24.031 ± 0.691
mber of spikelets per culm.	30.658 ± 0.094	2.454 ± 0.067	8.004 ± 0.218
tal weight of kernels per plant.	16.679 ± 0.279	7.230 ± 0.197	43.348 ± 1.384
ight of kernels per culm	1.114 ± 0.007	0.200 ± 0.005	17.953 ± 0.505

SUMMARY.

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1. The original data of barley used in this study is from the New Zealand two-rowed Chevalier variety, obtained from the Montana State College Experiment Station.

2. The study made indicates that as the number of culms per plant increases, the chances are a little more than even that there will be taller plants, a larger number of kernels per culm, a lesser number of rudimentary spikelets, a smaller kernel, and a smaller yield per culm. But above all, there is a high positive correlation showing that there will be an increase in yield per plant to a very large extent.

3. From the tall plants a fair majority of long heads, a larger number of kernels, a larger number of spikelets and a greater yield are found, and a small majority

have a larger yield per culm. The larger number of rudimentary spikelets and the larger kernels will appear indiscriminately on tall or short plants.

4. As the heads increase in length, there is nearly a corresponding increase in the number of kernels and to a fairly large extent an increase in the number of rudimentary spikelets and in size of kernel. A large yield is obtained about equally from long or short heads or that as a rule the best yield will be obtained from the longest heads.

5. Rudimentary spikelets will appear as many times on heads with a large or small number of kernels. Larger kernels and a larger total yield will generally be found on plants having a larger number of kernels per head to a fairly large extent.

6. Large kernels do not as a rule, give a low yield per plant. The presence

of large kernels on a head gives a very positive indication of a large yield per culm.

7. The presence of a large number of rudimentary spikelets gives a slight indication of a low yield per plant. It may be termed an undesirable character.

8. The large variations of correlations which have been obtained by various writers may possible be due to the use of different varieties or different crops or to different conditions under which crops may have grown.

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