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Digest

From the data reported the following conclusions seem to be justified.

1. No correlation exists between the length of head and the yield in the succeeding generations. **The selection of long heads in a field is not a means of increasing the yield of a variety.**

2. The length of the culm is correlated with the length of head that it bears but there is no correlation between length of heads and the length of culms produced by these heads in the succeeding generations.

3. Long heads are as a rule borne on long culms but seed from long heads may or may not give rise to plants with long culms.

4. The highest average yield of Marquis wheat, in grams per row, for four years was secured from strains that come from mother heads of 11.5 centimeters length.

5. Inasmuch as no general correlation was found between length of mother heads and yield of progeny, it seems possible that the mother heads indicated represented a separate strain, thus incidentally separated. Some further investigation of this question is being made.

Correlations Between Length of Spike and Culm in Wheat and Certain Characters of Progeny, Including Yield

By A. N. Hume, E. W. Hardies and Clifford Franzke*

Many wheat growers are of the opinion that the yielding capacity of a wheat variety can be increased by selecting and using for seed the longest heads or spikes that occur in a field. The breeding of wheat is receiving universal attention. High yields, combined with quality and disease resistance, are the characters desired. In order to produce high yielding varieties, it is very important and necessary to know what morphological characters, if any, are associated with yielding ability, the relation between these characters, and the inheritance of them.

The present report deals principally with the correlation between length of spike of the wheat plants and other characters of the plants and their progeny. Special attention is given to correlation or absence of the same between length of spike and yield, whether yielding capacity be traceable to a single character or to a number of characters.

The investigation reported herein is virtually a continuance of a similar one, reported in South Dakota Bulletin 187. That report summarized data secured with Bluestem wheat.

Hume, Champlin, and Fowlds (4) * * working on bluestem wheat found a slight correlation between long heads and the weight of grain harvested the first year. In the succeeding years they found no correlation. "The slight increased yield in the first generation failed to persist in the following generations."

Lyon, T. L. (7) in 1906, classifying wheat according to number of kernels per head, found that "the heads of slightly more than medium size produced the largest yield of grain, that the weight of the average kernel did not increase with the size of the heads, that the plant with medium sized heads or slightly less tillered most largely." He further says that the largest yielding plants are those of medium yield per head and that the number of heads on a plant is more important in determining its productiveness than is the size of the heads.

Richardson and Greene (12) found "that the kernels located in the middle of the spike weighed more, had a higher germination per cent, and gave a much higher yield than the kernels of the remainder of the head."

Later Ewart (3) repeated that part of the experiment relative to the rate of germination of the kernels taken from different positions of the head. From single heads, he found a marked fluctuation but the average of several heads show that the kernels occupying the

*All wheat plants used as a basis for this report were produced in the nursery and then records preserved by Mathew Fowlds.
**Reference by number is to "Literature Cited.")

middle of the spike germinated first and the average rate of germination decreases toward the base and apex of the head.

Clark (1) found that with timothy the mean values were highest under most favorable conditions. Variations due to seasonal conditions were quite marked.

Love (6) studied variation in peas, buckwheat, corn, and asters, and concluded from the data presented that an increase in nutrition gives an increase in variability and that correlations decrease as fertility increases.

Davenport and Rietz (2) in a study of ears of corn grown upon plots with different degrees of fertility, conclude that variability is not greatly influenced by fertility.

The data secured by Leighty (5) shows "that tall plants are better yielders than shorter ones; that all culms of tall plants are on the average heavy yielders and any head from such a plant may usually be selected for high yields."

Myers (8) found a good correlation between the weight of the culm and the weight of grain per culm.

Parker (9) found that the number of internodes in wheat varies to a much smaller extent than does the total length of the head. If the rachis is short, which means a short head, the spikelets are pressed closely together and if the rachis is long there is some space between one spiklet and the other above and below. He further found a very good correlation between the length of the internodes and the length of the entire rachis in wheat.

Roberts (13) found that the taller plants generally produce longer heads, and Westermeirer (15) found a short head correlated with a short culm.

MATERIAL AND METHOD

In the spring of 1919, a plat consisting of 256 plants of Marquis wheat was planted on the College farm at Brookings, South Dakota. The plants were spaced equal distance apart so that every plant would have the same amount of space for development and growth. Differences in the length of heads or length of culms of the different plants were not caused by spacing within the rows. Certain of these "mother" plants grown in the nursery in 1919 were found to bear long heads or spikes upon central culms, and others to bear relatively short heads on the central culms. Before maturity that year, measurements were made of the length of the central culm of each plant and the length of head or spike on that culm.

These mother plants were harvested and threshed spearately and preserved by number from 1 to 256 inclusive. These numbers were retained during the duration of the experiment.

In 1920 the seed of the long and short heads thus preserved was used in planting nursery or head rows. An equal number of kernels, twenty from each of the spikes measured was seeded alternately from relatively long and short mother heads. The same order

of planting was followed the succeeding years. By alternating the progeny of long and short heads, the difference in yield due to differences in soil fertility is greatly reduced. The heads and plants measured in 1919 will be called "mother heads" and "mother plants" respectively. In the discussions of this bulletin, the ordinary methods of biometrical analysis are used. Detailed descriptions of the methods may be found in Biometrika, Principles of Breeding by Davenport, Genetics in Relation to Agriculture, by Babcock and Clausen, and Breeding Crop Plants, by Hayes and Garber. The following points will be discussed:

1. Did the nursery rows planted from long mother heads yield more than the rows planted from shorter heads; and if so, will such influence persist through successive generations?
2. Did the rows planted to seed produced on long culms yield more than the rows planted to seed from short culms, and was this difference persistent through the successive generations?
3. Are the longer heads borne on the tall culms?

Relation Between the Length of Spikes and Yield

It was found that the heads or spikes of different plants varied in length. The spikes of the central culm of each plant was measured and the influence that long heads have on yield was studied. Tables I to IV inclusive give the relationship found between the length of heads in 1919 and the yields of seeds from those heads for 1920, 1921, 1922 and 1923.

TABLE 1.—LENGTH OF HEADS OF MOTHER PLANTS IN CM. OF MARQUIS WHEAT SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1920.

Length of heads in cm.	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	
8.0	2	1	2	...	1	4	...	2	...	...	...	...	...	...	...	12
8.5	...	...	1	2	1	1	...	1	...	...	...	...	...	...	...	6
9.0	...	2	7	7	5	7	9	7	3	5	1	1	...	...	...	54
9.5	...	2	3	1	5	5	2	2	4	1	3	1	...	...	...	29
10.0	...	1	4	2	6	2	6	3	3	...	...	...	...	...	...	27
10.5	2	1	4	8	7	8	9	8	1	...	2	...	...	1	1	52
11.0	...	2	5	5	15	10	9	6	8	2	3	1	1	...	...	67
11.5	...	...	...	1	...	...	...	...	...	...	...	...	...	...	1	2
12.0	...	...	1	1	2	1	2	...	...	...	...	...	...	...	...	7
	4	9	27	27	42	38	37	29	19	8	9	3	1	1	2	256

$r = .0960 \pm .0418$
Mean weight of grain $3.0914 \pm .0535$ gms.
Mean length of heads $10.0332 \pm .0399$ cm.

Table I shows the correlation between the length of heads and the yield of the first generation. The coefficient of correlation as shown in Table I is small, though somewhat higher than its probable error. Not very great emphasis may be placed upon so small a degree of correlation. This slight correlation of higher yield with greater length of spike in the first generation progeny is in agreement with the results reported in South Dakota Bulletin 187.

The possibility of slight incidental variations, even within pure lines has long been recognized. However, these incidental variations are not heritable. Early crop breeders, such as Hallet, assumed that these variations would be heritable and cumulative, however slight. It is theoretically and practically important to know whether and when such variations occur, and whether they have the slightest measurable effect.

The experiments with Bluestem and Marquis wheats admit the possibility of such slight incidental variations within pure lines, and indicate further that they are lost entirely in generations later than the first one succeeding the original selections.

TABLE II.—LENGTH OF HEADS OF MOTHER PLANTS IN CM. OF MARQUIS WHEAT SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS., HARVESTED IN 1921.

Length of heads in cm	2.8	4.3	5.8	7.3	8.8	10.3	11.8	13.3	14.8	16.3	17.8	19.3	20.8	
8.0	1	....	3	2	1	1	....	2	2	....	....	....	....	12
8.5	....	....	2	1	1	1	....	1	....	....	....	....	....	6
9.0	6	8	1	8	11	7	6	4	2	1	....	....	....	54
9.5	1	4	3	1	2	7	4	2	1	1	1	1	1	29
10.0	1	2	1	6	3	4	3	2	1	1	2	1	....	27
10.5	2	9	5	9	8	5	3	6	2	2	....	1	....	52
11.0	7	8	12	12	10	4	2	4	4	2	1	....	....	67
11.5	....	....	....	1	....	....	....	....	....	....	1	....	....	2
12.0	....	1	1	....	1	1	2	....	....	....	1	....	....	7
	18	32	28	40	37	30	20	21	12	8	6	3	1	256

$r = -.0132 \pm .0412$
Mean weight of grain $8.9289 \pm .1697$ gms.
Mean length of heads $10.0332 \pm .0399$ cm.

Correlating the length of heads measured in 1919 with the yield of the second generation gives a coefficient of $-.0132 \pm .0412$. This would indicate that for the year 1921, the yields are independent of the length of the heads selected and that the selection and planting of the long heads does not increase the yield.

TABLE III.—LENGTH OF HEADS OF MOTHER PLANTS IN CM. OF MARQUIS WHEAT SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1922.

Length of heads in cms.	3.5	6.5	9.5	12.5	15.5	18.5	21.5	24.5	27.5	30.5	33.5	36.5	39.5	42.5	45.5	
8.0	2	4	...	1	2	...	1	...	1	...	...	1	...	...	...	12
8.5	...	2	...	1	2	...	1	...	...	...	...	...	...	...	...	6
9.0	1	16	5	8	6	7	6	3	1	...	...	...	1	...	...	54
9.5	1	5	6	4	2	1	2	3	...	3	...	2	...	...	...	29
10.0	3	6	2	7	3	2	2	...	...	1	1	...	...	...	...	27
10.5	4	7	6	7	9	4	9	3	1	1	...	...	...	1	...	52
11.0	10	11	10	11	7	2	3	3	3	2	2	1	1	...	1	67
11.5	...	...	1	...	...	...	...	...	...	1	...	...	...	...	...	2
12.0	...	2	...	3	...	1	...	...	...	...	1	...	...	...	...	7
	21	53	30	42	31	17	24	12	6	8	4	4	2	1	1	256

$r = -.0618 \pm .0395$
Mean weight of grain $14.4102 \pm .3628$ gms.
Mean length of heads $10.0332 \pm .0399$ cm.

The third year the mean weight of the rows was $14.4102 \pm .3628$ grams. The coefficient of correlation is small and negative, $-.0618 \pm .0395$. It does not show the existence of any degree of association, between length of heads and yield of the progeny.

TABLE IV.—LENGTH OF HEADS OF MOTHER PLANTS IN CM. OF MARQUIS WHEAT SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1923.

Length of heads in cm.	4.5	6.5	8.5	10.5	12.5	14.5	16.5	18.5	20.5	22.5	24.5	26.5	
8.0	2	2	2	2	1	1	1	....	....	1	....	....	12
8.5	....	....	1	3	1	....	1	....	....	....	....	....	6
9.0	2	6	7	13	14	6	2	1	3	....	....	....	54
9.5	1	4	5	1	7	4	4	2	....	....	....	....	29
10.0	....	5	4	7	7	2	2	....	....	....	....	....	27
10.5	1	4	6	15	7	10	3	4	2	....	....	1	52
11.0	6	6	8	21	12	9	3	1	....	1	....	....	67
11.5	....	....	....	....	1	....	....	....	1	....	....	....	2
12.0	....	....	3	2	1	....	....	....	....	1	....	....	7
	12	27	36	64	51	32	16	8	6	30	....	1	256

$r = .0129 \pm .0421$
Mean weight of grain $11.4765 \pm .1669$ gms.
Mean length of heads $10.0332 \pm .0399$ cm.

In table IV, the coefficient of correlation between the length of heads in 1919 and the weight of grain harvested in 1923 is .0129 ±.0421. The mean yield is 11.4765±.1669 grams. A positive correlation exists but it does not show any pronounced degree of relationship between the length of the original mother heads and the yield in the fourth generation.

The above tables indicate that there is no correlation between the length of wheat heads and the yield of their progeny.

Parker (9) found a good correlation between the length of internodes and the length of the entire rachis of a wheat head. If the rachis is short, which means a short head, the spikelets are pushed closely together, while if the rachis is long there is some space between one spikelet and the other above and below it.

Hume et al (4) working with bluestem wheat found a very slight positive correlation between length of head and yield in the first generation but not in the succeeding generations.

TABLE V.—MEAN YIELD, STANDARD DEVIATION, COEFFICIENTS OF VARIABILITY AND COEFFICIENTS OF CORRELATION BETWEEN YIELD AND LENGTH OF MOTHER HEADS FOR FOUR YEARS.

Year	Mean weight of the grain in gm.	Standard Deviation	Coefficient of Variability	Coefficient of Correlation
1920	3.0914±.0535	1.2691±.0378	41.074 ±1.2334	.0960±.0418
1921	8.9289±.1697	4.0258±.1229	45.0873±1.344	—.0132±.0412
1922	14.4102±.3628	8.6070±.2565	59.7288±1.7804	—.0618±.0395
1923	11.4765±.1668	3.9600±.1181	34.5054±1.0285	.0129±.0421

Table V shows that as the mean yield of the rows decreased, the varibility decreased with the exception of one year, 1923, when the yield was larger than that of 1921, 11.4765±.1668 and 8.9289 ±.1697 grams respectively, and the standard deviation for the two years is 3.9600±.1181 and 4.0258±.1229 respectively. Leighty (5) working with oats found that as the mean decreased, the variability also decreased. Wolfe (16) working with corn did not find this to be true.

The coefficients of correlation do not establish any constant degree of relationship between the length of the mother heads and the yields in the following generations. In 1920 and 1923 the correlation was positive while the other two years, 1921 and 1922, a negative correlation was found.

Relation Between the Length of Culms and Yield

Field observations show that there is a difference in the length of culm found in a wheat field. The question arises immediately are the seeds from long culms more valuable for seed purposes than seeds from shorter culms. Tables VI to IX inclusive show the relationship between the length of culms of plants in 1919 and the yields secured from those plants in 1920, 1921, 1922 and 1923.

TABLE VI.—LENGTH OF CULMS IN CM. SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1920.

Length of culms in cm.	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0	7.5	
79	...	...	...	...	...	...	...	...	1	...	...	...	...	...	...	1
82	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0
85	...	...	2	1	...	1	1	...	...	...	...	...	...	...	...	5
88	...	2	1	...	2	..1	...	1	...	...	...	1	...	...	...	8
91	1	...	3	2	4	3	3	4	2	1	...	...	...	...	...	23
94	2	2	7	7	5	9	9	8	5	...	1	...	...	...	1	56
97	...	2	6	10	12	6	9	2	6	3	4	2	...	...	...	62
100	1	3	4	3	6	14	9	7	5	2	2	...	...	...	...	56
103	...	...	1	1	7	3	4	4	...	2	...	...	1	1	1	25
106	...	...	3	3	6	1	1	1	...	...	2	...	...	...	...	17
109	...	...	...	...	...	...	1	2	...	...	...	...	...	...	...	3
	4	9	27	27	42	38	37	29	19	8	9	3	1	1	2	256

r = .0997±.0418
Mean weight of grain 3.0918±.0535 gms.
Mean length of culms 97.1992±.2066 cm.

Table VI gives the coefficient of correlation obtained between the length of culms selected in 1919 and the yield produced by seed from these culms in 1920. The coefficient is .0997±.0418 and does not show any degree of relationship between height of mother plants one year and yield the following year.

TABLE VII.—LENGTH OF CULMS IN CM. SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1921.

Length of culms in cm	2.8	4.3	5.8	7.3	8.8	10.3	11.8	13.3	14.8	16.3	17.8	19.3	20.8	
79	....	....	....	....	....	....	....	....	....	1	....	....	....	1
82	....	....	....	....	....	....	....	....	....	....	....	....	....	0
85	....	....	1	....	1	....	....	1	1	....	....	1	....	5
88	2	....	....	3	1	1	....	....	1	....	....	....	....	8
91	1	2	2	3	1	3	3	5	3	....	....	....	....	23
94	3	7	4	7	9	12	3	5	4	....	1	1	....	56
97	3	4	10	10	6	4	9	1	2	3	3	....	1	62
100	2	10	5	13	8	8	2	3	....	3	2	....	....	56
103	....	5	3	....	7	1	2	4	1	1	....	1	....	25
106	1	4	3	3	3	1	1	1	....	....	....	....	....	17
109	....	....	....	1	1	....	....	1	....	....	....	....	....	3
	18	32	28	40	37	30	20	21	12	8	6	3	1	256

r = —.1177±.0478
Mean weight of grain 8.9289±.1697 gms.
Mean length of culms 97.1992±.2066 cm.

Correlating the length of culms in 1919 with the yield of 1921, the coefficient of correlation is —.1177±.0478. The mean weight of grain harvested was 8.9289±.1697 grams and the mean length of the culms of the mother plants was 97.1992±.2066 cm.

TABLE VIII.—LENGTH OF CULMS IN CM. SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1922.

Length of culms in cm	3.5	6.5	9.5	12.5	15.5	18.5	21.5	24.5	27.5	30.5	33.5	36.5	39.5	42.5	45.5	
79	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	1
82	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	0
85	2	1	...	...	2	...	...	...	...	...	...	...	...	...	...	5
88	...	5	1	...	...	...	...	...	1	...	...	...	1	...	...	8
91	...	2	3	5	3	3	2	4	...	...	...	1	...	...	...	23
94	7	9	6	10	7	5	5	2	1	3	...	1	...	...	...	56
97	3	16	7	10	6	4	7	3	1	2	1	1	1	1	1	62
100	7	11	10	7	6	2	5	1	2	...	2	1	...	...	...	56
103	1	4	2	6	4	...	5	2	...	1	...	...	...	...	...	25
106	1	4	1	3	2	3	...	...	1	1	1	...	...	...	...	17
109	...	...	...	1	1	...	...	...	...	1	...	...	...	...	...	3
	21	53	30	42	31	17	24	12	6	8	4	4	2	1	1	256

r = .0542±.0430
Mean weight of grain 14.4102±.3628 gms.
Mean length of culms 97.1992±.2066 cm.

In 1922, the coefficient of correlation between the weight of grain harvested and the length of culms in 1919 is .0542±.0430. The mean weight of grain harvested is 14.4102±.3628 grams. The correlation existing is positive but small and indicates no marked degree of relationship.

TABLE IX.—LENGTH OF CULMS IN CM. SELECTED IN 1919 CORRELATED WITH WEIGHT OF GRAIN IN GMS. HARVESTED IN 1923.

Length of culms in cm.	4.5	6.5	8.5	10.5	12.5	14.5	16.5	18.5	20.5	22.5	24.5	26.5	
79	....	....	....	1	....	....	....	....	....	....	....	....	1
82	....	....	....	....	....	....	....	....	....	....	....	....	0
85	....	....	1	2	2	....	....	....	....	....	....	....	5
88	....	1	3	1	....	2	....	....	1	....	....	....	8
91	3	1	3	4	5	3	2	1	....	1	....	....	23
94	1	9	8	12	8	6	6	4	2	....	....	1	56
97	6	10	7	16	9	8	4	....	1	1	....	....	62
100	1	4	5	18	15	9	2	1	....	....	....	....	56
103	....	1	7	4	6	4	1	2	....	....	....	....	25
106	1	1	2	6	4	....	....	....	2	1	....	....	17
109	....	....	....	....	2	....	1	....	....	....	....	....	3
	12	27	36	64	51	32	16	8	4	3	0	1	256

r = .0491±.0420
Mean weight of grain 11.4765±.1669 gms.
Mean length of culms 97.1992±.2066 cm.

The coefficient of correlation between the weight of grain harvested in 1923 and the length of culms of the mother plants is .0491±.0420. The mean weight of grain harvested is 11.4765±.1669 grams.

The following summarized table gives the mean weight of grain in grams, the standard deviation, the coefficients of variability for the years of 1920, 1921, 1922, and 1923, and the coefficients of correlation between the length of culms of the mother plants in 1919 and the weight of grain harvested during the four succeeding years.

TABLE X.—SUMMARY TABLE

Year	Mean weight of the grain in gms.	Standard Deviation	Coefficient of Variability	Coefficient of Correlation
1920	3.0918±.0535	1.2691±.0378	41.0740±1.2334	.0997±.0418
1921	8.9289±.1697	4.0258±.1229	45.0873±1.3440	—.1177±.0478
1922	14.4102±.3628	8.6070±.2565	59.7285±1.7804	.0542±.0430
1923	11.4765±.1669	3.9600±.1181	34.5054±1.0285	.0491±.0420

The coefficient of correlation between the length of culms of the mother plants selected in 1919 and the yield of the succeeding generation as shown in Table X, indicates no direct relationship between length of culm and yield in the following years. In the first generation the correlation is .0997±.0418 while in the second generation it is —.1177±.0477. In the third and fourth generations it is again positive, .0542±.0430 and .0491±.0420 respectively. Leighty (5) working with oats states that heads from tall plants may usually be selected for high yield. On wheat, Myers (8) found a good correlation between the weight of the culm and the weight of grain per culm.

Relation Between Length of Culms and Length of Heads

It is a common belief that long heads are associated with long culms and that the longer the culms the longer the heads.

TABLE XI.—LENGTH OF CULMS OF MARQUIS WHEAT IN 1919 CORRELATED WITH LENGTH OF HEADS IN 1919.

Length of culms in cm.	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	
79	....	....	1	....	....	....	....	....	....	1
82	....	....	....	....	....	....	....	....	....	0
85	....	1	2	1	....	1	....	....	....	5
88	3	1	4	....	....	....	....	....	....	8
91	2	2	8	2	2	3	4	....	....	23
94	5	1	14	11	8	10	5	1	1	56
97	1	1	10	9	5	13	20	....	3	62
100	1	....	8	4	8	12	23	....	....	56
103	....	....	3	2	2	8	9	....	1	25
106	....	....	4	....	....	4	6	1	2	17
109	....	....	....	....	2	1	....	....	....	3
	12	6	54	29	27	52	67	2	7	256

r = .4822±.0323

Mean length of culms 97.1992±.2066 cm.

Mean length of head 10.0332±.0399 cm.

Table XI shows the relationship between length of culm and length of head. A coefficient of correlation .4822±.0323 is found which indicates the existence of a distinct correlation. Percival (11) reports a correlation of .439±.017 between length of straw and length of head. Westermeier (15) found a short head correlated with a short culm, and Roberts (13) found that taller plants generally produce longer heads.

TABLE XII.—LENGTH OF CULMS OF MARQUIS WHEAT IN 1922 CORRELATED WITH LENGTH OF HEADS IN 1919.

Length of culms in cm.	8.0	8.5	9.0	9.5	10.0	10.5	11.0	11.5	12.0	
79	1	....	....	2	4	2	2	....	1	12
82	2	3	12	9	10	15	19	1	1	72
85	4	2	19	13	6	22	22	....	2	90
88	4	1	15	5	3	12	15	....	1	56
91	1	....	5	....	3	1	7	1	2	20
94	....	....	3	....	1	....	....	....	....	4
97	....	....	....	....	....	....	1	....	....	1
100	....	....	....	....	....	....	1	....	....	1
	12	6	54	29	27	52	67	2	7	256

$r = -.0061 \pm .0421$
Mean length of culms 85.2461±.1436 cm.
Mean length of heads 10.0332±.0399 cm.

In Table XII, the length of the heads measured in 1919 are correlated with the length of culms produced in 1922. Measurements of the length of culms were not made for the other years so the correlation can only be given for the third generation. It will be seen that the correlation is —.0061±.0421, which does not indicate that any relation exists between length of heads and length of culms in the succeeding generations. A positive correlation exists between length of culm and length of head of the same year as indicated by Table XI, but plants producing long heads one year may or may not produce tall plants the following years.

Placing the 256 mother heads into groups established by the measurements of the heads, we find that the group representing two mother heads, 11.5 cm. long, yielded higher for each of the four years than any other group.

TABLE XIII.—AVERAGE YIELD IN GMS. OF ROWS PLANTED WITH SEED FROM MOTHER HEADS OF DIFFERENT LENGTHS.

Length of mother heads in cm.	No. of heads	Yield in Grams 1920	1921	1922	1923	Ave.
8.0	12	2.3	9.2	14.1	10.4	9.0
8.5	6	2.6	11.7	11.2	11.5	9.3
9.0	54	3.1	8.6	14.3	11.6	9.4
9.5	29	3.3	10.4	16.8	12.5	10.8
10.0	27	2.9	10.5	13.3	10.8	9.4
10.5	52	3.1	9.0	15.5	12.2	9.9
11.0	67	3.2	8.3	14.8	10.8	9.3
11.5	2	4.8	13.0	20.5	16.0	13.6
12.0	7	2.6	10.2	15.1	11.3	9.8
Average		3.1	10.1	15.1	11.9	

Although the two mother heads measuring 11.5 cm. averaged the highest yield as a group, neither one of these plants was the highest yielder for any single year as is shown by the following table:

TABLE XIV.—SHOWING THE LENGTH OF MOTHER HEAD GIVING THE LARGEST YIELD DURING THE FOUR YEARS.

Year	Row No.	Length of spike in cm.	Yield in gms.
1920	86	10.5	7.7
1921	127	9.5	21.0
1922	126	11.0	46.0
1923	105	9.5	26.0

No single spike was the highest yielder for more than one year, and in no case was the progeny from the longest nor that from the shortest mother head the highest yielder. The highest yielder for the different years fluctuated around the average length of mother heads.

Another means of showing the results expressed in Table XIII is by means of a graph. Figure I is a graphic presentation of the average yields of the rows grown from mother heads of different lengths.

A study of Figure I shows that the yields from the rows produced from heads 11.5 cm. long averaged the highest for the entire four years. In no single case did these head rows from heads of this length yield the highest, (Table XIV) but their average yield was highest. With the exception of the yields from heads 11.5 cm. long, there is no tendency for the yield to increase with an increased length of mother heads. Since these two heads measuring 11.5 cm. are consistently high yielders, it seems that we are dealing with a mixed population.

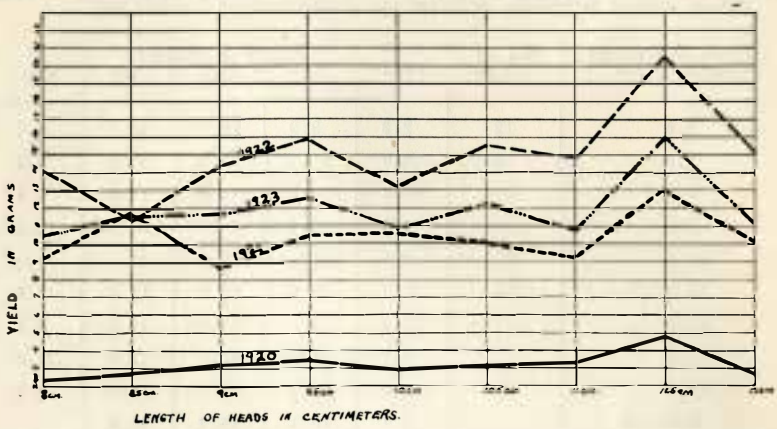

FIGURE 1.—YIELDS FROM DIFFERENT LENGTHS OF HEADS MEASURED IN 1919.

Summary

Measurements of the central culm and head of 256 plants of Marquis wheat were made in 1919, which were called "mother heads" and "mother culms" respectively. Each head was threshed separately and an equal number of kernels from each, sown in nursery rows with the seed from long heads alternating with that from short heads. The same order of planting was followed during the length of the experiment. Each row was threshed separately and seed saved for the following year.

The correlations between the length of mother heads and the yield from rows secured in the 1st, 2nd, 3rd and 4th generations are .0960±.0418; —.0132±.0412; —.0618±.0395 and .0129±.0421 respectively.

The length of culms of the mother plants correlated with the yields secured in 1920, 1921, 1922 and 1923, gives the following coefficients of correlation: .0997±.0418; —.1177±.0478; .0542±.0430; and .0491±.0420 respectively.

A correlation of .4822±.0323 was found between the length of culms and the length of heads borne on them. Correlating the length of mother heads with the length of culms in 1922, the third generation, a coefficient of —.0061±.0421 was found.

The average yield produced by seed from mother heads measuring 11.5 cm. was the highest for each of the four years.

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