In Table 9 are given the means, standard deviations, and coefficients of variability, with their probable errors, of the different variates or characters dealt with in this paper.

In Table 10 is given a résumé of the coefficients of correlation embodied in this paper.

SUMMARY

In recapitulation it may be said that the data dealt with in this paper show that tall plants are better yielders than short 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 yield; that, contrary to the results of Waldron, the larger kernels are not as a rule obtained from the shorter plants, or from those usually not considered better for breeding purposes; that as the number of heads borne by the plant increases the total yield of the plant also increases; that as the number of culms per plant increases the amount of grain obtained from each culm increases, on the average, to quite a large extent; that large kernels are obtained about equally from plants with many or few culms; that as the number of culms increases the number of kernels borne by each culm increases; that large kernels are as likely to be found in a head which produces few as in a head which produces many kernels, or that the largest kernels are not as a rule found on the plants giving the smallest yield; that there is possibly a difference as regards correlation of characters between different varieties, or between pure lines and varieties.

EFFECT OF FERTILITY UPON VARIATION AND CORRELATION IN WHEAT*

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The study of the correlations of various characters is a very important one and has received increased attention during the last few years, especially from biologists who are working from the statistical standpoint. While correlations have long been studied in a general way, it is only by statistical methods that such relationships can be accurately measured and determined.

In the breeding of cereals, many data have been obtained upon

* Paper No. 18, Department of Plant Breeding, Cornell University, Ithaca, N. Y.

the question of large and small seed as associated with yield. The results, however, are conflicting, and the question remains a mooted one. The influence of nutrition upon the size of the seed is not definitely known any more than is the influence of the size of the seed upon the progeny.

Nutrition has long been considered one of the most important factors influencing the variability of plants. Darwin^a states that "Of all the causes which induce variability, excess of food, whether or not changed in nature, is probably the most powerful." He also observed the correlation of characters in connection with their variability.

Before Darwin, Knight^b was led to the belief that variation in both plants and animals was due to a more abundant supply of nourishment or more favorable climate, than was natural to the species.

Schleiden^c was also inclined to this view, especially in regard to the inorganic elements of food.

De Vries^d devotes considerable space to the question of the influence of nutrition upon the variability of plants. He regards nutrition, in the widest sense, as the basis of all variation. He sees no distinction between nutritional modifications and individual variations. In general, favorable conditions tend to give plus variations while unfavorable conditions give minus variations. Selection, according to DeVries, is the choice of the best nourished individuals, the younger the plant, the greater the influence of external conditions upon its variability. "The nutrition of the seed on the mother plant, has in many cases, at any rate, a greater effect on variability than nutrition during germination and vegetative life itself." DeVries sowed poppies on three beds, one of sand, one of garden soil and one of richly manured soil. This species is quite variable. One form is distinguished by the conversion of the inner stamens into carpels. These carpels may vary in number from a few to 150 or more. In the experiment referred to, the number of these carpels increased markedly as the fertility increased.

Rheinol^e found that the number of stamens of *Stellaria media* increased as the food supply increased and that the poorly fed plants were less variable than those more highly nourished.

^a *Animals and Plants under Domestication*, II, p. 236.

^b *Treatise on the Culture of the Apple*.

^c *The Plant*. (1848)

^d *The Mutation Theory*.

^e Die Variation in Andröceum der *Stellaria media* Cyr., *Bot. Zeit.* (1903) p. 159.

Miss Tammes^f studied the effect upon flax, of good and poor soil and thin and thick plantings. Her conclusion is that the more favorable growth conditions tend to lessen variability. She states that the variability is least under the most favorable or the most unfavorable conditions. The greatest correlations occurred upon the poor soil.

E. Davenport,^g in his study of ears of corn grown upon plots of different degrees of fertility, concludes that variability is not greatly influenced by fertility.

Love^h studied variation in peas, buckwheat, corn and asters. His conclusions from the data presented were that, in general, increase in nutrition gave an increase in variability and that correlations decreased as fertility increased.

Humbertⁱ arrived at the conclusion that an increase of food supply was coupled with a decrease in variability and an increase in correlation.

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

The present paper is a preliminary report of some work with wheat. As stated before, the question of correlations is an important one, especially from the breeding standpoint, and any data which will shed light upon the problem should be of some value.

The wheat, upon which the data for this paper was taken, is the variety known as Dawson's Golden Chaff. The seed was from a mixed population and was planted in the fall of 1909 upon three plots of different degrees of fertility. The seed were planted far enough apart so that individual plants could be distinguished. The first of the plots was dug out to a depth of one foot, the sides lined with boards and then filled with sand. The second plot was ordinary garden soil without treatment. The third was of the same soil but fertilized in 1909 with manure at the rate of eighty tons per acre and with acid phosphate at the rate of 900 pounds per acre. The garden in which these plots are located is river bottom land and is quite fertile. An analysis of the soil of these plots is shown in Table 1.

^f *Die Flachstengel Naturk. Verhandl. Holland. Maatsch. Wetensch. Haarlem.*, 3, ser. 6 (1907) No. 4.

^g *Illinois Ex. Sta. Bul.* 119.

^h *Studies of Variation in Plants*, Cornell Uni. Agr. Ex. Sta. Bul. 297.

ⁱ A quantitative Study of Variation, Natural and Induced in Pure Lines of *Silene Noctiflora*. *Zeitschrift für induktive Abstammungs- und Vererbungslehre* 1911 Bd. iv, Heft 3 u. 4.

^k *Cornell Agr. Ex. Sta., Bul.* 279.

TABLE 1.—Analysis of soil from three plots of different degrees of fertility.

	Ordinary.	Sand.	Manured.
	<i>Per cent.</i>	<i>Per cent.</i>	<i>Per cent.</i>
K ₂ O.....	0.57	0.29	0.76
P ₂ O ₅	0.275	0.125	0.35
N.....	0.280	0.03	0.44
Organic Matter.....	10.40	01.66	15.20
Acidity.....	15.00 cc.	Alk.	20.00 cc.
Moisture.....	1.80	0.13	2.57

NOTE.—Acidity number is the number cubic centimeters of $\frac{N}{40}$ Ca(OH)₂ required to neutralize the acidity of 10 grams of the soil.

The wheat was harvested by individual plants and the following data was taken for each plant, using the culm as the basis for measurement: The total number of culms produced; the total weight of the several culms, straw and grain, in grams; the height of culms in centimeters measured from the base to the tip of the spike; the length of the spike in centimeters; the number of spikelets; the number of rudimentary spikelets at the base; the total number of kernels and the weight of the kernels in grams. In the correlation tables following, the averages for plants will be considered except in the correlations between the gross weight of the culm and the weight of the grain from the culm. That is, the average height of plant is found by dividing the sum of the heights of all the culms of the plant by the number of culms. In a like manner the average weight per kernel is found by dividing the sum of the weights of the kernels of each culm by the sum of the numbers of kernels of each culm. The ordinary statistical constants are employed, the short method, as explained by E. Davenport,¹ being used for standard deviation and the coefficient of correlation.

The following points will be considered:

1. The correlation of the average weight of kernel with the number of culms. That is, do the kernels become smaller as the number of culms per plant increases?
2. The correlation of the average weight of kernel with the height of culms. Are the larger kernels from the shorter or taller plants?
3. The correlation between the gross weight of the culm and the net weight of the grain. In other words, is the total weight of the culm an index of the amount of grain it produces?
4. What effect has fertility upon these correlations and upon variability in general?

¹ Principles of Breeding.

Table 2 shows the correlation between the number of culms and the average weight of the kernels of wheat grown upon sand. The correlation in this case is not large but is distinct and positive, amounting to practically 33 per cent.

TABLE 2.—Correlation of number of culms per plant and average weight of kernels per plant of wheat grown on sand.

$r = 0.301 \pm 0.027.$

		Number of culms per plant.							Totals
		1	2	3	4	5	6	7	
Average weight of kernels per plant, in milligrams.	2-3	1							1
	3-4								0
	4-5	5							5
	5-6	2							2
	6-7	2		1					3
	7-8								0
	8-9	3	2		1				6
	9-10	7	1	2					10
	10-11	3			1				4
	11-12	6	1						7
	12-13	7	2	1					10
	13-14	7	2	1			1		11
	14-15	17	1	2					20
	15-16	7	2	1	1				11
	16-17	7	3						10
	17-18	10	6	3	1				20
	18-19	10	1						11
	19-20	18	9	1	2				30
	20-21	8	7	1	2				18
	21-22	15	8	2			1		26
	22-23	15	11	8	1				35
	23-24	14	10	5	2				31
	24-25	17	9	6	1				33
	25-26	9	11	4					24
	26-27	9	10	7	2	1			29
	27-28	8	12	8	3				31
	28-29	8	6	4	3				21
	29-30	10	9	1	2		1		23
	30-31	4	3	4	2				13
	31-32	3	3	1	3		1		11
	32-33	2	2	2	1				7
	33-34	2	6	2	1			1	12
	34-35	3	1	3		2			9
	35-36		7	1		1			9
	36-37		2						2
	37-38			1	1				2
	38-39		1						1
	39-40	1	1	1					3
	40-41		1						1
Totals...		240	150	73	30	4	4	1	502

Table 3 shows the correlation of the same characters of wheat grown upon ordinary soil. Here the amount of positive correlation, a little more than 1 per cent, is so small as to be almost negligible. These results are neither directly contradictory nor are they entirely concordant. The same seasonal conditions may affect the plants of the two plots differently.

TABLE 3.—Correlation of number of culms per plant and average weight of kernels per plant of wheat grown on ordinary soil.

$r = 0.013 \pm 0.032.$

		Number of culms per plant.								Totals.	
		1	2	3	4	5	6	7	8		9
Average weight of kernels per plant, in milligrams.	9-10	1									1
	10-11										0
	11-12			1							1
	12-13										0
	13-14										0
	14-15										0
	15-16		1								1
	16-17		1								1
	17-18										0
	18-19			1							1
	19-20		1		1						2
	20-21		1	1							2
	21-22			2							2
	22-23			3							3
	23-24		2	3	2		1				8
	24-25	1		2	1		1				5
	25-26			6	1	3					10
	26-27		5	7	6	3		2			23
	27-28	2	1	6	5		1	1			16
	28-29		1	16	15	4	1	2		1	40
	29-30	1	6	12	11	7	4	2			43
	30-31		8	14	17	13	1				53
	31-32	2	6	21	25	4	3	1			62
	32-33		7	14	15	10	2	3			51
	33-34		3	17	15	5	3		1		44
	34-35		3	12	4	5	1				25
	35-36		2	6	7	1	1	1			18
	36-37	1	1	6	2						10
	37-38	1	4	3	4						12
	38-39			2		2					4
	39-40	2	2								4
	40-41			2							2
	41-42										0
	42-43										0
	43-44										0
	44-45			1							1
Totals....		11	55	158	131	57	19	12	1	1	445

Table 4 shows the correlation between the average height of culms and the average weight of kernels of wheat grown upon sand and Table 5 the correlation of the same characters of wheat grown upon ordinary soil. There is a positive correlation in both cases, amounting to 51 per cent in the first and to 43 per cent in the second. From the data presented in these two tables it is evident that, for this series of plants,

TABLE 4.—Correlation of average height of culms per plant and average weight of kernels per plant of wheat grown on sand.

[r = 0.509 ± 0.022.]

		Average height of culms per plant.																		Totals.
		13 18	18 23	23 28	28 33	33 38	38 43	43 48	48 53	53 58	58 63	63 68	68 73	73 78	78 83	83 88	88 93	93 98		
Average weight of kernels per plant, in milligrams.	2-3							1											1	
	3-4																		0	
	4-5	1	1	1	1	1	1												5	
	5-6				1							1							2	
	6-7	1				1	1												3	
	7-8																		0	
	8-9	1	1	1	1	1	1		1										6	
	9-10		2	1	2	2	1	1		1									10	
	10-11				1	1	1						1	1					4	
	11-12			1	1	2	1	1			1								7	
	12-13		2	1	1	1	1	1			1		1	1					10	
	13-14			1	2	1	3	2			1								11	
	14-15		1	2	2	4	3	2	1	2	1	1	1						20	
	15-16	1				1	3	2	1	2									11	
	16-17			1		1	1		1	5	1								10	
	17-18		1		1	4	2	1	1	2	5	1	1	1					20	
	18-19		1		1	2	2	1		4	1	1							11	
	19-20		1	1	4	2			2	5	4	2	2	1	4		2		30	
	20-21				1	1	1		3	6	3	3	1	1	1				18	
	21-22				1		2	2	2	3	6	3	4	4	1				26	
	22-23				1	1	3	2	2	7	9	1	4	2	3				35	
	23-24			1			3	3	3	1	5	3	7	4	2			1	31	
	24-25				2	2	2	4	1	5	6	5	5	4	1				33	
	25-26			1			3	4		3	4	7							24	
	26-27						2	4		4	4	5	5		1				20	
	27-28			1	1	2	1	2	4	3	1	6	4	2	3	1			31	
	28-29					1	2	2	2	3	4	3	5	3	1				21	
	29-30		1	1		1	2	1	2	2	1	2	5	3	1	1			23	
	30-31						1	1	2			1		1	1		4		13	
	31-32							1		2	5			1				1	11	
	32-33								1	1	1	1					1		7	
	33-34								2		2	1	2						12	
	34-35								1	1	1	2		2	1	1		1	9	
	35-36					1				1	1	1	1		1	1		1	9	
	36-37													1	1				2	
	37-38										1						1		2	
	38-39							1											1	
	39-40										1				2				3	
	40-41																1		1	
Totals..		4	12	16	24	31	42	40	37	64	68	47	47	28	23	11	5	3	502	

the heavier kernels are produced by the taller culms. This does not agree with the work of Waldron^m who found, in wheat, but a slight positive correlation between height of culms and average weight of kernel. His results led to the conclusion that greater or less average

^m A Suggestion Regarding Heavy and Light Seed Grain, *Amer. Nat.*, vol. xlv, pp. 48-56.

height of culms did not imply any particular weight of kernels. However, as Waldron suggests in regard to his work upon oats, there may be varietal differences which influence these correlations. Clark^a has pointed out, in the case of timothy, that seasonal variations may influence the coefficients of correlation. A paper by Love^o which appears elsewhere in this report, indicates that correlation in pure

TABLE 5.—Correlation of average height of culms per plant and average weight of kernels per plant of wheat grown on ordinary soil.

[r = 0.480 ± 0.025.]

		Average height of culms per plant.																		Totals.
		28 33	33 38	38 43	43 48	48 53	53 58	58 63	63 68	68 73	73 78	78 83	83 88	88 93	93 98	98 103	103 108	108 113	113 118	
Average weight of kernels per plant, in milligrams.	9-10			1																1
	10-11																			0
	11-12	1																		1
	12-13																			0
	13-14																			0
	14-15																			0
	15-16										1									1
	16-17									1										1
	17-18																			0
	18-19									1										1
	19-20					1						1								2
	20-21				1															2
	21-22												1		1					3
	22-23												2							2
	23-24					1				1	1	1			1			1		8
	24-25				1	1														5
	25-26										1					1				10
	26-27											3			2	2				23
	27-28									1		6			2	2				16
	28-29										1				5	4				40
	29-30	1					1			1	3		3		11	7		5		43
	30-31												7		15	9				53
	31-32											1			15	19		3	5	62
	32-33						1			2	2				11	10		8	1	51
	33-34											2			7	8		12	3	44
	34-35														3	4		5	4	25
	35-36						1								3	3		4	3	18
	36-37									1					2	2				10
	37-38												1					3	5	12
	38-39															1				4
	39-40												1					1		4
	40-41																			2
	41-42													1						0
	42-43																			0
	43-44																			0
	44-45															1				1
Totals..		2		1	2	3	4			5	14	27	57	83	82	71	60	26	8	445

lines may differ from those in mixed populations. As stated previously, the data presented in the present paper was taken upon a mixed population.

It may be observed in passing that in every instance the correlation is greater upon the sand plot than upon the plot of ordinary soil.

^a Cornell Uni. Agr. Ex. Sta., Bul. 279.
^o A Study of the Large and Small Grain Question.

The correlation between the total weight of the culm and the weight of the grain shelled from the culm, is a very important one from the breeding standpoint. If the gross weight of the plant, including the straw and grain, can be taken as an index of the weight of the grain, then breeding operations may be facilitated to a considerable extent for the selections may be made by comparing the total weights of the plants or rows without shelling and weighing the grain. So far as the writer is aware, no data upon this question has been presented in a statistical way. Some observations have been made in connection with variety tests.

FIG. 1. CURVE SHOWING THE RELATION OF STRAW TO GRAIN OF WHEAT.

Figures at the left are pounds of straw per acre. Figures at the right are bushels of grain per acre. Solid line represents yields of straw arranged in ascending order. Broken line represents corresponding yields of grain. Results of three years' variety tests at the Kentucky Station.

Scherffius and Woosley^p report the yields of straw and grain of a three years test of some 31 varieties of wheat at the Kentucky Experiment Station. One of the conclusions from this work was "that there is no absolute relation between the yield of straw and grain but that, generally, the highest yields of straw are associated with low yields of grain under normal conditions."

A careful analysis of the data presented does not entirely support this conclusion. In Fig. 1, these results are represented graphically.

^p Kentucky Ex. Station Bul. 135.

The solid line represents the three year average yields of straw, arranged in ascending order. The broken line represents the corresponding yields of grain. With a few exceptions, it is apparent that, in general, the yields of straw and grain increase together. The one striking exception is so far below the normal that we are led to the conclusion that its growth and development was affected in some abnormal way, perhaps by disease or accident. Omitting the middle point and comparing the 15 highest with the 15 lowest we have the results given in Table 6.

TABLE 6.—*Comparison of yields of straw and grain in wheat. Three years' test at the Kentucky Station.*

	Straw pounds per acre.	Grain bushels per acre.
Average yield of 15 test above the average.....	3210	27.48
Average yield of 15 test below the average.....	2847	25.25
Difference.....	363	2.23

An inspection of this table shows that in general the highest yielders of grain also produce the most straw.

Other data is available which throws light upon this question. In the Ontario Report for 1909, are given the results of a five years test with 22 varieties of spring wheat and of a fourteen years test

TABLE 7.—*Comparison of yields of straw and grain in wheat. Five-year test with spring, and fourteen-year test with winter varieties at the Ontario Station.*

	Straw, tons per acre.	Grain, bushels per acre.
Average yield 7 winter varieties above average.....	3.3	48.8
Average yield 7 winter varieties below average.....	2.9	45.1
Difference.....	0.4	3.7
Average yield 11 spring varieties above average.....	1.9	33.3
Average yield 11 spring varieties below average.....	1.7	29.7
Difference.....	0.2	3.6

with 15 varieties of winter wheat. These results are tabulated in Table 7. In both the spring and winter varieties, the highest yields of grain are associated with the higher yields of straw.

Noll^a gives a summary of the variety tests of wheat at the Pennsylvania State College. These tests are 32 in number and range from

^a Penn. State College, Bul. 94.

1 to 19 years in duration. The weights of straw and grain are given for each of these tests. These results are arranged for comparison in Table 8. An inspection of this table shows that there is a positive correlation between the weight of straw and grain.

TABLE 8.—Comparison of yields of straw and grain in wheat. Variety tests at Pennsylvania State College.

	Straw, pounds per acre.	Grain, bushels per acre.
Average yield of 16 tests above the average.....	3477	30.5
Average yield of 16 tests below the average.....	3055	29.2
Difference.....	422	1.3

There may be varietal differences in regard to this relation between straw and grain but the results given in Tables 6, 7 and 8 include a large number of tests, in different localities, extending over considerable period of time, and they are quite consistent. However, all of these tests have been variety tests made under field conditions.

The question comes to the breeder, whether or not this correlation of grain and straw holds good for individual culms or plants. From

TABLE 9.—Correlation of gross weight of culm and weight of grain per culm of wheat grown on ordinary soil.

($r = 0.925 \pm 0.004.$)

		Weight of grain, in grams.												Totals.
		0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	
		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	2.4	
Gross weight of culms, in grams.	0.5-1.0	5	1											6
	1.0-1.5	1	16	3										20
	1.5-2.0		6	18	7									31
	2.0-2.5			7	33	7	1							48
	2.5-3.0			1	17	40	12							70
	3.0-3.5				1	2	30	53	20					106
	3.5-4.0						7	28	35	13	1			84
	4.0-4.5						1	3	20	36	9			69
	4.5-5.0							2	4	18	17	4		45
	5.0-5.5									2	4	4	2	12
	5.5-6.0										2	5		8
	6.0-6.5												1	1
Totals.		6	23	30	59	85	99	79	69	33	13	2	2	500

the plants grown upon ordinary soil and upon manured soil the writer has taken the gross weights of culms and the weights of the grain from the culms. These results appear in Tables 9 and 10. There is an extremely high positive correlation in both instances, amounting in the first to 93 per cent and in the second to 89 per cent. In this series of plants, at least, the gross weight of the plant would have been a safe index of the weight of the grain.

TABLE 10.—*Correlation of gross weight of culm and weight of grain per culm of wheat grown on manured soil.*
($r = 0.890 \pm 0.006.$)

		Weight of grain, in grams.											Totals.
		0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	
		0.2	0.4	0.6	0.8	1.0	1.2	1.4	1.6	1.8	2.0	2.2	
Gross weight of culms, in Grams.	0.5-1.0	3	1										4
	1.0-1.5	1	3	1									5
	1.5-2.0		2	18	3								23
	2.0-2.5		1	7	19	4							31
	2.5-3.0			5	21	41	4						71
	3.0-3.5				9	32	49	3					93
	3.5-4.0				1	3	20	47	41	1			113
	4.0-4.5						3	20	48	19			90
	4.5-5.0							4	11	19	7	1	42
	5.0-5.5								3	3	14	3	23
	5.5-6.0										1	2	4
	6.0-6.5											1	1
Totals.		4	7	32	55	100	124	106	42	22	7	1	500

The data presented by the writer in this paper does not offer a great deal of evidence upon the question of the effect of fertility or nutrition upon variability. But since it concerns a fairly large number of individuals and is consistent, it furnishes evidence of some value.

It was observed in connection with the correlation tables that in every instance the coefficient of correlation was greater upon the less fertile plot. In Table 11 are shown the constants for the various characters studied.

An inspection of Table 11 shows some interesting and fairly consistent results as regards variability. The means increase decidedly as we pass from the sand plot to the ordinary plot. In passing from the ordinary to the highly manured plot the difference is not so decided. Indeed, the mean is increased in the case of the gross

TABLE 11.—Constants for characters of wheat grown upon plots of different fertility.

Character.	Mean.	Standard deviation.	Coefficient of variability.
Sand plot, 502 plants:			
Average weight of kernels.....	22.853 ± 0.213	7.083 ± 0.151	30.994 ± 0.720
Number of culms.....	1.853 ± 0.028	1.044 ± 0.022	56.341 ± 1.534
Average height of culms.....	55.061 ± 0.504	16.733 ± 0.356	32.906 ± 0.773
Ordinary plot, 445 plants:			
Average weight of kernels.....	30.878 ± 0.127	3.987 ± 0.090	12.912 ± 0.297
Number of culms.....	3.638 ± 0.040	1.258 ± 0.028	34.497 ± 0.867
Average height of culms.....	93.545 ± 0.391	12.238 ± 0.277	13.082 ± 0.301
Gross weight of culms.....	3.332 ± 0.032	1.047 ± 0.022	31.423 ± 0.733
Weight of grain.....	1.090 ± 0.012	0.409 ± 0.009	37.523 ± 0.906
Manured plot :			
Gross weight of culms.....	3.545 ± 0.028	0.939 ± 0.020	26.488 ± 0.603
Weight of grain.....	1.074 ± 0.010	0.337 ± 0.007	31.378 ± 0.731

In taking the data for the correlation of the gross weight of the culm with the weight of grain from the culm, the individual culm was used as the basis instead of the plant. Five hundred culms were considered.

weight of culms and decreased in the case of the weight of grain from the culm.

The coefficient of variability is greater in every instance for the plants grown upon the less fertile soil. Here again, the distinction is not so marked between the ordinary and manured plots, as between the sand and the ordinary plots. This is what might be expected, since the coefficient of variability is so strongly influenced by the mean, which in these instances is not so different.

If we measure the variability of these plants by the standard deviation, again we see that it is greatest upon the poorer soil. To be exact, in four cases out of five, the standard deviation is less upon the more highly fertilized plots.

In general, then, we see that the variability of these wheat plants is greatest upon the poorer soil. This is not in accordance with the results reported by Love.^r He found that in a majority of cases, increased nutrition was coupled with an increase in variability. However, he found less correlation upon good soil where Humbert^s found the greater correlation. It is very probable that seasonal variations may explain these conflicting results. Definite conclusions cannot be drawn until much more data, extending over a period of years, is amassed.

^r Studies of Variation in Plants, Cornell Uni. Agr. Ex. Sta. Bul. 297.

^s A Quantitative Study of Variation, Natural and Induced in Pure Lines of *Silene Noctiflora*. *Zeitschrift für induktive Abstammung—und Vererbungslehre*, 1911, Bd. iv, Heft 3 u. 4.

SUMMARY

The results discussed with this particular lot of data may be summarized as follows:

1. The original data of wheat used in this study is from a mixed population of the variety known as Dawson's Golden Chaff. The data used in Tables 6, 7 and 8 and in Fig. 1, was derived from sources as stated.

2. There is a slight positive correlation between number of culms and the average weight of kernel. That is, the majority of the heavier kernels are produced by the plants with the larger number of culms.

3. In general, the taller plants produce the heavier kernels.

4. There is an absolute relation between the weight of straw and the weight of grain. This relation is most marked in the case of individuals culms.

5. All correlations are greatest upon the poorer soil.

6. Increased fertility tends to decrease variability.

7. More data is needed before definite conclusions can be drawn.

VALUE OF CONTINUOUS SELECTION AND ITS BEARING UPON HARDINESS IN WINTER WHEAT

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One of the engrossing subjects of breeding is the possibility of producing changes by continuous selection. But a few years ago, it was the common belief that changes could be so produced. As things are going, but a few years will see a radical change in the "mode" of belief so that the common opinion will be against the efficiency of continuous selection.

Continuous selection, baldly stated, is this: May we, by selecting taller and taller wheat plants each year, finally secure a plant that averages taller than the one with which we started?

In 1900, von Rümker of Germany commenced with a small sample of Petkus rye, a variety said to have originated from a single plant. When he started, the plants of one group produced on the average about 63 per cent of green-colored kernels, the remainder being yellow. Another group had plants with 54 per cent of yellow kernels, the