SOME CORRELATIONS IN SUGAR BEETS

F. S. HARRIS AND J. C. HOGENSON

Utah Experiment Station, Logan, Utah

[Received March 21, 1916]

INTRODUCTORY

The beet sugar industry, amounting to hundreds of millions of dollars every year, is the direct result of scientific breeding done on the sugar beet, which has been developed from a plant with a sugar content too low to permit of the commercial extraction of sugar, up to its present high sugar content. If the industry is to be permanent, it is necessary to maintain in the sugar beet its present high sugar content; and it is highly desirable to increase the percentage of sugar as much as possible. This means that breeding methods will need to be applied to the sugar beet as long as it is used in the manufacture of sugar.

The improving of any plant is necessarily a slow and expensive process. This is particularly true of the sugar beet, since two years are required for the production of seed, and also a vast amount of expensive chemical work is necessary in determining the quality of the plants. It is, therefore, highly desirable to learn as much as possible of the nature of the sugar beet and of the correlation of its various characters in order, if possible, to obtain short cuts in the process of improvement.

At the UTAH EXPERIMENT STATION the selection of sugar beets has been going on for thirteen years. During this time, fairly complete records, including pedigrees, have been kept. These records furnish the data necessary to determine the correlation of characters herein discussed.

LITERATURE

Considerable work has been done on the correlation of different characters in sugar beets; but the results are not entirely uniform and they have led to considerable divergence of opinion.

LASKOWSKY (1893) as a result of experiments in the Waki district, Russia, concluded that beets of the highest sugar content are produced from the smallest seed balls; also that the individual seeds in these smallest seed balls are highest in fat.

TOWAR (1901) found that the varieties of beets which gave the highest yield contained the lowest percentage of sugar.

MAAS (1906) obtained results which showed that the percentage of sugar within a variety decreased as the weight of the beet increased, but the rate of increase was not the same, so that the total quantity of sugar was more dependent on the quantity than on the quality of beets.

ANDRLIK and URBAN (1908) showed from analyses that abnormally large sugar beets had a characteristically low sugar content.

Later, they in conjunction with BARTOS (ANDRLIK, BARTOS and URBAN 1912) concluded that the weight of sugar beets is more readily modified than the sugar content. They denied the truth of the statement that the greater the weight the less the sugar content except in extreme, and hence rare, cases. From data presented, they conclude that the weight of the beet root shows fluctuating variability in accordance with the QUETELET-GALTON law. Each strain shows its own correlation between root weight and sugar percentage. In only a few unusual cases does it occur that low sugar content accompanies a very unusual root weight, and these cases probably result from abnormalities in the use of plant food.

HARRIS and GORTNER (1913) conclude that the notes presented by ANDRLIK, BARTOS, and URBAN "form a very slender basis for the conclusion that in beets of the same strain there is no negative correlation between weight and sugar content. Nevertheless one must recognize the possibility of the correctness of the conclusion. Should it be valid, the suggestion follows that the negative correlation demonstrated in commercial cultures has a genetic origin, i.e., that strains characterized by large root size are also characterized by low sugar content, and that when these strains are intermingled and intercrossed in field cultures there results a negative correlation between the weight of the individual beet and the sugar content of its juice."

METHODS

The work reported in this paper was done at the UTAH EXPERIMENT STATION in Logan, Utah. It was begun in 1902, when a number of strains of seed were obtained from the U. S. DEPARTMENT OF AGRICULTURE and from local sugar companies. Since that time, selections have been made for high sugar content and yield and for desirable size and shape of beets.

From the beets raised each year samples having a desirable size and

shape were saved and analyzed. The very large and the very small beets were eliminated and only the medium beets saved. This eliminates the extremes which ANDRLIK, BARTOS, and URBAN consider to be the only ones in which a negative correlation between size and sugar content is shown. Certainly if these extremes had been included, the correlation would have been more striking.

The analyses were made from pulp obtained by boring a diagonal hole through each beet. The beets were then siloed over winter in dry sand and in the spring were planted four feet apart each way. During the blossoming period, the tops were covered with mosquito bar to prevent an interchange of pollen by insects. At maturity of the seed, determinations were made of the height of plants, number of stems, average number of leaves on each stem, weight of seed, and number of days from planting to maturity of seed. These data, together with the weight of the mother beet and the percentage sugar it contained, furnish the material for the correlation tables which are here presented.

The method of calculating the coefficient of correlation and the probable error is that explained by EUGENE DAVENPORT in his "*Principles of Breeding*," pp. 419-472. Where there is a perfect correlation in two characters, the coefficient of correlation is 1, while if there is no correlation the coefficient is zero. As the correlation varies from none to complete, the coefficient varies from 0 to 1. Where the correlation is negative the coefficient is preceded by a minus sign.

CORRELATIONS

1. *Weight of beet and sugar content*

As pointed out in the literature review, there has been considerable controversy over the relation between the size of beets and their sugar content.

Table 1 shows results for 6984 beets which were raised during a number of years. A negative correlation of $-.2878$ is shown between these two characters, with a probable error of $\pm .0074$. It must be kept in mind that neither the very small nor the very large beets were used. As already pointed out, ANDRLIK, BARTOS, and URBAN (1912) have shown these extremes to give the most obvious relationship between these two characters. It would seem, therefore, that the correlation can be considered as fairly definite though by no means complete. The smaller beets tend to have a higher percentage sugar than the larger ones.

TABLE I
Correlation of weight of beet with percentage sugar

		Percent sucrose.																			
		Below 6.5	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	21.5+			
Weight of beets in kilograms	2.1											1							1		
	2.0				2		2	12	14	11	6	4	2	1					54		
	1.9							4	4	5	4	5	5	1					28		
	1.8				1	1	3	3	14	8	16	9	4	2					61		
	1.7					2	5	7	9	10	13	13	7	6	1				73		
	1.6			1		1	3	5	19	28	32	22	20	8	2	1			142		
	1.5					4	3	7	20	32	39	38	29	25	8	1			206		
	1.4		1		3	2	3	11	31	46	51	38	42	34	13	4			279		
	1.3		1		4	3	6	20	27	57	55	88	67	53	25	4	1		411		
	1.2	2	1	2	1	4	11	15	31	60	72	79	69	63	37	19	2	2	470		
	1.1	3	1	5	2	7	6	20	42	48	88	112	91	116	49	27	5		622		
	1.0	2	2	2	3	13	14	22	24	65	98	113	133	105	68	32	5		701		
	.9	5	6	3	5	8	7	18	40	57	96	108	167	138	115	41	10	1	825		
	.8		1	6	8	13	16	17	26	60	80	81	141	134	105	51	11	1	751		
	.7	7	1	2	5	9	7	17	24	35	60	84	135	124	65	55	6		636		
	.6	3	2	2	7	6	8	14	20	21	45	69	97	106	60	42	4	2	508		
	.5	1				14	4	4	6	23	30	49	90	105	44	43	8	9	430		
	.4					4	3	5	4	12	28	49	57	85	69	42	16	11	385		
	.3					3		3	5	8	25	28	35	72	50	31	12	11	283		
.2							1	6	3	6	10	15	33	14	14	6	10	118			
		23	16	23	41	94	101	205	366	589	844	1000	1206	1211	725	407	86	47	Total 6984		
		Correlation = — .2878 ± .0074.																			

Correlation = $-.2878 \pm .0074$.

Mean weight of beets $9328 \pm .0297$; standard deviation $3.681 \pm .0210$

Mean percent sucrose $16.1327 \pm .0205$; standard deviation $2.537 \pm .0145$

2. *Percentage sugar in mother beet and weight of seed*

An examination of table 2 shows a correlation of .0049 between the percentage sugar in the mother beet and the weight of seed produced. The probable error is $\pm .0143$ which is greater than the correlation. This means that there is no correlation whatever between these characters.

TABLE 2

Correlation of percent sugar in the mother beet with the weight of seed produced.

Weight of seed in kilograms.

	Weight of seed in kilograms.														
	Below	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.15 +	
Above	22			1	1	1		1			1				5
22		2	5	3	8	2			2						22
21		5	18	12	12	11	3	3	1						65
20		9	23	41	49	56	17	7	2	6	2		1		213
19		27	39	35	56	71	45	17	12	7	3	1	3	1	317
18		38	56	61	103	142	96	50	16	9	8	6	3	4	592
17		5	17	32	76	97	59	21	13	12	5	7	6	1	351
16		9	4	9	11	15	9	9	17	4	11	9	4	4	115
15		7	9	7	8	12	13	5	3	5	7	6	3	4	89
14		7	15	15	17	12	11	11	8	7	2	3	1	6	115
13		6	10	10	17	15	5	2	2	2	1	1	3	1	75
12		1	10	16	18	12	8					1			66
11			5	12	21	12	5	3	1	1					60
10		2	7	13	17	11	4			1					55
9		1	4	11	10	6	1								33
8		1	9	15	15	12							1		53
		120	231	293	439	487	276	129	77	54	40	34	25	21	Total 2226

Correlation = .0049 $\pm$.0143.

Mean weight of seed .3789 $\pm$.03408; standard deviation 2.384 $\pm$.0241

Mean percent sucrose 16.7800 $\pm$.0433; standard deviation 3.029 $\pm$.0306

3. Height of plant and weight of seed

Table 3 gives results with 1954 beets, and shows a correlation of .3985 with a probable error of $\pm .0128$. The higher plants, therefore, have more seed than the lower ones.

TABLE 3
Correlation of height of plants with weight of seed produced.

		Weight of seed in kilograms.												
		Below	.15	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.05 +	
Height of plant in meters.	Above													
	1.4	6	6	6	15	8	14	14	13	16	9	12	119	
	1.4	13	13	21	16	17	9	8	8	6	4	5	120	
	1.3	11	18	37	43	36	18	12	12	5	7	7	206	
	1.2	66	66	81	99	86	34	18	6	5	2	8	471	
	1.1	42	43	70	113	63	27	11	8	7	1	3	388	
	1.0	13	40	62	78	44	17	2	3	2	1		262	
	.9	42	31	59	43	21	6	4		2			208	
	.8	26	25	21	13	4	3						92	
	.7	5	7	7	8	1	1						29	
	.6	11	3	3	2								19	
	.5	12	3	3									18	
	.4	18	1	1	2								22	
		265	256	371	432	280	129	69	50	43	24	35	Total 1954	

Correlation = .3985 $\pm$.0128.

Mean weights of seed .3934 $\pm$.0339; standard deviation 2.222 $\pm$.0240

Mean height of plant 1.1150 $\pm$.0324; standard deviation 2.125 $\pm$.0229

4. Weight of mother beet and yield of seed

A comparison of the relative quantity of seed produced by 2168 beets showed that there was a correlation of .3075 $\pm$.0131 between quantity of seed and the weight of the mother beets. That is, large beets on the average yielded more seed than small ones.

TABLE 4
Correlation of weight of mother beet with weight of seed produced.

		Weight of seed in kilograms.																
		Below	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.15	+		
Weight of beets in kilograms.	Above																	
	2.0				1		2	1						1			5	
	2.0								2								2	
	1.9						1	1		1	1			1	1		6	
	1.8				2			2		1					1		6	
	1.7	1		1	2	3	3	1			2		1	1	2		17	
	1.6	1	1	5	2	6	5	2	2			2	1	1	1		29	
	1.5	2		3	4	8	6	9	1	1			1				41	
	1.4	1	2	1	3	6	11	3	3	3	4			1	1		39	
	1.3	1	3	2	4	22	15	14	4	4	2	5	1	1	2		79	
	1.2	2	3	10	12	28	18	11	13	9	3	5	1	6			121	
	1.1	1	3	10	17	29	20	19	11	11	12	3	4	3			143	
	1.0	10	11	8	25	41	38	23	18	15	6	6	8	4			213	
	.9	5	13	22	39	51	54	38	18	16	12	9	7	3			287	
	.8	7	17	20	43	70	52	24	25	18	12	6	3	4			301	
	.7	16	12	27	35	52	49	27	17	14	6	6	2	1			264	
	.6	14	35	25	40	50	32	25	11	5	9	6	2	3			257	
	.5	15	25	20	31	26	27	7	3	4	3	2	1				164	
	.4	20	22	21	15	12	2	1	1		2		1				97	
	.3	15	28	12	8	3	2	1									69	
	.2	4	5	5	4	4	3					1	1	1			28	
		115	180	195	284	414	341	207	134	103	75	51	37	32		Total	2168	

Correlation = .3075 $\pm$.0131.

Mean weight of beets .8448 $\pm$.0462; standard deviation 3.189 $\pm$.0327

Mean weight of seed .4503 $\pm$.0388; standard deviation 2.680 $\pm$.0274

5. Number of stems and yield of seed

Table 5 shows a correlation of .2771, with probable error of $\pm .0133$, between the number of stems on each plant and the weight of seed. As would be expected, the plants having most stems produce the largest quantity of seed.

TABLE 5
Correlation of number of stems per plant with the weight of seed produced
Weight of seed in kilograms.

	Weight of seed in kilograms.													
	Below .05	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.15 +	
Above 34			3	8	12	6	5		1	1	1	1	1	39
32-34		1	1	2	3	3	2	3	1	1		1	1	19
30-32		1	3	3	6	5			2		1	2		23
28-30			2	3	7	2	3	2	1	1		1		22
26-28		1	3	7	9	2	3		1	1	1			28
24-26	1		3	8	16	8	3	1	1		1			42
22-24		3	6	18	19	12	3	3			2	1	3	70
20-22		2	9	21	18	15	6	2	2	2	1	1	1	80
18-20		4	21	31	35	20	8	5	2	4	1	2		133
16-18	5	13	25	34	42	23	8	5		5	5	2		167
14-16	2	14	28	55	70	41	20	9	8	6	7	6	3	269
12-14	6	25	36	59	86	48	22	11	7	6	4	3	3	316
10-12	8	25	36	72	81	40	21	13	12	5		3	4	320
8-10	10	35	47	63	36	27	10	14	7	4	6	1	3	263
6-8	21	28	41	27	20	7	6	10	3	5	2	1	1	172
4-6	21	31	23	24	10	4	1		4		2		1	121
2-4	23	22	13	3	6	3	1		1					72
1-2	26	15	4	2	2									49
	123	220	304	440	478	266	122	78	53	41	34	25	21	Total 2205

Correlation = .2771 $\pm$.0133.

Mean weight of seed .3777 $\pm$.0344; standard deviation 2.392 $\pm$.0243

Mean number of stems 14.5642 $\pm$.0990; standard deviation 6.892 $\pm$.070

6. Number of days to mature and yield of seed

The time required to mature seed varied from 88 to 148 days, most of the beets maturing in about 105 days. Table 6, including 1724 beets, shows that the yield of seed was somewhat higher in the beets requiring the longest time to mature. The coefficient of correlation between these characters was $.1954 \pm .0156$.

TABLE 6
Correlation of number of days to mature with the weight of seed produced.

		Weight of seed in kilograms.														
		Below .05	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.15+		
Days from planting to maturity of seed.	Above 148	1	1												2	
	144-148		4	1									1		6	
	140-144	1	4	3		1									9	
	136-140	6	6	1		3	1	2		1	1				21	
	132-136	1	1	2	3	5	1	1	1	1	2			1	19	
	128-132	7	2	4	2	1	7	8	6	9	8	6	2	2	64	
	124-128	10	12	9	11	9	3	4	12	8	5	8	4	8	103	
	120-124	2	7	4	9	1	1	7	7	2	6	3	1		50	
	116-120	2	5	21	33	23	7	5	11	5	7	2	5	6	132	
	112-116	4	10	14	14	11	6	6	15	7	2	7	6	2	104	
	108-112	2	20	20	16	19	9	12	9	9	5	3	3	1	128	
	104-108	15	30	51	74	84	72	19	9	10	4	3	2	1	374	
	100-104	10	11	28	67	116	61	27	7	2					329	
	96-100	5	19	19	39	67	41	16							206	
	92-96	2	5	12	34	37	22	4			1	1			118	
	88-92	7	2	9	17	15	3								53	
	88		4	2											6	
		75	139	202	321	392	234	111	77	54	41	33	24	21	Total	1724

Correlation = $.1954 \pm .0156$.

Mean weight of seed $.4116 \pm .0401$; standard deviation $2.471 \pm .0284$

Mean days to mature $110.2230 \pm .1848$; standard deviation $11.372 \pm .131$

7. Number of leaves and yield of seed

TABLE 7
Correlation of the number of leaves on each stem with the weight of seed produced.
Weight of seed in kilograms.

	Below	.05	.1	.2	.3	.4	.5	.6	.7	.8	.9	1.0	1.1	1.15+	
Above															
29	1	1	3	8	17	7	3								40
29			1	2	3	2	6	1							15
28			1	2	3	4	1								11
27			1	3	8	2	2								16
26	1		2	6	9	1	2								21
25		1	5	10	12	2									30
24		4		8	15	6	2	2							37
23			2	8	16	7	3								36
22		1	7	8	16	18	3	2						1	56
21		4	5	14	12	9	1		1	1					47
20	5	19	21	19	18	12	3	1	1	1					100
19	17	40	31	31	22	16	3	2	1						163
18	15	26	27	25	33	17	6		1	2			1		153
17	14	27	19	16	25	21	5	1	2	2				1	133
16	3	15	27	41	40	14	7	5	3	2	3	1	3		164
15	10	17	23	43	43	20	14	4	2	5	6	2	3		192
14	6	11	24	41	43	26	14	11	2	5	2	3			188
13	3	4	12	24	27	19	7	9	6	4	2	5			122
12	5	15	26	50	37	22	16	10	12	3	7	3	6		212
11	6	2	16	20	26	16	6	9	4	5	3	2	1		116
10	8	12	28	34	29	10	12	12	11	6	3	5	3		173
9	3	5	4	3	6	7	4	6	7	5	4	3	2		59
9	23	7	7	10	9	5	1	2	2		3		1		70
	120	211	292	426	469	263	121	77	55	41	33	25	21	Total	2154

Correlation = .1217 $\pm$.0143.

Mean weight of seed .3805 $\pm$.0349; standard deviation 2.403 $\pm$.0247
Mean number of leaves per stem 15.8222 $\pm$.0710; standard deviation 4.886 $\pm$.0502

While there seems to be some correlation between the number of leaves on each stem and the quantity of seed produced by a beet, it is not so great as between some of the other characters already compared. Table 7 shows this correlation to be $.1217 \pm .0143$.

8. Number of days to mature and height of plants

On comparing the days to mature with the height of plants, it is found in table 8 that a relationship exists, but this relation is not great, the correlation being $.1748 \pm .0163$. The taller plants require a slightly longer time to mature than shorter ones.

TABLE 8
Correlation of the days to mature with the height of plants.

		Height of plant in meters.													
		Below .35	.4	.5	.6	.7	.8	.9	1.0	1.1	1.2	1.3	1.4	1.45+	
Days from planting to maturity of seed.	Above 144			2	2			2			10				16
	140-144			1	3		8	4			3				19
	136-140			1	2	1	5	4		3	3	3		2	24
	132-136				1	1	1	3	2	2	1	1	1	3	16
	128-132			1			3	1	1	4	14	12	9	25	70
	124-128	1	1	4	2	1	1	8	6	16	23	14	8	22	107
	120-124			4			1	6	3	7	11	5	9	11	57
	116-120		1	2	1	1	2	12	17	20	16	12	9	15	108
	112-116			1			1	9	7	14	15	8	2		57
	108-112				1	3	6	13	10	20	22	4	4	2	85
	104-108	3		4	5	1	9	34	45	64	98	46	17	12	338
	100-104	1	3	2	4	5	15	25	58	93	84	27	9	3	329
	96-100	1	1	3	2	8	9	34	32	39	58	11	8	1	207
	92-96	1	1		3	5	15	21	23	20	18	5	2	2	116
	88-92	4	1	2	1	4	7	12	5	9	3	5			53
	88					2	2	1						1	6
		11	8	27	27	32	85	189	209	311	379	153	78	99	Total 1608

Correlation = $.1748 \pm .0163$.

Mean height of plant $1.0940 \pm .0381$; standard deviation $2.266 \pm .0269$

Mean days to mature $110.5100 \pm .2084$; standard deviation $12.384 \pm .147$

9. *Percentage sugar in mother beet and time to mature seed*

Table 9 shows a negative correlation of $-.1292$ with a probable error of $\pm .0155$ between the sugar content and the date of maturity of seed. That is, the higher the sugar content of the mother beet the less time is required to mature seed. The correlation is low however.

TABLE 9

Correlation of the days to mature seed with the percentage sucrose in the mother beet.

		Percentage sucrose in mother beets.																	
Below		8.5	9	10	11	12	13	14	15	16	17	18	19	20	21	21.5+			
Above	148											4			1	2	7		
144-148										1		1		1	3	3	9		
140-144							1	1		2		4	5	5	3		21		
136-140								2		4	1	3	4	7	1		22		
132-136								3	2	3	3	3	2	2	1	1	20		
128-132				1			4	8	6	10	8	14	15	5	2	1	74		
124-128						1	7	15	14	15	11	25	12	14	4	4	122		
120-124							1	4	6	8	5	15	15	4	1	1	60		
116-120		5	8	7	5	6	8	16	11	17	18	14	15	7	1	1	139		
112-116		1			1			2	8	8	14	23	16	20	7	5	105		
108-112		4		4	3	3	2	5	3	7	19	41	18	9	8	2	128		
104-108		1	1	2	2	6	7	12	10	12	86	139	63	42	14	3	400		
100-104				2	3	1	5	11	6	9	85	108	61	38	6	6	341		
96-100				1	1	5	3		3	3	36	79	46	26	8	1	212		
92-96								1	2	1	13	49	26	17	2	1	112		
88-92				1	2						6	16	14	8	3	2	52		
88							1					1	2	1	1		6		
																	Total		
		11	9	18	17	22	39	80	71	100	305	539	314	206	66	33	1830		

Correlation = $-.1292 \pm .0155$.

Mean percent sucrose in mother $17.5831 \pm .0371$; standard deviation $2.3548 \pm .0262$

Mean days to mature $111.0200 \pm .1892$; standard deviation $12.384 \pm .134$

10. *Sugar of mother beet and leaves on each stalk*

TABLE 10

Correlation of the number of leaves on each stalk with the percentage sugar in the mother beet.

Percentage sucrose in mother beets.

		Below 8.5	9	10	11	12	13	14	15	16	17	18	19	20	21	21.5 +	
Number of leaves on each stalk.	30 and more				1	1		2	1	1	11	15	6	3		1	42
	29								1		3	6	4		1		15
	28										5	3	2	1			11
	27									1	3	9	1	2			16
	26					1	1			2	6	7	2	1		1	21
	25	1					1	2		1	8	8	7	1			29
	24										9	19	4	3			35
	23				1						4	21	8	1	1		36
	22			1				2	1	1	12	29	6	3	1	1	57
	21				1					1	7	20	12	8		2	51
	20						2	2	1	4	14	35	26	19	3	2	108
	19			1				1	1	1	10	67	57	31	12	8	189
	18	1			3	2		1	4	3	17	52	32	21	8	1	145
	17	1				1	2	2	1	4	26	46	31	17	10	3	144
	16	7	6	7	8	12	10	11	9	5	24	24	18	12	5	2	160
	15	7	6	10	9	9	9	12	12	14	28	38	20	14	1	3	192
	14	10	5	9	7	6	8	11	9	9	21	38	23	18	6	3	183
	13	4	3	6	4	2	6	7	4	8	30	22	18	10	2		126
	12	8	2	7	9	10	9	20	16	17	30	52	15	10	1		206
	11	1	4	2	5	4	4	5	5	10	23	23	12	14	4	3	119
	10	9	5	8	9	10	12	12	11	16	32	26	9	12	3	1	175
	9	1		1	1	1	3	6	5	7	9	13	3	8	2	3	63
	8 and less	2	2	2	1	3	3	11	7	5	9	12	12	15	8	1	93
																	Total
		52	33	54	59	62	70	107	88	110	341	585	328	224	68	35	2216

Correlation = $.2484 \pm .0134$.

Mean percent sucrose $16.8642 \pm .0441$; standard deviation $3.080 \pm .0312$

Mean number of leaves per stem $15.7897 \pm .0706$; standard deviation $4.927 \pm .0499$

Table 10 shows a variation in the number of leaves on each stalk from about 8 to about 30. The correlation of this character with the sugar content of the mother is shown to be $.2484 \pm .0134$. This coefficient of correlation seems sufficiently large to justify the statement that as the mother beet increases in sugar there is a tendency for more leaves to grow on each seed stalk.

SUMMARY

The tables which have been presented show the following correlations of characters in sugar beets:

1. Weight of beet with percentage sugar = $-.2878 \pm .0074$.
2. Percentage sugar in the mother beet with quantity of seed produced = $.0049 \pm .0143$.
3. Height of plants with weight of seed produced = $.3985 \pm .0128$.
4. Weight of mother with quantity of seed produced = $.3075 \pm .0131$.
5. Number of stems on each plant with the quantity of seed produced = $.2771 \pm .0133$.
6. Number of days to mature with quantity of seed produced = $.1954 \pm .0156$.
7. Number of leaves on each stalk with quantity of seed produced = $.1217 \pm .0143$.
8. Days to mature with height of plant = $.1748 \pm .0163$.
9. Percentage of sucrose in mother beet with days to mature seed = $-.1292 \pm .0155$.
10. Percentage of sucrose in mother beet with number of leaves on each stalk = $.2484 \pm .0134$.

LITERATURE CITED

- ANDRLIK, K., and URBAN, J., 1908 Abnormally large beets. *Zeitschr. Zuckerindus. Böhmen* **32**: 493-496. Abstract Exp. Sta. Record **20**: 747.
- ANDRLIK, K., BARTOS, V., and URBAN, J., 1912 The mutual relations of weight and sugar content in *Beta vulgaris saccharifera*. *Zeitschr. Zuckerindus. Böhmen* **36**: 193-210. Abstract Exp. Sta. Record **27**: 642.
- HARRIS, J. A., and GORTNER, R. A., 1913 On the relationship between the weight of the sugar beet and the composition of its juice. *Jour. Indus. Engin. Chem.* **5**: 192-195, and *Biochem. Bull.* **2**: 524-529.
- LASKOWSKY, N., 1893 The relation between the size and composition of beet seeds and the size and composition of the roots produced by them. *Landbote* **14**: 600. Abstract Exp. Sta. Record **5**: 335.
- MAAS, H., 1906 Investigations on correlation in fodder beets. *Landw. Jahrb.* **35**: 84-113.
- TOWAR, J. D., 1901 The influence of size of beets on sugar content. *Michigan Exp. Sta. Bull.* 197, pp. 140-144.