Influence of Size of Fruit and Seed on Germination of A Monogerm Sugar Beet Variety[1]

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The advent of the monogerm sugar beet has accelerated the trend toward completely mechanized production. However, mechanized cultural operations in the spring depend on the successful solution of such problems as precision space-planting, adequate emergence, weed control, and disease control. A sugar beet variety that produced uniformly sized and shaped fruits[3], each containing a single seed that germinates rapidly, would seem to be the most desirable for complete mechanization.

In a study of bulked fruits (seedballs) of multigerm varieties, Price and Carsner (4)[4] observed that seeds germinated more rapidly and completely and grew more vigorously from seedballs remaining on 4- and 3.5-mm screens than those from seedballs passing through a 3 mm, but remaining on a 2.5 mm screen. In ocntrast, Ustimenko (9), in studying bulked fruits of monogerm strains, observed that seeds in fruits with a high weight per 1,000 fruits germinated slower and less completely than those in fruits having less weight. In one multigerm and two monogerm varieties he found that the large fruits contained, both absolutely and relatively, a larger mass of pericarp than the smaller fruits. He ascribed the slower germination to the relatively greater amount of pericarp. Decorticating the fruits hastened emergence. Water absorption by decorticated fruits was complete after 40 to 50 hours, while non-decorticated fruits required 80 to 90 hours. Only one-half to one-third as much water was imbibed by decorticated fruits.

Savitsky (5) observed that the weight of seeds increased in proportion to the size of the monogerm fruits. Savitsky et al. (6) reported that seeds in large fruits of inbred monogerm lines germinated more slowly than those in small fruits.

Sedlmayr (7), using seedballs of a uniform size-class, demonstrated that speed of germination of the multigerm sugar beet variety US 401 is heritable. Differences in speed of germination

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3 A fruit is defined as an individual structure which contains one or more true seeds. In this paper, the term seed refers only to the true seed contained within the fruit.

4 Numbers in parentheses refer to literature cited.

were due mainly to the physical and chemical nature of the maternal tissues of the fruit which surround the true seed (7, 8). Doxtator and Helmerick (1) observed that large-fruited parents produce progenies with large fruits.

Before breeding for uniform fruits the breeder should know whether there is a most desirable size and what other characteristics of fruit and seed may influence his choice of size. Since previous work suggested that the size of fruit influences germination performance, this research was undertaken to separate the effect of fruit size from the effect of seed size on germination when the seed is germinated within the intact fruit.

Methods and Materials

The data were collected on an individual plant basis as a control on variability that exists between plants for quality and concentration of inhibitors in their fruits as well as the mechanical properties of the fruit affecting germination. Simple and partial correlations were then used to evaluate the data for within plants, for between plants, and for the variety.

In the experimental procedures (3) employed to improve the monogerm variety SP 5832-0, each root of 141 selections was planted in a soil bed in the greenhouse at East Lansing, Michigan, in December 1958. Mature fruits were harvested separately from each of 131 plants. All fruits were treated with fungicide but received no other treatment. Eleven to 22 grams of fruits from each of 19 plants were sized for diameter and then for thickness. The percentages by weight of fruits with a single ovarian cavity (multiple ovarian cavities discarded) in each of the size classes were listed by plant source. In this study, the 12/64-inch diameter class refers to fruits that passed through a 13/64-inch round-hole screen and remained on an 11/64-inch screen. The 9/64-inch thickness class refers to fruits that passed through a 10/64-inch slotted screen and remained on an 8/64-inch screen.

An index of uniformity was calculated both for diameter and thickness of fruit. The indexes were calculated from the fruit-size distribution data as follows: The modal class was assigned a value of zero, the class on either side of the mode was assigned a value of 0.1, the second classes from the mode were assigned a value of 0.2, the third a value of 0.4, and the fourth a value of 0.8. The assigned class value was multiplied by the percentage by weight of fruits in that class and the sum of these products is the index of uniformity. Thus, the smaller the values of the index, the more uniform the size of fruits.

Volume of fruit was calculated since it offered the possibility of better relating fruit size to germination response than either diameter or thickness. The formula for the volume of an oblate spheroid ($V=4/3\ a^2b$) appeared to be the best one for an initial estimation of the volume per fruit where "a" is the diameter and "b" is the thickness. The actual volumes were determined for each size class by volumetric displacement in Stoddard's solvent[5]. The fruits used in this determination were from the same variety but not necessarily from the same 19 plants as used for radiographing.

Data on the relation of fruit diameter and fruit thickness to germination time were obtained for each plant.

An X-ray technique (2) was used to determine the diameter of the seed while intact within its fruit. Samples of fruits from each of 19 plants, sized for diameter and thickness, were placed on sticky cellophane tape by plant source and by size class for X-ray. Thus it was possible to obtain data on an individual basis. A total of 6,782 single-cavity fruits, ranging from a minimum of 228 to a maximum of 480 fruits per plant, was radiographed. In addition to the diameter of the seed, the number of fruits containing no developed seed and those containing 1, 2, 3, or 4 seeds in the single ovarian cavity were recorded. The identity of each fruit was maintained on the germination blotter and the time required to germinate was recorded for each seed. Weighted averages for seed size were used to calculate the average seed size for a plant, since fruit size classes that were radiographed were not always taken in proportional amounts.

The data obtained by individual fruits were evaluated for inter-relationships by simple and partial correlations. The data consisted of: (A) germination time; (B) fruit diameter; (C) fruit thickness, (D) seed diameter; (E) number of seeds in ovarian cavity; and (F) volume of the fruit. Correlation coefficients were calculated for within-plant samples, for between-plant samples, and for all samples combined to represent the variety.

Results

Fruit size

The fruit diameter and thickness data (Table 1) for this monogerm variety revealed diameters ranging between 6/64 and 17/64 and thicknesses from 4/64 to 11/64 of an inch. Each plant had at least a few fruits in the smallest diameter and thickness class while only about half of the plants had fruits in the largest diameter and thickness class. Plants differed in uniformity of fruit size.

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[5] Trade names are mentioned for identification only and do not consittute recommendation by United States Department of Agriculture.

Table 1.—Fruit size-class distributions for diameter and thickness of 19 plants of monogerm sugar beet variety SP 5832-0.

Plant number	Percentages by weight in diameter class[1]						Index of diameter uniformity[2]	Percentages by weight in thickness class[1]					Index of thickness uniformity[2]
	16	14	12	10	8	6		10.5	9	7.3	5.8	4.5	
70	18.8	42.0	24.3	9.4	3.6	1.7	9.0	1.5	43.3	39.3	11.4	4.3	8.1
41	0.6	12.3	52.0	29.4	4.9	0.7	5.5	0.3	11.9	57.0	28.5	2.2	4.6
64	0.8	7.7	48.9	34.0	8.4	0.1	6.1	0.1	13.4	60.2	25.3	0.9	4.0
11	0.6	7.3	42.2	29.8	17.9	2.2	8.3	0.1	6.1	38.3	45.2	10.3	6.0
23	1.6	16.6	38.4	29.0	12.9	1.5	8.1	0.2	15.7	45.5	27.3	11.3	6.6
54	0.0	0.2	12.6	53.6	30.4	3.4	5.0	0.0	0.6	14.7	58.2	26.7	4.3
59	0.0	0.6	24.2	53.0	20.2	2.3	5.0	0.0	11.3	53.6	29.3	6.1	5.2
2	0.0	0.2	10.1	50.1	36.7	2.9	5.3	0.0	1.9	47.6	44.7	5.8	5.9
43	0.0	0.8	26.2	49.6	21.5	1.9	5.4	0.0	4.3	58.0	33.1	4.6	4.6
20	0.0	2.2	22.2	47.2	27.7	0.8	5.6	0.1	5.2	41.1	49.3	4.4	5.5
110	1.4	3.0	25.0	44.1	24.0	2.6	6.6	0.5	8.2	39.0	45.9	6.5	6.4
18	0.0	1.9	29.9	43.9	18.9	5.6	6.4	0.0	7.7	43.7	34.6	14.2	7.1
24	2.1	9.5	36.1	41.1	10.4	1.0	7.5	0.8	9.6	37.2	43.4	9.2	6.8
95	1.6	5.1	20.6	38.5	28.4	5.9	7.7	0.5	17.4	48.8	27.7	5.9	5.8
33	12.5	14.0	24.0	30.4	16.3	2.6	12.3	8.2	18.9	41.7	26.5	4.5	7.1
22	4.8	22.7	28.0	29.0	14.0	1.4	10.9	0.1	6.1	35.7	41.5	16.5	6.5
60	0.0	0.0	0.5	39.8	55.5	4.2	4.5	0.0	0.0	2.3	72.3	25.4	2.7
48	0.0	0.0	1.0	32.4	53.6	13.1	4.7	0.0	0.0	5.1	54.5	40.5	4.6
34	0.0	0.0	8.4	39.4	46.1	5.9	6.2	0.0	2.3	29.7	43.8	24.0	5.9

[1] The units of measurement: 64th of an inch, median value used for each class, modal size classes underlined.
[2] See text for method of calculation.

Table 2.—Summary of fruit and seed characteristics of 19 plants of monogerm sugar beet variety SP 5832-0.

Plant number	Fruit Diameter[1] Avg.	Fruit Diameter[1] SD	Fruit Thickness[1] Avg.	Fruit Thickness[1] SD	Shape Thick./Diam.	Seed Diameter[1] Avg.	Seed Diameter[1] SD	Seed diam. as % fruit diameter	Volume mother tissue[2]	3-day germination (Percent)
70	11.86	±2.85	7.03	±1.62	0.59	5.75	±0.57	48.5	185	6.6
41	11.05	1.59	6.72	1.06	0.61	5.64	0.60	51.0	152	25.4
64	10.75	1.60	6.84	0.99	0.64	5.58	0.57	51.9	146	23.1
24	10.63	1.87	6.27	1.19	0.59	6.19	0.58	58.2	124	35.5
22	10.49	2.34	5.85	1.12	0.56	5.74	0.69	54.7	118	46.8
23	10.39	2.05	6.29	1.33	0.61	5.77	0.71	55.5	123	50.7
11	10.22	1.99	6.09	1.10	0.60	5.52	0.68	54.0	118	40.5
33	10.09	2.38	6.61	1.39	0.66	5.65	0.71	56.0	121	30.8
43	9.63	1.54	6.43	0.97	0.67	5.67	0.64	58.9	106	24.3
59	9.61	1.48	6.52	1.12	0.68	5.19	0.53	54.0	114	31.7
20	9.58	1.54	6.25	0.92	0.65	5.37	0.67	56.1	106	58.9
110	9.52	1.71	6.20	1.06	0.65	4.94	0.55	51.9	107	78.7
18	9.26	1.83	6.01	1.20	0.65	5.33	0.68	57.6	95	51.0
54	9.01	1.45	5.41	0.82	0.60	4.82	0.57	53.5	86	47.7
2	8.87	1.39	6.23	0.98	0.70	5.60	0.63	63.1	85	28.3
95	8.86	1.87	6.36	1.30	0.72	5.21	0.74	58.8	91	75.1
34	8.50	1.38	5.62	1.07	0.66	5.25	0.58	61.8	74	81.3
60	8.36	1.14	5.31	0.64	0.64	5.58	0.59	66.7	64	56.5
48	8.07	1.21	5.15	0.72	0.64	4.88	0.74	60.5	64	79.6
Average	9.54	1.79	6.07	1.06	0.64	5.39	0.64	56.5	109	45.9

[1] Expressed in 64th of an inch. SD = standard deviation. The largest and smallest values are underlined.
[2] Expressed on a per fruit basis as cubic centimeters x 10,000.

The calculated volume exceeded the actual volume per fruit, however, when the calculated volume was substituted in the formula $Y = 0.598x + 0.0013$, this corrected volume closely approximated the actual volume per fruit as measured by volumetric displacement.

The shape of fruits varied by plants from one in which the fruit thickness was 56% of the diameter to one in which it was 72% (Table 2).

Seed size and numbers of seeds per cavity

The diameter of the seed generally varied directly with the diameter of the fruit and also fruit thickness. This trend and its exceptions may be noted in the summary of fruit and seed characteristics in Table 2. The smaller fruits tend to contain relatively larger seeds as shown by the "seed diameter as % fruit diameter" column.

Table 3.—Content of the ovarian cavity by plants in the monogerm variety SP 5832-0, with a variety summary by fruit size.

Plant number	Average fruit diameter	No. of fruits examined	Percent of fruits containing one seed	multiple seeds	aborted seeds	aborted seeds in larger[1] fruits
70	11.86	316	62.7	2.5	34.8	15.9
41	11.05	354	63.8	23.8	12.4	1.1
64	10.75	358	82.1	10.0	7.8	1.9
24	10.63	440	81.8	8.5	9.8	1.0
22	10.49	423	80.6	11.8	7.6	2.9
23	10.39	449	90.6	2.0	7.3	1.3
11	10.22	401	93.5	1.7	4.7	1.6
33	10.09	480	76.5	0.0	23.5	14.6
43	9.63	300	84.7	4.3	11.0	2.8
59	9.61	301	92.7	1.0	6.3	0.6
20	9.58	386	93.3	2.3	4.4	0.9
110	9.52	392	92.6	0.3	7.1	2.1
18	9.26	350	97.7	0.3	2.0	1.1
54	9.01	324	90.1	0.0	9.9	6.7
2	8.87	321	87.9	3.7	8.4	0.8
95	8.86	378	81.5	5.8	11.9	1.5
34	8.50	312	95.8	0.0	4.2	0.6
60	8.36	228	72.8	10.5	16.7	0.0
48	8.07	269	88.8	8.2	3.0	0.7
Above data accumulated by fruit diameter class[2] to represent the variety.						
	16	269	78.8	13.1	8.2	
	14	526	75.5	20.8	3.8	
	12	1,368	90.1	7.5	2.4	
	10	2,016	92.7	3.8	3.5	
	8	1,900	86.8	0.9	12.3	
	6	703	55.8	0.1	44.1	

1 Fruits that remained on top of a 9/64 inch round-hole screen.

2 Mid-value obtained using 2/64 inch increments between screen sizes.

The data on the content of the ovarian cavities, obtained by means of the X-ray technique, are summarized in Table 3. Individual plants of this monogerm variety varied greatly in the percentage of fruits containing a single seed. Six of the plants had more than 10 percent seedless fruits (aborted seeds). Four of the plants had 10 percent or more of their fruits containing two or more seeds. More than 23 percent of the fruits of plant 41 contained multiple seeds. Of the fruits in the 16/24 of an inch diameter size-class, more than 8% were seedless.

Speed of germination

The germination data were used to calculate the amount of delay in germination that can be expected from an increase in fruit diameter or an increase in fruit thickness. When fruit thickness was maintained between 6½ to 8/64th of an inch, the time to attain 80% germination was approximately a day longer for each increase of 2/64th of an inch in fruit diameter. When the fruit diameter was maintained at either 9 to 11/64th or 11 to 13/64th of an inch, an extra day was required to attain 80% germination by increasing the thickness class from 5 to 6½ to 6½ to 8/64th. Except for the smallest seeds and fruits, germination time correlated positively with fruit volume (Table 4).

Of the 6,782 single-cavity fruits that were radiographed, 2.5% were sacrificed to gain experience in reading the radiographs and 10.2% contained no developed seeds. Of the remaining fruits, 97.6% germinated within the 25-day limit of the experiment, 1.9% had seeds that were fully developed and appeared as though

Table 4.—Relation of fruit volume to time required for germination of seeds of sugar beet variety SP 5832-0.

Fruit volume[1]	No. seeds germinated	Germination time in half days
44	226	8.5
54	111	8.8
69	373	6.3
85	919	6.1
101	201	5.7
104	260	6.1
126	846	6.8
155	727	7.2
176	444	7.4
189	63	9.8
218	489	8.7
235	15	9.1
266	255	9.4
293	209	10.3
358	161	11.6
378	38	11.9
415	6	14.0
463	109	12.3
538	57	15.3

[1] Expressed as cubic centimeters x 10,000.

they should have germinated, and 0.5% had seeds that appeared incompletely developed and were non-viable.

Correlation studies

The within-plant correlations were calculated for each plant, but only the extremes and the means of these data are given in Table 5. The between-plant and within-variety correlations are also listed.

Table 5.—Correlation coefficients between various fruit dimensions, seed diameter, and germination time for samples from 19 plants of monogerm sugar beet variety SP 5832-0.

Characters	Symbols	Within plant samples			Between plant samples	Variety (samples combined)
		Extreme values:		Mean:		
Simple correlation:						
Germination time						
vs fruit diameter	AB	—0.24**	+0.61**	+0.28	+0.57*	+0.32**
fruit thickness	AC	—0.02	+0.64**	+0.30	+0.43	+0.30**
fruit volume	AF	—0.15*	+0.66**	+0.34	+0.56*	+0.38**
seed diameter	AD	—0.27**	+0.53**	+0.19	+0.45	+0.23**
seeds per cavity	AE	—0.04	+0.13	+0.04	+0.06	
Fruit diameter						
vs fruit thickness	BC	+0.22**	+0.86**	+0.62	+0.77**	+0.67**
fruit volume	BF	+0.87**	+0.97**		+0.97**	
seed diameter	BD	+0.54**	+0.82**	+0.68	+0.56*	+0.68**
seeds per cavity	BE				+0.22	
Fruit thickness						
vs fruit volume	CF				+0.87**	
seed diameter	CD	+0.44**	+0.74**	+0.62	+0.36	+0.59**
seeds per cavity	CE	+0.001	+0.36**		+0.10	
Fruit volume						
vs seed diameter	FD	+0.53**	+0.79**	+0.68	+0.53*	+0.65**
seeds per cavity	FE	+0.01	+0.49**		+0.15	+0.22**
Partial correlation:						
	AD • BC				+0.20	—0.02
	AD • F	-0.23**	+0.28**	—0.06	+0.22	—0.03
	EF • D					+0.04

* Significant at 5% level and ** at 1% level.

Within-plant correlations for germination time versus fruit size [diameter (AB), thickness (AC), or volume (AF)] and also seed diameter (AD) revealed 16 plants with significant positive correlations, two with no correlation (numbers 2 and 60), and one with a negative correlation. The extreme negative within-plant correlations of characters with germination time (Table 5) were obtained from plant 48 while the extreme positive ones were from plant 110.

In all cases, there was a significant positive correlation between fruit diameter and fruit thickness (BC), fruit volume (BF), and seed diameter (BD). Fruit thickness was positively correlated with seed diameter (CD) and fruit volume was positively correlated with seed diameter (FD). Simple correlations between seed diameter and germination time (AD) are misleading due to the high correlation of seed diameter (D) with fruit size characteristics (B, C, & F). Partial correlations of seed diameter with germination time, by removing the effect of fruit volume (AD.F), revealed four significant correlations within plants (three were negative and one positive). In all cases their values were less than ± 0.29. The between-plant and within-variety partial correlations for these three characters were not significant.

The within-plant correlations for fruit diameter versus seeds-per-cavity (BE) were not obtained from the electronic computer, but for fruit thickness versus seeds-per-cavity (CE) the values ranged from 0.00 to +0.36 and for fruit volume versus seeds-per-cavity (FE) from +0.01 to +0.49. None of the between-plant correlations of seeds-per-cavity with fruit diameter (BE), fruit thickness (CE), or fruit volume (FE) were significant. The within-variety correlation of seeds-per-cavity with fruit volume (FE) was highly significant at +0.22.

Discussion

The data clearly reveal a significant positive relationship between fruit size (diameter, thickness, or volume) and the time required for germination. Of the fruit size characters, volume appears to be the best for correlation studies because it involves both diameter and thickness. In general, fruit volume gave the highest correlations with time required for germination. The simple correlations between germination time and seed diameter gave values very similar to those between germination time and fruit size due to the high positive correlations between seed size and the various fruit size attributes.

When the effects of fruit volume were removed by a partial correlation then plants 48, 59, 60, and 110 had $r_{AD.F}$ values of -0.23, -0.18, -0.19 and $+0.28$ respectively. All other plant had non-significant values. When coefficients of determination were calculated, the minor role of seed diameter *per se* in germination time was apparent.

From this study it is evident that fruit size, whether it be diameter, thickness, or volume, is a poor indicator of the content of the ovarian cavity. Many fruits 9/64 inch in diameter or larger were found to contain aborted seeds. Multiple seeds were found in both small and large fruits. Correlations between fruit volume and seeds-per-cavity were possible with the data from a few of the plants. The r values ranged from +0.01 to +0.49 which would mean that for some plants there is a tendency for the larger fruits to have more seeds per cavity but for other plants this tendency does not exist. Thus, if a breeder is going to select against multiple seeds per cavity, he must examine adequately all fruit sizes on a plant rather than just the larger fruits.

The shape of the whole monogerm fruit was examined by dividing the fruit thickness by the fruit diameter (Table 2) and by the correlations between fruit diameter and fruit thickness (Table 5). Since the extremes in the thickness by diameter ratio only differed from the mean by 12.5% and since the between-plant correlation for fruit diameter versus fruit thickness was +0.77, there appears to be only a small chance to change the shape of fruit of this variety by breeding.

If the composite data are considered as representing the variety, then general relations between fruit size and seed diameter may be indicated. The larger the fruit, the slower the seed within it germinated. Seed diameter had no significant effect on speed of germination. For any given plant in which viable seeds of different diameters were contained in fruits of fixed volume, differences in speed of germination varied by as much as 24 hours, but generally the variation averaged 12 hours or less. In comparison, seeds of the same diameter in fruits of different sizes, from the same plant and particularly from different plants (presumably differing in kinds and amounts of inhibitors), differed in speed of germination by as much as 10 days. Except for the markedly slower germination of the seeds in the two smallest fruit volume classes (Table 4) which appears to be controlled internally by the seeds, speed of germination of seeds in larger fruits is regulated mainly by the maternal tissues of the fruit. Generally because of chemical inhibitors in the fruit, seeds *in situ* in fruits germinate more slowly than seeds removed from them. However, a stimulatory effect of the fruit on speed of germination has been observed (7, 8). If samples of fruits having only a stimulating action could be isolated, then larger fruits probably would be desired.

Summary

Samples of whole fruits from 19 plants of the monogerm sugar beet variety SP 5832-0 were sized for diameter and thickness into a number of size classes. An X-ray technique was used to examine the contents and to determine the diameter of the seed within each of 6,782 fruits. Seedless ovarian cavities were found in 10.2% of the fruits. Two or more seeds per cavity were found within some of the fruits from 15 of the plants. The fruits were placed on blotters and the time required for germination was recorded (in ½-day increments) for each seed that germinated within 25 days.

Fruit size, as measured by diameter, thickness, or volume, significantly influenced the time required for germination. Generally seeds in the larger fruits germinated more slowly. Fruit size was a poor indicator of either seedless fruits or multiple-seeded fruits.

Since fruit volume was highly correlated with seed diameter, a partial correlation which removed the effects of fruit volume was used to determine the relationship between seed diameter and germination time. The $r_{AD.F}$ value for the variety of -0.03 indicated that seed diameter *per se* had little effect on the germination rate. Within individual plants, however, the $r_{AD.F}$ values ranged from -0.23 to $+0.28$ which indicated that certain populations could be isolated in which seed diameter *per se* could influence the germination rate.

If germination time (speed of germination) is to be the criterion for selection of monogerm plants, then, in most cases, large seeds would not be desirable because of the high correlation between large seeds and large fruits.

Literature Cited

(1). DOXTATOR, C. W. and R. H. HELMERICK. 1962. Selection for seed size in monogerm varieties. Am. Soc. Sugar Beet Technol. J. 12 (3): 268-272.

(2) HOGABOAM, G. J. 1961. Radiographing as a method of observing some seed characters in monogerm sugar beet fruits. Am. Soc. Sugar Beet Technol. J. 11: 605-609.

(3) HOGABOAM, G. J., F. W. SNYDER and H. W. BOCKSTAHLER. 1959. Selecting for yield and sucrose improvement of a monogerm sugar beet variety. Am. Soc. Sugar Beet Technol. Eastern Reg. Proc. 10: 21-28.

(4) PRICE, C. and E. CARSNER. 1946. Seed size in relation to development and yield of sugar beets. Am. Soc. Sugar Beet Technol. Proc. 4: 263-269.

(5) SAVITSKY, V. F. 1954. Relation between the weight of fruit and weight of germ in mono- and multigerm beets. Am. Soc. Sugar Beet Technol. Proc. 8 (2): 16-22.

(6) SAVITSKY, V. F., G. K. RYSER, G. E. RUSH and C. P. PARRISH. 1954. Inter-relation between weight of seed and fruit and utilitarian characters in inbred lines and hybrids of monogerm sugar beets. Am. Soc. Sugar Beet Technol. Proc. 8 (2): 399-403.

(7) SEDLMAYR, T. E. 1960. Inheritance of speed of germination in sugar beets (*Beta vulgaris L.*). Doctoral dissertation, Michigan State University.

(8) SNYDER, F. W. 1959. Influence of the seedball on speed of germination of sugar beet seeds. Am. Soc. Sugar Beet Technol. J. 10: 513-520.

(9) USTIMENKO, S. P. 1957. Effect of pericarp on the sprouting energy of seeds of monogerm sugar beet. (In Russian) Sakh. Svekla 2 (12): 24-27.