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The selection effectiveness of various forms of sugar beet in early ontogenesis

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Abstract
The selection of cold-tolerant forms was carried out during seed germination at a temperature of 9^{0}C. Root material was grown in flowerpots, seeds were obtained by self-pollination in individual isolators. After repeated selections, the combining ability of the most valuable forms was studied as the parent components of the cross when creating new hybrids. The offspring of genotypes selected with the help of a cold background exceeded the control on the basis of germination and length of the seedling.
The effectiveness of such studies is shown by the example of new hybrids Azimut, Kuban MS-95, and Uspekh.

Keywords: sugar beet, selection, cold tolerance, seeds, germination, root length, combining ability, hybrid, hybrid productivity

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INTRODUCTION

Most sugar beet hybrids included in the State Register of Breeding Achievements of the Russian Federation are characterized by insufficient resistance to adverse environmental factors and, in particular, to cold stress in the spring during sprouting.

Even a temporary suppression of growth processes, as a result of temperature exposure, may turn out to be one of the reasons for the decrease in yield and quality indicators of sugar beet hybrids (Udovenko 1982, Ushakov 1982). At low temperatures, seeds and seedlings are more affected by various pathogenic organisms (Likhachev 1983, Shevchenko 1950).

During natural selection, plants preserved only those signs and properties of the current forms of sugar beet, which determined the adaptability of organisms to these environmental conditions. Artificial selection usually left the most productive plants, which are rich in reserve substances in the form of sucrose. As a result of multiple selection, the nutritional and economic value of sugar beets increased, while at the same time it became less resistant to adverse environmental conditions (Balkov 1978).

For sugar beets during the sowing-seedling period, the soil temperature, in combination with other conditions, and above all with humidity, has a decisive influence on the rate of growth processes, field germination and all subsequent ontogenesis stages (Berezhko 1986, Udovenko 1982).

The low positive soil temperature affects not so much the germination rate as the growth during the initial growth period and the seedlings overcome the soil resistance when they come to the day surface (Logvinov 1982, Ushakov 1982). Thus, growth and development reflect the totality of the processes of interaction of genotypes with environmental factors (Balkov 1978).A decrease in the completeness of seedlings at low temperature in individual genotypes can occur due to damage to cell membranes, impaired synthesis of protein substances, accumulation of non-protein nitrogen and free amino acids in seedlings that inhibit seed germination (Zhuchenko 2001).The extension of the period of seed germination and emergence of seedlings can be determined, in addition to external conditions, by individual genotypic characteristics of individual seeds, which are not able to all start growing at the same time (Balkov 1978, Suslov 2010).

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Thus, phenotypically close sugar beet genotypes under optimal conditions have similar parameters, however, under stressful conditions they can have contrasting indices. It hence follows that plants that seem typical under ordinary conditions can carry genotype defects that manifest themselves only under stressful conditions (Balkov. 1978).

A genetically determined level of resistance is the potential for sugar beet forms to adapt to extreme conditions. Under normal conditions, this opportunity remains unrealized and therefore the level of sustainability cannot be fully identified. To identify it, it is necessary to have extreme conditions of sufficient tension and duration (Logvinov 1982, Sichkar (982).

In this regard, the use of physiological methods of testing breeding materials becomes extremely necessary with the accelerated implementation of breeding programs and in improving the techniques of varietal agricultural technology (Suslov 2010, Ushakov 1982).

The objective of the research was to evaluate the constant combinable lines of sugar beet based on resistance to low positive temperature and select the most stable ones. On their basis to get a competitive cost-effective and cold-resistant hybrid of sugar beet.

METHODS

The resistance of the parent forms and hybrids of sugar beets to low temperatures was characterized by how much the germination and length of the root changes under the influence of this factor. Therefore, the degree of decline of these indicators of this form in extreme conditions was adopted as a quantitative measure of stability compared with its performance on the optimal background. Studies with cereal crops have shown that differences in the degree of resistance persist with different severity of the extreme factor (Udovenko 1982).

Usually, the degree of stability of sugar beet hybrids was evaluated in the field, which is very laborious and time consuming.

Previous studies on the assessment of the stability of crops show that sufficiently developed laboratory methods can significantly reduce the time, laboriousness of work and increase the reliability of the results when creating resistance donors for this crop (Ushakov 1982, Shevchenko 1950, Hajheidari et al. 2005).

However, to date, methods for assessing various forms of beets by reaction to cold stress partially cover the full potential of the plant and cannot act as a full description (Shevchenko 2010, Lindberg, Banas, Stymne, 2005). Information on assessing the stability of sugar beets using seed germination is fragmentary and was carried out on varieties and hybrids that have been discontinued.

All studied seed materials were prepared in the same way, the selection of each form during seed germination was 400-600 seeds. The evaluation criterion was the percentage of normally germinated seeds and the growth rate of seedlings (roots), as signs that reflect the totality of the processes of interaction of the genotype with environmental factors. The lower the indicators of these signs under the influence of temperature, in comparison with the control, the less stability was considered (Suslov, 2010, Chołuj et al. 2008, Romano et al. 2013).

For practical purposes, a short duration is important for the emergence of friendly seedlings with active growth at low positive temperatures in the spring (Shpaar 2004).

To evaluate genotypically determined cold resistance, a method of germinating seeds of different lines (MS lines and pollinator lines) of sugar beets was used in the seed laboratory of Pervomaisk breeding experimental station, in thermostat cabinets at a temperature of 9 and 20^{0}C. Seeds were germinated on filter paper in an aqueous medium. Counts and measurements were carried out on day 7, 10, and 15 of germination.

The reaction of sugar beet lines was determined by the value the germination rate and seedling length were reduced by when germinating at low positive temperatures compared with control.

For study in subsequent generations, on a cold background, 5-10% of the most developed seedlings were selected. The experimental options were the MS lines SK 4935, SK 4935x7994, SK 12169 and the pollinator lines SKL 5121, SKL 10632, SKL 5063P96, both selected and control.

The most developed seedlings of pollinating lines and sterility fixing lines, selected against a cold background, were placed in flowerpots and then grown on an experimental plot of individual isolation in order to obtain seeds from self-pollination. Seeds of the studied lines for the control variant were obtained under the same conditions, but without selection.

After laboratory preparation, the grown seeds were re-germinated at a temperature of + 9°C, the most resistant seeds were selected and included for evaluation based on their combinability (Shevchenko 2010, Sadeghian, Yavari 2004).

RESULTS

The data in **Table 1** show the effectiveness of the selection of all studied forms of sugar beet, both in germination and in the length of seedlings (2015-2016).

Among the MS forms, the MS line SK 4935x7994 (SCL 7994 sterility fixer) was more pronounced; among the pollinator lines, SKL 10632, SKL 5121 and SKL 5063P96 were promising for further breeding and seed research.

Table 1. Germination and sprout length when germinating seeds of various forms of sugar beet (germination temperature +9^{0}C)

No.	Parent forms	Germinability, %		Sprout length, mm	
		unselected	selected	unselected	selected
1	SK 4935	59	72	5.0	9.9
2	SK 4935x7994	71	85	7.6	12.0
3	SK 12169	54	76	6.0	11.0
4	SKL 5121	67	68	6.0	13.0
5	SKL 10632	68	89	6.0	12.4
6	SKL 5063, P96	86	86	14.0	16.0
Experimental mean		67	79	7.4	12.4
MS form mean		61	78	6.2	11.0
Pollination line mean		74	81	8.7	13.8
HCP 05		9%		5.2 mm	
Sampling factor influence rate		27.6%		29.4%	

Note: Measurements were carried out after seven days of germination

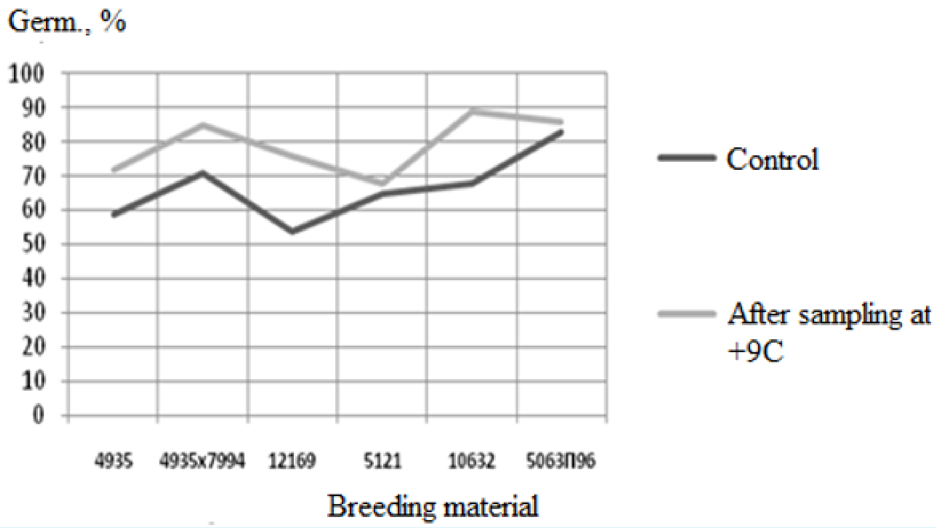

Fig. 1. Effect of selection on seed germination during germination at a temperature of +9°C

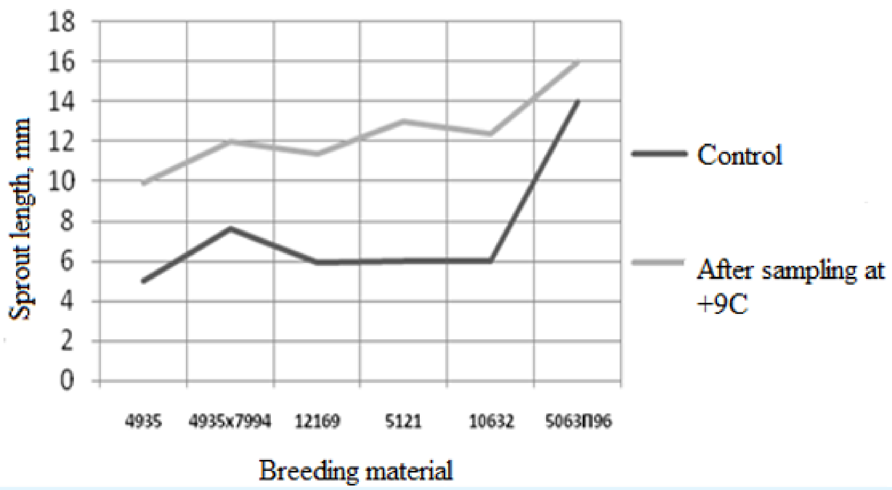

Fig. 2. Effect of selection on the length of seedlings during germination at a temperature of +9°C

Clearly, the data of **Table 1** are presented graphically in **Figs. 1** and **2**.

The studied forms of sugar beets reacted differently to the influence of low positive temperatures. With decreasing temperature, seed germination decreased, and growth processes in all studied forms were inhibited.

The nature of the changes in the length of the seedling in different lines was identical. The differences between the forms were manifested only in the amplitude of germination and growth rate, that is, they had a pronounced quantitative character.

The offspring of the most developed biotypes selected against a cold background showed a significant excess in germination and length of seedlings compared to the control (without selection). They were included in the programs on the study of combinability and the most valuable of them were used as the parent cross components for new hybrids Azimut, Kuban MS-95, and Uspekh.

In 2019, a number of beet-growing farms in the Krasnodar and Stavropol Territories continued to study the productivity of new hybrids of sugar beet Azimut, Kuban MS-95, and Uspekh.

In each beet-growing farm, control registration sites were planned on the field in accordance with the requirements of generally accepted methodological recommendations.

The following measurements were carried out from September 3 to 16:

- density of planting in each field;
- biological productivity in case of manual digging;
- sugar content and technological qualities at the Uspensky sugar factory.

During manual digging, root crops were cleaned from the ground, tops, the tail part of the root crop was cut 1 cm thick. 20 root crops were selected without a choice for determining sugar content and technological qualities. Root crops were placed in a bag on which a label was hung indicating the economy, field, hybrid, date of sampling.

The average data on Azimut is presented for 8 farms with density, biological productivity, sugar content, sugar yield, and the quality of purified juice, respectively 104 thousand/ha; 70.3 t/ha; 17.4%; 12.1 t/ha and 88.3%. Yields varied across farms from 51.0 to 95.7 t/ha, sugar yield from 9.2 to 15.9 t/ha (on irrigation).

The average values for Kuban MS 95 hybrid were obtained as follows: density - 107 thousand/ha, yield - 78.7 t/ha, sugar content - 16.9%, sugar yield - 13.2 t/ha, and high-quality juice - 88.5%. Productivity ranged from 65.8 to 95.8 t/ha, sugar collection 11.0 to 15 t/ha.

The average indicators for Uspekh hybrid (parent forms did not qualify against a cold background) are presented for 12 farms: density - 112 thousand/ha, yield 65.2 t/ha, sugar content - 17.2%, sugar yield - 11.3 t/ha, and high-quality juice - 88.5%. Productivity ranged from 48.0 to 84.3 t/ha, sugar yield from 8.8 to 13.4 t/ha.

The highest sugar yield of 15.9 t/ha was obtained in Azimut hybrid (under irrigation). Uspekh productivity was inferior to Azimuth and Kuban MS-95 hybrids.

On average, all 3 hybrids according to the data of all farms had the following indicators: density - 107 thousand/ha, yield (biological) - 71.4 t/ha, sugar content 17.2%, sugar yield 12.2 t/ha, purified juice quality - 88.4%.

With mechanized harvesting, all the main elements of productivity (productivity, sugar content, sugar collection) were lower compared to manual digging. Uspekh in basic parameters was also inferior to Azimut and Kuban MS-95.

According to Agrosvodki data (as of October 11) in the main areas where the surveys were carried out, the yield in 2019 was as follows, t/ha: Gulkevichsky - 57.6; Novokubansky - 49.2; Otradnensky - 54.1; Uspensky - 49.5. The average yield in the Krasnodar Territory was 52.6 t/ha.

CONCLUSION

1. The offspring of the most developed biotypes selected against a cold background significantly exceeded the germination and length of the seedlings compared to the control ones (unselected).
2. The background of germination of seeds with a temperature of $+9^{0}C$ was used as a differentiating (ranking) in the selection of cold-tolerant genotypes.
3. Some genotypes after two cycles of selection on the basis of cold resistance were evaluated on the basis of general and combinational ability and were used to create promising Azimut and Kuban MS-95 hybrids, which under high production conditions showed high productivity.

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