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Use of recombinant materials in selection of parent components of sugar beet hybrids in the root shape

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The purpose. Creation and implementation in selection process of recombinant materials of beet with improved parameters of the shape of root for the further selection of parent components of hybrids of sugar beet on CMS basis. **Methods.** Field, laboratory, statistical. **Results.** By results of probes they selected one-seeded forms of sugar beet (candidates for lines of O-type) with improved shape of root, gained by fission of hybrid materials of different genetic structure. It is fixed that the extent of setting of seeds at autogamy of plants is low enough (16,4 – 25,3%), and it is also observed lowering sowing qualities of seeds of inbreeding-materials. These materials were characterized by oval-conic and wide-conic shape of roots (index «F» was within the limits of 0,98 – 1,24). Analysis of biometrical indexes of roots testifies to the following: in newly created materials in comparison with sugar beet (lines of O-type) have descended essential augmentation of length of a root (on 9,1%), distances from the plane of maximum diameter of a root to vertex of a head (37,0%), and mass of a root (28,6%). First backcross mating is accomplished of the select forms with pollinators-fixers of sterility, and heightening level of sugariness of roots and penetrances of genes xxzz (up to 50%) at hybrids BC1 is achieved. **Conclusions.** Recombinant genotypes of plants are the valuable initial stock for selection of parent components of hybrids of sugar beet by the shape of a root. At use of hybridization and inbreeding already in the 2-nd generation of hybrids (F2) it is possible to select candidates for pollinators-fixers of sterility (lines of O-type) with oval-conic and wide-conic shape of roots. That attribute is stably inherited by offspring at the subsequent stages of selection on building lines of pollinators-fixing agents of sterility and their CMS analogs.

Key words: *sugar beet, initial stock, hybridization, mating, inbreeding, heterosis, shape of a root, extent of setting of seeds.*

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The priority task of the native science is the creation of a new generation of highly productive sugar beet hybrids, adapted to environmental conditions, suitable for energy and environmental conservation technologies of cultivation and different uses of raw materials.

The success of breeding work on the creation of high-yield sugar beet hybrids is largely ensured by the genetic value of the source material, its variety, as well as the degree of study of the genetic determination of economic-valuable features and patterns of their inheritance [1,2].

Solving these tasks will help increase the intensity and efficiency of the breeding process, expand and enrich the domestic gene pool of the source material and improve its genetic potential.

Analysis of recent research and publications. The use of breeding genetic methods, in particular, different hybrid schemes, makes it possible both to create new genotypes of plants and to improve existing ones. Hybridization expands the process of forming, increases the genetic variability of plants in a complex of biological and economic properties. Therefore, this is the most common method of creating a new source material with the desired complex of selection-genetic traits [3,4].

The main method for obtaining linear materials of beet sugar in breeding for heterosis is inbreeding. Its significance is evident both in theoretical developments and in practice. If the basis of population selection were different forms of mass and group selection, then heterosis selection is based on the use of lines that are homozygous for selective features and their subsequent hybridization [5,6].

Inbreeding method allows differentiation of the complex cross-pollinated population and to detach many valuable genotypes of plants with features that have a recessive nature. Therefore, inbreeding M. Vavilov was rightly considered a form creative factor. This method in heterosis selection should be used also because already in the early stages of breeding work are eliminated defective and non-viable plants that carry lethal and semi-lethal genes [7]. The main obstacle to its application is the very poor planting of seeds on isolated plants. The creation of self-pollinated lines is hindered by the system of genetic incompatibility, which is inherent in cross-breeding crops, including sugar beet [8,9].

The genetic system of self-incompatibility is explained by the hypothesis of oppositional factors. In sugar beet it belongs to the gametophytic type, the feature of which is the independent action of the plural series of S-alleles in pollen grains and the acceptance of the pistil. The genetic interpretation of self-incompatibility is given by Owen's hypothesis (1942), according to which this sign is controlled by two complementary genes that have an independent effect on each other [10]. In the presence of the same alleles in the pollen tube and the fabric of the flask, the plant is not capable of self-pollination, but it binds the seeds from pollination by foreign pollen, which carries non-identical alleles. So, if the plant has the genotype s1s2s3s3, the pollen tubes of the genotype s1s3 and s2s3 cause an incompatibility reaction; instead, the ingestion of the pollen carrying the allele s1s4, s2s4, s1s5, s2s6, etc., this reaction is suppressed, resulting in the formation of a parent plant seed. Differences between the genotypes of pollen grains and the acceptors at least one allele lead to self-pollination [5,11].

The harmful influence of self-pollination on sugar beet was studied by B. Bartos, K. Andrlick, G. Felich, G. Corn, B. Kayanus, G. Shaw, E. Bauer. They noticed that due to the forced self-pollination, the planting of the seeds worsens, defective plants appear, and the indices of similarity of the seeds, yield and sugar content of the roots are reduced [12,13].

The purpose of researches. To create and introduce into the breeding process recombinant sugar beet materials with improved root shape parameters for further selection of pollinators-fixers of sterility (O-types) and their CMS analogues.

Materials and methods of researches. The research was conducted at the Research Station of Tobacco of NAAS in 2015–2017. To the field experiments, 64 recombinant forms were obtained, which were obtained by controlling the crossings of various genotypes of sugar and fodder beets.

Parents forms and obtained hybrids have been studied according to the complex of economic and valuable features in accordance with the method of variety testing, developed by scientists of the Institute of Bioenergetic Cultures and Sugar Beet of NAAS. Selection trials were conducted with three-line sites with an accounting area of 10.8 m^2, repetition - three times, placement of variants on sites - renamed. The sample of roots for analysis was 75 pcs. with each repetition.

To determine the root shape index, a methodology based on the indexation of the form of each root by the ratio of its metric indices was used [14,15].

Index of root shape (F), calculated using the formula:

$$F = \frac{K \times D \times B}{L \times d},$$

where F - root shape index; K - coefficient, expressed in absolute units (determined by the weight of the roots, divided by 1000); D - maximum root diameter, cm; B is the distance from the plane of the maximum diameter of the root to the vertex of the head, where the top begins to form, cm; L - the length of the root itself, the distance from the top of the head to the tip of the tail part, cm; d - diameter at the tail part of the root, sm.

Depending on the value of the index "F", the following classification was used: from 0.01 to 0.25 – spindle-shaped; 0,26 –0,50 – narrow-conical; 0,51–0,75 – conical; 0,76–1,00 – wide-conical; 1.01–1.50 – oval-conical; 1,51–2,50 – round-conical.

The energy of germination and the similarity of the seeds, the weight of 1000 fruits were determined according to the current standards DSTU 2292-93, 4232-2003, 4328-2004.

Degree of planting of fruits on seeds of beet sugar (by the method of Slyusarenko Z., Berezhko S.) [16].

The technology of sugar beet cultivation was generally accepted for beet harvesting zones.

Research results. For the creation of new genotypes of the O-type lines and their CMS analogues with improved parameters of the root shape, 64 recombinant beet samples were obtained by hybridization of detached pollinators-fixers of sterility of sugar beet with fodder beet. In the genotype of plant parts of the this recombinant materials, the recessive genes ,,x" and ,,z" are located that control the fixing ability and various alleles of the L_1, L_2 and Sh_1, Sh_2 genes that determine the root shape.

According to the results of studying the recombinant materials of beets in the root shape, their significant differences from the initial samples of sugar beet (O-type lines) were established. These breeding materials were characterized by oval-conical and broad-conical root shape (the index "F" was within the range of 0.98–1.24). Roots of sugar beet (O-type lines) had a conical shape with a variation of this indicator in the range of 0.65–0.73.

Table 1. Average values of biometric indices of root shape of the recombinant beet materials (OtxFB) and their parent components, 2015-2017

Materials	L, cm	D, cm	d, cm	B, cm	K	Index of root shape (F)	Root shape
Sugar-fodder hybrids (F_1)	24,6	9,0	1,0	4,3	0,72	1,13	oval-conical
Sugar beet (O-type lines)	22,5	8,8	1,0	3,2	0,56	0,69	conical
Fodder beet	26,1	9,2	1,0	4,9	0,84	1,46	oval-conical

Analysis of biometric indices of root shape (table 1) shows that the newly created materials, in comparison with sugar beet (O-type lines), significantly increased the length of the root (L), the distance from the plane of the maximum root diameter to the top of the head (B) and weight of the root (m).

If we take the average values of the biometric indices of sugar beet roots (O-type lines) by 100%, then the recombinant beet materials show an excess of the parent form by the length of the root (L) by 9.1 %, the distance from the plane of the largest diameter to the top of the head (B) by 37.0 % and the weight of the root crop by 28.6 % (Fig. 1).

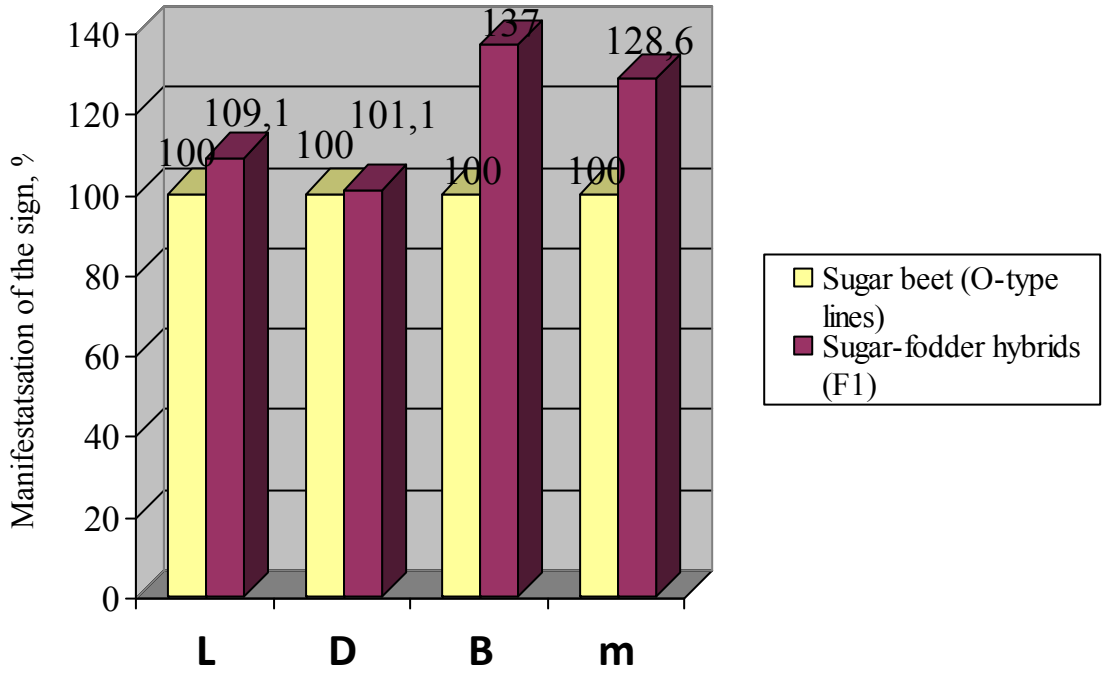

Fig.1. Changing the biometric indices of roots of recombinant forms in comparison with sugar beet (O-type lines), %

The roots of hybrid beet materials, due to the recombination of various alleles of the L_1, L_2 and Sh_1, Sh_2 genes, were characterized by a smooth surface with a shallow orthoshite and a larger protrusion above the soil surface in comparison with sugar beets, which in turn would contribute to lowering energy costs during their excavation and reducing the removal of the fertile soil layer from the field.

This is a valuable starting material for the further selection of parent components of sugar beet hybrids in the root shape.

The next stage of the research was to select in the second generation (F_2), by self-pollination of hybrid plants (F_1), single-breeding forms and their re-crossing with fixers of sterility (O-types) to raise the sugar content of the roots and increase the penetrance of the genes of the fixing capacity, "x" and "z". Studies by many scientists [17,18] found that the multi-growth and single-growth of the seeds are controlled by one genome, which has different manifestations (M-m). Therefore, according to the patterns of inheritance of traits first developed by G. Mendel, in the self-pollination of plants of these recombinant forms of beet (F_1) in the second generation (F_2) is theoretically assumed the splitting of the fruitfulness of the seeds in the ratio of 3:1 (3 plants of multiseed , 1 – singleseed).

According to the results of the conducted research, it was established that the degree of planting of seeds during self-pollination of sugar beet plants is characterized by low indicators. Depending on the origin of the parent components, they were in the range of 16.4–25.3 % (Fig. 1). If we consider the extreme values of this indicator, then they ranged from 5.7 % to 40.1 %.

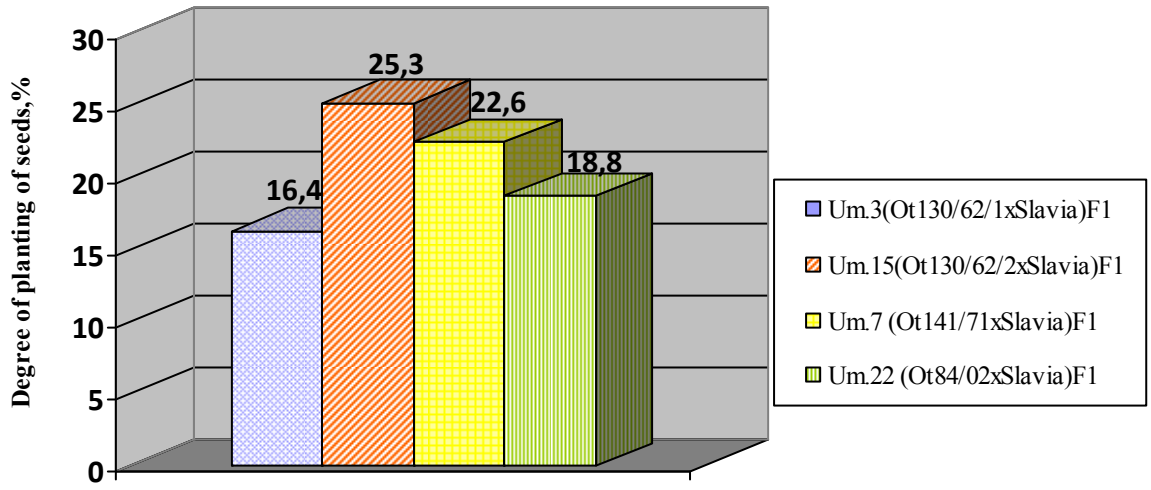

Fig. 1. Degree of planting of seeds at self-pollination of plants of recombinant forms of sugar beets of different genetic origin

Seed quality of seeds of inbreeding plants, as a result of the system of self-compatibility and unfavorable conditions of growth and development, formed under the insulator, were also quite low. The energy of germination of seeds of various breeding samples varied within the range of 10–13%, the similarity –14–18 % (Table 2).

2. Indexes of seed quality obtained by self-pollination plants of recombinant forms of beet of different genetic origin, 2016

Origin of materials	The plants analyzed, pcs.	Weight of 1000 seeds, g	Germination energy,%	Germination, %
Um.3 (Ot130/62/1xSlavia)F_1	37	11,4	12	16
Um.15 (Ot130/62/2xSlavia)F_1	47	9,9	13	18
Um.7 (Ot141/71xSlavia)F_1	39	12,1	11	15
Um.22 (Ot84/02xSlavia)F_1	44	12,3	10	14
LSD_{05}	–	*1,7*	*1,4*	*1,6*

In 2017, roots-shtekling grown from seeds F_2 and roots recaptured O-type forms are planted on an isolated site, according to the scheme of a number of plants of the O type - a number of plants F_2. In the process of vegetation, they were evaluated on the basis of "sterility-fertility of pollen" and "fertility of the seeds". All multiseeds plants have been discarded, and singleseeds plants are left for a cycle of back crosses with selected O-types. The ratio of multiseeds and singleseeds genotypes confirms the monogenic nature of the inheritance of this trait (Table 3).

3. Splitting of hybrids F_2 for fertility of seeds, 2017

Class by split	The fertility of seeds	Number of plants, pcs.	Correlation
1	MM	104	3
2	mm	32	1

According to the results of the selection, 32 singleseeds genotypes of plants were isolated, which were re-enclosed with selected fixers of sterility in isolation, in pairs (one hybrid plant F_2 2xmm and one plant O-type line). Thus, at the same time, an increase in the sugar content of the roots and penetrance of the xxzz genes (up to 50%) in the hybrids BC_1 was achieved. Also, the roots of these recombinant materials were characterized by an oval-conical shape and a partial projection above the surface of the soil.

Conclusions

Recombinant genotypes of plants are a valuable starting material for the selection of parent components of sugar beet hybrids in the shape of roots. With the use of hybridization and inbreeding already in the second generation of hybrids (F_2), it is possible to identify candidates of pollinators-fixers of sterility (O-types) with a oval-conical and broad-conical root shapes. This trait is stably inherited by the progeny at subsequent stages of breeding to create lines of pollinators-fixers of sterility and their CMS analogues. Changing the shape of the root will promote both the increase in the productivity of sugar beet hybrids and the development of energy and eco-conservation technologies for their cultivation.

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