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RECURRENT SELECTION AS A METHOD OF IMPROVING TECHNOLOGICAL QUALITY OF ROOT IN POLLINATOR COMPONENTS OF CMS SUGAR BEET HYBRIDS

Efficiency of recurrent selection as a method of improving technological quality of beetroot is studied. Given is comparative assessment of the mineral element content in initial population and selected groups, as well as the percentage of reduction to the standard in synthetics and CMS hybrids, which are based on pollinators of Uladiv breeding. Selected are the best pollinator genotypes feature combination of low potassium, sodium and alpha-amino nitrogen content for further breeding process aimed at high sugar yield.

Keywords: *hybrid; synthetic; pollinator; technological quality of root; potassium; sodium; alpha-amino nitrogen; recurrent selection.*

Introduction. Tough competition in the sugar market, as well as broad expansion of foreign varieties made plant breeders to face new priorities, such as creating advanced CMS hybrids of sugar beet capable to provide significant increase in sugar production [1]. Such a goal can be achieved primarily due to a significant improvement of technological quality of root that influences sugar yield.

Creating components for CMS hybrids of improved technological quality largely depends not only on the constituents of productivity, such as yield and sugar content, but also on the content of detrimental components which adversely affect the raw materials processing by increasing the solubility of sucrose in molasses and sugar fixation. These include alkali ions K^+ and Na^+ , α -amino nitrogen (α -N), amino acids, and other nitrogen-containing compounds. To reduce their content is a practical goal of breeders at the present stage of creating hybrids [2].

The efficiency of this work is closely connected with the choosing selection methods and criteria, based on the laws of inheritance and variability characteristics that are the components of technological quality. Recurrent (periodic selection) is a very effective method of creating improved populations. It suggests selection of the best plants for agronomic characters through tester crossing (using clones), while original forms are repollinated to create synthetics with enriched gene pool, which serve both starting material for the next cycle, and a source of improved breeding materials with recombinant signs. As a result of the periodic selection imposed on varietal populations, lines serving as pollinator component to pollen-sterile (female parent) appear. Hybridization involving the best of them leads to an increase in the concentration of desirable genes controlling these traits in the CMS hybrids [3].

The goal of our study was to determine the efficiency of the first cycle of recurrent selection aimed at selection of starting forms of polyspermous pollinators of Uladiv origin and creates lines and synthetics that will serve components of sugar beet hybrids with improved technological root.

Materials and methods. The study was carried out in 2008-2013 at Uladiv EBS. A starting material served polyspermous sugar beet breeding material of high-yield (population U752) and sugary (U1948) lines. Recurrent selection to improve technological quality of pollinator's roots was carried out by the method of [4]. It included following steps: studying individual variability of the starting forms; studying CMS testers served as differentiators of breeding material for the genetic value; selecting the best of them to use in the next cycle of recurrent selection; creating inbred lines of the first generation; studying productivity of top-cross CMS hybrids based upon them; determining combinability of lines and creating synthetics on their basis.

To assess genetic value of the lines while self-pollinating, crossing (top-cross) was performed in separate insulators. Genotypes were assessed by general combining ability (GCA). Reassessment of pollen sterile lines and testers was performed on spatially isolated plots [5].

Seeds collected from pollinator plants were propagated in breeding nursery. Pollinator plants were crossed with CMS tester in insulators. Seeds obtained from pollinator made up the first generation of self-pollinating I_1 , seeds from CMS plants were hybrid seeds that have been experienced on the ground of their value. Seeds I_1 were sown in reproduction. After their estimation, the best selected genotypes of I_1 lines were crossed in the plot of free transpollination with two CMS lines to re-test CMS hybrid seeds, to obtain improved populations of pollinators and to find out heterotic hybrids feature low content of mineral elements. Efficiency of recurrent selection was determined by comparing the selection groups (SG), synthetics (Sint) and best hybrid combinations (HC) with initial populations and group standard (variety Uladiv one-seeded 35, hybrid Ivanovo CMS33 and Ramses).

Results and discussion. Investigating content of mineral elements in populations of yield (U752) and sugary (U1948) direction established that they were characterized by considerable individual variability. They had the highest variation indices on the basis of potassium content (45.2 and 56.0 in populations and - 30.0 and 33.6 % in selection groups). For the content of potassium under equal its value in the studied population (4.3 meq), variability of the initial form of sugary direction (U1948) was higher than in that of sugary (U752) and amounted to 29.7 and 22.2%. In selection groups, ash content differed significantly from the original forms (Table 1). It should be noted that confirmation of heritability technological quality in progeny only allows to select valuable genotypes for further breeding process. The general trend was the fact that the variation index in the selection groups was lower than in populations.

Table 1

Ash content and variability in plant populations and selection groups, 2008-2009

Population	Ash content (meq) and variation index, V,%					
	potassium	V,%	sodium	V,%	α -N	V,%
U 752	4.3	22.2	2.0	45.2	4.0	23.2
GR-Y52	3.5	18.4	1.6	30.0	3.1	17.4
U 1948	4.3	29.7	1.5	56.0	6.9	40.5
GR-1948	3.4	21.5	1.3	33.6	4.1	22.7
LSD ₀₅	0.42		0.17		0.9	

On the basis of the best lines from the first inbred generation 133 hybrid combinations (top-cross hybrids) were created against the background of two pollen sterile testers: 62 with lines-pollinators from the population U752, and 71 from U1948. Selected were only those HC, which were characterized by significantly lower values of molasses-makers K^+ , Na^+ and α -N $^-$ content as compared with the average for the population. Percentage of selection, which fluctuated 14.1 to 41.9% together with the trait variation indicates the heterogeneity of CMS populations and a possibility to select the best of them (Table 2).

It is known that phenotypic population structure for the quantitative traits is defined by both genotypic and environmental compounds that often mask genetic differences between breeding samples. It is under the influence of selection, mutation and recombination processes, changes the structure of the population and trait is evolving [6]. As for the ash content, the selection leads to the reduction of trait-components of technological quality of roots (the contents of K^+ , Na^+ and α -N $^-$). While selecting pairs for crossing, it is necessary to chose lines with negative combining ability effects; while improving breeding samples – with reliably low values of traits (in respect to the standard).

The best genotypes and the molasses-maker content variation in top-cross CMS hybrids, 2009-2010

Starting population	Mineral elements content, average for a population	Number of estimated genotypes based on two testers, pcs.	Number of selected genotypes		Content variation, meq	
			pcs.	%	min	max
Potassium						
U 752	3.8	62	25	41.9	1.28	8.27
U1948	4.0	71	18	25.3	1.21	7.70
Sodium						
U 752	2.1	62	13	21.0	0.50	4.04
U1948	1.6	71	19	26.8	0.53	3.94
α -N ⁻						
U 752	4.2	62	20	32.3	1.59	7.08
U1948	4.5	71	10	14.1	1.82	7.56

Based on every line under study characterized by negative general combining ability effects (GCA), generated were synthetics with a low content of potassium, sodium and α -N⁻ (Figure). They can serve not only CMS pollinators when creating hybrids, but also donors of desirable traits for improving technological quality of root.

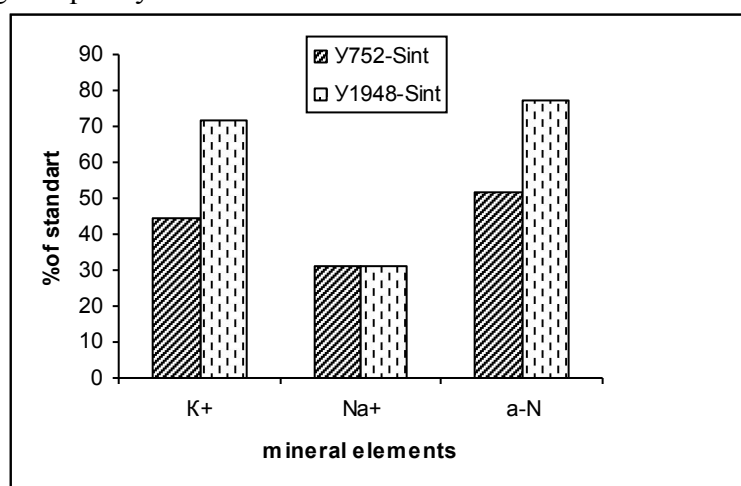


Figure. The content of mineral elements in synthetics of the first cycle of recurrent selection U752-Sint and U1948-Sint (% of standard), 2011-2012

As it can be seen from the Figure, synthetic U752-Sint, based on an initial population of yield direction, had better selection effect on potassium and α -N⁻ than synthetics U1948-Sint, which was obtained from the initial population of sugary direction. It was almost the same for sodium content (30.9 and 31.1% of the standard, respectively). This effective reduction in potassium and sodium content resulted from recurrent selection could be explained by high coefficient of inheritance (in the narrow sense): population U752 had it 0.84 and 0.76, respectively, and population U1948 - 0.67 and 0.71.

For breeding aimed at heterosis, of special importance is combining ability of hybrid components. It worth to be noted, that selection-valuable lines for one element content only are not those for others. However, having done a large amount of crosses it is possible to select genotypes that combine low values of all components responsible for technological quality of beetroot. Only five lines that are genetically valuable on the grounds on which the selection was performed out of

133 were successively selected (three of them originating from the yielding population, two from sugary direction) (Table 3).

Table 3

Content of mineral elements in CMS hybrids, GCA of the best pollinators and the effect of selection on the content of mineral elements, 2012

CMS hybrid	Potassium			Sodium			Alpha-amino nitrogen		
	meq	GCA effect	% of standard	meq	GCA effect	% of standard	meq	GCA effect	% of standard
145/50	1.76	-2.04*	45.4	0.84	-1.29*	34.4	2.12	-2.09*	38.4
122/56	1.75	-2.05*	45.1	0.85	-1.23*	32.3	1.61	-2.60*	44.4
117/52	1.79	-2.04*	45.4	0.81	-1.27*	33.7	1.59	2.63*	43.7
133/62	1.97	-2.11*	50.1	0.75	-0.86*	30.8	1.87	-2.66*	83.6
135/63	1.95	-2.13*	50.4	0.60	-1.01*	30.3	1.83	-2.70*	51.4

Note: GCA effects, reliable at 5% significance level

Table 3 shows that all five selected lines were characterized by genetically determined low ash content, since they had their GCA effects negative and reliable. The content of potassium in pollinator was half as that of standard, of sodium - three times lower (45.1-50.4 and 30.3-34.4%, respectively). The selection effect on the content of alpha-amino nitrogen was 38.4-83.4% of the standard. Having compared the values of traits under study in synthetics and hybrid combinations (Figure and Table 3), it can be stated that a significant reduction effect is achieved in the last, which is a result of directed selection of parents subject to interaction of genes controlling polygenic traits. A significant value shift in quality elements could also be explained by a significant proportion of the additive genotypic variations in the structure of these traits, which earlier was pointed out by some authors [7].

As a result of studying the breeding material at Uladiv EBS in 2013 we selected combination CMS2/32, which had a low content of ash as compared with CMS hybrid Ramses, listed in the State Register of Plant Varieties of Ukraine (2009). The effect of reducing parameters of the traits was: -0.49 to potassium -0.26 to sodium, - 0.20 meq to the alpha-amino nitrogen. Within the system of environmental quality testing Betacross, the best hybrid combinations created with Uladiv breeding material excess sugar content group standard by 14.0 ... 14.6%, indicating the efficiency of recurrent selection as a method of breeding for improving technological quality of sugar beet root.

Conclusions. Thus, the pollinators of Uman selection experimentally proved the effectiveness of the first cycle of recurrent selection as a method of reducing the amount of potassium, sodium and alpha-amino nitrogen, which helps to improve technological quality of root. When creating synthetics and CMS hybrids, pollinators originated from yielding populations U752 had greater response to the pressure of recurrent selection as compared with the sugary population U1948. The greatest reduction effect in CMS hybrids and synthetics was observed for potassium, then for sodium and alpha-amino nitrogen. We selected five hybrid combinations feature genetically determined low ash content, which is a component of technological quality of root.

References

1. Роїк М.В. Гібриди нового покоління буряку цукрового і їхня роль у процесі інтенсифікації галузі. / М.В. Роїк, М.О. Корнеєва // Сортовивчення та охорона прав на сорти рослин. – 2006. – № 3. – С. 71-81.
2. Селекційно-генетичне покращення цукрових буряків за технологічною якістю коренеплодів / [М.О. Корнеєва, Я.А. Мельник, М.Б. Мацук та ін.] // Наукові праці Інституту біоенергетичних культур і цукрових буряків : зб. наук. пр. – Київ, 2013. – Вип. 18. – С. 35-40.
3. Турбин Н.В. Периодический отбор в селекции растений / Н.В. Турбин, Л.В. Хотылева, Л.Н. Каминская. – Минск: Наука и техника, 1976. – 144 с.

4. Підвищення технологічної якості цукрових буряків селекційно-генетичними методами: методичні рекомендації / [М.О. Корнеєва, Я.А. Мельник, М.Б. Мацук та ін.]. – К.: ТОВ Поліграф-Консалтинг, 2013. – 23 с.

5. Корнеєва М.О. Системи контрольованих схрещувань при оцінці комбінаційної здатності селекційних матеріалів цукрових буряків / М.О. Корнеєва, М.В. Власюк // Фактори експериментальної еволюції організмів: зб. наук. праць. – К.: Аграрна наука, 2004. – С. 227-233.

6. Соскин А.А. О прогнозировании результатов отбора по количественным признакам / А.А. Соскин, Г.А. Стакан // Вопросы математической генетики. – Минск, 1969. – С. 67-76.

7. Мельник Я.А. Оцінка технологічної якості гібридів буряку цукрового (*B. vulgaris* L.) / Я.А. Мельник, М.О. Корнеєва // Сортовивчення та охорона прав на сорти рослин. – 2012. – № 2 (16). – С. 19-23.

Анотація

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Рекурентна селекція як метод покращення технологічної якості коренеплодів запилювачів – компонентів *сс* гібридів цукрових буряків

Досліджена ефективність використання рекурентного добору як методу поліпшення технологічної якості коренеплодів цукрових буряків. Дана порівняльна оцінка вмісту зольних елементів у вихідних популяції і груп добору з них, а також відсоток їх зниження щодо стандарту у синтетиків і *СС* гібридів, створених на основі запилювачів уладівської селекції. Виділено кращі генотипи запилювачів з поєднанням низького вмісту калію, натрію та альфа-амінного азоту для селекції *СС* гібридів з підвищеним виходом цукру.

Ключові слова: гібрид, синтетик, запилювач, технологічна якість коренеплодів, калій, натрій, альфа-аміний азот, рекурентний добір.

Аннотация

Корнеева М.А., Фалатюк Л.В., Мельник Я.А.

Рекуррентная селекция как метод улучшения технологических качеств корнеплодов опылителей – компонентов *СС* гибридов сахарной свеклы

Исследована эффективность использования рекуррентного отбора как метода улучшения технологических качеств корнеплодов сахарной свеклы. Дана сравнительная оценка содержания зольных элементов в исходных популяциях и групп отборов из них, а также процент их снижения относительно стандарта у синтетиков и *СС* гибридов, созданных на основе опылителей уладовской селекции. Выделены лучшие генотипы опылителей, сочетающие низкое содержание калия, натрия и альфа-аминного азота, для селекции *СС* гибридов с повышенным выходом сахара.

Ключевые слова: гибрид, синтетик, опылитель, технологические качества корнеплодов, калий, натрий, альфа-аминный азот, рекуррентный отбор