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SIMPLE AND TRIPLE-CROSS HYBRIDS OF SUGAR BEET

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Abstract

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The use of monogerm pollen sterility lines as maternal components of sugar beet hybrids allows full hybridization in the technical seed production. Because of the long-term self-pollination and the narrow genetic basis the male sterile lines are still with lower productivity, quality parameters and disease resistance. Test results of simple and triple-cross hybrids of six MS lines with two diploid and two tetraploid multigerm pollinators have been discussed. The participation of a second "O" type in maternal components' breeding scheme increases to some extent the productivity of the MS-simple hybrids because of the increased heterozygousity, but this does not reflect in relatively higher productivity and quality of the triple-cross hybrids – diploid and triploid. The differences between the simple and the triple-cross hybrids of sugar beet are due to the different combining ability of the parents in the respective crosses. The conclusion is that the inclusion of second "O" type in the sugar beet breeding scheme is not expedient, because this does not bring to higher productivity and quality of the raw material of the triple-cross sugar beet hybrids.

Key words: sugar beet, "O" type, MS-simple hybrids, triple-cross hybrids
Abbreviations: MS – male sterile, "O" type – sterility maintainer, MS X "O"$_2$ – MS-simple hybrid with second "O" type

Introduction

The modern sugar beet varieties are hybrids of monogerm male sterile lines with multigerm pollinators. The hermaphrodite structure of beet's flowers and the impossible castration on a large scale force the use of pollen sterility lines as maternal components (Antonov, 1997), and the use of multigerm pollinators is determined by the circumstance, that the multigerm sugar beet forms exceed significantly the monogerm forms regarding the most important economic indices (Zakhariev, 1996; Shevtzov, 1996). Dozens of male-sterile lines have been created in our country, a big part of them having 95-100% sterility. This allows complete hybridization in the technical seed production. But due to the long-term self pollination and the narrow genetic basis the most of the monogerm lines have lower productivity, unsatisfactory technological qualities, and lower resistance to diseases. These disadvantages are overcome mostly by hybridization with multigerm donors of valuable features (Antonov and Zakhariev, 1994). In the USA and some other countries monogerm MS-simple hybrids are used as maternal components of the hybrid

varieties (Balkov et al., 1980). This is prompted by the necessity to overcome the inbreeding depression, due to which the MS lines are usually with lower seeds yield. This breeding scheme is more complicated and continuous, as it is necessary to find and maintain a second "O" type (sterility maintainer) with high combining ability (Petrenko and Balkov, 1982). The tests of huge number of crosses in our country, using monogerm MS lines and MS-simple hybrids as maternal components, have shown, that both groups of hybrids do not differ significantly in any of the indices (Antonov, 1982; Popov, 1983), and what is more, the MS-simple hybrids do not exceed significantly the relevant MS lines even regarding their seed yield. Antonov (1996) claims that the hybridization between different MS lines and "O" types does not bring to increase of the seeds germination if compared with the maternal component, i.e. in this case there is no any heterosis effect. On the other hand, Uchkunov and Uchkunova (2008) speak about increased productivity and improved raw material's qualities of the triple-cross diploid and triploid hybrids. With the present research we aim to make things clear, showing and discussing our results of comparative tests of simple and triple-cross hybrids of sugar beet regarding some basic parameters of the productivity and their technological qualities.

Materials and Methods

Six stabilized monogerm MS lines - MS 015, MS 146, MS 190, MS 142, MS 1023 and MS 106 are included in the study, as well as their MS-simple hybrids with a second sterility maintainer "O" 1931 (O_2), genetically distant in its origin from the "O" types of the relevant lines and having high combining ability. Four multigerm pollinators are used as paternal components in hybridization – two normal pollinators (diploid and tetraploid), and two tolerant to Rhizomania pollinators (diploid and tetraploid). The crosses are made in sunflower isolation and the ratio MS line (respectively MS-single hybrid): pollinator is 3:1. The tests of the simple and triple-cross hybrids for their economic qualities are carried out in the experimental fields of the Agricultural Institute – Shumen during 2004-2006. The field tests are made on carbonate black-earth with weakly alkaline reaction of the soil solution under non-irrigation conditions. The randomization is by the two-seated lattice method, 49 variants in 4 repetitions, with area of the experimental plot 10.8 m^2, for group Standard are used the commercial varieties Endje-316, Elit and Radnevo. The root yield, sugar content and white sugar yield from a unit of area are measured, in percentage towards the values of these indices of the Standard. The results are treated by dispersion analysis according to Lidanski (1988).

Results and Discussion

Data for the root yield during the period of study (Table 1) show that all the multigerm pollinators, used as paternal components of the single and triple-cross hybrids, have equal to the Standard varieties' productivity. Among the MS lines the highest yield forms MS190 (110.2%), and the lines MS1023 and MS 142 have lower than Standard's yield. The MS-single hybrids form significantly higher root yield than the Standard varieties (mean of the MS-simple hybrids 111.6%). The yields of the MS-simple hybrids of MS142 and MS1023 are significantly higher than the yields of the MS lines themselves, and only MS190 X O_2 falls back, but not significantly, in its root yield. Definitely, in this case the word is about stabilized, homozygous MS lines and heterosis effect in the productivity of their MS-simple hybrids with different "O" type used as a paternal component. The question is to what an extent the higher productivity of the MS-simple hybrids would reflect on the productivity of the triple-cross hybrids with their participation. The triple-cross hybrids, obtained by cross-pollination with the normal diploid multigerm pollinator N, realize proven higher root yield (mean of 112.9%) than the Standard, but only the yield of the triple-cross diploid hybrids (MS142 X O_2) X N and (MS106 X O_2) X N have higher root yields than the yields of the relevant simple hybrids MS142 X N and MS106 X N, while the remaining simple and triple-cross hybrids do not differ significantly in their root yield. The situa-

Table 1

Root yield from simple and triple-cross hybrids in % to the Standard Group Standard - mean of Endje-316, Elit and Radnevo (5253 kg/da) = 100% 2004 - 2006

MS line	Root Yield %	Pollinator					
		N-2x %	R-2x %	Mean of 2x hybrids %	N-4x %	R-4x %	Mean of 3x hybrids %
		95.7	96.7	96.2	99.2	92.2	95.7
MS 015	105.4	107.1	115.8	111.5	110.8	93.6	102.2
MS 146	97.7	105.6	114.3	110.0	113.5	104.3	108.9
MS 190	110.2	109.0	116.3	112.7	100.9	105.1	103.0
MS 142	84.8	104.4	125.9	115.2	108.4	112.2	110.3
MS 1023	80.1	107.5	115.8	111.7	115.8	106.6	111.2
MS 106	108.3	101.8	106.0	103.9	105.2	98.9	102.1
Mean	97.8	105.9	115.7	110.8	109.1	103.5	106.3
MS 015 X O_2	111.0	106.5	110.4	108.5	112.7	101.5	107.1
MS 146 X O_2	105.2	111.8	113.0	112.4	101.0	110.4	105.7
MS 190 X O_2	107.1	109.0	105.2	107.1	121.2	93.2	107.2
MS 142 X O_2	111.0	121.7	96.9	109.3	101.7	104.1	102.9
MS 1023 X O_2	117.5	111.7	113.0	112.4	106.0	106.0	106.0
MS 106 X O_2	117.9	116.9	98.9	107.9	109.7	89.4	99.6
Mean	111.6	112.9	106.2	109.6	108.7	100.8	104.3
*P < 0.05	11.3						

tion is slightly different for the crosses with the tolerant to Rhizomania diploid pollinator R. Here the simple hybrids have significantly higher yield of roots compared with the group standard (115.7%), as well as if compared with the mean root yield of the triple-cross hybrids with the pollinator R. And if the exceeding for the other simple hybrids is not statistically proved, the root yield of the single hybrid MS142 X R exceeds the yield of the relevant triple-cross hybrid with very well proved difference. The fact that by hybridization with one pollinator (N) the triple-cross hybrid of one MS line is with a higher root yield than the simple hybrid of the same line, and just the opposite – when crossed with another pollinator (R), speaks about differences in the specific combining ability of the parents, participating in the crosses. The mean values of the diploid simple and triple-cross hybrids do not differ significantly between each other, although the proved higher root yield value of the maternal component in the triple-cross hybrids.

The simple triploid hybrid of MS146 with the normal tetraploid pollinator N (4xN) is with a higher yield than the corresponding triple-cross hybrid of the same line, and the triple-cross hybrid (MS190 X O_2) X 4xN is with significantly higher yield than that of the simple hybrid MS190 X 4xN. Even with proved higher than the Standard's yield of roots the simple hybrid of MS1023 and the triple-cross hybrid of MS015 do not differ substantially from (MS1023 X O_2) X 4xN and MS015 X 4xN. The differences between the remaining simple and triple-cross hybrids with 4xN are not significant. Only the simple hybrid of MS190 with the tetraploid tolerant to Rhizomania pollinator R (4xR) is with proven higher yield than that of the triple-cross hybrid of the same line. The remaining differences in the root yields of the simple and triple-cross hybrids

Table 2

Sugar content of simple and triple-cross hybrids in % to Standard Group Standard-mean of Endje-316, Elit and Radnevo (15.7%) = 100% 2004-2006

MS line	Sugar content %	Pollinator					
		N-2x %	R-2x %	Mean of 2x hybrids %	N-4x %	R-4x %	Mean of 3x hybrids %
		108.3	108.7	108.5	100.3	107.6	104.0
MS 015	100.5	102.1	106.5	104.3	96.6	107.2	101.9
MS 146	98.4	102.0	103.1	102.6	101.2	100.7	101.0
MS 190	94.2	104.6	102.9	103.8	104.8	112.2	108.5
MS 142	90.1	102.4	106.4	104.4	108.8	106.7	107.8
MS 1023	96.7	97.1	99.4	98.3	106.2	97.4	101.8
MS 106	101.5	99.8	98.6	99.2	98.6	100.1	99.4
Mean	96.9	101.3	102.8	102.1	102.7	104.1	103.4
MS 015 X O_2	99.3	99.9	105.3	102.6	104.8	107.1	106.0
MS 146 X O_2	95.3	104.4	106.4	105.4	91.0	100.6	95.8
MS 190 X O_2	94.1	101.2	102.0	101.6	100.0	110.2	105.1
MS 142 X O_2	94.9	106.3	97.7	102.0	108.7	102.0	105.4
MS 1023 X O_2	85.5	101.3	101.7	101.5	106.1	106.5	106.3
MS 106 X O_2	94.0	98.9	104.4	101.7	104.3	109.3	106.8
Mean	93.9	102.0	102.9	102.5	102.5	106.0	104.2
*P < 0.05	7.2						

of the MS lines with that pollinator are not reliable.

The sugar content is one of the basic technological indices. Data in Table 2 show, that MS1923 and MS108 have higher sugar content than their MS-simple hybrids. We are not surprised by the higher values of the sugar content in the MS lines, having in mind the very well expressed negative correlation between the yield of roots and the sugar content for the beets. At the other hand, the sugar content is more conservative character and it is no chance that only the sugar content of the simple diploid hybrid MS142 X R exceeds reliably the sugar content of the triple-cross hybrid with the same pollinator. We could summarize, that the tested simple and triple-cross hybrids do not differ significantly in regards to their sugar content. For the triploid simple and triple-cross hybrids there are certain differences. The sugar content of the simple triploid hybrids MS146 X N and MS190 X R is higher than that of the relevant triple-cross hybrids, and in the triple-cross hybrids (MS015 X O_2) X N, (MS1023 X O_2) X R and (MS106 X O_2) X R the sugar content is higher than that of the relevant simple hybrids. But these differences could be explained with the different influence of the tetraploid multigerm pollinator, whose participation with two genomes in the triploid hybrids determines to a great extent their qualitative parameters. From the discussion so far it is clear, that the inclusion of second "O" type in the breeding scheme really creats possibility for increase of the heterozygousity of the maternal component, but this does not bring to manifestation of heterosis in the triple-cross hybrids, i.e. increase of their yield and improvement of their raw material's quality. Data in Table 3, showing the white sugar yield from an unit of area as a resultative indice for the economical value of the sugar beet hybrids, do confirm that. Like for

Table 3

White sugar yield of simple and triple-cross hybrids in % of Standard Group Standard - mean of Endje-316, Elit and Radnevo (823 kg/da) = 100% 2004-2006

MS line	White sugar yield %	Pollinator					
		N-2x %	R-2x %	Mean of 2x hybrids %	N-4x %	R-4x %	Mean of 3x hybrids %
		105.2	108.4	106.8	99.1	99.5	99.3
MS 015	104.6	110.2	122.9	116.6	106.9	101.5	104.2
MS 146	95.7	109.0	120.3	114.7	116.1	105.1	110.6
MS 190	101.6	115.7	118.9	117.3	108.1	121.5	114.8
MS 142	70.6	106.6	134.7	120.7	121.2	122.6	121.9
MS 1023	77.1	102.0	113.9	108.0	126.3	102.1	114.2
MS 106	108.1	100.7	103.4	102.1	103.6	99.4	101.5
Mean	93.0	107.4	119.0	113.2	113.7	108.7	111.2
MS 015 X O_2	109.7	107.3	117.7	112.5	120.5	111.0	115.8
MS 146 X O_2	97.8	118.1	121.9	120.0	89.8	110.4	100.1
MS 190 X O_2	99.6	111.9	108.6	110.3	121.9	107.2	114.6
MS 142 X O_2	103.7	131.3	93.3	112.3	114.2	106.7	110.5
MS 1023 X O_2	95.8	115.1	112.3	113.7	115.4	115.6	115.5
MS 106 X O_2	107.8	115.5	105.2	110.4	117.0	100.3	108.7
Mean	102.4	116.5	109.8	113.2	113.1	108.5	110.9
*P < 0.05	13.6						

the root yield, the lines, which fall back significantly the Standard in their white sugar yield, have lower white sugar yield than that of the relevant MS-simple hybrids (MS142 and MS1023). Of course, that this determines also the necessity of work on the improvement of their "O" types' qualities. But excluding the diploid crosses (MS142 X O_2) X N and (MS106 X O_2) X N, and MS142 X R, there are no significant differences between the separate simple and triple-cross hybrids. For the triploid hybrids there are also some proven differences between separate simple and triple-cross hybrids – MS146 X N, MS190 X R, MS142 X R, (MS015 X O_2) X N, (MS190 X O_2) X N. We said already that the white sugar yield is a function of the root yield and the sugar content. And to a great extent the differences between the simple and triple-cross hybrids are due to the differences between them regarding the realized root yield. Only for the hybrid (MS015 X O_2) X N (4x) the proven difference is due to the proven higher sugar content of the relevant MS-simple hybrid.

Conclusions

Engagement of second "O" type in the breeding scheme of the sugar beet is not advisable, because it does not bring to a higher productivity and improved quality of the raw material from the triple-cross diploid and triploid hybrids.

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