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BIOLOGICAL PECULARITIES OF CYTOPLASMIC MALE STERILITY AND SCHEMES OF ITS USE

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Studies of cytoplasmic male sterility and breeding works on its basis are being held in Bulgaria since 1970. We received sources of cytoplasmic male sterility (CMS) and restorer lines from P. Leclercq (France) to whon we are much obliged. Currently, we have more than 150 sterile analogous lines which are in different backross generations — from BC_7 to BC_1.

In connection with the use of CMS it was necessary to establish in which backcross generation is to be expected the complete analogy in morphological, biological and biochemical traits as well as in combining ability. It was also necessary to study the influence of sterilizing cytoplasm and genes of restoration and more precisely the influence of chromosomes bearing these genes. The results show that after the fifth backcross, an analogy quite similar to the original lines can be obtained. Heterosis with respect to plant development is high in the first backcross generations till BC_3—BC_4. We got the same results from the analyses of other traits as weight of 1000 seeds and kernel oil content. Eckhard (after Jugenheimer, 1958) and Hadjinov methods were used for creating restorable analogous lines. Considering these results we drew the conclusion that five backcrosses are sufficient for obtaining restorable analogous lines.

According to Leclercq (1971), whose results were confirmed by many others as well as by our own, fertility restoration is controlled by one dominant gene. New sources of restoration genes were found in samples available in Bulgaria in 1971. Samples with these genes were of different origin : striped — from Bulgaria, Pioneer Sibiri and Barnaulsky 1501 coming from the USSR, Bernburger from Hungary, samples under the names *H. angustifolius* and *macrophyllus* of hybrid origin. In all these cases the restoration is controlled by one dominant gene. This year genetic analyses are being made to determine the number of genes.

Studies on the influence of *H. petiolaris* cytoplasm which causes pollen sterility showed that it does not depress the plants in the process of backcrossing and in hybrids between different lines. Field germination and all development processes were completely normal. Data in table 1 show that such traits as oil content in seeds and yield come to the level of the original lines when increasing the backcross number.

Table 1

The influence of the backcross generations on some traits

Traits and backcross	Plant height (cm)	Head diameter (cm)	Number of leaves	Seed yield per plant (g)	1000 seed weight (g)	% kernel	% oil in kernel
BC_3♀	156.3	24.9	24.2	72.00	61.42	74.42	59.03
♂	137.3	18.7	23.7	49.60	41.42	75.20	56.33
diff. from ♂	+19.0	+6.2	+0.5	+22.40	+20.00	— 0.58	+ 2.70
BC_4♀	159.1	24.4	24.7	69.00	58.88	76.97	59.54
♂	149.9	20.1	23.9	45.78	42.54	74.88	57.33
diff. from ♂	+ 9.2	+4.3	+0.8	+23.22	+16.34	+ 2.09	+ 2.21
BC_5♀	151.1	26.2	26.4	69.75	68.00	77.85	61.02
♂	140.6	24.0	27.2	52.94	66.95	76.24	58.58
diff. from ♂	+10.5	+2.2	−0.8	+18.81	+ 1.05	+ 1.61	+ 2.44
BC_6♀	149.2	24.2	25.9	76.06	63.50	81.05	61.06
♂	146.0	23.8	25.8	64.60	63.83	78.06	59.34
diff. from ♂	+ 3.2	+0.4	+0.1	+11.46	— 0.33	+ 2.99	+ 1.72

First results from analysis of fatty acid content show that the sterile analogous lines have an increased oleic acid content and decreased content of linoleic acid (table 2).

We have worked for four years for obtaining three generations yearly in a greenhouse without additional light. The conclusion is that the type of sterility used and the performance of restorer genes are characterized by a very high rate of stability. The same was observed in the field.

The studies we made on pollination by bees show that there are not differences in the number of bees visiting the heads of the sterile analogous plants or heads of lines with normal pollen fertility (table 3). The time of stay was the same and also the number of non-fertilized florets of the sterile and fertile plants.

Our first studies on heterosis based on CMS were performed with single hybrids. The schemes worked out for obtaining maize hybrids cannot be fully used for obtaining sunflower hybrids because sunflower differs in some biological pecularities as hermaphrodite structure of florets and entirely entomophilous pollination, which needs the corresponding space isolation. Keeping all that in mind we came to the conclusion that simpler schemes for obtaining hybrids should be used.

Table 2

The influence of CMS on the fatty acid composition

Backcross	Line, analogous	C 18 : 2	C 18 : 1
BC_6	1234♀	67.8	20.3
	1234♂	72.1	17.0
diff. from ♂		— 4.3	+ 3.3
BC_6	1734 ♀	59.5	28.3
	1734 ♂	66.0	22.3
diff. from ♂		— 6.5	+ 6.0
BC_5	1510 ♀	66.6	21.5
	1510 ♂	71.8	17.2
diff. from ♂		— 5.2	— 4.3
BC_5	1585 ♀	64.9	25.4
	1585 ♂	68.1	20.5
diff. from ♂		— 3.2	+ 4.9
BC_5	1607 ♀	66.6	22.1
	1607 ♂	68.5	20.2
diff. from ♂		— 1.9	+ 1.9
BC_5	1749 ♀	64.6	24.7
	1749 ♂	64.1	23.5
diff. from ♂		+ 0.5	+ 1.2
BC_5	2178 ♀	64.3	21.6
	2178 ♂	60.5	26.8
diff. from ♂		+ 3.8	— 5.2
BC_4	559 ♀	62.4	23.5
	559 ♂	65.8	22.6
diff. from ♂		— 3.4	+ 0.9
BC_4	1656 ♀	68.0	19.9
	1656 ♂	67.4	19.3
diff. from ♂		— 0.6	+ 0.6
BC_4	1770 ♀	61.8	27.1
	1770 ♂	63.4	26.6
diff. from ♂		— 1.6	+ 0.5
BC_4	2365 ♀	59.5	28.0
	2365 ♂	62.6	23.1
diff. from ♂		— 3.1	+ 4.9
Average		— 2.23	+ 2.15

Table 3

Data on natural pollination

Indices	Fertile heads	Sterile heads
1. Number of bees per hour	20.60	22.55
2. The maximum number of bees per hour	35	26
3. The average time of stay	123 sec.	140 sec.
4. Percentage of empty seeds	18,9	19.2

On the basis of our investigations on CMS we have developed and studied four schemes of hybrid seed production (fig. 1).

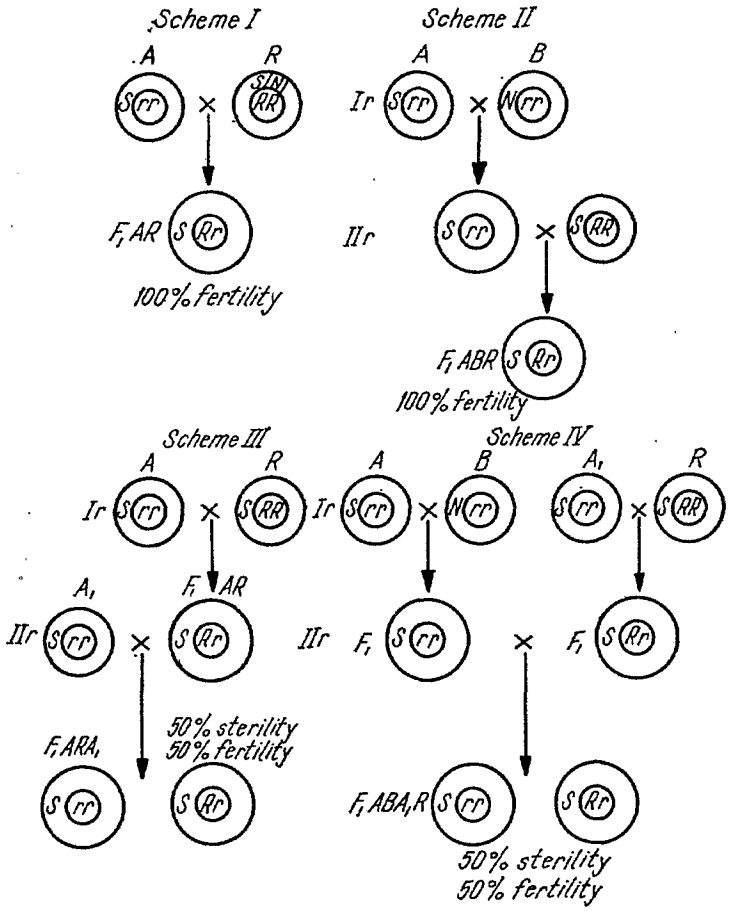

Fig. 1—Schemes of sunflower hybrid seed production on CMS basis.

1. Single cross of complete pollen fertility restoration.
2. Three-way cross (between three lines) of complete pollen fertility restoration.
3. Three-way cross (between three lines) of non-complete pollen fertility restoration.
4. Double cross (between four lines) of non-complete pollen fertility restoration.

Single hybrids for the production of which only two parental forms are necesary, one male inbred line and a sterile female line, are of greatest interest. If the seed yield of the female line is very low, the scheme of three-way hybrid with complete pollen fertility restoration could be used. In addition, in the scheme of such a hybrid a non-restorer line may take part as it does not need time for creating a sterile analogous. The third and the fourth scheme represent only a possibility for obtaining hybrids, but are of no practical value. They could be used only in the presence of low seed and pollen productive lines which are usually eliminated in selection.

In 1973, 320 single hybrids produced on the basis of CMS were tested under field conditions. Some of these hybrids exceeded the standard variety Peredovik in seed and oil yield per hectare (table 4).

Table 4

The yield of hybrids in competitive trials

Hybrid combination	Seed yield		Oil yield		
	kg/ha at 11% moisture	%	% oil in seed	kg/ha	%
Peredovik-check	3910	100	48.3	1781	100
204	4981	127.4	47.3	2096	117.0
195	4873	124.6	50.7	2196	122.0
324	4759	121.8	47.9	1989	111.4
327	4628	118.5	48.5	1995	111.6
182	4554	116.4	51.8	2097	117.1
299	4471	114.5	48.5	1926	107.8
314	4429	114.0	48.0	1900	106.1
179	4404	112.6	51.8	2028	114.4
205	4362	111.6	52.2	2027	114.3

REFERENCES

Hadjinov M. I., 1959, *Metodika selektzii sterilnih hidridov*, Kukuruza, *4*.

Jugenheimer R. W., 1958, *Hybrid maize breeding and seed production*, FAO Agr. Develop. Paper, *62*.

Leclercq P., 1971, *La sterilité mâle-cytoplasmique du tournesol. I. Premières études sur la restoration de la fertilité*, Ann. Amélior. Plantes, *21*, 45—54.