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THE CREATION OF LINEAL HYBRIDS ON THE BASIS OF MALE STERILITY

Utilization of the phenomenon of heterosis by creation of lineal hybrids, leads to a further increase of sunflower productivity. On the basis of the results already obtained, it is easy to conclude that sunflower hybrids have good prospects (Suchster 1964, Tungaer, 1966, Putt, 1966, etc.).

The basic objective of our research was to obtain single cross hybrids on the basis of both genetic and cytoplasmic male sterility. The hybrids should be suitable for various agro-climatic conditions of Iran and should also be resistant to the main diseases of sunflower. In order to reach these objectives, the following steps were required to be taken.

- Selection of inbred lines with a high combining ability from a genetically divergent material (varietal populations), to be used as father lines of single-cross hybrids.
- Selection of suitable sources of cytoplasmic male sterility to be incorporated with the high oil content inbred lines.
- Studying the existence of restorer genes in the available breeding material.
- Examining the combining ability of the inbred lines with a source of genetic male sterility with a marker gene.
- Subsequently the combining ability of the available restorer lines with the CMS lines should be examined.

Generally, it is important to find which hybrid combinations, based on either genetic or cytoplasmic male sterility, give the best results under the actual agricultural conditions of Iran.

The initial work was started on the material brought from Yugoslavia. They were inbred lines of S2 - S9 generations, and the source of the genetic type of male-sterility with a marker gene was GM-S. A9345, created in Novisad. The starting material of the cytoplasmic male sterility was one French CMS line. The restorer lines NS-RHA-1 and NS-RHA-2 with a gene PL1, resistant to Plasmopara Helianthi were used for testing CMS lines.

In 1970, a total number of 535 inbred lines of S2-S9 generations was planted. After five years, the number is now 2030 inbred lines of S6-S13 generations. Most of the inbred lines were planted in comparative trials in Karadj and Gorgan. Every year, 12 plants of each inbred line were planted in one row. The spacing was 70x40 cm. In order to obtain new generations of inbred lines, four plants of each line were selfed. These isolated plants, having sufficient quantities of seed, were used for the creation of new generations in the following years. The necessary phenological observations were performed on each inbred line in the course of vegetation period. After flowering, the plant height was measured; the head diameter was measured immediately before harvesting.

After harvesting (performed manually) the yield of each plant was measured, both under selfing and open pollinated conditions. Analyses of percentage of husks, weight of 1000 seeds, and oil content in seeds were measured afterwards. In 1971, the first crosses between lines of the genetic type of male sterility with a marker gene and the inbred lines were made. The number of crosses increased each year, and in 1974 all the oil inbred lines were included in the crossing programme. Crossing between the CMS sources and inbred lines started in 1972, and the number of crosses increased considerably in 1974.

The oil inbred lines (around 500) are being transformed into the CMS form by back-crossing. Since the most reliable results on combining ability of the hybrid combinations were obtained in 1974, the basic characteristics of the most interesting combinations obtained in 1974 will be presented in this report. In Karadj, there were 260 combinations of GMS x Inbred lines and 210 combination of CMS x Inbred lines.

In Gorgan, there were 337 combinations of GMS x Inbred lines and 319 combinations of CMS x Inbred lines.

The research on a large number of hybrid combinations based on the genetic type of male-sterility with a marker gene and on the cytoplasmic male sterility started in 1972. In this paper the results of the hybrid combinations which in 1974 were superior to variety Rekord (standard) are given as following:

a) Research on the combining ability on the basis of the genetic type of male sterility with a marker gene.

The sterility of the applied source of the genetic type of male sterility with a marker gene (GMS-A9345) was conditioned by a recessive gene (ms) which is linked in the same chromosom with a gene (t) for the green color of the plants and other vegetative organs, i.e. with the dominant gene which conditions the anthocyan red color of the fertile plants (T gene). This makes it possible to apply this source of male sterility in the creation of the single-cross sunflower hybrids.

In 1974, a large number of hybrid combinations with this type of male sterility had a higher grain yield than the standard varieties, particularly the variety Rekord.

The applied source of male sterility, the line GMS-A9345 in combination with some inbred lines gave high yielding and early hybrids.

Particularly good early hybrids were obtained with the lines S1314 and S1316. Their good characteristics were fully expressed in Karadj where their seed and oil yield was 14-17% more than that of the Rekord variety.

Comparison of the grain yield and oil per hectare of these two hybrids with those of the early variety Zaria shows a significant difference. Of course, these results should be further confirmed by growing the hybrids in larger plots. Although in Karadj a large number of hybrids had higher grain yields per hectare than the standard varieties, only the hybrid GMS-A9345 x S1928 had a significantly higher grain yield than the variety Rekord. However, the oil yield of this hybrid is not significantly higher than the yields of the standard varieties.

In Gorgan too, a large number of these hybrid combinations had significantly higher grain yield than the variety Rekord, most of them having shorter growth periods.

The results obtained in Gorgan indicate that the line GM-S A9345 gives the best combination with the line S83. The growth period of this hybrid is 18 days shorter than that of the variety Rekord. The hybrid's grain and oil yields per hectare were significantly higher than those of the variety Rekord (by 29.8 and 30.2% respectively). Other hybrids like Nos. 23, 54, 59, 68, 19, 50 and 33 should also be mentioned; they have short vegetation periods and much better production characteristics than the variety Rekord.

On the basis of the results obtained in Karadj and Gorgan, it should be concluded that a large number of inbred lines could successfully combine with the applied source of the CMS with a marker gene (CMS A9345). These combinations give early hybrids with the grain and oil yields higher than those of the standard varieties. Of course, the successful combinations will be multiplied in order to con-

firm the results on a larger scale.

2. The research on the combining ability based on the cytoplasmic male sterility (CMS).

A large number of hybrid combinations based on CMS have been studied in two places (Karadj and Gorgan) with the following objectives:

- a) Evaluation of their combining ability.
- b) Search for restorer genes.
- c) Studying the possibility of using three-way crosses in sunflower hybrid seed production.

In Karadj, a number of hybrid combinations had higher grain yields, oil content in seed and oil yield than the standard varieties (from 2% to 4%). However, the values were not significantly higher. The hybrid combinations S285, S969, S1637, S1728, S1638, S1944, S1836, S1838, and S1917 had very good production characteristics; they surpassed the Rekord variety by 4-22% in the seed yield and by 4-19% in the oil yield. These combinations should be crossed with the restorer lines NS-RHA-1 and NS-RHA-2 to examine the possibility of obtaining the three-way crosses resistant to *Plasmopara Helianthi*, because the restorer lines have the gene PL1. Also, the combinations should be transformed into the CMS form by using two generations of back-crosses in one year. It should be mentioned that in Karadj two lines with the restorer genes were found (S1732 and S1761). These lines should be further separated into sub-lines with regard to the homozygosity of the restorer gene.

In Gorgan, there was a number of hybrid combinations with the grain and oil yields significantly higher than those of the variety Rekord, most of them having a higher oil content in seed than the standard varieties. The lines S1315, S1318, S1911, S1381, S1570, S1838, S1855, S1919, S1313, S1326, S893, S1048, S1145, S1200, S690, S761, S999 had

a particularly good combining ability. Their hybrids' seed and oils yield was 50-110% more than that of Rekord.

The hybrid combinations with NS-RHA-1 and NS-RHA-2 indicated that there is a possibility of obtaining a hybrid on the basis of CMS which would be resistant to *Plasmopara Helianthi*. The informative results from 1974 indicate the advantages of these hybrid combinations over the variety Rekord. Thus the combination GMS x NS-RHA-2 surpassed the Rekord variety in the oil yield by 12% in Karadj and by 26% in Gorgan.

On the basis of the five-year research on a large number of inbred lines of S2-S13 generations, the following conclusions can be drawn: in spite of the negative effects of selfing, there were some inbred lines with high oil contents in seed and high values of other characteristics.

The source of the genetic type of male sterility with a marker gene, the line GMS-A9345 - offers the possibility of practical utilization of heterosis in the creation of single-cross sunflower hybrids.

A large number of hybrid combinations based on the line GMS-A9345 and the inbred lines were examined.

The results obtained indicate that a large number of inbred lines can be combined with the line of the genetic type of male sterility with a marker gene. Most of these hybrid combinations have shorter growth periods than the variety Rekord (in some cases up to 20 days).

In Karadj, the male sterile line GMS-A9345 gave the best results with the inbred lines S1314, S1316 and S1928. The obtained hybrids are earlier, with better production characteristics than the variety Rekord.

In Gorgan, the male sterile line combined well with a large number of inbred lines. The best results were obtained with line S83 -

giving the grain and oil yields 30% higher than those of the variety Rekord. Hybrids with the following lines could also be successfully produced: S1841, S132, S1557, S1856, S718, S1852 and S633.

It is planned to multiply this material further, in order to produce and test the hybrid combinations in various regions of Iran. Up to now, the restorer genes were found in four inbred lines.