SUNFLOWER HYBRIDS RESISTANT TO DOWNY MILDEW OBTAINED ON CYTOPLASMIC MALE STERILITY BASIS

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Downy mildew (*Plasmopara helianthi* Novot.) is the most harmful disease of sunflowers in Romania, causing substantial yield reduction in recent years. Sunflower varieties cultivated in the past and at present do not contain factors for resistance to this aggressive parasite, the only preventing or limitating means being the cultural hygienic measures and a long crop rotation at 6—7 years. That is why the development of resistant hybrids is one of the main objectives in sunflower breeding and an important way of getting high and constant seed and oil yields.

In our works at the Research Institute for Cereals and Industrial Crops at Fundulea, sunflower breeding for resistance to downy mildew is based on the identification of *Pl* genes by selfing under artificial inoculation and the introduction of these genes into the parental lines of the best hybrids. Self-pollination allows to maintain the factors for resistance in homozygous status and to transfer them into other genotypes.

On this way, the inbred line AD-66 was obtained in 1966 (Vrânceanu, 1967), proving to be completely resistant to downy mildew under controlled infections. Subsequent genetic studies revealed one single dominant gene, noted Pl_1, responsible for resistance to *Plasmopara* (Vrânceanu, 1970; Vrânceanu and Stoenescu, 1970). This gene was supposed to come from the natural crosses of the cultivated sunflowers with the wild annual *Helianthus annuus* from Renner-Texas and to be pleiotropical or linked with R_1 gene for rust resistance.

Shortly after the identification of the first gene which confers resistance to downy mildew, Zimmer and Kinman (1971; 1972) communicated the presence of a second gene (Pl_2) in the American line HA-61. They established that Pl_1 gene does not confer resistance to the American race of *Plasmopara* (called Red River). There is a paper (Vear and Leclercq, 1971) ascribing to the same American line

(HA-61) a third gene which is effective against the European race but not to the American one.

Another gene pool for resistance to downy mildew are the artificial hybrids *Helianthus tuberosus* x *H. annuus* used on a large scale at VNIIMK-Krasnodar for obtaining open pollination varieties resistant to downy mildew (G. V. Pustovoit, 1963).

In our works starting from the synthetic population S-11 which contains factors for resistance to downy mildew and for pollen fertility restoration, inbred lines resistant to downy mildew were developed and used as male parent of sunflower hybrids produced on cytoplasmic male sterility basis.

The first hybrids resistant to downy mildew were obtained by transferring the Pl_1 gene into the genotype of the single hybrids produced on genetic male sterility basis. In some cases the Pl_2 gene was also used. To this type of hybrids — noted with RM letters — belong HS 42 RM, HS 62 RM, HS 52 RM and HS 53 RM. The single hybrid HS 53 RM, which is in fact the resistant variant of the commercial hybrid Romsun HS 53 largely grown in Romania, has the same yielding performances as the susceptible hybrid, exceeding the local variety Record by 16%.

Due to the fact that sunflower hybrids obtained on genetic male sterility basis are being replaced by those produced on cytoplasmic male sterility basis, works are directed at the Research Institute for Cereals and Industrial Crops — Fundulea towards the development of resistant hybrids of this type, using as germplasm inbred lines with high oil content and good combining ability but lacking the genetic factors for resistance to downy mildew and for pollen fertility restoration. The inbred line AD 66 carrying the Pl_1 gene cannot be used directly as parental form because of its high husk percentage. The American line HA-61 which contains the Pl_2 gene, although used in some French or American hybrids, has low combining ability and gives hybrids with unsatisfactory oil content. On the other hand, not all restoration sources are good starting material for selfing and selection of the adequate inbred lines.

For this reason our breeding programme is based on the transfer of *Pl* and *Rf* genes into the genotype of the parental lines of the best hybrids resulted from diallel crosses among high oil content inbreds.

In connection with breeding for resistance to down mildew, the effect of gene doses on the resistance or susceptibility of the host presents a certain interest. On the basis of this hypothesis it is possible to obtain a much greater resistance with three or four *Pl* doses than with one or two. This means the necessity to introduce *Pl* genes into all parental lines of sunflower single or three-way hybrids, although the presence of the homozygous gene in one of the two parents only, would be enough for assuring the resistance of the F_1 hybrids. Having at disposal at least two genes which confer resistance to different downy mildew races, it is possible to obtain a broader resistance spectrum, introducing Pl_1 in one of the parental lines and Pl_2 into the other line.

The genes for resistance to downy mildew are effective even when they are transferred in sterile „petiolaris" cytoplasm, making easy the development of cytoplasmic male sterile and resistant to downy mildew lines and the selection of pollen fertility restorers containing *Rf* and *Pl* genes in the same sterile cytoplasm. In our backcrosses the gene Pl_1 was always effective in sterile „petiolaris" cytoplasm, in opposition to some existing in literature assertions (L e c l e r c q, 1972).

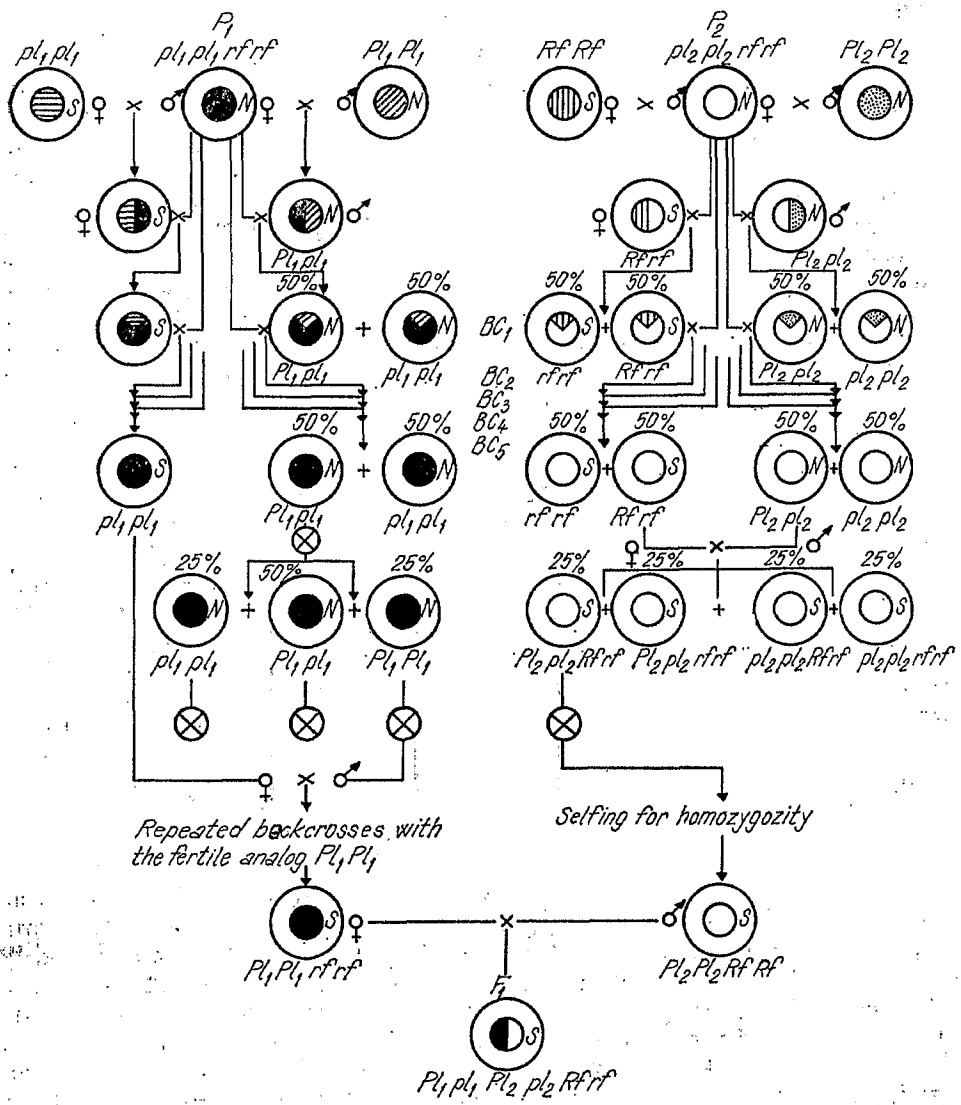

Fig. 1 — The scheme for getting sunflower single hybrids on cytoplasmic male sterility and pollen fertility restoration basis, with two genes for resistance to downy mildew.

The working scheme is presented in figure 1.

The female line (P_1) having the initial idiotype N *pl pl rf rf* is transformed into cytoplasmic male sterile line (A) and the fertile analogous (B) whose continuous reproduction of the line is made with, gets the Pl_1 gene.

The male line (P_2) lacking initially the genes for pollen fertility restoration and for resistance to downy mildew becomes after a succession of 5—6 backcrosses, restoring and resistant, having the idiotype *S Rf Rf* Pl_2 Pl_2.

In all stages of the proposed scheme, identification and maintenance of *Pl* genes is done in special fields for artificial infections and in greenhouses.

Within the CRM group of hybrids obtained on cytoplasmic male sterility basis with pollen fertility restoration and one or two genes for resistance to downy mildew, the single hybrid HS 80 CRM distinguished itself by high seed yields, overyielding the susceptible hybrid Romsun HS 53 by 16% (Table 1). The first three-way hybrids as HT 60 CRM and HT 50 CRM, having as female parent a single cytoplasmic male sterile hybrid with Pl_1 and Pl_2 genes for resistance to downy mildew and as male parent one restoring and resistant line, homozygous for these characteristics, gave also satisfactory results both for seed yield and for oil content in the seed.

Table 1

Performances of sunflower hybrids resistant to downy mildew, produced on cytoplasmic male sterility basis (I.C.C.P.T.-Fundulea, 1972—1974)

Hybrids	Genes for resistance	Seed yield (11% moisture)		% Oil in dried seed (0% moisture)
		kg/ha	%	
HS 80 CRM	Pl_1	3 750	116***	51.1
HS 82 CRM	Pl_1	3 640	112***	51.2
HT 60 CRM	Pl_1, Pl_2	3 580	110**	51.7
HT 50 CRM	Pl_1, Pl_2	3 530	109*	52.0
ROMSUN HS 53	—	3 240	100	51.7

The single and three-way hybrids with broad spectrum of resistance to downy mildew and high oil content, obtained on cytoplasmic male sterility basis, represent a superior stage of sunflower breeding works which will contribute to the radical increase of the economic efficiency of this crop, assuring high and constant seed and oil yields. The extension of these hybrids will permit to reduce the number of years from 6—7 to 3—4 after which sunflowers can be grown on the same land, so that this crop could be concentrated with better results in favourable and very favourable zones for sunflower culture.

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