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TO NEW BROOMRAPE RACES

The history of sunflower cultivation in the Soviet Union proves that breeding for immunity to broomrape is a task of signal importance. Breeders only achieve partial and temporary successes on developing sunflower varieties resistant to broomrape, because new and more virulent broomrape races appear as a result of the linked evolution of the host and parasite.

Today following the breeders victories over "good" and "evil" broomrape, we evidence the third wave of broomrape attack. In some regions of the Soviet Union, in Bulgaria, Romania and Yugoslavia sunflower varieties, recently considered resistant, are now affected by new races. This requires more studies in the field of immunity to improve breeding methods and assure reliable control over broomrape.

Theoretical studies are needed in the field of biology of relationships between sunflower and broomrape so that we can find the nature of immunity towards new races. Studies of nature of sunflower resistance to broomrape have a long history, beginning with the works of A.I. Stebut in 1914-1916 at the Saratov experimental station. There are many literary data with different explanations of the causes of resistance. For example the following causes of sunflower resistance to broomrape were suggested: the concentration level of hydrogen ions (pH) in the cell sap of sunflower roots (A.A. Richter); absence of stimulator of broomrape seed germination in excretions of sunflower roots (N.A. Uspensky); the intensity of sunflower root respiration (B.T. Ukrainsky); hydrocarbon and nitrogen compounds correlation in sunflower roots resulted from differences in photosynthetic intensity (P.A. Pyzhov and L.N. Bereznigovskaya); sunflower leaf synthesis of special che-

mical agents preventing broomrape invasion (I.F. Lyashchenko); a large amount of electrophoretic fractions of water soluble proteins in the sunflower seed (C.I. Shcherback).

Diverse research trends and explanations of the nature of immunity show that there was no right choice of an effective path for research. The common drawback of the past studies was the tendency to find the causes of resistance in the peculiarities of processes such as photosynthesis, respiration, transpiration, pH of the cell sap, which are common to all plants, are related to many links of metabolism and possess a wide range of modifications. The observed correlations between the character of the process under study and the resistance to broomrape were accidental, had no causal connection and were not proved by later research. As a result of such an approach to the nature of immunity no attempts were made until recently to study the anatomic and morphologic picture of broomrape invasion into the root of a resistant sunflower form to determine at what stage of the infection process, where and how the parasite perishes.

In 1973-1975 in the Pustovoit All-Union Research Institute for Oil Crops Anatomic, morphologic and histochemical studies were conducted on the broomrape invasion into the sunflower root and on the peculiarities of defensive reactions in resistant forms. The results obtained are of some importance for the theory of immunity and for improving the breeding methods.

It was found that the early stages of the infection process are similar both in susceptible and in resistant sunflower forms. Broomrape seed germination, formation of growth tube and its invasion into parenchyme; formation of the primary haustorium and its invasion into the zone of the central cylinder take 8-10 days. Further on in susceptible sunflower plants the cells of the primary haustorium start an energetic partition along the direction of vessels, the mass of

the parasite cells invades the xyleme vessels and surrounds them dividing and filling the zone of the central cylinder. Later on some of them differentiate into tracheides, and the common transport system of host and parasite is established; the broomrape develops rapidly and by the 12-14-th day its rounded yellow colour body can be seen with little magnification.

Another picture is observed in resistant plants. When the parasite's haustorium reaches the zone of the central cylinder a protective reaction can be easily seen; the walls of xyleme vessels are thickened by means of an intensive additional lignification. Along with the lignification of the vessels' primary wall, an additional thick layer of lignin coats the vessel wall embracing the primary and secondary covers, and parasite haustorium cannot invade the vessels of the sunflower root. Differentiation of its own vascular system does not take place and the haustorium dies out.

These results are interesting for breeding because they experimentally prove the possibility of an early diagnosis of immunity.

In practical breeding the main method of evaluation is the utilization of infected field background inoculated with broomrape seeds. The evaluation of the plants resistance is based on registration of the number of broomrape floriferous shoots during sunflower flowering. The author of this method is Academician V.S. Pustovoit who was the first to set an infection plot on the experimental field Kruglik in Krasnodar in 1914.

The evaluation of the breeding material in the field by its genotypical resistance to broomrape is made difficult because of the big changeability of the infection index - number of floriferous shoots of broomrape. V.S. Pustovoit (1919, 1937), A.Y. Panchenko (1947) and V.F. Kukin (1962) showed that evaluation can be effected considerably earlier by counting broomrape seedlings on sunflower roots.

These experimental results concerning the nature of the sunflower immunity to new broomrape races prove the possibility of reliable differentiation between susceptible and resistant forms by the 12-14-th day; they served as a base of a method of the early diagnosis of resistance to broomrape developed at VNIIMK. We have determined optimal temperatures and soil moisture levels, illumination conditions, mineral nutrition, and infection loading which provide a reliable infection and rapid broomrape growth necessary for early screening of susceptible forms. This underlay a highly productive method of evaluation of resistance to broomrape in sunflower breeding material on the 23-25th day after seedlings. The method allows a rather exact characterization of the degree of genotypical resistance. It was described in the journal *Vestnik selsk Khozyastvennoi nauki* (Agricultural Science Herald) No. 2, 1975, and is now used extensively.

Being cheap and precise the method opens possibilities of improving the effectiveness of sunflower breeding for immunity and of further shortening of period of developing new broomrape resistant varieties. Determination of resistant forms at an early stage makes it possible to transfer the plants and obtain seeds from them thus sharply increasing the resistance of the progeny.

In 1974-1975 this method was utilized to obtain resistant forms from several commercialized sunflower varieties highly susceptible to broomrape. Results are given in Table 1.

Thus, when the method of early diagnosing is used to select broomrape-resistant forms it considerably facilitates and accelerates the development of initial stocks for breeding for immunity to new races of broomrape and helps reduce the time needed to develop new broomrape-resistant varieties.

Table 1

Effectiveness of Direct Selection by Method  
of Early Diagnosis of Sunflower Resistance  
to Broomrape VNIIMK, 1974-1975

Variety	Percentage of resistant plants		
	in the va- riety	one-fold selection	two-fold selection
Peredovik	6.0	43-82	-
Armavirsky 3497	12.3	57-98	91-100
Zenit	6.1	39-88	-
Moldavsky 3	14.0	85,7	93-100
Romsun 53	23.4	63,0	70-100
Saratovsky 2	40,0	70-97	91-100
Kirovogradsky 23	48.0	68-100	85-100