

SUNFLOWER BREEDING FOR RESISTANCE TO *DIAPORTHE/PHOMOPSIS HELIANTHI* Munt.-Cvet. et al.

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INTRODUCTION

Stem canker caused by *Diaporthe/Phomopsis helianthi* Munt.-Cvet. et al. is one of the most widely distributed diseases of the cultivated sunflower. In recent years, the pathogen has kept spreading in several parts of the world. It was found in Yugoslavia by Mi-haljčević et al. (1980), Muntanola-Cvetković et al., (1981), and Aćimović and Straser (1981 and 1982). *Diaporthe/Phomopsis helianthi* appeared in 1980 in the north-east of Yugoslavia (Vojvodina Province), the south-west of Romania (Banat), and the south-east of Hungary. Herr et al. (1983) state to have observed the first occurrence of *Diaporthe* stem canker on sunflower in 1980 in Wayne County, Ohio. Yang et al. (1983) reported the occurrence of *Diaporthe helianthi* around Dimmitt, Texas, in 1982. There exist clear indications of stem canker presence on sunflowers in Brasil, Argentina and Australia.

Examining a large number of sunflower varieties and hybrids, Skorić (1982) found a high degree of susceptibility to stem canker in all hybrids and the majority of the varieties. The exception were the Soviet varieties Yubileynaya 60 and Progress which had up to 5% of plants in which the pathogen did not reach the stem. However, these plants were mostly incompatible in conditions of self-pollination and they could not be used as a source material in a programme of breeding for resistance to the pathogen. Čuk (1982) reported a certain number of wild sunflower species to be free of *Diaporthe/Phomopsis helianthi* and he assumed these species to be potential sources of resistance to the pathogen.

A large number of researchers have tried to control stem canker in sunflower by different fungicides. Positive results have been obtained in commercial production in Yugoslavia, Hungary and Romania. These results are extremely important because they show that it is feasible to protect sunflower against stem

canker during the growing season, i.e., that it is feasible to grow sunflower with economic profit before new resistant hybrids are produced.

MATERIALS AND METHODS

This report summarizes the results of a series of experiments conducted on over 5,000 inbred lines, 2,000 experimental hybrids analysed each year, more than 50 varieties, and a large number of commercial hybrids from different countries. The experiments were carried out in the period 1980—1984 at the experimental field of the Institute of Field and Vegetable Crops in Novi Sad and the Yugoslavia network of small — and large-plot sunflower trials. During that period, the population of *Diaporthe/Phomopsis helianthi* was very high and the results obtained under field conditions are quite reliable. In 1981, only four lines out of the entire breeding material demonstrated high tolerance to stem canker. Their tolerance was confirmed in subsequent years. The lines have different genetic origin. Two of them were made by crossing the cultivated sunflower with *H. tuberosus*, one originates from a local population from Morocco, the fourth one was derived from the cross *H. argophyllus* × Armavirski 9345. Three of them were converted to cms form and labeled cms Ha 74, cms Ha-BCPI, and cms Ha 22. The remaining one was converted to a restorer line and labeled SNRF-69. These lines were used for the development of resistant hybrids which are presently being introduced into the commercial production. A parallel programme deals with the accumulation of genes carrying tolerance or resistance to stem canker. Within that programme (Ha 74 × Ha 22) × Ha-BCPI were used to develop "B" lines and (Ha 74 × Ha 22) × (Ha-BCPI) × SNRF-69 were used to develop restorers. Growing the materials alternately in the greenhouse and in field, we

produced in a relatively short time a large number of lines with field tolerance or resistance to stem canker.

The intensity of infection was rated on the scale 0—4. The experimental plants were assessed for reaction to stem canker two times during the growing season, at the end of flowering and at physiological maturity. The obtained results are too voluminous to be dealt with in one turn. This report discusses only the most important lines and a few hybrids.

RESULTS AND DISCUSSION

The data presented in Table 1 are sufficiently illustrative to show that *Diaporthe/Phomopsis helianthi* is one of the most pathogenic diseases of sunflower. The results obtained in the network of large-plot trials conducted in 1981 in all sunflower-growing regions of Yugoslavia show that the average yields of the same sunflower hybrids grown in the region free of stem canker and in Vojvodina Province, where the attack by the pathogen was severe, differed by 83—118% in favour of the former region. It means that the pathogen, under agroecological conditions favourable for its development, utterly destroys sunflower plants causing almost total damage.

Table 1

Average seed yields (kg/ha) in 1981 large-plot trials conducted in a region free of stem canker (Slavonija) and the region attacked by the pathogen (Vojvodina)

Hybrids	Slavonija	Vojvodina	Difference in seed yield	
			kg/ha	%
NS-H-26-RM	3.061	1 658	1 403	84
NS-H-27-RM	3 062	1 404	1 658	118
NS-H-33-RM	3 110	1 693	1 417	83

Of the extensive breeding material studied in the five-year period, a high degree of tolerance, i.e., a kind of field resistance, was detected only in the lines Ha 74, Ha 22, Ha-BCPI, and SNRF-69 (Table 2).

Table 2

Reaction of four inbred lines to *Diaporthe/Phomopsis helianthi* in the period 1980—1984

Lines	Intensity of infection (on the scale 0—4)
Ha 22	0—1
Ha 74	0—1
Ha-BCPI	0—1
SNRF-69	0—1
NS-H-26-RM	4

The four lines had the same reaction to *Diaporthe/Phomopsis helianthi* during the five-year research period. These lines invariably had less than 10% of plants attacked by stem canker. The pathogen spread slowly in these plants reaching the stem too late to affect seriously the seed yield. Furthermore, over 90% of plants of these lines remained unattacked to the end of the growing season.

Genetic studies conducted so far have indicated that the resistance to *Diaporthe/Phomopsis helianthi* is not controlled by a single dominant gene. If we cross a highly tolerant, i.e., field resistant line with a susceptible one, the resulting hybrid reveals an intermediate expression regarding the analysed character. On the other hand, the cross of two highly tolerant lines will either retain the parents level of tolerance or it will be more resistant than the parents.

The hybrids between cms Ha 22, cms Ha-BCPI, and cms Ha 74 and the restorer SNRF-69, NS-H-43, NS-H-44 and NS-H-45, may serve as a convincing illustration of the method of developing sunflower hybrids highly tolerant to *Diaporthe/Phomopsis helianthi*. These hybrids have the same genetic potential for seed yield as the hybrid NS-H-RM. However, the realization of the genetic potential for seed yield is significantly higher in NS-H-43, NS-H-44, and NS-H-45 than in NS-H-26-RM due to their high degree of tolerance to stem canker (Table 3).

Table 3

Seed yields of sunflower hybrids highly tolerant to *Diaporthe/Phomopsis helianthi*
Locality : Novi Sad - Year : 1984

Hybrids	Seed yield		Intensity of infection (on the scale 0—4)
	kg/ha	%	
NS-H-26-RM (Check)	1 618	100	4
NS-H-43-RM	2 791	172	0—1
NS-H-44-RM	2 795	172	0—1
NS-H-45-RM	3 108	192	0—1

These experiments were conducted at the experimental field where the population of the pathogen was very high. Susceptible lines were heavily attacked by stem canker, making the obtained research results reliable. It may be expected that the inoculation tests yet to be performed will render the same results.

Presently, the field resistant lines are crossed with susceptible lines. It is also planned to make back-crosses. When these programmes are completed, it will be possible to make the genetic analysis and determine the mode of inheritance of resistance and the number of genes conditioning the resistance to *Diaporthe/*

Phomopsis helianthi.

The results obtained so far are in full agreement with those of Vrânceanu et al. (1983) which indicate that the resistance to *Diaporthe/Phomopsis helianthi* is positively correlated with the character called "stay green" stem. Practically, the resistance to stem canker is positively correlated with the resistance to *Macrophomina phaseoli* and the resistance to drought. Perhaps we deal with linked characters. Our study indicates also that the resistance to stem canker correlates positively with the resistance to *Phoma oleracea* var. *helianthi-tuberosi* since the lines SRB-77 and SRB-169 displayed the resistance to that pathogen under field conditions.

Again, our results confirm those of Vrânceanu et al. (1983) regarding the problems related to the handling of hybrids resistant to stem canker. Green stems of these hybrids complicate combine harvesting and increase the content of organic substances in harvested seed. It is reasonable to expect desiccation to become an integral part of the technology of growing sunflower hybrids resistant to stem canker.

A more intensive inclusion of wild sunflower species in breeding programmes may increase the genetic variability of the cultivated sunflower and make the breeding for resistance to *Diaporthe/Phomopsis helianthi* more successful. The results of Čuk published in 1982 and yet unpublished data of the same author indicate that several wild species are prospective sources of resistance to stem canker, especially *H. argophyllus*, *H. debilis*, *H. tuberosus*, *H. rigidus* and a few more.

CONCLUSIONS

The following conclusions may be drawn on the basis of five-year studies of extensive breeding materials of sunflower :

— It is feasible to control genetically *Diaporthe/Phomopsis helianthi* in sunflower by developing highly tolerant or resistant hybrids.

— A high degree of tolerance, i.e., field resistance, to stem canker was detected in the lines Ha 22, Ha 74, Ha-BCPI and SNRF-69. Their hybrids display the same degree of resistance to the pathogen.

— The resistance to *Diaporthe/Phomopsis helianthi* is most probably controlled by at least two or more complementary genes.

— New lines were derived from hybrid combinations of Ha 22, Ha 74, Ha-BCPI and SNRF-69. These lines, designated SRB-77, SRB-82, SRB-169 and S-1-184, are field resistant to stem canker.

— The resistance to stem canker is positively correlated with the resistance to *Macrophomina phaseoli*, *Phoma oleracea* var. *helian-*

thi-tuberosi and drought. It remains to be seen whether these resistances are controlled by linked genes.

— Several wild sunflower species display resistance to stem canker. They deserve to be included more intensively into sunflower breeding programmes for resistance.

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AMÉLIORATION DU TOURNESOL POUR LA RÉSISTANCE À L'ATTAQUE DE DIAPORTHE-PHOMOPSIS HELIANTHI

Résumé

Un nombre de lignées et hybrides de tournesol a été analysé quant à la réaction à l'attaque du champignon *Diaporthe-Phomopsis helianthi*, dans le champ d'amélioration de Novi Sad. Bien que la plupart des génotypes essayés se sont avérés sensibles, quelques lignées autofécondées hautement tolérantes ont été identifiées, par exemple les lignées Ha 22, Ha 74, Ha-BCPI et SNRF-69. Les hybrides obtenus par le croisement de ces lignées montrent une résistance similaire. Les nouvelles lignées résistantes ont été extraites des combinaisons hybrides de quatre lignées mentionnées ci-dessus. Une très bonne résistance génétique a été également mise en évidence chez certaines espèces sauvages de tournesol.

La résistance vis-à-vis de l'attaque du champignon *Diaporthe-Phomopsis helianthi* semble être conditionnée par au moins deux ou plusieurs gènes complémentaires. Tout en confirmant les données antérieures obtenues en Roumanie, il semble que la résistance est positivement corrélée à la propriété de la tige de rester verte à la maturité.

MEJORA DE GIRASOL PARA RESISTENCIA
AL ATAQUE DE
DIAPORTHE-PHOMOPSIS HELIANTHI

Resumen

Gran número de líneas e híbridos de girasol fue analizado en cuanto a la reacción al ataque del hongo *Diaporthe-Phomopsis helianthi*, en el campo de mejora de Novi Sad. A pesar de que la mayoría de los genotipos testados se mostraron sensibles, se identificaron unas líneas consanguíneas con alto grado de tolerancia, como las líneas Ha 22, Ha 74, Ha-BCPI y

SNRF-69. Los híbridos obtenidos por el cruce de estas líneas poseen una resistencia similar. Nuevas líneas resistentes fueron extraídas de las combinaciones híbridas de las cuatro líneas arriba mencionadas. Una resistencia genética muy buena fue puesta de relieve también en unas especies salvajes de girasol.

La resistencia al ataque del hongo *Diaporthe-Phomopsis helianthi* parece estar condicionada de por lo menos dos o más genes complementarias. Confirmando los datos anteriores obtenidos en Rumanía, parece que la resistencia está correlada positivamente a la característica del tallo de permanecer verde a la madurez.