RECENT RESEARCH ON THE DOWNY MILDEW OF SUNFLOWER IN HUNGARY

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The "downy mildew story" is well-known for all of us. With the introduction of high oil sunflower cultivars into Europe, the downy mildew pathogen, *Plasmopora halstedii* (Farl.) Berl. et de Toni has become one of the most limiting factors of sunflower production throughout the continent. Fortunately, intensive breeding works have started worldwide and, as a result, more and more downy mildew resistant hybrids were released. In addition, an effective chemical control has recently been achieved by using metalaxyl, a highly specific systemic fungicide against downy mildews and related fungi.

In spite of these results, I am afraid, the story has not yet finished. We still have problems, and I would like to mention some of them together with our prospective findings.

In his excellent review of the downy mildew of sunflower, Sackston (1981) has drawn our attention to the lack of knowledge of *P. helstedii* oospores. Although these fungal propagules are of greatest importance in inducing primary infection in the field, we do not know how long they can survive. A crop rotation of 4—5 years is generally recommended for the grower to minimize the risk of disease incidence but there is no guarantee that susceptible sunflower plants escape infection when grown in such fields in subsequent years, particularly if weather conditions favour downy mildew development. For example, in Hungary this year, we observed a disease incidence of about 30% in a field where no sunflower has been grown since 1976, and the susceptible hybrid, Marianne was sown without seed-dressing. It seems likely, therefore, that one of the major subjects in future studies should be the biology of the oospores, their formation, dormancy, viability, and possibly biodegradation.

We have just a few information about the fungus population existing in our countries, as well. We do not know what we exactly have under the names of *P. halstedii* or *P. helianthi.* On the basis of experimental data and field observations of the last 10 years, we can conclude that in Hungary the *P. halstedii* complex exists (Table 1), rather than the highly specialized species *P. helianthi,* as it was earlier indicated by Novotelnova (1966) in the U.S.S.R. Our *P. halstedii* population is able to infect not only wild *Helianthus* species but also other members of the *Compositae.* Thus, *Xanthium strumarium* proved to be a natural host of the fungus in some areas of Hungary.

Table 1

Host plants of *Plasmopara halstedii*

Species	Compatibility	Site
Helianthus annuus (cultivated)	+	N
Helianthus annuus (wild)	+	E
Helianthus annuus × *H. salicifolius*	+	E
Helianthus angustifolius	—	E
Helianthus argophyllus	+	E
Helianthus debilis	+	E
Helianthus decapetalus	—	E
Helianthus divaricatus	+	E
Helianthus doronicoides	—	E
Helianthus grosseserratus	+	E
Helianthus maximiliani	—	E
Helianthus mollis	—	E
Helianthus multiflorus	—	E
Helianthus nuttallii	—	E
Helianthus occidentalis	—	E
Helianthus petiolaris	+	E
Helianthus resinosus	—	E
Helianthus rigidus	—	E
Helianthus salicifolius	—	E
Helianthus scaberrimus	—	E
Helianthus serotinus	—	E
Helianthus strumosus	—	E
Helianthus tuberosus	—	E
Helianthus tuberosus × *H. scaberrimus*	—	E
Artemisia vulgaris	+	E
Centaurea cyanus	—	E
Xanthium strumarium	+	N

N — natural occurrence
E — artificial inoculation

Another subject of further studies would be to continue with work on races or pathogenic forms of *P. halstedii*, particularly on factors affecting pathogenic variability. Table 2 shows *P. halstedii* races and sunflower genotypes reported to date. Although there are four resistance genes against 3 or 4 races, the newly

Table 2

Genes for resistance to races of *Plasmopara halstedii* : a present status

Genes for resistance	Races		Fundulea	South Dakota
	European	Red River		
Pl_1	R	S	S	S
Pl_2	R	R	R	S
Pl_3	R	S	S	S
Pl_4	R	R	—	S
Pl_5	R	R	R	R

discovered South Dakota race is still uncontrolled *. During the last three years we made a number of isolations from various locations in Hungary and collected 35 different isolates of *P. halstedii*. In order to determine their pathogenicity, various sunflower genotypes were inoculated with some of these isolates representing the most important sunflower producing areas of the country. The reactions obtained were compared by means of a disease index (DI%) described earlier (Mohamed and Virányi, 1983), and the results are summarized in Table 3. There are no significant differences between reactions of AD-66 and HA-61, the sunflower lines possessing Pl_1 or Pl_2 genes, respectively. Furthermore, the isolates tested showed slight differences in their pathogenic character on the various sunflower genotypes.Of course, this work has to be continued and extended to more isolates and analyses. We intended to perform, therefore, studies on the genetic base of pathogenicity by using isogenic lines of both the host and pathogen. An international co-operation would be of a great practical importance to scan the *P. halstedii* populations in the European countries concerned, and to test them on a series of host differentials based on the gene pool to be used for resistance breeding.

Integrated plant protection is an increasing demand in agriculture. In spite of their effectiveness, both genetic and chemical control measures are time-consuming and expensive. Any effort, therefore, to increase the natural fitness of sunflower to diseases should be of a practical value. In the recent years a research programme has been carried out in our institute to investigate relationships between

* Dr. J. F. Miller (NDSU, U.S.A.,) reported at the same consultation in Novi Sad about the discovery of a R-gene to be found effective against the South Dakota race of *P. halstedii* in U.S.A.

Table 3

Incomplete resistance of sunflower genotypes to Hungarian isolates of *Plasmopara halstedii*

Isolates	Genotypes		
	GK-70 (susceptible)	AD-66 (Pl_1)	HA-61 (Pl_2, Pl_3)
H-1	100	36	38
H-2	100	48	40
H-5	100	42	40
H-6	98	38	36
H-7	100	62	44
H-8	100	38	36
H-9	100	56	48
H-10	100	38	38
H-12	100	38	36
H-13	98	44	40
H-18	100	36	38
H-19	100	54	46
H-20	100	40	42
H-21	100	34	38
H-22	100	40	42
H-26	100	34	42
H-29	100	56	40
H-30	100	54	42
$\bar{x} \pm s$	99.8 ± 0.7	43.8 ± 8.9	40.3 ± 3.4

Values are given in disease index (DI%) ; based on this, the relative aggressiveness of the isolates tested varied between 83—100%.

nutrient supply of plants and their susceptibility to various pathogens. Thus, experiments have been conducted with sunflower and *P. halstedii* in relation to plant nutrition, and encouraging results have been achieved, in particular when changing the amount of nitrate-nitrogen in the nutrient solution for sunflower plants (Mohamed and Virányi, 1983). Figure 1 illustrates significant altera-

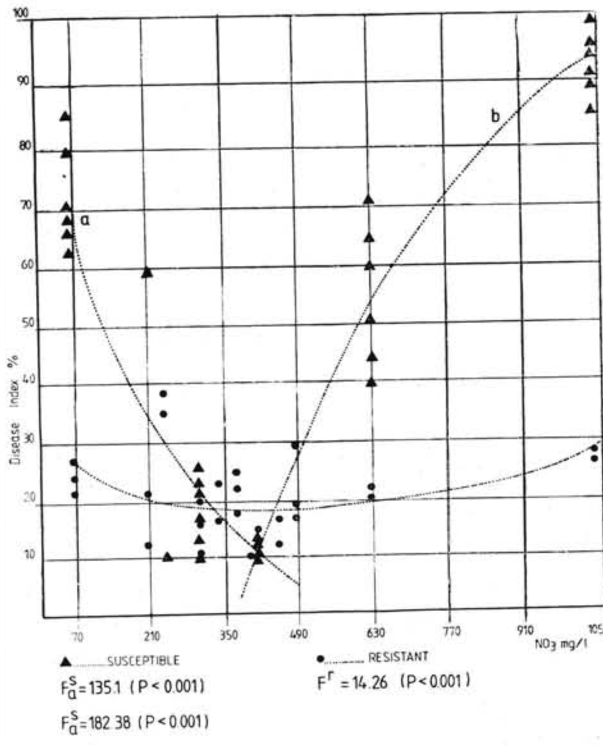

Fig. 1 — Effect of NO_3 — supply on downy mildew development in two sunflower genotypes

tions in the severity of downy mildew in both susceptible and resistant cultivars in relation to NO_3 treatments. The optimum level of nitrogen varied between 370 and 430 ppm, and this interval proved to be the best for plant development as well (Figures 2 and 3). The severe stunting obtained with susceptible sunflower either at low or extremely high levels of nitrate may be the result of an increased susceptibility to the pathogen or, more likely, a combination of this with altered plant response to unfavourable nutrition. Although the results obtained in our model experiments would necessitate field trials as well, one can conclude that the amount of nitrogen fertilizer may influence, either positively or negatively the behaviour of sunflower in the field, and might be a tool in the grower's hand to improve the effectiveness of disease control.

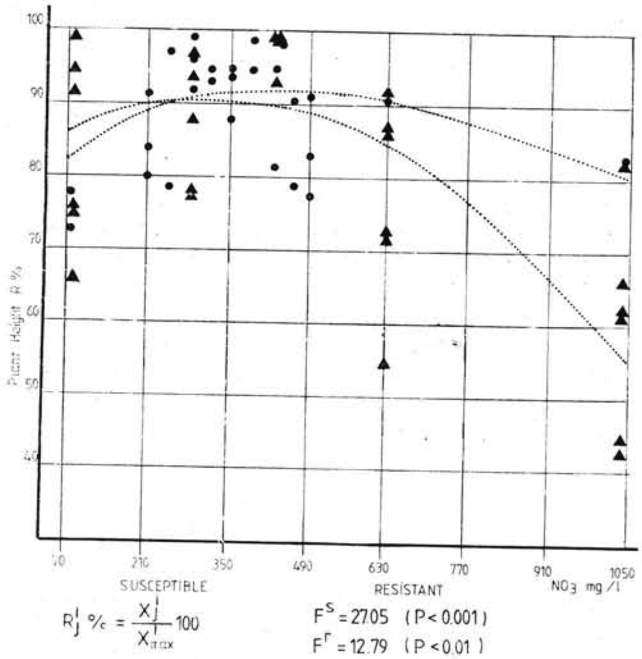

Fig. 2 — Plant growth pattern of mildewed sunflower in relation to NO_3 — supply

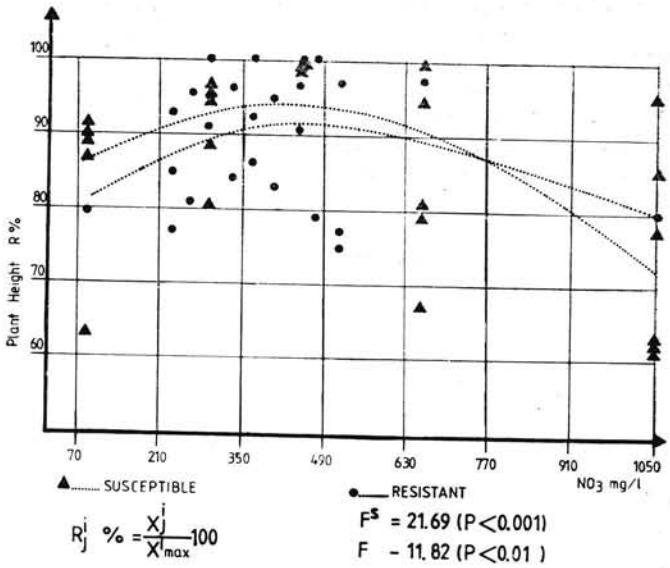

Fig. 3 — Plant growth pattern of healthy sunflower in relation to NO_3 — supply

Although metalaxyl has a good efficacy against the downy mildew of sunflower, the phenomenon of fungicide resistance is apparently approaching. Resistance to metalaxyl in the *Peronosporales* has already been shown in various countries (Table 4), and this was the case with *P. halstedii* under greenhouse experimental conditions as well (Oros and Virányi, unpublished). To avoid the occurrence of such resistant mutants or to postpone their appearance, efforts are made worldwide. Theoretically, there are several possibilities for this : (1) the use of other acylalanines might be good if no cross-resistance occurs ; (2) the combined application of metalaxyl with one of the contact fungicides may help against locally infecting downy mildew ; (3) developing a new chemical with at least the same activity seems to be difficult, and (4) the combination of two systemic compounds may improve the fungicidal effect. In our institute we have chosen the last mentioned possibility, and we have

Table 4

Acquired resistance to metalaxyl in the ***Peronosporales***

Species	Probability	Location	Year	References
Pythium ultimum	—	Canada	1982	Bruin and Edgington
Phytophthora infestans	10^{-6}—10^{-7}	The Netherlands	1981	Davidse et al.
Phytophthora infestans	—	UK	1981	Cooke
Phytophthora infestans	—	Ireland	1981	Dowley and O'Sullivan
Phytophthora infestans	10^{-7}	U.S.S.R.	1982	Dyakov et al.
Phytophthora infestans	—	Israel	1983	Cohen and Reuveni
Phytophthora megasperma f. sp. *medicaginis*	—	The Netherlands	1981	Davidse
Phytophthora megasperma	—	U.S.A.	1982	Hunger et al.
Phytophthora caspici	—	Canada	1982	Bruin and Edgington
Pseudoperonospora cubensis	—	Israel	1980	Reuveni et al.
Pseudoperonospora cubensis	—	Greece	1981	Georgopoulos and Grigoriu
Peronospora hyoscyami f. sp. *tabacina*	—	U.S.A.	1982	Bruck et al.
Plasmopara viticola	—	France	1982	Clerjeau and Simone
Plasmopara viticola	—	Switzerland	1983	Bosshard and Schüepp
Plasmopara halstedii	10^{-6}—10^{-7}	Hungary	1982	Oros and Virányi

developed a fungicide that is still under patent process. In both greenhouse and field trials it seemed to be promising against *P. halstedii* and other related species of the *Peronosporales*. This fungicide showed several advantages over metalaxyl in our case.

Considering the modern perspective of plant protection, we have to employ any kind of control measures that enables us to protect sunflower crop economically and with no hazard.

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RECHERCHES RÉCENTES CONCERNANT LE MILDIOU DU TOURNESOL EN HONGRIE

Résumé

Certaines considérations sont faites sur le mode de propagation du champignon, particulièrement par oospores, et sur les formes de mildiou existant à présent en Hongrie. Il y a déjà une population complexe de *Plasmopara halstedii*, en mesure d'attaquer non seulement le tournesol cultivé, mais aussi d'autres espèces de *Helianthus*, ainsi que certains membres de la famille de Compositae *(Xanthium strumarium)*.

À la suite de l'étude effectuée avec deux différentiateurs : AD-66 (Pl_1) et HA-61 (Pl_2) on n'a pas mis en évidence des différences concernant la pathogénité des 35 isolés de *P. halstedii*, récoltés des différentes localités de Hongrie. Une étude plus complète des souches de ce parasite pourrait être réalisés par une collaboration internationale dans ce domaine.

Les principales pratiques culturales menant à la prévention et à la lutte contre les maladies du tournesol, sont considérées. Le niveau optimum d'azote (NO_3), tant pour le développement des plantes, que pour l'attaque des maladies, est situé entre 370—430 ppm.

Bien que les traitements à methalaxyl se sont avérés très éfficaces contre l'attaque des *Peronosporales*, il est nécessaire de trouver et d'utiliser aussi d'autres produits chimiques, afin d'éviter l'apparition des mutants résistants du pathogène.

Dans l'Institut pour la protection des plantes on a choisi la voie des combinaisons à deux produits systèmiques, afin d'améliorer l'effet fongicide. Un nouveau fongicide est déjà découvert et il est en voie d'être homologué.

INVESTIGACIONES RECIENTES CONCERNIENDO EL MILDIU DE GIRASOL EN HUNGRÍA

Resúmen

En et trabajo se hacen algunas consideraciones en cuanto al modo de propagación del hongo (especialmente por oosporas) y las formas existentes actualmente en Hungría. Ya existe una probación compleja de *Plasmopara halstedii*, que es capaz de atacar no sólo el girasol cultivado sino también otras especies de *Helianthus* y asimismo algunos miembros de la familia Compositae *(Xanthium strumarium)*.

Tras el estudio ejecutado con dos diferenciadores AD-66 (Pl_1) y HA-61 (Pl_2) no se han puesto de relieve diferencias en cuanto a la patogenidad de 35 aisladas de *P. halstedii* cosechadas de diferentes lugares de Hungría. Un estudio más completo de las razas del parásito podría realizarse por una cooperación internacional en este dominio.

Están apreciadas las principales medidas agrofitotécnicas para prevenir y combatir las enfermedades del girasol. El nivel óptimo de nitrógeno (NO_3) se ha situado entre 370—430 ppm, tanto para el desarrollo de las plantas como para el ataque de enfermedades.

A pesar de que los tratamientos con metalaxyl se mostraron muy eficaces en contra del ataque de *Peronosporales*, para evitar la aparición de mutantes resistantes del patógeno hace falta que se encuentren y se empleen también otros productos químicos.

En el cuadro del Instituto de protección de las plantas se ha elegido el método de la combinación de dos productos sistémicos para mejorar el efecto fungicídico. Un nuevo fungicida eficaz ha sido ya descubierto y está en vía de homologación.