THE EFFECT OF *PHOMOPSIS* SP. INFECTION OF GRAIN YIELD AND OIL CONTENT ON SUNFLOWER PLANTS

Dr. MILIVOJE AĆIMOVIĆ
Institute of Field and Vegetable Crops
Novi Sad, Yugoslavia

INTRODUCTION

A great number of diseases attacks the sunflower plants. According to free estimations, diseases bring reduction of grain yield from 20 to 50%. It is very hard to give the exact estimation of yield decrease caused by a higher or lower infection rate and because of that there are not too many data in literature.

When the epidemic of wilted plants caused by the fungus *Sclerotium bataticola* occurred in Yugoslavia, we found out that the reduction in grain yield ranged from 20 to 50% (Aćimović, 1962).

The occurrence of *Phomopsis* epidemic on sunflower in early 80's resulted in quadruple decrease of acreage under this plant.

We wrote about the decrease in yield the next lines : „Higher infection rates were achieved if plants were infected before flowering than at the stage of flowering and it was almost ineffectual after the stage of flowering. In the first case, the reduction in yield was 50% even more, in the second 20—30% and in the third case, when the plants were infected at the stage of milk maturity, it was 10—20% and at the stage of waxy maturity it was practically inffective" (Aćimović et al., 1982 b). These facts were stated according to free estimation.

Our intention was to have some precise data about this. It was very difficult to eliminate the spontaneous infection of some other parasites on sunflower in the field conditions to be able to determine the harm caused only by *Phomopsis*. However, at the stage of vegetation in 1983, there was no great attack of *Phomopsis* or some other parasites until the stage of flowering. We took this advantage and inoculated uninfected plants with the pure culture (micelium) of *Phomopsis* in the middle of the stem. The success of inoculation was excellent, and the differences in yield between the uninfected and infected plants were great. It determined us to repeat this in 1984 but with more details. This time, sunflower plants were inoculated at all development stages. The aim of our work was to determine the degree of reduction in grain yield of plants infected by *Phomopsis* as compared to the uninfected plants.

MATERIALS AND METHODS

The experimental material was sown on 6th April, 1984 in the experimental field of the Institute of Field and Vegetable Crops in Novi Sad. The trial was founded with the seed of hybrid material NS-H-26-RM in four replications. There were 60 plants on the trial. The distance between rows was 0.7 m and between plants within rows 0.3 m.

According to our knowledge, the mass infection of sunflower with *Phomopsis* usually starts at the stage of flowering, and consequently the decrease in yield is the highest in that period. The infection of sunflower with this fungus in an earlier stage is rare.

Phomopsis affects leaves, stem and head, but the greatest harms are when the stem is affected because in that case plants wilt quickly and become dry.

Because of these and some other reasons, we chose three main developing stages for inoculation : budding, flowering and post-flowering.

At the stage of budding we made one inoculation in the middle of the stem.

At the stage of flowering we made five inoculations :

— one inoculation in the second internode ;
— one inoculation in the middle of the stem ;
— one inoculation in the head ;
— three inoculations in the second internode, and in the middle of the stem ;
— three inoculations the second internode, in the middle of the stem and in the top internode.

After flowering we made two inoculations :

— one in the middle of the stem ;
— one in the head.

Inoculation was performed by the "toothpick" method with the pure culture of *Pho-*

mopsis, isolation "Novi Sad" grown on nutritious medium of potatoes-dextrose agar.

From the beginning of vegetation period we followed the state of plant health and all spontaneously infected plants before and after inoculation were removed from the experimental field.

Inoculation was successful in each combination. Parallelly with the inoculated combinations, we had two controls : one untreated and one treated with atomizer M-10 with 2 kg of Benlate and 800 l/ha of water.

In the course of vegetation period there was no combination infected spontaneously with *Phomopsis.* At the end of the vegetation period, when the plants infected with *Phomopsis* were already wilted, plants in the control field wilted also because of spontaneous infection with *Sclerotium bataticola.*

During the harvest, we measured the yield of each combination, and analysed it statistically. We also determined the oil content and the content of the main fatty acids which also were statistically interpreted.

RESULTS AND DISCUSSION

In our previous examination of spontaneous infection we noticed that the infection rates were achieved regularly on the stem between the fourth and seventh pair of leaves, and the highest infection was between the fifth and sixth pair of leaves (Aćimović et al., 1982 a). As we mentioned before, the first infection occurs rarely before the stage of flowering. However, after occurrence of the first infection it can spread till the end of the vegetation period, if weather conditions are suitable (Aćimović et al., 1982 b). Because of that, we included in our examination the greatest period of vegetation, with the main stage of development and as the central point of inoculation the middle of the stem, because the spontaneous infection occurs most usually between the fifth and the sixth internode.

The results presented in Table 1 show that the success of artificial inoculation varied from 39.26—100% depending on the site and time of inoculation.

The highest infection rates were achieved with inoculation in the middle of the stem at the stage of budding, while it was lower at the stage of flowering and much lower at the post-flowering stage. The same was noticed with the head inoculation. If performed at the stage of flowering, the inoculation is higher in relation to the post-flowering stage. The conclusion can be that the older plants are more resistant to the infection in relation to the younger plants, which are more sensitive to *Phomopsis.*

The highest infection rate (100%) was achieved in all the cases with inoculation in the second internode and the lowest infection with the head inoculation. This can be explained by the favourable conditions for infection (temperature and moisture), in the site of the second internode where the intensity of the sun rays is weak, while in the head site the air moisture is lower, temperature is higher so that the head and inoculum are directly disposed to ultra violet rays of the sun, what is very unfavourable for the infection.

Table 1

Effect of time, site and number of inoculations with *Phomopsis* on sunflower yield and oil content

No	Time of inoculation	Site and number of inoculation	% wilted plants	Seed yield mc/ha $\bar{x}$	% oil in seed
1	Budding	One, middle of the stem	97.73	6.85	36.51
2	Flowering	One, second internode	100.00	10.20	34.33
3	Flowering	One, middle of the stem	92.50	15.68	39.22
4	Flowering	One, head	41.11	5.14	34.68
5	Flowering	Two, second internode, middle of the stem	100.00	6.45	35.74
6	Flowering	Three, second internode, middle of the stem, top internode	100.00	4.51	35.09
7	Post-flowering	One, middle of the stem	63.04	36.04	44.58
8	Post-flowering	One, head	39.26	33.54	43.47
9	Untreated control	—	48.39	37.47	45.13
10	Treated control	—	21.80	40.54	44.46
	L.S.D. 1%			11.90	
	L.S.D. 5%			8.81	

In our previous investigations we established the unequal number of spots in spontaneous infection of sunflower plants. Usually it was from 1 to 7 and the average number was 5 (Aćimović et al., 1982 a). We inoculated the sunflower plants at different sites once, twice and three times, at the stage of flowering. The results of Table 1 show that the highest infection rate (100%) with one inoculation on different sites, was achieved with inoculation into the second internode, it was lower in the middle of the stem and the lowest in the head.

Two inoculations into the second internode and in the middle of the stem and three into the second internode, in the middle of the stem and in the top internode, brought the highest infection rate (100%).

The occurrence of the symptoms on all combinations lasted for 3—5 days. The highest infection and spots were on plants inoculated at the stage of budding (10—30 cm) and after 10 days the plants wilted. But, on plants ino-

culated at the stage of flowering the plants wilted after 5 days, and at the post-flowering stage it occurred after 20—25 days. There was no spontaneous infection of sunflower with *Phomopsis* on controlled fields. The percentage of wilted plants on combinations 9 and 10 was caused by the fungus *Sclerotium bataticola.*

The yield was the lowest in the combination with the greatest number of inoculations (three), then with one in the head and with two at the stage of flowering, and in combination with one inoculation at the stage of budding. It is interesting to emphasize that two combinations, that were inoculated once into the second internode and in the middle of the stem, at the stage of flowering gave the same yield as that obtained in production during the epidemic of *Phomopsis* on sunflower in 1980, 1981, and 1982.

However, both combinations inoculated after flowering gave high yields, what is the same case with the control field. The yield obtained from the last four combinations (7, 8, 9 and 10) is real, because similar yields were brought by some producers on a large scale production during the low infection with *Phomopsis.*

Table 2

Effect of inoculation with *Phomopsis* on fatty acids composition of sunflower oil

No.	Time of inoculation	Site and no. of inoculations	Palmitic	Stearic	Oleic	Linoleic
1	Budding	One, middle of the stem	7.10	4.66	18.18	68.25
2	Flowering	One, second internode	6.75	5.10	24.10	62.17
3	Flowering	One, middle of the stem	6.89	4.79	22.12	64.27
4	Flowering	One, head	7.02	4.77	20.92	65.65
5	Flowering	Two, second internode and middle of the stem	7.11	4.96	20.87	65.21
6	Flowering	Three, second internode, middle of the stem, top internode	6.97	4.92	20.93	65.21
7	Post-flowering	One, middle of the stem	6.63	4.39	23.08	64.04
8	Post-flowering	One, head	6.82	4.12	22.85	64.51
9	Untreated control	—	6.68	4.10	22.54	64.97
10	Treated control	—	6.49	4.42	23.87	63.55
	L.S.D. 5%		0.46	0.46	2.43	2.16
	L.S.D. 1%		0.63	0.62	3.28	2.90

The oil content is also real. It was significantly high in controls, but reduced in combinations inoculated with *Phomopsis.* Significant reduction in oil content was noticed in the combinations that brought significantly reduced yield. The last four combinations, two inoculated after the stage of flowering and two controls had the same oil content as in the large scale production in 1984.

The effects of inoculation with *Phomopsis* on the content and ratio of the essential fatty acids are presented in Table 2. The inoculations brought about significant changes in this respect. For example, the lowest content of palmitic acid was in the treated control and significantly higher content in combinations 1, 4, 5 and 6.

The lowest content of stearic acid was in the untreated control. Significantly higher content was in all combinations inoculated at the stage of budding and flowering (1, 2, 3, 4, 5, 6).

The lowest content of oleic acid was in the combination inoculated at the stage of budding. Significantly higher content of oleic acid was in all the other inoculated combinations and in the treated and untreated controls.

The lowest content of linoleic acid was in the combinations inoculated at the stage of flowering. Significantly higher content of linoleic acid was in the inoculated combinations 1, 2, 3, 4, 5, 6, and 8 in the untreated control.

CONCLUSIONS

The experimental results presented in this paper show that the inoculation with *Phomopsis* brought significant reduction in grain yield and oil content, and significant changes in the content and ratio of essential fatty acids in sunflower oil.

The highest infection rates were achieved with one inoculation in the second internode or in the middle of the stem at the stage of flowering (100 and 92.50%, respectively), one inoculation at the stage of budding (97.73%), and two or three inoculations at the stage of flowering (100% in either case). The lowest infection rates were obtained with the inoculation in the head, regardless of the stage of development.

Grain yield and oil content varied in dependence on the time, site and number of inoculations. One inoculation in the middle of the stem was more detrimental to oil yield if performed at the stage of budding than at the stage of flowering. One inoculation in the head at the stage of flowering was more detrimental to grain yield and oil content than one inoculation after the stage of flowering. Two or three inoculations at the stage of flowering brought considerable reduction in grain yield and oil content. All variants of inoculation at the stage of budding (1) and flowering (2, 3,

4, 5 and 6) brought significant reductions in grain yield in relation to the variants of inoculation after flowering (7 and 8) and both controls (9 and 10).

The inoculations brought about significant changes in the content and ratio of the essential fatty acids in sunflower oil.

REFERENCES

Aćimović M., 1962, *Sclerotium bataticola* Taub. *as an agent of sunflower wilt in Vojvodina*, Plant Prot. 69—70, 125—138 (in Serbo-croatian, English summary).

Aćimović M., et al., 1982, *Phomopsis* sp. *novi parazit suncokreta*, Zaštita bilja, br. 160 : 117—158, Beograd.

Aćimović M. et al., 1982, *Mogućnost suzbijanja Phomopsis sp. i ostalih prouzrokovača bolesti suncokreta*, Zaštita bilja, br. 161 : 293—299, Beograd.

EFFET DE L'ATTAQUE DE *PHOMOPSIS* SP. SUR LE RENDEMENT EN GRAINES ET LA TENEUR EN HUILE DU TOURNESOL

Résumé

Les expériences ont été effectuées en 1983, année caractérisée par des infections naturelles faibles de l'entier complexe de pathogènes, particulièrement jusqu'à la floraison. Des plantes saines de tournesol ont été inoculées au milieu de la tige avec une culture pure de mycélium de *Phomopsis* sp. En 1984, les expériences ont été développées, les infections étant effectuées à plusieurs stades de développement de la plante.

L'attaque a diminué proportionnellement le rendement en graines, la teneur en huile et a déterminé des changements significatifs de la composition de l'huile.

La plus forte infection a été obtenue lors d'une seule inoculation pendant la floraison, au deuxième entre-noeud ou au milieu de la tige, ou une seule fois pendant la phase de bouton floral, au milieu de la tige. Des résultats également bons, ou même meilleurs ont été obtenus par inoculations concomitantes pendant la floraison, au deuxième entre-noeud et au milieu de la tige, ou au deuxième entre-noeud, au milieu de la tige et au dernier entre-noeud. L'inoculation au capitule s'est soldée par des infections plus faibles.

La plus forte diminution du rendement en graines a été provoquée par les inoculations prématurées. Le rendement en graines et la teneur en huile ont diminué presque proportionnellement au nombre d'inoculations de la même plante. Les plus importants changements de la proportion des acides gras ont été produits par les inoculations au milieu de la tige, en phase de bouton floral et au deuxième entre-noeud, pendant la floraison.

EFECTO DEL ATAQUE DE *PHOMOPSIS* SP. SOBRE LA PRODUCCIÓN DE SEMILLAS Y EL CONTENIDO DE ACEITE EN EL GIRASOL

Resúmen

Los experimentos se efectuaron en el año 1983, se caracterizaron por infecciones naturales suaves de todo el complejo de patogenes, especialmente hasta el florecimiento. Se inocularon plantas sanas de girasol, a la mitad del tallo, con cultura pura de micelio de *Phomopsis* sp.

El ataque redujo proporcionalmente la producción de semillas, el contenido de aceite y produjo asimismo cambios notables en la composición del aceite.

La más fuerte infección se obtuvo al efectuar la inoculación una sola vez, durante el florecimiento, en el seguando entrenudo o en la mitad del tallo, o bien una sóla vez durante la fase de botón floral, en la mitad del tallo. Resultados igualmente buenos, o hasta mejores, se obtuvieron con inoculaciones concomitantes, durante el florecimiento, en el segundo entrenudo y en la mitad del tallo, o bien en el segundo entrenudo, en la mitad del tallo y en el entrenudo postrero. La inoculación en el capítulo se acabó con infecciones mucho más suaves.

La producción de semillas fue disminuída especialmente por las inoculaciones tempranas.

La producción de semillas y el contenido de aceite se redujeron casi proporcionalmente con el número de inoculaciones en una misma planta. Los cambios más importantes en la proporción de acidos grasos fueron producidos por las inoculaciones en la mitad del tallo, durante la fase de botón floral y en el segundo entrenudo, durante el florecimiento.