OUTLOOK FOR BREEDING SUNFLOWERS WITH REFERENCE TO DISEASE RESISTANCE AND IMPROVEMENT OF OIL CONTENT AND QUALITY

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The wide extension of sunflower growing was followed also in Hungary by the appearance of various sunflower diseases. The decline in yield caused by these diseases and the simultaneous deterioration of oil quality, mainly an increase of oil acid number, are a steadily rising pre-occupation for sunflower growing farms as well as for the vegetable oil industry.

Until the early forties - while the sunflower was grown on lesser areas dispersedly - only the more or less important damages from sunflower pyralid moth (Homoesoma nebulellum) and sunflower broomrape (Orobanche cumana) have been known (Fig. 1 and 2). By the production of "Moth resistant" sunflower varieties within a few years, this damage practically ceased. For a final solution of the broomrape problem we had to wait a little more, but by the introduction of broomrape resistant Soviet sunflower varieties of high oil content, also this problem was solved.

A large-scale spread of various, mainly fungus diseases of sunflower occurred chiefly in the last five years. This is due mainly to the extremely rainy weather of these years. An increasing nutrient, mainly nitrogen supply, highly favouring the fungus diseases, contributed also much to their spread. In many places also the adverse practice of an unadequate crop sequence has been followed.

Main Sunflower Diseases Occurring in Hungary

In the sequence of appearance, the first sunflower disease is the Downy Mildew (Plasmopara halstedii) usually damaging young sunflower plants with four to six leaves. On severely infected areas and mainly in a humid warm weather, the mildew sometimes causes 30 to 50 percent mortality in the plants and corresponding yield losses. In some years, it damages also more developed sunflower plants with 10 to 14 leaves. In such cases, part of the plants "out grow" the disease, but many of them remain dwarf, have heads with poorly set, mostly empty seeds (Fig. 3).

Experience gained so far indicated that the cultivated sunflower varieties are more or less infected with the downy mildew. By a harmonious nutrient supply, but mainly by the strict observance of a proper crop sequence, which means, that on the same field, after sunflower, no sunflower should be grown, at least for five years, this disease can be effectively controlled.

Next in the sequence is the white mouldy stem and head rot of sunflowers caused by Sclerotinia sclerotiorum. Also this fungus disease appears often at a very young age, at the stage of 6 to 8 leaves, but its mass appearance

occurs only at flowering time. This results in both cases in the mortality of plants. If the symptoms of disease appear only at the beginning of ripening, on the stem or on the head, part of the yield can be harvested (Fig. 4).

According to our observations made so far, it can be stated that the sunflower varieties grown today are infected at a lesser or greater rate, depending upon the weather and the infection of soil. Yield losses can be as high as 10 to 30 percent. Besides, the amount and quality of oil, as it will be seen further on, decrease at a significant rate as well. Abundant nutrients, mostly on one-sided nitrogen supply, can multiply the infection rate. A similar effect is produced by an inadequate crop sequence. The best practical way to control this fungus is the dressing of seeds and the strict observance of a proper crop sequence.

The grey mould disease of sunflower caused by Botrytis cinerea is, at least in Hungary, a typical sunflower-head disease occurring on sunflowers in maturation. Usually only part of the fruits of affected plants perish. Yield losses range from 5 to 30 percent, depending upon variety and weather. Besides, as it will be seen further on, losses occur in oil content and oil quality (Fig. 5).

Our cultivated sunflower varieties are susceptible to the Botrytis disease. In rainy autumn weather, heavy damages occur mostly on infected areas. According to experiences made so far, damages can be moderated by seed dressing and by the strict observance of a proper crop sequence, but mostly by abundant phosphorus and potassium fertilization.

Of the Macrophomina disease of sunflower (Macrophomina phaseoli) we took notice only in the last years. It appears in greater patches at the time of maturation. Diseased plants start wilting and show a slow forced maturation. The Alternaria disease of sunflower (Alternaria zinniae) appears with similar symptoms. As a result of the forced maturation thousand-grain-weight and yield show a decrease. Oil content and quality remain nearly unchanged. According to estimates a yield decrease of 5 to 10 percent can be reckoned with depending upon the rate of infection (Fig. 6).

Our cultivated varieties are susceptible to these two diseases as well. No effective control method is known as yet. It has been encountered so far mostly in places where sunflower has been cultivated after sunflower within less than four to five years. The observance of a proper crop sequence is recommendable also from this point of view.

The sunflower rust (Puccinia helianthi) usually appearing in Hungary only after flowering on the maturing sunflower did not cause at least so far, more severe damages. All sunflower varieties cultivated in Hungary are susceptible to rust. In our control experiments, chemicals with "Zineb" content proved to be effective. Under farm-scale conditions, only spraying from aircraft can be taken into account because of the high closed stand of sunflower (Fig. 7).

The kernel necrosis (X infection) of sunflower appears in the shoulder region of the otherwise sound kernel as a burnt spot of 0,5 to 1,5 mm diameter. According to observations made so far, this disease causes no losses in yield, or oil content but affects oil quality more than any

other diseases (Fig. 8).

Our cultivated sunflower varieties show an infection of 5 to 25 percent, depending on year and variety. The cause thereof is unknown. Its development is not essentially influenced either by weather, or by the conditions of nutrient supply. The infection rate - as generally in fungus diseases - is closely related with the thickness of pericarp. Infection rate is essentially higher in "thin coated" black sunflower varieties than in "thick coated" striped sunflower varieties.

Effect of Yield Damaging Diseases on the Quality of Oil-mill Sunflower

On the basis of research results some useful advice can be offered to practice, as already seen, on how to reduce injuries caused by the above listed sunflower diseases. The possibilities of control being, however, limited, depending from the crop year and the cultivated varieties yields more or less infected mainly by Sclerotinia and Botrytis are delivered to the oil mills for processing. Therefore, the deteriorating effect of these two diseases on seed quality had to be more thoroughly examined.

For the examinations, a great number of healthy and diseased fruit samples were collected before harvest from standing sunflower fields. Results of the oil and acid number analysis thereof are shown in Table 1. As seen from the data, Sclerotinia and Botrytis diseases sometimes cause heavy, 4 to 10 percent losses in oil content. On the other hand oil acid number show a fivefold or tenfold increase, as the utilizable oil quantity decreases in proportion with the increase in acid number.

In the heads of sunflowers affected by Sclerotinia and Botrytis a lesser or greater part of achenes are becoming typically shabby in the striped sunflower varieties and are fading and losing their shine in black sunflowers of high oil content. In the lots delivered to the mills, the damaged seeds can be readily recognized (Fig. 9, 10, 11, 12). It was evident to continue the examination of apparently diseased fruits with the purpose of establishing the connections between changes in the kernel and deterioration in the quality of oil. After husking, part of these shabby, faded, shine-lost sunflower heads were found to show a characteristic turning into brown of a part or the whole kernels (Fig. 13). The proportion of sound, half-browned and completely browned kernels is changing according to varieties, as seen from data of Table 2. While from the shabby fruits of the domestic striped sunflower 89 percent, in the black sunflower varieties only 40 percent were sound. The other 11 percent and 60 percent, respectively, showed various rates of browning.

In a further step, the acid number, peroxide number and tocopherol content of the oil pressed from sound, half-brown and totally brown kernels were examined separately. As seen from data on Table 3, the acid number and peroxide number show a notable increase, whereas the tocopherol content decreases in both varieties with the progress of the browning degradation of kernels.

The fatty acid compositions of various oil samples was analyzed as well. According to data of Table 4, neutral oil is decomposed by fat decomposing lipase enzyme in the same way as by artificial hydrolysis.

Consequently, the free fatty acid content increased by enzyme activity did not change at an essential rate the fatty acid composition either in the neutral oil, or in the free fatty acids.

Further examinations could eventually decide the question, whether in case of a heavy degradation, with an about 50 percent rate of free fatty acids the fatty acid composition changes compared to neutral oil.

According to our examinations outlined the rate of browning of kernels in the shabby, faded fruits infected with Sclerotinia and Botrytis is closely related with the degradation of oil quality. In the knowledge of these numerical relations, the oil quality of a sunflower seed lot can be concluded upon by a comparatively simple test not requiring any device.

The Method and Outlook of Breeding for Resistance

The appearance and spread of different sunflower diseases, as seen in the foregoing, depends on many circumstances. Consequently, the rate of infection, registered in different crop years and at different places, only indicates the differences between varieties and does not express their genetically founded susceptibility, or resistance, respectively. Data of Table 5 e.g., offer information only on the rate of infestation in 1967 of the sunflower varieties mentioned with the different sunflower diseases under the existing ecological conditions. It seemed necessary therefore, to develop a method, the application of which could greatly increase the reliability of selection, and eliminate the modifying effect of environmental factors on the spread of diseases. Therefore, in the following years, large-scale provocation trials have been performed on superficial and interstitial infections with isolated Botrytis strains and diverse sclerotium suspensions. In the course of these experiments, the natural infection rate could be raised by 20 to 30 percent (Fig. 14).

In 1969, a further step was made: the numerous lines and registered material, respectively, originating from different varieties and crossing were sown in an isolated pathologic nursery, in which previously sunflower was sown in three successive years. To assure favourable conditions for the propagation of various fungus diseases, the field has been provided with an extra great dose of organic manures and unilateral nitrogen fertilizers. On the other hand, a large amount of diseased sunflower stems and heads collected in the surroundings have been ploughed into the soil every year to increase also by this measure the possibilities of infection.

Artificial inoculations into the sunflower heads have not been carried out, which made possible the registration of the sole effect of natural infection. In the course of the experiment, 360 lines of striped sunflower varieties (kernel average 65 percent, oil content 38 to 40 percent) and 144 ones of black sunflower varieties (kernel average 70 percent, oil content 48 to 50 percent) have been observed, in total 10,800 plants, not including the standards.

Table 6 shows the infection rate of the occurred diseases. As seen from the data, 10 percent of the whole stand of the striped varieties and 3.4 percent of the black varieties remained sound. On 30 to 40 percent of the total plant stand, two or three diseases appeared at the same time. It was found, as expected, that parallel with a decrease in

pericarp thickness, the occurrence and damage of sunflower head diseases increased.

Considered methodologically, from the side of selection, it can be seen, that in the pathologic nurseries prepared in this way, and completed with an artificial inoculation of the heads, also a group resistance trial of ready varieties or varietal hybrids can be carried out.

Naturally, these resistance trials can be joined to the starting of lines from seemingly healthy individuals, which can be utilized further on at will in later breeding works of any direction.

The low number of plants having remained healthy in our pathologic nurseries, however, shows in advance, that the breeding of sunflower for resistance charges the breeders with the solution of numerous problems, Only an extensive, well coordinated, enduring and rather expensive work is likely to result in the production of sunflower varieties and hybrids resistant or at least tolerant to diseases urgently needed in commercial growing and in the vegetable oil industry!

Ladies and Gentlemen!

I wish to remark finally, on the basis of the above said that it seems very likely that in countries, where a more extensive sunflower growing is under development, and the ecological conditions are similar to ours, earlier or later similar problems will arise, eventually in the same order, I wish to hope, therefore, that my modest report will give some useful advices and ideas to colleagues working in these countries and will save them many troubles and expenses, for which we have paid already the tuition-fees.

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Table 1 - Oil Content and Oil Acid Number in Sunflower Fruit Infected with Sclerotinia and Botrytis in 1967.

State of Health of Fruit	Oil Content Percent		Acid Number	
	Striped Sunflowers	Black Sunflowers	Striped Sunflowers	Black Sunflowers
Healthy	39,86	47,40	0,65	1,13
Infected with Stem Sclerotinia	33,91	43,32	0,43	1,42
Infected with Head-Sclerotinia	31,53	39,94	5,51	10,17
Infected with Head-Botrytis	28,70	40,93	3,20	9,26

Table 2 - Percentage Composition of Shabby and Faded Sunflower Fruits Infected with Sclerotinia and Botrytis on the Basis of Sound, Half-brown and Totally Brown Kernels.

Variety	Percentage of Kernels		
	Healthy	Half-Brown	Totally Brown
Striped Sunflowers	89	2	9
Black Sunflowers	40	40	20

Table 3 - Oil Acid Number, Peroxide Number and Tocopherol Content of Oil Pressed from Sunflower Varieties with Healthy, Half-brown and Totally Brown Kernels Originating from Shabby and Faded Sunflower Fruits Infected with Sclerotinia and Botrytis.

State of the Kernel	Acid Number		Peroxide Number		Tocopherol Content mg/%	
	Striped Sun-flowers	Black Sun-flowers	Striped Sun-flowers	Black Sun-flowers	Striped Sun-flowers	Black Sun-flowers
Healthy	0,67	0,94	1	2	39	15
Half-Brown	3,0	4,80	3	4	18	6
Totally Brown	48,65	49,38	6	8	5	3

Table 4 - Fatty Acid Composition Of Striped Sunflower Varieties and Black Ones In Original And Neutral Oil As Well As In Free Fatty Acid.

	Healthy Kernels (A)				Half Brown Diseased Kernels (B)				Totally Brown Diseased Kernels (C)			
	Palmic Acid	Stearic Acid	Oleic Acid %	Lino-leic Acid %	Palmic Acid	Stearic Acid	Oleic Acid	Lino-leic Acid %	Palmic Acid	Stearic Acid	Oleic Acid	Lino-leic Acid%
Striped Sunflowers												
From Original Oil	5,3	4,2	27,1	63,2	5,6	4,4	26,5	63,5	5,2	4,1	26,8	63,9
From Neutral Oil	5,2	4,5	27,1	63,2	5,7	4,8	26,2	63,3	5,5	3,8	26,5	64,2
From Free Fatty Acid	5,6	5,5	26,2	62,7	5,3	5,0	25,8	63,9	6,6	5,6	27,0	60,8
Black Sunflowers												
From Original Oil	5,8	3,7	25,5	65,0	5,7	3,7	25,4	65,2	5,7	3,6	24,8	65,9
From Neutral Oil	5,6	3,7	25,3	65,4	5,4	3,7	26,2	64,7	5,6	3,7	24,2	66,5
From Free Fatty Acid	5,9	3,6	25,4	65,1	6,1	3,7	25,2	65,0	6,3	4,8	24,6	64,3

Table 5 - Rate of Infection Caused by Sunflower Diseases in Commercial Growing 1967.

Sunflower Diseases	Varieties	
	Striped Sunflowers	Black Sunflowers
Plasmopara halstedii	22,63	35,17
Sclerotinia sclerotiorum	6,59	13,76
Botrytis cinerea	2,84	4,12

Table 6 - Rate of Infection Caused by Sunflower Diseases in Pathologic Nurseries 1969.

Sunflower Diseases	Percentage of Infection	
	Striped Sunflowers	Black Sunflowers
Totally Sound	10,0	3,4
Sclerotinia sclerotiorum	34,8	38,9
Botrytis cinerea	12,7	37,6
Macrophomina	52,9	68,7
Alternaria	58,2	76,4
Squamous Detachment	29,8	36,5

Figure 1

Damage caused by sunflower pyralid moth (Homoesoma nebulellum).

Figure 2

Area heavily infested by sunflower broomrape (Orobanche cumana).

Figure 3

Sunflower Peronospora (Plasmopara halstedii). At left healthy, at right diseased plant.

Figure 4

White mouldy stem and head rot of sunflower (Sclerotinia sclerotiorum).

Figure 5

Grey mould disease of sunflower (Botrytis cinerea).

Figure 6

Sunflower stand infested by Macrophomina phaseoli.

Figure 7

Sunflower rust infection on sunflower head.

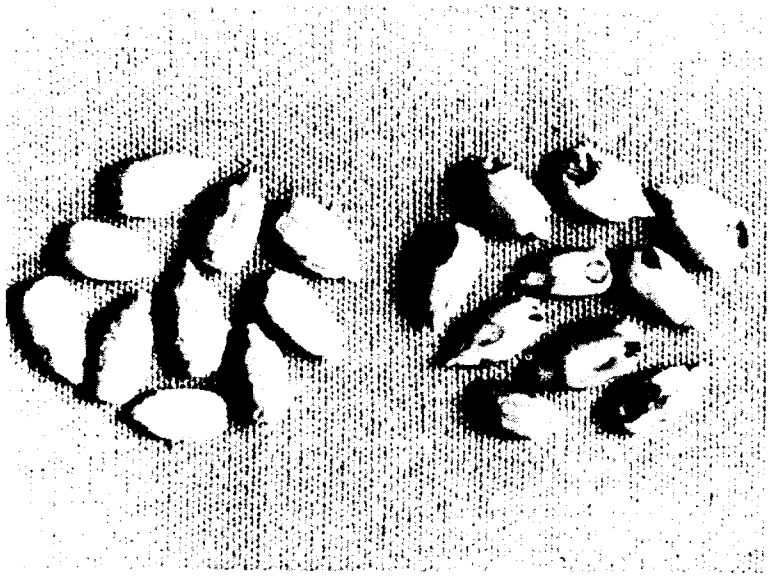

Figure 8

Necrotic disease of sunflower (X infection). At left healthy, at right characteristically "burnt" kernels".

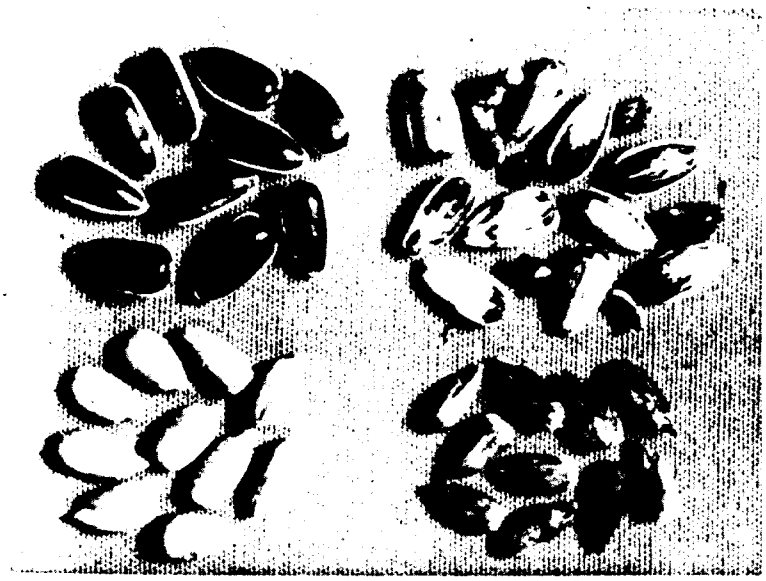

Figure 9

Damage caused by Sclerotinia sclerotiorum on striped sunflower seeds. At left healthy seeds, at right seed originating from diseased heads.

Figure 10

Damage caused by Sclerotinia sclerotiorum on black sunflower seeds. At left healthy seeds, at right seeds originating from diseased heads.

Figure 11

Damage caused by Botrytis cinerea on striped sunflower seeds. At left healthy seeds, at right seeds originating from diseased heads.

Figure 12

Damage caused by Botrytis cinerea on black sunflower seeds. At left healthy seeds, at right seeds originating from diseased heads.

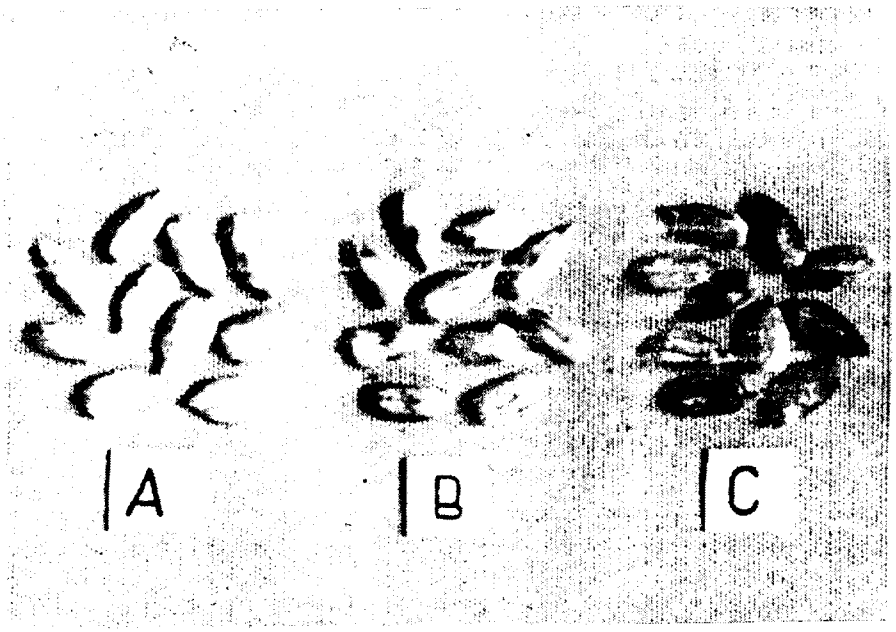

Figure 13

A = healthy kernels,
B = half-brown diseased kernels,
C = totally brown diseased kernels of sunflower.

Figure 14

Interstitial infection of sunflower head with mixed sclerotium suspension.