

EFFECT OF BROOMRAPE (*Orobanche cumana* Wallr.) INTENSITY OF ATTACK ON SOME MORPHOLOGICAL AND BIOCHEMICAL INDICES OF SUNFLOWER (*Helianthus annuus* L.)

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SUMMARY

The research was carried out at the Institute of Wheat and Sunflower "Dobroudja" near General Toshevo with the aim to ascertain the effect of broomrape intensity of attack on some morphological and biochemical indices that determine sunflower yield and quality. The objects of the study were the cultivar Peredovik and the hybrids Albena, Super start and NS-H-26, each attacked by the parasite to a different degree. Morphological measurements indicated that with the increase in the intensity of attack, the growth and development of sunflower plants were heavily suppressed - the plants were shorter, with smaller head diameter and lower yield per head. The broomrape attack caused considerable changes in some morphological and biochemical indices of sunflower seeds; the values for the mass of 1000 kernels, oil and protein content in 1000 kernels and net oil and protein in 1000 kernels were lower.

Key words: Sunflower, broomrape, intensity of attack, morphological and biochemical indices

INTRODUCTION

Broomrape (*Orobanche cumana* Wallr.) is a parasite which attacks the roots of sunflower plants. Consequently, their growth is suppressed, their development slow and the obtained production has deteriorated qualitative and quantitative indices.

According to Bošković (1962), broomrape attack leads to formation of smaller heads and decreased oil content in seeds. Lui and Li (1988) established that oil content in seeds of the plants attacked by the parasite drops down from 3 to 18 %. Studying the effect of broomrape attack on yield, Gonzales *et al.* (1982) found that it decreased from 20 to 30 %. According to Bošković (1962), this decrease is from 15 to 34%. Malychin and Leshtchok (1973) established that four parasites developing on the roots of one sunflower plant decreased the yield up to 20 %.

Up to now, no thorough research has been done on the extent of damage caused by broomrape on sunflowers in Bulgaria. Therefore, this study tries to establish how the different intensities of broomrape attack affect the growth and development of sunflower plants, as well as how they affect some indices that determine the yield and quality of sunflowers.

MATERIALS AND METHODS

The experiment was carried out in an infection field where the reaction of the breeding materials to broomrape has been tested annually. The object of the study were four susceptible sunflower genotypes: the cultivar Peredovik and the hybrids Albena, Super start and NS-H-26. Each of them is attacked to a different degree by the parasite. To be able to distinguish the intensities of attack in the tested plants, they were sown at the distance of 70 cm in the row and at 70 cm between the rows, which explains the relatively high yield per head. The Yugoslav hybrid NS-H-26 was an exception - its samples were taken from a field crop strongly attacked by broomrape. During the vegetation period, 100 plants from each genotype were rated for attack intensity using the following scale:

- 0 - no attack by the parasite (control),
- 1 - up to 5 parasites per sunflower plant,
- 2 - from 5 to 10 parasites per sunflower plant,
- 3 - from 10 to 15 parasites per sunflower plant,
- 4 - from 15 to 20 parasites per sunflower plant,
- 5 - from 20 to 30 parasites per sunflower plant,
- 6 - over 30 parasites per sunflower plant.

At the end of the vegetation season, the host plants were measured for height and head diameter. The heads of the tested plants were harvested individually. The seeds from each head were analyzed for the following indices: seed yield per head, mass of 1000 seeds, kernel percentage, oil and protein content in 1000 kernels and fatty acid composition of oil. Mass of 1000 seeds and kernel percentage were determined in four samples per tested genotype, each consisting of 50 seeds. Oil content was determined by the method of Roushkovskiy (1957), the protein content by the method of Kjeldhal. Fatty acid composition of oil was determined by gas chromatography.

The data of this study were averaged over three years, with the exception of the hybrid NS-H-26 which was studied for only one year.

The statistical analysis of the results was done by dispersion analysis (Cheffe, 1980).

RESULTS AND DISCUSSION

When discussing the results obtained, we should bear in mind that seed formation, hence the analyzed indices, depends on many factors such as the climatic conditions during seed forming, particular traits of individual crops, and individual reaction of the studied genotypes to the climatic conditions and to the penetrating parasite.

Table 1: Morphological characterization of sunflower hybrids /cultivars/ under different intensities of attack by broomrape

Hybrid (cultivar)	Intensity of attack						
parameter	0	1	2	3	4	5	6
PEREDOVIK							
Plant height (cm)	181.4	177.9	175.5*	168.1***	-	-	-
Head diameter (cm)	24.9	23.3*	21.6***	16.4***	-	-	-
Yield per head (g)	170.0	149.0*	103.0***	65.5***	-	-	-
ALBENA							
Plant height (cm)	171.5	162.0	147.4***	142.8***	-	-	-
Head diameter (cm)	25.8	23.0*	19.2***	16.4***	-	-	-
Yield per head (g)	164.0	159.0*	126.5*	108.5***	-	-	-
SUPER START							
Plant height (cm)	172.	171.7	168.9*	162.6**	-	-	-
Head diameter (cm)	23.6	21.9*	19.8***	13.2***	-	-	-
Yield per head (g)	136.0	107.5*	86.3**	43.2***	-	-	-
NS-H-26							
Plant height (cm)	161.8	-	157.0*	153.0***	147.3***	126.9***	119.6***
Head diameter (cm)	19.5	-	13.8*	12.4***	10.9***	9.1***	5.9***
Yield per head (g)	109.0	-	82.5***	66.3***	36.6***	25.7***	16.0***

*, **, *** - Significance at the levels 0.0, 0.01 and 0.001, respectively.

Table 1 shows the parameters of plant height, head diameter and seed yield per head. The presented data are a convincing proof that the growth of the plants parasitized by broomrape is heavily suppressed. In all studied genotypes, there was a tendency of decrease in plant height with the increase in the intensity of broomrape attack. This relationship was also observed in the variants with the lowest degree of attack (up to 5 parasites per host). The results from the variants where sunflower plants were attacked by 10 or more parasites are even more convincing; in these cases the differences in comparison with the control proved to have high degrees of statistical significance.

The broomrape attack also brought considerable decreases in head diameter (Table 1). In this case too, there was a tendency of decrease in the index value with the increase of the intensity of attack; the differences in comparison with the control were statistically proven even with the lowest intensity of attack. This indicated that the head diameter index was more closely related to the degree of attack than

the plant height index. A similar conclusion was drawn by Bošković (1962); in his opinion, reduced yields obtained by the parasitized plants are mainly due to a smaller head diameter.

Table 2: Qualitative characterization (presented as percentage from the whole seed) of sunflower seeds under different intensities of attack by broomrape

Hybrid (cultivar) parameter	Intensity of attack						
	0	1	2	3	4	5	6
PEREDOVİK							
Mass of 1000 seeds (g)	94.7	85.1*	81.9**	77.8***	-	-	-
Kernel (%)	77.6	76.0	76.3	76.5	-	-	-
Oil in kernel (%)	56.1	56.2	56.2	55.4	-	-	-
Protein in kernel (%)	29.1	27.7	24.9***	24.8***	-	-	-
Sum of oil and protein (%)	85.2	83.9	81.1**	80.2**	-	-	-
ALBENA							
Mass of 1000 seeds (g)	67.5	59.5***	54.8***	46.9***	-	-	-
Kernel (%)	71.7	71.6	72.3	70.6**	-	-	-
Oil in kernel (%)	57.5	57.6	56.7	57.5	-	-	-
Protein in kernel (%)	23.1	22.5	21.9*	20.3**	-	-	-
Sum of oil and protein (%)	80.6	80.1	78.6*	77.8**	-	-	-
SUPER START							
Mass of 1000 seeds (g)	77.2	57.3***	51.6***	43.9***	-	-	-
Kernel (%)	76.1	76.2	75.7	74.9*	-	-	-
Oil in kernel (%)	61.8	60.5	59.1	59.2	-	-	-
Protein in kernel (%)	22.0	21.1	20.6*	20.3*	-	-	-
Sum of oil and protein (%)	83.8	81.1	79.7	79.5	-	-	-
NS - H - 26							
Mass of 1000 seeds (g)	59.0	-	39.5***	36.1***	34.5***	37.2***	24.7***
Kernel (%)	77.2	-	77.0	78.6	79.1	77.2	76.4
Oil in kernel (%)	62.5	-	60.0	59.2	58.3**	58.2***	53.0***
Protein in kernel (%)	22.3	-	22.0	21.7	19.3**	18.6***	18.0***
Sum of oil and protein (%)	84.8	-	82.0	80.9	77.6**	76.8***	71.0***

*, **, *** - Significance at levels 0.05, 0.01 and 0.001, respectively.

Broomrape attack decreased the yield per head. This tendency was evident in all investigated genotypes, the decrease in the index value being directly proportional to the intensity of attack by the parasite. The differences in comparison with the control were statistically proven even with the lowest intensity of attack (up to 5 parasites per host plant) which guarantees the reliability of the obtained results. In fact, the most tangible idea for the loss caused by broomrape attack is given by the data for the hybrid NS-H-26. The samples of this hybrid were taken from a field crop where plants were grown under production conditions.

Our results confirm those of Hotyanskyi (1985). According to this author, a minimum-intensity attack (1-2 parasites) reduces the yield per plant by 4.8 g, but

when the plant is attacked by 20 or more parasites, the rate of decrease reaches up to 71.2 g.

Table 2 presents some characteristics of sunflower seeds obtained from the plants which were parasitized by broomrape to a different degree. Data for the mass of 1000 seeds, kernel percentage and oil and protein contents in the kernel are included. The mass of 1000 seeds obtained from the parasitized plants was decreased in comparison with the control. This relationship was observed in all genotypes and it was more pronounced with the increased intensities of the attack. In the seeds produced by plants attacked by broomrape, no significant changes in kernel percentage could be observed. This index remained stable for all studied genotypes and it was not affected by the intensity of the parasite's attack. Changes were observed in oil and protein contents in the kernel, however, but they were not specific for the individual genotypes and they did not occur at any regular terms.

Table 3: Qualitative characterization (presented as quantity in 1000 kernels) of sunflower seeds under different intensities of attack by broomrape

Hybrid (cultivar) parameter	Intensity of attack						
	0	1	2	3	4	5	6
PEREDOVİK							
Mass of 1000 kernel (g)	72.5	64.7*	62.5**	59.5***	-	-	-
Oil in 1000 kernel (g)	40.7	36.4*	37.6*	33.0***	-	-	-
Protein in 1000 kernel (g)	21.1	17.9**	15.6***	16.0***	-	-	-
Sum of oil and protein (g)	61.8	54.3*	53.2**	49.0***	-	-	-
ALBENA							
Mass of 1000 kernel (g)	48.4	42.6***	39.6***	33.1***	-	-	-
Oil in 1000 kernel (g)	27.8	24.5**	22.5***	17.0***	-	-	-
Protein in 1000 kernel (g)	12.6	11.1**	9.9***	9.1***	-	-	-
Sum of oil and protein (g)	40.4	35.6**	32.4***	26.1***	-	-	-
SUPER START							
Mass of 1000 kernel (g)	58.7	43.7***	39.1***	32.1***	-	-	-
Oil in 1000 kernel (g)	36.2	26.4***	23.1***	18.5***	-	-	-
Protein in 1000 kernel (g)	12.9	9.2***	8.1***	7.3***	-	-	-
Sum of oil and protein (g)	39.1	35.6***	31.2***	25.8***	-	-	-
NS - H - 26							
Mass of 1000 kernel (g)	45.5	-	31.2***	31.0***	28.6***	26.6***	18.9***
Oil in 1000 kernel (g)	28.4	-	20.6***	20.2***	17.5***	17.0***	11.3***
Protein in 1000 kernel (g)	10.1	-	5.8***	6.0***	6.4***	5.6***	4.3***
Sum of oil and protein (g)	38.5	-	26.4***	26.2***	23.7***	22.6***	15.6***

*, **, *** - Significance at levels 0.05, 0.01 and 0.001, respectively.

When the characteristics are presented as percentages from the whole seed or from the kernel, these percentages reflect the interrelations of the studied indices (Table 2). A complete notion for seed quality can be obtained when all results are taken into consideration, namely, mass of 1000 kernels, kernel percentage and oil

and protein quantity. This is the most common method of characterizing sunflower seeds. A clearer notion for the accumulation of storage substances can be obtained when the data are presented as a quantity in 1000 kernels. Then we start to deal with absolute instead of relative values, the relationships between the factors mentioned above are no longer valid (Table 3). The data for the mass of 1000 kernels confirm the data from Table 2. In all investigated genotypes the oil in 1000 kernels decreases with the increase in the intensity of the parasite's attack. There is a similar tendency for the index of protein content in 1000 kernels.

The clearest notion of the decrease of yield regarding the economically important components of the kernel is given by the sum index of oil and proteins in 1000 kernels. The results in Table 3 show that when there is a broomrape attack, the yield is strongly reduced with regard to its most valuable components such as oil and proteins.

The data for changes in the fatty acid composition of oil are given in Table 4. They reveal a slight increase in linoleic acid, and a respective decrease in oleic acid. This tendency grew stronger with the increase in the intensity of the parasite's attack although it did not lead to a change in the quality of the obtained oil.

Table 4: Fatty acid composition of oil in sunflower genotypes under different intensities of attack by broomrape

Hybrid (cultivar) fatty acid (%)	Intensity of attack						
	0	1	2	3	4	5	6
PEREDOVİK							
Linoleic	59.5	62.8*	64.1***	62.5**	-	-	-
Oleic	27.6	25.5*	23.5**	27.0	-	-	-
Stearic	6.8	5.6	5.5	5.0	-	-	-
Palmitic	6.1	6.1	6.9	5.5	-	-	-
ALBENA							
Linoleic	56.3	57.2	58.3**	58.8**	-	-	-
Oleic	33.5	33.0	31.9	30.5**	-	-	-
Stearic	4.4	4.0	3.7	4.5	-	-	-
Palmitic	5.8	5.8	6.1	6.2	-	-	-
SUPER START							
Linoleic	65.1	65.4	67.3**	68.4**	-	-	-
Oleic	25.2	23.6*	21.3**	19.6***	-	-	-
Stearic	3.9	4.2	4.5	4.4	-	-	-
Palmitic	5.8	6.8	6.9	7.6	-	-	-
NS - H - 26							
Linoleic	61.3	-	64.4**	64.6**	63.5*	65.2***	65.9***
Oleic	26.5	-	24.2*	23.2**	24.8*	23.5**	23.6**
Stearic	5.3	-	4.9	4.7	4.7	4.5	5.2
Palmitic	6.9	-	6.5	7.5	7.0	7.0	7.3

*, **, *** - Significance at levels 0.05, 0.01 and 0.001, respectively.

Bearing in mind the mechanism of interaction between the parasite and the host plant, it can be assumed that the changes in the qualitative and quantitative parameters of sunflower seeds discussed above are not a result of the direct interaction between the parasite and the host, but of physiological disturbances which occur in the host - strong water and nutrient deficiency, irregular water supply, reduced assimilation area, etc.

CONCLUSIONS

The results of the present study allow us to draw the following important conclusions:

The sunflower plants attacked by broomrape and the seeds produced by them suffered serious morphological and biochemical changes which are directly dependent on the intensity of the parasite's attack. The attack led to:

- Decreases in plant height, head diameter and yield per head.
- Decreases in the mass of 1000 seeds, oil and protein contents in 1000 kernels, as well as the net value of oil and proteins in 1000 kernels.
- No changes were observed in the quality composition of the analyzed fatty acids.

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EFFECTO DEL GRADO DE ATAQUE DEL JOPO (*Orobanche cumana* Wallr.) EN ALGUNOS INDICES BIOQUÍMICOS Y MORFOLÓGICOS DEL GIRASOL (*Helianthus annuus* L.)

RESUMEN

La investigación se llevó a cabo en el Instituto de trigo, girasol "Dobroudja", (General Toshevo) con el objetivo de comprobar el efecto del grado de ataque del jopo en algunos índices bioquímicos y morfológicos que dan lugar al rendimiento y calidad del producto obtenido. El material del estudio fueron los cultivares Peredovik y los híbridos, Albena y Super Start y NS-H-26, cada uno atacado con diferente grado de ataque por el parásito. Los resultados de las medidas histológicas indican que con el incremento del grado de ataque, el crecimiento y desarrollo de las plantas es altamente dis-

minuido. Las plantas son más pequeñas, con diámetros de capítulo menores y menor rendimiento por capítulo. El grado de ataque del jopo es la razón de los cambios considerables en alguno de los índices bioquímicos y morfológicos de las semillas del girasol, con valores mas bajos para los índices peso de 1000 almendras, contenidos de aceite y proteína y suma de aceite y proteína de 1000 almendras.

**EFFETS DE L'INTENSITÉ DE L'ATTAQUE D'Orobanche
(*Orobanche cumana* Wallr.), SUR QUELQUES
PARAMÈTRES BIOCHIMIQUES ET MORPHOLOGIQUES DU
TOURNESOL (*Helianthus annuus* L.)**

RÉSUMÉ

L'étude a été réalisée à l'Institut du blé et du tournesol "Dobroudja", près de General Toshevo, avec pour objectifs la détermination de l'incidence de la gravité de l'attaque d'Orobanche sur quelques caractéristiques morphologiques et biochimiques liées au rendement et à la qualité du produit. Dans ce but, on a utilisé le cultivar Peredovick et les hybrides Albena, Super Start et NSH-26, tous présentant différents degrés de sensibilité au parasite. Les résultats concernant les mesures morphologiques indiquent qu'avec l'augmentation de la gravité de l'attaque, la croissance et le développement des plantes de tournesol sont fortement affectés - les plantes sont plus courtes, avec un diamètre du capitule réduit et une production de grains par capitule plus basse. La gravité de l'attaque par l'Orobanche est la cause des modifications notables de plusieurs paramètres morphologiques et biochimiques des graines de tournesol - leur valeur étant plus faible pour le poids de 1000 akènes, la teneur en huile et en protéines dans 1000 akènes ainsi que pour le cumul de l'huile et des protéines dans 1000 akènes.