

INFLUENCE OF BROOMRAPE ON SOME PRODUCTIVITY INDICES OF SUNFLOWER

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Abstract

The action of the holoparasite *Orobanche cumana* Wallr. on sunflower may be very different, from the non-visible damage of plant tissues and the stagnation of host plant development until its death. Depending on the aggressiveness of the broomrape and the climatic conditions, the yield losses vary within 5-90%, affecting the quantity and quality (protein and lipids content) of the seeds. The aim of present investigation was to study some productivity indices, such as hectolitre weight and 1000-seed weight, plant height, head diameter, number of seeds per head in a series of experimental and commercial hybrids from the Republic Moldova and Romania in the conditions of infestation. The analyses were performed during 2012 and 2013 years in the field with natural infection. As a control serves the productivity indices of hybrids in the field without infection.

It was established that *Orobanche cumana* affects significantly the productivity indexes of sunflower hybrids. The degree of infestation correlates, in particular, with the head diameter and seeds yield per head, and lesser with the plant's height. Thus, in the case of a strong attack, the productivity losses in most cases exceed 20%, with maximum values (30-40%) in susceptible hybrids Doina and Performer characterized by the highest attack degree (60-70%). The values of the analyzed productivity indices vary a lot depending on the genotypes. So some hybrids (e.g. the Milenium hybrid) are tolerant to broomrape and endure pathogen attack with low losses.

The data obtained are of major interest in the development and proposal of key intervention and control measurements in integrated pest management programs.

Key words: *Orobanche cumana* Wallr., sunflower, plant height, head diameter, number of seeds per head, attack degree

Helianthus annuus L. is one of major crops of global importance. Grown on about 23 million hectares, with annual production of 40 million metric tons it is the fifth largest oilseed crop in the world (<http://www.fas.usda.gov>). Sunflower seeds are an excellent source of essential fatty acids and vitamin E which offer a variety of potential health benefits (healthy blood cholesterol concentrations, children's growth, role in memory and cognitive functions) (Gunstone F., 2011).

Due to increased market demand for sunflower seeds and high crop tolerance to drought, which ensure the stability of production and, respectively, the possibility to obtain stable annual income, sunflower is one of the most popular oilseeds grown by producers. In this context, it is important to note the actual problem of significant expansion of sunflower area, irrational exploitation of the land and failure of crop rotation, which lead to the increasing of frequency and aggressiveness of various pathogen

(Boincean B. *et al.*, 2011; Duca M., 2015; Duca M. *et al.*, 2016), such as the mycelial fungus *Plasmopara halstedii*, *Puccinia helianthi*, *Sclerotinia sclerotiorum*, *Septoria helianthi*, *Verticillium dahliae*, as well as parasitic angiosperm *Orobanche cumana* (Škorić, D. 2016 Sujatha, M. *et al.* 2003; Prashith Kekuda TR, *et al.* 2016; Duca, M. *et al.*, 2012) etc.

The influence of holoparasite *O. cumana* on sunflower may be very different, from the invisible plant tissues damage and stagnation of host plant development until its death (Vrânceanu A, 2000; Labrousse P. *et al.*, 2001). The most affected traits are plant height, head diameter, seed yield per plant, 1000 seed weight, lipid and protein content in the seeds and oil content (Alcantara E. *et al.*, 2006, Duca M. *et al.*, 2013). The yield losses vary substantially depending on the intensity of the parasite incidence and the climatic conditions. Thus, the production can be reduced by 5-20% in the case of slight infection,

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from 20 to 50% – in the case of medium rate of attack and can exceed 90% when high level of infection is registered (Domínguez J., 1996; Procop S.-M *et al.*, 2012; Louarn J., 2016).

According to these considerations, we propose to study a series of productivity indices, such as plant height, head diameter, seed yield per plant, 1000 seeds weight and the hectoliter mass in some experimental and commercial sunflower hybrids under natural infestation in the field.

MATERIAL AND METHODS

For the study were used 17 commercial and experimental sunflower hybrids from the Republic of Moldova and Romania. Researches have been carried out over two years (2012, 2013) in the fields naturally infested with broomrape.

The trial design was randomized blocks. The experiment consisted of 3 replications; 6 rows/plot. Row spacing was 70 cm, distance between plants – 35 cm.

Plant height, head diameter, seed yield per plant, 1000 seeds weight and the hectoliter mass were established. Ten plants were randomly selected from each replication and their height was measured from ground level to the top edge of the calatidium and then their average was calculated. The head diameter was determined by measurements made at 10 plants in each block and repetitions in the field and calculation of average. Number of seeds per head was recorded from ten plants taken randomly from each replication and then their average was calculated. Thousand achene's weight from each plot and replications was counted and their weight was recorded.

The hectoliter mass was determined by calculation of the weight of seeds required to fill a container with volume of 1 liter.

Broomrape occurrence was evaluated for frequency (F), intensity (I) and attacking rate (AR). (Kaya Y. *et al.*, 2004).

Frequency of attack was calculated as the percent of sunflower plants attacked by broomrape:

$$F(\%) = \frac{N}{N_t} \times 100$$

when: N = the number of plant infested by broomrape; N_t = the total number of analyzed plants.

Intensity of attack is represented by the number of broomrape plants formed on one sunflower plant:

$$I(\%) = \frac{a}{N}$$

when: a= total number of *Orobancha* plants; N=number of sunflower plants attacked by broomrape.

Attack rate was calculated according to formulae:

$$A.R.(%) = \frac{F(\%) \times I(\%)}{100}$$

RESULTS AND DISCUSSION

Seed yield and oil content are the most important economic traits in sunflower. It was established that total leaf area, plant height, total seed per head and 1000 seeds weight have a positive influence on seed yield (Hladni *et al.*, 2004, 2010; Marinković, 1992). It is known that *O. cumana* has a negative effect on sunflower development. Thus, in the presence of broomrape the plants are smaller; the head diameter is reduced and, respectively the seed yield is affected (Alcantara E. *et al.*, 2006; Duca M., 2015).

The assessment of the height of different sunflower hybrids in the absence of infection during a 2-year period (2012, 2013) highlights values ranging from 144-178 cm, with a maximum in the case of hybrid Performer and minimum in the case of genotype HS 5822. It should be noted that in 2012, the analyzed hybrids presented higher values of plant height, mainly ranged from 167 to 178 cm, compared to 2013 with an average value of 160 cm.

On the other hand, the values of the attack rate were lower in 2013 compared to 2012, which is due to the fact that in 2013, the amount of rainfall was higher, and in high humidity conditions, the broomrape development was slower (Figure 1).

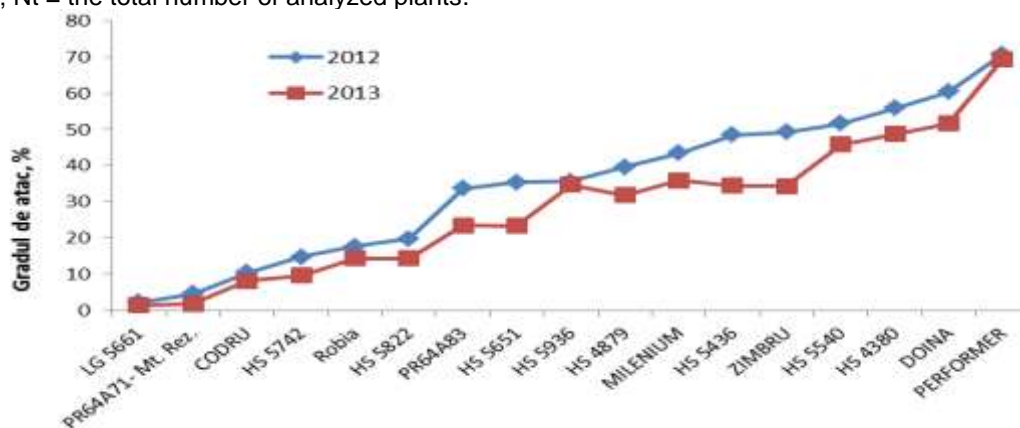


Figure 1. The attack degree depending on genotype in 2012 and 2013

Taking into account this fact, in the present paper the results obtained in 2012 are more detailed discussed, the data from 2013 serving in particular to confirm or invalidate the established correlations.

According to the observations, in 2013, broomrape has not influenced the height of the plant, whereas in 2012 this index decreased on average by 10% (Figure 2). The hybrids HS 5436, HS 5540, Doina and Performer were the most affected, the values were by 15-21% lower compared to samples cultivated on non-infected fields. The maximal decrease in the plant's height

(-21%) was found in the hybrid Performer, which is susceptible to parasite and has presented the highest rate of attack (70.8% in 2012 and 69.4% in 2013). In the case of hybrids HS 5651, HS 4380, HS 4879, Zimbru, Milenium, PR64A83 and HS 5936 no correlations between the rate of attack and plant height were observed. Thus, although the degree of attack was high (33.7-60.4%) it has less (around 10%) or no influence on the analyzed parameter. The absence of correlations between sunflower height and the number of broomrape shoots were reported by Louarn J. and coauthors (Louarn J. et al., 2016).

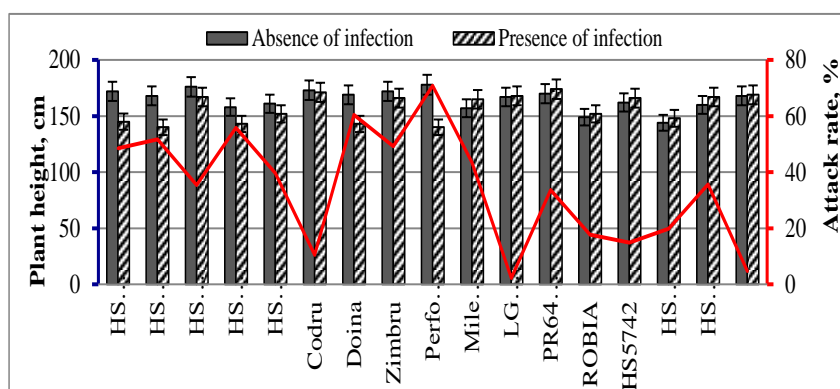


Figure 2. Influence of *Orobanche cumana* Wallr. attack rate (in the conditions of natural infestation) on the height of the sunflower plants, 2012

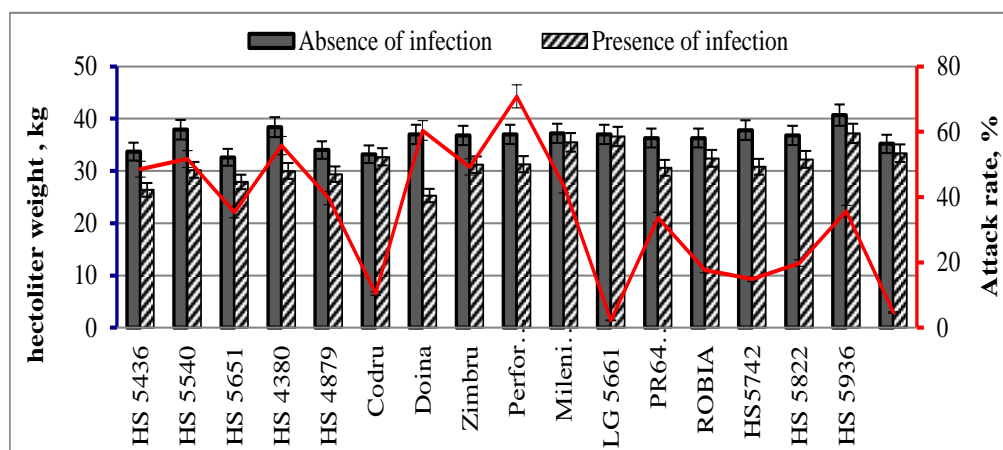


Figure 3. Influence of *Orobanche cumana* Wallr. attack rate (in the conditions of natural infestation) on the hectoliter weight of the sunflower seeds, 2012

The values related to the parameter *the hectoliter mass* ranged from 32.0 to 43.7 kg in the absence of infection and 25.3-40.7 kg in the presence of broomrape, with the maximum presented by the hybrid HS 5936 (Figure 3). The hectoliter mass were decreased in 2012 for an average by 14% and in 2013 by around 10%,

respectively, affecting especially the hybrids Doina (-31.6% in 2012 and -23.0 in 2013), HS5436 (-21.7% and -28.0%, respectively), HS 4380 (-21.9%) and HS 5540 (-20.3% and -33.7%, respectively). The mentioned hybrids are also characterized by increased susceptibility to the parasite *O. cumana*, the rate of attack ranging

between 48.5-60.4%. In the hybrid Performer with the highest level of attack, the hectoliter mass was less influenced.

The weight of 1000 seeds, also, recorded the lowest values in the case of high infestation (Figure 4). In 2012, the 1000 achene's weight was lower in the presence of infection compared to non-infectious conditions; with the average of 58.6g versus 65.2g. The minimal values were obtained for hybrids HS 5651, HS 5436, HS 5540 and Doina, with losses ranging from 15 to 33.7%.

The most affected was hybrid HS 5540 (-33.7%), followed by HS 5436 (-28.0%).

The weight of 1000 seeds of sensitive hybrid Performer constituted 61.7 g in the presence of infection and 69.1g in non-infected field, with losses of about 10%.

In the case of the hybrid Milenium, which was characterized by a high rate of attack, the values of the hectoliter mass and the weight of 1000 seeds did not show any major differences compared to the uninfected variant.

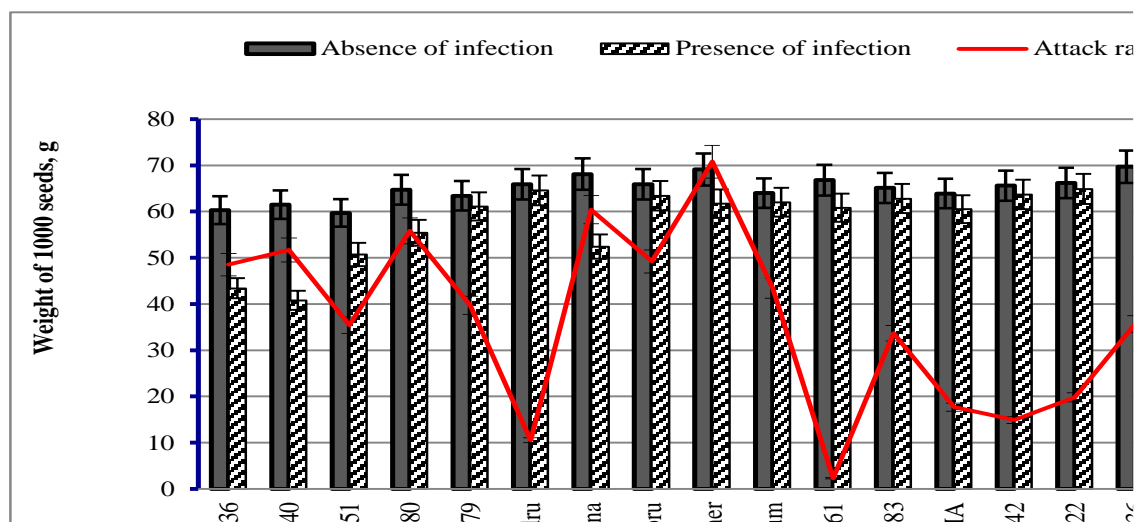


Figure 4. Influence of *Orobanche cumana* Wallr. attack rate (in the conditions of natural infestation) on the weight of 1000 sunflower seeds, 2012

It was found that head diameter and the number of filled seeds per head were significantly influenced by the broomrape attack. Thus, in the case of a high rate of attack, these parameters decreased by 40% and 21%, respectively, in the

case of the susceptible hybrid Performer (Figure 5, 6). Similar, essential productivity losses (-19%) in the susceptible hybrid Performer were reported by Pricop et. al. (Pricop S.-M. et al., 2006).

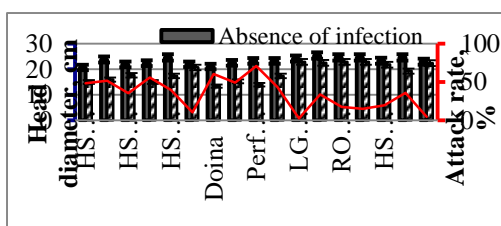


Figure 5. Influence of *Orobanche cumana* Wallr. attack rate (in the conditions of natural infestation) on head diameter, 2012

Some correlations between attack rate and the head diameter have been highlighted. Thus, the

lowest values of head diameter, ranging from 13.4 to 17.4 cm under infection conditions, compared to

21.1-23.8 cm in the absence of infection, were recorded in hybrids HS5436, HS5540, HS4380, HS4879, Doina and Performer, characterized by the high level of infestation. On the other hand, the values of head diameter of hybrids Codru, LG5661 and PR64A71 (with lowest degree of attack) were similar in the presence and absence of infection.

A more pronounced decrease (15.6-23.0%) of a filled seeds per head in infestation conditions

was established in hybrids, HS-4380, HS 5540, HS-4879, Zimbru, Doina and Performer.

It was found that hybrids Doina and Performer with the highest degree of attack were the most affected by broomrape, showing significantly decreased indices for all the studied characteristics.

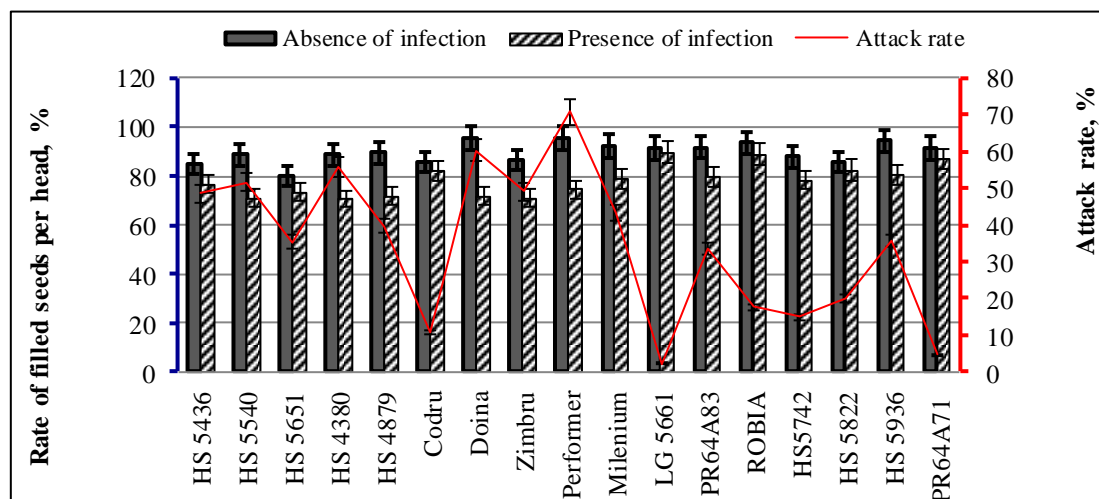


Figure 6. Influence of *Orobanche cumana* Wallr. attack rate (in the conditions of natural infestation) on the filled seeds per head, 2012

According to obtained data, we can mention that broomrape have a negative effect on productivity indices. Some correlations between the rate of attack and the value of the productivity indices were found in the case of the head diameter, which has decreased essentially in all the genotypes characterized by the major degree of infestation. A higher association of the rate of attack with head diameter and the weight of 1,000 seeds compared with the plant height index were reported by Shindrova and coauthors (Shindrova P., 1998).

Alcantara and coauthors, who similarly have emphasized the negative influence of the broomrape on plant height and head diameter, proposed a hypothesis regarding the mechanism of action of the parasite on these parameters. According to this hypothesis observed alterations are related to indirect effects through perturbations of the host physiology (Alcantara et al., 2006).

CONCLUSIONS

Research has shown that the holoparasite *Orobanche cumana* Wallr. significantly affects the productivity of sunflower crops. The rate of attack with broomrape correlates, especially with the head diameter and the number of filled seeds per head and lesser with plant's height. Thus, in

the conditions of a high attack rate, the differences between the values registered in the presence of infection and these observed in the absence of broomrape in the most cases exceed 20%, with maximum (30-40%) in susceptible hybrids Doina and Performer.

The values of the analyzed productivity indices vary a lot depending on the genotypes. So some hybrids (e.g. the hybrid Milenium) are tolerant to broomrape and endure pathogen attack with low losses.

The data obtained are of major interest in the development and proposal of key intervention and control measurements in integrated pest management programs.

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