ANALYSIS OF THE SOIL PARAMETERS IN THE CONTEXT OF SUNFLOWER INFECTION BY *Orobanche cumana* WALLR.

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Abstract

The holoparasitic angiosperm plant *Orobanche cumana* Wallr. is one of the main constraints on sunflower production. Environmental factors (temperature, rainfall average), soil fertility and the nutrient availability are important factors which influence the development and spreading of infestation. According to reported data, broomrape infection tends to be associated with less fertile soil conditions, high pH, low nitrogen and available phosphor content.

The aim of present study was to estimate the influence of soil parameters on the frequency and intensity of the broomrape attack in different habitats from Moldova with variable level of natural infection. The frequency and intensity of the broomrape attack in natural the conditions has been established by field observation in settlements across the center, south and north of Moldova, during July-August, 2014. From each infected habitats soil samples has been collected and analyzed (humus, nitrogen, phosphorus and mineral elements content, pH, humidity etc.).

Some correlation between soil parameters and *Orobanche* attack intensity has been established. Thus, in majority of studied habitats, the broomrape attack frequency is positively influenced by high humus content and negatively by high potassium concentration. In the most of locations from south part of Moldova the attack frequency correlated with the pH value. Total nitrogen, ammonium and available phosphor content had no effect on *Orobanche* attack intensity.

Key words: *Orobanche cumana,* attack frequency, sunflower, soil parameters

The holoparasitic angiosperm plant *Orobanche cumana* Wallr. is one of the main constraints on sunflower production in Southern Europe, Mediterranean and Black Sea region, the Middle East, as well as in the Republic of Moldova (Fernández-Martínez J. *et al*, 2009; Parker C., 1994). The damage in sunflower caused by the broomrape attacks is often devastating, with reported yield losses between 5-100%, leading to a significant reduction in the amount and quality of the oil (Domínguez J., 1996; Duca M. *et al*, 2012, 2013). The *O. cumana* seeds can remain viable in the soil for more than 10 years (Linke K. *et al*, 1989). For germination they require a conditioning period of 1 to 2 weeks at the temperature 15 °C to 20 °C and adequate humidity (Glijin A., 2012). The germination is induced by chemical substances exuded by host-crop roots. Most of the germination stimulants isolated and identified were shown to be isoprenoid and belong to one chemical class, collectively called the strigolactones (SLs) (Ayman A., *et al*, 2006; Matusova R. *et al*, 2005).

Different studies have revealed that the level of macronutrients (different forms of nitrogen, phosphor, and carbon) in the soil is a limiting factor of the biosynthesis and exudation of SLs. The first data about the correlation between nutrient deficiency and a higher secretion of SLs were reported in 2007 (Marzek M. *et al*, 2013; Yoneyama K. *et al*, 2007). Thus, the amount of SLs in the exudates obtained from the roots of two rice cultivars grown under deficiency of P and N was higher than in the root exudate of control plants. Also, a positive relationship was found between the amount of SLs and *Striga hermonthica* germination. These results confirmed the efficiency of N and P containing fertilizer application in parasite control, due to the suppression of SLs production, followed, by the reduced rate of weed seeds germination and number of attachments (Jamil M. *et al*, 2011).

Another important factor is the stability of chemical stimulant in the soil conditions. It has been reported the instability of SLs particularly at pH >7.5 (Fernández-Aparicio M. *et al*, 2016).

The main effects of environmental factors on the development of broomrape could be due to the reduction of synthesis and exudation of germination stimulant or their instability, as describe below, or by direct damage to *Orobanche* seeds and seedlings in the soil. It has been demonstrated that nitrogen in the ammonium form determines the reduction in germination of *O. ramosa* (Abu-Irmaileh B. E., 1994). Also, ammonium ions are involved in direct inhibition of radicle elongation (Westwood J.H. *et al*, 1999).

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Broomrape infection tends to be associated with less fertile soil conditions, acid pH, low nitrogen and available phosphor content (Habimana S. *et al*, 2014; Lyra D. *et al*, 2016; Miladinović D. *et al*, 2012). On the other hand, reported data are very contradictory, depending on specific eco-geographic conditions and other multiple aspects of host-parasite interaction. In this context, it is interesting to estimate the relationships of soil parameters and broomrape attack in different habitats from Republic of Moldova with variable level of natural infection.

MATERIAL AND METHOD

The investigations were conducted in the period of July-August, 2014, in different locations from center, south and north of Republic of Moldova.

The frequency and intensity of the broomrape attack in natural conditions has been established by field observation. Each investigated filed has been divided into a number of plots of 10 x 10 m square. It has been analyzed 9 randomized plots from each group. The intensity of the attack was assessed by number of broomrape plants formed on one sunflower plant and was considered to be *small* when host plant was affected by 1-4 parasitic plants; *medium* - in the presence of 5 to 10 broomrape shoots and *severe* - in the presence of 10 or more parasite plants (Vrânceanu A., 2000). Attack frequency was calculated on the basis of the relation F (%) = (N x 100) / Nt where N – number of infected plants, Nt - total number of plants (Kaya Y. *et al*, 2004). From infected habitats soil samples from 0-30 cm arable layer has been collected and analyzed by the Republican Center of Applied Pedololy from Moldova according to standardized methods. Following soil parameters have been determined: pH (potentiometrically); Ca (volumetrically); available P_2O_5 and K_2O content (according to Macighin method); humus content - N-NO3, N-NH4 (according to Tiurin method in modification TINAO).

RESULTS AND DISCUSSIONS

It was found that *O. cumana* Wallr. is preferentially widespread in the central and south part of country, frequency and intensity of broomrape attack, being higher in the south (*table 1, 2)*. Thus, in 5 from 10 of analyzed southern locations the level of attack frequency is higher than 50% (60-80%), while in central part the maximal value of this parameter is 40%, in most cases being around 10%. Also, the highest attack intensity was observed in 40-60% of infected plants from south district Cahul (Alexanderfeld, Slobozia-Mare) and Basarabeasca. Around 30% of infested sunflower plants from Leova, Cahul and Basarabeasca were affected medium and in 80-100% of these from Comrat and Stefan Voda the number of parasite shots was less than 4. Contrary, in the central part a sever intensity attack was established only in 30% of plants from Telenesti, Brinzeni, in the majority of locations the degree of attack being small.

The soil samples from both regions were characterized by reduced humus content. In 53% of cases the humus content was less than 3.5% - the critical level established for the temperate zones. The humus content ranged between 1.85 (in Telenesti, Cazanesti) and 4.05% (Straseni, Rassvet) with the average of 2.92%. The total nitrogen content fell between 0.15 and 0.31%, being lower in southern area. Also, samples belonging from south districts were characterized by higher values of pH (7.8-8.3).

Researches revealed a high variability of available phosphorus content (from 1.2 to 9.3 mg/100 g), the deficit in mobile phosphorus being more evident in central region. The content of potassium is more stable, the values ranging between 25.8 and 64.0 mg/100 g in central part of Moldova and 19.0-59.4 mg/100 g – in south.

In the majority of studied habitats, the broomrape attack frequency is positively influenced by high humus content and negatively by high potassium concentration. Thus, in the field from central region the maximal level of frequency and intensity of *O. cumana* attack was observed in Telenesti, Brinzeni; Orhei, Ciocilteni; mun. Chisinau and Hincesti, Buteni, characterized by highest content of humus (3.05-3.70%). The exception was only village Rassvet from district Straseni where the humus level was maximal, while the attack frequency was 10%, with small attack intensity. Similarly, in south part, the highest level of humus (2.8-3.45%) were determined in the soil samples from Leova, Cazangic; Basarabeasca, Carabetovca and 3 villages from Cahul - Alexanderfeld, Manta and Slobozia-Mare, where sunflower fields were the most infected. In this case, exception was Ermoclia, Stefan-Voda.

Similar correlation was highlighted by Lyra et al. referring to *Phelipanche ramosa* infestation in tobacco fields. Researchers observed the maximal number of broomrape per tobacco plant in Domokos and Lamia regions (Central Greece), with soil characterized by high organic matter content values and slightly acid to slightly alkaline pH. (Lyra D. *et al*, 2016). Also, the distribution and severity of *O. ramosa* and *O. aegyptiaca* in Greece are shown to be correlated with soil pH and content of organic matter (Economou G. *et al*, 2009).

Table 1

Characteristic of soil samples collected from infected habitats of central region of Republic of Moldova

Locations	Attack intensity, %			Attack frequency, %	Soil parameters							
					pH	%		mg/100 g				me/ 100 g
	>10	5-10	1-4			Humus	N total	NH_4	NO_3	P_2O_5	K_2O	Ca
Telenesti, Verejeni	-	20	80	10	7.50	2.25	0.24	0.6	18.1	5.9	60.6	22.00
Telenesti, Cazanesti	1	15	84	10	8.00	1.85	0.31	0.7	3.7	9.3	64.0	22.90
Telenesti, Brinzeni	30	20	50	25	7.80	2.95	0.28	0.9	7.4	2.7	51.6	21.60
Orhei, Ciocilteni	8	17	75	40	7.80	3.65	0.26	0.9	1.8	1.5	29.0	22.60
Mun. Chisinau	-	50	50	30	7.30	3.70	0.20	0.6	1.6	1.2	28.2	21.10
Hincesti, Buteni	5	20	75	30	8.00	3.05	0.19	0.6	4.9	1.5	30.2	27.60
Hincesti, Sarata-Mereseni	-	-	100	10	7.40	2.65	0.26	1.1	1.0	3.8	26.6	16.80
Hincesti, Fundul-Galbenei	-	-	100	5	7.40	2.65	0.16	0.6	5.8	1.4	25.8	20.25
Straseni, Rassvet	-	-	100	10	7.90	4.05	0.16	0.5	3.9	1.9	50.0	15.10

Table 2

Characteristic of soil samples collected from infected habitats of south region of Republic of Moldova

Locations	Attack intensity, %			Attack frequency, %	Soil parameters							
					pH	%		mg/100 g				me/ 100 g
	>10	5-10	1-4			Humus	N total	NH_4	NO_3	P_2O_5	K_2O	Ca
Leova, Cazangic	-	30	70	70	7.45	3.30	0.15	0.6	1.4	1.3	21.4	13.25
Stefan-Voda, Ermoclia	-	20	80	10	8.20	3.45	0.22	1.1	29.3	3.7	24.6	27.90
Comrat, Chirsova	-	-	100	10	8.30	2.30	0.18	0.6	4.3	1.6	24.6	19.10
Comrat, Besalma	-	-	100	20	8.20	2.50	0.18	0.9	24.4	4.0	29.4	18.00
Comrat, Svetlii	-	-	100	10	8.25	2.30	0.18	0.7	3.9	1.8	23.4	18.50
Basarabeasca, Carabetovca	60	30	10	60	8.30	2.80	0.18	0.7	11.4	1.4	19.0	16.90
Cahul, Alexanderfeld	50	50	-	70	7.75	3.45	0.16	0.9	2.0	4.2	32.0	23.10
Cahul, Manta	10	30	60	80	7.75	3.25	0.24	0.9	2.3	3.9	19.0	23.10
Cahul, Slobozia-Mare	40	30	30	80	7.90	3.25	0.24	1.0	2.1	8.0	25.0	19.25
Cahul, Crihana-Veche	-	-	100	30	7.80	2.10	0.21	0.8	7.4	4.8	59.4	17.75

On the other hand, no effect of humus, total N, soil texture and pH on *Orobanche* attack intensity in sunflower has been established, the attack being inversely associated only with P availability (Miladinović D. *et al*, 2012).

Related to the potassium content, it was established that in central part of Moldova 3 from 5 fields with minimal level of broomrape attack frequency (5-10%) contained maximal concentrations of available potassium (50.0-64.0 mg/100g). In south, 5 from 7 locations with highest potassium content (24.6-59.4 mg/100g) were characterized by low level of frequency attack. As exceptions we can mention two villages from Cahul – Alexanderfeld and Slobozia-Mare where the concentration of potassium was between above-mentioned limits, while the infection frequency value was maximal, as well as Leova, Cazangic with low content of available potassium and high level of infection.

Results of the soil pH study indicate an obvious influence of this parameter on the broomrape attack frequency only in the south part of Moldova. Thus, the maximum infestation by *O. cumana* was observed, especially in Leova and Cahul, where soils were slightly alkaline (pH 7.45-7.90), and minimum – in Comrat and Stefan-Voda with the pH lies between 8.2-8.3.

The relationships between infestation and soil pH reported by other authors are very different. So, similarly with us, Lyra et al. observed the maximum infestation by *Phelipanche ramosa* in Domokos, where soils were characterized by being almost neutral to slightly alkaline (pH 7.1) and lower broomrape abundance was detected in the regions, where pH was higher (Lyra D. *et al*, 2016). Contrary, Van Hezewijk et al. established that soil pH has little influence on parasite *O. crenata.* The germination was not reduced at any pH between 5 and 8.5, although

growth of the radicle was favored by higher pH (Van Hezewijk M. J. *et al*, 1994).

Total nitrogen, ammonium and available phosphor content had no effect on *Orobanche* attack intensity.

CONCLUSIONS

In majority of studied habitats, the broomrape attack frequency is positively influenced by high humus content and negatively by high potassium concentration. An obvious interdependence of pH value and attack frequency was revealed in the south part of Moldova, the maximum infestation by *Orobanche cumana* being characteristic especially for fields with slightly alkaline pH (7.45-7.90). Total nitrogen, ammonium and available phosphor content had no effect on broomrape attack intensity.

A better understanding of the abiotic factors limiting the distribution and virulence of *Orobanche* could help researchers to elaborate integrative and effective tools for broomrape control, prevention and protection against parasite.

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