RESEARCHES REGARDING WEED CONTROL IN WINTER WHEAT IN THE CONTEXT OF CLIMATE CHANGES

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Abstract

The aim of the researches carried out in Tămădăul Mare village from Călăraşi county, during 2015-2018 was the weeds control in winter wheat crop. The segetal flora that infests wheat crops in Romania is varied both in species and especially as a species-related relationship, being subject to permanent changes, especially in the context of climatic changes. The changes occurred in the structure of the segetal flora represent the qualitative and quantitative expression of the influence of the soil seed stock dynamics, of the changes in the plant cultivation technology and of the weed control management, of the climatic variations and, last but not least, of the influences related to the economic and social factors. These changes involve and justify permanent monitoring of weed structure and dynamics in a certain territory in order to establish the most effective and rational methods of control, having the effect of reducing the yield losses. In wheat cultivated fields, aspects related to: the dynamics of the degree of weed infestation, the identification of the problematic weeds, the criteria for choosing the most effective herbicides and the optimal moments of application were studied. The best results in weed control of autumn wheat crops were obtained by integrating agrotechnical, phytotechnical and chemical measures, conclusion resulting also from this study.

Key words: wheat, control weeds, herbicides.

Wheat (*Triticum aestivum* L) is one of the oldest and most important of the cereal crops, being the most extensively grown cereal crop in the world, covering about 237 million hectares annually, accounting for a total of 420 million tonnes (Langer R.H.M., Hill G.D., 1991; Olabanji O.G. *et al*, 2007). Wheat is a dietary mainstay for approximately one-third of the total world population (Johnson V.A., 1984). Worldwide, wheat provides nearly 55% of the carbohydrates and 20% of the food calories consumed globally (Breiman A., Graur D.,1995). Wheat is a basic agricultural crop in Romanian farms, being cultivated in 2017 on an area of 2027 thousand hectares, producing a total yield of 9877 thousand tons, about 1446 thousand tons more than in 2016 (*, 2018). Weed control is the main work of the wheat crop technology. Weeds are one of the major constraints in wheat production because they reduce productivity due to competition, allelopathy, determining increasing the cost at harvest, having toxic effects for humans and animals, favoring and transmitting insect pests and disease pathogens (Jalis A., 1987; Arnold R.N. *et al*, 1988; Berca M., 2004; Abbas S. *et al*, 2009). Weeds may reduce about 40-50% grain yield in wheat crop (Oad F.C. *et al*, 2003, 2007; Mayerová M. *et al*, 2018). Autumn wheat is yearly weed - infested by a rich and varied segetal flora due to the high seed reserve in the soil and because it has a relatively low capacity to compete with the weeds. Due to the long vegetation period, the segetal species that make up the floral spectrum - are characteristic to wheat crop, as it practically goes through all four seasons of the year when very diverse weed species emerge (Anghel G. *et al*, 1972). The critical weed competition period in wheat is 30 to 60 days after sowing (Nadeem M.A. *et al*, 2013). After 60 days of sowing there is no economic benefit to eradicate weeds from wheat crop (Ahmad R., Shaikh A.S., 2003). Successful weed control requires the use of integrated cultural and chemical practices (Şarpe N. *et al*, 1983; Cheema M.S. *et al*, 1988; Blackshaw R.E., 1990; Barberi P., 2000). No one technique will adequately eliminate weed problems. Herbicides should be used in combination with good preventative, physical and cultural practices. However, choosing the most appropriate herbicides, corresponding time of application and the appropriate dosage is an important element for lucrative profits. On the other hand, chemical weed control dependence only involves an

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excessive use of herbicides, which results in environmental pollution and inter-and intra-specific exchange (Hassan G., Marvat K.B., 2001). It is now accepted that in order to develop an adequate management of the integrated weed control we have to conduct experiments of physiological, herbological, ecological, morphological nature, etc., for each method considered to be the best for reducing the degree of weed infestation (Ionescu N. *et al*, 2011).

This approach must encompass the role of conservation tillage, knowledge of the critical period of weed interference, alternative methods of weed control, enhancement of crop competitiveness, modeling of crop-weed interference, influence of crop rotation and seed bank dynamics, and education and extension of the findings. The complexity involved in addressing these issues requires a multi-disciplinary approach. Taking account of these various, complex and very important aspects, the present paper displays results regarding the degree of weed - infestation to autumn wheat crop and results on weed control by integrating agro-technical measures with herbicides.

MATERIALS AND METHODS

In order to achieve objectives, the following methods and materials were used:

A. Researches on weed - infestation of autumn wheat crop has been done through the weed mapping action. Weed mapping was conducted in 10 fields cultivated with winter wheat included in a suitable crop rotation and in 10 winter wheat cultivated fields in monoculture from the Tămădăul Mare, Călăraşi counties, during the period 2015-2017.The numerical method of weeds assessments was used to which the phenophase and the average height of each plant were added. There were8 samples made for each one-hectare surface. The winter wheat field in which the assessments were made were cultivated by private farmers according to their own technologies. For each field, land sheets of weed - infestation have been done and they present both general data on the location, the soil type, the previous crop and specific data on the density, participation and constancy of each weed species, class (monocotyledonous or dicotyledonous) as well the life period of each weed (ephemeral, annual, biennial, or perennial). Finally, the weeds were distributed in density categories in descending order to identify the dominant species and the problem weeds, the results obtained by mapping being an important tool in taking the most appropriate weed control measures in a crop.

B. For the researches on weed control, the following agro-technical measures have been applied: practicing corresponding to the crop rotations, rational choice of the preceding plant, deep plowing in summer to 30 cm depth, seedbed preparation through 2 passes with disk harrow followed by milling, good quality seeds and sowing in optimum time at appropriate densities respecting the technology of cultivation. The experiment was performed by the randomized block design with 8 variants in 4 replications, with plot area of 30 m². The efficacy of herbicides Secator OD (100 g/l amidosulfuron + 25 g/l jodosulfuron + 250 g/l mefenpyrdiethyl-antidote) and Biathlon 4 D (714 g/kg tritosulfuron+ 54 g/kg florasulam) applied in registered rates was evaluated. The herbicides were applied in two phenophases of the crop - 1st – 2nd stem node BBCH 30-32) and flag leaf (BBCH 37-39). Weed density was assessed in ground % and in plants number on square meter. Weed control (efficacy) was assessed at 14, 28, and 56 days after each application in % control in comparasion with the untreated plots. Also, there were performed observations on the weeds present in the experimental plots before treatment, and selectivity - at each date of the efficacy assessments. Determination of segetal flora was performed on a square meter using a metric frame. Statistical preparation of the results was based on the analysis of ARM-9 software (P=.05, Student-Newman-Keuls).

RESULTS AND DISCUSSIONS

A. Results on the degree of weed - infestation in winter wheat

Compared to hoed crops, due to high density of rows sowing, wheat creates the image of a crop with a lower degree of weed - infestation because it covers the soil better. In actual fact, winter wheat crops in Romania are yearly weed-infested, especially in monoculture, with segetal species belonging to diverse botanical families, some of them very difficult to fight against. Thus, in wheat monoculture crop 41 weed species with an average density of 338 plants/m^2 were identified (table 1). In order to identify the problem weeds and establish the target species, the studied weeds were divided into 4 density categories. The first category, with the highest density, with 20-40 plants/m^2, included the species: Veronica hederifolia L., Polygonum *convolvulus* L., *Chenopodium album* L., *Echinochloa crus-galli* (L.) Pal. Beauv and *Descurainia sophia* L. The second category had a density of 10-20 plants/m^2, being found the following species: *Thlaspi arvense* L., *Veronica persica* Poir., *Convolvulus arvensis* L., *Matricaria inodora* L., *Cirsium arvense* (L.) Scop., *Setaria pumila* (Poir.) Roem. & Schult and *Sinapis arvensis* L.. From the third group, with 5-10

plants/m^2, there were identified: *Galium aparine* L., *Erigeron annuus* (L.) Pers., *Viola arvensis* Murray., *Capsella bursa-pastoris* (L.) Medic., *Papaver rhoeas* L. and *Stellaria media* (L.). The fourth group with 1-5 plants/m^2 was the largest, including 23 species, the most important being as follows: *Cardaria draba* (L.), *Lamium amplexicaule* L., Desv., *Centaurea cyanus* L., *Galepo sistetrahist* L., *Lithospermum arvense* L. etc.. Generally, the species that infest the wheat crops are part of the group of weeds that grow in the spring and systematically they are usually annual and perennial dicots (Anghel et al., 1972). The dominant species both in crop rotation system and monoculture belonged to the *Veronica* species, exceeding an average density of 50 plants/m^2 in wheat monoculture in experimental fields included the species: *V. hederifolia, V. persica and V. arvessis*

Table 1

Weeds in wheat monoculture, Tămădăul Mare, Călăraşi county

No.	Species	Growth stage/height (cm)	Average no./m^2	P (%)	K (%)	Family	Botanical group
1.	*Veronica hederifolia*	A-B-C (6-10)	40.5	12.0	100.0	*Plantaginaceae*	DA
2.	*Polygonum convolvulus*	A (10-25-30)	36.0	10.6	100.0	*Polygonaceae*	DA
3.	*Chenopodium album*	A (10-25)	26.0	7.6	100.0	*Amaranthaceae*	DA
4.	*Echinochloa crus-galli*	A (3-15-20)	21.0	6.2	100.0	*Poaceae*	MA
5.	*Descurainia sophia*	A (15-20)	20.0	6.0	87.5	*Brasiacaceae*	DA
6.	*Thlaspi arvense*	A (10-16)	16.0	4.8	87.5	*Brasiacaceae*	DA
7.	*Veronica persica*	A-B-C (6-10-12)	12.5	4.0	75.0	*Plantaginaceae*	DAWI
8.	*Convolvulus arvensis*	A-B (10-15-25)	12.0	3.5	75.0	*Convolvulaceae*	DP
9.	*Matricaria inodora*	A-C (20-25)	12.0	3.5	87.5	*Asteraceae*	DA
10.	*Cirsium arvense*	A (12)	10.5	3.2	62.5	*Asteraceae*	DP
11.	*Sinapis arvensis*	A (15)	10.0	3.0	62.5	*Brasiacaceae*	DAW
12.	*Setaria pumila*	A (8-20)	10.0	3.0	50.0	*Poaceae*	MA
13.	*Galium aparine*	A-B (20-25-35)	8.5	2.5	50.0	*Rubiaceae*	DA
14.	*Erigeron annuus*	A (15-20-25)	8.0	2.4	62.5	*Asteraceae*	DAI
15.	*Viola arvensis*	A-B-C (6-10-15)	8.0	2.4	50.0	*Violaceae*	DA
16.	*Capsella bursa-pastoris*	A (10)	6.5	2.0	37.5	*Brasiacaceae*	DA
17.	*Papaver rhoeas*	A (10-25)	6.0	1.6	37.5	*Papaveraceae*	DA
18.	*Stellaria media*	A (10-15)	6.0	1.6	37.5	*Caryophyllaceae*	DA
OTHER SPECIES: 23, with 1-5 plants/m^2 , **TOTAL SPECIES: 338**							

Regarding the distribution of weed species on botanical groups, in wheat monoculture predominated the annual dicotyledonous with 32 species which had an average density of 266.5 plants/m^2 and a rate of 78.6% in the general weed infestation process (*figure 1*).

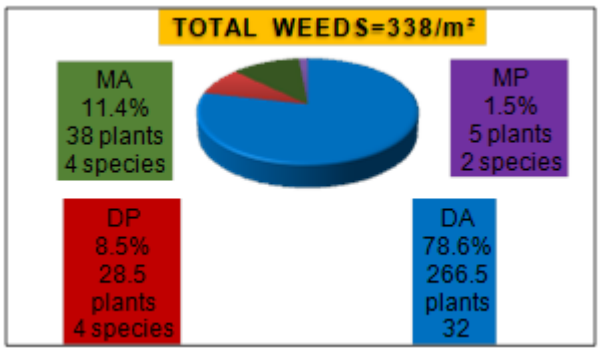

Figure 1 **Weeds distribution in wheat monoculture**

When the wheat was included in anappropriate crop rotation, having had the winter oil rape as previous crop, only 18 species with an average density of 184.5 plants/m^2 were determined. The first category, having a density of>20 plants/m^2, included the species: *V. hederifolia, V. persica* and *S. media*, with a participation of more than 30% in general infestation and a constancy (K%) of 100% being present at all points where observations and determinations were made *(figure 2*).

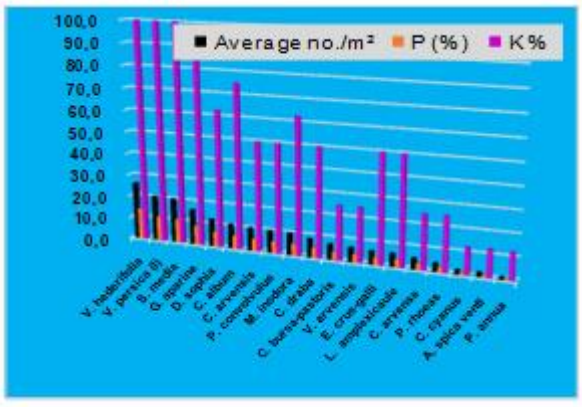

Figure 2. **Weeds in wheat rotation**

Regarding the distribution of weed species on botanical groups, when the wheat was included in an appropriate crop rotation predominated the annual dicotyledonous with 12 species which had an average density of 151.5 plants/m^2 and a rate of 82.1% in the general weed infestation process (*figure 3*).

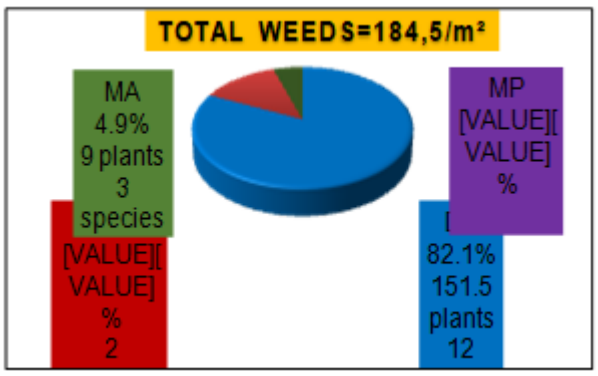

Figure 3 **Weeds distribution in wheat rotation**

In the wheat monoculture crop in Călăraşi county (*table 1*), there were also identified 5 invasive species (*V. persica, E. annuus, Bromus secalinus, Conyza canadensis, L. arvense* compared to wheat in crop rotation system where only one species was identified (*V .persica*).

Perennial monocotyledonous were sporadically present in wheat crops, especially in the form of small, dispersed and irregular areas.

The analysis of the obtained data shows that the distribution of weed species by botanical groups was specific and demonstrates the high degree of weed-infestation in the wheat crop as well as it establishes the clear way of action to find the strategic solutions for weed control.

Mapping shows the total number of species, each density, ratio of botanical categories, constancy, problem-species with target-species, the emergence of new invasive species.

The annual structure between the three categories of weeds (DA, DP, MA) was also different, fluctuating, demonstrating the variability of the occurrence, the evolution of their vegetation in relation to the interspecific competitiveness degree and what ultimately resulted (Sagar R., 1968; Christensen S., 2009).

B. Results on weed control in wheat crop.

In experimental field the predominant weeds were annual dicotyledonous: *V. hederifolia, D. sophia, P. rhoeas, G. aparine, V. persica and perennial dicots C.arvense* (*table 2, 3*). There is large number of chemical applications for weed control (Ionescu N., 2011). There were present also the species: *S. media, C.album, C. bursa-pastoris, Matricaria* spp., *Thlaspi arvense, E. crus-galli, C. arvenis* but in lower number. Analyzing the data presented in Tables 3 and 4, it is noticed that before the post-emergence treatment application, *Veronica* species had a density of 18 plants m² with a coverage rate of 20%, and before the post-emergence treatment application they exceeded 27 plants/m², with a coverage rate of 30%.Their development can be stopped, not by eradication, but at levels which no longer produce economic damages.

Table 2

Density of weeds in wheat crop before treatments early postemergence

Variants/ Herbicides	Rates l (kg)/ha	*Veronica species*		*D. sophia*		*P. rhoeas*		*G. aparine*		*C. arvense*	
		Density BBCH 30-32									
		Nr.* (m^2)	Gr. ** (%)	Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)
Untreated	-	18.0	20.0	10.0	12.0	7.0	8.5	8.0	10.5	8.0	10.0
Secator OD	0.1	15.0a	17.0a	7.0a	8.5a	5.0a	6.5a	8.0a	10.5a	10.0a	12.0a
	0.15	13.5a	16.0a	8.0a	9.5a	2.0a	3.0a	9.0a	11.5a	6.0a	7.0a
Biathlon 4 D + Dash	0.04+1.0	13.0a	15.0a	7.0a	8.5a	5.0a	6.5a	10.0a	12.5a	8.0a	10.0a
	0.07+1.0	18.0a	20.0a	10.0a	12.0a	5.0a	6.5a	8.0 a	10.5a	6.0a	7.0a
LSD P=.05		10.73	11.15	9.73	10.23	7.29	8.59	5.76	5.58	9.31	11.02
Standard Deviation		6.97	7.24	6.73	6.64	4.73	5.58	3.74	3.62	6.37	7.16
*Nr. (m^2) - number of weeds per square meter; ** Gr. (%) = ground % of weeds											

Table 3

Density of weed in wheat crop before treatments late postemergence

Variants/ Herbicides	Rates l (kg)/ha	*Veronica species*		*D. sophia*		*P. rhoeas*		*G. aparine*		*C. arvense*	
		Density BBCH 37-39									
		Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)	Nr. (m^2)	Gr. (%)
Untreated	-	27.5	32.5	16.0	18.0	11.5	13.5	15.3	18.0	16.0	19.5
Secator OD	0.1	23.5a	28.0a	14.5a	16.5a	14.5a	16.5a	16.0a	18.5a	15.0a	18.0a
	0.15	27.5a	32.5a	14.5a	16.5a	11.a	13.a	12.8a	15.5a	15.0a	18.0a
Biathlon 4 D + Dash	0.04+1.0	24.5a	29.0a	16.0a	18.0a	10.0a	12.0a	16.0a	18.5a	15.0a	18.0a
	0.07+1.0	21.0a	25.0a	13.0a	16.0a	14.5a	16.5a	14.5a	16.5a	15.0a	18.0a
LSD P=.05		15.01	14.77	7.80	7.72	9.78	9.78	9.91	11.11	10.19	9.72
Standard Deviation		9.74	5.59	5.06	5.01	6.35	6.35	6.43	7.21	6.61	6.31

The spectrum of weeds in winter wheat crops has a specific characteristic and is in constant evolution, especially in the context of climatic changes (Berca M., 2004). Some species in the genus *Veronica* are considered invasive species, out of these, the most

important two species being *V. hederifolia* and *V. persica* and *V. arvensis* (Dihoru G., 2004). Although it is an ephemera species of the *Plantaginaceae* family, *V. hederifolia* is harder to fight especially when its density exceeds 25 plants/m². In practice, it is very difficult to choose effective herbicides for this weed because in the product label these species are grouped most often as *Veronica* spp., followed by the popular name of a single species (Hălmăjan H.V., 2017). Farmers have to be careful how they identify the species, because they have a different sensitivity to herbicides. In these conditions of wheat crop weed - infestation, the most sensitive to the studied herbicide rates were the weeds *D. sophia*, *G. aparine* and *V. persica*. In table 4 is shown the efficacy of Secator OD and Biathlon 4 D against weeds presents in experimental fields.

Table 4

Herbicide efficacy against the weeds in winter wheat

Variants/ Herbicides	Rates l (kg)/ha	BBCH	Efficacy (%) on 56th day after treatments					
			V.hederifolia	*D. sophia*	*P. rhoeas*	*G.aparine*	*V.persica*	*C.arvense*
Untreated	-	-	0.0	0.0	0.0	0.0	0.0	0.0
Secator OD	0.1	30-32	45.5 ab	98.1 a	62.0 c	92.8 a	60.0 c	80.5 c
	0.15	30-32	48.5 a	99.7 a	74.5 b	95.3 a	81.8 b	86.5 b
	0.1	37-39	38.0 c	100.0 a	52.0 d	95.5 a	78.3 b	81.5 c
	0.15	37-39	43.5 bc	99.3 a	72.5 b	92.8 a	89.0 a	91.0 a
Biathlon 4 D + Dash	0.04+1.0	30-32	48.5 a	100.0 a	89.0 a	95.5 a	78.3 b	91.0 a
	0.07+1.0	30-32	52.0a	100.0 a	90.0 a	95.3 a	89.0 a	93.0 a
	0.04+1.0	37-39	41.0 c	100.0 a	72.5 b	91.5 a	81.8 b	86.5 b
	0.07+1.0	37-39	50.0 a	100.0 a	74.5 b	95.5 a	90.0 a	95.0 a
LSD P=.05			3.26	1.4 – 1.8	1.66	3.27	4.53	2,71
Standard Deviation			2.11	4.44 t	1.08	2.12	2.94	1.76

The product Secator OD applied in phenophase of beginning of stem elongation – node 2 at least 2 cm above node 1 of the wheat showed unsatisfactory results of efficacy against common poppy (62-74%). At the phenophase of flag leaf of the crop, the control of the weeds was more diminished and varied from 52 to 72%.

It was observed that the common poppy acquired resistance to the sulfonylurea herbicide Secator OD. Biathlon 4 D showed higher efficacy against the common poppy in comparison to Secator OD, due to the active substance florasulam, belonging to triazolepyrimidine group of herbicides. Even though in the phenophase flag leaf of the wheat Biathlon 4 D showed moderate efficacy against common poppy (72-74%).

Among the annual weeds, the *V. hederifolia* was the most resistant (*table 2*). The biological efficacy of Secator OD against this weed varied from 45 to 48%. For the late application at phenophase flag leaf the efficacy was from 38 to 43%. Biathlon 4 D also was not effective enough against ivy-leaved speedwell. Only at the high rate of 0.07 applied together with the adjuvant Dash in rateof 1.0 l/ha in phenophase spindling of the wheat, barely 52%efficacy was recorded. Similar results by Mitkov A. *et al*, in 2017 were reported. In the case of the creeping thistle, higher biological efficacy was obtained after the application of Biathlon 4 D in comparison with herbicides Secator OD.

No phytotoxicity symptoms have been shown in experimental plots. No symptoms such as chlorosis, necrosis and deformation of leaves as well as reduction of the plants height, distortion and delay of the anthesis were observed.

CONCLUSIONS

Wheat (*Triticum aestivum* L) has a major place in the agricultural economy of Romania, and are yearly weed-infested, especially in monoculture, with segetal species belonging to diverse botanical families, some of them very difficult to fight against.

Weed mapping is a necessary measure to determine the degree of infestation and the prognosis of weed emergence in agricultural crops.

By centralizing the data according to density and constancy and by separation by botanical groups, the weed control strategy is established.

In wheat monoculture crop 41 weed species with an average density of 338 plants/m^2, were identified.

When the wheat was included in an appropriate crop rotation, having had the winter oil rape a previous crop, were identified only 18 species with an average density of 184.5 plants/m^2.

By applying the crop rotation the degree of weed-infestation is significantly reduced compared to monoculture.

In the context of climatic changes, some the weed species considered ephemeral become dominant, changing themselves into problem – weeds, as *Veronica* species did, too.

The best control of the weed has been carried by integrating agro-technical measures with products for plant protection.

Regardless of the method chosen for controlling weeds (chemical, cultural, biological, etc.), the aim is to reduce the wheat crop infestation to levels that no longer cause economic damages.

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