

INFLUENCE OF AGRICULTURAL SYSTEM ON THE CONTROL OF *BROMUS TECTORUM* ON WINTER WHEAT

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Abstract. *Bromus tectorum* causes special problems because of its ability to reproduce through seeds and also because it's relative tolerance to numerous herbicides. Extending new tillage systems, conservative systems specific to conservative sustainable agriculture, is a difficult task to accomplish under the circumstances of strong monocotyledonous weed infested *Bromus tectorum* is one of the most dangerous monocotyledonous weeds when applying unconventional system. A research was conducted in the pedoclimate condition of Agricultural Research and Development Station Turda, investigating the control of *Bromus tectorum* by conservative tillage. The goal was to determine the relationship between agricultural system and weeding degree on winter wheat. The use of minimum tillage and no tillage systems, caused at the end of a three year crop rotation, the increase of the *Bromus tectorum* pervasion in two systems, MD and NT. The occurrence of *B. tectorum* it is caused mainly due to the fact that the seeds are located in the first cm of the soil. Total weed density was significantly lower under the conventional tillage system (CS) and minim-chisel (MC) than under the minimum tillage-disk (MD) and no till (NT) system. The main benefit of the conventional tillage (CS) is a highly important decline of weeds.

Key words: agricultural system, *Bromus tectorum*, climate, winter wheat, yield

INTRODUCTION

The literature mentions that *Bromus tectorum*, known as downy brome, drooping brome (BSBI List, 2007) or cheat grass, is a winter annual grass native to Europe, Southwestern Asia, and Northern Africa, but has become invasive in many other areas (Upadhyaya et al., 1986). In the eastern U.S. *B. tectorum* is common along roadsides and as a crop weed, but usually does not dominate an ecosystem. It has become a dominant species because this weed its rapid growth and with prolific seed production (Blank et al., 2015; Chambers et al., 2016). A majority of research during 2011-2017 has focused on the use of herbicides to control *B. tectorum* and their effect on native plant communities. When using herbicides, to suppress winter annual grasses, the two most important factors that influence success are application timing and lasting effect (Sebastian et al., 2016; wikipedia.org). *B. tectorum* creates problems in the cultivation of straw cereals, especially wheat due to the vegetation cycle consistent with wheat in particular. Because the germination of seeds takes place in autumn or spring, it grows, from a vegetative and generative point of view, in autumn-winter and in April-May it blooms. Some of the plants that have sprouted in the spring go through the whole biological cycle and in the autumn they bloom. The control of the *B. tectorum* in the crops is done by an appropriate agrotechnics, the rotation of the crops will be respected, the roadsides, the banks of the canals will be cleaned, as well as the uncultivated areas around the high voltage poles, the hydrants etc. (Domuța, 2008; Berca, 2011; Rusu et al., 2013, 2014; www.agrimedia.ro).

In recent years there have been increasing problems with drought, so it is necessary to conserve water from the soil, and the choice of the range of equipment and technologies has the most important role (Rusu et al., 2009; Chețan, 2020; Ruja et al., 2021; Deryng et al., 2014). Limiting the effects of drought can also be achieved through agro-phytotechnics measures for the accumulation, conservation and efficient recovery of water from precipitation. By protecting the soil with plant debris (mulch), it avoids the loss of water by evaporation but also the suffocation of rising or rising weeds (Feiza et al., 2005; Berca, 2004; Rusu, 2005; Chețan et al., 2018). The choice of the optimal technological variant must take into account the technological properties of the soil: texture, humidity, soil exposure, humus content, etc., but also the climatic conditions of the agricultural year and the technological capacity to capitalize on these resources (Ștefanic et al., 1997; Szajdak and Rusu, 2016).

In the Transylvanian Plain there is an interaction of a large number of limiting factors for agricultural technologies, two of which show a dominant action. The first is the thermal factor with low temperature level and with large temporal variations and the second is the hilly orography of the land with numerous soils degraded by erosion (Rusu et al., 2009; 2014; Chețan, 2020, 2021). Recently, there has been a slight increase in average annual temperatures, as well as a high fluctuation in the distribution of rainfall. Thus, the reduction of the effects of atmospheric and pedological drought is part of the reasons that determine the orientation towards new variants of soil works.

The paper presents the results of research conducted, in the hilly area of the Transylvanian Plain, regarding on the influence of tillage system on the weeding degree and winter wheat yield, in the period 2019-2021.

MATERIALS AND METHODS

The experiments have been carried out at the Agriculture Research and Development Station Turda, located in West of the Transylvanian Plain, Turda town. The experimental field was placed on a Phaeozem argic soil type (Romanian Soil Taxonomy System, 2012), having the following properties (Methodology for elaborating pedological studies, 1987): neutral pH; good and very good supply with mobile phosphorus and potassium; the content in humus is average. The experiment being included in a crop rotation of three years: soybeans - autumn wheat - maize.

The biological material chosen for this trial was represented by the winter wheat Andrada variety.

The sowing was done with the Directa-400 machine (at the same time as sowing was applied the fertilizer $N_{56}P_{56}K_{56}$ a.c/ha (active substance), avoiding repeated passes with heavy aggregates on the soil surface), at 18 cm distance between the rows and 550 germinating grain/m² density (g.g/m²).

The experimental factors were the following: factor **A**, agricultural system: a₁ classic with plow (CS) - control variant, a₂ minimum tillage with chisel (MC), a₃ minimum tillage with heavy disc (MD), a₄ no tillage-direct sowing (NT); factor **B**, fertilization level: b₁ 350 kg/ha NPK 16:16:16 at sowing, b₂ 350 kg/ha NPK 16:16:16 at sowing + 150 kg/ha Nitrocalcare in spring when vegetation started; factor **C**, agricultural year: c₁ 2019, c₂ 2020, c₃ 2021.

Direct seeding was done with direct drilling machine (Directa-400 machine), at the same time as sowing was applied the fertilizer $N_{56}P_{56}K_{56}$ a.c/ha (active substance/ha), avoiding repeated passes with heavy aggregates on the soil surface), at 18 cm distance between the rows and 550 germinating grain/m² density.

Disease control (*Blumeria graminis* f. Sp. *Tritici*, *Zymoseptoria tritici*, *Fusarium* sp., *Ustilago segetum* var. *Tritici*) and pest control (*Oulema melanopus*, *Schizaphis* sp., *Dolycoris baccarum*, *Phylotetra atra*) was ensured preventively by observing the integrated control measures (crop rotation, seed treatment) and curatively by carrying out the treatments on vegetation in three phenophases: at the end twinned simultaneously with the herbicide: 0,7 l/ ha fungicide based on prothioconazole 53 g/l + spiroxamine 224 g/l + tebuconazole 148 g/l) + 0,2 l/ha insecticide based on thiacloprid 240 g/l; in the bellows phenophase 0,8 l/ha fungicide based on 4% proquinazide + 16% tebuconazole + 32% prochloraz; at the end of flowering: 0,8 l/ha fungicide based on prothioconazole 175 g/l + trifloxystrobin 150 g/l.

The application timing of herbicide it is post-emergence in early spring when *Bromus tectorum* is a seedling and the dicotyledonous weeds are in the rosette phase. Herbicide was performed using systemic products: 0,15 l/ha based on amidosulfuron 100 g/l + iodosulfuron-methyl-Na 25 g/l + mefenpyr diethyl 250 g/l (safener) + 0,6 l/ha produced on base 660 g/l 2,4% D acid from dimethyl amine salt (825 g/l 2,4 D dimethyl amine salt).

The degree of weeding of the crop and the spectrum of weeds present were determined: visually and numerically using the metric frame. In the all agricultural systems, harvesting was performed with the harvester specific for experimental fields.

The resulted data were statistically processed using variance analysis and LSD (Least Significant Difference) test, which are commonly utilized in the multi-criterial statistical analysis (ANOVA, 2015).

The weather conditions during the 2019 - 2021 (measured at Meteorological Station Turda 23°47'Longitude; 46°35'Latitude; 427 m Altitude) can be seen in Table 1 and 2.

RESULTS AND DISCUSSIONS

The experiment was conducted on fertile soil, but also with susceptibility to rapid compaction when passes the large agricultural aggregates, or when working mechanically in conditions of high humidity, the soil moisture of 24-25% is high enough to produce a surface compaction. The land on which the experiment was set up has a high clay content (more than 40%).

From the data presented in the table 1, it can be seen that each year was warmer than the multiannual average for 65 years (9,2°C), especially the year 2019 with over 11°C. All the three years was rainy comparative with multiannual sum (493,4 mm) as can be seen from Table 2. The highest rainfall values are obtained in the summer months, especially in June, which is the rainiest month of the year.

Specific to the all years studied (2019, 2020, 2021), was the uneven distribution of rainfall, there were dry periods of time, followed by torrential rains. A major contribution to the yield of winter wheat is the rainfall on April, May and June, which correspond to the phases of elongation of the straw, the formation of the ear, the formation and filling of the grains.

Table 1. The thermal regime during 2019 - 2021 at ARDS Turda

Year/ month	Average monthly temperature (°C)												Annual average
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2019	-2.2	1.7	7.3	11.3	13.6	21.8	20.4	22.1	17.1	13.5	8.9	0.8	11.4
2020	-2.8	2.6	6.1	10.3	13.7	19.1	20.2	21.5	17.8	12.0	3.2	2.7	10.5
2021	-0.6	1.4	3.3	7.8	14.1	19.8	22.7	19.7	15.0	9.7	4.4	0.9	9.9
65 years	-3.3	-0.6	4.4	10.0	15.0	18.0	19.8	19.5	15.2	9.8	4.0	-1.3	9.2

Table 2. The rainfall regime during 2019 - 2021 at ARDS Turda

Year/ month	Precipitation - monthly amount (mm)												Annual sum
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
2019	11.4	17.1	45.3	70.8	77.9	118.2	16.5	148.6	32.6	18.6	6.1	17.7	580.8
2020	12.8	30.7	24.4	10.1	103.8	77.1	54.4	118.1	84.7	93.0	25.4	20.8	655.3
2021	17.3	11.2	30.3	58.4	89.0	136.8	125.2	9.0	41.0	45.4	21.1	45.9	630.6
65 years	9.5	22.4	53.5	8.4	31.4	113.4	52.5	38.1	3.4	77.8	48.0	35.0	493.4

In Table 3, it can be seen that out of 170 weeds (100%) determined in early spring, which represents the total number of the three experimental years, the dominance of DA weeds with 66 weeds (38,8%) is noticed, followed by 48 MA weeds (28,3%), 46 DP weeds (27,05%). The MP species represented by *Elymus repens* had a participation rate of 5,88%% (10 weeds). *Elymus repens*, has been present throughout the experimental years, its control in the culture of wheat grown in a conservative system (MD, NT) is also more difficult to achieve if the land is not plowed.

Table 3. The weeds species present in winter wheat culture in early spring, 2019- 2021

No.	Weed species	Years/Tillage system/ no.weeds/m ²											
		2019				2020				2021			
		SC	MC	MD	NT	SC	MC	MD	NT	SC	MC	MD	NT
1	<i>Avena fatua</i>	1	2	0	0	1	1	0	0	0	1	0	0
2	<i>Bromus tectorum</i>	0	0	0	1	0	2	2	4	1	1	4	7
3	<i>Setaria glauca</i>	1	1	1	1	1	2	2	2	0	1	1	0
4	<i>Apera spica venti</i>	0	1	2	1	0	0	0	1	1	0	0	1
	Total MA (48 weeds)	2	4	3	3	2	5	4	7	2	3	5	8
1	<i>Elymus repens</i>	0	0	1	1	0	0	2	1	0	0	3	2
	Total MP (10 weeds)	0	0	1	1	0	0	2	1	0	0	3	2
1	<i>Adonis aestivalis</i>	1	1	0	0	1	2	1	0	0	1	0	2
2	<i>Bifora radians</i>	1	0	0	0	0	0	1	0	1	0	0	0
3	<i>Fumaria vaillantii</i>	0	1	0	0	1	0	0	0	0	1	0	0
4	<i>Galeopsis tetrahit</i>	0	1	1	0	1	0	0	2	0	0	0	0
5	<i>Gallium parviflorum</i>	1	1	1	0	0	1	1	0	1	0	0	0
6	<i>Myosotis arvensis</i>	0	1	1	0	1	0	0	0	0	1	1	0
7	<i>Raphanus raphanistrum</i>	0	1	0	0	1	0	0	1	0	0	0	0
8	<i>Sinapis arvensis</i>	1	0	1	1	0	0	0	0	0	0	0	1
9	<i>Stachys annua</i>	1	1	1	0	0	0	0	0	0	0	0	0
10	<i>Stelaria media</i>	2	1	2	0	0	0	0	1	0	0	0	0
11	<i>Veronica hederifolia</i>	1	1	2	1	0	0	0	0	0	1	0	0
12	<i>Viola arvensis</i>	0	1	2	1	1	0	1	1	0	1	2	3
	Total DA (66 weeds)	8	10	11	3	6	3	4	5	2	5	3	6
1	<i>Convolvulus arvensis</i>	1	2	2	2	1	1	3	2	0	1	3	3
2	<i>Rubus caesius</i>	0	0	0	1	0	0	2	1	0	0	2	3
3	<i>Lathyrus tuberosus</i>	0	0	1	1	0	1	2	2	1	1	2	2
4	<i>Taraxacum officinale</i>	0	0	0	0	0	0	0	0	0	0	1	2
	Total DP (46 weeds)	1	2	3	4	1	2	7	5	1	2	8	10
	TOTAL WEEDS: 170 (100%)	11	16	18	11	9	10	17	18	5	10	19	26

The monocotyledonous species *Bromus tectorum* has been present in the NT system since the beginning of the experiment (2019), in 2020 in all unconventional systems (without plowing) and in the last year it has expanded so that we find it in the classic version. Due to the fact that this species has spread even further in wheat

cultivation, we believe that a different approach is needed regarding the tillage system, herbicides used (active substance) and the time of their application. From the research conducted by Ionescu (2011) at A.R.D.S. Pitesti, Albota Commune, Argeş County, results that in wheat culture 75% of the weeds present were annual dicotyledons, 16% perennial dicotyledons and 9% monocotyledons annual. And another research carried out by Torcea (2018) in the Arad County, it presented that in the winter wheat the dominant species was *Bromus tectorum* (22,23%) followed by *Setaria glauca* (13,17%) and *Amaranthus retroflexus* (10,97%).

The yield obtained, by applying the different tillage systems, show that differentiated results can be obtained, the choice of the cultivation variant and the fertilization variant being decisive. Soil tillage, doses and types of fertilizers, protection of plants from disease and pest attack in interaction with other important factors (variety, climatic conditions) have a direct influence on the yield of winter wheat. In the case of the CS the average yield obtained was 7637 kg/ha and for the conservation system it was lower yield. The differences of 122 - 332 kg/ha proved that conventional system (CS) recorded a higher production compared to the performance level registered by the systems MC, MD and NT. Between the average values of the obtained yield under the influence of the four agriculture systems there are significant negative differences, as can be seen from the Figure 1.

It seems that existing difference between the four agriculture systems is explained by the the reduced soil porosity and the increased the weeding. The yield declines in the MD and NT systems also seem to be caused by the higher number of weeds present in these variants.

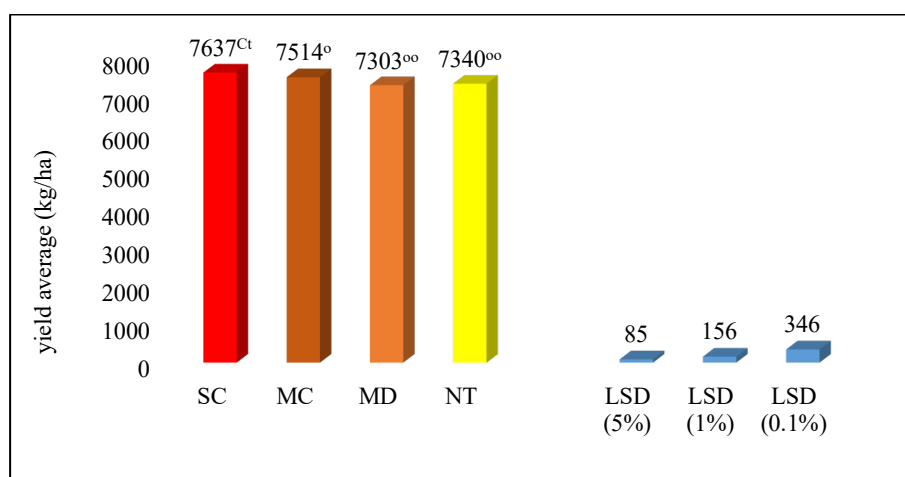


Figure 1. The influence of the agricultural system on winter wheat yield, 2019 - 2021

In the case of one fertilization with $N_{56}P_{56}K_{56}$, the control variant, the average wheat yield was 7268 kg/ha and the variant with highest fertilizer dose $N_{56}P_{56}K_{56} + N_{40,5}$ performed 7630 kg/ha, the difference being 362 kg/ha. Therefore, the higher the fertilization level, the higher the wheat yield (Figure 2). Analyzing the influence of fertilization level on winter wheat yield it was noticed that the additional amount of fertilizer has determined a very significant increase of the yield (Mustăţea et al., 2009; Grigoraş et al., 2013)

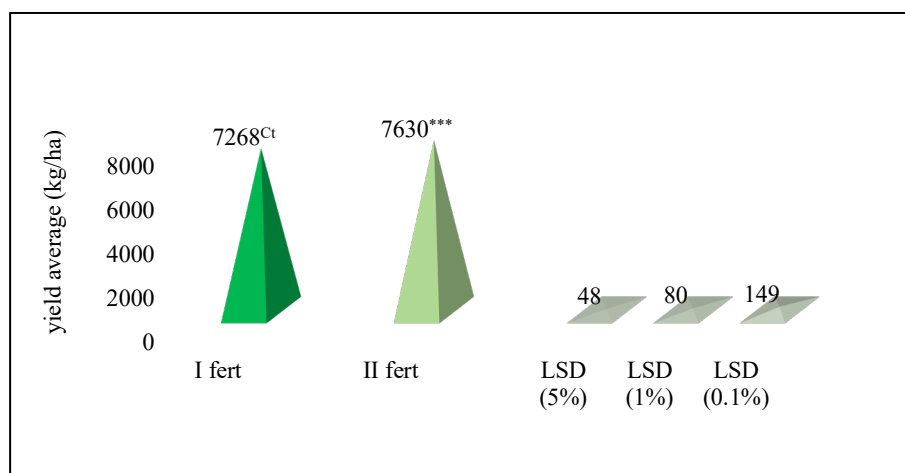


Figure 2. The influence of fertilization on winter wheat yield, 2019 - 2021

The analysis of the data from figure 3 regarding the influence of the agriculture year on winter wheat yield, revealed that the 2020 year has determined a lower yield (7270 kg/ha) compared to the control variant-years average (7449 kg/ha), with an insignificant difference of 179 kg/ha.

We believe that this result is the consequence of the drought that has been installed since the last 3 months of 2019 as well as the lower rainfall in March (24,4 mm) and June (77,1 mm) in 2020. The yield obtained in 2019 was very close to control variant, the difference of 32 kg/ha does not show statistical assurance. It seems that in 2021, more favorable conditions for winter wheat cultivation were met, achieving the highest yield (7619 kg/ha), with a distinctly significant positive difference (170 kg/ha).

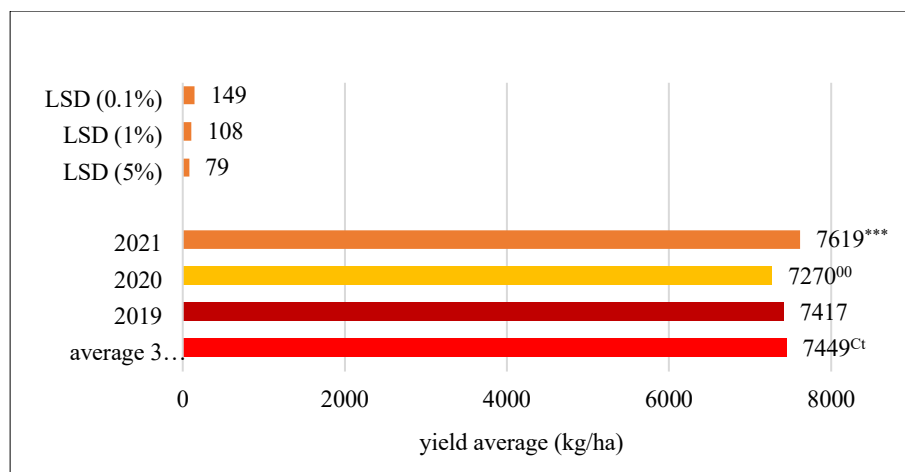


Figure 3. The influence of the agricultural year on winter wheat yield, 2019-2021

Compared to conventional agriculture (CS) + one fertilization, unconventional MD and NT systems determined a significant reduction of winter wheat yield accounting for 219 -336 kg/ha, the differences being statistically assured (distinctly significant negative). Analyzing the situation according to the second level of fertilization, compared to CS all unconventional systems (MC, MD, NT) determined the decrease of winter wheat yield (significantly influencing, respectively distinctly significantly negative), as shown in Table 4.

Table 4. The interaction between agricultural system x fertilization on winter wheat yield, during 2019-2021

The factor	Yield (kg/ha)	%	Differences
CS + N ₅₆ P ₅₆ K ₅₆	7432	100	0 ^{Ct}
MC + N ₅₆ P ₅₆ K ₅₆	7330	99	-102
MD + N ₅₆ P ₅₆ K ₅₆	7096	96	-336 ⁰⁰
NT + N ₅₆ P ₅₆ K ₅₆	7213	97	-219 ⁰⁰
CS + N ₅₆ P ₅₆ K ₅₆ + N _{40.5}	7840	100	0
MC + N ₅₆ P ₅₆ K ₅₆ + N _{40.5}	7697	98	-142 ⁰
MD + N ₅₆ P ₅₆ K ₅₆ + N _{40.5}	7511	96	-329 ⁰⁰
NT + N ₅₆ P ₅₆ K ₅₆ + N _{40.5}	7473	95	-366 ⁰⁰

LSD (5%) = 109, LSD (1%) = 191, LSD (0.1%) = 398.

CONCLUSIONS

The conservation agriculture could be implemented in winter wheat cropping in the Transylvanian Plain but also in any other regions where pedoclimate conditions are similar.

The yield differences between the classic variant and the unconventional ones are below 400 kg/ha.

The annual dicotyledonous and monocotyledonous weeds predominate in the experiment.

The farmers could apply unconventional system but they have to pay attention to fertilization level and measures to control weeds, especially problem weeds, such as *Bromus tectorum* species, which has spread in recent years.

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