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Weed infestation in durum wheat (*Triticum durum* L.) under different fertilization methods

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SUMMARY

The aim of this study was to determine the influence of different organic fertilizers on weed infestation in durum wheat over a two-year period. The experiment was conducted at the „Radmilovac” experimental field, managed by the University of Belgrade, Faculty of Agriculture. The durum wheat cultivar „Durumko” was selected for this study. The experiment was established as two factorial, with three repetitions. Factor A consisted of two growing seasons (2023/24 and 2024/25), while factor B included six fertilization treatments involving different organic fertilizers (ZEO PULLUS, ZEO MAG, ZEO FOS and their combination with microbiological fertilizer Slavol) and control treatment. Annual weeds were predominantly represented, with *Ambrosia artemisiifolia* L. and *Consolida regalis* S. F. Gray identified as the most abundant species. The highest total number of weeds was recorded in the treatment where organic fertilizer ZEO MAG and microbiological fertilizer Slavol were applied simultaneously. The highest fresh weed biomass was recorded in the treatment with the organic fertilizer ZEO FOS (152 g m⁻²), and the highest air-dried biomass was also observed in this treatment. Proper fertilization management, harmonized with agroecological conditions, represents an important agronomic measure in the control of weed infestation in durum wheat.

Keywords: weed control, annual weeds, fertilization management, competitors, alternative crop species.

INTRODUCTION

Durum wheat (*Triticum durum* L.) is an important raw material for pasta production and is widely utilized in the food industry (Sall et al., 2019). According to FAOSTAT, global durum wheat production amounts to approximately 37 million tons annually, accounting for nearly 6% of the total world wheat production. The leading producers of durum wheat include Canada, Turkey, USA, Algeria, Mexico, and Kazakhstan (Xynias et al., 2020).

Durum wheat yield and cultivated area are determined not only by cultivar, climate, and soil conditions during the growing season, but also by agronomic practices that are adjusted to the plant's physiological requirements throughout its successive growth and developmental stages (Martínez-Moreno et al., 2022). Durum wheat has specific agronomic requirements. High temperatures and water deficit are considered important factors influencing the grain yield (Grosse-Heilmann et al., 2024). However, they also represent stress factors that determine the duration of each phenological stage. Furthermore, the degree of utilization of the biological potential of durum wheat is significantly influenced by sowing density, nitrogen fertilization and the application of plant growth regulators (Božek et al., 2021). The main advantage of this cereal lies in its high content of proteins, carbohydrates, and vitamins B and E, with a considerably lower gluten content, compared with common wheat. Consequently, in recent years, durum wheat has gained increased popularity and has become widely used as an alternative crop species (Dolijanović et al., 2020).

In the context of organic agriculture, it is essential to select alternative crop species suitable for such production systems (Kovačević et al., 2014). Organic agricultural production is highly specific. Therefore, for alternative crops such as durum wheat, it is necessary to develop an appropriate cultivation technology based on the principles of agroecology. Consequently, the implementation of crop rotations with a higher proportion of legumes, crop residues, and green manure is required in order to preserve soil quality. In addition, the use of microbiological preparations, mechanical cultivation practices, and biological control of diseases, pests, and weeds is considered beneficial (Minhas et al., 2023).

Weed infestation represents one of the major challenges in agricultural production due to the competitive relationships established between weed species and cultivated crops. In organic farming systems, the issue of weed infestation is even more pronounced because of the prohibition of herbicide application as a protective measure (Roljević Nikolić et al., 2017). An important component of weed management strategies is the selection of cultivars and species capable of successfully competing with weeds for limited resources, releasing allelochemicals that inhibit weed growth, and reducing economic losses by maintaining high grain yields. Therefore, understanding the morphological and physiological traits of plant species that constitute the basis of their competitive ability against weeds is of great importance (Roljević Nikolić et al., 2020).

The aim of this study was to determine the influence of different organic fertilizers on weed infestation in durum wheat during two growing seasons.

MATERIAL AND METHODS

The weed infestation of durum wheat under different fertilization treatments was investigated at the experimental field „Radmilovac” managed by the Faculty of Agriculture, University of Belgrade. The study was conducted on chernozem soil type. The experiment was established using randomized block system, with an elementary plot size of 6 m². The winter – spring durum wheat cultivar „Durumko”, commonly used for the production of high quality pasta, was selected for the study. The cultivar is characterized by good winter hardiness and resistance to diseases such as powdery mildew.

The experiment was designed as a two-factor trial with three replications. Factor A was represented by two growing seasons: 2023/24 and 2024/25. Factor B included fertilization treatments involving different organic fertilizers. The first treatment represented the control variant without fertilizer application. The second treatment involved fertilization with the organic fertilizer ZEO PULLUS, the third with ZEO MAG and the fourth with ZEO FOS, while the fifth, sixth and seventh treatments consisted of combinations of these fertilizers with Slavol. ZEO PULLUS was applied at a rate of 0.3 kg m⁻², whereas ZEO MAG and ZEO FOS were applied at a rate of 0.09 kg m⁻².

ZEO PULLUS is an enriched poultry manure product supplemented with natural zeolite. In addition to providing plant nutrition throughout the entire growing season, it contributes to soil humification due to its high organic matter content, promotes the introduction of beneficial bacteria and supplies humic and fulvic acids.

ZEO MAG is primarily intended for soil improvement and magnesium nutrition of plants. In addition to its primary function, it positively affects soil structure, improves the soil water – air regime, contributes to the immobilization of heavy metals and increases the availability of phosphorus and calcium.

ZEO FOS is a powdered soil amendment and fertilizer intended for plant nutrition with phosphorus, magnesium, and calcium. Application of this fertilizer additionally increases phosphorus availability by enhancing the nutritional level of phosphorus already present in the soil.

Slavol is a liquid microbiological fertilizer and biostimulant intended for foliar plant nutrition. It contains beneficial microorganisms and naturally active substances that stimulate plant growth, improve nutrient uptake and enhance plant vitality. The product is certified for organic production and is included on the list of permitted substances approved by the Ministry of Agriculture of the Republic of Serbia. It contains nitrogen-fixing bacteria, phosphorus-mineralizing microorganisms, and growth regulators. In addition to supplying plants with nitrogen and phosphorus, the mechanism of action of this product also involves the production of entomotoxins that protect plants against insect pests.

All agronomic practices were identical among all treatments and consistent with standard organic durum wheat production practices. Primary soil tillage using a moldboard plow was performed to a depth of 25 cm in mid-October during both study years. The organic fertilizer was incorporated into the soil at a rate of 3 t ha⁻¹ simultaneously with tillage. Immediately prior to sowing, seedbed preparation was carried out using a harrow disc. The experiment

was established within a four crop rotation system that included the following sequence of crops: maize → winter wheat → spring barley + red clover → red clover. In both experimental years, maize served as a preceding crop.

The floristic composition of weed synusia was determined using the quadrat sampling method. At the experimental field, the floristic composition, number of weed species, number of weed individuals, and fresh biomass were assessed, while biomass in the air dry state was measured after drying the plants under natural conditions.

The data obtained during the study, after confirming their normal distribution and homogeneity of variance, were statistically analyzed using analysis of variance (ANOVA), while the significance of differences between treatments was evaluated using the LSD test. Statistical analysis of the obtained parameters was carried out using the STATISTICA 12 software package (StatSoft, Inc., 1984–2014, Tulsa, OK, USA).

Meteorological conditions. The Walter climate diagram during 2023/24 growing season (Figure 1) illustrates the relationship between mean monthly temperatures and precipitation.

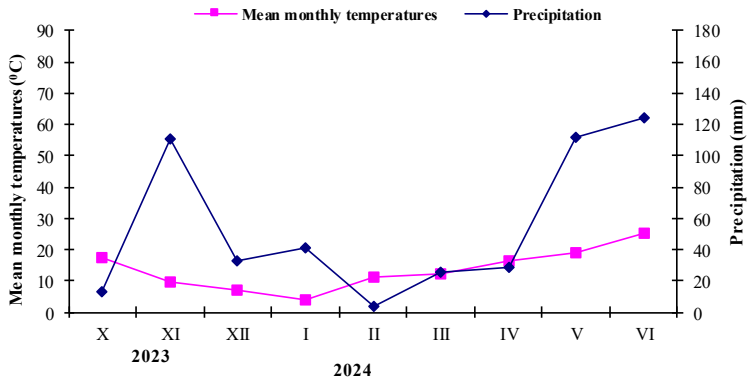


Figure 1. Walter climate diagram for 2023/24 growing season.

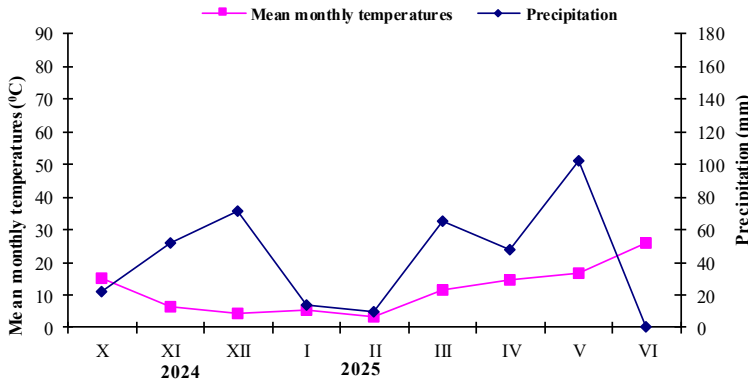


Figure 2. Walter climate diagram for 2024/25 growing season.

Temperature and pluviometric conditions were variable, with more pronounced precipitation occurring during autumn and late spring. The average monthly temperature during this time was approximately 13.5°C, while the total precipitation amounted to 492.3 mm.

During the 2024/25 growing season (Figure 2), the average monthly temperature was approximately 11.5°C, while the total precipitation amounted to 384.4 mm. Minimum temperatures were recorded during January and February (5.2 and 3.3°C), followed by gradual increase during spring and early summer.

Precipitation was unevenly disturbed over the growing season. Higher amounts of precipitation were recorded during December (71.8 mm), March (64.8 mm) and particularly May (101.7 mm), whereas February was notably dry.

RESULTS AND DISCUSSION

Considering the two-year-long experimental period, annual weed species were predominantly represented, among which *Ambrosia artemisiifolia* L. and *Consolida regalis* S. F. Gray were identified as the most abundant species (Table 1). Their presence was most pronounced in the treatment where the organic fertilizer ZEO MAG and microbiological

fertilizer Slavol were applied simultaneously. This phenomenon may be explained by the effect of Slavol (Roljević Nikolić et al., 2022), which, in addition to influencing the productivity of durum wheat, may also significantly affect the weed synusia by increasing weed biomass and the number of individuals. Furthermore, the effect of organic fertilizers was also evident, since by improving soil fertility they create favorable conditions for weed growth. Among the perennial weed species, *Convolvulus arvensis* L. was the most prevalent. A particularly high abundance of this weed species was observed in the control treatment without fertilizer application. Although certain weed species were present in relatively high numbers, the overall number of weed species was not particularly high.

Regarding the weed abundance, the highest number of weed individuals was recorded in the fifth treatment, where the organic fertilizer ZEO MAG and the microbiological fertilizer Slavol were simultaneously applied (128.0 individuals m⁻²), whereas the highest number of weed species were observed in the control treatment. In the study conducted by Dolijanović et al. (2025), which among other factors examined the effect of soil tillage and nitrogen fertilization levels on weed infestation in winter wheat, the average number of weed individuals reached up to 32.3 m⁻². This value was lower than the weed abundance observed in most treatments of the present study, indicating that soil tillage practices substantially contribute to reducing weed populations within a given area. This statement is further supported by the findings of Soroka et al. (2025), where the number of weed species was also considerably lower in conventional tillage systems, although such systems are not permitted in organic farming.

Table 1. Floristic composition of weed community in durum wheat over a two-year period (2023/24–2024/2025).

Weed species	Treatment						
	T ₀	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆
Annual weeds							
<i>Ambrosia artemisiifolia</i> L.	40.0	-	8.0	-	-	72.0	-
<i>Avena fatua</i> L.	-	-	-	-	-	-	24.0
<i>Bylderdykia convolvulus</i> (L.) Dum.	4.0	-	-	-	-	-	-
<i>Consolida regalis</i> S.F. Gray	4.0	12.0	12.0	32.0	28.0	56.0	28.0
<i>Sinapis arvensis</i> L.	4.0	-	-	-	-	-	-
Perennial weeds							
<i>Cirsium arvense</i> (L.) Scop.	-	-	-	4.0	-	-	-
<i>Convolvulus arvensis</i> L.	12.0	8.0	-	8.0	-	-	-
Total number of weeds (m ⁻²)	64.0	20.0	20.0	44.0	28.0	128.0	52.0
Total number of weed species	5	2	2	3	1	2	2
Number of annual weeds (m ⁻²)	4	1	1	1	1	2	2
Number of perennial weeds (m ⁻²)	1	1	1	2	-	-	-

To- control treatment; T₁. fertilization with ZEO PULLUS; T₂. fertilization with ZEO MAG; T₃. fertilization with ZEO FOS; T₄. fertilization with ZEO PULLUS + Slavol; T₅. fertilization with ZEO MAG + Slavol; T₆. fertilization with ZEO PULLUS + Slavol.

Table 2. Effect of different fertilizing treatments on fresh and air-dried weed weight.

Year	Treatment							Average
	T ₀	T ₁	T ₂	T ₃	T ₄	T ₅	T ₆	
Fresh aboveground weed weight (g m ⁻²)								
2023/24	58.0	138.4	104.0	188.0	142.8	90.4	122.8	120.6
2024/25	45.6	43.6	29.6	116.0	106.0	103.6	107.2	78.8
Average A	51.8	91.0	66.8	152.0	124.4	97.0	115.0	
Air-dried weed weight (g m ⁻²)								
2023/24	16.8	39.6	30.0	63.6	40.0	22.0	26.4	34.1
2024/25	20.0	18.0	15.6	44.8	41.6	49.2	44.0	33.3
Average B	18.4	28.2	22.8	54.2	40.8	35.6	35.2	

To- control treatment; T₁. fertilization with ZEO PULLUS; T₂. fertilization with ZEO MAG; T₃. fertilization with ZEO FOS; T₄. fertilization with ZEO PULLUS + Slavol; T₅. fertilization with ZEO MAG + Slavol; T₆. fertilization with ZEO PULLUS + Slavol.

Analysis of fresh weed biomass (Table 2) showed that higher fresh weed biomass occurred during the 2023/24 growing season (120.6 g m⁻²). This value was significantly different compared to the fresh weed biomass recorded during the second experimental year (78.8 g m⁻²). Agro-climatic conditions in this period significantly influenced the dynamics of weed emergence, germination, and development. Higher precipitation during the autumn period provided optimal moisture conditions in the surface soil layer, which favored the germination and emergence of weed species. Regarding fertilization treatments, the highest fresh weed biomass was observed in the treatment with the application of the organic fertilizer ZEO FOS (152.0 g m⁻²), whereas the lowest fresh weed biomass was recorded in the control treatment (51.8 g m⁻²). The difference between these values was highly significant. The highest recorded

fresh weed biomass occurred in the treatment with ZEO FOS during the first experimental year (188.0 g m^{-2}) and this value differed very significantly from the lowest recorded fresh biomass value (29.6 g m^{-2}), which was observed in the treatment with ZEO MAG during the second year of the study. It can be concluded that the meteorological conditions recorded during this experimental period had a significant influence on weed biomass production. Considering the interactions between the factors A and B, predominantly statistically significant differences were observed. An interesting finding was that fresh weed biomass was almost consistently higher in treatments where a combination of organic fertilizers and Slavol were applied, compared with treatments where only organic fertilizers were used.

With regards to the air-dried weed biomass, no statistically significant difference was observed when comparing the average values between the two experimental years. The highest dry biomass was recorded, similarly to the fresh biomass, in the fourth treatment (54.2 g m^{-2}), whereas the lowest value was recorded in the control treatment (18.4 g m^{-2}), representing a statistically very significant difference. When treatments and years were analyzed individually, the highest air-dried weed biomass was observed in the treatment with ZEO FOS during the 2023/24 growing season (63.6 g m^{-2}), while the lowest was recorded in the treatment with ZEO PULLUS during the 2024/25 season (18.0 g m^{-2}). The difference between these values was highly significant. Increased precipitation during early winter period influenced the emergence of perennial weeds. At the same time, lower temperatures during this period slowed the vegetative growth of weeds, but did not significantly limit those species tolerant to lower temperatures. In the study conducted by Woźniak (2020), the highest air-dried weed biomass was recorded in durum wheat grown under monoculture conditions, indicating that crop rotation, which was also implemented for durum wheat cultivation in the present study, can substantially contribute to weed management and reduce weed competitiveness. Furthermore, air-dried weed weight was higher under conservation tillage and no-tillage systems than under conventional tillage, highlighting one of the major challenges in organic farming, where conventional soil tillage practices are not permitted. Nevertheless, balanced fertilization with organic fertilizers, combined with the implementation of crop rotation, can provide favorable growing conditions for crop plants, thereby reducing weed infestation and its adverse effects on crop performance.

Table 3. Significance thresholds.

	Experimental factors		
	A	B	AB
Fresh aboveground weed weight (g m^{-2})			
LSD 0.05	2.59	4.84	6.85
LSD 0.01	3.55	6.65	9.40
Air-dried weed weight (g m^{-2})			
LSD 0.05	2.59	4.84	6.85
LSD 0.01	3.55	6.65	9.40

LSD 0.05- statistically significant difference; LSD 0.01- statistically highly significant difference;
A- growing seasons; B-fertilization treatments; AB-interaction between those two factors.

CONCLUSION

Weed infestation in durum wheat is significantly influenced by the applied fertilization method. Organic fertilizer ZEO FOS contributed most to the weed species growth. Proper and balanced fertilization contributes to a more intensive crop growth and improved crop resistance, thereby enhancing the ability of durum wheat to suppress weeds. Conversely, inadequate or excessive fertilizer application may favor the development of certain weed species and increase the level of weed infestation.

Meteorological conditions during the experimental period were highly unfavorable, particularly during the first year of study, which additionally contributed to an increase in weed abundance. Therefore, the selection of fertilization strategies should be harmonized with agroecological conditions and crop rotation system. Proper fertilization management represents an important agronomic measure in the control of weed infestations in durum wheat.

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Zakorovljenost tvrde pšenice (*Triticum durum* L.) u zavisnosti od načina đubrenja

REZIME

Cilj ovog istraživanja bio je da se utvrdi uticaj različitih organskih đubriva na zakorovljenost durum pšenice tokom dvogodišnjeg perioda. Ogled je izveden na eksperimentalnom dobru "Radmilovac", kojim upravlja Poljoprivredni fakultet, Univerziteta u Beogradu. Za ovo istraživanje odabrana je sorta durum pšenice Durumko. Eksperiment je postavljen kao dvofaktorijski ogled sa tri ponavljanja. Faktor A obuhvatao je dve vegetacione sezone (2023/24 i 2024/25), dok je faktor B uključivao šest tretmana sa različitim organskim đubrivima (ZEO PULLUS, ZEO FOS, ZEO MAG i njihova kombinacija sa mikrobiološkim đubrivom Slavolom) i kontrolni tretman. Jednogodišnji korovi bili su dominantno zastupljeni, pri čemu su vrste *Ambrosia artemisiifolia* L. i *Consolida regalis* S.F. Gray identifikovane kao najzastupljenije. Najveći ukupni broj korova zabeležen je u tretmanu u kojem su istovremeno primenjeni organsko đubrivo ZEO MAG i mikrobiološko đubrivo Slavol. Najveća sveža biomasa korova zabeležena je u tretmanu sa primenom organskog đubriva ZEO FOS (152 g m⁻²), dok je najveća vazdušno suva biomasa takođe utvrđena u ovom tretmanu. Pravilno upravljanje đubrenjem, usklađeno sa agroekološkim uslovima predstavlja važnu agrotehničku meru u kontroli zakorovljenosti durum pšenice.

Ključne reči: suzbijanje korova, jednogodišnji korovi, upravljanje đubrenjem, kompeticija, alternativne biljne vrste.