Dynamics of weeds and integrated weed control in crop rotation with cereals

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Abstract
In arable soils weeds are the main competitors of agricultural crops in terms of water and nutrients, suppress growth reduce yields and profitability of production per unit area.

The study aims to determine the dynamics of the wedding of cereal crops and to explore the possibilities for applying successful weed control under the conditions of Haplic Vertisols from the Sofia region. The influence of two increasing fertilizer norms and a non-fertilization control variant, two soil tillage systems (conventional and minimal), and chemical control with a herbicide mixture and a herbicide with complex action within a two-field crop rotation (maize-triticale) under non-irrigated conditions has been studied.

It has been established that the agrotechnical factors tested - crop rotation, soil tillage, fertilization, and chemical control of weeds – positively impact the degree of weeding in Haplic Vertisols cereal crops. The mechanical tillage of the soil has a more significant impact than chemical application. In variants with the main soil tillage "loosening" (var.O_1) the total general weeding and especially that of perennial root weeds are lower compared to the reduced tillage option (O_2).

In the case of wheat and triticale, after the spraying with the broad-spectrum herbicide Pallas 75 VG and for the maize with the herbicide mixture of Sirio 4 SK + Magneto against annual wheat and broadleaf weeds in both crops, a significant part of the weeds were removed from the whole experimental area.

Key words: weeds; integrated control; crop rotation; cereals crops; maize; wheat and triticale

INTRODUCTION

The dynamics and degree of weeding in crops are subject to constant changes due to compensation processes arising from changes in cultivation technologies, application of various methods and means of weed control, and continued use of herbicides of one chemical group (Atanasova & Zarkov, 2007). Weed control involves weed density management. Thus, the determination of the nature of weed population and weed diversity is of particular importance (Hyvonen et al., 2003; Bengtsson et al., 2005; Kaar & Freyer, 2008). The high biological and ecological plasticity of weeds complicates their control. In order for it to be successful, it is necessary to systematically monitor and forecast the weed vegetation and improve the methods of its control. (Dimitrova et al., 2014; Stoimenova & Aleksieva, 2002; Koocheki et al., 2009; Darmency, 2019; Eliçin et al., 2018).

The integrated control is best suited for maintaining the purity of cereal crops. Its advantages include a more complete destruction of weeds and a lower risk of environmental pollution (Serafimov et al., 2013). The agrotechnical method of weed control does not require significant additional costs, but can significantly improve the ecological environment (Atanasova & Zarkov, 2007). Crop rotation is one of the oldest and most effective agrotechnical means of weed control and at the same time is fundamentally important for the development of sustainable and ecological weed control strategies (Mitova & Gerasimova, 2018; Koocheki et al., 2009). The tillage systems, the type of crops involved in the crop rotation have a differentiated effect on the density and weed species associations (Shrestha et al., 2002).

A large number of weed species are characterised by a rapid build-up of resistance to most plant protection products used in the long-term control. This necessitates the need for new studies to increase the scope of weed control and to keep weed populations below the threshold of economic harm (Lozanova, 2021; Van Evert et al., 2017; Cirujeda et al., 2019).

The aim of the study is to establish the dynamics of weeding of cereal crops and to study the possibilities for effective weed control under the conditions of Haplic Vertisols of the Sofia valley.

MATERIALS AND METHODS

In order to achieve the target set in the period 2020-2021, a field experiment is performed in the experimental base "Bozhurishte" of IPAZR "N. Pushkarov", Sofia Province. The experimental field falls within the area of the high fields in Western Bulgaria, the Sofia - Kraishte ecological region. The experiment is based on the block method (standard) with long plots with a total area of 3.5 da. The scheme of the experiment includes two field crop rotation of the type - "spring row crop-winter cereal crop" (Table 1). Crop rotation includes 24 plots with an experimental area of 90 m^2 and a harvest area of 70m^2.

Table 1. Crop rotation

Crop rotation	Years and crop rotation	
	2020	2020 – 2021
Crops	Maize	Triticale

During the experiment in 2020, maize was grown for grain, and triticale winter cereal crop was grown in the period 2020-2021. Varieties and hybrid crops used include: maize - medium-early hybrid Pioneer P-8834 from FAO Group 310 of Pioneer and triticale variety - "Colorit".

Two factors from the general agrotechnical complex are studied: two soil tillage variants (O_1 and O_2) and three mineral fertilisation variants (T_0, T_1 and T_2) listed in Table 2.

Soil tillage – two tillage systems are applied for each crop rotation. The first system includes intensive tillage (option O_1) with an alternation of loosening at 35-40 cm for the row crop (maize) in the first crop rotation field and ploughingat 15-18 cm for the winter cereal crop (triticale) at the next crop rotation. During the second tillage system, ploughing at 22-25 cm for maize and diskingat 10-12 cm in the crop rotation of triticale was performed, as a variant of minimum soil tillage (O_2).

Fertilization of crops in the crop rotation:

Two fertilization norms and a non-fertilization control variant are tested in the experiment: T_0 – non-fertilized, T_1 – $N_{120}P_{80}$ and T_2 – $N_{160}P_{120}$ kg/ha for maize and T_1 -$N_{120}P_{80}$ and T_2 – $N_{140}P_{100}$ kg/ha for winter cereal crop (triticale).

To achieve the goal of the scientific research, the following parameters are used:

Quantification of weeding:

• density (total number of weeds per unit area, (no per/m^2).

• total biomass of weeds (fresh and dry weight) distributed to species and biological groups of weeds (g/m^2).

Quantitative weighting methods are used to determine the density of weeds and the qualitative

Table 2. Crops, fertilization norm, and tillage systems in crop rotation

	Crop	Fertilization/ kg/ha	Soil tillage systems	
			O_1	O_2
2020	Maize	T_0	Loosening 35-40 cm	Plowing 22–25cm
		T_1- $N_{120}P_{80}$		
		T_2- $N_{160}P_{120}$		
2020-2021	Triticale	T_0	Plowing 15-18 cm	Discing 10-12 cm
		T_1 - $N_{120}P_{80}$		
		T_2- $N_{140}P_{100}$		

characteristic of weeding and the weeds are measured using a sample area of 1 m^2. The readings are performed in three replicates in each variant in certain stages of crop vegetation.

Chemical control of weeds includes the following herbicides and herbicide mixtures: for the crop with a merged surface (triticale), product Pallas 75 VG (active ingredient: pyroxsulam 75 g/kg) at a dose of 25 g/da, for control of annual cereals and deciduous weeds; in maize, Sirio 4 SK (active ingredient: nicosulfuron 40 g/l), 125 ml/da + Magneto (active ingredient: 2,4-D 360 g/l + active ingredient: dicamba120 g/l), at a dose of 120 ml/da.

Herbicides are introduced in the form of an aqueous solution with a tractor sprayer at 30 l/da working solution. Spraying is carried out in the “5-6 leaf” tillering stage for maize and in the jointing stage for the cereal crop - triticale.

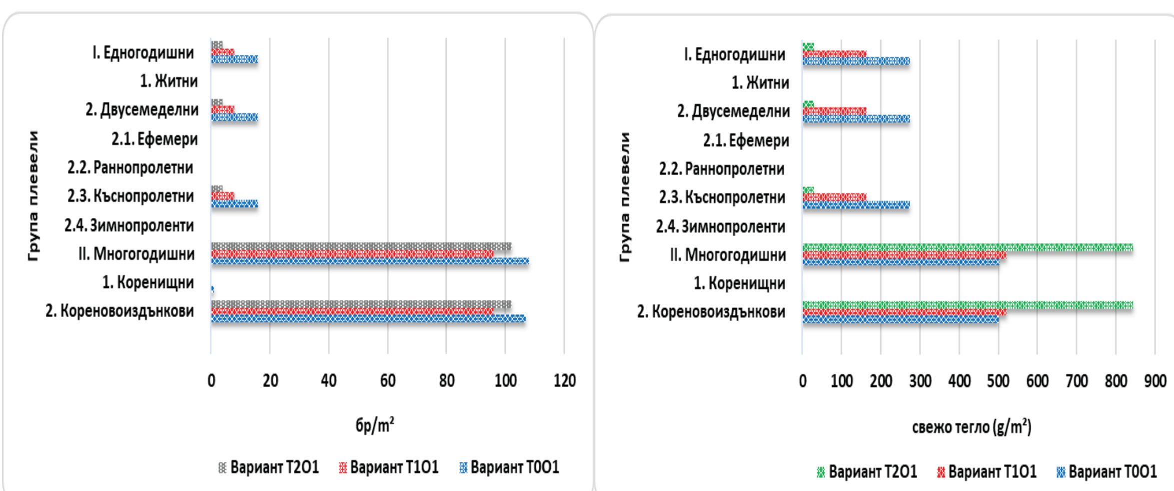
The experiments are performed under non-irrigated conditions in Haplic Vertisols, which is a representative of the heaviest variety in terms of mechanical composition. The content of physical clay is 78-80 %, and the content of silt is 62 %. The relative density of the soil is 2.68. The volumetric density in a dry state is 1.95-2.0 g/cm^3, and for field capacity- 1.23-1.25 g/cm^3.

The study period covers years that differ in quantity and distribution of rainfall during the growing season of crops.

The growth and development of maize in the 2020 vegetation period was determined by the very good quantity of rainwater from sprouting to full maturity (428.5 mm). This amount is higher than the multi-annual average, but a period of drought is recorded in July with rainfall of only 43 mm. In August, the 89 mm rainfall ensured a good development of maize plants and a favorable transition to the reproductive stage. Growth and development of the triticale in the 2020/2021 growing season initially took place with very low rainfall. In November and December, the rainfall is extremely low and only in January the rainfall increased to 160 mm. Later rainfall in March had a positive effect on the growth and simultaneous transition of all plants to the tillering stage. After the crop was grown, a period of drought began with a peak during grain filling.

RESULTS AND DISCUSSION

Weeding of crops is recorded in two main stages of their development. In 2020, the reports are carried out in the “3-5 leaf” stage and in the stage of full maturity of the maize. Taking into account the weeds in “3-5 leaf” stage, it was found that in the first crop rotation in both tillage systems, (O_1, O_2), weeding with annual dicotyledonous and cereal species was lower, with fewer species of the early spring group -wild buckwheat (*Poligonum Convolvulus*), fat hen (*Chenopodium album L.*),common cocklebur (*Xanthium pensylvanicum L.*) and redroot pigweed (*Amaranthus retroflexus L.*). The im-



a) number of weeds (no per/m^2) b) fresh weight of weeds (g/m^2)

Figure 1. Number of weeds and fresh weight per 1m^2 in maize – „3-5 leaf” stage - crop rotation, tillage system O_1, 2020

portance of this group of weeds in numbers and biomass is about 20 %.

The number of annual weeds in the non-fertilized variant (T_0O_1) is higher than in the fertilized variants (T_2O_1 and T_1O_1) by 33 % and its fresh and dry biomass is 29 % higher (Figure 1a, b). The analysis of data shows that the rate of weeding with annual dicotyledonous is 62 % lower after loosening (O_1) compared to plowing (O_2). The highest number of annual weeds in first crop rotation are reported in the fertilized variant T_1O_2-53 no per/m^2 and fresh biomass of 80.6 g/m^2 (Table 3).

Perennial weeds are mainly represented by species from the group of rhizome weeds - field bindweed (*Convolvulus arvensis.L.*) - 98 no per/m^2, with fresh biomass - 387.86 g/m^2; field thistle (*Cirsium arvense Pers.*) - 48 no per/m^2, with fresh biomass 682.22, g/m^2 and field sow thistle (*Sonchus arvensis L.*) - 9 no per/m^2, with fresh biomass -113.85g/m^2. From the group of rhizome weeds, the predominant one is quack grass (*Agropyron repens L.*), and weeding with this species is weaker.

Under the conditions of increased content of soil moisture and sufficient heat, perennial weeds have a greater number and develop significant biomass, and in the variant without fertilization (T_0O_1, T_0O_2) the density reaches from 108 to 116 pieces/m^2 and fresh biomass from 503.15 to 898.42 g/m^2, showing a difference of 7.5% in numbers and 44% in biomass between the two soil treatments (O_1 and O_2) (Figure 1a, b and Table 3). The reason is the smaller number of maize plants per unit area, which reduces the competitiveness of the crop compared to weeds. In the fertilized variants (T_1O_1 and T_2O_1), the fresh and dry biomass of perennial weeds is 35% higher in comparison with the non-fertilized variant T_0O_1 (Figure 1b). The greater amount of accumulated fresh biomass can be explained by the progression of the growing season and the change in temperature and humidity conditions, which create favorable conditions for weeds to accumulate the maximum amount of biomass together with the development of the crops.

In the "3-5 leaf" maize stage, after inter-row cultivation and before application of herbicides, it was found that during mechanical control, mainly the annual weeds were destroyed. A part of them, representatives of the early spring and winter-spring weed groups, have completed their vegetative development. Perennial weeds, however, remained largely unharmed by inter-row tillage. The tested agrotechnical factors have a significant influence on the weeding of the crop. When loosening at a depth of 40-45 cm (O_1) is applied as the main treatment, better mechanical regulation of weeds is achieved compared to ploughing at 22-25 cm (O_2). The weeding of the crop depending on the fertilization norms is in the following order $T_0 < T_2 < T_1$.

The second weed count in 2020 is made at full maturity of maize. As the vegetation of the crop progresses, there is a change in the type of weeding. Weed density decreased compared to the previous report, which is a result of inter-row tillage during the growing season and spraying with herbicides in the "5-6 leaf" maize stage. The weed species of the late spring group continue to be the main species in

Table 3. Number and weight of weeds per 1m^2, "3-5 leaf" maize stage - crop rotation, tillage system O_2, 2020

	Variant – T_0O_2			**Variant - T_1 O_2**			**Variant -T_2 O_2**		
Groups of weeds	**No per/ m²**	**fresh w., g**	**dry w., g**	**No per/ m²**	**fresh w., g**	**dry w., g**	**No per/ m²**	**fresh w., g**	**dry w., g**
I. Annual weeds	**17**	**64.64**	**12.92**	**53**	**80.6**	**11.42**	**5**	**53.2**	**6.4**
Cereals	-	-	-	1	0.58	0.28	-	-	-
Dicotyledonous	17	64.64	12.92	52	80.02	11.14	5	53.2	6.4
1. Ephemera	-	-	-	-	-	-	-	-	-
2. Early spring	**14**	**29.56**	**7.62**	-	-	-	-	-	-
3. Late spring	**3**	**35.08**	**5.3**	**53**	**80.6**	**11.42**	**5**	**53.2**	**6.4**
4. Winter spring	-	-	-	-	-	-	-	-	-
II. Perennial weeds	**116**	**898.42**	**165.68**	**77**	**348.32**	**73.14**	**91**	**380.36**	**90.98**
1. Rhizome	-	-	-	-	-	-	**6**	**15.92**	**4.1**
2. Root shoots	**116**	**898.42**	**165.68**	**77**	**348.32**	**73.14**	**85**	**364.44**	**86.88**

the overall weed structure, but in significantly lower numbers. The main representatives of the annual dicotyledonous species are bladder hibiscus (*Hibiscus trionum L.*), fat hen (*Chenopodium album L.*) and redroot pigweed (*Amaranthus retroflexus L.*). Among the annual wheat weeds, the main species are (*Setaria glauca L., P. B.*) and barn grass (*Echinochloa crus-galli L.*).

The integrated weed control throughout the maize growing season helps to significantly reduce the rate and quantity of annual weeds. When considering weeds in the first cropping rotation, in the fertilization variants, weeding rates with annual dicotyledonous species and wheat weeds differed by 40% in numbers between the two soil treatments (O_1 and O_2) (Table 4).

A slightly higher fresh weight is reported in the T_2O_2 fertilized variant – 78.52 g/m^2. In the non-fertilized variants (T_0O_1, T_0O_2) a low weeding of 5 to 9 pieces/m^2 and fresh weight of 10.8 to 28.02 g/m^2 is also reported, which shows that weeding in the variants with plowing (O_2) is higher by 44% in numbers and 60% in fresh biomass compared to the variants with loosening (O_1).

The density of perennial weeds is significantly reduced as a result of inter-row tillage and spraying with herbicides.

The development of perennial weeds in the fertilized variants (T_1O_1, T_2O_1) is more distinct in terms of fresh and dry mass (up to 330.3 and 91.69 g/m^2), while the numbers are low (from 39 to 89 pieces/m^2) (Table 4). During this stage, the number of weeds decreased, and their fresh mass and dry biomass were 15% and 24% higher, respectively, in the fertilized variants with ploughing (O_2) compared to variants with loosening (O_1). The main weeding is with species from the group of rhizome weeds - field thistle (*Cirsium arvense Pers.*), field bindweed (*Convolvulus arvensis. L.*) and field sow this the (*Sonchus arvensis L.*), while quack grass (*Agropyron repens L.*) is the prevailing species of the rhizome weeds. According to study by (Dimitrov et al., 2003), fertilization also affects weed development. In the fertilized variants, their fresh biomass has higher values, which shows that they significantly increase in parallel with the development of the cultivated crops, thanks to a better supply of nutrients.

After treatment with the herbicide mixture (Sirio and Magneto) in the "5-6 leaf" maize stage, a significant reduction in weed density by annual and perennial weeds was reported. The effect of applying the herbicide mixture was 77% removal of the reported weed species.

During the 2020/2021 growing season, the quantitative and specific weeding was recorded in two stages of the development of the winter wheat crop - the tillering stage and the beginning of "milk maturity".

Single weeds are established after sowing of triticale- ephemeral and perennial rhizome weeds. Due to the dry conditions and as a result of the pre-sowing tillage, a large portion of reported species have been destroyed. The degree of weeding with annual and perennial species and the total weeding

Table 4. Number and weight of weeds per 1m^2, maize „sweeping stage"- crop rotation, tillage system O_1, 2020

Groups of weeds	Variant – T_0O_1			Variant - T_1 O_1			Variant -T_2 O_1		
	No per/ m^2	fresh w., g	dry w., g	No per/ m^2	fresh w., g	dry w., g	No per/ m^2	fresh w., g	dry w., g
I. Annual weeds	**5**	**10, 08**	**8.8**	**9**	**25.06**	**6.9**	**18**	**78.52**	**20.39**
Cereals	3	3, 22	7.38	-	-	-	4	10.7	1.64
Dicotyledonous	2	6.86	1.42	9	25.06	6.9	14	67.82	18.75
1. Ephemera	-	-	-	-	-	-	-	-	-
2. Early spring	-	-	-	-	-	-	-	-	-
3. Late spring	**4**	**21.64**	**7.48**	**9**	**25.06**	**6.9**	**17**	**54.96**	**13.77**
4. Winter spring	**1**	**6.38**	**1.32**	-	-	-	**1**	**23.56**	**6.62**
II. Perennial weeds	**37**	**196.36**	**89.88**	**89**	**330.3**	**91.69**	**39**	**309.54**	**80.76**
1. Rhizome	**8**	**97.12**	**48.52**	**6**	**5.74**	**2.84**	**2**	**10.32**	**4.8**
2. Root shoots	**29**	**99.24**	**41.36**	**83**	**324.56**	**88.85**	**37**	**299.22**	**75.96**

at the end of the tillering stage, before spraying with herbicides, is characterized by divergent values in different research variants.

The observations made in the crop rotation sown with triticale show that in the tillering stage of the culture, the weeding is mixed, with the predominance of annual and perennial species from the group of rhizome weeds. In the fertilization, variants are reported annual dicotyledonous weeds, representatives of ephemeral, early-spring and winter-spring groups.

The number of annual weeds in the non-fertilized variants (T_0O_1, T_0O_2) is in the range of 22 to 30 no per/m^2, where the weeding density is higher compared to the fertilized variants in both tillage systems (O_1 and O_2) (Figure 2a and Table 5). The degree of weeding with this group of weeds was 25% higher in the variants with shallow ploughing (O_2) compared to the deeper loosening (O_1). The highest weeding with annual weeds in terms of numbers and biomass is reported in the fertilized variants, reaching 30 pieces/m^2 in T_1O_2, with a fresh biomass of 56.9 g/m^2 and variant T_2O_2 -18 pieces/m^2, with a fresh biomass of 97, 72 g/m^2 (Figure 2a, b). The difference between the fertilized (T_1O_2 and T_2O_2) and non-fertilized variant (T_0O_2) in number of weeds is 40%, while the fresh biomass in the fertilized is more than five times higher (Figure 2b). These results are similar to those obtained by other authors (Dimitrov et al., 2003). According to a study by (Lozanova, 2021), regardless of tillage, fertilization increases the fresh biomass of the examined weed species.

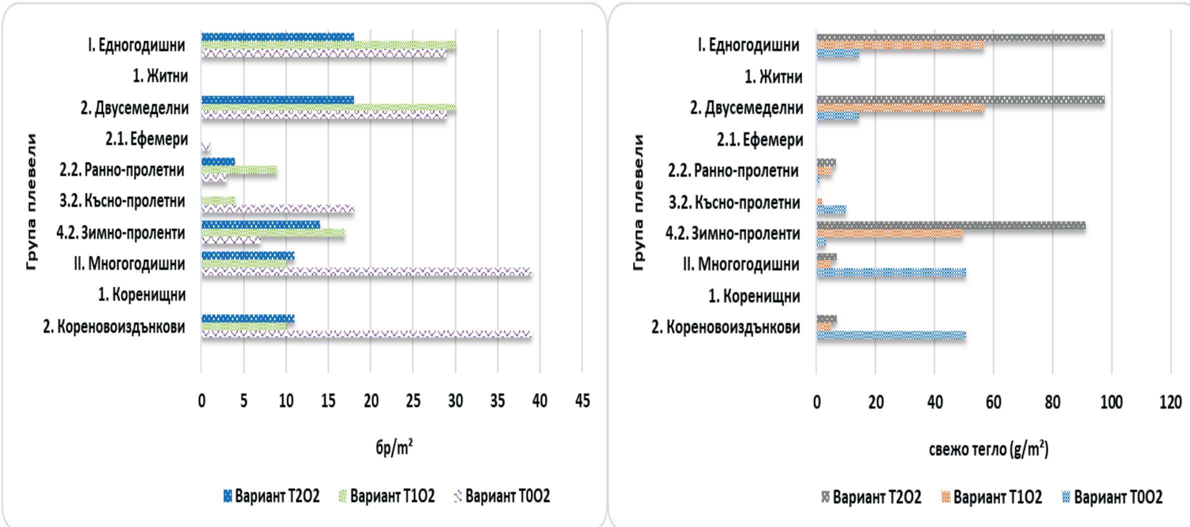
The reported numbers of perennial weed species in the non-fertilized variants (T_0O_2, T_0O_1) are from 23 to 39 no per/m^2, i.e. with a difference of 40 % between the two soil tillage treatments. (Figure 2a and Table 5). Lower degree of weeding with perennial weeds is reported in the fertilized variants (T_1O_2 and T_2O_2) (10-11 no per/m^2), while higher degree of weeding is reported in the non-fertilized variant (T_0O_2), which was 50% by numbers, 75% in terms of fresh biomass, and 79% in terms of dry biomass more than those reported in the variants with fertilization (Figure 2a, b).

After spraying with the herbicide Pallas 75 VG against annual wheat and broadleaf weeds in the jointing stage of the cereal crops (triticale and wheat) the effect of the application of the herbicide was 86% removal of the reported weed species.

The second weed count was carried out during the "milk maturity" of triticale cereal crop, where it was found that a large portion of weed species had completed their vegetative development and had dried up. In the experimental area with Haplic Vertisols, the herbicidal effect of the product had a lasting impact on the development of weeds. Therefore, their quantitative presence in the experimental plots was weak. During this reporting period, annual weeds from the late spring group prevailed - bladder hibiscus (*Hibiscus trionum L.*), red chickweed (*Anagallis arvensis L.*) and common knotgrass

Table 5. Number and weight of weeds per 1m^2 in triticale – „tillering stage", crop rotation, tillage system O_1, 2021

Groups of weeds	Variant – T_0O_1			Variant - T_1 O_1			Variant -T_2 O_1		
	No per/ m²	**fresh w., g**	**dry w., g**	**No per/ m²**	**fresh w., g**	**dry w., g**	**No per/ m²**	**fresh w., g**	**dry w., g**
I. Annual weeds	**22**	**11.86**	**1.84**	**18**	**51.02**	**10.35**	**19**	**75.28**	**15.44**
Cereals	-	-	-	-	-	-	-	-	-
Dicotyledonous	22	11.86	1.84	18	51.02	10.35	19	75.28	15.44
1. Ephemera	-	-	-	**3**	**6.16**	**1.58**	**1**	**9.5**	**1.54**
2. Early spring	**3**	**1.9**	**0.4**	**1**	**0.06**	**0.01**	**3**	**2.58**	**0.48**
3. Late spring	**13**	**8.02**	**1.14**	**3**	**1.48**	**0.16**	-	-	-
4. Winter spring	**6**	**1.94**	**0.3**	**11**	**43.32**	**8.6**	**15**	**63.2**	**13.42**
II. Perennial weeds	**23**	**16.2**	**3.44**	**10**	**4.95**	**17.38**	**15**	**6.53**	**1.01**
1. Rhizome	-	-	-	-	-	-	-	-	-
2. Root shoots	**23**	**16.2**	**3.44**	**10**	**4.95**	**17.38**	**15**	**6.53**	**1.01**



a) number of weeds (no per/m²) b) fresh weight of weeds (g/m²)

Figure 2. Number of weeds and fresh weight per 1m²in triticale– „tillering stage" - crop rotation, tillage system O_2, 2021

(*Polygonum aviculare L*). Among the annual wheat weeds, the main species are yellow foxtail (*Setaria glaucaL., P.B.*) and barn grass (*Echinochloa crus-galli L.*). The winter-spring weedsare presented by forking larkspur (*Consolida regalis L.*), corn chamomile (*Anthemis arvensis L.*) and violet (*Viola tricolor L.*).

Considering the weeds in the triticale crop rotation, the presence of annual dicotyledonous weeds in the non-fertilized variants (T_0O_1 and T_0O_2) was significant (from 42 to 43 pieces/m²), with a small difference of 2% between the two soil treatments (O_1 and O_2). Regarding the fresh and dry biomass, higher values are recorded for the variants with T_1O_2 fertilization (156.9 g/m², 53.8 g/m²) and T_2O_2 (194.57 g/m², 58.19 g/m²) and applied ploughing (O_2) (Table 6). The results are similar and confirm our other studies (Mitova & Gerasimova, 2018; Lozanova, 2021) regarding the fresh and dry biomass of weeds, i.e. the trend is the opposite - they have a greater weight in the fertilized variants, which is due to the supply of nutrients. Fertilized variants

Table 6. Number and weight of weeds per 1m² in triticale –„maturity stage", crop rotation, tillage system O_2, 2021

Groups of weeds	Variant – T_0O_2			Variant - T_1 O_2			Variant -T_2 O_2		
	No per/ m²	**fresh w., g**	**dry w., g**	**No per/ m²**	**fresh w., g**	**dry w., g**	**No per/ m²**	**fresh w., g**	**dry w., g**
I. Annual weeds	**42**	**54.49**	**16.96**	**26**	**156.9**	**53.8**	**19**	**194.57**	**58.19**
Cereals	7	5.82	1.06	1	4.3	0.8	1	0.22	0.09
Dicotyledonous	35	48.67	15.9	25	152.6	53	18	194.35	58.1
1. Ephemera	-	-	-	-	-	-	-	-	-
2. Early spring	**18**	**26.48**	**8.28**	**3**	**5.98**	**1.62**	**2**	**4.14**	**1.2**
3. Late spring	**14**	**9.18**	**1.84**	**1**	**4.3**	**0.8**	**2**	**3.37**	**1.23**
4. Winter spring	**10**	**18.83**	**6.84**	**22**	**146.62**	**51.38**	**15**	**187.06**	**55.76**
II. Perennial weeds	**49**	**153.56**	**39.5**	**24**	**60.88**	**16.14**	**22**	**122.42**	**30.44**
1. Rhizome	-	-	-	-	-	-	-	-	-
2. Root shoots	**49**	**153.56**	**39.5**	**24**	**60.88**	**16.14**	**22**	**122.42**	**30.44**

with applied loosening (O_1) have lower fresh and dry biomass by 62% and 63%, respectively, compared to those with ploughing treatment (O_2).

Regarding perennial weeds, their quantitates are greater again in the variants without fertilization (T_0O_1 and T_0O_2) from 29 to 49 no per/m^2, with a difference of 40% between the two soil treatments (O_1 and $O_{2)}$. In the fertilized variants (T_1O_2 and T_2O_2), the total number of perennial weeds is 6% lower compared to the variant without fertilization (T_0O_2), while their fresh biomass is higher than it by 20% (Table 6). Very often, studies confirm the thesis that with a good nutritional regime, triticale plants successfully compete with stubborn weed vegetation (Baeva et al., 2011; Dimitrova et al., 2014).

The tendency for greater weed density in the variants with ploughing O_2 is maintained.

CONCLUSIONS

From the data of the two-year field research in a two-field crop rotation (maize-triticale) under non-irrigated conditions, it was established that the tested agrotechnical factors (crop rotation, soil treatment, mineral fertilization, and chemical control) impact the degree of weeding in Haplic Vertisols cereal crops.

The application of integrated weed control has a positive effect on the development and productivity of cultivated crops. Mechanical tillage has a more significant impact than chemical control. In the variants with the basic treatment "loosening" (O_1), the general weeding and especially that with perennial rhizome weeds is weaker compared to the variant with reduced treatment (O_2).

The analysis of results shows that weeding of the crops in the two-field crop rotation, maize - triticale/wheat is of a mixed type (annual dicotyledonous and perennial rhizome weeds). The alternation of crops in crop rotation, agrotechnical measures and the good vegetative development of crops created conditions for limiting the degree of weeding. Fertilization also affects the development of weed vegetation primarily by providing a good nutritional regime and conditions for the rapid development of cultivated plants in a competitive environment. The weeding of the crop depending on the fertilization rates is in the following sequence $T_0 < T_2 < T_1$. When fertilizing is excluded, the number of weeds per unit area increases and their mass is lower than in the variants with applied fertilizing.

77 to 86% of reported weed species are controlled within the entire experimental area after spraying against annual wheat and broadleaf weeds with the broad-spectrum herbicide Pallas 75 VG in the jointing stage of triticale and with the herbicide mixture of Sirio 4 SK and Magneto in the "5-6 leaf" stage of maize.

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