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Weediness And Yield Of Spring Barley Depending On The Farmingsystem Elements.

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ABSTRACT

Studies were conducted in 1977-2017 on three experimental fields of the Samara State Agricultural Academy with the purpose of studying the influence of the basic elements of the farming system on the weediness and yield of spring barley. Schemes of experiments included options: the type of fallow in the crop rotation (black, seeded and green-manuredfallow), fertilizer systems (organomineral recommended, organomineral intensive and organic) and various methods and depths of soil tillage for barley. Observations and accounting were conducted according to generally accepted methods. The soil of the fieldswas ordinary chernozems and typical medium-thickloamy chernozems (humus content was from 6.0 to 8.3%, mobile phosphorus was from 90 to 155 mg/kg, exchange potassium was from 129 to 190 mg/kg, $pH_{salt}$was from 6.3 to 6.8 %). The type of fallow due to the considerable remoteness of spring barley from the fallow fields has little effect on the crop weediness and yield. Fertilizer systems greatly altered the species composition of the weeds and contributed to an increase in perennials in 4.7-7.3 times more compared with organomineral fertilizer systems. The highest yield was obtained under an intensive organomineral fertilizer system, it was 2.49 t/ha, which wason 0.29 and 0.68 t/ha higher than the recommended and organomineral and organic fertilizer systems. However, systematic plowless, and especially zero tillagelead to increase in the number of perennials in 1.5-2.7 times in comparison with plowing. Only the integrated application of minimal tillage with effective herbicides allows us to restrain the weediness of barley crops at approximately the same level. The methods and depths of soil tillage practically do not have a significant effect on the yield of spring barley. Only the absence of mechanical soil treatment led to a reliable reduction in yieldin the most years of research.

Keywords: weediness of crops, yield of spring barley, type of fellow, fertilizer system, soil tillage.

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INTRODUCTION

Spring barley is one of the most important major grain-fodder crops of the world. It has a large share in gross harvest and sowing areas among grain crops, both in our country and in world agriculture [1-5].

Barley by sowing areas in the world is not the first only in relation to wheat, rapeseed and corn. Agricultural commodity producers cultivate barley mainly for livestock, as its grain, in comparison with other crops, is better balanced for protein, including the basic essential aminoacids [6-10].

Spring barley is one of the main grain crops of our region and the Russian Federation [11-13].

The conditions of the Volga region allow us to receive high gross collection of grain and other agricultural products annually. However, such yieldsarerestricted not only by the lack of moisture, but also by the low stability of the phytosanitary state of crops (outbreaks of mass pest reproduction, epiphytotic diseases, widespread of weed plants) [14-16].

At present, one of the most important conditions on which the increase of crop yields depends is the control of weeds [1]. It is a common fact that weeds are the necessary component of almost all field agrophytocenosis. This means that when grown together, cultural and weed plants compete with each other for environmental conditions, which leads to a remarkable decrease in crop yields and deterioration in the quality of products [15, 17, 18].

In agriculture of Russia, only 17% of the grain harvest is lost annually because of the contamination of crops [1].

At present, within the current natural and economic conditions for sustainable production of grain and increasing the efficiency of production of crops, it is necessary to improve thefarming system, revision and reassessment of its efficiency and individual agricultural practices [13].

In solving this problem, an important place is given to such elements of the adaptive landscape system of agriculture as the placement of crops in crop rotations, fertilizer systems and soil tillage technologies, but their significance has not been studied sufficiently [5].

MATERIALS AND METHODS

The purpose of our research was to study the influence of the main elements of farming systems on the weediness of crops and the yield of spring barley.

The experimental part of the research was carried out in three experimental fields of the Departments of Agriculture and Land Management, Soil Science and Agrochemistry of the Samara State Agricultural Academy.

In the first experiment the work was carried out in 1977-1992 in the six-field crop rotation (experimental field "5th crop rotation") on ordinary heavy-loamychernozem with the content of humus in the plow layer 8.3% (according to Tyurin), mobile phosphorus and potassium (according to Chirikov) 153 and 170 mg/kg, respectively, pH_{salt}6.3-7.3 (State Standard (GOST) 26483-85).

Soft spring wheat was used as a precursor of barley. The studies were carried out on a fertilized background: $N_{30}P_{30}K_{30}$ for main tillage, P_{10} for sowing.

The scheme of the experiment provided for the studying of 5 variants of the main soil tillage for barley: plowing at 20-22 cm (control), subsurface cultivator tillage at 20-22 cm, subsurface cultivator shallow tillage by 10-12 cm, shallow tillage by a heavy disc harrow by 8-10 cm, without the autumn mechanical tillage ("zero tillage"), instead of which herbicide 2.4-dimethylamine salt in a dose of 5 liters/ha was usedafter harvesting the precursor.

In the second experiment (experimental field "Bee", 1996-2000), spring barley was placed in three six-field crop rotations with the following alternation of fallow and crops: fallow (black, seeded and green-manured) - winter wheat - millet wheat – corn for silage - barley on ordinary heavy-loamychernozem. Before the experiment, the soil in the plow layer was characterized by the following agrochemical indicators: humus content (according to Tyurin) 7.9-8.3%, mobile phosphorus and potassium (according to Chirikov), respectively 145-155 and 155-190 mg/kg, pH_{salt} - 6.8 (GOST 26483-85).

As fallow-growing crops peas were sown in a seeded fallow, vetch-oat mixture was sown in a green-manured fallow.

Three fertilizer systems were used in crop rotations: 1) organomineral, recommended for the central zone of the Samara region (application of manure for fallows in a dose of 40 tons/ha and application of mineral fertilizers). $N_{45}P_{50}K_{30}$ (control) was applied to the barley; 2) organomineral intensive, optimized for obtaining the maximum possible yield undermoisture supply (application of manure for fallows in a dose of 40 tons/ha and the use of mineral fertilizers). For barley, $N_{45}P_{60}K_{20}$ was used in the rotation with black fallow and $N_{40}P_{65}K_{20}$ in crop rotations with seeded and green-manuredfallows; 3) organic, calculated to obtain the maximum possible yield under moisture supply (manure application in a black fallowwas 75 t/ha, in a seededfallowit was 40 t/ha, in green-manuredfallow it was 20 t/ha). Under the barley, it included the effect and aftereffect of manure applied into corn at a dose of 120 tons/ha in crop rotations with all kinds of fallows, and the leaving of crushed straw of precursors in the fields.

The main soil tillage included the following options: stubble breaking by BDT-3 for 6-8 cm and plowingby plow with SibIME racks at 20-22 m (control); stubble breaking by BDT-3 by 6-8 cm and soil treatment by AKP-2.5 by 10-12 cm; double soil tillage by BDT-3 by 6-8 cm. Secondary tillage in all variants was the same and generally accepted for the conditions of Samara region.

In the third experiment (the experimental field "Ugorye") studies in 2006-2017 conducted on typical medium-thick loamy chernozem. The humus content (according to Tyurin) in the 0-30 cm layer was 6-7%, the supply of mobile phosphorus and potassium (according to Chirikov) was 90 and 129 mg/kg, pH_{salt} was 6.8 (GOST 26483-85).

In five-field field crop rotations with black and green-manured fallows there wereblack fallow and green-manured fallow - winter wheat - soybean - spring wheat - spring barley). The mustard was sownas a green manure culture.

The main tillage for fallow included the following options: plowing at 20-22 cm (control); shallow tillage with a heavy disc harrow for 10-12 cm; without autumn mechanical tillage ("zero tillage").

In the first two variants, both in the first and second experiments, immediately after harvesting the precursor, preliminary stubble breaking was carried out to a depth of 6-8 cm.In the third experiment only a systematic herbicide (Tornado 3 l/ha) was used.

Studies were carried out with a minimal dose of phosphorus fertilizer (P_{15} during sowing).

Replications in all the experiments were threefold. Observations and records (weediness of crops, accounting of the crop yield and its mathematical processing) were carried out according to the generally accepted methods: the weediness of crops was determined by the quantitative-weight method according to the method of Moscow Timiryazev Agricultural Academy. On variants with soil tillage methods, the accounting was carried out in the tillering phase and before barley harvesting by counting weeds on trial patches 0.5 x 0.5 (0.25 m2) in four randomly selected sites of each plot. Weed weights were counted as a result of weighing their wet mass [17]. The yield calculation was carried out during the harvesting through direct combining by the “Sampo” and “TERRION” harvesters in the phase of complete ripeness of the grain with the reduction to standard purity and humidity [18]. Statistical processing of yield data was carried out using the B.A. Dospekhov’s method [19].

Theweatherconditions during the years of research varied significantly, which allows an objective assessment of the results of the research.

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The most important problem of agriculture is the maintenance of the optimal phytosanitary condition of crops, in particular, providing their cleanliness from weeds. The economic threshold of harmfulness from weeds in spring crops is 10-20 pieces/m^2 for juvenile weeds and 2-3 pcs/m^2 for perennials [19].

RESULTS AND DISCUSSION

In conditions of modern agriculture, the leading place in the weed control remains under the agrotechnical methods, as the cheaper ones. Crop rotation is among them as it is one of the main elements of modern farming systems, which is the most affordable, low-cost and environmentally friendly way of regulating weediness and maintaining the weed component in crops at a level that would not have a significant impact on crop yields [9].

Analysis of the species composition of weeds in the experimental fields during the periods studied showed that in the spring barley weeds were mainly represented by juvenile weeds, among which the wild buckwheat (Fallopia convolvulus L.), the dog nettle (Galeopsisladanum L.), the prickly lettuce (Lactucavirosa L.), the pale pigeon grass (Setariaglauca L.), the green foxtail grass (Setariaviridis L.). Among the perennial weeds the most common were the Canadian thistle (Cirsiumarvense L.), the lesser bindweed (Convolvulus arvensis L.), the sow thistle (Sonchusarvensis L.), theclammy Campion(Obernabehen L.).

The results of the studies showed that the replacement of black fallow by the seeded and green-manured fallows in the first two experiments resulted in an insignificant increase in the total weediness of barley crops as a closing crop in six-field crop rotations (table 1). However, the type of fallow significantly influenced the species composition of weed plants. Thus, the exclusion of black fallow from crop rotation contributed to an increase in the amount and mass of weeds in the first experiment by 5 times, in the second - by 2 times. In the third experiment, the replacement of black fallow by green-manured was accompanied by a reliable increase in the total number of weed plants in spring barley crops. The mass of weeds and the presence of perennials in the crops did not differ significantly due to the use of modern effective herbicides in the autumn period and in the tillering phase.

Mineral and organic fertilizers are an important factor in regulating the processes occurring in agrocenosis. That is why their influence on the phytosanitary state is diverse, including on soil and crop contamination. Weed plants change the effectiveness of fertilizers. Improving the nitrogenous nutrition during the initial stage of growth often leads, especially with a low crop producing culture, to an increase of the weediness, although the data on this research topic are rather contradictory [20-22].

In our experience, the fertilizer system had a reliable effect on the total number of weed plants. The least quantity of weeds was observed within the intensive fertilizer system - 74.6 pcs/m^2, by 17.3 and 35.4 pcs/m^2 less than within the recommended organomineral and organic fertilizer systems, respectively. Improvement of nitrogenous nutrition in the initial phases of growth and development increased the height of plants in the tubing phase by 5-6 cm and increased the competitiveness of the crop in comparison with the recommended organomineralfertilizer system.

Table 1:The influence of the type of fallow in crop rotation, fertilizer systems and soil tillage on the weediness of barley crops before harvesting

The studied factors and years	Option of experience	Total weediness		By perrenials	
		pcs/m^2	g/m^2	pcs/m^2	g/m^2
Experimental field "5th crop rotation"					
Type of fallow (years 1982,1984, 1985)	black	254,8	29,0	2,2	2,1
	seeded	329,1	37,6	9,8	10,6
Soil tillage (years 1977-1992)	plowing at 20-22 cm	183,8	98,8	1,8	9,6
	subsurface cultivator tillage at 20-22 cm	240,3	95,8	3,1	9,7
	shallow tillageat 10-12 cm	230,2	94,2	2,7	10,6
	shallow tillage by discs at 8-10 cm	198,2	88,4	3,2	21,0

	zero tillage	280,9	118,7	4,8	23,8
Experimental field "Bee"					
Type of fallow(years 1996-2000)	black	78,0	136,9	3,9	45,5
	seeded	86,1	175,3	6,8	73,9
	green-manured	110,0	169,1	5,0	48,0
Fertilizer system (years 1996-2000)	organomineral recommended	91,9	146,9	5,3	52,8
	organomineral intensive	74,6	147,5	3,2	45,2
	organic	102,4	169,7	23,4	50,7
Soil tillage (years 1996-2000)	subsurface cultivator tillage at 20-22 cm	110,4	144,5	3,3	33,3
	shallow tillage at 10-12 cm	83,2	157,1	4,1	48,9
	surface tillage at 6-8 cm	80,0	179,6	8,3	85,6
Experimental field "Ugorye"					
Type of fallow (years 2007-2010, 2012)	black	38,1	152,5	2,0	15,6
	green-manured	53,8	137,6	2,1	15,1
Soil tillage (years 2007-2017)	plowing at 20-22 cm	45,0	121,0	4,4	26,4
	shallow tillage at 10-12 cm	47,3	143,5	4,9	41,1
	zero tillage	51,6	162,2	4,5	49,8
The least significant difference (05) - LSD_{05}: withinthefirstexperiment– typeoffallow –76,3*and9,5/3,8 and4,2; soiltillage –57,6and53,1/2,1 and 8,6; withinthesecondexperience – typeof fallow –43,6and 67,6; 2,4 and 28,1; fertilizer system –5,6and 29,9/5,6 and2,8; soil tillage –43,1 and 67,6/2,4 and27,7; within the third experience – type of shallow –1,7and 38,7/1,4 and 7,3; soil tillage –14,9 and 63,0/1,2pcs/m^2and35,1g/m^2					

Note. *In the numeratorit is a total weediness, in the denominator it is the weediness by perennial weeds; the first figure is the number of weeds (pcs/m^2), the second figure is their green weight (g/m^2).

The organic fertilizer system, on the contrary, worsened the nitrogen supply of barley plants and greatly altered the species composition of weed plants. So, according to the organic fertilizer system, the number of perennials increased from 3.2-5.0 pcs/m^2 to 23.4 pcs/m^2, i.e. in 4,7 and 7,3 times in comparison with organomineral recommended and organomineral intensive, respectively. This is due to the fact that a large number of weed seeds go to the soil with the manure and straw, including the most harmful group which areoffset weeds. For example, the data obtained in the link "corn for silage - barley". In the autumn of 1997, only mineral fertilizers ($N_{90}P_{80}K_{60}$) were applied to corn.The number of weeds in the spring of the following before sowing of corn was 3 times less than in the variant with an organic fertilizer system. These differences were observed as even more significant during the growing season of culture. A high level of weediness remained in the organic fertilizer system also in the following year.It was 11 times higher before sowing barley than with the application of only mineral fertilizers. This pattern has been preserved in the future.

The soil tillage has got the leading role in regulating the number of weed plants and preventing their spread in agrocenoses. Plowing reduces the contamination of crops by juvenile and perennial weeds by 50-60%. However, this treatment has a high energy intensity, so it became necessary to find ways to minimize soil tillage using modern effective herbicides. According to numerous studies, it has been established that the methods and depths of soil tillage affect the weediness of crops and the yield of grain crops differently [9]. The contradictory in the achieved data indicates that this issue is not well studied.

In the first experiment, the exclusion of autumn mechanical tillage increased the amount of weeds by 29.4 and 34.6% compared to the shallow tillage by discs and plowing. For the remaining options, there were no significant differences in this indicator. However, there were no significant differences in weeds mass between soil tillage options. The studying of the dynamics of weediness of spring barley on various methods of soil tillage showed that the least growth of weed plants occured by plowing. Thus, for the period from the first rotation to the second in the crop rotation, the number of weeds increased by plowing at 1.7, subsurface cultivationat 20-22 cm - by 2.6, shallow tillage - by 2.9, shallow tillage by disks - by 3.2, zero tillage–by 3.8 times. The same pattern was observed in the mass of weed plants, it increased by 3.1-5.6 times. The methods of tillage markedly altered the species composition of weed plants. Systematicplowless and especially zero tillage, led to an increase in the number of perennials of 1.5-2.7 times compared with plowing. At the same time, the mass of weeds increased by 2 times only on variants with zero tillage and, where the soil was treated with disks, the weight of perennials was approximately the same on the remaining options.

In the second experiment, soil tillage without plowingat 20-22 cm led to a slight decrease in the total amount of weeds by 23.2-37.3% compared to shallow and surface tillage. However, the surface tillage increased the weediness by perennial weeds by a quantity of 2.0-2.5 times, and by their wet weight by 175.0-257.0% compared to the shallow tillage and subsurface cultivationat 20-22 cm respectively.

In the third experiment, the soil tillage had no significant effect on the total quantity and the wet weight of weed plants in barley crops. The weediness by perennial weeds also did not depend on the methods of soil tillage.

The main indicator of the evaluation of different elements of farming system is the amount of the crop yield.

In the first experiment the type of fallow provided a small reliable increase in the grain yield (0.06-0.10 t/ha) together with plowing, subsurface cultivation at 20-22 cm and 10-12 cm (table 2). On the options of shallow tillage and zero tillage crop yields did not depend on the type of fallow in the crop rotation. In the second and third experiments, the advantage of the type of fallow on the barley yield was not established, which is explained by the remoteness of the fallow fields from the last crop in crop rotation.

The fertilizer systems had a significant effect on the yield of barley grain. The highest yield was recorded for an intensive organomineral system - 2.49 t/ha. According to the recommended organomineral and organic fertilizer systems, the yield of the crop decreased by 0.29 and 0.78 t/ha, or by 11.6% and 31.3% compared to the intensive fertilizer system. Consequently, the transition to a purely organic system of fertilization is possible only in a limited area (small near-farming rotations, plots of land attached to a house, gardens, etc.), on which elements of nutritionwill be taken from other fields with manure.

In the closing crop rotation field, the methods and depths of the main tillage on average for the years of research turned out to be the same for barley grain yields. The lack of mechanical tillage in most years of research led to a decrease in its yield.

In the second and third experiments, the yield of spring barley was practically independent of the methods of soil tillage. In wet years, when there is a strong growth of weeds and the use of herbicides is difficult, plowing is an advantage, and in arid ones - the soil tillage methods, with the exception of zero tillage, have no significant effect on crop yields.

During the years of the experiments, an average correlation was established between the crop yield and the weediness (r = 0.669) only in the second experiment on the factor of the main tillage. This is due to the fact that the greatest damage, primarily by perennial weeds, is observed in the initial phases of growth and development of crop, when the main generative organs are being formed. During this period the most foul were plots where an organic fertilizer system was applied, especially in combination with shallow and surface tillage.

Table 2:The influence of the type of fallow in crop rotation, fertilizer systems and soil tillage on the yield of spring barley

The studied factors and years	Option of experience	Crop yield, t/ha
Experimental field "5th crop rotation"		
Type of fallow(years 1978-1992)	Black	2,26
	Seeded	2,21
Soil tillage (years 1978-1992)	plowing at 20-22 cm	2,34
	subsurface cultivator tillage at 20-22 cm	2,30
	shallow tillageat 10-12 cm	2,18
	shallow tillage by discs at 8-10 cm	2,26
	zero tillage	2,11
Experimental field "Bee"		
Type of fallow (years 1996-2000)	Black	2,16

	Seeded	2,03
	green-manured	2,21
Fertilizersystem (years 1996-2000)	organomineral recommended	2,20
	organomineral intensive	2,49
	Organic	1,71
Soil tillage (years 1996-2000)	subsurface cultivator tillage at 20-22 cm	2,12
	shallow tillage at 10-12 cm	2,16
	surface tillage at 6-8 cm	2,12
Experimental field "Ugorye"		
Type of fallow (years 2006-2012)	Black	1,92
	green-manured	1,87
Soil tillage (years 2006-2017)	plowing at 20-22 cm	1,82
	shallow tillage at 10-12 cm	1,79
	zero tillage	1,72
The least significant difference (05) - LSD_{05}: for the first experiment - the type of fallow -0,05; soil tillage-0.17; for the second experiment - the type of fallow -0.27; fertilizer system -0.28; soil tillage -0.07; for the third experiment - the type of fallow -0,09; soil tillage -0,15 t/ha.		

CONCLUSIONS

1. The type of fallow does not have a significant effect on the general weediness of crops. Replacement of black fallow by the seeded and green-manured fallows increases the weediness of the crop by perennial weeds in two-five times. The use of modern effective herbicides in the autumn period and at the beginning of the growing season (in the tillering phase) restrains the growth of weed plants and significantly neutralizes the purifying effect of black fallow.

2. The use of organic fertilizer system reduces the general weediness by juvenile weeds, but contributes to the growth of weediness by perennial weeds in 4.7-7.3 times compared with organomineral fertilizer systems. Higher doses of mineral nitrogen fertilizers improved the nitrogen nutrition of plants, and thereby increased the competitiveness of culture and reduced the mass of perennials.

3. The methods and depth of the soil tillage have little effect on the general weediness of crops. However, systematic subsurface cultivations, and especially zero tillage, contribute to an increase in the number of perennials in 1.5-2.7 times in comparison with plowing. Only the integrated application of minimal treatments with effective herbicides allows us to restrain the weediness of barley crops at approximately the same level.

4. The type of fallow due to the considerable remoteness of spring barley from the fallow fields has little effect on its yield.

5. An intensive organomineral fertilizer system contributed to obtaining the maximum yield of barley grain. It provided a maximum crop yield of 2.49 t/ha, which is 0.29 and 0.78 t/ha higher than for the recommended organomineral and organic fertilizer systems.

6. The methods and depths of soil tillage practically do not have a significant effect on the yield of spring barley. Only the absence of mechanical tillage led in most years of research to a reliable reduction in yield. At the same time, in wet years, the advantage over the crop yield remains on the plowing side, and in arid years the soil tillage methods, with the exception of zero tillage, have no significant effect on crop yields.

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