BIO Web of Conferences **17**, 00144 (2020) https://doi.org/10.1051/bioconf/20201700144
FIES 2019

Weediness and yield of winter wheat depending on the basic elements of farming system

V.G. Kutilkin, *S.N.* Zudilin*, and *S.N.* Shevchenko

Samara State Agrarian University, 446442 Kinel, Samara region, Russia

Abstract. Through the period of 1977–2018, studies were conducted 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 the yield of winter wheat. Experimental schemes included the following options: the type of fallow in the crop rotation (black, seeded and green-manured), fertilizer systems (organic-mineral recommended, organic-mineral intensive and organic) and various methods and depths of soil tillage of fallow lands. Observations and surveys were carried out according to generally accepted methods. The soil of the plots was ordinary chernozem and typical medium-thick loamy chernozem (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). Replacing black fallow with seeded or green-manured fallow increased the weediness of crops 1.4–1.6 times and reduces the yield of winter wheat by 0.29–1.03 t/ha. Organic fertilizer systems significantly changed the weed species compositions and contributed to an increase in the number of perennials by a factor of 3.0, and their masses by a factor of 1.3–1.4 in comparison with organic-mineral fertilizer system. Organic-mineral fertilizer systems did not have a significant effect on the yield of winter wheat. The organic fertilizer system led to a slight (0.26–0.31 t/ha) grain shortage compared with organic-mineral. The methods and depths of soil tillage did not have a practically significant effect on the weediness and yield of winter wheat.

1 Introduction

The Middle Volga region is the largest region for the production of commercial winter wheat grain [1].

What is important for winter wheat is the phytosanitary situation, created by such factors as forecrop [2], fertilizer systems and soil tillage.

There are more than 100 weed species present in the region, but only 25–50 of them are the most harmful and massive.

They are dangerous not only because of their diversity, but also for their high amplification ability, which inhibits agricultural crops of agrophytocenosis and leads to a decrease in the yield class and quantity. At the same time, the interaction of cultivated plants and weeds is multivalued and depends on their life forms, their number on the field, especially phytomass and the amount of consumed resources.

In Russia alone, about 17 % of the grain yield is lost annually due to the weediness of crops. When crops are heavily infested with weeds, yield losses can reach up to 30-40% or more [3].

Providing the crops with the optimal phytosanitary conditions allows plants to use all the vital factors and form high yields with good quality [4].

The best forecrop in the arid conditions of the region is black fallow. Its use leads to an improvement in moisture availability, accumulation of nitrogen, reduction of weediness of crops [5]. At the same time, land, material and labour resources are unproductively spent [6].

Mineral and organic fertilizers are an important factor in the regulation of processes in the agrocenosis. Improving the supply of nutrients often leads, especially with a low farming culture, to an increase in the weediness of crops, although these research data are rather contradictory [7].

In agriculture, various systems of soil tillage for fallow lands are used, but in recent years, preference has been given to minimum soil tillage technologies and technologies for growing crops without tillage, which are more economically expedient [8–10].

Thus, at present, in the current natural and economic conditions, to attain sustainable grain production and enhancement of production efficiency, it is necessary to improve its cultivation technology, revise and reassess efficiency, and individual agricultural methods [11].

In solving this problem, an important place is given to such elements of the adaptive-landscape system of farming as crop rotations, fertilizer systems and soil tillage, but their significance has not been studied enough [12].

* Corresponding author: zudilin_sn@mail.ru

2 Materials and methods

The aim of our research is to study the influence of the basic elements of farming systems on the weediness and the yield of winter wheat.

The experimental part of the research was carried out at three experimental fields of the departments of agriculture and land management, soil science and agrochemistry of the Samara State Agricultural Academy (now it is Samara State Agrarian University).

In the first experiment, work was carried out in 1978–1992 in the links of crop rotation: fallows – winter wheat (experimental field “5th crop rotation”) on black ordinary heavy loamy chernozem with the content of humus in the arable layer 8.3 % (according to Tyurin), mobile phosphorus and exchange potassium (according to Chirikov) 153 and 170 mg/kg, pH_{salt} 6.3–7.3 (GOST 26483-85).

Black and seeded (with pea) fallows were used as the forecrops of winter wheat. Studies were carried out on a fertilized background: N60P60K60 for main tillage, P10 for sowing, N30 feeding in early spring.

In the experiment, the variants of the main soil tillage for fallow fields were studied: plowing at 28–30 cm (control), subsurface cultivation at 20–22 cm, shallow subsurface cultivation at 10–12 cm, shallow tillage by a heavy disc harrow at 8–10 cm, without autumn mechanical tillage (“zero tillage”), instead of which the herbicide 2.4-dimethylamine salt in a dose of 5 liters/ha was used after harvesting the previous crop.

In the second experiment (experimental field “Bee” in 1992–2001, studies were carried out in the links of crop rotation: fallows – winter wheat on ordinary heavy loamy chernozem. The following types of fallows were studied as forecrops: black, seeded (by pea) and green-manured (vetch-oat mixture).

Fertilizer systems were studied in the links of crop rotation. They were organic-mineral, recommended for the central zone of Samara region (application of manure on fallows at a dose of 40 t/ha and the use of mineral fertilizers in the following doses: N30P65K45 with black fallow, N30P85K45 with peas, N105P130K90 with vetch-oat); intensive organic-mineral, designed to obtain the maximum possible yield according to moisture content (application of manure on fallows at a dose of 40 t/ha and the use of mineral fertilizers in the doses N145P20K135 with black fallow, N190P40K65 with peas, N120P80K90 with vetch-oat); organic in doses designed to obtain the maximum possible yield according to moisture content (application of manure in black fallow of 75 t/ha, in the seeded fallow 40 t/ha, in the green-manured fallow 20 t/ha and leaving chopped forecrop straw).

From autumn, tillage after preliminary tillage included options: plowing with SibIME stands at 20–22 cm (control); tillage by AKP-2.5 at 10–12 cm; soil tillage by BDT-3 at 6–8 cm. Pre-sowing tillage in all variants was of the same type as generally accepted for the conditions of the Samara region.

The soil in the arable layer was characterized by the following agrochemical parameters: humus content (according to Tyurin) 7.9–8.3 %, mobile phosphorus and exchange potassium (according to Chirikov) – 145–155 and 155–190 mg/kg respectively, pH_{salt} – 6.8 (GOST 26483-85).

In the third experiment (experimental field “Ugorye”) research carried out in 2003–2018 in the link of crop rotation fallow – winter wheat on the typical medium-thick loamy chernozem. The forecrops were black fallow and green-manured fallow (mustard).

The main soil tillage for fallow included options: plowing at 20–22 cm (control), shallow tillage by a heavy disc harrow at 10–12 cm, without autumn mechanical tillage (“zero tillage”).

In the first two variants, immediately after the previous crop was harvested, preliminary tillage was carried out with disc tools to a depth of 6–8 cm. In the third variant we only applied a continuous action herbicide (Tornado 3 liters/ha).

Studies were conducted on the background content of the minimum dose of phosphate fertilizer (P15 during sowing).

The humus content (according to Tyurin) in the 0–30 cm layer was 6–7 %, the availability of mobile phosphorus and potassium (according to Chirikov) was 90 and 129 mg/kg, pH_{salt} – 6.8 (GOST 26483-85).

Replications in all the experiments were threefold.

Observations and surveys (weediness of crops, crop accounting) were carried out according to generally accepted methods. Statistical data processing on yield was carried out by the dispersion method [13].

3 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 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 [6].

In the course of agricultural production intensification, the growth and development conditions for either cultivated plants or numerous weeds are changing. The plant species that are the most resistant to various influences are being distributed through the crops.

In our investigation, the analysis of the weed species composition in agrophytocenosis showed that in winter wheat crops it was represented by the following species (the main of which are non-perennial weeds): goose grass (Gallium aparine L.), scentless mayweed (Matricaria inodora L.), prickly lettuce (Lactuca serriola L.), field pennycress (Thlaspi arvense L.) as wintering ones; climbing buckwheat (Polygonum convolvulus L.) as early spring one; yellow foxtail (Setaria glauca L.), dog nettle (Galeopsis ladanum L.) as late spring ones; field bindweed (Convolvulus arvensis L.), way thistle (Cirsium arvense L.), sow-thistle (Sonchus arvensis L.)

as perennial ones; cowbell (Silene vulgaris L.) as biennial one.

The most effective agrotechnical method of clearing the fields from weeds was the black fallow.

In the first experiment, when placing winter wheat after the black fallow, the weediness by the time of harvesting by the number of weeds and their wet weight, respectively, was 33.0 pcs/m^2 and 20.5 g/m^2, which is 1.9 and 2.1 times lower than when placing the crop after peas. When replacing black fallow with a seeded one, the number of perennial weeds increased from 0.7 to 6.1 pcs/m^2, with their mass increasing 4.9 times (Table 1).

The total weediness varied slightly, depending on the main soil tillage. At the same time, the wet weight of weeds in variants of plowing at 20–22 cm and shallow tillage at 10–12 cm increased by 1.9–2.1 times, in variant of disking it increased in 3.2 and in the variant autumn tilled it increased by 3.5 times compared to plowing.

In the second experiment, the weediness of winter wheat was also the smallest when it placed after the black fallow (37.6 pcs/m^2 with their wet weight of 171.4 g/m^2). Replacing black fallow with the seeded one contributed to an increase in the number of weeds by 1.6 times and their weight by 1.4 times, and the replacing of it with the green-manured fallow, the number of weeds and their weight increased 1.4 and 1.4 times, respectively. When placing the crop on seeded and green-manured fallows, the weediness by perennial weeds increased by 3.5–6.0 times by the number of weeds and by 1.4–2.1 times by wet weight. At the same time, weediness of wheat in seeded and green-manured fallows is noticeably different. The weediness of wheat is less when it placed on green-manured fallow than on seeded fallow, and it is explained by the fact that the green mass was mowed and incorporated in the soil earlier than pea was harvested, i.e. when seeds of many weed species have not matured yet.

Fertilizer systems in the second experiment did not have a significant impact on the weediness of winter wheat, but significantly changed the species composition of the weeds. The organic fertilizer system led to an increase in the number and mass of perennials by 3.0 and 1.3–1.4 times as compared with organic-mineral fertilizer systems. The increase in crop weediness while using only organic fertilizer system compared to organic-mineral fertilizer system is explained by the fact that significantly higher number of weed seeds enter the soil with higher rates of manure application and leaving straw on the fields.

Plowless tillage methods slightly changed the total weediness of winter wheat and the species composition of weeds. A slight advantage in this indicator was when the soil was cultivated on 20–22 cm compared to shallow and surface tillage for fallow fields.

In the third experiment, the differences in weediness of winter wheat between the types of fallow, as well as between the methods of the main soil tillage were insignificant because of the use of modern highly effective herbicides.

The main indicator of the assessment of various elements of the crop production technology is the amount of crop yield.

Table 1. The influence of the type of fallow in crop rotation, fertilizer systems and main soil tillage on the weediness of winter wheat before harvesting

Factor and years studied	Variant of the experience	Total weediness		By perennial weeds	
		Pcs/m^2	G/m^2	Pcs/m^2	G/m^2
Experimental field “5th crop rotation”*					
Fallow (1978–1991)	Black	33.0	20.5	0.7	2.0
	Seeded	61.6	42.4	6.1	9.8
Main soil tillage (1978–1991)	Plowing at 20–22 cm	27.8	9.7	0.6	2.6
	Cultivation at 20–22 cm	30.6	20.4	0.9	5.4
	Shallow tillage at 10–12 cm	34.4	19.6	0.9	4.9
	Shallow tillage with discs at 8–10 cm	39.6	31.0	0.9	8.3
	Zero tillage	32.4	34.0	0.4	9.1
Experimental field “Bee”**					
Fallow (1992–2000)	Black	37.6	171.4	1.2	66.8
	Seeded	60.8	316.6	7.3	142.0
	Green-manured	53.2	236.5	4.2	93.7
Fertilizer system (1992–2000)	Organic-mineral recommended	50.5	228.2	3.0	95.5
	Organic-mineral intensive	48.2	242.4	2.8	85.9
	Organic	50.9	258.2	6.0	121.1
Main soil tillage (1992–2000)	Cultivation at 20–22 cm	48.6	212.5	3.1	82.2
	Shallow tillage at 10–12 cm	52.8	250.1	4.1	103.1
	Surface tillage at 6–8 cm	51.4	261.4	5.5	117.1
Experimental field “Ugorye”**					
Fallow (2003–2010)	Black	42.0	166.4	5.8	53.0
	Green-manured	47.7	163.0	5.9	52.4
Main soil tillage (2003–2018)	Plowing at 20–22 cm	34.4	166.7	5.2	47.2
	Shallow tillage at 10–12 cm	39.8	185.4	4.4	46.3
	Zero tillage	40.7	188.0	5.0	51.0
The least significant difference (05) (LSD05): in “5th crop rotation” 6.3*** and 9.5/ 3.8 and 4.2 for fallow type; in “Bee” 57.6 and 53.1;/ 2.1 and 8.6 for main soil tillage; 43.6 and 67.6; 2.4 and 28.1 for fallow type; 5.6 and 29.9/5.6 and 2.8 for fertilizer system; 43.1 and 67.6/ 2.4 and 27.7 for main soil tillage; in “Ugorye” 5.7 and 38.7/ 1.4 and 7.3 for fallow type; 10.9 and 25.0/1.2 for mail soil tillage (pcs/m^2 and g/m^2)					

* – air-dry mass of weeds; ** – wet weight of weeds; *** – in the numerator: total weediness, in the denominator – by perennial weeds; the first number is the number of weeds (pcs/m^2), the second number is the mass (g/m^2).

In the first experiment, black fallow provided a small reliable increase in the grain yield (0.29 t/ha) as compared with its placement after the seeded or green-manured fallows (Table 2). In the second and third experiments, the yield of winter wheat after the black fallow was 0.97 and 1.03 t/ha higher than when it was placed after the green-manured and seeded fallows, respectively.

Organic-mineral fertilizer systems did not have a significant impact on the yield of winter wheat. Organic fertilizer system have led to lower crop yields compared to organic-mineral.

The main soil tillage had no significant effect on the yield of winter wheat.

Table 2. The influence of the type of fallow in crop rotation, fertilizer systems and main soil tillage on the yield of winter wheat

Factor and years studied	Variant of the experience	Yield, t/ha
Experimental field “5th crop rotation”		
Fallow (1978–1992)	Black	3.18
	Seeded	2.89
Main soil tillage (1978–1992)	Plowing at 20–22 cm	2.99
	Cultivation at 20–22 cm	3.05
	Shallow tillage at 10–12 cm	3.04
	Shallow tillage with discs at 8–10 cm	3.10
	Zero tillage	3.00
Experimental field “Bee”		
Fallow(1992–2001)	Black	3.05
	Seeded	2.02
	Green–manured	2.08
Fertilizer system (1992–2001)	Organic–mineral recommended	2.48
	Organic–mineral intensive	2.53
	Organic	2.22
Main soil tillage (1992–2001)	Cultivation at 20–22 cm	2.42
	Shallow tillage at 10–12 cm	2.40
	Surface tillage at 6–8 cm	2.40
Experimental field “Ugorye”		
Fallow (2003–2010)	Black	1.92
	Green–manured	1.87
Main soil tillage (1992–2001)	Plowing at 20–22 cm	2.63
	Shallow tillage at 10–12 cm	2.61
	Zero tillage	2.61
The least significant difference (05) (LSD_{05}): in “5th crop rotation” 0.13 for fallow type; 0.23 for main soil tillage; in “Bee” 0.22 for fallow type; 0.30 for fertilizer system; 0.10 for main soil tillage; in “Ugorye” 0.25 for fallow type; 0.30 for mail soil tillage.		

4 Conclusion

Thus, the placement of winter wheat after the black fallow on the organic-mineral fertilizer systems background helps reduce weediness and increase crop yields compared to sowing crops after the seeded or green-manured fallow within the organic fertilizer system. The crop yield is essentially independent of the main soil tillage of fallows.

References

1. V.G. Kutilkin, S.N. Zudilin, *The influence of the basic elements of the farming system on the efficiency of using solar energy and moisture in winter wheat crops*, Agricult., **2** (2018)
2. A.G. Gurin, I.M. Chadaev, *Impact of legume forecrops on the weediness of winter wheat crops*, Agricult., **4** (2018)
3. A.N. Orlov, O.A. Tkachuk, E.V. Pavlikova, *Weediness and yield of spring wheat depending on the elements of the production technology*, Young scientist, **2** (2012)
4. G.I. Bazdyrev, *The concept of modern protection of field crops from weeds*, Soil Fertility, **5** (2002)
5. V.I. Kiryushin, *Ecologization of agriculture and technological policy* (Moscow Agricultural Academy, Moscow, 2000)
6. V.A. Korchagin, S.N. Zudilin, O.I. Goryanin et al., *Biologization of agriculture in the Middle Volga* (Kinel, 2017)
7. N.G. Zakharov, M.A. Polyakov, *The influence of the main soil tillage on the weediness of spring wheat*, in *Modern systems of agriculture: experience, problems, prospects, Mater. of the Int. sci.-pract. Conf. dedicated to the 80th anniversary of the birth of Prof. Morozov V.I.* (Ulyanovsk State Agricultural Academy, Ulyanovsk, 2011)
8. V.G. Kutilkin, *Combined tillage system in the Forest-Steppe of the Middle Trans-Volga*, Agricult., **7** (2014)
9. V.D. Solovichenko, A.N. Voronin, V.V. Nikitin, E.V. Navolneva, *Barley productivity depending on the type of fallow, method of tillage and fertilizer*, Agricult., **7** (2017)
10. V.I. Usenko, S.V. Usenko, *Water regime of leached chernozem, depending on the forecrop and the method of preliminary tillage*, Agricult., **2** (2018)
11. O.I. Goryanin, A.P. Chichkin, T.A. Goryanin, *Barley is the main spring grain crop in Samara region*, Achievem. of sci. and technol. of agricult., **8** (2011)
12. V.I. Kiryushin, *Minimalization of tillage: prospects and contradictions*, Agricult., **5** (2006)
13. B.A. Dospekhov, *Field experience methods* (Kolos, Moscow, 1985)