Effects of precursor and growth regulators on the productivity of winter wheat

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Abstract

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The effect of winter wheat precursors on the water properties of leached Chernozem was studied. It was found that the reserve of productive soil moisture in all phases of growth and development of the crop was largest in the variant with black fallow. Effectiveness of the use of growth regulators with retardant action in the technology of winter wheat cultivation is proved. The highest productivity of winter wheat (3.58 t/ha) was established in the variant using the black fallow with application of growth regulator Reggae at the tillering phase (1.2 l/ha). The introduction of the occupied fallow in the structure of the crop rotation led to an increase in the weediness of winter wheat of 16.3%. The highest content of raw gluten (29.6%) in grains of winter wheat was observed in the variant of crop rotation with an occupied fallow and the treatment with growth regulator Moddus at the tillering phase (0.4 l/ha).

Key words: winter wheat; productive moisture; black fallow; growth regulators

INTRODUCTION

In the conditions of market economy, the main means of increasing yield and economic efficiency of agriculture is its intensification – a scientifically grounded organization of land and a technology for cultivating agricultural crops that ensure the most complete use of soil and climatic resources and the bioecological potential of plants for crop formation and reproduction of soil fertility (Kochmin et al., 2016; Morozov et al., 2016; Toygildin et al., 2016).

Increasing the productivity of winter wheat in the grain balance of the Volga region is only possible through development of new advanced technologies capable of providing high, stable harvests of quality grain, reducing material costs, excluding the negative impact on the ecological state of the environment (Tkachuk, 2007; Bogomazov et al., 2016).

In the balance of energy resources of agrolandscape ecosystems of agriculture in the forest-steppe of the Volga region, the expenditure part is not compensated by an income part. With an acute shortage of organic matter, risk of degradation of black soils is inevitable. It leads to a slowdown in the growth of yields and a rise in cost of crop production (Bogomazov et al., 2015; Podsevalov et al., 2016).

The most accessible reserve of preservation of soil fertility is biogenic resources created in agroecosystems on the basis of biologization of crop rotations (Christen et al., 1992; Babulicová and Gavurníková, 2015; Barányiová and Klem, 2016).

The productivity of plants and the yield of agrocenoses depend on the influence of many internal and external factors (Thorsted et al., 2006; Sakharova, 2008; Shapoval et al., 2014).

The quantity and quality of the crop can be managed by optimizing and balancing the growth processes, photosynthesis and accumulation of economically valuable products of secondary metabolism, since there is a high correlation between the indicators of plant growth in ontogenesis and the pa-

rameters of the production process (Ma et al., 1994; Sanvicente et al., 1999; Griffin and Hollis, 2017).

The aim of the study was to investigate the impact of precursor on the water properties of the soil and the effect of growth regulators on the productivity in winter wheat.

MATERIALS AND METHODS

The experiment was carried out in 2014-2017 in the eight-field grain-and-cereal crop rotation on the basis of the stationary field experience of the Department of General Agriculture and Land Management of the FSBEE HT Penza State Agrarian University. The soil of the experimental area is represented by leached Chernozem, heavy loam on a granulometric composition. The average humus content in the experiment was 6.5%, the reaction of the medium was acidic (pH 4.8-4.9), and the supply of nitrogen, mobile phosphorus and exchange potassium were high.

The scheme of the experiment included the following factors and their gradations:

Factor A – type of fallow:

A_0 – black fallow (control);

A_1 – occupied fallow (red clover on the 2nd year of use).

Factor B – use of growth regulators with retardant effect on winter wheat:

B_0 – without cultivation (control);

B_1 – spraying of the crop in the phase of spring tillering with growth regulator Moddus, 0.4 l/ha;

B_2 – spraying of the crop in the phase of spring tillering with growth regulator Reggae, 1.2 l/ha.

The active substance of the growth regulator Moddus is trinexapac-ethyl – a compound with retardant qualities from the group of ethyl esters of carboxylic acid. It suppresses the biosynthesis of gibberellin GK3, an active phytohormone that promotes the acceleration of plant growth. It can influence the increase in the level of abscisic acid in plants, which prevents their intensive growth and contributes to an increase in the content of sugars, which increase the winter hardiness of the crop. The result of its action is to reduce the height of plants, strengthen the stem by increasing its thickness and increasing the mass of roots, which stimulates the resistance of plants to lodging.

Reggae, VRK (chloromequat chloride, 750 g/l) is a classical growth regulator designed to prevent the lodging of cereals and rape under intensive cultivation technologies, as well as in unfavorable soil and climatic conditions that promote excessive plant growth or lodging. Chlormequat chloride inhibits the biosynthesis of active isomers of gibberellins, thereby contributing to a reduction in the length of the straw, better development of mechanical tissues and an increase in the number of productive stems.

As a research object, the winter wheat variety Bezenchuk 380, recommended for cultivation in the Penza region, was used. The seeding rate was 5.5 million germinated grains per hectare.

Agrotechnology of cultivation in winter wheat is common for black soils of the Penza region. The method of split plots was used, with four repetitions. The total area of the plots of the first order was 8400 m^2, the accounting area – 6000 m^2. The total area of the plots of the second order was 150 m^2, the accounting area – 125 m^2.

RESULTS AND DISCUSSION

The conducted studies showed that the greatest accumulation of productive moisture reserves in

Table 1. Reserves of productive soil moisture in winter wheat cultivation, mm (2014-2017)

Type of fallow	Soil layer, cm	Before sowing	Tillering phase	Before harvesting
Black fallow	0-30	46.2	56.9	42.3
	0-100	160.3	189.9	142.5
Occupied fallow	0-30	37.1	53.7	39.9
	0-100	150.4	183.9	139.2
HCP_{05}	0-30	6.6	5.1	3.7
	0-100	7.9	6.9	7.1

the 0-30 cm layer was observed on the black fallow (Table 1). Before sowing winter wheat, the difference compared to the occupied steam averaged 9.1 mm. During the tillering phase, as well as before harvesting, the difference in moisture reserves over predecessors gradually flattened and it was 3.2 mm and 2.4 mm, respectively.

When analyzing the moisture reserves in the meter layer of soil, a tendency also has been found of reducing the productive moisture in the occupied fallow. So, before sowing winter wheat, the difference in the types of fallow was 9.9 mm, in the tillering phase – 6.0 mm, before harvesting – 3.3 mm.

Analyzing the weediness of winter wheat crops (Table 2) during the spring tillering period, it should be noted that the introduction of the occupied fallow in the crop rotation structure resulted in an increase in the number of weeds of 7 pcs/m^2. In the phase of spring tillering, the background treatment of the crop with a tank mix of herbicides (Banvel, BP, 0.15

Table 2. Weediness of winter wheat, pcs/m^2 (2014-2017)

Type of fallow	Weeds, pcs/m^2		
	Annual	Perennial	Total
	Tillering phase		
Black fallow	29	15	43
Occupied fallow	32	19	50
	Before harvesting		
Black fallow	8	3	11
Occupied fallow	10	4	14

Table 3. Elements of yield structure in winter wheat (2015-2017)

Indicators	**Factor B – application of growth regulators**		
	B_0 – without application of growth regulators	**B_1 – application of Moddus in tillering phase**	**B_2 – application of Reggae in tillering phase**
Factor A – type of fallow			
A_0 – black fallow			
Productive tillers, pcs/m^2	400	415	412
Height of plants, cm	98.0	88.0	77.5
Number of grains per spike	21	22	22
Grain weight per spike, g	0.84	0.89	0.90
Weight of 1000 grains, g	38.41	39.76	40.49
Biological yield, t/ha	3.21	3.55	3.58
A_1 – occupied fallow			
Productive tillers, pcs/m^2	375	382	381
Height of plants, cm	100.0	85.0	77.5
Number of grains per spike	19	21	21
Grain weight per spike, g	0.78	0.88	0.88
Weight of 1000 grains, g	39.72	41.39	42.61
Biological yield, t/ha	2.84	3.24	3.24

l/ha + Logran, EDC, 8 g/ha) was carried out. Depending on the types of fallow, no significant differences in the contamination were observed before harvesting, and this indicator did not exceed the economic threshold of damage.

Yield is one of the main indicators determining the efficiency of agricultural production. Precursors of winter wheat and growth regulators influenced the elements of crop structure and, as a consequence, the productivity of winter wheat (Tables 3, 4).

The largest number of productive stems of winter wheat before harvesting on 1 m^2 was established in the variant with black fallow with application of growth regulator Moddus. The treatment of the crop in the phase of spring tillering with Moddus with a rate of flow of 0.4 l/ha reduced the height of the plants by an average of 10-15 cm. The best effect in lowering the height was noted in the variant with spraying of crop with the growth regulator Reggae. The use of this growth regulator allowed to reduce the height of plants in comparison with the control version by 20.5-22.5 cm. In general, over the whole period of research, the use of growth regulators had a significant effect on the productivity of winter wheat.

The highest grain weight from one spike and, respectively, the yield of winter wheat (3.58 t/ha) was noted in the variant of treatment with Reggae with

Table 4. Yield of winter wheat, t/ha (2015-2017)

Factor A – type of fallow	Factor B – use of growth regulators	Yield, t/ha
A_0 – black fallow (control)	B_0 – without treatment (control)	3.21
	B_1 – application of Moddus in tillering phase, 0.4 l/ha	3.55
	B_2 – application of Reggae in tillering phase, 1.2 l/ha	3.58
A_1 – occupied fallow	B_0 – without treatment (control)	2.84
	B_1 – application of Moddus in tillering phase, 0.4 l/ha	3.24
	B_2 – application of Reggae in tillering phase, 1.2 l/ha	3.24
HCP_{05} (A)		0.12
HCP_{05} (B)		0.14

Table 5. Content and quality of raw gluten in the grain of winter wheat (2015-2017)

Indicators	Factor B – application of growth regulators		
	B_0 – without application of growth regulators	**B_1 – application of Moddus in tillering phase**	**B_2 – application of Reggae in tillering phase**
Factor A – type of fallow			
A_0 – black fallow			
Content of raw gluten in grain, %	25.0	27.9	27.4
Indicator of gluten-deformation meter-1, units	99.5	81.0	83.0
Quality of gluten	Satisfactory weak	Satisfactory weak	Satisfactory weak
A_1 – occupied fallow			
Content of raw gluten in grain, %	27.1	29.6	29.1
Indicator of gluten-deformation meter-1, units	85.0	77.0	78.0
Quality of gluten	Satisfactory weak	Good	Satisfactory weak

a rate of 1.2 l/ha in tillering phase. The increment in relation to the control was 0.37 t/ha.

The use of occupied fallow as a precursor led to a decrease in yield by an average of 0.31-0.37 t/ha. The average yield of winter wheat for black fallow was 3.45 t/ha, for occupied fallow – 3.11 t/ha.

Obtaining high quality grain is one of the main priorities in the cultivation of grain crops. In the experiment it was established that the content and the quality of gluten in the grain of winter wheat was influenced by the precursors and the use of growth regulators (Table 5).

The application of growth regulator Moddus on the occupied fallow had the greatest impact on the quantity and quality of raw gluten, the content of which was 29.6%, which is 4.6% more than the control variant.

The use of an occupied fallow as precursor of winter wheat increased the gluten content by an average of 1.8%, and the use of growth regulators - by 2.5%.

CONCLUSIONS

1. The analysis of the dependence of winter wheat yield on the supply of productive moisture in the soil confirms the role of limiting factors in agriculture.

2. The introduction of an occupied fallow in the crop rotation structure of winter wheat leads to an increase in the contamination with weeds by 16.3%.

3. The use of growth regulators with retardant action in cultivation technology of winter wheat lead to an increase in yield of 0.34-0.40 t/ha and an improvement in grain quality.

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