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АГРОНОМИЯ

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Efficiency of the application of various types of fertilizers in the cultivation of spring durum wheat

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Abstract. The work studied the influence of various methods of basic soil cultivation: plowing, minimal tillage and plant nutrition systems: mineral fertilizer ammophos, microbiological fertilizer Azofit and complex mineral fertilizers Strada N, Microel on the productivity of spring durum wheat (Luch 25 variety). In recent years, there has been a steady decline in the area under spring wheat crops, especially durum wheat, in the region, which in turn indicates the need to improve its cultivation, taking into account climatic changes.

Keywords: basic soil cultivation; mineral fertilizers; plowing; minimal tillage; yield; efficiency.
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AGRONOMY

Original article

Эффективность применения различных удобрений при возделывании яровой твердой пшеницы

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Аннотация. В работе изучено влияние различных способов основной обработки почвы: вспашки, минимальной обработки почвы и систем питания растений (минеральное удобрение аммофос, микробиологическое удобрение азофит и комплексные минеральные удобрения страда N, микроэл) на продуктивность яровой твердой пшеницы (сорт Луч 25). В последние годы в регионе наблюдается неуклонное сокращение посевных площадей яровой пшеницы, особенно твердой пшеницы, что в свою очередь свидетельствует о необходимости улучшения ее возделывания с учетом климатических изменений.

Ключевые слова: основная обработка почвы; минеральные удобрения; вспашка; минимальная обработка почвы; урожай; эффективность.
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Introduction. In recent years, the area under spring wheat crops (especially durum wheat), has been decreasing in the region, which indicates the need to improve its cultivation, taking into account climatic changes.

A decrease in the efficiency and rise in the cost of mineral fertilizers requires the search for new preparations that increases the resistance of plants to food stress with a lack of nutrients in the soil and the productivity of agricultural crops. The application of micronutrients during various soil treatments in combination with mineral nutrition allows plants to more fully use nutrients from the soil and smooths out stress from unfavorable weather conditions, which in turn leads to an increase in spring wheat yield and grain quality.

Different soil and climatic conditions in the Russian Federation requires the use of various methods of basic soil cultivation and their combinations with the application of mineral and micronutrient fertilizers in specific conditions of agricultural production.

The yield of spring wheat during plowing in the Middle Trans-Volga region was 18.8 centner/ha, during resource-saving tillage – 18.7–19.5 centner/ha [1].

When cultivation spring wheat in the Ulyanovsk region, production costs were the lowest during minimal spring tillage. However, the highest yield (28.8–27.6 centner/ha), and, consequently, the highest net income was after plowing [2].

On the southern chernozem of the Saratov Right Bank, after non-moldboard tillage to-a depth of 20–22 cm, the yield of spring wheat was 0.81 t / ha, and after surface (14–16 cm) tillage the productivity falls by 10 % [3]. According to Yu.F. Kurdyukov [4], the yield of spring wheat after hulling decreased by 24 % compared to plowing to-a depth of 20–22 cm, and after deep plowing it increased by 17 %.

The maximum yield of spring wheat on southern chernozem in the Volgograd region was after plowing with PN-3-35 and PN-8-40 (1.25–1.96 t / ha). After surface tillage with APK-6 on average for 3 years the yield was lower by 0.1–0.15 t / ha [5].

The positive role of plowing is most clearly traced in years with insufficient precipitation: the difference in yield increases in comparison with surface tillage was 0.22–1.20 t/ ha, with chisel one it was 0.24–0.29. In a year with sufficient precipitation, the difference in the level of increase between plowing and plowless tillage decreased to 0.13 t/ha [6].

Application of micronutrients improves plant nutrition during critical periods by increasing the utilization of nutrients. The greatest effect is observed after application of growth stimulants against the background of mineral fertilizers. At the same time, it is possible to increase the yield of spring wheat by 29.7–31.3 % [7].

Spraying of crops with Reasil and Potassium Humate increased grain yield during autumn disking by 8.9–20.6 %, during no tillage – by 25.0–28.9 %, during deep moldboard plowing – by 5.9–7.8 %, respectively [8–10].

Thus, the study of the combined effect of mineral and micronutrients on the productivity of spring durum wheat during different methods of basic tillage is an urgent task.

Methods. The studies were carried out in 2020–2020 at the experimental field of the Saratov State University of Genetics, Biotechnology and Engineering named after N.I. Vavilov, UNPO “Povolzhye” (Stepnoye, Engels district, Saratov region). The soil cover is represented by dark chestnut, heavy loamy soils. The humus content in the arable layer is 2.9 %. The area of the experiment is located in the zone of chernozem steppes. The climate of this area is characterized as moderately hot and moderately dry.

The survey year was characterized as moderately hot and dry. For the growing season of 2020, hydrothermal index was 0.25, which corresponds to a dry year. In total, 50.7 % of the annual average precipitation fell during the growing season.

The authors studied the influence of various types of basic tillage and plant nutrition systems on the productivity of spring durum wheat variety Luch 25. Types of basic tillage include plowing and minimal tillage; plant nutrition systems include mineral fertilizer ammophos, microbiological fertilizer azofit and complex fertilizers strada N, and mikroel.

Ammophos is a highly concentrated mineral fertilizer containing nitrogen and phosphorus. The ratio of the active components of ammophos is 12:52. The fertilizer is produced in the form of soluble granules. The composition does not contain ballast substances.

Azofit (active ingredient: *Azotobacter vinelandii*) is a microbiological fertilizer containing live nitrogen-fixing bacteria, biologically active products of their vital activity and trace elements that have a positive effect on the growth and development of plants, which in turn leads to an increase in crop yields.

Strada N is a liquid complex mineral fertilizer with microelements, highly concentrated suspension, containing 27 % of nitrogen, which is comparable to nitrogen fertilization during the growing season. It possesses a high rate of assimilation by plants.

The fertilizer contains microelements in chelated form: N, P_2O_5, K_2O, MgO, S, Fe, Mn, B, Zn, Cu, Mo, Co, Se.

Mikroel is a liquid complex mineral fertilizer for foliar application, and a highly concentrated solution of 4 macro- and 11 microelements in an easily available form of chelates.

The fertilizer contains the following elements in a chelated form: Mn, Mo, MgO, Zn, Cu, Fe, Co, B, Cr, Ni, Li, Se, S, N, K_2O.

To study the influence of the described factors on the productivity of spring durum wheat, a two-factor field experiment was launched.

Factor A includes methods of soil cultivation (plowing with a PLN-5-35 plow to-a depth of 23–25 cm (control 1), minimal tillage with a BDM 7 × 3 disk harrow to a depth of 10–12 cm).

Factor B includes mineral and microbiological fertilizers (ammophos 60 kg/ha, strada N – 3 l/ha, mikroel – 0.2 l /ha, azofit – 2 l/ha).

Experimental design

B_1 – without fertilizers, H_2O (control 2);
B_2 – azofit;
B_3 – strada N;
B_4 – Microel;
B_5 – ammophos;
B_6 – azofit + ammophos;
B_7 – strada N + ammophos;
B_8 – microel + ammophos.

The predecessor of spring wheat was chickpea. Ammophos was introduced during pre-sowing cultivation of the crop. Foliar application with micronutrient fertilizers was carried out in the tillering and earing phases.

The area of each plot is 70 m^2, the counting area is 50 m^2. The experiment was repeated three times. The location of the plots is randomized. The seeding rate is 4.5 million viable seeds per hectare.

The field experience included observations and research in accordance with generally accepted methodological guidelines (Dospekhov B.A., 1985).

The yield was taken into account by the method of test sheaves with 7-fold repetition.

The calculation of the economic efficiency of the studied agricultural practices was carried out using the calculation and normative method based on technological maps.

Results of the research. The results of studies conducted in 2020–2022 showed that both the methods of tillage and the types of mineral and microbiological fertilizers used have a significant impact on the increase in the productivity of spring durum wheat (Table 1).

Analyzing the data obtained over the three years of the study, it can be concluded that in the acutely dry year of 2020 (hydrothermic coefficient 0.25), the liquid mineral fertilizer strada N increased the yield more effectively, both against the background of ammophos and without it. This trend was observed both at moldboard and minimum tillage. In the years with an average moisture supply of 2021 and 2022 (hydrothermic coefficient 0.47 and 0.62), double foliar top dressing of spring durum wheat crops with liquid mineral fertilizer strada N turned out to be the most effective on plowing. the combined use of ammophos and azofit more effectively increased the grain yield of hard spring wheat compared to the combined use of other studied liquid fertilizers against the background of applying granular mineral fertilizer.

The level of profitability in moldboard tillage in the variant without fertilization was 70.06 %. With the introduction of ammophos, a decrease in the level of profitability to 62.82 % was noted, despite the increase in the yield of spring durum wheat. A similar trend was observed in the variants with foliar fertilizing with complex mineral fertilizers strada N and microel: according to the experimental variants,

Table 1

Yield of spring durum wheat on average for three years, 2020–2022

Experimental option		Yield, t/ha	Overmeasure	
Factor A	Factor B		t/ha	%
Plowing	Without fertilizers	1.24	–	–
	Azofit	1.38	0.14	11.56
	Strada N	1.37	0.13	10.75
	Microel	1.34	0.10	8.06
	Ammofos	1.41	0.17	13.98
	Azofit + ammofos	1.63	0.39	31.18
	Strada N + ammofos	1.71	0.47	37.90
	Microel + ammofos	1.58	0.34	27.15
Minimal tillage	Without fertilizers	1.02	–	–
	Azofit	1.18	0.16	15.74
	Strada N	1.17	0.15	15.08
	Microel	1.14	0.12	12.13
	Ammofos	1.17	0.15	14.75
	Azofit + ammofos	1.42	0.41	40.00
	Strada N + ammofos	1.41	0.40	39.02
	Microel + ammofos	1.39	0.37	36.39

the profitability of production decreased to 62.10 and 68.52 %, which is lower than the variant without fertilization by 7.96 and 1.54 %. With the pre-sowing application of ammophos and foliar treatment of crops with liquid mineral and microbiological fertilizers, the profitability of grain production of spring durum wheat varied from 70.07 to 75.33 %. The maximum cultivation efficiency of spring durum wheat was noted in the variant with the introduction of ammophos and the microbiological fertilizer azofit – 75.33 %, despite the fact that, on average, over the years of research on plowing, the maximum yield was noted in the variant with the use of ammophos and two-fold treatment of crops with mineral nitrogen fertilizer strada N. It should be noted that in all analyzed options, azofit showed the maximum profitability of grain production, both with and without ammophos (Table 2).

During the minimal tillage in the variant without fertilization, the profitability was 74.29 %. With presowing treatment with ammophos, it decreased by 11.18 % (up to 63.11 %). The use of liquid mineral nitrogen fertilizer strada N, from an economic point of view, was also economically unprofitable, both with the use of ammophos and without it: the value of the analyzed indicator decreased to 69.60 and 66.81 %, respectively, according to the experimental options, which is lower than the profitability of the unfertilized option.

Conclusion. Fertilization and soil tillage also influenced the yield of spring durum wheat. Thus, during moldboard plowing, the efficiency of microbiological fertilizer decreased due to leaching of granulated mineral fertilizer into the lower horizons in wet years. At minimal tillage, due to loosening of the soil layer to a shallower depth, granular mineral fertilizers introduced into pre-sowing cultivation remained in the habitable zone of azophyt fertilizer bacteria, which increased the degree of their assimilation by plants.

When cultivating spring durum wheat on plowing, the maximum profitability of cultivating spring durum wheat was noted in the variant with the complex use of ammophos in pre-sowing cultivation and foliar fertilizing with microbiological fertilizer Azofit – 75.33 %, despite the fact that the maximum productivity of spring durum wheat was noted in the variant “Strada N + ammophos”.

At the minimum tillage, from an economic point of view, the joint application of ammophos and azofit also turned out to be the most effective, the profitability level was 82.02 %, despite the fact that

Table 2

The economic efficiency of the application of mineral and microbiological fertilizers in the cultivation of spring durum wheat

Experimental option		Yield, t/ha	Costs, thousand rubles/ha	Product price, thousand rubles/ha	Prime cost of 1 t, thousand rubles	Net profit, thousand rubles/ha	Profitability level, %
Factor A	Factor B						
Plowing	Without fertilizers	1.24	10.50	17.86	8.47	7.36	70.06
	Azofit	1.38	11.46	19.92	8.28	8.46	73.82
	Strada N	1.37	12.20	19.78	8.88	7.58	62.10
	Microel	1.34	11.45	19.30	8.54	7.85	68.52
	Ammofos	1.41	12.50	20.35	8.84	7.85	62.82
	Azofit + ammofos	1.63	13.36	23.42	8.21	10.06	75.33
	Strada N + ammofos	1.71	14.10	24.62	8.25	10.52	74.64
	Microel + ammofos	1.58	13.35	22.70	8.47	9.35	70.07
Minimal tillage	Without fertilizers	1.02	8.40	14.64	8.26	6.24	74.29
	Azofit	1.18	9.36	16.94	7.95	7.58	81.03
	Strada N	1.17	10.10	16.85	8.63	6.75	66.81
	Microel	1.14	9.35	16.42	8.20	7.07	75.57
	Ammofos	1.17	10.30	16.80	8.83	6.50	63.11
	Azofit + ammofos	1.42	11.26	20.50	7.91	9.24	82.02
	Strada N + ammofos	1.41	12.00	20.35	8.49	8.35	69.60
	Microel + ammofos	1.39	11.25	19.97	8.11	8.72	77.49

when using ammophos, the effect of azofit and strada N was almost equivalent, the yield on these options was 1.42 and 1.41 t/ha, respectively, according to the variants of the experiment.

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