IMPACT OF AGRICULTURAL MACHINERY ON INCREASING EFFICIENCY OF NITROGEN FERTILIZERS USED IN TOP-DRESSING OF WINTER WHEAT GROWN WITH NO-TILL TECHNOLOGY

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Abstract. Scientific studies of nitrogen agrochemistry should be aimed at finding new ways for the most rational use of nitrogen fertilizers, ensuring a reduction in its unproductive losses and an increase in payback by yield increase. One of the factors affecting the efficiency of technical nitrogen use is forms of nitrogen-containing fertilizers. The importance of nitrogen top-dressings in the production of winter crops in modern conditions has increased due to the fact that over the past 15 years arable land saturation with organic fertilizers has decreased significantly, and the stocks of available nitrogen compounds in soils are often negligible. The search for methods to increase the efficiency of using nitrogen fertilizers under conditions of a significant decrease in their production and use necessitates a more detailed study of issues related to plant nutrition, their absorption of nutrients from the soil and applied fertilizers. The article reflects the results of studies on the effectiveness of various forms of nitrogen fertilizers used in different ways to fertilize winter wheat with no-till technology. As a result of the research for the 2015-2018 agricultural years, it was found that the highest productivity of the crop was obtained using the in-soil application of liquid nitrogen fertilizers, which exceeded the figures for the use of agricultural tools for surface application of the AMAZONE ZF-M 1500 spreader and AMAZONE UX 4200 Super sprayer, solid and liquid forms of nitrogen fertilizers.

Keywords: introduction methods, winter wheat yield, grain quality, nitrogen fertilizers, feeding.

Introduction

According to the UN estimates, with the current growth rate the earth's population may exceed 8 billion people by 2025. To solve the food problem in the first quarter of the XXI century, it is necessary to double the gross harvest, or to grow about 4 billion tons of grain. This can be achieved only on the basis of intensification of crop farming [1].

To meet the needs of the Russian population in agricultural products and expanded soil fertility reproduction, it is required to make about 16.5 million tons of mineral fertilizers annually, according to the far from optimal forecasts [2].

The analysis of the experimental data of the comparative assessment of different systems of crop farming in many countries of the world allows to make a conclusion that achievements in crop production are possible not due to the development of alternative forms of plant cultivation, but due to the improvement of the existing ones. This requires the development and implementation of optimal (resource – and energy-saving) zonal fertilizer systems in typical crop rotations, ensuring the preservation and expanded reproduction of soil fertility, achieving a sustainable increase in yield, improving product quality, increasing crop rotation productivity and increasing the economic efficiency [3;4].

To achieve optimal performance in increasing the yield and quality of farm crops, it is necessary to select the timing, techniques and methods of fertilizer introduction. It is essential to create conditions for maximum availability of nutrients for plants, to provide plants with optimal nutrition during the growing season, in particular during critical periods, that is, during the periods of the greatest need for fertilizers; to reduce losses of nutrients from leaching [5;6].

Methods and technologies of fertilizer introduction should ensure the placement of fertilizers in the zone of root system development and their minimal fixation by soil. Fertilizers should be introduced into a stable moist soil layer to ensure their good availability during the growing season. It should also be taken into consideration that nutrients can be washed out and shift as a result of diffusion. Mainly nitrogen fertilizers in the form of nitrates are washed out. This process usually takes place in early spring and late autumn, so it is important to choose the right time and method of nitrogen fertilizer introduction in order to bring it closer to the period of intensive nitrogen assimilation by plants [7-9].

No-till technology helps stop degradation and preserves soil fertility, increases material resources saving, as well as profitability of production. It is necessary to keep up to date and pay attention not

only to the technologies of soil cultivation, but also to the in-depth study of effective methods of fertilizer introduction by various devices [10].

Materials and methods

The research was carried out from 2015 to 2017. Field experiments were conducted in the Central part of the Stavropol region, characterized by arid climatic conditions. The average annual precipitation was 506 mm, the average annual air temperature was 10.7 ºC. The soil cover of land use is mainly represented by southern black soil, which is currently characterized by an average content of humus (3.4-3.9 %), mobile phosphorus (18-21 mg·kg^{-1}) and increased content of exchange potassium (319-350 mg·kg^{-1}). The reaction of the soil solution in the upper horizons of the soil is alkaline in the range of 7.6 to 8.0.

The objective of the research was to study the effect of methods of nitrogen fertilizer introduction in early spring fertilizing on the yield of winter wheat, cultivated on no-till technology, on the southern black soil in the arid climatic zone.

The object of the research – variety of winter wheat "Grom".

The subject of the research were application methods of nitrogen fertilizers in feeding by means of different devices, presented in Table 1.

Table 1

Scheme of experience

Variant	Device
Ammophos $N_{12}P_{52}$ – background (control)	-
background + Ammonium nitrate Naa $_{87}$ (common technology)	mineral fertilizer spreader AMAZONE ZF-M 1500
background + CAM87 kg / ha	sprinkler AMAZONE UX 4200 Super
background + CAM 87 kg / ha	multi-injector Tuman-2
background + CAM 87 kg / ha	Duport liquilazer

Results and discussion

In the experiment the influence of methods of nitrogen fertilizer introduction to feeding on the yield of winter wheat cultivated on no-till technology in the Stavropol region was studied.

Weather conditions in 2014-2015 and 2015-2016 were unfavorable for the formation of the crop. Uneven distribution of precipitation in spring and summer had an adverse effect on the formation of the winter wheat crop. In general, 440 mm of precipitation fell in 2014-2015, which was lower than the average annual indicators by 13 %. The increased temperature regime was observed throughout the growing season of the crops, the average annual temperature exceeded the long-term indicators by 0.2 ºC in 2015-2016, 449 mm of precipitation fell, the average annual temperature reached 10 ºC.

The most favorable agro-meteorological conditions for winter wheat yield formation were in 2016-2017. The amount of precipitation during the growing season of the crops (511 mm) exceeded the norm by 18 %, however, their distribution is contributed to the optimal moisture of crops and the formation of the highest yield of winter wheat. The average annual air temperature corresponded to the mean annual values of 10.7 ºC.

Invariant 2 Ammonium nitrate was introduced by means of the mineral fertilizer spreader – AMAZONE (Figure 1). Carbamide-ammonia mixture (CAM) in a dose of 87 kg of active substance of nitrogen; in variant 3 it was introduced by means of a trailed sprayer (Figure 2); in variant 4 – by means of a multi-injector (Figure 3); in variant 5 – by means of the Duport liquiliser (Figure 4).

The applied fertilizers, their doses and methods of their introduction in the experiment had a positive impact on the yield of winter wheat and quality indicators of the crop. Nitrogen fertilizers increased the crop yield relative to control by 1.86-2.66 t·ha^{-1} and formed the grain of the fourth grade. In the control variant, the yield of winter wheat was almost two times lower in the formation of fodder grain.

As a result, on the variant without the use of nitrogen fertilizers in winter wheat feeding the lowest yield in the experiment was formed – 2.68 t·ha^{-1} with quality indicators corresponding to the grain of the fifth grade (Table 2).

Fig. 1. **Ammonium nitrate introduction by means ofmineral fertilizer spreaderAMAZONE ZF-M 1500**

Fig. 2. **Liquid nitrogen fertilizers introduction by means oftrailed sprayerAMAZONE UX 4200 Super**

Fig. 3.**Liquid nitrogen fertilizers introduction by means of multi-injector Tuman-2**

Fig. 4. **Liquid nitrogen fertilizers introduction by means of Duport liquiliser**

Table 2

Winter wheat quality and yield depending on the methods of nitrogen fertilizer introduction to feeding (average for 2015-2017)

Name	Variant1	Variant 2	Variant 3	Variant 4	Variant 5
Feeding: 1-st	Control	Naa (87 active substance) mineral fertilizer spreader AMAZONE ZF-M 1500	CAM (87 active substance) sprinkler AMAZONE UX 4200 Super	CAM (87 active substance) multi-injector Tuman-2	CAM (87 active substance) Duport Liquiliser
Protein	9.1	10.8	11.0	11.2	12.6
Nature	749	824	825	815	830
Weightof 1000 grains, tonns	35.9	41.7	42.8	41.8	41.9
Glutenamount, %	15.2	18.1	18.3	18.9	23.8
Gluten deformation index	90.6	56	80	53.0	60.3
Group	2	1	1	1	1
Grade	5	4	4	4	4
Yield, t·ha^{-1}	2.68	4.54	5.16	5.34	5.30

Table 3 shows that all nitrogen fertilizers studied in the experiment increased the main indicators of the economic efficiency compared to the control variant due to higher yield and quality of winter wheat. Fertilizer introduction reduced the cost price of 1 ton of grain from 22 to 30 Euro, compared to the control variant and increased the profit on 175-254 Euro and the level of profitability by 48.4-67.6 %.

The maximum economic efficiency indicators among all variants were obtained on the variant with the use of CAM at a dose of 87 kg of active substance of nitrogen by means of a multi-injector, which gave the greatest economic efficiency and the level of profitability was 73.5 %.

Table 3

Economic efficiency assessment of nitrogen fertilizer introduction methods in winter wheat feeding

Item	Unit	Variant 1 (control)	Variant 2	Variant 3	Variant 4	Variant 5
Basicfertilizer	kg	Not introduced				
Presowingfertilizer	kg	100 kg·/ ha Ammophos (MAP-N12P52)				
Feeding	kg	–	Naa (87 active substance) mineral fertilizer spreaderAMAZONE ZF-M 1500	CAM (87 active substance) sprinkler AMAZONE UX 4200 Super	CAM (87 active substance) multi-injector Tuman-2	CAM (87 active substance) Duport liquiliser
Totalcostsfor 1 ha	EUR·ha^{-1}	266	352	365	368	367
Wagesandtaxes	EUR·ha^{-1}	46	77	88	91	90
Seeds	EUR·ha^{-1}	26	26	26	26	26
Plantprotectionagents	EUR·ha^{-1}	21	21	21	21	21
Rentpayment	EUR·ha^{-1}	57	57	57	57	57
Bankinterest	EUR·ha^{-1}	28	28	28	28	28
Others	EUR·ha^{-1}	12	15	15	15	15
Mineral fertilizers in total, including	EUR·ha^{-1}	36	86	89	89	89
whensowing	EUR·ha^{-1}	36	36	36	36	36
Firstfeeding.	EUR·ha^{-1}	-	50	53	53	53
Fuelsandlubricants	EUR·ha^{-1}	11	11	11	11	11
Depreciation	EUR·ha^{-1}	29	29	29	29	29
Yield	t·ha^{-1}	2.68	4.54	5.16	5.34	5.30
Costprice	EUR·t^{-1}	99	77	71	69	69
Productprice	EUR·t^{-1}	105	119	119	119	119
Revenue	EUR·t^{-1}	282	542	616	638	633
Profit	EUR·t^{-1}	16	191	252	270	266
Efficiency	%	5.9	54.3	69.1	73.5	72.5

Conclusions

All doses of nitrogen fertilizers had a positive impact on the yield and structural parameters of winter wheat. Nitrogen fertilizers in a dose of 87 kg, introduced in various ways, increased the protein parameters by 1.7-3.5 %, nature by 66-81 units, weight of 1000 grains by 5.8-6.9 g, the amount of gluten by 2.9-7.6 %, and the gluten deformation index corresponded to 1 good group. The highest crop yield was obtained by mean of multi-injector Tuman-2 and Duport liquiliser 5.3 – 5.34 t·ha^{-1}, which exceeded the indicators of nitrogen fertilizer introduction by means of the mineral fertilizer spreaderAMAZONE ZF-1500 M and sprinklerAMAZONE UX 4200 Super of 0.8-0.18 t·ha^{-1}.

The maximum economic efficiency indicators among all variants were obtained in the variant with the use of CAM at a dose of 87 kg of active substance of nitrogen by means of the multi-injector, which gave the greatest economic efficiency-the level of profitability was 73.5 %.

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