The effectiveness of nitrogen fertilizers and nutrition systems for the winter wheat cultivation using no-till technology in the Stavropol Territory arid zone

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Abstract. The article presents materials on the effectiveness of nitrogen fertilizers in the nutrition system for the winter wheat cultivation using no-till technology in the Stavropol Territory arid zone for 2017-2019. As a result of the studies, it was found that all the studied doses of mineral fertilizers relative to the control option (without fertilizers) on average increased the content of nitrate (by 0.9-10.4 mg / kg) and ammonia nitrogen in the soil (by 0.2-6.7 mg / kg) during the vegetation phases. The urea ammonium nitrate (UAN) application using Duport liquilazer contributed to an increase in the nitrate and ammonium nitrogen content in the soil layer of 0-20 cm in all phases of the winter wheat development in comparison with similar experimental options in which nitrogen fertilizers were applied using a sprayer. According to the two years research results, a steady advantage of the intra-soil application of UAN using Duport liquilazer was noticed and the difference in yield, depending on the variant, was 0.15-0.25 t / ha. However, the more effective option was the introduction of UAN N20 autumn + UAN N87 spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) Duport liquilazer, which allowed to obtain a yield of 4.66 tons / ha.

1. Introduction
Winter wheat is the most important grain crop in Russia. Due to the high potential yield, occupying about 25% of the sown area of grain crops, winter wheat provides up to 30% of the gross grain harvest. Winter wheat responds well to the use of mineral fertilizers, primarily nitrogen fertilizers [1].

The average yield of winter wheat in the Russian Federation is 2.7 t / ha. Russia is in the 6th place in terms of yield of this crop, China is in the first place - 5.40 t / ha, European Union is in the second place - 5.36 t / ha, Argentina takes the third place - 3.25 t / ha, Canada – the fourth - 3.21 t / ha and the USA is in the fifth place - 3.2 t / ha. Russia receives low yields, unlike many countries, due to the low level of chemicalization of agriculture [2].

In order to get a high yield with good grain quality, it is necessary to provide plants with the necessary nutrients throughout the entire growing season. Intensive varieties can reveal their genetic potential only if they are fully provided with mineral nutrients, since they impose higher requirements on nutritional conditions [3,4].
Nitrogen fertilizer is a powerful factor in increasing productivity, giving from 30 to 60% increase in winter wheat yield. It is known that wheat tolerates nitrogen the most, potassium is in the second place in the removal, and phosphorus is the least abducted [5,6,7,8].

The competent distribution of the nitrogen required doses with the selection of the optimal timing and application methods creates the basis for the effective use of the potential yield of grain crops [9,10,11].

In this regard, the goal of our research was to study the effectiveness of nitrogen fertilizers and nutrition systems in the cultivation of winter wheat using no-till technology in the Stavropol Territory arid zone.

2. Materials and methods

Studies were carried out in peasant farms S.S. Vodopyanov Petrovsky district, Stavropol Territory from 2017 to 2019. The soil cover of the research site is represented by southern medium-humus medium-thick chernozem. In the course of the agrochemical examination before laying the experiment, it was revealed that the soils are low in organic matter (3.3-3.9%), on average they are provided with mobile phosphorus (14-21 mg / kg) and exchange potassium (260-300 mg / kg). The reaction of the soil solution is slightly alkaline (7.1-7.5 units).

The farm land use territory belongs to the arid agro-climatic region.

According to long-term data, the average annual amount of precipitation is 449 mm, the sum of active temperatures is in the range of 3200-3500 °C, and the hydrothermal index (HTI) is 0.7-0.9. Two agricultural years of the experiments were characterized by an increased temperature regime: the difference with the long-term average norm was: in 2017-2018 - 2.8 °C, in 2018-2019 - 2.3 °C. The amount of precipitation for 2017-2018 amounted to 417.3 mm, in 2018-2019 - 393.0 mm, which is 7-12% lower than the average annual value.

Experience outline: option 1 – without fertilizers; option 2 - 1st fertilizing the renewal of spring vegetation (UAN in a dose of 87 kg of nitrogen (209 l UAN -32) the application of a sprayer); option 3 – fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) the application of a sprayer); option 4 - fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) +1st feeding of the renewal of spring vegetation of UAN in a dose of 87 kg of nitrogen (209 l UAN -32) the application of a sprayer); option 5 - fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) +1st feeding of the renewal of spring vegetation of UAN in a dose of 87 kg of nitrogen (209 l UAN-32) + 2nd top dressing in a phase of the tube lying 20:20:20 (2kg/ha) making sprayer); option 6 - fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) + first feeding of the renewal of spring vegetation of UAN in a dose of 87 kg of nitrogen (209 l UAN-32) + 2nd top dressing in a phase of the booting 20:20:20 (2kg/ha) + 3d feeding in the phase of earing lying 20:20:20 (2kg/ha) making sprayer); option 7 - 1st fertilizing the renewal of spring vegetation (UAN in a dose of 87 kg of nitrogen (209 l UAN-32) the Duport liquilazer application); option 8 - fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) the Duport liquilazer application); option 9 - the fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) +1st feeding of the renewal of spring vegetation of UAN in a dose of 87 kg of nitrogen (209 l UAN-32) the Duport liquilazer application); option 10 - autumn (UAN dose of 20 kg nitrogen (48 liters UAN -32) +1st feeding of the renewal of spring vegetation of UAN in a dose of 87 kg of nitrogen (209 l UAN-32) + 2nd top dressing in a phase of the booting 20:20:20 (2kg/ha) Duport liquilazer application); option 11 - the fall (UAN at a dose of 20 kg nitrogen (48 liters UAN -32) +1st feeding of the renewal of spring vegetation of UAN in a dose of 87 kg of nitrogen (209 l UAN-32) + 2nd top dressing in a phase of the booting 20:20:20 (2kg/ha) + 3d feeding in the phase of earing lying 20:20:20 (2kg/ha) Duport liquilazer application).

The forerunner in the experiment is sunflower. The content of nitrate nitrogen was determined by the ionometric method, GOST 26951–86: ammonia nitrogen according to the Central Research Institute of Agrochemical Services (CRAS) method, the harvest was recorded by the mechanized harvesting method, followed by conversion to standard humidity and purity according to the state variety testing method of agricultural crops of 1989.
3. Results
The maximum content of nitrate nitrogen in the soil during the growing season of winter wheat was, on average, experimentally observed in the phase of entry into the tube and, on average, by experiment was 20.0 mg / kg of soil, which exceeded the tillering phase in autumn by 11.3 mg / kg, tillering phase in the spring at 0.6 mg / kg, the earing phase at 4.2 mg / kg, the full ripening phase at 10.7 mg / kg (table 1).

Table 1. Dynamics of the content (mg / kg) of nitrate nitrogen in a 0-20 cm soil layer during the growing season of winter wheat under the conditions of peasant farm S.S. Vodopyanov (average for 2017-2019)

| Option | Tillering (fall) | Tillering (spring) | Booting | Earing | Full ripeness |
|--------|------------------|--------------------|---------|--------|---------------|
| 1      | 6.1              | 11.8               | 11.1    | 8.4    | 4.5           |
| 2      | 5.5              | 18.9               | 20.4    | 14.7   | 8.1           |
| 3      | 8.9              | 13.4               | 11.9    | 8.2    | 4.0           |
| 4      | 9.1              | 20.4               | 22.1    | 17.1   | 9.5           |
| 5      | 8.5              | 21.0               | 21.5    | 18.0   | 9.0           |
| 6      | 9.5              | 19.5               | 22.6    | 17.5   | 10.0          |
| 7      | 5.2              | 22.5               | 23.4    | 19.0   | 12.5          |
| 8      | 10.8             | 14.2               | 13.0    | 9.5    | 6.0           |
| 9      | 11.0             | 24.2               | 25.0    | 20.1   | 13.2          |
| 10     | 10.5             | 23.5               | 24.5    | 20.5   | 13.0          |
| 11     | 11.0             | 24.5               | 25.0    | 21.0   | 12.5          |
| NSR    | 0.8              | 1.5                | 2.0     | 1.4    | 1.2           |

3.1. When sowing on all variants, Af N2P32 was applied
1 - control (without fertilizers); 2 - UAN N87 in the spring Sprayer; 3 - UAN N20 autumn Sprayer; 4 - UAN N20 autumn + UAN N87 spring Sprayer; 5 - UAN N20 autumn + UAN N87 spring + water-soluble organic substance 20:20:20 (2 kg / ha) Sprayer; 6 - UAN N20 autumn + UAN N87 spring + water-soluble organic substance 20:20:20 (2 kg / ha) + water-soluble organic substance 20:20:20 (2 kg / ha) Sprayer; 7 - UAN N87 in spring Duport liquilazer; 8 - UAN N20 autumn Duport liquilazer; 9 - UAN N20 autumn + UAN N20 spring Duport liquilazer; 10 - UAN N20 autumn + UAN N87 spring + ASU 20:20:20 (2 kg / ha) Duport liquilazer; 11 -UAN N20 fall + UAN N87 spring + water-soluble organic substance 20:20:20 (2 kg / ha) + water-soluble organic substance 20:20:20 (2 kg / ha) Duport liquilazer.

In almost all test cases, autumn and spring tillering stages and the phase of booting were fed with UAN, which provided the plant with nitrogen and increased the concentration of the element in the soil from the tillering phase (autumn) to the phase of booting, from the phase of booting to during the full ripeness phase, the element concentration decreases, as the amount of nitrogen consumed by plants increases.

All experimental variants increased the content of nitrate nitrogen in the soil from 0.9-10.4 mg / kg on average over the vegetation phases relative to the control variant.

The introduction of UAN N87 in the fall by the sprayer and Duport liquilazer did not significantly affect the nitrate form of nitrogen in the 0-20 cm soil layer compared to the control and significantly reduced these indicators relative to the indicators of other fertilized options.

The greatest supply with the nitrate form of nitrogen in the experiment is formed by the variants using UAN N20 autumn + UAN N87 spring Duport liquilazer - 18.7 mg / kg and UAN N20 autumn +
UAN N<sub>87</sub> spring + UAN N<sub>87</sub> spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20 : 20: 20 (2kg / ha) Duport liqulizer - 18.8 mg / kg.

The application of UAN using Duport liqulizer contributed to an increase in the content of nitrate nitrogen in the soil layer of 0-20 cm in all phases of the development of winter wheat compared with similar experimental options in which nitrogen fertilizers were applied using a sprayer.

The maximum content of ammonia nitrogen in the soil during the growing season of winter wheat was noted in the tillering phase in the spring and, on average, was experimentally 26.5 mg / kg of soil, which exceeded the tillering phase in the fall by 9.1 mg / kg, the exit phase into booting by 2 , 9 mg / kg, a heading phase of 5.7 mg / kg, a full ripening phase of 9.3 mg / kg (table 2).

From the tillering phase (spring) to the phase of full ripeness, a steady decrease in the concentration of ammonium nitrogen occurs. This trend is explained by the fact that with an increase in the biomass of plants, the amount of nitrogen consumed also increases; therefore, its content in the soil decreases with the development of plants.

All experimental variants increased the average ammonium nitrogen content in the soil from 0.2-6.7 mg / kg over the vegetation phases relative to the control variant.

The UAN application using Duport liqulizer contributed to an increase in the content of ammonia nitrogen in the soil layer of 0-20 cm in all phases of the winter wheat development in comparison with similar experimental options in which nitrogen fertilizers were applied using a sprayer.

The greatest availability of ammonia form of nitrogen in the experiment is formed by the variants using UAN N<sub>20</sub> autum + UAN N<sub>87</sub> spring + water-soluble organic substance 20:20:20 (2kg / ha) Duport liqulizer - 23.5 mg / kg and UAN N<sub>20</sub> autum + UAN N<sub>87</sub> spring + water-soluble organic substance 20 : 20: 20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) Duport liqulizer - 23.7 mg / kg.

**Table 2.** Dynamics of the content (mg / kg) of ammonia nitrogen in a 0-20 cm soil layer during the growing season of winter wheat under the conditions of peasant farm S.S. Vodopyanov (average for 2017-2019)

| Option | Tillering (fall) | Tillering (spring) | Booting | Earing | Full ripeness |
|--------|-----------------|--------------------|---------|--------|---------------|
| 1      | 16.3            | 20.4               | 18.2    | 15.2   | 12.7          |
| 2      | 15.4            | 26.8               | 23.1    | 21.1   | 17.4          |
| 3      | 17.9            | 21.2               | 19.0    | 15.6   | 12.4          |
| 4      | 17.7            | 27.8               | 24.7    | 22.3   | 19.0          |
| 5      | 18.1            | 27.5               | 25.3    | 21.9   | 18.2          |
| 6      | 17.5            | 27.4               | 24.8    | 22.6   | 19.3          |
| 7      | 15.0            | 29.2               | 25.4    | 23.0   | 18.4          |
| 8      | 18.5            | 22.1               | 19.8    | 16.3   | 13.1          |
| 9      | 18.3            | 29.1               | 26.1    | 23.1   | 19.5          |
| 10     | 18.5            | 29.6               | 27.1    | 23.4   | 19.0          |
| 11     | 18.1            | 30.2               | 26.5    | 24.0   | 19.8          |
| NSR    | 0.5             | 1.3                | 1.1     | 0.8    | 0.5           |

3.2. **When sowing on all variants, Af N<sub>12</sub>P<sub>32</sub> was applied**

1 - control (without fertilizers); 2- UAN N<sub>87</sub> in the spring Sprayer; 3- UAN N<sub>20</sub> autumn Sprayer; 4 UAN N<sub>20</sub> autumn + UAN N<sub>87</sub> spring Sprayer; 5- UAN N<sub>20</sub> autum + UAN N<sub>87</sub> spring + water-soluble organic substance 20:20:20 (2kg / ha) Sprayer; 6-UAN N<sub>20</sub> autumn + UAN N<sub>87</sub> spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) Sprayer; 7- UAN N<sub>87</sub> in spring Duport liqulizer; 8- UAN N<sub>20</sub> autum Duport liqulizer; 9- UAN N<sub>20</sub> autumn + UAN N<sub>20</sub> spring Duport liqulizer; 10- UAN N<sub>20</sub> autumn + UAN N<sub>87</sub> spring + water-soluble organic substance
20:20:20 (2kg / ha) Duport liquilazer; 11-UAN N$_{20}$ fall + UAN N$_{87}$ spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) liquilazer.

The application of UAN N$_{20}$ by a sprayer and Duport liquilazer in the fall did not significantly affect the content of ammonia form of nitrogen in a 0-20 cm soil layer compared to the control and significantly reduced these indicators relative to the indicators of other fertilized options.

The use of nitrogen fertilizers in the conditions of the experiment, despite the insufficient amount of precipitation and increased temperature conditions, made it possible to obtain a sufficiently high yield of winter wheat after the sunflower precursor. Without the use of nitrogen fertilizers in top dressing of winter wheat, the lowest yield in the experiment was formed - 3.35 t / ha, which turned out to be lower than the options with the application of nitrogen fertilizers from 0.04 to 1.31 t / ha (table 3).

The maximum yield of winter wheat grain, regardless of the method of applying nitrogen fertilizers, was ensured by a combination of autumn and spring application of UAN and one or two times feeding of water-soluble organic substance (2 kg / ha). Unilateral autumnal application of nitrogen fertilizers in the studied dose was ineffective in all methods of application. A steady advantage of the intra-soil application of UAN using Duport liquilazer was noted and the difference in yield, depending on the variant, was 0.15-0.25 t / ha.

Table 3. Productivity of winter wheat in the conditions of peasant farm S.S. Vodopyanov Petrovsky district (average for 2018-2019).

| Option | Autumn application | First feeding | Second feeding | Third feeding | Agricultural machine | Productivity, t / ha |
|--------|--------------------|---------------|----------------|--------------|----------------------|---------------------|
| 1      | Control (without nitrogen fertilizers) | - | - | - | Sprayer | 3.35 |
| 2      | UAN N$_{87}$ | - | - | - | Sprayer | 4.16 |
| 3      | UAN N$_{20}$ | - | - | - | Sprayer | 3.39 |
| 4      | UAN N$_{20}$ UAN N$_{87}$ | - | - | - | Sprayer | 4.27 |
| 5      | UAN N$_{87}$ | - | - | - | Sprayer | 4.38 |
| 6      | UAN N$_{87}$ | - | - | - | Sprayer | 4.40 |
| 7      | UAN N$_{87}$ | - | - | - | Duport liquilazer | 4.31 |
| 8      | UAN N$_{20}$ | - | - | - | Duport liquilazer | 3.44 |
| 9      | UAN N$_{20}$ UAN N$_{87}$ | - | - | - | Duport liquilazer | 4.52 |
| 10     | UAN N$_{87}$ | - | - | - | Duport liquilazer | 4.62 |
| 11     | UAN N$_{20}$ UAN N$_{87}$ | - | - | - | Duport liquilazer | 4.66 |
| HCP    | 0.25 |

* When sowing on all variants, Af N$_{12}P_{52}$ was applied
I-control (without fertilizers); 2- UAN N\textsubscript{87} in the spring Sprayer; 3- UAN N\textsubscript{20} autumn Sprayer; 4- UAN N\textsubscript{20} autumn + UAN N\textsubscript{87} spring Sprayer; 5- UAN N\textsubscript{20} autumn + UAN N\textsubscript{87} spring + water-soluble organic substance 20:20:20 (2kg / ha) Sprayer; 6-UAN N\textsubscript{20} autumn + UAN N\textsubscript{87} spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) Sprayer; 7- UAN N\textsubscript{87} in spring Duport liquilazer; 8- UAN N\textsubscript{20} autumn Duport liquilazer; 9- UAN N\textsubscript{20} autumn + UAN N\textsubscript{20} spring Duport liquilazer; 10- UAN N\textsubscript{20} autumn + UAN N\textsubscript{87} spring + water-soluble organic substance 20:20:20 (2kg / ha) Duport liquilazer; 11-UAN N\textsubscript{20} fall + UAN N\textsubscript{87} spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) liquilazer.

Thus, the use of nitrogen top dressing contributes to an increase in the yield of winter wheat grains relative to the control by 0.04-1.31 t / ha. However, the more effective option was the introduction of UAN N\textsubscript{20} autumn + UAN N\textsubscript{87} spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) Duport liquilazer, which allowed to obtain a yield of 4.66 tons / ha.

4. Conclusion

When conducting research from 2017 to 2019 the results on the effect of doses of nitrogen fertilizers on the dynamics in the soil of nitrate and ammonium nitrogen and the yield of winter wheat were obtained. All the studied doses of mineral fertilizers relative to the control variant (without fertilizers) on average during the growing phases increased the content of nitrate nitrogen in the soil by 0.9-10.4 mg / kg, ammonia nitrogen by 0.2-6.7 mg / kg. The introduction of UAN using Duport liquilazer contributed to an increase in the content of nitrate and ammonium nitrogen in the soil layer of 0-20 cm in all phases of the development of winter wheat in comparison with similar experimental options in which nitrogen fertilizers were applied using a sprayer. In all variants of the experiment with regard to control, the productivity of winter wheat increased by 0.04-1.31 t / ha. The steady advantage of the intra-soil application of UAN using Duport liquilazer compared to the sprayer, depending on the variant, the difference was 0.15-0.25 t / ha. When cultivating winter wheat using no-till technology in the arid zone of the Stavropol Territory, production is recommended the most effective option with the introduction of UAN N\textsubscript{20} autumn + UAN N\textsubscript{87} spring + water-soluble organic substance 20:20:20 (2kg / ha) + water-soluble organic substance 20:20:20 (2kg / ha) Duport liquilazer, which allowed to obtain a yield of 4.66 t / ha.

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