Increasing yield and quality of grain wheat in steam grain-steamed crop rotation in the lower Volga region

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Abstract. The scientific work shows the influence of agrochemicals and methods of the main tillage in the steam link of grain-row crop rotation on the yield and the proportion of protein in dry matter in winter wheat grain. The analysis of soil moisture and moisture reserves in a fallow field during the sowing of winter wheat in the Lower Volga region was carried out. Three-year data show that the main processing of black fallow by 10-12 cm for sowing winter wheat reduces its yield by 0.25 t / ha (10.6%). The maximum values of the yield of winter wheat were obtained on combined processing - 2.40 t / ha, with an insignificant increase (2.1%) in relation to the control (moldboard processing). Deep moldboard-free loosening of the soil by 30-32 cm did not provide a significant decrease in yield (-0.03 t / ha). Foliar feeding of winter wheat crops with micronutrient fertilizers increased the yield by 7.3-11.4%, a growth stimulator (GSN-2004) by 3.8 - 8.2%. Giberelon (growth regulator) in the severely arid years of research on the dark chestnut soils of the Lower Volga region did not have a significant effect on the grain yield of winter wheat. A significant increase in the protein content was formed in the variants with feeding Megamix No. 10 - 0.4-0.5%, Mikrovit – 0.4-0.6% (mineral fertilizers) and GSN-2004 (growth stimulant) - 0.5-0.6%.

1. Introduction
In the arid conditions of the Saratov region, winter soft wheat is the most profitable and most productive grain crop. According to the published data of the regional Ministry of Agriculture, the sown area of winter wheat in the region was more than a million hectares [1].

An increase in the average annual air temperature in the Lower Volga region by 1.2-1.3 ºC (over 30 years) led to an increase in the number of droughts, dry winds, and an increase in transpiration of agricultural plants [2].

Therefore, research is needed to improve the adaptation of winter wheat plants to the arid conditions of the Lower Volga region.

The process of adaptation of agricultural plants includes two stages:

- Stress reaction is a short-term protective organism against death during the period of exposure to an extreme factor;
- Specialized adaptation - the formation of proteins specific to each extreme factor.

The use of micro fertilizers allows an agricultural plant to receive dissolved nutrients in an accessible form and contributes to a positive response to the impact of a stress factor. At the same
time, agricultural plants consume less energy for the formation of specialized mechanisms of adaptation to unfavorable factors [3].

Plants undergo changes in cells and microbiological composition when exposed to stress. The intensity of the reaction of cells to a factor that is at a minimum characterizes the ability of plants to resist stress [4].

With a moisture deficit in plants, dehydrin proteins are formed, which contribute to the hydration of macromolecules, as a result of which dehydration and denaturation of proteins decreases. These proteins more actively affect phytohormones, which increases the photosynthetic activity of agricultural plants [5].

The decisive role in optimizing the functions of the organism of agricultural plants under extreme conditions belongs to amino acids, which improve nitrogen metabolism, which increases the level of stress resistance, drought resistance of plants [6].

Under conditions of the action of a stress factor, plants begin to produce and accumulate in cells an additional amount of proline, 15-20 times more than plants that do not experience a moisture deficit in the soil [7; 8].

In the Lower Volga region and especially in the Saratov Trans-Volga region, a lack of productive moisture in the soil and an insignificant amount of precipitation during the growing season are negative factors in increasing the yield of winter wheat. According to the literature, the cheapest and most promising ways to improve the water regime of the soil are phytomelioration [9-12] and resource-saving tillage [13-15], which provide good water infiltration into the lower soil horizons and reduce moisture loss for physical evaporation. To increase the adaptability of agricultural plants to moisture deficit, it is necessary to use foliar dressing with fertilizers with microelements, growth regulators [13; 16; 17], therefore, research in this direction is relevant in scientific and practical application.

2. Materials and methods

The studies were carried out on the dark chestnut soil of the experimental field of the UNPO "Volga Region" of the Saratov State Vavilov Agrarian University in 2017 - 2020. The humus content in the arable layer is low - 2.8% (according to Tyurin, GOST 26213-91). The nitrification capacity is average - 12.9 mg / kg of soil (according to Kravkov, GOST 26107-84), the content of available phosphorus is average - 29.7 mg / kg of soil and available potassium average - 294 mg / kg (according to Machigin, GOST 26205-91). The content of trace elements is low: sulfur - 3.3 mg / kg, manganese - 4.7 mg / kg, copper - 0.06 mg / kg, boron - 1.85 mg / kg, zinc - 0.36 mg / kg soil.

According to the agro climatic characteristics, the experimental zone is characterized as arid with a continental climate with an average annual precipitation of 366 mm. During the period of active growth and development of winter wheat (from May to August), the SCC amounted to: SCC2018 - 0.63, SCC 2019 - 0.21, SCC 2020 - 0.20.

To reduce the effect of stress factors when using energy-saving technologies and increase the quality of wheat winter grain, a two-factor experience was laid to study the effectiveness of using foliar feeding with various agricultural chemicals in the extreme conditions of the Saratov Trans-Volga region.

Factor A - methods of basic soil cultivation with pure (black) steam:

- Moldboard plowing with a PLN-8-35 plow to a depth of 23-25 cm (control 1);
- Moldless plowing with SSD-4 deep ripper to a depth of 30-32 cm;
- Minimum processing of a 7×3 PM discator to a depth of 10-12 cm;
- Combined plowing with a Boykov PBS-10 P plow to a depth of 23-25 cm.

Factor B - agrochemicals (mineral fertilizers, growth regulator, growth stimulant):

- Without fertilizers (control 2);
• AgroVerm - 3 l / ha (fertilizers based on humic acids);
• Reasil - 1.5 l / ha (fertilizers based on humic acids);
• Megamix No. 10 - 0.5 l / ha (mineral fertilizer);
• NanoSilicon 100 g / ha (mineral fertilizer);
• Microvit - 0.5 l / ha (mineral fertilizer);
• Giberelon, GRP 40 - 120 g / ha (growth regulator);
• GSN- 2004 - 2.5 l / ha (growth stimulator).

According to factor A - total area of plots - 1500 m$^2$, accounting 1000 m$^2$, according to factor B - total 30 m$^2$, accounting 20 m$^2$. Threefold repetition according to factor A and six times according to factor B. The location of the plots is randomized. The object of research is winter wheat, cultivar Novoershovskaya.

In the phase of spring tillering of winter wheat, 100 kg / ha (fertilizer) of ammonium nitrate was introduced for harrowing. Foliar top dressing with agrochemicals according to the experimental scheme for factor B - the tillering phase and the heading phase of winter wheat were performed twice.

To combat diseases and pests in the heading phase, the crops were treated with the Altyn insecticide 0.2 l / ha and the fungicide Kolosal Pro 0.4 l / ha. During the ripening period, the insecticide Borey 150 g / ha was used.

The field experience was accompanied by observations and research in accordance with generally accepted methods and methodological guidelines [18-19]. Grain quality indicators for winter wheat were determined using the infrared analyzer INFRASCAN-1050.

3. Results and Discussion
It is shown that during the sowing of winter soil in 2017 (4.09), the maximum degree of moisture in the meter layer was noted on classical plowing - 15.1% and on combined plowing - 15.0%, and the minimum value in the third option (BDT 7 × 3 on depth of 10-12 cm - 14.6% Moisture of the cultivated layer (0-30 cm) varied from 14.1% of the mass of absolutely dry soil to a minimum to treatment of 15.1% by classical moldboard plowing (figure 1).

![Figure 1. Soil moisture during the sowing of winter wheat in the 0 - 30 cm layer, 2017-2019.](image-url)
In 2018, during the sowing of winter wheat (25.08), the maximum moisture content of the arable layer was recorded on plowing with Boykov plow - 13.3%, the lowest for non-moldboard and minimum tillage - 12.1%, which is 0.9% lower than classical plowing. In a meter layer, soil moisture increased from 12.8% on discs to 14.3% on combined plowing (figure 2).

The rains that fell at the end of July and at the beginning of August 2019 (25.7 mm of effective precipitation) kept the moisture content of the upper 30 cm layer for sowing winter wheat (21.08) at 14.4% for minimal tillage and 15.6% for classic plowing (the control). In the meter horizon of the soil, the maximum soil size is formed on the variants plowed PLN-8-35 and PBS - 10 P - 16.0%, which exceeds the minimum tillage by 0.9%.

Estimation of productive moisture reserves in 2017 according to A.F. Vadyunina, Z.A. Korchagina, [20] shows unsatisfactory reserves in the 0-20 cm layer (8-10 mm) and poor in the meter horizon (69-76 mm) (table 1).

Table 1. Assessment of productive moisture reserves in clean fallow before sowing winter wheat, mm.

| Soil layer, cm | Productive moisture reserve | Assessment of moisture reserves | Years of research |
|----------------|-----------------------------|---------------------------------|-------------------|
| 0-20           | more than 40                | good                            | 2017              |
|                | 40-20                       | satisfactory                    | 2018              |
|                | less than 20                | unsatisfactory                  | 2019              |
| 0-100          | 160                         | good                            | 8-10              |
|                | 160-130                     | very good                       | 3-6               |
|                | 130-90                      | good                            | 8-11              |
|                | 90-60                       | satisfactory                    | 69-76             |
|                | less than 60                | bad                             | 43-64             |

The worst conditions for productive moisture reserves were formed in 2018, in the 0-20 cm layer they were unsatisfactory (3-6 mm), and in the 0-100 cm horizon they were very bad and bad (43-64 mm).
A comparative assessment of productive moisture reserves shows that in 2019 they were unsatisfactory in the 0-20 cm layer (8-11 mm), and bad in the 0-100 cm layer (76-88 mm).

Accounting for the yield of winter wheat according to the variants of the experiment showed that, on average, over three years, the maximum yield was obtained on the option with combined plowing PBS -10 P - 2.40 t / ha, which exceeded the control by 0.05 t / ha, but the data the differences were within the experimental error (НСР05 according to the factor А = 0.088) (table 2).

| Experience options | factor A | factor B | Yield | Deviation from control |
|--------------------|----------|----------|-------|------------------------|
| average for 2018-2020 | average by factor B | t / ha | % |
| control 2 | 2.35 | 2.29 | - | - |
| AgroVern | 2.47 | 2.41 | +0.12 | 5.1 |
| Reasil | 2.39 | 2.37 | +0.04 | 1.7 |
| Megamix | 2.59 | 2.50 | +0.24 | 10.2 |
| NanoSilicon | 2.44 | 2.39 | +0.09 | 3.8 |
| Microvit | 2.61 | 2.52 | +0.26 | 11.1 |
| Gibberelone | 2.33 | 2.31 | -0.02 | 0.8 |
| GSN - 2004 | 2.44 | 2.43 | +0.09 | 3.8 |
| Average by factor A | 2.45 | - | - |
| control 2 | 2.32 | -0.03 | 1.3 |
| AgroVern | 2.43 | +0.11 | 4.7 |
| Reasil | 2.39 | +0.07 | 3.0 |
| SSD - 4 × 30-32 cm | 2.49 | +0.17 | 7.3 |
| Megamix | 2.38 | +0.06 | 2.6 |
| NanoSilicon | 2.54 | +0.22 | 9.5 |
| Microvit | 2.34 | +0.02 | 0.8 |
| GSN - 2004 | 2.51 | +0.19 | 8.2 |
| Average by factor A | 2.43 | - | - |
| control 2 | 2.10 | -0.25 | 10.6 |
| AgroVern | 2.25 | +0.15 | 7.1 |
| Reasil | 2.23 | +0.13 | 6.2 |
| PM 7 × 3 for 10-12 cm | 2.32 | +0.22 | 10.5 |
| Megamix | 2.27 | +0.17 | 8.1 |
| NanoSilicon | 2.34 | +0.24 | 11.4 |
| Microvit | 2.17 | +0.07 | 3.3 |
| GSN - 2004 | 2.27 | +0.17 | 8.1 |
| Average by factor A | 2.24 | - | - |
| control 2 | 2.40 | +0.05 | 2.1 |
| AgroVern | 2.51 | +0.11 | 4.6 |
| Reasil | 2.47 | +0.07 | 2.9 |
| PBS - 10 P by 23-25 cm | 2.61 | +0.21 | 8.8 |
| Megamix | 2.48 | +0.08 | 3.3 |
| NanoSilicon | 2.59 | +0.19 | 7.9 |
| Microvit | 2.41 | +0.01 | 0.4 |
| GSN - 2004 | 2.51 | +0.11 | 4.6 |
| Average by factor A | 2.50 | - | - |
| HCP0.05 for private secondary | 0.135 |
| HCP by factor A | 0.088 |
| HCP by factor B | 0.103 |
| HCP by factor AB | F<sub>T</sub> < F<sub>T</sub> |
On the variant with deep moldboard-free tillage, there was no significant decrease in the yield of winter wheat (-0.03 t / ha). Minimization of basic tillage in clean fallow reduced the yield by 0.25 t / ha or 10.6%.

Monitoring the yield of winter wheat by factor B (agrochemicals) showed that on dump, non-dump and combined treatments, a significant increase in yield (HCP05 by factor B = 0.103) was observed only from foliar dressing with mineral fertilizers (Megamix - 0.17 - 0.24 t / ha, Mikrovit - 0.19 - 0.26 t / ha) and from fertilizers based on humic acids (AgroVerm - 0.11 - 0.12 t / ha). Modern farming systems lead to a decrease in the content of microelements available to plants in the soil, therefore, the use of micronutrients is highly effective when growing intensive varieties on soils with a low content of microelements.

For non-moldboard and combined processing, a significant increase in yield was noted from the use of the growth stimulator GSN - 2004 - 0.11 - 0.19 t / ha. On minimal processing with a disk tool, a significant increase in yield was not recorded only from spraying with a growth regulator (Giberelon) - 0.07 t / ha. The rest of the studied agrochemicals increased the yield of winter wheat by 0.13 - 0.24 t / ha, or 6.2 - 11.4%.

Determination of the mass fraction of protein in winter wheat grain for 2018 - 2020 showed that the methods and depth of soil cultivation did not significantly affect this indicator (figure 3).

![Figure 3. Protein content in winter wheat grain, 2018-2020.](image)

4. Conclusion
In the Saratov Trans-Volga region, during the sowing of winter wheat, the lowest soil moisture of the 1-meter horizon was formed on the PM 7 x 3 variant - 13.5% and 14.2%, which is 1.4 and 0.9% less than classical plowing. Productive moisture reserves in the 1-meter horizon were poor and very poor, 43 - 88 mm.

Minimization of tillage in black fallow for winter wheat reduces its yield by 0.25 t / ha or 10.6%. The maximum yield of winter wheat is ensured by combined processing (PBS - 10 P at a depth of 23-25 cm) - 2.40 t / ha, which exceeds the classic plowing by 2.1%.

Two-fold processing of winter wheat crops with AgroVerm increased the yield on average for soil cultivation options by 5.2%, protein content by 0.3%; Reasil, respectively, by 3.5%, 0.2%; NanoSilicon 4.4%, 0.3%; Megamixom 9.2%, 0.4%; Mikrovit 10.0%, 0.5%; GSN– 2004 by 6.1%, 0.5%. Giberelon (growth regulator) in the dry years of research on the dark chestnut soils of the Lower
Volga region did not have a significant effect on the yield and the mass fraction of protein in the grain of winter wheat.

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