The results of the use of the complex of microbiological preparation on *Triticum aestivum* L. on the traditional farming system and no-till

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**Abstract.** The aim of our research was to study the influence of *Triticum aestivum* L. cultivation technology by direct sowing in comparison with traditional technology using a complex microbiological preparation on growth and development, as well as the yield and quality of the products obtained by the most common field crop in Russia. Scientific research was conducted from 2015 to 2018. in stationary experience. Weed control was carried out by a combination of mechanical and chemical methods according to the traditional system and direct-sowing chemicals. With direct sowing technology, the Gherardi G117 seeder was used. According to the traditional system, the SZ-3.6 seeder was used. The studied crop rotations are typical for the region. The laying of experiments and conducting research is carried out in accordance with generally accepted methods of field experiments in agriculture and crop production. The spike length was 0.5 cm longer according to the traditional system. The number of grains from ten plants was 82 in the classical agricultural system and 27.0 more in the variant without processing the biological product. The grain weight of 10 plants according to the traditional farming system was 1.5 g more. The number of grains in one ear by the classical farming system was 3.4 units significantly higher than by the technology without tillage. Productivity for three years does not have a significant increase in the study of agricultural systems. The mass of 1000 grains on average for 2016–2018. was 3 grams more in direct sowing.

1. **Introduction**

*Triticum aestivum* L. is a food crop, which owns one of the main places in the world. It gives high yields of high-quality grain products [1]. Its grain is valuable because it contains the optimum amount of proteins about 15% and carbohydrates about 79%. In bakery and pasta industry, winter wheat grain is the main raw material [2]. Chaff and wastes that remain during the production of flour are used to feed farm animals [3], and plant residues from wheat are used as litter [4].
In the Russian Federation, winter wheat occupies a leading place in terms of cultivated areas and gross harvests of grain products (cultivated areas in 2019 amounted to 27.2 million hectares, over the past 5 years (compared to 2013), the sown area of wheat in Russia increased by 8, 7%) [5].

*Triticum aestivum* L. is resistant to frost. If the soil temperature is 1–3 °C, then the seeds begin to germinate, and the optimal parameter is 9–11 °C. The root system is fibrous, highly developed, penetrates to a depth of 190 cm. When the seed germinates, the primary root system is first formed, then secondary from the underground stems, while the primary ones do not die. Starting from the tillering phase of winter wheat, the need for moisture increases, and the tillering process normally proceeds with productive moisture reserves of 30 mm or more in a 20-cm layer. Winter wheat is very demanding on soil fertility, therefore, the best predecessors, such as clean and busy vapours, annual bean crops (chickpeas, peas, rank, lentils, guar and others), perennial leguminous herbs (sainfoin, alfalfa, clover) [6–8].

For this period, 95% of the agrarians of our region work according to the traditional farming system, including deep cultivation with or without turnover of the reservoir in a steam field; for all other crops in short-rotation crop rotations, shallow or surface cultivation by disk, plane-cutting, often combined tools [9].

In connection with a number of innovations that have occurred in Russia - a change in land ownership, the disappearance of the livestock industry, worsening weather and climate conditions, a decrease in the species diversity of cultivated crops, a significant increase in the prices of fuels and lubricants, for all types of fertilizers and for high-quality products chemical protection, the decline in soil fertility and, as a result, the change for the worse of all the physicochemical parameters of the arable soil layer, agrarians are looking for new ways to develop agriculture [10].

Since the beginning of the century, direct sowing in untreated soil, known around the world as No-till, has been popular with farmers. With this technology, mechanical processing of the soil is excluded, the fight against weeds, pests and diseases is carried out through the introduction of pesticides. Mineral fertilizing and sowing operations are combined and conducted by special combined seeders. As a result, the machine and tractor fleet are reduced to a minimum. Reducing the mechanical effect on the soil positively affects all parameters of soil fertility and the cost of production. Many farmers of the Southern Federal District have succeeded in introducing new farming technology, and the data obtained on their fields are popular not only in Russia but also abroad [11–12].

In Russia, there are very few experiments on studying the farming system without tillage and, as a rule, they are narrowly focused on studying the physical properties of the soil. Therefore, the aim of our research was to study the influence of *Triticum aestivum* L. cultivation technology by direct sowing in comparison with traditional technology using a complex microbiological preparation on growth and development, as well as the yield and quality of the products of the most common field crop in Russia.

### 2. Research methods and conditions

To study the system of agriculture of direct sowing in comparison with the classical in the experimental field p. In Klepinino, Krasnogvardeisky district, in 2015, stationary experience was laid, which includes two crop rotation. Crop rotation is the same, except for the first field: the traditional one is represented by fields - black steam - winter wheat - oilseed flax - winter barley - sorghum and direct sowing system - the first field - clean steam was replaced by sowing peas.

According to the classical technology, cattle manure is applied at the rate of thirty tons per hectare, followed by dump plowing to a depth of 20–22 cm. Subsequently, the field was kept in its pure form by cultivation. The application of phosphorus and nitrogen mineral fertilizers was carried out under the main tillage in the autumn, in doses of N30P0 for the active substance. For direct sowing in a dose of N30P30 for the active substance during sowing. Weed control was carried out by a combination of mechanical and chemical methods according to the traditional system and direct-sowing chemicals.
With direct sowing technology, the Gherardi G117 seeder was used. According to the traditional system, the SZ-3.6 seeder was used.

The laying of experiments and conducting research is carried out in accordance with generally accepted methods of field experiments in agriculture and crop production according to B. Dospehov [13].

In our research, we studied a complex biological product. Before sowing, winter wheat seeds were inoculated with a microbial preparation according to V.V. melodic recommendations. Volcagon [14]. The control was treated with water. The composition of the studied complex microbiological preparation (CMP) includes three strains of microorganisms: 1. Free-living nitrogen fixers; 2. Phosphorus mobilizing bacteria; 3. Phytopathogenic microorganisms.

Over the years of research, winter wheat was sown in the second decade of October. The seeding rate is 4.5 million germinating seeds of 1 ha. According to the traditional system, the sowing was rolled. In early spring, without fail, its crops were fed with nitrogen fertilizers (the first decade of March), and a little later, before going into the tube, they were treated with herbicides - a tank mixture against weeds. All work was carried out simultaneously by technology. Sampo 500 harvesters carried out harvesting by direct combine harvesting.

Weather conditions over the years of research (2016–2018) are characterized by a large difference in all recorded climatic parameters. By precipitation and average daily average monthly air temperature. The presence of productive moisture in the soil, and, consequently, the growth and development of cultivated plants, depends on the amount of precipitation and the timeliness of their precipitation. During the first year of experiments, during the growing season of winter wheat, 644 mm fell or 1.5 times the norm. In subsequent years, their number was in 2016–2017. 46 mm less. In 2017–2018 the difference was 127 mm, i.e. almost 1.5 times less than the average annual indicator, or more than 2 times less than in the growing season 2015–2016. Autumn (2017) was especially unfavorable, that is, during the sowing season, only 48.9 mm (1.9 times less than the norm). The dry spring was even more unfavorable: in the most critical and vital phases of winter wheat development, a minimum of precipitation fell (for March-May - 41.5 mm).

The average daily temperature for the vegetation of winter wheat was above normal for all years of research: in 2016–2017 the excess was 0.6 °C, in the first and third years 2.1 and 2.6 °C, respectively. Maximum temperatures above normal were observed in the spring of 2018 at 2.8-3.7 °C.

In total, according to the data obtained, the following conclusions can be drawn from the prevailing climatic conditions: 1. The first year of research turned out to be the most favorable, the excess of air temperature was combined with heavy rainfall. 2. The second year is relatively favorable in air temperature, but the decrease in moisture was affected. 3. The third year was not just unfavorable, during this period severe weather conditions for winter wheat developed, elevated air temperatures throughout the entire pre-sowing season and wheat vegetation, and minimal or no rainfall in September (0.1 mm) and April (3.1 mm) (an emergency was declared in the region).

3. Research results
Due to the large contrast of weather and climate conditions prevailing in the studied years, data are provided by year. The results of the analysis of sheaves of winter wheat plants for 2016 are presented in table 1. Due to the particularly favorable vegetation conditions of 2015–2016. the height of winter wheat plants, both according to the traditional farming system (precursor - pure steam) and direct sowing (predecessor - peas) was equal. When processing seeds with a complex of microbial preparations and at the control of plant height was also the same. The spike length in all studied variants did not have a significant increase. The number of grains from ten plants was reliably greater by 55 in the application of CMP. By the weight of the spike we do not have significant differences. The grain weight from one ear during the application of the traditional farming system was 0.07 g higher (HCP05 - 0.04 g).
Table 1. Growth and development of winter wheat plants upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2016

| Agriculture System (Factor A) | Seed Processing (Factor B) | Plant height, cm | Spike length, cm | The number of grains from 10 plants, pieces | Grain mass from 10 plants, grams | Number of grains in 1 ear, pieces | Grain weight from 1 ear, grams |
|------------------------------|---------------------------|-----------------|-----------------|--------------------------------------------|---------------------------------|---------------------------------|--------------------------------|
| TC* A1                       | Control                   | 74.2            | 5.3             | 402                                        | 16.2                            | 32.0                            | 1.31                           |
|                              | B1                        |                 |                 |                                            |                                 |                                 |                                |
|                              | CMP***                    | 72.6            | 5.1             | 300                                        | 13.3                            | 28.4                            | 1.27                           |
|                              | B2                        |                 |                 |                                            |                                 |                                 |                                |
| A1 factor average            |                           | 73.4            | 5.2             | 351                                        | 14.7                            | 30.2                            | 1.29                           |
| III** A2                     | Control                   | 72.8            | 5.0             | 337                                        | 14.4                            | 27.7                            | 1.18                           |
|                              | B1                        |                 |                 |                                            |                                 |                                 |                                |
|                              | CMP B2                    | 75.0            | 5.2             | 329                                        | 14.5                            | 28.3                            | 1.25                           |
| A2 factor average            | Control                   | 73.9            | 5.1             | 333                                        | 14.4                            | 28.0                            | 1.22                           |
|                              | CMP                       |                 |                 |                                            |                                 |                                 |                                |
| HCP05                        | A                         | 2.21            | 0.21            | 21.1                                       | 0.54                            | 3.54                            | 0.04                           |
|                              | B                         | 2.24            | 0.24            | 35.1                                       | 1.61                            | 4.21                            | 0.05                           |
|                              | AB                        | 3.54            | 0.31            | 59.2                                       | 2.54                            | 4.36                            | 0.06                           |

* - traditional system; ** - direct sowing; CMP *** is a complex microbiological preparation.

Productivity and product quality obtained in 2016 are presented in table 2. As the study showed, when processing KMP, a reliable increase in yield was obtained - 0.35 t / ha, in comparison with the control. The weight of 1000 grains during processing with a biological product was 2.2 g higher. The gluten content in the control was 21.2%, during the processing of CMP - 25.0%, which is 3.8% higher. The results of the analysis of sheaves of winter wheat plants for 2017 are presented in table 3. The spike length according to the traditional system is 1 cm longer when processing CMPs by 0.7 cm. The number of grains from 10 plants when processed with the preparation is 40 more than in the control. The grain weight of 10 plants in the control was significantly greater by 5.1 g. The number of grains in the ear according to the traditional system exceeds 4.7 pieces compared to direct sowing.

Productivity and product quality obtained in 2017 are presented in table 4. For both factors studied, a reliable increase was obtained in yield: according to the traditional system, yield was higher at 0.95 t / ha; the use of CMP reduced the yield by 0.42 t / ha. The mass of 1000 grains in direct sowing was 6.1 g higher. The no-till nature was 33 g / l higher. The glassiness according to the traditional system is higher by 8.9%, with the use of CMP it decreased, compared with the control, by 12.9%. The protein content in the classical farming system is higher by 3.9%, while inoculation is higher by 1%. The gluten content in the traditional farming system was 3.9% higher. The starch content in direct sowing is 2.7% higher than in the traditional system. A correlation dependence is traced between the farming systems in terms of protein and starch content.
Table 2. Productivity and quality of winter wheat production upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2016

| Agriculture System (Factor A) | Seed Processing (Factor B) | Productivity, t / ha | Mass of 1000 grains, g | Nature, g / l | Vitrescence, % | The protein content, % | Gluten, % | Starch, % |
|------------------------------|----------------------------|----------------------|------------------------|---------------|---------------|----------------------|-----------|-----------|
| TC A1                       | Control B1                | 3.53                 | 37.0                   | 665           | 50.1          | 11.3                 | 21.3      | 70.9      |
|                             | CMP B2                    | 3.77                 | 38.6                   | 676           | 50.1          | 12.7                 | 25.0      | 70.0      |
| A1 factor average           |                           | 3.65                 | 37.8                   | 670           | 50.1          | 12.0                 | 23.1      | 70.5      |
| ПП A2                      | Control B1                | 3.37                 | 37.1                   | 662           | 49.6          | 11.0                 | 21.0      | 70.9      |
|                             | CMP B2                    | 3.83                 | 40.0                   | 666           | 50.8          | 12.6                 | 25.0      | 70.0      |
| A2 factor average           |                           | 3.60                 | 38.5                   | 664           | 50.2          | 11.8                 | 23.0      | 70.5      |
| Factor B                    | Control CMP               | 3.45                 | 37.1                   | 663           | 49.8          | 11.2                 | 21.2      | 70.9      |
| HCP05                       | A                          | 0.18                 | 0.87                   | 11.3          | 1.13          | 0.73                 | 0.71      | 0.92      |
|                             | B                          | 0.12                 | 1.34                   | 21.3          | 2.13          | 0.73                 | 0.71      | 0.92      |
|                             | AB                         | 0.39                 | 3.04                   | 26.0          | 1.60          | 1.04                 | 1.01      | 1.31      |

Table 3. Growth and development of winter wheat plants upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2017

| Agriculture System (Factor A) | Seed Processing (Factor B) | Plant height, cm | Spike length, cm | The number of grains from 10 plants, pieces | Grain mass from 10 plants, g | Number of grains in 1 ear, pieces | Grain weight from 1 ear, g |
|------------------------------|----------------------------|------------------|------------------|---------------------------------------------|-------------------------------|---------------------------------|---------------------------|
| TC A1                       | Control B1                | 49.7             | 7.8              | 310                                         | 18.3                          | 38.8                            | 1.3                       |
|                             | CMP B2                    | 48.9             | 6.8              | 356                                         | 16.5                          | 38.1                            | 1.3                       |
| A1 factor average           |                           | 49.3             | 7.3              | 333                                         | 17.4                          | 38.5                            | 1.3                       |
| ПП A2                      | Control B1                | 47.8             | 6.4              | 341                                         | 12.1                          | 33.9                            | 1.2                       |
|                             | CMP B2                    | 51.9             | 6.1              | 375                                         | 12.5                          | 33.7                            | 1.4                       |
| A2 factor average           |                           | 49.8             | 6.3              | 358                                         | 12.3                          | 33.8                            | 1.3                       |
| Factor B                    | Control CMP               | 48.7             | 7.1              | 325                                         | 15.2                          | 36.3                            | 1.2                       |
| average                     |                           | 50.4             | 6.4              | 365                                         | 14.5                          | 35.9                            | 1.3                       |
| HCP05                       | A                          | 1.21             | 0.36             | 28.6                                        | 1.25                          | 2.31                            | 0.05                      |
|                             | B                          | 2.31             | 0.45             | 35.2                                        | 0.87                          | 1.21                            | 0.11                      |
|                             | AB                         | 3.24             | 0.87             | 41.0                                        | 1.20                          | 3.21                            | 0.12                      |
Table 4. Productivity and quality of winter wheat production upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2017

| Agriculture System (Factor A) | Seed Processing (Factor B) | Productivity, t/ha | Mass of 1000 grains, g | Nature, g/L | Vitreulence, % | The protein content, % | Gluten, % | Starch, % |
|------------------------------|----------------------------|---------------------|------------------------|-------------|---------------|-----------------------|-----------|----------|
| TC A1                        | Control B$_1$              | 3.96                | 28.2                   | 708         | 72.0          | 15.1                  | 30.8      | 67.3     |
|                              | CMP B$_2$                 | 3.59                | 29.0                   | 712         | 70.8          | 14.1                  | 28.3      | 68.2     |
| A1 factor average            |                            | 3.78                | 28.6                   | 710         | 71.4          | 14.6                  | 29.5      | 67.7     |
| ΠΠ A2                       | Control B$_1$              | 3.06                | 35.3                   | 751         | 58.3          | 11.7                  | 26.9      | 71.4     |
|                              | CMP B$_2$                 | 2.59                | 34.1                   | 735         | 66.8          | 12.6                  | 24.4      | 69.5     |
| A2 factor average            |                            | 2.83                | 34.7                   | 743         | 62.5          | 12.2                  | 25.6      | 70.4     |
| Factor B average             | Control                   | 3.51                | 31.7                   | 730         | 65.2          | 12.4                  | 23.9      | 69.4     |
|                              | CMP                       | 3.09                | 31.6                   | 723         | 52.3          | 13.4                  | 26.4      | 66.9     |
| HCP$_{05}$                   | A                         | 0.25                | 2.89                   | 27.9        | 2.61          | 0.46                  | 2.64      | 2.38     |
|                              | B                         | 0.25                | 0.89                   | 27.9        | 2.61          | 0.46                  | 2.64      | 2.38     |
|                              | AB                        | 0.34                | 1.26                   | 39.4        | 3.69          | 0.65                  | 3.73      | 3.37     |

The results of the analysis of sheaves of winter wheat plants for 2018 are presented in table 5. The height of plants this year was 4.2 cm higher by the traditional farming system. The mass of grains from 10 plants with direct sowing provided a reliable increase of 1 g from 10 plants. The number of grains by 3.4 pieces in one ear was more according to the traditional system, in comparison with direct sowing.

Table 5. Growth and development of winter wheat plants upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2017

| Agriculture System (Factor A) | Seed Processing (Factor B) | Plant height, cm | Spike length, cm | The number of grains from 10 plants, pieces | Grain mass from 10 g | Number of grains in 1 ear, pieces | Grain mass from 1 ear, g |
|------------------------------|----------------------------|------------------|------------------|-------------------------------------------|----------------------|----------------------------------|------------------------|
| TC A1                        | Control B$_1$              | 55.9             | 6.5              | 260                                       | 7.7                  | 35.4                             | 1.26                   |
|                              | CMP B$_2$                 | 49.3             | 6.1              | 246                                       | 7.1                  | 33.2                             | 1.24                   |
| A1 factor average            |                            | 52.6             | 6.3              | 253                                       | 7.4                  | 34.3                             | 1.25                   |
| ΠΠ A2                       | Control B$_1$              | 44.7             | 6.2              | 257                                       | 8.6                  | 30.8                             | 1.19                   |
|                              | CMP B$_2$                 | 52.1             | 5.6              | 240                                       | 8.2                  | 31.0                             | 1.33                   |
| A2 factor average            |                            | 48.4             | 5.9              | 248                                       | 8.4                  | 30.9                             | 1.26                   |
| Factor B average             | Control                   | 50.3             | 6.3              | 258                                       | 8.1                  | 33.1                             | 1.22                   |
|                              | CMP                       | 50.7             | 5.8              | 243                                       | 7.6                  | 32.1                             | 1.28                   |
| HCP$_{05}$                   | A                         | 2.50             | 0.4              | 15.2                                      | 0.4                  | 1.74                             | 0.04                   |
|                              | B                         | 1.25             | 0.5              | 18.4                                      | 0.5                  | 1.25                             | 0.06                   |
|                              | AB                        | 3.54             | 0.6              | 19.5                                      | 0.6                  | 2.14                             |                        |
Productivity and product quality obtained in 2018 are presented in Table 6. 0.7 t/ha yielded more yield according to the traditional farming system. The mass of 1000 grains were significantly greater by 2.1 g in direct sowing. The grain nature by 57 g/l exceeded in direct sowing the traditional farming system. Glassy for both studied factors did not give a difference. The protein content was 3% higher with the traditional farming system and 1.3% higher with the use of CMP. Gluten according to the traditional system was 8.00% more, while using the biological product by 3.5%. The direct starch content increased by 2.3%. As in the previous year, a correlation dependence is traced between the farming systems in terms of protein and starch content.

**Table 6.** Productivity and quality of winter wheat production upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2018

| Agriculture System (Factor A) | Seed Processing (Factor B) | Productivity, t/ha | Mass of 1000 grains, g | Nature, g/l | Viurnescence, % | The protein content, % | Gluten, % | Starch, % |
|-------------------------------|-----------------------------|--------------------|-----------------------|-------------|-----------------|----------------------|-----------|----------|
| TC A1                         | Control B₁                  | 3.91               | 28.0                  | 689         | 66.3            | 14.6                 | 29.7      | 67.8     |
|                               | CMP B₂                      | 3.80               | 26.3                  | 676         | 63.3            | 16.7                 | 35.3      | 66.4     |
| A1 factor average             |                             | 3.85               | 27.1                  | 682         | 64.8            | 15.6                 | 32.5      | 67.1     |
| III A2                       | Control B₁                  | 3.10               | 28.6                  | 745         | 68.8            | 12.3                 | 23.8      | 69.6     |
|                               | CMP B₂                      | 3.20               | 29.8                  | 734         | 70.3            | 12.9                 | 25.2      | 69.2     |
| A2 factor average            |                             | 3.15               | 29.2                  | 739         | 69.5            | 12.6                 | 24.5      | 69.4     |
| Factor average B             | Control                     | 3.51               | 28.3                  | 717         | 67.6            | 13.5                 | 26.7      | 68.7     |
|                               | CMP                         | 3.50               | 28.0                  | 705         | 66.8            | 14.8                 | 30.2      | 67.8     |
| HCP₀₅                        | A                           | 0.38               | 0.84                  | 33.4        | 5.00            | 0.74                 | 1.40      | 1.25     |
|                               | B                           | 0.36               | 0.84                  | 33.4        | 5.00            | 0.74                 | 1.48      | 1.24     |
|                               | AB                          | 1.08               | 1.19                  | 47.2        | 7.07            | 0.89                 | 3.39      | 6.35     |

On average, for three years of research, when analyzing sheaf material, the following results were obtained (Table 7). The spike length was 0.5 cm longer according to the traditional system. The number of grains from ten plants was 82 in the classical system of agriculture and 27.0 more in the variant without treatment of CMP. The grain weight of 10 plants according to the traditional farming system was 1.5 g more. The number of grains in one ear according to the classical farming system was 3.4 units significantly higher than by the technology without tillage.

Productivity and product quality obtained on average over the years of research are presented in Table 8. Productivity over three years does not have a significant increase in the study of farming systems, but it is worth noting that there is a tendency to increase it according to the traditional system (predecessor black steam) in individual years. The mass of 1000 grains on average for 2016–2018. was 3 grams more in direct sowing. The grain nature of winter wheat was no-till higher by 28 g/l. Glassiness did not have a significant difference in the studied factors. The protein content was reliable with the traditional method of cultivating winter wheat was 2.3% higher, and when using the CMP 1.2% higher. The gluten content in the classical farming system was significantly higher by 5.6%, and when applying the CMP by 3.3%. Starch in winter wheat grain for direct sowing by 1.7% on average over the years of research more.
### Table 7. Growth and development of winter wheat plants upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2016–2018

| Agriculture System (Factor A) | Seed Processing (Factor B) | Plant height, cm | Spike length, cm | The number of grains from 10 plants, pieces | Grain mass from 10 plants, g | Number of grains in 1 ear, pieces | Grain mass from 1 ear, g |
|------------------------------|----------------------------|------------------|------------------|--------------------------------------------|-----------------------------|-------------------------------|------------------------|
| TC A1                        | Control                    | 59.9             | 6.5              | 424                                        | 14.1                        | 35.4                          | 1.26                   |
|                              | B1                         | 56.9             | 6.0              | 368                                        | 12.3                        | 33.2                          | 1.24                   |
| A1 factor average            |                            | 58.4             | 6.2              | 396                                        | 13.2                        | 34.3                          | 1.25                   |
| III A2                      | Control                    | 56.1             | 5.8              | 312                                        | 11.7                        | 30.8                          | 1.19                   |
|                              | B1                         | 59.7             | 5.6              | 315                                        | 11.7                        | 31.0                          | 1.33                   |
| A2 factor average            |                            | 57.9             | 5.7              | 314                                        | 11.7                        | 30.9                          | 1.26                   |
| Factor B average            | Control                    | 58.0             | 6.1              | 368                                        | 12.9                        | 33.1                          | 1.22                   |
|                              | CMP                        | 58.3             | 5.8              | 341                                        | 12.0                        | 32.1                          | 1.28                   |
| HCP<sub>05</sub>             | A                          | 2.21             | 0.31             | 31.2                                       | 0.96                        | 3.10                          | 0.06                   |
|                              | B                          | 0.98             | 0.31             | 21.2                                       | 0.97                        | 1.21                          | 0.07                   |
|                              | AB                         | 3.21             | 0.35             | 32.1                                       | 1.02                        | 3.21                          | 0.08                   |

### Table 8. Productivity and quality of winter wheat production upon inoculation of its seeds with a complex microbiological preparation, against the background of the traditional farming system and direct sowing, 2016–2018

| Agriculture System (Factor A) | Seed Processing (Factor B) | Productivity, t / ha | Mass of 1000 grains, g | Nature, % | Vitreousness, % | The protein content, % | Gluten, % | Starch, % |
|------------------------------|----------------------------|----------------------|------------------------|-----------|-----------------|-----------------------|-----------|-----------|
| TC A1                        | ControlB1                  | 3.80                 | 31.1                   | 688       | 62.8            | 13.7                  | 27.3      | 68.7      |
|                              | CMPB2                      | 3.72                 | 31.2                   | 688       | 61.4            | 14.5                  | 29.5      | 68.2      |
| A1 factor average            |                            | 3.76                 | 31.2                   | 688       | 62.1            | 14.1                  | 28.4      | 68.4      |
| TC A1                        | Control B1                 | 3.17                 | 33.7                   | 719       | 58.9            | 11.0                  | 20.6      | 70.6      |
|                              | CMPB2                      | 3.20                 | 34.6                   | 712       | 62.6            | 12.7                  | 24.9      | 69.6      |
| A2 factor average            |                            | 3.19                 | 34.2                   | 716       | 60.8            | 11.8                  | 22.8      | 70.1      |
| Factor B average            | Control                    | 3.49                 | 32.4                   | 703       | 60.8            | 12.4                  | 23.9      | 69.6      |
|                              | CMP                        | 3.46                 | 32.9                   | 700       | 62.0            | 13.6                  | 27.2      | 68.9      |
| HCP<sub>05</sub>             | A                          | 0.64                 | 1.34                   | 22.7      | 5.09            | 0.71                  | 1.33      | 1.21      |
|                              | B                          | 0.64                 | 1.34                   | 22.7      | 5.09            | 0.71                  | 1.33      | 0.98      |
|                              | AB                         | 0.91                 | 1.90                   | 32.1      | 5.35            | 1.50                  | 1.88      | 1.56      |
4. Conclusion
On average, the following results were obtained over three years of research. Direct sowing significantly reduced the growth and development parameters of winter wheat plants. The number of grains was significantly greater when processed with a complex biological preparation by 27.0 pieces. The mass of 1000 grains and the nature of the grain were significantly greater with direct sowing of 3 g and 28 g/l, respectively. The protein and gluten content were significantly higher in the traditional system by 2.3% and 5.6%. Treatment with CMP significantly increased the protein and gluten content by 1.2% and 3.3%. When studying agricultural systems, a correlation between the content of protein and starch in the grain of winter wheat is traced (with an increase in one parameter, the amount of the other decreases, and vice versa).

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