Effect of new biologies on winter wheat structure and technological properties

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Abstract. The paper discusses the scientific aspects towards new biologies based on the natural cells components for winter wheat curing, aimed at increasing wheat yield as well as the plant survival rate under adverse winter factors. Experimental data revealing the effect of new biologies on the technological properties of grain are presented. Biologies based on bean lectins and buckwheat bioflavonoids have a significant impact on shaping the yield structure elements. Thus, the spike grain content according to the experimental results has increased on average by 7.71%, spike productivity by 11%, weight of 1000 grains by 3.3%. The highest yield of winter wheat was obtained from the Leonida cultivar by using the biologies containing bean lectins and buckwheat bioflavonoids - 8.67 t/ha, the maximum yield increase for the hard cultivar 'Kristella' amounted to 0.87 t/ha or 33%. Biologies significantly improve the quality characteristics of winter wheat, increasing the gluten content from 5 to 22%, and changing the IDK indicators by 11 - 18 units.

The experimental material opens up the prospects to conduct further research in the field of winter resistance of plants under biologies influence.

1. Introduction

Currently, there is a significant gap between potential and actual yields for most types of crops, including winter wheat. This is due to many reasons: a) lack of new frost and cold tolerant cultivar grains, b) violation of agricultural techniques and other factors. At that, most of the crops die, and damaged plants slow down their growth, they are late with ripening that reduces resistance to disease, and, accordingly, it influences badly the yield and grain quality [1].

Agriculture faces some serious challenges in providing not only gross harvest, but also high quality products. Biotechnology offers tremendous potential to improve yield production which is expressed in lowering costs and food quality improvement. This can be performed in different ways, for example, by increasing the efficiency of fertilizer use, by using biologies, by preventing crop losses due to biotic stresses such as insects, diseases and weeds, or by reducing post-harvest losses due to insects, fungal and bacterial rot [2].

Winter wheat does not have a deep dormant period, but at low temperatures it is capable of drastically reducing growth rates and the intensity of physiological processes. During the autumn period, the main organs development takes place. At the same period, plants accumulate substances
that can protect the tillering node – these are sugars, flavonoids, including anthocyanins, proline, guaiacol peroxidase and other energy and active components [3].

Therefore, to obtain guaranteed high yields, such conditions and factors are necessary that would contribute not only to the growth, but also to the development of winter wheat, associated with the dynamics in accumulation of plastic substances.

2. Problem Statement
Global food security requires effective research related to yield production and food quality. Food security and food independence are determined primarily by grain farming and grain production. The world wheat production, currently averaging around 600 million tons per year, supports the population growth. Over the past half century, the production growth has been about 1 percent per year due to the technological progress and more advanced technologies in use. A future production increase should occur mainly due to the production rise per unit area, which will require more intensive research to grains and technologies improvement [4].

Winter and spring wheat acreages in Russia in 2019, according to the expert and analytical center of agribusiness, in farms of all categories amounted to 28,069.8 thousand ha (56.3% of all crops fell to winter wheat, 43.7% to spring wheat).

Plant growth and development are regulated by endogenous phytohormones synthesized by the plants themselves. The treatment of plants or their seeds with synthetic growth regulators allows to some extent to control the processes of a plant life. Modern plant growth regulators stimulate seed germination, substances transporting, photosynthesis, plant-resistance to abiotic stresses, diseases and pests [5].

In this regard, the prospect of using effective and environmentally friendly biologies, growth regulators that increase the adaptive properties of winter wheat to unfavorable abiotic environmental factors in the autumn-winter-spring period becomes obvious.

3. Methods and materials
The objects are the winter wheat grains of domestic selection: Sineva, Scipeter, Leonida, Grom, Kristella (Table 1).

| Sample         | Grom | Leonida          | Sineva           | Kristella         | Scipeter          |
|----------------|------|------------------|------------------|-------------------|-------------------|
| Drought resistance |      | Resistant        | Resistant        | Highly resistant  | Medium resistant  |
| Winter resistance |      | Resistant        | Medium resistant | Resistant         | Highly resistant  |
| Height          | 64-89 cm | 76-98 cm | 65-87 cm | 71-84 cm | 81-96 cm |
| Lodging         | Resistant | Resistant| Medium resistant | Resistant | Resistant |
| Yield           | Consistently high | Resistant | High |                      |                   |
| Spikes          | Short slightly curved | Moderately curved medium length | Medium curved | Curved and long | Medium curved |
| Spike shape     | Pyramidal | Pyramidal | Cylindrical | Pyramidal | Pyramidal |
| Cultivar        | Erythrospermum | Erythrospermum | Leukurum | Leukurum | Leukurum |
Seed treatment was carried out by soaking them for 2 hours with biologies based on natural components, the composition of which is presented in table 2.

Seeding was carried out on the plots of 15 m\(^2\) with the SKS-6-10 - a selection seeder, row-spacing is 15 cm. The seeding rate of 5 million germinating grains per hectare.

The soils of the experimental field are dark gray forest, medium loamy, medium cultivated. The microrelief of the plot is aligned. Arable and meter soil layers are characterized by high water holding capacity of 118 and 345 mm, respectively. Before seeding in, an azofoska (N\(_{15}\)P\(_{15}\)K\(_{15}\)) was added in amount of 150 kg/ha.

When conducting the experimental studies the instrumental methods were used. When testing biologies for winter wheat cultivars, the following indicators were evaluated: grain yield, disease resistance, winter hardiness, plant height, bushiness, grain to straw ratio, 1000 grain weight, net kernel yield according to the state plants testing method applied to agricultural crops.

Grain quality indicators were determined according to the State Standards (GOST) R 54478-2011, ISO 520-2014, and 10987-76. Statistical processing of the experimental data was carried out with the parametric methods, through evaluating the descriptive statistics and with checking the normality of distribution done by the Kolmogorov-Smirnov and Shapiro-Wilko methods.

### Table 2. Experimental biologies characteristics

| Biologies number | Acting substances          | Excipients                                |
|------------------|---------------------------|-------------------------------------------|
| 1                | Lectins                   | Humic and sulfonic acids, salicylic acid, magnesium, zinc |
| 2                | Lectins                   |                                          |
| 3                | Buckwheat bioflavonoids   |                                          |
| 4                |                          | Humic and sulfonic acids of vermicompost |

### 4. Results and Discussion

The quality of grain and its nutritional value are determined by a balance of the essential substances. The determining factor is protein content and its amino-acid score. Spare proteins make up about 50% of the total protein in matured cereals and have an important effect on their nutritional qualities for people and livestock, as well as their functional properties in food processing.

Scientific studies on cereal proteins have been going on for over 250 years, and the release of wheat gluten was firstly described in 1745. Gluten proteins shape a continuous matrix in matured dry endosperm cells. When flour is mixed with water to form a dough, protein matrices in individual cells combine to form a continuous network (gluten). This gives viscoelastic properties that allow dough to expand by fermentation, then, it is baked into yeast bread or into macaroni, noodles and a number of other products.

In this regard, the values of gluten of the wheat grain, its quality, vitreous and the mass of 1000 seeds collected according to processing options were determined. Table 3 shows the data we obtained.

The analysis results targeted the individual technological properties of wheat grain have revealed that the biologies-based treatment positively affected grain protein formation.

Thus, the use of biologies leads to improvement in the quality characteristics of winter wheat grains, increasing the gluten content from 5 to 22%, changing the IDC indicators by 11-18 units.

The quality of the wheat crop to a large extent depended on stimulating effect of pre-seeding treatments towards seeds and on the survival rate in the autumn-winter-spring period. This interdependence can be traced in the following experimental results (Table 4).

For example, the number of grains in a spike during biologies-based treatment II increases in the Kristella cultivar from 35.6 pcs to 41.5 (16.57%); in the cultivar Leonida, from 38 to 42.8 (12.63%); in the cultivar Sineva from 55.5 to 57.2 (3.06%); in the Scipeter cultivar, from 40.7 to 42.9 (5.4%); in the cultivar Grom from 33.6 to 33.9 (0.89%). The mass of 1000 grains from the main spike also increases by average of 3.3%.
Table 3. Separate technological properties of wheat grain under biologies influence

| Indicator                          | Control | Biologies | Biologies | Biologies | Biologies |
|------------------------------------|---------|-----------|-----------|-----------|-----------|
|                                    |         | (1)       | 2         | 3         | 4         |
| Grom cultivar                      |         |           |           |           |           |
| Total glassiness,%                 | 35      | 26        | 48        | 47.5      | 57        |
| Mass fraction of gluten,%          | 16.8    | 15.2      | 18.4      | 21.2      | 14.8      |
| IDK, units                         | 58.6    | 46.2      | 49        | 30.8      | 31.6      |
| 1000 seed weight, gr.              | 39.5    | 41.9      | 40.8      | 42.2      | 44.4      |
| Sineva cultivar                    |         |           |           |           |           |
| Total glassiness,%                 | 44      | 49.5      | 41        | 44.5      | 42        |
| Mass fraction of gluten,%          | 25.8    | 17.9      | 19.6      | 14        | 16.8      |
| IDK, units                         | 54.6    | 42.4      | 13.8      | 13.4      | 0.5       |
| 1000 seed weight, gr.              | 47.6    | 42.8      | 41.3      | 43.6      | 41.2      |
| Kristella grain                    |         |           |           |           |           |
| Total glassiness,%                 | 70      | 65        | 67.7      | 79        | 78        |
| Mass fraction of gluten,%          | 14.8    | 24        | 24        | 20.6      | 15.2      |
| IDK, units                         | 67.6    | 80        | 63.6      | 68.4      | 58        |
| 1000 seed weight, gr.              | 45.5    | 44.3      | 42.5      | 38.5      | 45.1      |
| Scipeter grain                     |         |           |           |           |           |
| Total glassiness,%                 | 38      | 23        | 26        | 60        | 35.5      |
| Mass fraction of gluten,%          | 19.6    | 20.4      | 19.3      | 15.2      | 18        |
| IDK, units                         | 15.8    | 44.4      | 67.2      | 45.2      | 40        |
| 1000 seed weight, gr.              | 44.6    | 43.9      | 44.7      | 48.9      | 45.3      |
| Leonida cultivar                   |         |           |           |           |           |
| Total glassiness,%                 | 44.5    | 41.5      | 32        | 42        | 34        |
| Mass fraction of gluten,%          | 17      | 19.6      | 21.75     | 18.8      | 15.2      |
| IDK, units                         | 49.8    | 49.6      | 70.2      | 30.8      | 23.2      |
| 1000 seed weight, gr.              | 46.1    | 45.6      | 47.1      | 44.8      | 47.2      |

Table 4. Structural analysis of winter wheat grains with biologies use

| Treatment option | Plant height | Dry weight | Bushiness | Spike length | Spike weight | The number of grains in a spike | Grain mass from the bottom | Mass 1000 grains from the main spike |
|------------------|--------------|------------|-----------|--------------|--------------|---------------------------------|-------------------------------|----------------------------------|
|                  |              |            |           |              |              |                                 |                               |                                  |
| Control          | 100.8        | 7.34       | 4.7       | 11.1         | 3.18         | 55.5                            | 2.51                          | 5.89                             | 45.1                             |
| 1                | 88.7         | 3.23       | 2.6       | 9.0          | 2.38         | 40.4                            | 1.83                          | 1.96                             | 44.44                            |
| 2                | 96.9         | 8.72       | 6.4       | 11.0         | 3.36         | 57.2                            | 2.66                          | 9.98                             | 46.5                             |
| 3                | 96.7         | 4.77       | 3.3       | 10.2         | 3.28         | 56.3                            | 2.65                          | 3.64                             | 46.7                             |
| 4                | 91.8         | 4.74       | 3.6       | 11.0         | 3.26         | 54.1                            | 2.54                          | 3.93                             | 46.9                             |
The biologies use contributes to an increase in the length and weight of the spike. In this case, the height of the plant, dry weight, bushiness is reduced.

Biologies based on bean lectins and buckwheat bioflavonoids have a significant impact on shaping the crop structure elements. Thus, the spike grain content according to the experimental results has increased on average by 7.71%, spike productivity by 11%, weight of 1000 grains by 3.3%.

Table 5 presents the data on the yield of prototypes.

| Cultivar   | Control | Biologies | Biologies | Biologies | NDS 05 |
|------------|---------|-----------|-----------|-----------|--------|
|            |         | 1         | 2         | 3         | 4      |
| Scipeter   | 5.67    | 5.03      | 6.40      | 6.33      | 6.80   | 0.07  |
| Grom       | 6.67    | 7.07      | 7.53      | 7.73      | 6.77   | 0.06  |
| Leonida    | 8.11    | 8.67      | 6.67      | 6.80      | 6.60   | 0.07  |
| Sineva     | 6.80    | 6.07      | 5.47      | 6.40      | 5.73   | 0.07  |
| Kristella  | 2.73    | 3.33      | 3.60      | 3.60      | 3.33   | 0.09  |
| The average biologies adding to control within 5 cultivars, % |      | +0.63 | -1.03 | +2.93 | -2.5 |

The highest yield of winter wheat from the cultivars we studied was found in the Leonida cultivar (8.11 t/ha). The biologies use (number 1) increases the yield to 8.67 t/ha, which equals 6.9%.

The biocompost use as an option for pre-seeding treatment on the Scipeter cultivar gives an increase in yield by 19.9%, and biologies number 2 by 12.8%.
The biologies number 3 provides an increase by 1.06 t/ha with the Grom, which is 15.9%.

The maximum yield increase for the hard cultivar Kristella was 0.87 t/ha or 33% when the biologies 2 and 3 are in use.

The bioflavonoids use made it possible to obtain yield gains within the Grom and Kristella by 13 and 31%, respectively. The yield for the Leonid decreased by 1.4 t/ha.

5. Conclusion
Thus, all biologies provide the yield growth in 3 cultivars out of 5.

Given the indisputable advantage of biologies as elements of winter wheat cultivation technology, the investment attractiveness to develop these biological products is obvious. Biological products or biologies based on buckwheat lectins and bioflavonoids, used from the moment of seed dressing, increase the field germination, enhance the germination process, provide mobilization of nutrients from soil minerals, and promote the accumulation of easily soluble sugars, increasing cold and frost resistance of plants.

Naturally, such a comprehensive positive effect of biologies that lie in the core of the technology targeted at using growth regulators, leads to yields increase, especially in the risky farming zone, but the quality of winter wheat grain is not always high. All this creates the prerequisites to develop a new biological product formula that also will improve the quality of grain on all cultivars including soft and hard wheat.

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