Triticale. The techniques of cultivation and processing

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Abstract. The use of growth regulators in triticale crops has a positive effect on plant growth and development. Seed treatment reduces some plant diseases. The treatment with growth regulators increases productive tilling, which contributes to the growth of yields. The use of seedlings in the production of functional food products is a promising direction for the use of triticale grain. The high content of essential amino acids and biologically active substances in triticale seedlings explains their high nutritional and biological value.

1. Introduction

Triticale is a first artificially developed grain crop that can predominate wheat and rye in certain characteristics. This crop can take a worthy place among cultivated crops, taking into account the fact that it has a high productive potential and stability of yields on an annual basis. At present, a significant part of the acreage planted to triticale is concentrated in European countries.

The main factors constraining the increase in the structure of the acreage planted to triticale in the Russian Federation are the lack of a specific segment of the market for triticale, the problems of product standardization and price formation. The implementation of triticale into the manufacture is complicated by the inherent negative traits of rye triticale varieties and the lack of processing technologies. The baking advantage of triticale grain is worse than that of wheat, as the bread has a smaller volume, jamming and cheesy crumb, sometimes the crust is covered with cracks. Critically, the baking quality of triticale flour is much worse. The structure and properties of the dough made from triticale flour are similar to the wheat dough of poor quality. This is due to the lack of quality and quantity of gluten, the high activity of amylolytic and proteolytic enzymes. However, the growth of cattle breeding in some regions of the Russian Federation may contribute to an increase in the acreage planted to triticale to produce feeder grain.

The tendency of agricultural enterprises to obtain a high yield led to the fact that agricultural producers began to use actively chemicals in the manufacture, including plant growth regulators [2]. Growth regulators can stimulate the behaviour of such processes as seed germination, photosynthesis, protection from pathogenic microflora, the formation of vegetative and generative organs of plants [7].

At present, the implementation of crop production technologies using growth regulators and bacterial fertilizers is becoming more profitable both from an economic and environmental point of view. The biologization of crop production technologies, as well as the desire for the production of organic products, forced farmers to reduce the use of mineral fertilizers, pesticides, apply modern scientific achievements to improve the quality of products and reduce their cost.
Currently, breeding work on triticale is successfully proceeding. There are many modern varieties of triticale: Nemchinovsky 1, Talva-100, Privada, Doctrina-110, etc, which show high productivity of 8.0 ... 9.0 t / ha and high resistance to diseases, pests, other adverse environmental factors. Rondo variety, along with high winter hardiness and productivity of 8.0 ... 8.5 c / ha has high grain quality.

The main goal of the research is to establish the rules for the use of growth regulators in winter triticale crops and to determine the possible direction of the grown grain use, considering its technological characteristics.

2. Materials and methods
The studies used the method of setting up field experiments and a series of laboratory tests.

The following zoned winter triticale varieties served as objects of study: Privada, Talva-100, Doctrine-110; and growth regulator preparations: Albite, Binoram, Biosil. The seed material of the studied varieties was treated by specified growth regulators at different concentrations (Table 1). The control is water treating. The optimal time for seeding winter crops in the conditions of the Central Black Soil Region is approximately September 1. The seeding rate is 4 million germinating seeds per hectare. According to the field experiment scheme, the day before seeding, the seed is processed by growth regulators.

| Preparation | Consumption rate of preparation | Consumption of working solution |
|-------------|--------------------------------|--------------------------------|
| Albite      | 10 ml / t                      | 10 l / t                       |
|            | 30 ml / t                      | 10 l / t                       |
|            | 50 ml / t                      | 10 l / t                       |
| Binoram     | 50 ml / t                      | 10 l / t                       |
|            | 70 ml / t                      | 10 l / t                       |
|            | 30 ml / t                      | 10 l / t                       |
| BioSil      | 50 ml / t                      | 10 l / t                       |
|            | 70 ml / t                      | 10 l / t                       |

3. Results and discussion
For sowing, it used prepared seeds. Seed grains are sorted by size and weight [1]. Treating seeds with growth regulators had a positive effect on the duration of the sowing-seedling period. Treating the seed by Albite accelerated the emergence of the seedlings by 1 ... 2 days in comparison with the control. This is because the composition of the preparation includes a starting set of trace elements. Binoram and Biosil treatment did not contribute to the acceleration of seedlings emergence. The seedling phase was noted simultaneously with the control on 7 ... 9 days after sowing. Treatment with growth regulators contributed to the active process of tillering. With the emergence of seedlings in plants every 3 ... 4 days, new leaves appeared. The number of sprouting at the end of the autumn vegetation was: grade Privada 3 ... 4 pcs.; grade Talva-100 - 3 ... 4 pcs.; variety Doctrine-110 - 4 ... 5 pcs.

In the variants treating with water, the autumn vegetation was less intense. Tillering knot in 80% of plants was formed only on 10 ... 11 days after emergence. The number of sprouting before leaving in the winter was lower by 1 ... 2 pcs.

Thus, pre-sowing seed treating with growth regulators promotes high germination in a short time, shortens the period of the tillering node, and also allows plants to actively grow during the autumn growing season.
In the years of research on winter triticale, there was no mass spread of diseases. However, some varieties were slightly affected by brown rust and septoria. During the field experiment, the resistance of plants to diseases was evaluated depending on the preparations used for growth regulators. The damage degree to plants by snow mold, brown rust and septoria was determined in vivo on a 9-point scale of resistance to diseases and pests [6].

Plants processing by Albit and Biosil preparation were rarely affected by diseases (Table 2). This is due to the fact that Albit contains purified active substances from soil bacteria Bacillus megaterium and Pseudomonas aureofaciens. In natural conditions, these bacteria live on the roots of plants, stimulate their growth, protect the plant from diseases and adverse environmental conditions. Biosil is intended for pre-sowing seed treatment as a growth regulator and inducer of immunity to a complex of fungal, bacterial and viral diseases for cultivated plants. The active substance is triterpene acids isolated from Siberian fir needles (Abies sibirica).

![Table 2. Influence of growth regulators on winter triticale stability to snow mold, septoria and brown rust, 2016-2018](image)

| Variety  | Preparation  | Snow mold (2016) | Brown rust (2016) | Septoria (2016) | Snow mold (2017) | Brown rust (2017) | Septoria (2017) | Snow mold (2018) | Brown rust (2018) | Septoria (2018) |
|----------|--------------|------------------|-------------------|----------------|-----------------|------------------|----------------|-----------------|------------------|----------------|
| Taliwa-100 | BioSil       | 7.9              | 8.4               | 7.9            | 7.1             | 8.6              | 7.1            | 8.3             | 8.6              |
|          | Binoram      | 9.0              | 8.9               | 7.9            | 8.1             | 8.6              | 8.5            | 8.1             | 9.0              |
|          | Albite       | 8.6              | 8.9               | 7.9            | 7.9             | 8.5              | 8.5            | 8.1             | 9.0              |
|          | Treatment with water | 6.1              | 6.4               | 7.7            | 6.4             | 7.1              | 7.1            | 6.9             | 5.7              |
|          | BioSil       | 7.7              | 7.9               | 8.4            | 8.4             | 8.6              | 8.6            | 7.2             | 8.7              |
|          | Binoram      | 9.0              | 8.9               | 8.5            | 7.9             | 9.0              | 7.9            | 8.3             | 8.9              |
|          | Albite       | 7.9              | 8.7               | 8.4            | 7.9             | 8.1              | 7.6            | 7.4             | 8.1              |
|          | Treatment with water | 6.5              | 6.7               | 7.9            | 5.9             | 6.9              | 7.1            | 6.8             | 7.3              |
| Doctrine-110 | BioSil     | 8.1              | 8.1               | 8.1            | 7.4             | 9.1              | 6.9            | 7.1             | 7.6              |
|          | Binoram      | 9.0              | 8.9               | 8.9            | 7.9             | 8.7             | 9.0            | 7.9             | 8.6              |
|          | Albite       | 8.1              | 7.9               | 7.4            | 7.4             | 7.9             | 8.5            | 7.9             | 7.6              |
|          | Treatment with water | 5.9              | 7.1               | 6.9            | 6.7             | 6.9             | 7.6            | 6.9             | 7.1              |

It should be noted that when treating seeds by Binoram, triticale plants did not practically suffer from snow mold. The mechanism of action of binoram is based on the antagonism between the bacteria Pseudomonas, the active substance of binoram, and phytopathogenic organisms, due to many factors. The bacteria that make up the preparation, secrete indolyl-3-acetic acid, which has a growth-promoting effect on plants. Binoram suppresses only pathogenic microflora, mainly lower fungi and does not affect nitrogen-fixing nodule bacteria. The living bacteria that make up Binoram release antibiotics in the process of vital activity and actively enter into competition for the nutrient substrate, in contrast to organisms harmful to the plant. As a result, many plant pathogens are suppressed, improving the phytosanitary situation, such as Fusarium spp., Bipolaris spp., Helminthosporium spp., Alternaria spp., Rizoktonia spp., Xanthomonas campetris, Erwinia carotovora, etc. Phytopathogens not only reduce the quantity and quality of the crop but also contribute to the accumulation in plants, especially crop products, of mycotoxins that are hazardous to human and animal health.

The mass spread of diseases is not established. There were variants slightly affected by septoria leaf spot and brown rust. Treating by Biosil and Albit, the varieties had rarely snow mold. Treating seeds by Binoram reduced the infection of plants by snow mold to isolated incidences.
Early spring harrowing and foliar top dressing with ammonium nitrate of 30 kg/ha activated plant vegetation. Stem elongation was noted in the first decade of May. The duration of the renewing of ear stage was 53-55 days. Treating seeds with the growth regulators had no effect on the speed of these processes. Flowering process of the plants lasted 8-10 days. The duration of the full blossoming of triticale florescences was 47-50 days. The phase of grain formation in triticale plants began with the fertilization period and lasted until the beginning of the milk stage, which was 14-18 days. The milk stage of the grain took place in winter crops from the end of formation to the dough-like condition (12-15 days). The stage of the dough-like condition of the grain lasted from 4 to 7 days. The grain acquired the consistency of the dough and the characteristic colour, the humidity decreased to 38-48%. The wax ripeness stage of grain in winter crops came after the dough-like condition and lasted 7-9 days. On this stage, the grain decreased in size, the moisture content reduced to 20-24%. The influx of plastic substances developing in the grain stopped by the end of the wax ripeness stage. The full ripeness stage of the grain was noted when the grain moisture reached 16-17%. The analyzed growth regulators had a positive effect on the yield of winter triticale (Table 3).

Table 3. The influence of pre-sowing seed treatment by regulators growth on winter triticale yield, 2016-2018

| Variety     | Preparation | 2016 | 2017 | 2018 | Medium for 3 years |
|-------------|-------------|------|------|------|-------------------|
| Taliwa-100  | BioSil      | 4.35 | 4.47 | 4.05 | 4.39              |
|             | Binoram     | 4.73 | 4.59 | 4.38 | 4.57              |
|             | Albite      | 4.51 | 4.74 | 4.23 | 4.49              |
|             | Treating with water | 4.04 | 4.14 | 3.81 | 4.00              |
| Doctrine-110 | BioSil      | 5.19 | 5.37 | 4.28 | 5.22              |
|             | Binoram     | 5.44 | 5.65 | 4.71 | 5.27              |
|             | Albite      | 5.07 | 5.53 | 4.56 | 5.05              |
|             | Treating with water | 4.68 | 4.88 | 4.07 | 4.54              |
| Privada     | BioSil      | 4.44 | 4.23 | 4.03 | 4.33              |
|             | Binoram     | 4.83 | 4.44 | 4.04 | 4.44              |
|             | Albite      | 4.58 | 4.69 | 4.17 | 4.48              |
|             | Treating with water | 4.12 | 4.04 | 3.68 | 3.95              |

At the average, the yield of winter triticale in 2016-2019 was: Privada - 4.42 t/ha, Talva-100 - 4.48 t/ha, Doctrine-110 – 5.18 t/ha. A reliable increase of the yield was provided by treatment with growth regulators. The maximum yield increase was in the Doctrine-110 variety in 2016, and depending on the growth regulator drugs used was: BioSil - 0.49 t/ha, Binoram - 0.77 t/ha, Albite - 0.66 t/ha. The yield variety under the control is 4.88 t/ha. The yield increase was just lower in the varieties of Taliwa-100 and Privada. A significant increase in the yield was recorded when seeds were treated with Binoram and Albite. The consumption rate of the drugs was 50 ml/t. For Privada and Talva-100 varieties, the yield increase was 0.67 and 0.62 t/ha, respectively, when using albite; 0.41 and 0.46 t/ha when using Binoram.

It was confirmed that the spring treatment with the analyzed growth regulators affects the height of winter triticale plants. The treatment with BioSil did not lead to a decrease in plant height. The drug is based on triterpenic acid isolated from the needles of Siberian fir. In addition, this reduces the retardant effect and increases the biological activity against the main pathogens.
Spring spraying of plants with Binoram caused a reduction of the straw in the Privada variety in 8-12 cm, the Taliwa-100 variety in 6-10 cm, and in the variety of Doctrine-110 in 5-8 cm. Since the bacteria comprised in the drug secrete indolyl-3-acetic acid which has a growth-regulating effect on plants, it is not recommended to use Binoram simultaneously with the growth regulators based on heteroauxin and gibberellin. The optimal consumption rate of the drug is 30 ml/ha.

Vegetative treatment with albite allowed to protect plants from aerogenic infections (powdery mildew, brown rust, Septoria and other spots, late blight, cercosporosis, etc.). The growth of secondary roots increased, so the plants had increased drought resistance. The optimal consumption rate of the drug providing the greatest increase in yield is 70 ml/ha.

For winter triticale, as for all crops, the main elements of the crop structure, at any size, are: the number of productive stems per unit area, the number of grains in the ear and the weight of 1,000 grains. The number of grains in the ear is determined by the level of mineral nutrition and environmental conditions during the periods of laying, ear differentiation and flowering. The number of grains in the ear triticale is in the wide range from 30-35 to 67-80 pcs. The study of the crop structure allowed to discover and learn about the mechanism of its formation (table. 4).

| Independent variable                        | The regression coefficient | The proportion of the factor, % | Coefficient of correlation |
|---------------------------------------------|----------------------------|---------------------------------|---------------------------|
| Weight of 1,000 grains, g                   | 5.022                      | 26.1                            | 0.56                      |
| Grains per ear, pcs.                       | 11.068                     | 29.3                            | 0.50                      |
| The number of productive stems, pcs/m²     | 0.478                      | 34.7                            | 0.61                      |
| Weight of 1,000 grains, g                   | 4.525                      | 38.2                            | 0.80                      |
| Grains per ear, pcs.                       | 7.704                      | 21.0                            | 0.73                      |
| The number of productive stems, pcs/m²     | 0.203                      | 12.6                            | 0.22                      |
| Weight of 1,000 grains, g                   | 37.7                       | 0.57                            | 0.60                      |
| Grains per ear, pcs.                       | 28.0                       | 0.42                            | 0.63                      |
| The number of productive stems, pcs/m²     | 19.1                       | 0.39                            | 0.27                      |

Field germination had a significant impact on the formation of elements of the crop structure, the density of sprouts, the number of surviving plants during the growing season and others. Productive tilling capacity depends on the impact of a number of factors on the plant. The study of the crop structure showed that in the variants treated with growth regulators, the number of plants and productive tilling capacity per unit of the sown area were higher in comparison with the control. Productive tilling capacity in cases of seed treatment with growth regulators is 5-17% higher compared to the control (table 5).

It is established that the treatment of crops with growth regulators leads to an increase in the number of grains in the ear. This is due to an increase in the length of the ears and the number of spikelets in the ear. Although the yield of winter triticale is due to the components mentioned above, the increase in the yield is created due to the additive influence of these components in the examined varieties.

The influence of the weight of 1,000 grains, the ear grain content and the number of productive stems on the dispersion of winter triticale grain yield was established. The impact of the factor reflects a comparative assessment of the contribution of an element of the crop structure.

The impact of the ear grain content of the variety of Privada is 29.3 % of cases, Taliwa-100 – 21.0 % Doctrine-110 – 28.0 %. Based on this, it can be concluded that an increase in the number of grains in the ear, due to the action of growth regulators, will undoubtedly lead to an increase in productivity. The
same principle is observed for other elements of the crop structure, take into account that the correlation coefficients between these studied features are quite low.

Thus, spring treatment of winter triticale plants with growth regulators allows obtaining an increase in the grain yield in the amount of 0.3 to 2.1 t/ha. Optimal consumption of growth regulators for spring processing is: BioSil-30 ml/ha, Binoram-30 ml/ha, Albite-70 ml/ha.

Table 5. The influence of growth regulators on the elements of productivity and yield formation of winter triticale in 2016-2018

| Variety   | Preparation | Number of productive stems per 1 m² by the harvesting, pcs. | Productive tilling capacity, pcs | Plant height, cm | The length of the ear, cm | Number of grains per ear, pcs | Number of grains per ear, cm | Weight of 1,000 grains, g. |
|-----------|-------------|-------------------------------------------------------------|---------------------------------|------------------|------------------------|-----------------------------|-----------------------------|--------------------------|
| Privada   | BioSil      | 233                                                         | 2.7                             | 106.8            | 10.9                   | 26.4                        | 51.9                        | 46.3                     |
|           | Binoram     | 263                                                         | 3.0                             | 109.2            | 11.0                   | 27.3                        | 56.3                        | 46.8                     |
|           | Albite      | 229                                                         | 2.6                             | 104.8            | 11.0                   | 26.2                        | 55.6                        | 45.0                     |
|           | Treatment with water | 201                                                         | 2.5                             | 111.9            | 10.5                   | 26.0                        | 55.0                        | 45.6                     |
|           | BioSil      | 275                                                         | 2.9                             | 106.7            | 12.0                   | 27.3                        | 57.5                        | 44.7                     |
|           | Binoram     | 268                                                         | 3.2                             | 109.6            | 12.7                   | 27.1                        | 57.2                        | 46.2                     |
| Taliwa-100| Albite      | 259                                                         | 2.9                             | 106.7            | 12.5                   | 26.2                        | 56.9                        | 43.9                     |
|           | Treatment with water | 216                                                         | 2.7                             | 112.5            | 12.0                   | 26.9                        | 56.0                        | 44.8                     |
|           | BioSil      | 281                                                         | 3.3                             | 95.1             | 10.6                   | 28.9                        | 58.5                        | 48.6                     |
|           | Binoram     | 296                                                         | 3.2                             | 97.0             | 11.4                   | 29.3                        | 61.6                        | 47.5                     |
| Doctrine-110| Albite   | 287                                                         | 2.8                             | 98.9             | 10.9                   | 28.2                        | 54.9                        | 47.6                     |
|           | Treatment with water | 246                                                         | 2.6                             | 101.9            | 10.4                   | 27.5                        | 57.7                        | 48.2                     |

Sprouted seeds, crushed or whole sprouts, can be used in the production of functional foods. The high content of amino acids, in comparison with other cereal crops, favorably characterizes this culture as a raw material for food production [3]. A series of experiments was carried out to establish optimal conditions for germination of triticale in order to obtain a natural food product - triticale seedlings [5]. Generally accepted and standard methods of germination were used in the investigation. As a result, the main stages and terms of the germination process were determined [4].

Preparation of triticale seeds for germination process includes washing the grain in running water and disinfection. Disinfection is carried out in two stages: 1) seed aging in a slightly pink solution of KMnO₄ for 30 minutes; 2) seed washing at the end of the first stage and repeated seed aging in the solution for 60 minutes. At the end of the disinfection process, the seeds were washed. Soaking of the disinfected and washed grain mass was carried out at a temperature of 20 °C for 15 hours. Germination was carried out in plants on filter paper. The temperature in the thermostat is 20 °C, the thickness of the seed layer is 1-1.5 cm. The duration of germination in the thermostat - 24 hours. The length of sprouts as a result of germination: 1-3 mm.

The inverse relationship between the starch content and the duration of germination was established. The recommended modes are the duration of germination of 25 hours at an air temperature of 5-15 °C, 20-25 hours at an air temperature of 20 °C, and 15-20 hours at 25-30 °C. The activity of enzymes in these modes of germination is significantly increased, which activates the process of hydrolysis of starch. A comprehensive study of changes in the chemical composition of triticale grain during germination will allow organizing competently the technological process of
obtaining grain products of increased biological value.

4. Conclusion
Pre-sowing treatment with growth regulators of winter triticale seeds contributes to the emergence of good sprouts, the increase of field germination, and the increase of plant resistance to various diseases. These processes have an impact on the formation of elements of the crop structure, the density of seedlings, number of surviving plants during the growing season, productive tilling capacity and others, which provides a significant increase in the yield of the examined varieties of winter triticale by 6.8-17.4%.

The high content of essential amino acids and biologically active substances in triticale seedlings causes their wide usage in the production of functional foods [10]. The development and implementation of the germination process in production will allow to use rationally the grown grain and to obtain a fundamentally new type of product, which is highly competitive with the known traditional food products in nutritional value.

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