Influence of processing of crops of a winter rye by growth factors on crop productivity and grain quality

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Abstract. The research on studying of influence of growth such as Epin, Immunotsitofit and Zir-con on crop productivity and grain quality of winter rye has been conducted. It is revealed that processing of winter rye by growth stimulants Epin significantly increases crop productivity and improves quality of grain. Productivity of sowings of agricultural crops depends on size and duration of the functioning of a photosynthetic apparatus of plants. Photosynthetic potential of sowing is closely correlated both with biological and economic productivity of plants. Researches have shown that processing of winter rye crops by growth stimulator Epin significantly increases the heavity and improves grain quality.

1. Introduction
Production of grain is the main and decisive basis of development of all branches of agriculture. Winter rye in the agriculture of Russia especially in the non-Chernozem region re-served one of the leading places. Despite the fact that in the last years has seen a significant re-duction of crops of winter rye in the world, Russia occupies a leading place in area sown and gross yield of grain. The country is currently winter rye planted about 2 million hectares and produces about 3,5-4 million tons of grain per year.

One of the reasons of instability of high yields of agricultural crops in non-Chernozem zone of Russia is the low level of soil fertility. In recent years, due to the fact that there is a sys-tematic increase in the cost of fertilizers, plant protection products and energy resources, this problem has become more urgent. That is why the farmers of the country must find and apply new low-cost technologies of cultivation of agricultural crops. One of the most perspective di-rec-tions in modern technologies of crop production is using of biological drugs and plant growth stimulants [1-3].

Growth stimulants allow to make active the immune system of plants, "smooth" limiting factors in getting potential yields of crops (increase resistance to a drought or excess moisture, high or low ambient temperature), also speed up or slow down a maturing of plants, increase quantity of ovaries, promote the redistribution of nutrients in the economic important plant or-gans [4-6]. The achievement which rarely provides with traditional elements of technology.

2. Methodology of research
We have conducted a research in 2014-2016 to study the influence of stimulants on growth and development of yield and grain quality of winter rye. Field experiments were conducted in crop rotation on the experimental field of the Mari State University according to the following scheme:
The soil of experimental plot is sod-podzolic medium loam, the content of hydrolysis nitrogen was 83, mobile phosphorus was 212 and exchange potassium was 121 mg/kg. The experience was repeated six times. The location of the repeatnesses tiered, they have systematical plots. The total area of plots is 2.25, accounting area is 1.44 m².

Technology of cultivation of winter rye was common for the area. Winter rye (variety Tatiana) were sown in the green manure (vetch/oats) a couple in the optimum time for a zone with the norm 6.0 million viable seeds per hectare. With biological mass of green fertilizer into the soil were made 220.1 kg/ha the active substance NPK, including nitrogen – 106.6, phosphorus – 36.9 and potassium – 76.6 kg/ha. Sowing of winter rye was treated with growth stimulants in the early phase of shooting. Consumption rate of the stimulants were: Epin – 50 ml/ha, Immunotsitofit – 60 g/ha and Zircon – 20 ml/ha, and a working fluid – 300 l/ha. Observations, surveys and analysis were conducted on relevant procedures.

3. Results and considerations
Productivity of sowings of agricultural crops depends on size and duration of the functioning of a photosynthetic apparatus of plants. Photosynthetic potential of sowing is closely correlated both with biological and economic productivity of plants. This indicator allows to evaluate the power of the working surface of crop leaves in a certain period or, in General, over the whole vegetation period. Every agricultural event, which is held with the aim of increasing the economic crops, can be effective only if it has a positive effect on the photosynthetic activity of crops [7-9].

Researches have shown that the highest leaf area of winter rye has formed in the earing phase of 43.9÷46.9 thousand m²/ha, depending on the version of the experiment (table 1). It is established that the processing of crops of winter rye by growth stimulants promoted the increase in the area of leaves. At the same time it is revealed that higher area of leaves during the vegetation period of winter rye is provided using Epin.

Table 1. Area of leaf surface of winter rye, thousand m²/ha (average for 2014-2016).

| Versions of the experiments | Before sowing | Phenological phase | Milk ripeness |
|-----------------------------|--------------|-------------------|---------------|
| Water (control)             | 5.4          | 32.7              | 43.9          | 24.6 | 6.9 |
| Epin                        | 5.4          | 33.4              | 46.9          | 26.7 | 9.1 |
| Immunotsitofit              | 5.4          | 33.1              | 45.4          | 25.8 | 7.7 |
| Zircon                      | 5.4          | 33.3              | 46.2          | 26.4 | 8.4 |

Photosynthetic potential of winter rye crop on average over three years of researches during the period from spring regrowth to full ripening ranged from 1782.9 to 1897.9 thousand m²/ha × day, depending on the variants (table 2). Researches revealed that the higher photosynthetic potential of winter rye with the application of Epin – 1897.9 thousand m²/ha × day that 1.3-6.1 percent higher than all options. Absolute productivity photosynthesis of winter rye in using of Epin was also the highest and amounted 3.58 g/m² × day.

Results of experiments showed that processing of crops of a winter rye by growth stimulants promotes the increase of grain yield (table 3). At the same time higher yields of grain and a significant increase of yield, on average for years of researches was at the use the Epin and has made 2.93 t/hectare that is 260 kg/hectare higher than control version. In other variants the grain yield of winter
rye was lower on 4.5÷7.9 %. It should be noted that the use of Zircon in the first two years of researches gave significant increase in grain yield of winter rye, and the use of Immunotsitofit did not provide a significant gain for the entire period.

Table 2. Photosynthetic potential and absolute productivity of photosynthesis of winter rye (average for 2014-2016).

| Versions of experiments | Photosynthetic potential, thousand m²/ha × day | Absolute productivity photosynthesis, g/m² × day |
|-------------------------|-----------------------------------------------|--------------------------------------------------|
| Water (control)         | 1782.9                                        | 3.47                                             |
| Epin                    | 1897.9                                        | 3.58                                             |
| Immunotsitofit          | 1840.4                                        | 3.41                                             |
| Zircon                  | 1873.2                                        | 3.50                                             |

Table 3. Grain yield of winter rye, t/ha.

| Versions of the experiments | Years | On average +,- to control, kg/ha |
|-----------------------------|-------|----------------------------------|
|                             | 2014  | 2015  | 2016  | +,- to control |
| Water (control)             | 2.48  | 2.80  | 2.72  | 2.67           |
| Epin                        | 2.59  | 3.28  | 2.92  | 2.93           |
| Immunotsitofit              | 2.53  | 2.76  | 2.80  | 2.70           |
| Zircon                      | 2.55  | 3.08  | 2.86  | 2.83           |
| SSDₜₐₜ                      | 0.06  | 0.15  | 0.17  | 0.16           |

Analysis of the yield structure elements gives the most complete idea about the conditions of yield formation of agricultural yields. Analysis of yield structure of winter rye (table 4) showed that higher yield of grain in variant with the use of Epin is caused by such elements as quantity of plants per 1 m² – 105.8 pieces, of productive tillering – 3.1, weight of 1000 grains – 31.3 g. In other variants, indicators of the structure of crops was somewhat lower.

Grain quality of agricultural heavy intended for food purposes, is mainly determined by its chemical structure and technological properties. Limited arrival of photosynthetic active radiation and low fertility of sod-podzolic soil of the Republic of Mari El limit the formation of protein and gluten in grain reduces its quality. In this regard, in the region grow up mainly forage grain.

Chemical analysis of grain of a winter rye (table 5) has shown that the nitrogen structure depending on the type of the experiment varied from 1.98 to 2.09 %, phosphorus from of 1.02 to 1.11 % and potassium from 0.75 to 0.81 %. Clear patterns in change of the structure of these elements is not identified, were observed just a tendency to increase of major nutrients by spraying with growth stimulants of crops of winter rye.

Our researches have shown that this technique of agrotechnology as use of growth stimulants can improve quality of the grain. So the protein in grain of winter rye depending on the type amounted from 11.7 to 12.2 %. The processing of crops of winter rye by stimulants Zircon and Epin promoted the increase protein content in grain respectively, at 0.4 and 0.6 % in comparison with the control variant. At the same time high protein content in grain was observed by using Epin – 12.2 %.

Table 4. Structure of yield of winter rye (average for 2014-2016).

| Versions of the experiments | The number of plants, PCs./m² | Productive tillering | Length of spike, cm | The number of kernels per spike, PCs. | Weight of 1000 grains, g |
|----------------------------|------------------------------|----------------------|---------------------|--------------------------------------|------------------------|
| Water (control)            | 102.4                        | 2.8                  | 9.0                 | 40.7                                 | 30.1                   |
| Epin                       | 105.8                        | 3.1                  | 9.4                 | 42.8                                 | 31.3                   |
The number of falling is a key indicator of quality of food grain of rye. Carbohydrate-amylase complex of grain of a winter rye of the studied variants conformed to technological requirements, keeping within on falling number in the interval from 188.9 to 196.7 seconds. The quality of this grain belongs to the second class. By processing of grain in flour stable good quality bread is guaranteed.

Table 5. Grain quality of winter rye (average for 2014-2016).

| Versions of the experiments | Content, % | Falling number, sec. | Class quality falling number |
|-----------------------------|------------|----------------------|-----------------------------|
|                             | N  P  K protein |                       |                             |
| Water (control)             | 2.00 1.02 0.75 11.6 | 188.9                      | II                          |
| Epin                        | 2.09 1.11 0.81 12.2 | 196.7                      | II                          |
| Immunotsitofit              | 1.98 1.07 0.77 11.6 | 190.5                      | II                          |
| Zircon                     | 2.06 1.08 0.79 12.0 | 194.3                      | II                          |

The indicators that have an important technological value of rye include weight of 1000 grains. According to research results, the weight of 1000 grains ranged from 30.1 to 31.3 g (table 4). At the same time higher rate was by processing of crops with Epin – 31.3 g.

4. Conclusion
So the obtained experimental data allow to conclude that the use of plant growth stimulants is one of the perspective directions of modern technology of crop production. Researches have shown that processing of winter rye crops by growth stimulator Epin significantly increases the heavty and improves grain quality.

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