Seed productivity of festulolium (× Festulolium F. Ashers. EtGraebn.) of the Emerald variety in the forest-steppe conditions of the Middle Volga region

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Abstract. The current research deals with the effect of exogenous seed treatment of festulolium plants with the Emerald festulolium variety. The results allow to conclude that Megamix-Profi at a dose of 2 l/t of seeds increases the photosynthetic activity of festulolium plants, improves the structure of the yields, and increases yields in quantity and quality by an average of 149 kg/ha, which is 18.5% higher than in the control. Moreover, the examined crops obtained the greatest indicators of adaptability and stability to cultivation conditions.

1. Introduction
Perennial grasses are an important source for the production of feeds balanced in protein, high in essential amino acids and minerals. They are characterized by a high degree of adaptation, accelerated development, the ability to intensively gain green mass, as well as a shortened recovery period after mowing or grazing. They also improve soil fertility and counteract the harmful effects of water erosion and deflation. At the same time, the bluegrass plants have special characteristics as an extensive species diversity, which makes it possible being engaged in scientifically grounded introduction of new species. One of these is festulolium. Festulolium (× Festulolium F. Ashers. EtGraebn.) is an intergeneric hybrid of fescue and ryegrass. It was obtained using the methods of distant hybridization and experimental polyploidy. The crop is characterized by a wide range of uses: the possibility of cultivation for green fodder, silage, hay. It is also irreplaceable when organizing highly productive forage lands [1-5].

Since festulolium is first introduced in the forest-steppe conditions of the Middle Volga region, for a successful introduction it is necessary to create a system of sustainable seed-growing of festulolium in the region. This requires the development of an adaptive cultivation technology based on resource conservation along with a rationalized system of crop exploitation. As a result, this can become the key to organizing seed production in order to use and create qualitatively new varieties of festulolium adapted to local agro-climatic conditions [6].

One of the methods of resource conservation is the use of complex microelement fertilizers. They allow to control the life cycle of plants during ontogenesis and are able to purposefully affect growth and development. At the same time, the degree of realization of the genetic potential of crops is significantly increased, due to an increase in the resistance of the plant organism to pathogens and pests, stress from external factors and phytopathogens are greatly reduced [7-8].
2. Materials and methods
Experimental research, to examine the effect of exogenous seeds treatment of festulolium plants on seed productivity of agrocenosis, was carried out at the experimental field of Penza State Agrarian University (Russia). Field experiments were organized according to the methodological instructions of B.A. Dospekhova. In accordance with that technique, experiments and results were analyzed. The experiment scheme included the following options: 1. Control (water treatment); 2. Azosol-36 Extra (2.5 l/t); 3. Megamix-Profi (2 l/t); 4. Siliplant (60 ml/t); 5. Zircon (2 ml/t). The object of research was festulolium of the Emerald variety. Winter wheat was chosen as the predecessor. Sowing method is traditional (row spacing 15 cm). The seeding rate is 8.0 kg/ha. Sowing was done manually. The experiment was organised four times. Systematic placement of experience options, accounting plot area 10 m². Agrotechnics generally accepted for bluegrass plants in the Penza region [9].

3. Results
Weather conditions during the years of research had a significant impact on the length of the growing season. With insufficient moisture with Selyaninov's hydrothermal moistening coefficient (HMC) HMC 0.9, the duration of the growing season decreased and, conversely, with HMC-1.1, it lengthened. Mathematical analysis showed a close correlation between the duration of the "spring regrowth-flowering" phase and air temperature (r = 0.78) and HMC (r = 0.79). The duration of the interfacial period "spring regrowth - flowering" had an average conjugation with the growing season, the correlation coefficient here was 0.50 (Table 1). The total duration of the growing season of festulollium positively correlated with air temperature (r = 0.72) and with HMC (r = 0.78). The duration of the "flowering-ripeness" period had an average dependence on the average daily air temperature and on precipitation, the conjugation with which was 0.61 and 0.67, respectively.

| Development phases               | Correlation coefficients |
|----------------------------------|--------------------------|
|                                  | Temperature, °C | Humidification, HMC | Vegetation period |
| Vegetation period                | 0.72            | 0.78                | -                |
| Spring regrowth - flowering      | 0.80            | 0.82                | 0.54             |
| Flowering-ripeness              | 0.61            | 0.67                | 0.72             |

The limiting factor for obtaining high productivity of perennial grasses is an increase in the photosynthetic activity of agrocenoses, which is an important element of the life of crops, since it determines the productivity of the sowing and the accumulation of the required amount of nutrients in it. According to the comprehensive theory of photosynthetic productivity of plants, crops are considered as integral optical-biological systems. Their yield depends on the amount of absorbed energy of sunlight and on the coefficient of energy use for photosynthesis. Research results on the effect of exogenous processing seeds with microelement preparations on the productivity of photosynthesis are shown in Table 2.

Table 2. Productivity of photosynthesis of festulolium variety Izumrudny agrocenoses, depending on exogenous seed treatment with microelement fertilizers (2019-2021).

| Option          | Leaf area, thousand m²/ha | Photosynthetic potential, thousand m² day/ha | Productivity of photosynthesis, g/m²/day |
|-----------------|----------------------------|-----------------------------------------------|------------------------------------------|
| Control         | 47.6                       | 273.0                                         | 3.11                                     |
| Azosol-36 Extra | 48.0                       | 275.3                                         | 3.12                                     |
| Megamix-Profi   | 49.5                       | 279.3                                         | 3.14                                     |
| Siliplant       | 48.3                       | 275.0                                         | 3.13                                     |
| Zircon          | 47.9                       | 274.7                                         | 3.12                                     |
The analysis of the photosynthetic activity of crops shows that the largest area of leaves of the festulolium variety Emerald (49.5 thousand m²/ha) was formed during the pre-sowing treatment of seeds with the microelement fertilizer Megamix-Profi. The least effect on the formation of the leaf surface was exerted by the preparation Zircon (47.9 thousand m²/ha).

Photosynthetic potential and net productivity of photosynthesis are important indicators that determine the degree of photosynthetic activity of agrocenoses of festulolium. Thus, the maximum indicators of FP and PPF of festulolium crops were observed when using the microelement fertilizer Megamix-Profi and amounted to 273.9 thousand m² days/ha and 3.14 g/m²/day with control of 273.0 thousand m² day/ha and 3.11 g/m²/day, respectively.

The degree of optimization of festulolium plants mineral nutrition by exogenous pre-sowing seeds treatment and an increase in photosynthetic activity had a positive effect on the formation of seed herbage of festulolium (Table 3).

Table 3. The structure of seed herbage of festulolium variety Emerald, depending on the exogenous seeds treatment with microelement fertilizers (2019-2021).

| Option         | The number of generative springs, pcs/m² | The length of the inflorescences, cm | The number of spikelets per inflorescence, pcs | The number of seeds per inflorescence, pcs | Weight of 1000 seeds, g |
|----------------|------------------------------------------|--------------------------------------|-----------------------------------------------|--------------------------------------------|------------------------|
| Control        | 646                                      | 21.9                                 | 34.3                                          | 73.6                                       | 3.14                   |
| Azosol-36 Extra| 663                                      | 22.3                                 | 35.3                                          | 75.3                                       | 3.18                   |
| Megamix-Profi  | 693                                      | 22.9                                 | 37.0                                          | 77.0                                       | 3.23                   |
| Siliplant      | 669                                      | 22.3                                 | 35.0                                          | 75.6                                       | 3.18                   |
| Zircon         | 663                                      | 22.2                                 | 35.0                                          | 74.3                                       | 3.16                   |

Analysis of the structure of seed herbage of the festulolium variety Emerald for the period 2019-2021 showed that the indicators of the number of generative springs, along with the length of the inflorescences, as well as the number of spikelets in the inflorescence were the highest when the seeds were treated with Megamix-Profi and amounted to 693 pcs/m², 22.9 cm and 37 pcs in comparison with the control - 646 pcs/m², 21.9 cm and 34.3 pcs. At the same time, the effectiveness of using the Megamix-Profi preparation is demonstrated when considering such elements of the yield structure as the number of seeds in the inflorescence and the weight of 1000 seeds - 77.0 pcs and 3.23 g with control values of 73.6 pcs and 3.14 g. An integral indicator of the formation of elements for the agricultural crops productivity is the yield of seeds. So for three years of research (2019-2021), the yield of the hybrid was influenced not only by microelement fertilizers, but also by the local agro-climatic conditions of the introduction area along with a certain year of use (Table 4).

Table 4. Seed productivity of the festulolium variety Emerald, depending on exogenous seed treatment with microelement fertilizers.

| Option        | Seed yields, kg/ha | +/- control |
|---------------|--------------------|-------------|
|               | 2019   | 2020   | 2021   | average | 2019 | 2020 | 2021 | %   |
| Control       | 639    | 712    | 621    | 657     | -    | -    | -    | -   |
| Azosol-36 Extra| 737    | 798    | 715    | 750     | 93   | 12.4 |
| Megamix-Profi | 785    | 874    | 761    | 807     | 149  | 18.5 |
| Siliplant     | 721    | 812    | 708    | 747     | 90   | 12.0 |
| Zircon        | 705    | 756    | 698    | 720     | 62   | 8.7  |
| LSD           | 24.1   | 26.3   | 21.4   |         |      |      |

Graphically, the dependence of the yield of festulolium seeds on photosynthesis is shown below (Figure 1).
Seed yield, kg/ha = 103,0004+9,9712*x-217,0187*y+0.2263*x*x-10,0634*x*y+111,7689*y*y

Figure 1. Correlation between seed yield (Z) on leaf area (X) and photosynthesis productivity (Y).

Analysis of seed productivity of the festulolium variety Izumrudny presents the following data that the best yield indicators were observed in 2020, favorable for weather conditions, and amounted to 756-874 kg/ha, while control was 712 kg/ha. At the same time, the use of microelement fertilizers contributed to an increase in yield, on average, by 62-149 kg/ha or by 8.7-18.5%. The highest yield indicators on average for three years of research were achieved with the use of Megamix-Profi - 761-874 kg/ha, which is 140-162 kg/ha higher than the control.

Evaluation of the festulolium productivity when using microelement fertilizers in terms of adaptability and stability to cultivation conditions showed that the biological plasticity index (bi) was the highest in the variant with Megamix-Profi 1.07 (control 0.98), the highest stability criterion was also noted there σdr2 = 0.12, and the stability index is 15.96%, which shows high adaptability to changing growing conditions.

4. Conclusion
In the conditions of the Middle Volga region, festulolium is a highly productive forage crop with sustainable seed production. The use of festulolium seeds treatment with the microelement fertilizer Megamix-Profi increases the adaptability, adaptability and stability of the crop to growing conditions, allowing for stable seed yields of 700-760 kg/ha, regardless of weather conditions.

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