Spring wheat productivity when using Megamix liquid fertilizers

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Abstract. At present, the attention of scientists is increasingly attracted by the study of the effect of stimulating preparations on agricultural plants. They have a rich composition of macro-, meso- and microelements in an easily accessible form for plants, the use of which has a positive effect on plant development and, as a consequence, contributes to improving the quantity and quality of crop production, including in the specific climate of the forest-steppe of the Middle Volga region. In this connection on the fields of Scientific Research Laboratory "Korma" of Samara SAU the work to identify the impact of application of stimulating preparations Megamix in the form of liquid fertilizer mixtures in pre-sowing seed preparation and treatment of crops during the growing season of spring wheat was carried out during five years (2017-2021). The paper presents the results of research on the effect of stimulating preparations on the development of soft spring wheat agrophytocenosis at different seeding rates (4.0; 4.5; 5.0 mln germinating seeds/ha). The analysis of the influence of the use of Megamix preparations on the indices of photosynthetic activity of plants, indices of yield structure and yield of spring wheat was carried out. It was found that the use of liquid fertilizers Megamix during seed treatment and in the growing season has a positive impact on the index of photosynthetic potential of crops. This indicator increases with the use of Megamix. It reaches its maximum value in the experimental variants, where seeds are treated with a stimulating preparation Megamix Seeds - 2 l/t, followed by treatment of spring wheat crops with Megamix Profi - 0.5 l/ha (in the phase of tillering (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)), which forms the maximum yield of 3.98 t/ha.

1. Introduction.
To obtain high yields of spring wheat grain under modern cultivation technologies, an important role should be given to various methods of treatment of seeds and plants during the growing season with environmentally safe preparations that promote plant growth and development, and also have a beneficial effect on increasing their productivity and resistance to stress [2,3].

When growing high yields, the plant should be fully supplied with compounds of nitrogen, phosphorus, potassium and micronutrients. The optimum content of microelements has a positive effect on the plant uptake of mineral fertilizers, which, in turn, contribute to the activation of vital processes of cultivated plants. Mineral fertilizers are essential for plants at all stages of organogenesis, without exception. Therefore, it is necessary to include systems of mineral fertilizers with a complete set of macro-, meso- and microelements in the cultivation technology. [5,6,7,8,9].
Due to the current environmental situation, organic crop production is becoming more and more popular every year. One of the modern solutions in ecologization of crop production can be the use of microfertilizer mixtures in the form of mineral fertilizers in liquid form, which can have a positive impact on the potential of plants, as well as have a direct impact on the adaptation of valuable crops to local climatic conditions [1].

Therefore, the use of means for foliar feeding in the form of liquid mineral fertilizers containing in their composition a large number of microelements in an easily accessible form for plants is considered one of the most popular innovations in crop production nowadays.

Also an important task for obtaining a large yield of high quality in the extreme conditions of the forest-steppe of the Middle Volga region is to create an optimal density of crops in order to maximize the potential of the crop in terms of agroecosystem [4].

The influence of microfertilizer mixtures in the form of liquid mineral fertilizers on the productivity of spring wheat has been studied widely enough, but the systematic evaluation of seed pre-sowing treatment and treatment during the growing season at different stages of plant development on crops with different seeding rates in the forest-steppe of the Middle Volga region has not yet been studied enough. Therefore, the purpose of our research work is to study the effect of the above factors on the plants of soft spring wheat.

The objectives of our research include: evaluation of photosynthetic activity of plants of soft spring wheat, yield structure and yield in general, at different seeding rates and application of stimulating preparations Megamix in pre-sowing treatment and during the growing season.

2. Methods and Materials

The object of the research was soft spring wheat crops, the subject of the research was a three-factor field experiment on the formation of agrophytocenosis and assessment of productivity of spring wheat at different seeding rates and application of fertilizer mixtures in the form of Megamix liquid mineral fertilizers during seed treatment and treatments during the growing season.

In our experiments, spring wheat was grown under the agricultural technology, which includes stubble plowing, spring plowing, early spring harrowing and pre-sowing cultivation to a depth of 4...6 cm, sowing by an AMAZONE D9-25 seeder in the usual row method. The application of stimulating agents was carried out in accordance with the scheme of the experiment. Harvesting was carried out on a piecemeal basis in the phase of full ripeness.

A three-factor field experiment consists of factors:
- Seeding rate: 4.0 million germinating seeds/ha, 4.5 million germinating seeds/ha, 5.0 million germinating seeds (factor A);
- Seed treatment: control without treatment, Megamix Seeds (MS) 2 l/t, (factor B);
- Seed treatment during vegetation: control without treatment (K), Megamix Profi (MP) (in the tillering phase (29 BBCH)) -0.5 l/ha, Megamix Profi (in the tillering phase (29 BBCH)) - 0.5 l/ha + Megamix Nitrogen (MA) (in the phase of the flag leaf (39 BBCH)) 0.5 l/ha (factor C)

Experimental work is carried out taking into account the method of field experiment by B.A. Dospekhov [10].

Liquid mineral fertilizers of "Megamix" brand were used in the research:
- Megamix Seeds - a stimulating preparation in the form of a liquid mineral fertilizer for pre-sowing seed treatment based on micro-, meso- and macroelements.
  - This preparation contains - micronutrients, g/l: B - 4.6, Cu - 33, Zn - 31, Mn - 3.0, Co - 2.8, Mo - 7.0, Cr - 0.5, Se - 0.1, Ni - 0.1; mesoelements Fe - 4.0, Mg - 22; macroelements, g/l - N - 58, P - 6, K - 58, S - 50.

- Megamix Profi. A stimulating preparation in the form of a liquid mineral fertilizer with high content of microelements and mesoelements, for pre-sowing seed treatment and foliar dressing.
  - It contains - microelements, g/l: B - 1.7, Cu - 12, Zn - 11, Mn - 2.5, Mo - 1.7, Co - 0.5, Se - 0.06; mesoelements Fe - 2.0, Mg - 17; macroelements, g/l - N - 2.5, S - 25.
Megamix Nitrogen is a stimulating preparation in the form of a liquid fertilizer for foliar feeding with a rich content of microelements and nitrogen. It contains - microelements, g/l: B - 0.8, Cu - 2.5, Zn - 2.5, Mn - 1.0, Mo - 0.6, Co - 0.12, Se - 0.06; mesoelements Mg - 6, Fe - 1.0; macronutrients, g/l - N - 116, S - 8.

3. Results and Discussion

Our research focuses on the effect of fertilizer mixtures as stimulating preparations: Megamix Seeds, Megamix Profi and Megamix Nitrogen on the intensity of photosynthetic activity and yield of spring wheat.

The maximum leaf area, on average over the five years of research (2017-2021), in all variants of the experiment was formed by the stage of the flag leaf (39 BBCH).

According to the variants of seed treatment and different treatment of crops with Megamix stimulating preparations, at different rates of seeding the best value of the leaf area was noted in the variants, where pre-sowing treatment of seeds with a stimulating preparation Megamix Seeds followed by treatment of plants with stimulating preparations Megamix Profi 0.5 l/ha (in the tillering phase (29BBCH)) + Megamix Nitrogen 0.5 l/ha (in the phase of a green leaf (39BBCH)) at the rate of seeding of 4.5 mln germinating seeds/ha with a rate of - 29.5 thousand m²/ha.

During the field study it was found that the photosynthetic potential was also higher in the variants, where the presowing treatment of seeds with the stimulating agent Megamix Seeds and double plant treatment with the stimulating agents Megamix Profi - 0.5 l/ha (in the tillering phase (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) and with a seeding rate of 4.5 million germinating seeds/ha with a rate of 1.203 mln m²/ha days. Analyzing the index in dynamics during the period of vegetation it was established that photosynthetic potential (PP) of spring wheat sowings during the period from shoots to the stage of flag leaf (09-39BBCH) on average for five years of the research ranged from 0.233 to 0.427 mln m²/ha day (Table 1). In the period from the stage of the flag leaf to earring (39-59BBCH) the best results were achieved in the same variant, treating seeds with Megamix Seeds at 4.5 million germinating seeds/ha - 0.474, million m²/ha days.

In the period from earring to early wax maturity (59-83BBCH) on average over the five years of research the maximum values were recorded in the variants with seed treatment with Megamix Seeds and plant treatment during the growing season with Megamix Profi - 0.5 l/ha (in the tillering phase (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) with the seeding rate of 4.5 million germinating seed/ha with an index of 0.302 million m²/ha d. Summarizing the indices of photosynthetic activity of spring wheat plants during the vegetation period it was found that the total photosynthetic potential of spring wheat during the vegetation period was in the range from 0.637 (in control without treatment) to 1.203 mln m²/ha days. In the period from earring to early wax maturity of spring wheat, the best results were achieved in the same variant, treating seeds with Megamix Seeds and plant treatment with stimulating preparations Megamix Profi - 0.5 l/ha (in the phase of tillering (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) for crops with the rate of seeding of 4.5 million germinating seeds/ha (Table 1).

In the period from earring to early wax maturity (59-83BBCH) on average over the five years of research the maximum values were recorded in the variants with seed treatment with Megamix Seeds and plant treatment during the growing season with Megamix Profi - 0.5 l/ha (in the tillering phase (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) with the seeding rate of 4.5 million germinating seed/ha with an index of 0.302 million m²/ha d. Summarizing the indices of photosynthetic activity of spring wheat plants during the vegetation period it was found that the total photosynthetic potential of spring wheat during the vegetation period was in the range from 0.637 (in control without treatment) to 1.203 mln m²/ha. Summarizing the indices of photosynthetic activity of spring wheat plants during the vegetation period it was found that the total photosynthetic potential of spring wheat during the vegetation period was in the range from 0.637 (in control without treatment) to 1.203 mln m²/ha days, when using Megamix Seed and two-times treatment of crops with stimulating preparations Megamix Profi - 0.5 l/ha (in the phase of tillering (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) for crops with the rate of seeding of 4.5 million germinating seeds/ha (Table 1). The indicator that determines the nature of dry matter accumulation by soft spring wheat plants is the net photosynthetic productivity. Net photosynthetic productivity (NPP) reflects the productivity of photosynthetic activity of cultivated plants. In our research we found that in spring wheat the index (NPP) was in the range from 4.16 g/m² day to 6.96 g/m² day (Table 1).

It should be noted that the use of Megamix stimulating preparations during the growing season does not contribute to the increase of this indicator, which may be due to a more intense growth process and, consequently, a decrease in the dry matter content in the plants. When analyzing the structure of the obtained yield of spring wheat, for five years of research, it was possible to trace the dependence of a set of factors obtained in the experiment with the application of stimulants and seeding rate with biological yield. It has been found that the number of productive stems in the crop increases with increasing yield. So, if the seeding rate was 4.0 million germinants/ha, the number of ears with grain on 1 m² was in the range of 368-413 pcs/m², when sowing 4.5 million germinating seeds/ha - 348-431 pcs/m², when sowing
5.0 million germinating seeds/ha - 363-468 pcs/m². Moreover, when treated with Megamix Seeds, this figure increased significantly and was in the range of 360-413 pcs/m², 420-431 pcs/m², 413-468 pcs/m², respectively, for variants of seeding rate (Table 2).

### Table 1. Indicators of photosynthetic activity of spring wheat plants, 2017-2021.

| Seeding rate, mln germ. seeds | Variant | Maximum S of leaves (flag leaf 39ВВСН), thous. m²/ha | ∑ PP, mln. m²/ha days | Average NPP g/m² days |
|-------------------------------|---------|---------------------------------------------------|----------------------|----------------------|
| 4.0                           | C       | 16.1                                              | 0.637                | 6.84                 |
|                               | MPb     | 19.8                                              | 0.791                | 6.08                 |
|                               | MP + MNc| 23.3                                              | 0.968                | 4.47                 |
|                               | C       | 18.8                                              | 0.745                | 5.98                 |
|                               | MSa     | 24.0                                              | 0.952                | 4.88                 |
|                               | MPb     | 27.1                                              | 1.081                | 4.32                 |
|                               | C       | 20.7                                              | 0.783                | 6.02                 |
|                               | Cd      | 21.1                                              | 0.845                | 5.96                 |
|                               | MP + MNc| 23.7                                              | 0.971                | 5.05                 |
|                               | C       | 21.2                                              | 0.817                | 5.69                 |
|                               | 4.5     |                                                   |                      |                      |
|                               | MSa     | 27.7                                              | 1.081                | 5.02                 |
|                               | MPb     | 29.5                                              | 1.203                | 4.22                 |
|                               | C       | 22.2                                              | 0.862                | 6.10                 |
|                               | Cd      | 19.8                                              | 0.823                | 6.15                 |
|                               | MP + MNc| 26.2                                              | 1.058                | 4.94                 |
|                               | C       | 21.9                                              | 0.872                | 5.73                 |
|                               | 5.0     |                                                   |                      |                      |
|                               | MSa     | 25.3                                              | 1.039                | 5.77                 |
|                               | MPb     | 27.8                                              | 1.129                | 5.08                 |
|                               | MP + MNc| 28.2                                              | 1.058                | 4.94                 |
|                               | 4.0     |                                                   |                      |                      |
|                               | C       | 254                                               | 338                  | 22.9                 | 41.4                 |
|                               | MPb     | 251                                               | 338                  | 25.1                 | 44.3                 |
|                               | MP + MNc| 258                                               | 368                  | 26.8                 | 38.7                 |
|                               | C       | 282                                               | 360                  | 22.9                 | 40.7                 |
|                               | 4.5     |                                                   |                      |                      |
|                               | C       | 298                                               | 369                  | 25.3                 | 40.8                 |
|                               | MPb     | 305                                               | 413                  | 29.2                 | 41.3                 |
|                               | MP + MNc| 271                                               | 348                  | 23.7                 | 38.0                 |
|                               | C       | 265                                               | 371                  | 25.1                 | 40.3                 |
|                               | 5.0     |                                                   |                      |                      |
|                               | C       | 285                                               | 380                  | 30.1                 | 39.3                 |
|                               | MPb     | 314                                               | 420                  | 23.4                 | 39.4                 |
|                               | MP + MNc| 319                                               | 410                  | 26.0                 | 39.6                 |
|                               | 4.0     |                                                   |                      |                      |
|                               | C       | 319                                               | 431                  | 28.1                 | 41.6                 |
|                               | MPb     | 303                                               | 363                  | 22.9                 | 41.1                 |
|                               | MP + MNc| 314                                               | 382                  | 23.4                 | 42.3                 |
|                               | 4.5     |                                                   |                      |                      |
|                               | C       | 322                                               | 407                  | 27.2                 | 36.5                 |
|                               | MPb     | 354                                               | 413                  | 23.0                 | 39.2                 |
|                               | MP + MNc| 364                                               | 444                  | 26.7                 | 41.2                 |
|                               | 5.0     |                                                   |                      |                      |
|                               | MPb     | 380                                               | 468                  | 26.5                 | 40.9                 |

Table 2. Spring wheat yield structure for 2017-2021.

| Seeding rate, mln germ. seeds | Variant | Number of plants pcs/m² | Grained ears, pcs/m² | Number of grains per ear, pcs. | Weight of 1000 seeds, g |
|-------------------------------|---------|--------------------------|----------------------|-------------------------------|-------------------------|
| 4.0                           | C       | 254                      | 338                  | 22.9                          | 41.4                    |
|                               | MPb     | 251                      | 338                  | 25.1                          | 44.3                    |
|                               | MP + MNc| 258                      | 368                  | 26.8                          | 38.7                    |
|                               | C       | 282                      | 360                  | 22.9                          | 40.7                    |
|                               | 4.5     |                          |                      |                               |                         |
|                               | C       | 298                      | 369                  | 25.3                          | 40.8                    |
|                               | MPb     | 305                      | 413                  | 29.2                          | 41.3                    |
|                               | MP + MNc| 271                      | 348                  | 23.7                          | 38.0                    |
|                               | C       | 265                      | 371                  | 25.1                          | 40.3                    |
|                               | 5.0     |                          |                      |                               |                         |
|                               | C       | 285                      | 380                  | 30.1                          | 39.3                    |
|                               | MPb     | 314                      | 420                  | 23.4                          | 39.4                    |
|                               | MP + MNc| 319                      | 410                  | 26.0                          | 39.6                    |
|                               | 4.0     |                          |                      |                               |                         |
|                               | C       | 319                      | 431                  | 28.1                          | 41.6                    |
|                               | MPb     | 303                      | 363                  | 22.9                          | 41.1                    |
|                               | MP + MNc| 314                      | 382                  | 23.4                          | 42.3                    |
|                               | 4.5     |                          |                      |                               |                         |
|                               | C       | 322                      | 407                  | 27.2                          | 36.5                    |
|                               | MPb     | 354                      | 413                  | 23.0                          | 39.2                    |
|                               | MP + MNc| 364                      | 444                  | 26.7                          | 41.2                    |
|                               | 5.0     |                          |                      |                               |                         |
|                               | MPb     | 380                      | 468                  | 26.5                          | 40.9                    |

The highest values for the indicator of 1000 seeds mass have been achieved on the variants of field experiment with the rate of seeding of 4.0 million germinating seeds/ha, without seed treatment, where
the treatment of plants during vegetation by stimulating agent Megamix Profi - 0.5 l/ha (in the phase of tillering (29 BBCH)) was carried out. In the remaining variants an increase in the weight of 1000 seeds was observed when the seeds were treated with the seed preparation Megamix Seeds and when the crop was co-treated with liquid mineral fertilizers Megamix Profi - 0.5 l/ha (in the phase of tillering (29 BBCH)) + Megamix Nitrogen - 0.5 l/ha (flag leaf (39 BBCH)). This value ranged from 36.5 to 41.6 g.

An increase in biological yield was achieved at the rate of spring wheat seeding of 4.5 mln germinating seeds/ha with foliar dressing of crops with Megamix Profi - 0.5 l/ha (in the phase of tillering (29 BBCH)) + Megamix Nitrogen - 0.5 l/ha (flag leaf (39 BBCH)), together with seed pretreatment with a stimulating preparation Megamix Seeds. The highest biological yield of 4.97 t/ha was achieved in this variant.

According to the data obtained on average over the five years of research, the following patterns of formation of soft spring wheat yields were revealed. The influence of stimulating preparations Megamix is clearly noticeable. The regularity of yield increase is visible, where the seed material was treated with seed preparation Megamix Seeds - 3.70 t/ha compared to the control variants (no treatment). (Table 3).

**Table 3. Spring wheat yield for 2017-2021.**

| Seeding rate, mln germ. Seeds (A) | Seed treatment (B) | Vegetation treatment (C) | Yield, t/ha. | Average for seed treatment, t/ha | Average for seeding rate, t/ha |
|----------------------------------|--------------------|--------------------------|--------------|----------------------------------|------------------------------|
| 4.0                              | C                  | C                        | 2.33         | 2.73                             | 3.08                         |
|                                  | MP                 | MP + MN                  | 2.90         | 2.78                             | 3.15                         |
|                                  | C                  |                          | 2.40         |                                  |                              |
| MSa                              | MP                 | MP + MN                  | 3.22         | 3.36                             |                              |
|                                  | C                  |                          | 2.63         |                                  |                              |
| 4.5                              | C                  |                          | 2.96         |                                  | 3.40                         |
|                                  | MP                 | MP + MN                  | 3.47         | 3.70                             |                              |
|                                  | C                  |                          | 2.98         |                                  |                              |
| MSa                              | MP                 | MP + MN                  | 3.98         |                                  |                              |
|                                  | C                  |                          | 2.59         |                                  |                              |
| 5.0                              | C                  |                          | 3.03         | 3.38                             |                              |
|                                  | MP                 | MP + MN                  | 3.70         | 3.68                             |                              |
|                                  | C                  |                          | 3.26         |                                  |                              |
|                                  | MP + MN            |                          | 3.87         |                                  |                              |

2017 LSD GEN.=0.297; LSD A =0.099; LSD B =0.099; LSD C =0.099; LSD AB=0.171; LSD AC=0.171; LSD BC=0.171.
2018 LSD GEN.=0.153; LSD A=0.048; LSD B=0.048; LSD C=0.048; LSD AB=0.031; LSD AC=0.031; LSD BC=0.031.
2019 LSD GEN.=0.092; LSD A=0.031; LSD B=0.031; LSD C=0.031; LSD AB=0.053; LSD AC=0.053; LSD BC=0.053.
2020 LSD GEN.=0.360; LSD A =0.120; LSD B =0.120; LSD C =0.120; LSD AB=0.208; LSD AC =0.208; LSD BC =0.208.
2021 LSD GEN.=0.186; LSD A =0.094; LSD B =0.083; LSD C =0.070; LSD AB=0.054; LSD AC=0.055; LSD BC=0.102.

* – Megamix Seeds, *– Megamix Profi, *– Megamix Nitrogen, *– Control

Yields obtained from spring wheat with seeding rate of 4.5 mln germinating seeds/ha and 5.0 mln germinating seeds/ha in the variants with seed treatment with Megamix Seeds were practically identical - 3.70-3.68 t/ha with a difference of 0.02 t. In the same way, all variants yielded 3.40 t/ha at 4.5 million germinating seeds per hectare and 3.38 t/ha at 5.0 million germinating seeds per hectare. At the rate of 4.0 million germinating seeds/ha the yield was 3.08 t/ha, which was significantly lower. Thus the obtained data on yields give us reason to consider the seeding rate of 4.5 mln. germinated seeds/ha.
seeds/ha the best in the cultivation of spring wheat in the soil and climatic conditions of the forest-steppe of the Middle Volga region. (Table. 3).

It was found that on all variants of the experiment with the treatment of crops during the growing season, a reliable increase was obtained. It was best when double-treated with Megamix Profi - 0.5 l/ha (in the tillering phase (29 BBCH)) + Megamix Nitrogen - 0.5 l/ha (flag leaf (39 BBCH)) and at 4.5 million germinating seeds/ha with a maximum rate of 3.98 t/ha.

4. Conclusion
Spring wheat with systemic application of liquid fertilizer mixtures Megamix forms photosynthetic potential (PP) in the range from 0.637 in the control without treatment to 1.203 mln m2/ha days, when using the preparation with seed treatment with Megamix Seeds and double treatment of crops with stimulating preparations Megamix Profi - 0.5 l/ha (in the phase of tillering (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) at the rate of 4.5 million germinating seeds/ha.

The treatment of seeds and crops with Megamix stimulant contributes to an increase in the yield of soft spring wheat. At the rate of seeding of 4.5 million germinating seeds/ha, the treatment of seeds with the preparation Megamix Seeds provides 3.70 t/ha, which is significantly higher than the control - 3.15 t/ha. The yield at the seeding rate of 4.5 million germinating seeds/ha in a system using liquid fertilizer mixtures with seed treatment with the preparation Megamix Seeds and stimulating drug treatment during the growing season with Megamix Profi - 0.5 l/ha (in the tillering phase (29BBCH)) + Megamix Nitrogen - 0.5 l/ha (in the phase of the flag leaf (39BBCH)) reaches its maximum value - 3.98 t/ha. The yield does not increase when the seeding rate is increased to 5.0 million germinating seeds/ha.

References
[1] Karpova L V, Karpova G A and Strogonova A V 2020 Effectiveness of complex liquid fertilizers in chelate form on the background of natural and mineral nutrition of spring wheat plants Niva Povolzhya 4 (57) 51–57
[2] Remeslo E V and Zubochenko A A 2018 Effect of liquid organo-mineral fertilizers on productivity and quality of winter wheat grain in the steppe Crimea Current State, Problems and Prospects for Agrarian Sciences Materials of the III International Scientific Conference Scientific editor V.S. Pashtetsky pp 168–169
[3] Andreev N N 2017 Effect of Megamix preparation on quality indicators of feed barley grain Vestnik of Ulyanovsk State Agricultural Academy № 4 (40) 9–13
[4] Burunov A N 2011 Efficiency of application of microelement fertilizer "Megamix" on spring wheat Niva Povolzhya 1 9–12
[5] Vasin V G, Elchaninova N N, Vasin A V and Vasin V G 2009 Crop production (Samara: Samara SAA) p 358
[6] Vasin A V 2010 Effectiveness of growth stimulants application in growing fodder crops // Agroindustrial Complex of Upper Volga Region Herald №2 (10) 17–20
[7] Toirov N H, Kiseleva L V and Kozhevnikova O P 2018 Effect of microfertilizer mixture Megamix N 10 on the yield of various sub-species of barley Education and Science in Modern Realities Collection of Materials of VI International Scientific and Practical Conference. Editorial board O.N. Shirokov [et al] pp 95–100
[8] Serzhanov I M, Shaikhraziev Sh Sh, Galiyakhmetov L V and Shaikhutdinov F Sh 2009 Photosynthetic activity of spring wheat crops depending on seeding rates and feeding background Bulletin of Kazan State Agrarian University. 4(14) 128–131
[9] Nikitin S N 2017 Photosynthetic activity of plants in crops and dynamics of growth processes when using biological preparations Successes of modern natural science 3 33–38
[10] Dospekhov B A 1985 Methodology of field experiment (Moscow: Agropromizdat) p 351