Increasing the resistance of the drug calendula to abiotic environmental factors

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Abstract. Currently, medicinal plant growing is one of the promising areas of activity of agricultural enterprises in the Russian Federation. This area has a high economic potential. The deterioration of the general ecological situation, the instability of weather conditions have a negative impact on the growth and development of medicinal crops, leading to a decrease in plant resistance to stress factors and the inability to fully realize their potential with cultivated varieties. Plant growth regulators are one of the most promising groups of pesticides, the advantages of which are that they are harmless, environmentally friendly and highly effective at low consumption rates of biologically active substances of polyfunctional action. Exogenous use of growth regulators makes it possible to activate physiological and biochemical processes, regulate individual stages of morphogenesis, in order to mobilize the potential of the plant organism, aimed at overcoming unfavorable environmental conditions by plants, increasing their resistance to harmful organisms and ensuring optimal productivity. On the territory of the collection nursery of the Middle Volga branch of the FSBI VILAR in 2018-2020, an experiment was carried out in order to study the effect of growth regulators and micronutrient fertilizers Zircon, Epin-extra, Ferovit and Siliplant, on the resistance of plants to unfavorable growing conditions, increasing the yield of inflorescences and seeds of calendula officinalis. Ferovit turned out to be the best result of application in the raw material areas for three years of research in the prevailing weather conditions. The average yield of raw materials of air-dried inflorescences was 2.10 t / ha, which is 0.45 t / ha more than the control variant. On seed plots, the best indicators were obtained with the use of Siliplant micronutrient fertilizer 1.25 t / ha, which is 0.2 t / ha more than the option without the use of drugs.

1. Introduction
In recent years, there has been an increased interest in medicinal plants (MP) and the use of biologically active compounds isolated from them in medicine. Medicinal plants are used industrially for the production of medicines, pharmaceuticals, nutraceuticals and cosmeceuticals, and their use is expected to grow faster than conventional therapeutic chemicals. After a sharp decline in the late 1990s, the areas under medicinal plants in Russia have been growing in recent years and in 2016 amounted to 8410 ha, from which 6460 t of medicinal plant materials were collected [1].

In recent years, the medicinal plant growing industry in Russia has begun to recover as part of the implementation of the Project "Revival of the medicinal plant growing industry in the Russian
The presence of various classes of medicinal plants and preparations and create up to 300 thousand farms united in agricultural production cooperatives that will be engaged in cultivation, primary processing and storage of medicinal raw materials. It is also envisaged to create an "international network platform for the coordination of ecologically pure medicinal plants and the production of concentrated liquid, dry and granular herbal medicinal substances and preparations” [1].

One of the most famous medicinal plants is calendula officinalis (medicinal marigold, Calendula officinalis L.), which is massively cultivated in the Russian Federation, and in the form of varieties with high productivity ("Rayskiy sad", "Zolotoye more", "Kalta", "Ryzhik" and others). The wide spectrum of pharmacological activity of calendula flowers (antimicrobial, anti-inflammatory, regenerating, expectorant, choleretic properties) is justified by the presence of various classes of biologically active substances, namely: flavonoids, carotenoids, saponins [2,3,4,5]. This factor makes calendula a highly promising resource for new herbal medicines and cosmetics.

In 2018-2020, on the territory of the collection nursery of the Middle Volga region and is located within two natural and climatic zones - forest-steppe and steppe. The climate is sharply continental. The average annual air temperature is +2.9 ... + 3.9. In summer, the maximum temperature can reach +40°C and even higher, and in winter, in some years, the minimum air temperature drops to -40°C - 45°C and below.

The main factor limiting the successful growth of medicinal plants are frequent droughts in spring and summer, as well as hot dry weather, leading to disruption of the process of micro- and macrogametogenesis during the period of flowering and seed formation [6].

The experiment was carried out in four replicates. Plot area - 6 m2, accommodation - randomized. The experiment scheme provided for five options:

1. Control - without drug treatment.
2. Zircon - 0.1 l / ha, working solution consumption - 300 l / ha.
3. Epin - Extra - 0.1 l / ha, working solution consumption - 300 l / ha.
4. Ferovit - 0.45 l / ha, working solution consumption - 300 l / ha.
5. Siliplant - 0.6 l / ha, working solution consumption - 300 l / ha.

Sowing was carried out manually, to a depth of 2-3 cm. The seeding rate of seeds is 12 kg / ha, with a row spacing of 45 cm. Sowing was carried out in 2018 - May 5, in 2019 - April 19, 2020 - April 26.

Foliar treatment of plants was carried out in the budding phase. In 2018 - July 2, in 2019 - June 21, in 2020 - June 29.

The collection of inflorescences was carried out manually, in ten stages, after 6 - 7 days, as new inflorescences grew and weather conditions. The seeds of calendula officinalis were collected in two stages as they ripen.

The following growth regulators and microfertilizers were used in the experiments:

Zircon is a natural regulator of non-hormonal origin, obtained from Echinacea purpurea. It is based on a complex of hydroxycinnamic acids and their derivatives, which stimulate growth processes, protect against stress and constitute a plant life support system;
Epin-extra is an artificially created analogue of a natural plant biostimulator, an adaptogen with a pronounced anti-stress effect. Epin activates the plant's own protective functions, developing their immunity to an aggressive environment;

Ferovit is a solution of chelated iron at least 75 l / ha and nitrogen - 40 g / l in the form of urea. Accelerates the growth and development of plants, prevents flowers from falling off. It causes early and friendly flowering. Improves plant acclimatization.

Siliplant is a silicon-containing microfertilizer that increases the content of auxins and cytokinins, that is, those hormones that determine the growth processes of plants. Along with this, Siliplant has an anti-stress effect.

2. Research results

Cultivation of agricultural crops, including medicinal plants, and, in particular, medicinal calendula, is determined, first of all, by its biological characteristics and meteorological conditions during the growing season of plants. The climatic conditions of the growing season in 2018 and 2020 were characterized by an increased temperature regime and a deficit of precipitation in the period from May to September. The average temperature of these months in 2018 was 18.0°C, and in 2020 - 18.2°C, with an average long-term value of 16.5°C. The sum of effective temperatures above + 5°C at the end of the growing season was 1767°C and 2234°C, respectively, with a norm of 1800°C. During the growing season of 2018, 91.9 mm of precipitation fell, and in 2020 - 157.3 mm, with a norm of 235 mm, the bulk of which fell in 2020 in May - early June (about 53%). The climatic conditions of the growing season in 2019 were at the level of average annual values. The average air temperature was 16.7°C, the sum of effective temperatures above + 5°C for the growing season was 1782°C. The amount of precipitation in 2019 was 224.3 mm, which corresponds to 102% of the norm. But it should be noted that a significant proportion of precipitation fell at the end of the growing season, which influenced the process of seed maturation.

The influence of growth regulators and micronutrient fertilizers on biometric indicators of calendula officinalis 2018-2020 are presented in table 1.

Table 1. Influence of growth regulators and micronutrient fertilizers on biometric indicators, calendula officinalis 2018 – 2020.

| Experiment Option | Density, pcs / m² | Plant height, cm | Inflorescence diameter, cm |
|-------------------|-------------------|------------------|--------------------------|
|                   | 2018   | 2019 | 2020 | average | 2018 | 2019 | 2020 | average | 2018 | 2019 | 2020 | average |
| Control           | 24     | 27   | 21   | 24      | 44.7 | 41.0 | 43.8 | 43.2 | 4.28 | 4.50 | 3.59 | 4.12    |
| Zircon 0.1 l/ha   | 31     | 27   | 25   | 28      | 44.2 | 41.0 | 45.9 | 43.7 | 4.42 | 5.60 | 3.70 | 4.57    |
| Epin-Extra 0.1 l/ha | 27   | 27   | 26   | 27      | 43.2 | 43.0 | 43.9 | 43.4 | 4.42 | 6.00 | 3.20 | 4.54    |
| Ferovit 0.45 l/ha | 23     | 29   | 24   | 25      | 48.0 | 43.0 | 44.0 | 45.0 | 4.48 | 5.50 | 3.31 | 4.43    |
| Siliplant 0.6 l/ha| 25     | 27   | 20   | 24      | 43.3 | 40.0 | 43.8 | 42.4 | 4.29 | 5.90 | 3.41 | 4.53    |

One of the most important conditions determining the productivity of crops is the density of plants. Treatment of calendula with medicinal growth stimulants and micronutrient fertilizers had a positive effect on the density of plants in dry conditions in 2018 and 2020. the treatment options with Zircon 0.1 l/ha and Epin-Extra 0.1 l/ha had an advantage, and in the conditions of 2019, the option using Ferovit 0.45 l/ha.
Over the years of research, the best indicators for plant height were observed when plants were sprayed with Ferovit 0.45 l / ha (on average over 3 years, 1.8 cm higher than in the control), in 2020, a variant with the use of Zircon 0.1 l / ha was also noted (on average for 3 years 0.5 cm higher than in the control).

The diameter of inflorescences was positively influenced on average over 3 years by variants with the use of Zircon 0.1 l / ha, Epin-Extra 0.1 l / ha and Siliplant 0.6 l / ha (0.45 cm, 0.42 cm and 0.41 cm more than in the control, respectively).

Thus, the use of growth regulators and micronutrient fertilizers in general had a positive effect on the biometric parameters of calendula officinalis.

Comparative results of the effect of growth regulators and micronutrient fertilizers on the yield of air-dried inflorescences and seeds of calendula officinalis are presented in table 2.

**Table 2. The influence of growth regulators and micronutrient fertilizers on the yield of air-dried inflorescences and calendula seeds are presented, 2018-2020.**

| Experiment Option | Productivity of air-dry inflorescences, t / ha | Seed yield, t / ha |
|-------------------|-----------------------------------------------|-------------------|
|                   | 2018 | 2019 | 2020 | average | 2018 | 2019 | 2020 | average |
| Control           | 1.73 | 1.73 | 1.49 | 1.65   | 1.17 | 1.15 | 0.82 | 1.05   |
| Zircon – 0.1 l/ha | 1.80 | 1.93 | 1.74 | 1.82   | 1.45 | 1.12 | 0.98 | 1.18   |
| Epin-Extra – 0.1 l/ha | 1.72 | 1.84 | 1.39 | 1.65   | 1.11 | 1.44 | 0.70 | 1.08   |
| Ferovit – 0.45 l/ha | 2.33 | 2.19 | 1.77 | 2.10   | 1.03 | 1.40 | 0.89 | 1.11   |
| Siliplant – 0.6 l/ha | 1.95 | 1.97 | 1.56 | 1.83   | 1.38 | 1.45 | 0.92 | 1.25   |
| HCP05             | 0.15 | 0.27 | 0.13 | -      | 0.12 | 0.21 | 0.07 | -      |

In the years of research, the yield of air-dry inflorescences significantly exceeded the control in the variant with the use of Ferovit at a dose of 0.45 l / ha, on average for 2018-2020 in this variant it was 2.1 t / ha, and in the control - 1.65 t / ha.

The effect of growth regulators and microfertilizers on the yield of calendula seeds varied from year to year. In the dry conditions of 2018 and 2020, significant increases were noted in variants with the use of Zircon 0.1 l / ha and Siliplant 0.6 l / ha, and in 2019 - when plants were sprayed with the growth stimulator Epin-Extra 0.1 l / ha and micronutrient fertilizers Ferovit 0.45 l / ha and Siliplant 0.6 l / ha. On average, over three years, the highest seed productivity of calendula officinalis was on the variant with the use of Siliplant 0.6 l / ha (0.2 t / ha higher than in the control), and an increase in seed productivity was also obtained on the variant with Zircon 0.1 l / ha (on 0.13 t / ha higher than in the control). The efficiency of Ferovit on seed plantations is low (only 0.6 t / ha than in the control variant). The use of Epin-Extra on the crops of calendula officinalis did not have a positive effect on the yield of air-dried inflorescences and seeds.

### 3. Conclusion

To increase the adaptability of calendula officinalis to conditions of insufficient moisture and the action of high temperatures in the Middle Volga region and to obtain the highest yield, an effective option on raw plantations turned out to be the option of using Ferovit microfertilizer in the budding phase, 0.45 l / ha, and at receiving seeds - option with Siliplant micronutrient fertilizer, 0.6 l / ha.
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