Influence of biologics on the growth and productivity of tomato plants

T M Trifonova

Pacific National University, 136, Tihookeanskaya st., Khabarovsk, 680035, Russia

E-mail: zam-obcsh@mail.ru

**Abstract.** For the first time in the conditions of the Khabarovsk Territory, the possibility of using growth- and immunostimulators at different stages of tomato culture development has been confirmed. The energy of germination of seeds of the Basilisk Tooth variety under the influence of biologics Aqua energen and Baikal humate increased by 23%, for seeds of the De Barao Red variety in the variant of the experiment with Baikal humate-by 28%. In comparison with the control, an increase in the leaf surface area from 8.92% to 296.46% was noted. We also found an increase in the yield of the studied crop by 11.5% in the variant of the experiment with tomato seeds of the De Barao Red variety treated with Aqua energen.

1. **Introduction**

Tomato on the territory of the Khabarovsk Territory is one of the most common and popular cultures. It is appreciated both for its use for almost any type of technical processing, as well as for high productivity. Moreover, in the soil and climatic conditions of the Khabarovsk Territory, the limiting factors for the development of tomato plants are excessive moisture, strong daily temperature differences in summer and a complex of pests and phytopathogens. In recent decades, a wide range of pesticides has been used to control phytophages and vegetable diseases [1]. At the same time, pathogens gain the ability to adapt to chemical means of protection and easily get used to the changing environmental conditions. The emergence of resistant forms of pests and diseases can lead to mass reproduction of new species that were not previously considered harmful. Changes in the species composition of phytophages and the pathogenic background of tomato plantings cause plant responses to the complex impact of abiotic and biotic environmental factors, manifested in a sharp deterioration in the overall condition of plants and their productivity [2].

The relevance of the study at present consists of the integrated use of growth regulators that have both growth-promoting, and anti-stress and immunomodulating effects in the general system of other technology elements. The use of growth and development regulators in the agricultural industry is a modern area of crop production, based on the latest developments in molecular biology, phytophysiology and other sciences. The practice of using biological agents gives an ever-increasing economic effect. The use of new synthetic growth regulators is regularly expanding. The requirements of crop production are related simultaneously to the protection of the environment from the toxic effects of growth regulators and the specifics of their application, which requires some additional studies. It is becoming increasingly important, along with the search for new ones, to expand the scope of existing drugs. The development of new growth and development regulators should be aimed at improving the quality and quantity of crops, increasing crop productivity while reducing their cost. Based on this...
concept, production should be focused on solving the problems of suppressing vegetative growth and increasing the generative phase associated with the formation of seeds, storage organs and kidneys, extending or suppressing dormancy, accelerating maturation, affecting the basics of plant metabolism and fruit colour [3].

The work aims to identify the most effective growth regulators that are appropriate to apply in the general technology of tomato cultivation in the conditions of the Khabarovsk Territory.

1.1. In our work, we set the following tasks:
- to study the dynamics of growth processes of leaves of tomato plants, depending on the use of biological products;
- to reveal the influence of the studied drugs on the germination energy, germination and yield of various cultivars.

The hypothesis of our study is: the studied drugs have an immunostimulating effect, promote the stimulation of growth processes, increasing the leaf surface area of the leaf as the main photosynthetic organ, increase the resistance of plants to the action of negative environmental factors, and also improve their productivity. The results of the study can be introduced into the educational process as part of laboratory work in elective classes in biology.

The object of research is the study of tomato cultivation technology.

The subject of the study is the study of growth and immunostimulating properties of biological products used in the general technology of growing tomatoes.

The scientific novelty of the study lies in the fact that for the first time studies have been conducted to identify the effect of biologics Aqua energen, Baikal humate on the development and growth of tomato plants grown in the Khabarovsk Territory.

The practical significance of the study lies in the fact that experimentally confirmed the possibility of using the Aqua energen and the Baikal humate in the technology of growing various varieties of tomato in the Khabarovsk Territory.

2. Material and research methods

The studies were conducted on the plantings of two varieties of tomato De Barao Red and Tooth Basilisk in the period from June to September 2018. Seedlings before planting in the open ground were grown in laboratory conditions in universal soil for seedlings Fasko with trace elements from April to June. Agricultural technology in experience is generally accepted for the Khabarovsk district of the Khabarovsk Territory. Plantings of tomatoes grown in the open ground were located on sod-podzolic soils with a heavy mechanical composition, the root-inhabiting layer of which is 15–22 cm. In studies, the Aqua energen and the Baikal humate were used as stimulators of plant growth and development. The repetition in the experiments is threefold.

2.1. Scheme of experiments and technological methods:

2.1.1. Experience I. Stimulation of growth processes in tomato plants of the variety De Barao Red.
- Control (soaking seeds in water);
- The Aqua energen - working solution with a concentration of 0.6 g/1l of water (soaking seeds in the working solution, as well as a top dressing in the emergence phase);
- The Baikal humate - a working solution with a concentration of 1.5 - 2.0 g/10l of water (soaking seeds in a working solution, as well as a top dressing in the emergence phase).

2.1.2. Experience II. Stimulation of growth processes in tomato plants of the variety Basilisk Tooth.
- Control (soaking seeds in water);
- The Aqua energen - working solution with a concentration of 0.6 g/1l of water (soaking seeds in the working solution, as well as a top dressing in the emergence phase);
• The Baikal humate - a working solution with a concentration of 1.5 - 2.0 g/10l of water (soaking seeds in a working solution, as well as a top dressing in the emergence phase).

In experiments with tomatoes, the germination energy and germination of seeds was initially determined. For this, 150 pieces of each variety were counted from the pure seed fraction without selection. In the laboratory, the fraction was divided into three groups of 50 pieces. The seeds were laid out in rows on moistened gauze covering the bottom of the Petri dish. On the third day, the number of germinated seeds was calculated. The same thing was done on the seventh day. The data obtained were then added to the germination energy data (number of germinated seeds on day 3). Thus, the germination of seeds was determined during the study.

The surface area of tomato leaves was determined by M.S. Miller [4]. The fulfilment of the tasks was carried out using such methods as observation, description and experiment, as well as a comparative method. In the work, standard methods of field research were applied under the method of B.A. Dospekhov [5-7].

3. Research results

The soil conditions of the vegetation period of 2018 were generally satisfactory for the tomato culture. The meteorological conditions during the study period were varied, quite fully reflected the characteristics of the region, which made it possible to find out the possibility of using the tested drugs in specific conditions of biotic and abiotic factors. The weather conditions of the vegetation period of 2018 were characterized by an excess of moisture and relatively low temperatures characteristic of our region. The air temperature during the growing season varied on average from +120°C to +210°C, with an average long-term temperature of +230°C. The highest air temperature was observed in July. On some days, the air temperature increased to +310°C, air humidity up to 40% and higher. Analyzing the amount of precipitation and their distribution throughout research, it should be noted the uneven distribution over the phases of plant development. The least precipitation fell during flowering and fruit maturation (July).

The effectiveness of the studied drugs was evaluated according to some criteria: germination energy and seed germination, the rate of passage of the phenological phases of plants, as well as crop yield.

In the conditions of risky agriculture that has developed on the territory, including the Khabarovsk Territory, it is extremely important that the seeds of all agricultural plants give friendly and even seedlings. Therefore, studies were conducted to identify the effectiveness of the Aqua energen and Baikal humate on the germination energy and germination of tomato seeds. First, tomato seeds were soaked under the experiment scheme. On the third day, as a result of the calculations, it was found that the indicators of germination energy in the control variant, in which the seeds were soaked in water, are much lower than the variants in which the seeds were soaked in biological products. The highest indices of germination energy for seeds of the Basilisk Tooth cultivar were noted in the variants using the Aqua energen and the Baikal humate and amounted to 43%, which is 23% higher than in the control variant. In seeds of the De Barao Red variety, the highest germination energy was noted in the variant in which the seeds were soaked in the Baikal humate preparation and it amounted to 51%, which is 28% higher than the control variant. In the variant with the use of the Aqua energen, the germination energy was also higher than in the control variant, but only by 7% (table 1).

The determination of germination is one of the most important types of assessing the quality of seeds, since the seeding rates, and then some biological qualities of the seed, are associated with varying degrees of germination. Sowing seeds without preliminary verification of germination can lead to some unforeseen phenomena and is equivalent to the work being done blindly.

When determining the germination capacity of tomato seeds under laboratory conditions, the high efficiency of the Baikal humate preparation was revealed in the variant with soaking seeds of the De Barao Red variety, the germination in this variant was the highest and exceeded the control variant by 13%. The seeds of the Basilisk Tooth cultivar were less responsive to the action of the studied drugs. Germination in seeds of this variety turned out to be the highest in the control variant, in which the seeds were pre-soaked in water and amounted to 60% (table 2).
Table 1. The effect of biological agents on the germination energy of tomato seeds.

| #  | Option-drug  | Germination energy of tomato seeds, % |
|----|--------------|---------------------------------------|
|    | variety      | Variety                               |
| 1  | Control      | De Barao the Red 23% The Basilisk Tooth 20% |
| 2  | Aqua energen | 30% 43%                               |
| 3  | Baikal humate| 51% 43%                               |

Table 2. The influence of biological agents on the germination of tomato seeds.

| #  | Option-drug  | Germination of tomato seeds, % |
|----|--------------|--------------------------------|
|    | variety      | Variety                          |
| 1  | Control      | De Barao the Red 50% The Basilisk Tooth 60% |
| 2  | Aqua energen | 23% 41%                           |
| 3  | Baikal humate| 63% 43%                           |

Studying the effect of biologics on the rate of passage of phenological phases of tomato plants, we conducted phenological observations, during which we noted the beginning of each phase when it was observed in 10% of plants of each variant, as well as the mass onset – in 75% of plants. The following phenophases were observed in tomato plants: the emergence of seedlings, appearance of the first two true leaves, budding, flowering, and crop maturation.

The seeds germinated in laboratory conditions were planted in open ground on April 2, 2018. The appearance of the first tomato seedlings was noted on April 03 in the control version, the mass appearance of seedlings – on April 05, 2018. A high rate of growth processes was noted in the control variant with all seeds of the tomato variety De Barao Red and the emergence of seedlings was noted in 100% of the seeds. Growth processes in the seeds of the De Barao Krasny variety soaked in a working solution with Aqua energen were less intense and 54% of plants had grown by April 3. In the experiment with the Baikal humate preparation, the number of seedlings was 18% of the total number of seeds. By April 08, 2018, there was a massive emergence of seedlings in all experimental variants, even though seed germination in the experimental variants was different.

The appearance of the first true leaves usually occurs on the 5-7th day after the emergence of seedlings. The appearance of the first true leaves was noted in plants of the De Barao Red variety, whose seeds were soaked in a solution of the Aqua energen preparation. Further observations revealed the massive appearance of true leaves by April 25th.

The flowering period is one of the most important and responsible during the cultivation of tomatoes. If before that it was important for tomatoes to maintain a suitable temperature regime and give plants the maximum possible illumination and watering, then after the appearance of the first buds, the correct and timely feeding of tomato bushes comes to the fore. During the study, the watering of the test samples was carried out with working solutions. The period of budding came at the beginning of July when heavy precipitation and a decrease in temperature were observed. The average temperature at that time was about 20°C, which is considered unfavourable for the period of flowering of tomato. The beginning of flowering was noted on June 14, despite the low temperatures. The plants of the tomato De Barao Red of the experiment variant with the Aqua energen were the first to bloom. The proportion of plants that entered the phase of the onset of flowering amounted to 71% of the total number of plants. The number of flowering tomato plants of the variety Basilisk Tooth, the seeds of which were soaked in the Baikal humate, amounted to 46%. Only 29% of the plants bloomed in the control.
Mass flowering in tomato plants occurred on June 29. Of the plants of the De Barao Red variety, earlier, mass flowering was noted in a variant of the experiment in which the seeds were soaked in a working solution of the Aqua energen. In the variant of the experiment with the Baikal humate, only about 50% of plants bloomed. In the control variant, mass flowering occurred a few days later.

Weather conditions improved, but waterlogging of the soil remained for a long period. The first fruits started on July 10 on tomato plants of the De Barao Red variety in an experiment using an Aqua energen solution. The mass appearance of tomato fruits came in the second half of July. The average air temperature was +24°С. Humidity was more than 70%.

It is known that humate-based growth and fertilizer regulators, weakening the influence of external environmental factors on plants, significantly enhance photosynthesis processes. Photosynthesis is a complex system of various reactions from photophysical to biochemical, controlled by hormones, during which carbon dioxide is absorbed by the plant and the formation of organic matter. During the study, tomato leaves of varieties De Barao Red and Basilisk Tooth were collected for analysis in the phase of intensive fruit growth, corresponding to the activity of photosynthetic reactions. Biological treatment affects the development of the assimilation apparatus of plants, as evidenced by the increase in the leaf area of the studied culture, compared with the control.

The size of the leaf surface of plants, as the main nourishing organ, is of particular importance in their productivity. As can be seen from table 3, the drugs affected the area of the leaf surface. In the experiment with seeds of the De Barao Red variety, the largest significant increase in leaf area was noted in the variant using the Baikal humate preparation, the increase compared to the control in it was 8.92%. In the experiment with the seeds of the Basilisk Tooth variety in the variants with the Aqua energen and the Baikal humate, an increase in the leaf surface area was revealed compared with the control by 296.46% and 282.18%, respectively.

**Table 3.** The influence of biological agents on the surface area of the leaf of tomato plants.

| #   | Option-drug     | Leaf surface area |            |                  |            |                  |
|-----|-----------------|-------------------|------------|-----------------|------------|-----------------|
|     |                 | De Barao the Red  | Variety    | The Basilisk Tooth | % to control | % to control |
|     |                 | see² | % to control | see² | % to control |
| 1   | Control         | 51.01±0.01        | -          | 14.14±0.01      | -          |
| 2   | Aqua energen    | 46.97±0.02        | - 8        | 56.06±0.01      | 296.46     |
| 3   | Baikal humate   | 55.56±0.01        | 8.92       | 54.04±0.02      | 282.18     |

Currently, an important factor in the effectiveness of growing any crop is high yield. Productivity is affected by many properties and characteristics of plants (disease resistance, photosynthesis efficiency, the nature of the root system development, the ability to withstand various extreme environmental conditions, and much more). In this regard, there is a need to use biologics both for growth-stimulating action and for reducing interphase periods and increasing productivity, as well as increasing the resistance of plants to adverse factors [2].

The main purpose of cultivating crops is to obtain a high-quality crop that meets the requirements of environmental safety. In the course of the research, the largest tomato crop was obtained in an experiment with seeds of the De Barao Red variety (table 4). The average productivity of tomato plants of this variety in this embodiment was 2.3 kg/1 bush. At the same time, the largest yield increase of 11.5% compared with the control was revealed in the experiment in which the plants were treated with the Aqua energen.

In the experiment with seeds of the Basilisk Tooth variety, the largest increase in yield was observed in variants with the Aqua energen and Baikal humate and amounted to 2.5 and 2.6 kg/1 bush, respectively.
Table 4. The Effect of biological agents on the productivity of tomato plants.

| #  | Option-drug          | variety             | Productivity, kg/bush |
|----|----------------------|---------------------|-----------------------|
|    |                      | De Barao the Red    |                       |
| 1  | Control              | 2.034±0.01          | 2.166±0.01            |
| 2  | Aqua energen         | 2.269±0.02          | 2.467±0.01            |
| 3  | Baikal humate        | 2.099±0.01          | 2.571±0.01            |

| #  | Option-drug          | variety             | Productivity, kg/bush |
|----|----------------------|---------------------|-----------------------|
|    |                      | The Basilisk Tooth  |                       |
|    |                      |                     |                       |

4. Conclusion
In the course of the study, the possibility of using growth and development regulators on seeds and plants of tomato culture as growth and immunostimulants were confirmed. The use of drugs during the growing season affects both the plants as a whole and their productivity. In comparison with the control, an increase in the leaf surface area was noted up to 296.46% in the experiment with the seeds of the Basilisk Tooth variety and up to 8.92% in the experiment with the seeds of De Barao Red. The largest yield increase of 11.5% was noted in the variant with tomato seeds of the variety De Barao Red, treated with the Aqua energen. In the experiment with seeds of the Basilisk Tooth variety, the largest increase in yield was observed in variants with the Aqua energen and Baikal humate and amounted to 2.5 and 2.6 kg/1 bush, respectively.

References:
[1] Izhevskiy S S 2006 Negative consequences of the use of pesticides Protection and quarantine of plants 5 16-9
[2] Andreev Yu M 2002 Vegetable growing: a Textbook for the beginning (Moscow, Russia: Profobrizdat) p 256
[3] Vakulenko V V and Shapoval O A 2000 New growth regulators in agricultural production. Scientific support and improvement of the methodology of agrochemical service of agriculture in Russia (Moscow, Russia) pp 71–89
[4] Skazkin F D, Miller M S and Obukhov G A 1973 Summer practical classes in plant physiology. (Moscow, USSR: Prosveshenie) p 207
[5] Dospelkov B A 1985 Methods of field experience (Moscow, USSR: Kolos) p 416
[6] Lankin G F 1990 Biometrics (Moscow, Russia: Higher. School) p 352
[7] Moiseychenko V F, Zaiverykha A Kh and Trifonova M F 1994 Basics of scientific research in fruit growing, vegetable growing and viticulture (Moscow, Russia: Kolos) p 383