The influence of red algae ahnfeltia tobuchiensis on the growth and development of cress salad under protected ground

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Abstract. In the modern world, special attention is paid to the rational use of natural resources and the provision of the population with safe food for health. In this connection, the study of the effectiveness of algae-based fertilizers is a relevant and promising direction, as it allows to reduce chemical pressure on agrobiocenoses. This article presents the results of a study on the effect of fertilization from the red alga Ahnfeltia tobuchiensis on the germination and growth rate of watercress Zabava variety in protected ground conditions. When making anfelcia, it was found that the effectiveness of its use as a fertilizer significantly depends on the size of its particles. The weight of the harvested watercress crop was on average 87% higher compared to the control when using fertilizer with a particle size of 1-5 mm. The rate of development of watercress when using anfelcia with a particle size of 0.25-1.0 mm was at the control level, and the yield weight was 44.5% more than in the control. The minimum crop weight was observed when using fertilizer with a particle size of more than 5 mm. When anfelcia is added as a fertilizer to the soil in the watercress samples, an increase in the content of mineral substances in general and individual elements (potassium, calcium, sodium, manganese, etc.) is noted.

1. Introduction

In recent decades, in many countries of the world, it has become increasingly popular to obtain agricultural products without the use of synthetic chemical fertilizers and pesticides. In this case, algae fertilizers are of great interest. The special mineral composition of algae improves plant nutrition, and substances such as polysaccharides, polyphenols, betaines, sterols affect their growth and development [1]. Algae as fertilizers are used in different forms, both without deep processing (raw, dry, whole, crushed), and in the form of humus, algal ash and extracts. Quite a lot of works have been published on the world experience of using extracts from seaweed in agriculture [2]. Phytohormones that stimulate or inhibit plant growth and morphogenesis, such as auxins, cytokinins, ethylene, gibberellins, abscisic acid, etc., were found in seaweed extracts [3]. Algae extracts stimulate not only plant growth [4], but also the content of chlorophyll, carotenoids and improve root development [5].

In Russia, the use of algae in agriculture is a new, but promising direction. There are known such methods for the production of fertilizers from waste processing of seaweed in the production of agar by processing secondary waste with acid, filtration and washing; another way is to put seaweed in pits or storage tanks, keeping them for 8-10 days, as a result the thallus turn into a semi-liquid mass; or placing storm emissions in a storage tank, washing in seawater from sand and pebbles, then in fresh
water, grinding and processing with a 1-2% solution of hydrochloric acid, stirring and obtaining a mass that is mixed with sawdust of deciduous trees and sand to moisture the final product 10-15% [6].

The available literature contains data on the use of only brown algae in crop production. However, in the Far East, especially in the Sea of Japan, there are significant reserves of the red alga Anfelta tobuchiensis (Ahnfeltia tobuchiensis), and large storm emissions are formed in the areas of its habitat [7]. There are no data in the literature on the use of freshly harvested anfelta or its storm emissions as fertilizer.

The purpose of this study is to study the effect of fertilization from storm emissions of anfelta on the growth rate and germination capacity of watercress Zabava variety in protected ground at the Primorskaya State Agricultural Academy.

2. Materials and methods

Objects of research: Storm emissions from Anfelta tobuchiensis collected onshore in the Stark Strait (Sea of Japan) in October 2019. Air-dry algae samples were crushed for chemical analysis.

Fertilizer for experiments was obtained on the basis of crushed air-dry anfelta. After crushing the algae, part of the sample was divided into fractions using sieves 1.0 mm and 0.25 mm (figure 1).

Watercress Variety Fun. The period from full germination to the beginning of the economic shelf life is 25-30 days. The rosette of leaves is raised, 20-30 cm high, 8-10 cm in diameter, the number of leaves is 7-8. The leaf is medium-sized, green, with a slight waxy bloom, elongated-oval, pinnately dissected, leaf blade 11-18 cm long, 3-4 cm wide.

An experiment on the effect of fertilizer from Anfelta Tobuchinskaya on the growth and development of watercress variety Zabava was carried out from 16.04 to 10.05. 2020 in protected ground conditions of the Primorskaya State Agricultural Academy.

Experiment scheme: 1) control (without fertilization); 2) experiment with fertilization, from 5 mm; 3) experiment with fertilization, particle size from 1.0 to 5.0 mm; 4) experiment with fertilization, particle size from 0.25 to 1.0 mm.

Soil weight 540 g, fertilizer weight 60 g (10%). The seeding rate of watercress is 1 g / pot.

In algae samples, the mass fractions of water, iodine and minerals were determined [8], the nitrogen content was determined by the Kjeldahl method using a Kjeltec auto 10 SO Analyzer (Tecator, Japan), the total lipid content was determined by the Bligh-Dyer method [9], the content of easily hydrolysable carbohydrates - by the colorimetric method at a wavelength of 620 nm [10], fiber - by the method of Kurschner and Haneck [11].

The preparation of plant materials for the atomic absorption determination of macro- and microelements was carried out by the method of acid mineralization according to GOST 26929-94 [12]. The concentration of elements in algae samples was determined on an atomic absorption spectrophotometer "Nippon Jarell Ash" AA-855 and "Shimadzu AA-6800".
3. Results
Anfelcia Tobuchinskaya is the main type of red algae in the Far East, from which agar is obtained. Its carbohydrates are represented by a complex mixture of polymers 3,6-anhydrogalactose and galactose [13]. In comparison with brown algae, Anfeltia Tobuchinskaya is distinguished by a high nitrogen content and a small amount (1.5–2.0% by weight of dry algae) of water-soluble organic substances [14]. The chemical composition of Ahnfeltia tobuchiensis (storm emissions) is presented in (table 1).

| Conditions for collecting algae | Content,% dry matter |
|--------------------------------|----------------------|
| Storm emissions                | mineral substances   |
|                                | squirrel, Nx6.25     |
|                                | lipids               |
|                                | LHP                  |
|                                | fiber                |
|                                | iodine               |
| 18.8                           | 18.5                 |
| 0.3                            | 4.0                  |
| 13.5                           | 0.19                 |

The content of individual elements of algae is presented in (table 2).

| Conditions for collecting algae | Ca | Na  | K    | Mg  | Mn  | Fe   | Zn   | Cu  | As  | Cd  | Pb  | Hg  |
|--------------------------------|----|-----|------|-----|-----|------|------|-----|-----|-----|-----|-----|
| Storm emissions                | 852| 9163| 2236 | 317 | 22.1| 2.05 | 0.47 | 0.43| 0.017| 0.16| 0.01|

The predominant macronutrient in Ahnfeltia tobuchiensis, as in many other seaweed species, is potassium. The content of calcium and magnesium is approximately 2.5 times, and magnesium is 7 times less than potassium. Of the remaining elements, a high content of iron and magnesium is noted.

As the experiment showed, fertilization in the form of crushed air-dry anfeltia changes the structure of the soil and affects the rate of seed germination. Seedlings appeared most rapidly in the control on the 5th day of the experiment, and on the 7th day of the experiment, seedlings appeared in all experimental groups (figure 2).

![Figure 2. Mass shoots of watercress on the 7th day of the experiment (22.04).](image)

The application of fertilizer in the form of an air-dry anfeltia to the soil also changes the rate of plant development. The differences were especially noticeable on the 12th day, when in the control and in the 4th experimental group the number of seedlings became comparable, and in the 3rd group and especially in the 2nd group it was noticeably less (figure 3).
Figure 3. Growth of watercress on the 12th day of the experiment (27.04).

In group 2, only single shoots are observed. Most likely, coarsely crushed anfelia interferes with the development of roots of watercress seedlings, as it compacts the soil structure and reduces air exchange. The easiest way to develop watercress was in test sample 4, where anfelia of the minimum size of grinding was used. However, by the time of harvest, on the 20th day (07.05), the largest number of plants was in group 3. At the same time, the plants were larger, uniformly green, while wilting of plants began in other groups and in the control (figure 4).

By this time, the physiologically active substances of the alga had a noticeable effect on the growth and development of watercress in all experiments. The plants developed larger than in the control, but the fertilization efficiency significantly depended on the size of the anfelia particles. In experimental sample 4, with a minimum size of anfelia particles (0.25-1.0 mm), the rate of development of watercress did not differ much from the control, and by the 20th day of the experiment, their growth slowed down. In 3 experimental sample (more than 1 mm), the rate of plant development during the first week was lower, but after 12 days it increased until the time of harvest.

These observations were confirmed by determining the weight of the harvested crop (Table 3). The maximum weight was determined in group 3, an average of 47% more than in the control. In group 4, the weight of plants was 31% more than in the control, and in group 2 - 29% less than in the control.

Consequently, the optimal conditions for the development of watercress were created when using anfelia as a fertilizer with a grinding degree of 1.0-5.0 mm. Pieces of algae in the ground to some extent prevented the rapid emergence of plants, in contrast to the control sample. However, in the future, under the influence of anfelia substances, they gained the maximum mass in comparison with other experimental samples.
Table 3. Weight of watercress (before drying).

| Experience Option                          | Repetition | Watercress weight, g |
|--------------------------------------------|------------|----------------------|
| Control (without fertilization)            | 1          | 4.98                 |
|                                            | 2          | 5.12                 |
|                                            | Average    | 5.05                 |
|                                            | 1          | 3.74                 |
| Experience with fertilization, no fractionation | 2          | 3.45                 |
|                                            | Average    | 3.59                 |
|                                            | 1          | 9.56                 |
| Fertilizer test, particle size from 1.0 mm  | 2          | 9.42                 |
|                                            | Average    | 9.49                 |
|                                            | 1          | 7.24                 |
| Fertilizer test, particle size 1.0 to 0.25 mm | 2          | 7.36                 |
|                                            | Average    | 7.30                 |

We investigated the effect of minerals and anfeltia iodine on the composition of watercress samples. In the experimental samples, especially in 3 and 4, the content of mineral substances in general increased markedly (table 4). They accumulated a significant amount of iodine, while iodine was not detected in the control and in the second sample.

Table 4. Content of minerals and iodine in watercress samples (dry weight).

| Experience Option                              | Moisture % | Iodine % | Minerals % |
|------------------------------------------------|------------|----------|------------|
| Control (without fertilization)                | 6.83       | 0.000    | 19.32      |
| Experience with fertilization, no chopping     | 7.05       | 0.000    | 20.10      |
| Fertilizer test, particle size from 1.0 mm     | 5.90       | 0.017    | 23.24      |
| Fertilizer experiment, particle size from 0.25 mm | 8.15       | 0.012    | 24.17      |

In all experimental samples, in comparison with the control, the amount of basic elements increased: Ca, Na, K, Mn, Fe, Cu (table 5). At the same time, the content of Mg, Zn slightly decreased.

An interesting fact is the decrease in the Pb content in the experimental watercress samples compared to the control. At the same time, the introduction of anfeltia in the form of fertilizer slightly increases the amount of cadmium in the experimental samples compared to the control, and also in them, in contrast to the control, Hg was detected. However, the content of these elements in watercress does not exceed the norm [15]. The most significant increase in the main elements (Ca, Na, Mn, Fe, Cu) was noted in sample 4, for the cultivation of which fertilizers with the finest grinding of anfeltia were used. It is possible that the high concentration of individual elements in the anfeltia and the excess of the norm in the needs of watercress in them led to a slowdown in the growth rate of the plant after 12 days of development and the accumulation of less mass than in the 3rd experimental sample. Based on the results of the studies carried out, we assume that the amount of organic fertilizer in the form of crushed anfeltia with a particle size of 0.25 mm to 1.0 mm should be reduced (less than 10% of the soil mass) when growing watercress or other objects in an enclosed space.

5. Conclusion
Based on the results obtained, it can be concluded that the effectiveness of using anfeltia as a fertilizer significantly depends on the size of its particles. The introduction of anfeltia changes the structure of the soil and affects the rate of seed germination and the development of watercress in protected ground conditions. The minimum rate of plant development and the weight of the yield was observed when using crushed anfeltia without fractionation as a fertilizer. The rate of development of watercress when using anfeltia with a particle size of 1.0-0.25 mm is at the control level, at the same time, the
yield weight was 44.5% higher than in the control. The application of fertilizer with a particle size of 1-5 mm contributed to a significant increase in the rate of plant development after 12 days of the experiment. The plants were larger, well developed, without signs of wilting. The weight of the harvested crop under these growing conditions was the maximum, on average 87% higher than in the control.

Table 5. Element content in watercress samples (mg / 100 g dry weight).

| The elements | Control (without fertilization) | Experience with fertilization, no chopping | Fertilizer test, particle size from 1.0 mm | Fertilizer experiment, particle size from 0.25 mm |
|--------------|---------------------------------|-------------------------------------------|------------------------------------------|-----------------------------------------------|
| Ca           | 462.90                          | 533.10                                     | 562.70                                   | 628.70                                        |
| Na           | 703.10                          | 817.00                                     | 802.20                                   | 831.70                                        |
| K            | 876.60                          | 884.60                                     | 946.90                                   | 886.70                                        |
| Mg           | 90.40                           | 86.10                                      | 87.40                                    | 90.10                                         |
| Mn           | 4.20                            | 9.00                                       | 6.20                                     | 15.70                                         |
| Fe           | 95.80                           | 102.40                                     | 96.70                                    | 136.20                                        |
| Zn           | 35.40                           | 24.30                                      | 25.60                                    | 28.60                                         |
| Cu           | 0.42                            | 0.46                                       | 0.99                                     | 1.240                                         |
| As           | 1.50                            | 7.50                                       | 0.35                                     | 1.85                                          |
| Cd           | 0.007                           | 0.012                                      | 0.011                                    | 0.014                                         |
| Pb           | 1.44                            | 0.96                                       | 0.80                                     | 1.77                                          |
| Hg           | 0.000                           | 0.849                                      | 0.239                                    | 0.200                                         |

When anfeltia is added as a fertilizer to the soil, an increase in the content of minerals in general and of individual elements (potassium, calcium, sodium, manganese, etc.) in the watercress samples is noted. Especially significant is the fact that iodine appears in the range of 0.012-0.017% (12-17 mg / 100 g) in watercress samples when using chopped anfelcia less than 5 mm.

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