Effect of vermitea on morphological parameters of wheat seedlings

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Abstract. It was shown that low concentrations of vermitea stimulated the development of wheat seedlings under water culture conditions. Both shoot length and root length were statistically significantly longer in the vermitea nutrient solution than in the control (Hewitt's solution). A very strong positive correlation (r=0.99) was found between the content of humic acids in hydroponic solutions and the length of roots formed by wheat seedlings.

1 Introduction

In a general sense, vermitea is an aqueous humate-mineral extract of vermicompost. The composition and concentration of substances in vermitea may vary depending on the composition of the initial vermicompost, the extraction time, the amount of extractant, the type of extractant (distilled, tap, artesian, tempered/non-permanent water). The methodological advantages of vermitea lie in the possibility of carrying out hydroponic experiments, including the hydroponic variant - water culture of plants. The aim of the experiments was to study the effect of low-concentrated vermitea, obtained from vermicompost based on woody leaves, on morphophysiological parameters of wheat seedlings. The low content of plant mineral nutrients made it possible to discriminate the effects of vermicomposts on the plants studied against the background of the reduced influence of the mineral component of nutrient solutions.

2 Materials and methods

The seedlings of spring wheat variety Irene (Triticum aestivum L.) of the 2019 harvest, kindly provided by the farm of IP Oryschenko V.P were chosen as the object of biological research. Irene is an early and high-yielding variety with a vegetation period of 70-80 days. According to the results of competitive variety testing, the variety of spring wheat Irene has been included in the State Register since 1998: Northern, North-Western, Central, Volgo-Vyatksy, Ural, Western Siberian, Eastern Siberian. The weight of 1000 grains is 35-42 g.

Twenty-five wheat seeds were placed in 90 mm diameter glass Petri dishes on filter paper pre-moistened with 7 milliliters of distilled water. Closed Petri dishes with wheat seeds were wrapped in food film, placed in a 20-liter TS-1/20 SPU dry-air thermostat and

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incubated for 48 hours at a temperature of 25±0.1 °C. At the end of the two-day exposure period in the thermostat, 10 visually similar and medium-sized seedlings were selected from each Petri dish. The seedlings were then placed in special growing vessels consisting of two parts: an outer cup and a smaller inner cup with 10 holes (2 mm diameter) around the circumference. The design of these vessels was developed by Y.E. Yakimov [1]. The large cup was filled with Hewitt's nutrient solution. The level of the solution was chosen so that the holes at the bottom of the inner cup were filled with liquid. The volume of solution in the container prepared for the plants varied between 290-310 ml. Selected wheat seedlings were placed between the holes and after 1-2 days the roots sprouted through the holes into the solution.

On the 5th day, the seedlings showed good rooting in the solution, which allowed further cultivation of shoots. The degree of rooting and root system development may vary depending on the composition of the nutrient solution.

Thus, the described hydroponic variant is suitable for observing the processes of primary shoot growth as well as the processes of root formation in wheat seedlings.

In this series of experiments, low-concentration vermitea prepared from willow and poplar leaf litter-based vermicompost was used as an experimental nutrient solution for wheat seedlings, and vermitea prepared from cattle manure-based vermicompost [2] was used as a variant for comparison. Hewitt's universal nutrient solution, a balanced complex of macro and micro elements, was used as a control for all vermitea variants.

For the preparation of vermitea, a sample of chopped air-dried vermicompost was poured with distilled water in a ratio of 1:50 by weight, shaken on a shaker for 3 minutes and left for further extraction for 24 hours at room temperature. The extracts obtained were then filtered through a blue ribbon filter, resulting in a clear but intensely coloured liquid, ranging in color from yellow to brown. The colouration of the extracts was due to the presence of vermigumates, humic substances extracted from vermicompost (including humic and fulvic acids). Initial samples of vermitea were analyzed for humic acid content according to the method described in the literature [3].

In order to prepare working hydroponic solutions, we used the method of balancing solutions obtained from different sources by the integral electrochemical parameter - electrical conductivity. Each of the vermitea concentrates and Hewitt's nutrient solution was diluted with distilled water until the electrical conductivity of the solution reached the value of 50 μS/cm. In this way, mineral-humate nutrient solutions with low concentrations of macronutrients were obtained. For example, the content of potassium ions in the solutions obtained did not exceed 0.3 mg·eq/L, which is an order of magnitude lower than the optimal concentration of this cation in a balanced nutrient solution. This approach allowed us to emphasize the effects of vermigumates on the plants studied against the background of the reduced influence of the mineral component of the nutrient solutions.

Hydroponic vessels containing wheat seedlings were placed in a small semi-homeostatic phytocamera, which is a chipboard frame reinforced with aluminium plates - struts. Six Uniel ULI-P10-18W SPRF SPRF IP40 LED photosynthetic lamps were mounted on the ceiling of the structure.

Main characteristics of luminaires:
- Power consumption, W - 18.
- Dimensions, mm, - 560×22×34.
- Peaks of emission spectrum, nm - 445 and 660.
- Hue of emitted light - light pink.

The area of the platform with fixed lamps is 0.24 m², the height of the vertical posts - 46 cm. Distance from the lamps to the bottom of the hydroponic vessel - 40 cm. Capacity of the phytocamera - 12 hydroponic vessels. The term "semi-homeostatic" means maintaining
a certain level of illumination and a 16:8 day/night light period (set by an electromechanical timer). Temperature and humidity in the chamber itself are not controlled, but are maintained at a pre-set level in the laboratory room by a Daikin (Japan) air conditioning unit.

The duration of seedling cultivation in the phytocamera was 7 days. At the end of cultivation, the seedlings were removed from the hydroponic vessels and the roots were dried on filter paper. The seedlings were placed on a dark cloth surface and photographed together with a calibration ruler for subsequent computer morphometry. Morphometric measurements were performed using the ImageJ computer program [4]. ImageJ is a cross-platform, open-source computer program for image analysis and processing. It was written in Java by staff at the National Institutes of Health (USA) and is distributed in the public domain without license restrictions. ImageJ has the ability to calibrate images and measure curve lengths, curvilinear areas, particle counts, etc. It is widely used in biomedical research, astronomy, geography and other image analysis disciplines. ImageJ is used for computational morphometry in agronomy, plant physiology and ecotoxicology [4].

From the results of the experiments, the following morphophysiological parameters of the wheat seedlings were determined:

- Length of shoots formed.
- Length of roots formed.

The set of statistical methods used in the work included calculation of the arithmetic mean, 95% confidence intervals for the arithmetic mean and correlation analysis. In all figures, data are presented as arithmetic means and 95% confidence intervals. All of the above statistical procedures were carried out using the STATISTICA application, 7.0.

3 Results and Discussion

Figure 1 shows that growing the wheat variety Irene on vermitea had a positive effect on shoot length compared to the control nutrient solution. The increase in shoot length in the variants with poplar, willow and manure was 18.7%, 26% and 27.3% respectively. Also, among the variants with vermitea, willow and manure were found to have the greatest shoot forming ability and poplar was statistically significantly inferior for this indicator.

![Fig. 1. Shoot length of Irene wheat seedlings grown on human mineral extracts under water culture conditions.](image)
Figure 2 shows data that also indicates the root-forming ability of vermitea. All varieties of vermitea are statistically different from the control. For example, in the willow-manure-poplar row, root growth was 24.2%, 49.2% and 85.1% relative to the control, respectively.

![Figure 2](image)

**Fig. 2.** Root length of daily seedlings of wheat variety Irene grown on humate-mineral extracts under water culture conditions

The content of humic acids in vermicompost samples from poplar and willow leaf litter was 12.7 and 5.32 mg/l, respectively. Vermitea from cattle dung based vermicompost contains 2.14 mg/l of humic acids. Table 1 shows the results of the correlation analysis between the morphological characteristics of wheat seedlings and the concentration of humic acids in the hydroponic solutions.

**Table 1.** Correlation analysis of the dependence of morphometric parameters of wheat seedlings on the content of humic acids (HA) in the cultivation medium.

<table>
<thead>
<tr>
<th>Feature pairs</th>
<th>Correlation coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>HA content - Shoot length</td>
<td>0.34</td>
</tr>
<tr>
<td>HA content - Root length</td>
<td>0.99*</td>
</tr>
</tbody>
</table>

* - significant difference at p<0.05

In experiments conducted by authors from India [5], pea plants treated with humic acid-rich vermicompost produced 109.17% and 82.97% more shoot and root biomass, respectively, and were 51.61% higher than the control. Interestingly, plants treated with HA-rich vermicompost also showed increased nodulation: the number of nodules increased by 45.49% compared to the control, by 68.84% compared to chemical fertilizers and by 33.50% compared to conventional vermicompost [5-6].

**4 Conclusion**

Thus, the data obtained in this study suggest that the beneficial effect of vermitea on wheat seedlings is largely due to the root stimulating effect of vermihumates.
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