Integrative features of biologically active substances and vermicompost in action on the anatomical features of decorative cultures

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Abstract. The article discusses alternative ways of protecting ornamental crops from stress factors of a biotic nature by increasing passive immunity when using vermicompost as the main source of macro- and microelements and biologically active substances, which differ in adaptogenic and immunomodulating properties. The change in the anatomical and physiological characteristics of ornamental plants of anthropogenic and cultural landscapes, which determine their environmental resistance to stress factors and harmful objects, is shown. The thickness of the epidermis of leaves of Rosa L. increased 1.5 times; Tulipa L. - 1.4; Gladiolus L. - 1.6 times; leaf mesophyll thickness of 1.9; 1.4; 1.6 times respectively; leaf thickness of Rosa L. and Gladiolus L. plants increased 1.2 times; Tulipa L. - 1.7 times. A significant increase in the osmotic pressure of plant cells of Tulipa L. and Gladiolus L. is significantly increased (by 26.8 and 28.3 kPa); different varieties of Rosa L. Weak opening of stomata was observed in experimental variants of Tulipa L. and Gladiolus L., as well as highly resistant varieties of Rosa L.

Introduction. Decorative cultures in anthropogenic and cultural landscape are exposed to a complex of stress factors of abiotic and biotic nature, in particular damage by pests and diseases [1,2]. The use of pesticides in urban ecosystems is impractical due to the toxicity of drugs and possible negative effects on human health. In addition to the negative impact on the environment and humans, pesticides can lead to a number of negative changes in the decorative qualities of cultivated plants, which serve for landscaping urban landscapes. Irrational use of pesticides causes a change in the color of leaves, flower petals, their decay. Thus, our studies on the protection of chrysanthemums from pests in protected ground conditions showed that when processing plants on the reference variant with the Dimethoat 400 insecticide, 40% ke, one hundred percent biological efficiency was achieved with respect to thrips tabaci. But a fact should be noted: the shelf life of cut flowers in the refrigerator was reduced by 3 times, the petals began to rot, while the flowers cut on experimental versions using biological preparations Fitoverm and Mival-Agro against the background of improved organic mineral nutrition retained freshness and decorative qualities under the same conditions [3,4].

Plant diseases that have a non-infectious and infectious beginning lead to a disruption in the normal metabolism of the plant, photosynthesis, enzymatic processes, respiration, carbohydrate, protein metabolism, as well as other physiological and biochemical processes, which is a prerequisite for a decrease in decorativeness, productivity, and in general, plant resistance [5,6,7,8,9]. Factors of passive
immunity are the anatomical features of plants, in particular, a change in leaf anatomy, which determines their resistance to the introduction of parasites. To increase the resistance of plants to biotic and abiotic stress factors, the development of passive immunity requires a versatile approach to finding alternative ways to improve the life support of plants, in particular, protection from harmful objects. The identification of the possibility of using biologically active substances (BAS) in combination with vermicompost for the development of passive immunity of ornamental crops is one of the urgent issues of applied botany, ecology, and plant protection [10, 11, 12].

The purpose of the study is to increase the resistance of flower plants to harmful objects when using a complex of biologically active substances and vermicompost. Materials and methods. The studies were carried out in the municipal unitary enterprise Zelenstroy of the city of Oryol in 2015-2019. Objects of study: Rosa L., Tulipa L. and Gladiolus L. The studied varieties of tea-hybrid roses: 'Aqua', 'Christophe Colomb', 'Double Delight', 'Elegance', 'Forever Young', 'Lovely Red', 'Nostalgie', 'Royal baccara', 'Shakira', 'Pullman Orient Express', characterized by high demands on growing conditions, prefer fertile well-structured soils. Vermicompost obtained on the basis of WWS, buckwheat husk and ash was used as fertilizers using earthworms from the Lumbricidae family. Sewage sludge (WWS) of the municipal unitary production enterprise of water supply and sewage facilities “Orelvodokanal”, buckwheat husk of LLC “Elita”. Characteristics of sewage sludge: N\textsubscript{total} 1.6%; P\textsubscript{2}O\textsubscript{5} 4.33%; K\textsubscript{2}O 0.57%; Ni 160.0; Cu 11.14; ZnO 108.49; MnO 159.1 (mg / kg); Buckwheat husk ash, OOO Elita, Oryol Oblast: pH 10.5; P\textsubscript{2}O\textsubscript{5} 3.01; K2O 36.0; CaO 17.23; MgO 17.25; SiO\textsubscript{2} 4.99; Al2O3 0.98; Fe2O3 0.41; MnO 0.34; Na2O 0.29 (% on dry matter). The plot area is 10 m\textsuperscript{2}, the repetition is threefold, the placement is randomized. Options for experience: 1. Control. 2. Vermicompost (6 kg / m\textsuperscript{2}) + Ash (100g / m\textsuperscript{2}). 3. Vermicompost (6 kg / m\textsuperscript{2}) + Ash (100 g / m\textsuperscript{2}) + Mival-Agro (processing of planting material) + Gumi (0.3 l / ha) + Bud (0.4 l / ha) + Mival-Agro, 95% r.p. (10 g / ha). Vermicompost and ash were introduced before planting; the roots of roses, bulbs of gladioli and corms of tulips were immersed in the Mival-Agro silicone biostimulator solution (0.03%), explanation for 12 hours, then dusted with ash. Three weeks after planting, Bud was sprayed (0.04%), two weeks later, Mival-Agro was treated twice (0.01%), and plants were irrigated with Gumi fertilizer.

The study of changes in the anatomical characteristics of plants Rosa L., Tulipa L. and Gladiolus L.; thickness, epidermis and leaf mesophyll; the physiological state (a change in the osmotic pressure in leaf cells, the degree of stomata opening) as a result of the influence of biologically active substances and non-traditional fertilizers was carried out using a Biolam S-13 biological microscope. Leaves were selected in the budding and flowering phases. The number of stomata was determined in the field of view of the microscope with recalculation per 1 mm\textsuperscript{2} of the surface of the epidermis. The method for determining the osmotic pressure of cell juice is plasmolytic [13]. Statistical processing of the results was carried out using the applied computer program Microsoft Excel.

Results and discussion. The integumentary tissue of the leaf serves as a mechanical obstacle for the penetration of harmful pathogens into plants, being one of the elements of structural immunity [Chernetskaya, Beloshapkina]. The anatomical features of the leaves of decorative cultures change under the influence of biologically active substances and vermicompost (figure 1, 2, 3).

![Figure 1](image-url)  
**Figure 1.** Change in the thickness of the epidermis of the leaves of Rosa L. plants under the influence of biologically active substances and vermicompost (average for 2015-2017) 5.2.
Figure 2. Change in the thickness of the mesophyll of the leaves of Rosa L. plants under the influence of biologically active substances and vermicompost (average for 2015-2017) not 4.3.

Figure 3. Change in leaf thickness of Rosa L. plants under the influence of biologically active substances and vermicompost (average for 2015-2017) not 4.9.

Figure 4. Change in the thickness of the epidermis of the leaves of plants of Tulipa L. and Gladiolus L. under the influence of biologically active substances and vermicompost (average for 2017-2019) not 7.8.

Figure 5. Change in the thickness of the mesophyll of the leaves of plants of Tulipa L. and Gladiolus L. under the influence of biologically active substances and vermicompost (average for 2017-2019) not 7.1.
Figure 6. Change in leaf thickness of plants Tulipa L. and Gladiolus L. under the influence of biologically active substances and vermicompost (average for 2017-2019).

It was established that the maximum leaf thickness in plants of Rosa L., Tulipa L. and Gladiolus L. (due to the epidermis and mesophyll) is observed when using biologically active substances and growing plants against the background of vermicompost. The greatest responsiveness was shown by Rosa L. plants. The thickness of the sheet in the control was 88.11 microns, when using fertilizer bases - 95.7 microns, with the addition of biologically active substances against a fertilizing background - 103.65 microns, which is more than 1.08 and 1 in comparison with the control, 18 times, respectively.

The ecological significance of osmotic pressure is great and is the most important criterion for plant adaptation. The introduction of pathogens into the cell of plants is significantly reduced or impossible with high osmotic pressure [9, 10]. The dependence of the osmotic pressure of Rosa L., Tulipa L. and Gladiolus L. cells on the use of biologically active substances and vermicompost is shown in tables 1, 2.

The highest osmotic pressure was observed in rose plants розы 'Christophe Colomb', 'Forever Young', 'Royal baccara', 'Shakira' and 'Pullman Orient Express'. Low osmotic pressure was recorded in rose plants of varieties 'Aqua', 'Double Delight', 'Lovely Red' and 'Nostalgie', which in an urbanized environment were more intensely affected by diseases: powdery mildew and black spotting [1].

It should be noted that under the influence of vermicompost and biologically active substances, a significant increase in osmotic pressure is observed in both highly resistant and unstable rose varieties (table 1). The best results were obtained on plants of rose varieties: 'Aqua', 'Double Delight', 'Shakira' and 'Pullman Orient Express'; osmotic pressure increased by 66.2; 61.6; 52.5 and 46.4 kPa, respectively.

Table 1. Dependence of the osmotic pressure of Rosa L. cells on the use of biologically active substances and vermicompost, kPa.

| Varieties (factor A)            | Variants of experience (factor B) |
|--------------------------------|-----------------------------------|
|                                | 1     | 2    | 3    |
| 'Aqua'                         | 110.3 | 132.3| 176.5|
| 'Christophe Colomb'            | 215.4 | 229.7| 255.9|
| 'Double Delight'               | 115.6 | 133.2| 177.2|
| 'Elegance'                     | 180.1 | 191.2| 207.5|
| 'Forever Young'                | 217.2 | 232.3| 259.8|
| 'Lovely Red'                   | 149.2 | 163.9| 189.6|
| 'Nostalgie'                    | 173.4 | 188.9| 199.2|
| 'Royal baccara'                | 210.5 | 234.5| 259.7|
| 'Shakira'                      | 200.2 | 229.2| 252.7|
| 'Pullman Orient Express'       | 219.3 | 231.5| 265.7|

HCP95 for factor A 17.1
HCP95 for factor B 23.2
Table 2. Change in the osmotic pressure of Tulipa L. and Gladiolus L. cells with the use of biologically active substances and vermicompost compositions, kPa.

| Varieties          | Experience Options |
|--------------------|--------------------|
| Tulipa L.          | 212.3 239.1 245.2  |
| Gladiolus L.       | 199.9 228.2 233.6  |
| HCP<sub>T</sub>Tulipa L.-9.2 Gladiolus L.-10.1 |

The osmotic pressure of plant cells Tulipa L. and Gladiolus L. increases significantly (by 26.8 and 28.3 kPa) with vermicompost (6 kg / m$^2$) and ash (100 g / m$^2$), which may be due to the influence of trace elements, included in the composition of fertilizers [1]. The additive effect of the tested fertilizers in combination with biologically active substances is also noted.

Stomata quickly and sensitively respond to external and internal changes in plants. The movement of stomata allows you to assess the condition of the plant, the degree of its adaptation to adverse factors. Apparently, under the influence of applied fertilizers and biologically active substances, the increasing osmotic pressure leads to the development of a hydro passive reaction, characterized by the closure of stomatal gaps, while the cell parenchyma is overflowed with water and mechanically compresses the closing cells.

The degree of opening of the stomata Rosa L. when using biologically active substances and vermicompost is shown in table 3. Tulipa L. and Gladiolus L. in table 4.

Table 3. The degree of disclosure of stomata Rosa L. when using biologically active substances and vermicompost.

| Varieties          | Experience Options |
|--------------------|--------------------|
| ‘Aqua’             | +++  ++  ++        |
| ‘Christophe Colomb’| +    +    +         |
| ‘Double Delight’    | +++  ++  ++        |
| ‘Elegance’         | ++    ++  +         |
| ‘Forever Young’    | +     +    +         |
| ‘Lovely Red’       | +++  ++  ++        |
| ‘Nostalgie’        | +++  ++  +         |
| ‘Royal baccara’    | +     +    +         |
| ‘Shakira’          | ++    +    +         |
| ‘Pullman Orient Express’ | +  +    +       |

+ Stomata weakly revealed
++ Stomata open medium
+++ Stomata exposed strongly

Weak stomata were found in the experimental varieties Tulipa L. and Gladiolus L., as well as the highly resistant varieties Rosa L.: ‘Christophe Colomb’, ‘Forever Young’, ‘Royal baccara’, ‘Shakira’ and ‘Pullman Orient Express’. The use of biologically active substances on Rosa L. plants grown on improved organomineral nutrition contributed to a decrease in the stomata opening on plants of unstable varieties: ‘Elegance’ and ‘Nostalgie’, which indirectly affects the reduction in plant morbidity.

Table 4. Dependence of the degree of opening of the stomata Tulipa L. and Gladiolus L. on the use of biologically active substances and vermicompost.

| Varieties          | Experience Options |
|--------------------|--------------------|
| Tulipa L.          | ++    +    +         |
Gladiolus L. ++ + + +
+ Stomata weakly revealed
++ Stomata open medium
+++ Stomata exposed strongly

Thus, the significant and multifaceted role of biologically active substances and vermicompost in changing the anatomical characteristics of plants, manifested in the modification of leaf thickness, integumentary tissues, mesophyll, stomatal opening, osmotic pressure of cells, which indirectly contributes to the development of passive immunity of ornamental cultures.

Findings. Biologically active substances against the background of vermicompost have a positive effect on the change in the anatomical characteristics of the plants Rosa L., Tulipa L. and Gladiolus L. The thickness of the epidermis of leaves of Rosa L. increased by 1.5 times; Tulipa L. - 1.4; Gladiolus L. - 1.6 times; leaf mesophyll thickness of 1.9; 1.4; 1.6 times respectively; leaf thickness of Rosa L. and Gladiolus L. plants increased 1.2 times; Tulipa L. - 1.7 times. A significant increase in the osmotic pressure of plant cells of Tulipa L. and Gladiolus L. is significantly increased (by 26.8 and 28.3 kPa); different varieties of Rosa L. Weak opening of stomata was observed in experimental variants of Tulipa L. and Gladiolus L., as well as highly resistant varieties of Rosa L. Changes in the anatomical and physiological characteristics of ornamental plants make it possible to develop passive immunity to stress factors.

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