# Bio-fertilizers (Blackjack, Geohumat, and Cu++) Against Environmental Pollution

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**ABSTRACT**

As the population grows, the demand for food increases, the production of which is impossible without soil. Healthy soil means healthy food. Soil is the foundation of all agronomy; therefore, it is crucial to pay great attention to caring for the soil and its fertility. From contaminated soils, plants can accumulate large quantities of toxic elements such as mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl), and lead (Pb). The uptake of these heavy metals causes soil pollution, which poses a significant threat to human health.

Bio-organic fertilizers hold great potential for soil restoration, health maintenance, and the development of green agriculture. They offer immense ecological and environmental benefits along with broad prospects for application. To prevent soil pollution and obtain ecologically safe products, ecologically safe bio-preparations – Blackjack, Geohumat, and Cu++ – were purposefully introduced for the first time in stationary field trials under a mandarin plantation in the red soils of Adjara.

Based on field trials in an Unshiu mandarin plantation within the coastal zone of Adjara, new ecologically clean preparations were purposefully selected for the first time, and their optimal norms and dosages were established. The efficiency indicators of the selected preparations were studied to prevent soil pollution and ensure the production of ecologically safe products.

To achieve this, experimental work was carried out under stationary field trial conditions. According to the experimental design, the ecologically clean bio-preparations (fertilizers) – Blackjack, Geo-humat, and Cu++ were applied to the mandarin plantation during the following periods: April, May, June, and July. Concurrently, soil samples were collected at a depth of 50 cm, along with leaf samples from model plants. Agrochemical and chemical indicator analyses were performed under laboratory conditions.

Based on the data obtained from the experiments, we can conclude that the applied bio-fertilizers showed the best results without the use of mineral fertilizers when administered as follows:

- Blackjack: Applied via soil drenching and foliar spraying;
- Geohumat: Applied via soil drenching and foliar spraying;
- Cu++: Used as a background treatment via foliar spraying (2 ml per 10 liters of water).

Judging by the data tables presented in this work, heavy metals (As,Cd,Cr,Hg,Pb) and pesticides were not detected in the soil, and consequently, were found neither in the plant nor in the fruit. This outcome is attributed to the fact that the soil was enriched exclusively with ecologically clean fertilizers, thereby preventing the pollution of Adjara's low-fertility red soils.

**KEYWORDS: Bio-fertilizer, Red soil (Tsitelmitsa), Citrus, Mandarin, Toxic elements**

Biofertilizers are organic substances. Obtained in a natural way, they enrich the soil with microorganisms, improve its structure and contribute to the natural balance. Biological fertilizers are natural and environmentally safe, they are used to increase soil fertility, increase plant nutrients, combat plant pests, combat soil pollution, obtain high-quality and high yields of tangerine fruits, and increase the storage capacity of fruits. Bioorganic fertilizer has great potential in the field of soil restoration, health maintenance and the development of green agriculture. It has enormous ecological and environmental benefits and prospects for wide application. Accordingly, the prospects for the development of bioorganic fertilizers are also very good and the profit potential is enormous. Biofertilizers promote the activity of beneficial microorganisms in the soil, enrich the soil in a natural way, and have a positive impact on the environment and ecosystem.{5}

Biofertilizers are not just a plant food, they are biostimulants that help balance all the components in plants that prevent the plant from developing. Biofertilizers are a source of energy that copes with harmful diseases, although it should be noted that the beneficial pests that the plant also has, the main thing is that biofertilizers do not affect them and do not threaten their mortality. With the help of biofertilizers, the plant's immune system improves, fungal diseases are reduced, and during this time the plant develops a strong root system and becomes healthier. In addition, it should be noted that the effect of biofertilizers on the plant does not have a negative impact on human health in the future. In citrus crops, various diseases are most common. In many cases, they are eliminated by using biofertilizers. (6)

Soil is the source of life, it is a mixture of minerals and organic substances that determine the germination and growth of plants. Soil affects the food that a person receives; water, air, flora, fauna, and human health. Therefore, its pollution causes chain reactions and negatively affects other components. The entire agronomy is based on the soil. With the growth of industrialization, the harmful effects of industrial waste on the environment, especially water and soil, where heavy metals accumulate, are significantly increasing. Soil and water pollution with heavy metals is a significant global problem worldwide. Ways to combat the problem of soil pollution require a lot of time, money and effort. Various methods have been introduced to combat this problem,

With the growth of the population, the demand for food is increasing, the production of which is impossible without soil. Healthy soil means healthy food, so it is important to pay great attention to caring for the soil and its fertility, especially today, when the problem of soil pollution is so relevant all over the world. From polluted soils, plants can accumulate large amounts of toxic elements in the soil, such as mercury (Hg), cadmium (Cd), arsenic (As), chromium (Cr), thallium (Tl) and lead (Pb) and cause soil pollution, which in turn is harmful to flora and fauna, as well as human health.

The absorption of large amounts of heavy metals poses a threat to human health. Excessive intake of cadmium can cause serious diseases such as cancer, bone loss, etc. Lead is especially dangerous for children, as it damages brain cells and the central nervous system. [1]

In order to prevent soil pollution and obtain environmentally safe products, we purposefully and for the first time in stationary field trials under a tangerine plantation in the red soil soils of Adjara, we included environmentally safe biopreparations: Blackjack, Geohumate. Insecticide Cu++ (without the addition of mineral fertilizers {4}he analyses were conducted using the following research methods: {2-3}

1. Soil sampling – GOST 28168-99, soil sample preparation for analysis – GOST 26583-85
2. Hygroscopic water – GOST 28268-89 by weight
3. PH – in water and KCI – by a peat meter, GOST 26483-85
4. Total humus % – Tyurin method, GOST 26213-91
5. Total nitrogen % – Kjeldahl microchrome method, GOST 2017 – 84
6. Plant-available phosphorus mg / 100 g – by Oniani method GOST 26205-91
7. Plant-available potassium mg / 100 g – by the SOIL TEST-500 apparatus and by the Peive method, GOST 2609-91
8. Hydrolytic nitrogen mg / kg by Tyurin and Konanova method GOST 26213-84
9. Total absorbed bases% by Kapen method, GOST 27821-88 titration.
10. Total nitrogen (in plant)% by Kjeldahl method, GOST 26107-84
11. Total potassium in plant% wet weight, GOST 20851-3-93
12. Total phosphorus%-wet weight GOST 26261-84
13. Also using a plasma atomic emission spectrophotometer (ICPE-Experimental part

Field trials were conducted on the Chakvi collection plot of the SSP IP in the mandarin "Unshius" (broad-leaf) plantation. In general, using the adopted method, 3-fold repetition – before and during the trial, soil samples were taken at a depth of 50 cm, as well as plant leaf samples and were determined by agrochemical and biochemical indicators. Biofertilizers were applied according to the scheme four times during the vegetation period (April, May, June, July) without mineral fertilizers. A comparison was made with the option of applying mineral fertilizers. The trials were set up according to the following scheme:

1. BlackJack – applied both as foliar spray and soil drench (8 mL dissolved in 2 L of water per plant; application interval: every 10–15 days). $Cu^{++}$ (10 mg dissolved in 3.5 L of water) applied as foliar spray.
2. GeoHumate – applied both as foliar spray and soil drench (5 mL dissolved in 1 L of water per plant; application interval: every 10–15 days). $Cu^{++}$ (10 mg dissolved in 3.5 L of water) applied as foliar spray.
3. Control (without biofertilizers)

After the experimental treatments, a multi-element analysis of the soil water extract was performed to determine the macro – and microelement composition. The analytical results are presented in Table 1.

**Table 1. Results of multi-element analysis in the soil water extract (red soil, Chakvi site, 08.07.2025)**

| Element | Concentration (mg/L) | Element | Concentration (mg/L) | Element | Concentration (mg/L) |
|---|---|---|---|---|---|
| **Al** | 1.81 | As | -0.0107 | B | 0.327 |
| **Ba** | 0.0031 | Be | 0.0012 L | Ca | 9.98 |
| **Cd** | -0.0201 | Co | -0.0122 | Cr | -0.0475 |
| **Cu** | -0.0998 | Fe | 3.18 | Hg | -2.43 |
| **K** | 3.13 | Li | 1.99 | Mg | 2.80 |

| | | | | | |
|---|---|---|---|---|---|
| **Mn** | 0.0144 | Mo | -0.0299 | Na | -0.364 |
| **Ni** | 0.0008 | P | 0.392 L | Pb | -0.155 |
| **Sb** | -0.0862 | Se | 0.0194 L | Si | 59.2 |
| **Ti** | 0.175 | Tl | -0.0107 | V | -0.154 |
| **Zn** | -0.0341 | | | | |

Emphasis was placed on determining the content of toxic elements—arsenic (As), cadmium (Cd), chromium (Cr), mercury (Hg), nickel (Ni), and lead (Pb) which are primarily responsible for soil contamination.

Specifically, the measured concentrations of these elements in the soil water extract were as follows: As – 0.011 mg/L, Cd – 0.020 mg/L, Cr – 0.046 mg/L, Hg – trace, Ni – 0.0008 mg/L, and Pb – 0.155 mg/L.

These results indicate that the concentrations of toxic heavy metals are extremely low, remaining below internationally accepted threshold limits, thereby confirming the absence of contamination and the ecological safety of the studied soils.

To further assess the effect of biofertilizer application, mandarin leaf samples were collected after treatment. The chemical composition (macro – and microelements) of the leaves was analyzed, and the results are presented in Table 2.

## Chemical Composition of Mandarin Leaves (Macro – and Microelements) After Biofertilizer Application (22–28 August 2025)

**Table 2. Composition of macro – and microelements in mandarin leaves following the application of biofertilizers.**

| Variant | Al (mg/L) | As (mg/L) | B (mg/L) | Ba (mg/L) | Be (mg/L) | Ca (mg/L) | Cd (mg/L) | Co (mg/L) | Cr (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| **BlackJack (20 mL per 3 L of water, applied to soil and foliage) + $Cu^{++}$ (20 mL per 10 L of water, foliar spray)** | 54.4 | -0.0723 | 15.0 | 30.0 | 0.0020L | 2043.37 | -0.0216 | -0.0206 | -0.083 |
| **GeoHumate (15 mL per 3 L of water, applied to soil and foliage) + $Cu^{++}$ (20 mL per 10 L of water, foliar spray)** | 66.3 | -0.0618 | 17.7 | 40.5 | 0.0021 L | 2174.00 | -0.0238 | -0.0264 | -0.049 |
| **Without biofertilizers (control)** | 27.9 | -0.102 | 8.4 | 18.4 | 0.0009 L | 1985.40 | -0.0284 | -0.0284 | -0.0487 |

**Table 3. Concentration of additional macro – and microelements in mandarin leaves after biofertilizer application (22–28 August 2025)**

| Variant | Cu (mg/L) | Fe (mg/L) | Hg (mg/L) | K (mg/L) | Li (mg/L) | Mg (mg/L) | Mn (mg/L) | Mo (mg/L) | Na (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| BlackJack (20 mL per 3 L of water, applied to soil and foliage) + $Cu^{++}$ (20 mL per 10 L of water, foliar spray) | 17.1 | 31.6 | -11.4 | 3400 | -2.33 | 844 | 8.58 | -0.095 | 311 |
| GeoHumate (15 mL per 3 L of water, applied to soil and foliage) + $Cu^{++}$ (20 mL per 10 L of water, foliar spray) | 36.4 | 35.4 | -11.7 | 3760 | -1.45 | 951 | 10.7 | -0.0321 | 427 |
| Without biofertilizers (control) | 4.32 | 16.9 | -7.7 | 2590 | -3.44 | 608 | 4.19 | -0.0358 | 372 |

**Table 4. Concentration of trace elements in mandarin leaves after biofertilizer application (22–28 August 2025)**

| Variant | Ni (mg/L) | P (mg/L) | Pb (mg/L) | Sb (mg/L) | Se (mg/L) | Si (mg/L) | Ti (mg/L) | Tl (mg/L) | V (mg/L) | Zn (mg/L) |
|---|---|---|---|---|---|---|---|---|---|---|
| BlackJack (20 mL/3 L water, soil + foliar application) + $Cu^{++}$ (20 mL/10 L water, foliar spray) | 1.28 | 978 | -0.12 | -0.452 | 0.227 L | 198 | -0.0816 L | -0.22 | -0.0177 | 7.20 |
| GeoHumate (15 mL/3 L water, soil + foliar application) + $Cu^{++}$ (20 mL/10 L water, foliar spray) | 1.35 | 1280 | -0.105 | -0.277 | 0.120 L | 254 | -0.0244 L | -0.299 | -0.0165 | 9.08 |
| Without biofertilizers (Control) | 0.575 | 766 | -0.251 | -0.426 | 0.144 L | 99.4 | 0.0387 L | -0.284 | -0.0338 | 3.59 |

The toxic elements, As, Hg, Cd, Sb, Pb, and Ni, were not detected in the mandarin leaves. As a background treatment, the $Cu^{++}$ insecticide was applied both to the soil (by drenching) and to the plants (by foliar spraying), which also exerted a positive effect on the suppression of pest and disease incidence. Multiple monitoring sessions conducted during the vegetation period confirmed the positive influence of the applied preparations on plant health and development.

The soil and plant analyses were performed at the Institute of Agrarian and Membrane Technologies, within the Laboratory of Agrochemistry and Soil Science, using a plasma atomic emission spectrophotometer (ICPE-9820). Analyses were carried out under both wet and dry ashing conditions [2,3].

Based on three years of experimental data, we can now provide scientifically validated recommendations and methodological guidelines. The results obtained can be effectively used by farmers, as well as by research centers and professionals in related fields, biochemists, biologists, agrochemists, soil scientists, and entomologists to prevent soil contamination. It is recommended that only the identified ecologically clean biofertilizers be used to achieve environmentally safe, high-quality yields.

## CONCLUSIONS

Based on the results obtained from the experiments conducted, the following conclusions were drawn:

- The applied biofertilizers BlackJack (soil and foliar application) and GeoHumate (soil and foliar application) in combination with $Cu^{++}$ (2 mL per 10 L of water, foliar spray), without the use of mineral fertilizers, produced the best overall results.
- Soil fertility improved significantly.
- The concentration of essential nutrient elements in mandarin leaves increased.
- During the vegetation period, a positive effect of the applied formulations was observed, and plant diseases and pest infestations were effectively suppressed.
- Most importantly, a high, ecologically clean, and high-quality yield was obtained.

According to the analytical data presented in the tables, no pesticide residues or toxic elements such as As, Cd, Cr, Hg, or Pb were detected in the soil, plants, or fruit. This confirms that the soil was enriched exclusively with environmentally safe fertilizers, thereby preventing contamination of the low-fertility red soils of Adjara.

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