



Agrochemical Composition of a New Organo-Humic Fertilizer and the Response of Cucumber Plants to Various Application Rates on Sandy Soils

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Abstract

A new organo-humic fertilizer, produced by accelerated fermentation of poultry manure using the "PEATGEL+" preparation, has a near-neutral reaction, is rich in macro- and microelements, and is free from heavy metals, toxic compounds, and radionuclides. The application of this new organo-humic fertilizer to sandy soil at a rate of 30–45 t/ha has a positive effect on the growth and development of cucumber plants of the "Izyashchny" variety.

Keywords: Poultry Manure; Accelerated Fermentation; Agrochemical Composition; Cucumber Plants; Morphophysiological Indicators

Introduction

Soil fertility is one of the key factors determining the success of crop cultivation and high yields. Soil serves not only as a physical foundation for supporting plants but also as a source of essential nutrients necessary for their full growth and development.

However, not all soil types possess the same capacity to provide crops with necessary nutrients. In some cases, due to natural characteristics, low humus content, or intensive farming, soils become infertile or depleted, leading to reduced yields and lower product quality [1, 2, 3].

One of the pressing problems in modern crop production is the cultivation of vegetables and other crops on soils initially ill-suited for agriculture, such as sandy soils [4]. Sandy soils generally contain extremely low amounts of organic matter, have low water-holding capacity, and poorly retain nutrients; therefore, plants grown on such substrates often experience an acute deficiency of nitrogen, phosphorus, potassium, and other macro- and microelements. As a result, it is practically impossible to achieve good results without the additional application of fertilizers [5, 6].

Another aspect of the problem relates to the quality and quantity of fertilizers applied. The fertilizer market offers a wide range of both mineral and organic products; however, not all of them are equivalent in terms of nutrient content and form [5]. Mineral (or chemical) fertilizers provide plants with necessary elements in an accessible form, but if used incorrectly or excessively, they can lead to soil salinization, disruption of biological balance, and the accumulation of harmful substances in food products [5]. Organic and organomineral fertilizers are generally safer, as in addition to providing basic nutrients, they promote the development of beneficial soil microflora, accelerate humus formation, improve soil structure, and increase its water-holding capacity [6, 7]. Nevertheless, the availability of high-quality organic fertilizers is often limited, or they are used in insufficient quantities, which also prevents full compensation for nutrient deficiencies [3].

These problems can be exacerbated by economic and environmental factors: high prices for mineral fertilizers, soil degradation resulting from improper application, and the accumulation of livestock waste, which often remains underutilized [8]. All of this necessitates the search for new solutions capable of not only maintaining but also improving soil fertility, particularly for those soils most at risk of depletion [4].

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In this context, an important direction is the use of chicken manure—one of the most effective organic fertilizers [7, 9, 10]. Chicken manure contains a high percentage of nitrogen, as well as significant amounts of phosphorus, potassium, and other micronutrients essential for plants [7, 9]. Furthermore, it helps improve the physicochemical properties of the soil, increases its biological activity, and stimulates the development of beneficial microflora [7]. Given the shortage of organic fertilizers and the growing demand for environmentally friendly agriculture, the use of chicken manure makes it possible to provide plant nutrition, reduce costs, and recycle poultry waste with maximum efficiency [10, 11, 12].

However, it should be noted that chicken manure can only be used after processing through fermentation.

The aim of this study is to investigate the comprehensive chemical composition and bioactive properties of an organo-humic fertilizer (OHF) derived via accelerated aerobic fermentation of poultry manure. The study evaluates the physiological and morphometric response of *Cucumis sativus* L. to varying application rates, aiming to establish optimal dosage thresholds for maximizing crop productivity and nutrient recovery efficiency within the inherently low-fertility conditions of sandy soil substrates.

Materials and Methods

The development of organo-humic fertilizers (OHF) based on chicken manure serves as a solution for recycling poultry waste and restoring soil fertility. In this study, a new OHF was produced via accelerated fermentation using the "PEATGEL+" preparation. Agrochemical analysis was conducted at the FSBI "RosAgrokhimsluzhba" (Kostroma branch) using the following standardized methods: atomic absorption spectrometry (Cu, Fe, Co, Mn — MMVI-80-2008), photometry (P, K, N — GOST 26717-85), gravimetry (moisture and organic matter — GOST 26713-85, GOST 27980-88/1), and potentiometry (pH KCl — GOST 27979-88).

To evaluate plant responsiveness, experiments were conducted on sandy soil in the phytotron of the FSBEI HE Kostroma State Agricultural Academy. Environmental conditions were strictly controlled: air temperature at 20–26°C (night/day), illumination at 5.5–6.0 thousand Lux, and a 12-hour photoperiod. The object of research was the "Izyashchnyy" cucumber variety (*Cucumis sativus*).

The experimental design included five groups based on a standard application dose of 30 t/ha:

1. Sand (control) - no fertilizer
2. Sand + manure (1.0 dose)
3. Sand + manure (1.5 doses)
4. Sand + manure (2.0 doses)

5. Sand + manure (2.5 doses)

By submitting this manuscript, the authors grant consent for the non-commercial use of the described materials and data by the scientific community. Data processing was performed using Microsoft Office software.

Results and Discussion

Raw Material Transformation and Safety

Fresh chicken manure is classified as a Hazard Class 3 substance due to its high ammonia, nitrate, and phosphate content, requiring mandatory treatment before agricultural use. While drying or lengthy composting are standard, this study utilized an accelerated fermentation method with the "PEATGEL+" preparation (developed by "ECOPAK" LLC). The use of "PEATGEL+" effectively intensified the biological conversion of organic matter, providing a comprehensive chemical profile necessary for predicting the fertilizer's impact on soil and plant physiology.

Agrochemical Characterization of OHF

Agrochemical analysis established that the resulting organo-humic fertilizer (OHF) has a neutral reaction (pH KCl 7.0) and is saturated with essential macronutrients. Notably, the ammonium nitrogen content in the OHF mass significantly decreased to 0.25% (Table 1), indicating a stabilized and safer product compared to the raw material.

Experimental Model and Environmental Control

The use of a sandy substrate within a controlled phytotron environment allowed for the isolation of the direct biological effects of various OHF doses by eliminating confounding environmental variables. The "Izyashchnyy" cucumber variety was selected as a strategic test object; its documented high sensitivity to variations in organic and mineral nutrition provided a clear visual and physiological assessment of the fertilizer's efficacy.

Plant Physiological Response and Growth Dynamics

The soil application of Organic Humic Fertilizer (OHF) facilitates a critical influx of essential micronutrients, which function as fundamental enzymatic cofactors within the complex metabolic frameworks of both the edaphic microbiota and the host plants (Table 2). This exogenous nutrient enrichment serves as a catalytic driver for microbial proliferation, subsequently enhancing the biochemical transformation of organic matter and optimizing the bioavailability of mineral elements within the rhizosphere. Consequently, the synergistic interaction between the stimulated soil microflora and the plant's internal physiological pathways establishes a stabilized nutritional continuum, ensuring peak metabolic efficiency during the critical phases of vegetative development.

A high micronutrient content is vital, as these elements are

Table 1: Agrochemical composition of peat and chicken manure-based fertilizers.

Fertilizer type	pH (KCl)	Organic matter, %	Total Nitrogen, %	Ammonium Nitrogen, %	Phosphorus, %	Potassium, %
Poultry manure	7,6	69,0	4,0	0,98	1,6	0,93
OHF	7,0	69,1	3,8	0,25	1,5	0,68

Table 2: Micronutrient content in the organo-humic fertilizer, mg/kg.

Fertilizer type	Mg	Fe	Cu	Co	Mn
OHF	1110	5000	10,0	5,0	100

Table 3: Effect of various organo-humic fertilizer doses on the growth and development of cucumber seedlings, day 21.

Options	Height, cm	Plant Mass, g	Number of leaves, pcs	Photosynthetic rate, mg C/dm ²
1) Sand (Control)	16,30	2,21	2,05	0,418
2) Sand + 1 dose of OGU	29,5	4,96	4,25	2,303
3) Sand + 1.5 doses of OGU	29,3	4,88	4,10	2,296
4) Sand + 2 doses of OGU	13,8	2,68	2,73	0,310
5) Sand + 2.5 doses of OGU	9,6	2,31	1,85	0,212
Least Significant Difference	3,4	0,93	0,77	-

necessary for the synthesis of enzymes that drive key metabolic processes, including photosynthesis and respiration. In this study, indicators such as cell sap concentration (CSC) and potential osmotic pressure (POP) were utilized to evaluate the plants' metabolic efficiency and overall responsiveness to the organo-humic formulation.

Impact of OHF Dosage on Morphophysiological Indicators

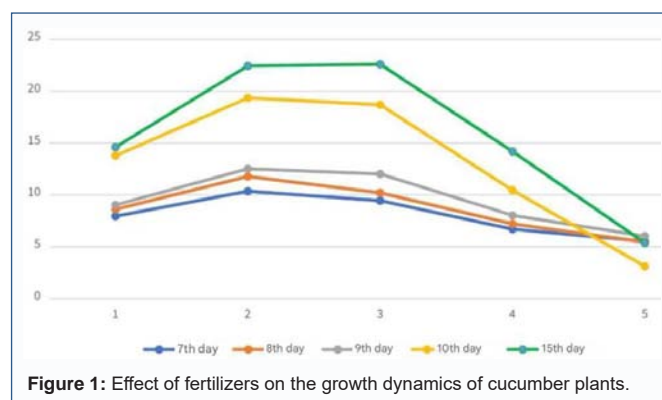
The study of various OHF doses revealed a clear non-linear relationship between application rates and plant development:

Within the scope of the experimental timeline, the most dynamic growth trajectories were observed in the variants corresponding to the optimal application doses of 1.0 and 1.5 (calculated at application rates of 30 and 45 t/ha, respectively). By the 15th day of development, plants in these treatment groups reached an average height of 22.5–22.6 cm (Figure 1), demonstrating a statistically significant lead over both the control and the high-dose variants. This rapid elongation of the primary axis indicates a high rate of cell division and expansion within the apical meristems, likely triggered by the synergistic effect of the Organic Liquid Fertilizer's (OLF) macro- and micro-nutrient components.

The data suggest that these specific concentrations create a "metabolic sweet spot," where the availability of nitrogen and phosphorus is perfectly calibrated to support early-stage organogenesis without inducing osmotic stress. This accelerated vertical progression serves as a vital indicator of the plant's physiological vigor, as taller plants with greater structural integrity are better positioned for light competition and subsequent reproductive success. Furthermore, the uniformity in height between the 1.0 and 1.5 dose variants implies that a plateau of maximum growth efficiency is reached within this range, providing a reliable benchmark for optimizing agricultural protocols. Such intensive height gain by day 15 provides the necessary structural framework for the subsequent expansion of the leaf canopy, ultimately driving the superior biomass accumulation recorded in the later stages of the experiment.

By the third week of the vegetative cycle, the experimental groups exhibited a dynamic surge in biometric parameters, with plant height reaching an impressive range of 29.3–29.5 cm. This performance represents a robust developmental advantage, significantly exceeding the control group, which stagnated at a mere 16.3 cm. Such a pronounced disparity - nearly twofold - underscores the efficacy of the optimized nutrient environment in accelerating primary stem elongation and apical dominance during this critical growth phase.

This vertical progression was closely mirrored by the intensive formation of the photosynthetic apparatus. By day 21, the number of true leaves reached a peak of 4.10–4.25 units (Table 3), indicating not only a faster rate of organogenesis but also a more efficient transition from the seedling stage to active vegetative expansion. The early

**Figure 1:** Effect of fertilizers on the growth dynamics of cucumber plants.

establishment of a larger leaf area likely facilitated a positive feedback loop, where enhanced light interception fueled further carbon assimilation and biomass partitioning.

The synchronicity between height gain and leaf emergence suggests that the 1.0–1.5 dose concentrations provided the requisite hormonal and nutritional cues to maintain high turgor pressure and cell division rates. In contrast, the control plants demonstrated limited morphogenetic activity, failing to achieve similar structural complexity within the same temporal window. These results confirm that the specific organic liquid fertilizer (OLF) treatments effectively bypassed the typical growth constraints observed in standard nutrient regimes, leading to the superior biometric profile recorded at the end of the three-week period.

The experimentally established significant increase in photosynthetic intensity within the 1.0 and 1.5 dose variants indicates that the plants have achieved an optimal physiological status. The balanced nutrient profile of the Organic Liquid Fertilizer (OLF) acts as a catalyst for chlorophyll biosynthesis and stabilizes the architecture of the photosynthetic apparatus, ensuring unimpeded gas exchange and high efficiency of the leaf mesophyll. This metabolic stimulation not only activates the carbon fixation cycle but also establishes a robust physiological foundation for the exponential accumulation of vegetative biomass. The optimization of trophic conditions at these concentrations facilitates the maximum realization of the crop's genetic potential, converting the nutrient influx into efficient energy for growth and productivity.

Conversely, upon reaching concentrations of 2.0 and 2.5 doses, a physiological threshold is observed, followed by a decline in the intensity of photosynthetic processes. This phenomenon is attributed to the increasing osmotic pressure of the soil solution and the partial inhibition of key carboxylation enzyme activities. The decrease in performance relative to peak values when exceeding the 45 t/ha threshold indicates a transition of the system into a phase

of metabolic stagnation, which limits growth processes and defines the bioproductivity boundaries for the studied crop under these environmental conditions.

Conclusion. The application of accelerated poultry manure fermentation using the 'PEATGEL+' preparation resulted in a new organic-humic fertilizer (OHF) with high agrochemical performance. Laboratory experiments established that the optimal application rates for cucumber seedlings in sandy soils are equivalent to 30–45 t/ha. The positive response of the plants to the OHF was reflected in a significant increase in height and mass, a higher leaf count, and enhanced photosynthetic rate.

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