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Organic Fertilizers Based on Plant Residues

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ABSTRACT

One of the key challenges in sustainable agriculture is preserving and restoring soil fertility while minimizing the negative environmental impacts of chemical intensification. Increasing crop yields and ensuring food security are impossible without the use of fertilizers. However, excessive application of mineral fertilizers has led to soil structure degradation, a decrease in humus content, accumulation of toxic compounds, and pollution of aquatic ecosystems. Therefore, growing attention from scientists and farmers is being directed towards organic fertilizers derived from plant residues, which are considered an environmentally safe and economically viable alternative to mineral fertilizers.

The relevance of using organic fertilizers from plant residues lies in their ability to restore soil biological activity, improve soil structure, water retention, aeration capacity, and enrich the soil with organic matter, macro- and micronutrients. Composting straw, crop residues, husks, leaves, and other plant by-products allows for the efficient recycling of large amounts of biomass accumulated annually in the agricultural sector. This not only solves the problem of plant waste disposal but also contributes to closing the nutrient cycle within agroecosystems.

KEYWORDS

humus, organic fertilizers, plant residues, composting, agroecosystems, soil biological activity, soil structure improvement, organo-mineral mixtures, sustainable agriculture, ecology.

INTRODUCTION

In the context of sustainable agricultural development, one of the most important challenges is to preserve and restore soil fertility while minimizing the negative environmental impact of chemical intensification. Increasing crop yields and ensuring food security are impossible without the use of fertilizers; however, the excessive application of mineral fertilizers has led to soil structure degradation, a decrease in humus content, the accumulation of toxic compounds, and pollution of aquatic ecosystems. For this reason, growing attention from scientists and farmers is being directed toward organic fertilizers based on plant residues, which are considered an environmentally safe and economically viable alternative to mineral fertilizers.

The relevance of using organic fertilizers derived from plant residues lies in their ability to restore soil biological activity, improve structure, water retention, and aeration capacity, as well as enrich the soil with organic matter and macro- and microelements. Composting of straw, crop

residues, husks, leaves, and other plant by-products allows the efficient recycling of large amounts of biomass accumulated annually in the agricultural sector. This not only addresses the problem of plant waste disposal but also contributes to closing the nutrient cycle within agroecosystems.

This approach is particularly significant for Uzbekistan and other countries with intensive agriculture, where soils are deficient in organic matter and land degradation rates are high. The use of composts and organo-mineral mixtures based on plant residues helps to increase humus content, stimulate soil microflora, reduce salinization, and restore soil structure. Thus, the development of technologies for producing and applying organic fertilizers from plant residues is not only scientifically important but also socio-economically relevant, ensuring the greening of agricultural production and improving its sustainability.

Soil humus, formed from organic substances and compounds of plant, animal, and microbial origin that have undergone humification and non-humification stages of stabilization, shapes and maintains the main functions of the soil and gives it a unique property — the ability to create and preserve fertility [1].

Unlike mineral fertilizers, humic fertilizers act as catalysts of biochemical processes in the soil due to their stimulating effect on soil microorganisms. As the number of microorganisms increases, the enzymatic activity of the soil also intensifies, which in turn enhances the mobility and availability of essential nutrients [2]. The humus content is one of the main indicators of soil fertility. Owing to humus, the fundamental functions of the soil are sustained, and its fertility is ensured; during mineralization, humic substances supply plants with nitrogen and other essential nutrients in an easily assimilable form.

The soils of Uzbekistan are classified as poor in humus content. The irrigated land fund of the country mainly consists of serozems, meadow-serozems, takyr-meadow soils, and, to a lesser extent, gray-brown and desert sandy soils. The humus content in these soils is relatively low: in the arable horizon, it ranges from 1.2–0.8% (in serozems, takyr, and meadow soils) to 0.8–0.55% (in gray-brown and desert sandy soils). The proportion of soils with low humus content (in serozems – 0.8–1%) accounts for almost two-thirds of the total area, those with medium content (1–1.2%) make up about one-third, while soils with high humus content (1.2–1.5% of soil mass) constitute only about 7% of the cultivated land.Проблема создания положительного баланса гумуса в почве одна из наиболее актуальных задач в земледелии. Только при оптимальном количестве гумуса в почве возможно получение высокого эффекта от выращивания сельскохозяйственных культур. При воспроизводстве гумуса роль органических и ОМУ незаменима.

The problem of maintaining a positive humus balance in soils remains one of the most pressing issues in modern agriculture. Only when an optimal amount of humus is present in the soil is it possible to achieve high efficiency in the cultivation of agricultural crops. In the process of humus reproduction, the role of organic and organo-mineral fertilizers (OMF) is indispensable.

One of the non-traditional sources for replenishing the reserves of humic substances (HS) in irrigated soils can be plant residues (PR). The object of this study was coarsely ground PR. The plant residues were dried to an air-dry state and then milled to a particle size of 0.25 mm. After grinding, an average representative sample was prepared with the following composition (wt.%): moisture – 6.86; ash – 10.74; organic matter – 82.4; content of extractive substances (ES) extracted with 1% NaOH solution – 4.37; content of ES extracted with water – 1.22.

To increase the amount of extractable substances — that is, to convert PR into humic and fulvic acids — the process of oxidation using nitric acid (HNO_3) and hydrogen peroxide (H_2O_2) was investigated. It was shown that the content of ES extractable by 1% sodium hydroxide solution

could be increased from 5.59% to 57.8% when oxidation was carried out with 20% HNO_3 at 40°C for one hour, at a weight ratio of the organic part of PR to monohydrate HNO_3 equal to 1:1.6. Based on the experimental data, taking into account the consumption of the oxidizing agent and the ES content in the oxidized PR, the optimal conditions were determined. Under these conditions — that is, at a 10% H_2O_2 concentration, a mass ratio of organic part of PR to H_2O_2 equal to 1:0.1, a temperature of 70°C, and an oxidation duration of 2 hours — the ES content increased from 5.59% to 61.24%.

The elemental composition of the ash from the initial PR, as well as the chemical composition of the initial and oxidized PR, extractive substances, and insoluble organic residues were analyzed, including the determination of their functional groups. Thus, the conducted study demonstrated that oxidation of plant residues with HNO_3 significantly increases the content of extractive substances, which are valuable precursors for the production of organic and organo-mineral fertilizers, as well as plant growth stimulants.

Literature

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