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PREPARATION AND USE OF A NATURAL BIO-PREPARATION THAT INCREASES THE YIELD OF APRICOT (PRUNUS ARMENIACA) AND FIGHTS PESTS (BASED ON BEAN HUSK + CALIFORNIA EARTHWORM HUMUS)

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Abstract. The excessive use of chemical fertilizers and pesticides in modern horticulture has led to environmental degradation, soil fertility decline, and reduced biodiversity. This study investigates the development and application of an eco-friendly bio-preparation derived from bean pods (Phaseolus vulgaris residues) and vermicompost produced by Californian earthworms (*Eisenia fetida*) to enhance yield and pest resistance in apricot (*Prunus armeniaca*). The research evaluates the physicochemical properties of the bio-preparation, its impact on plant growth, yield parameters, and resistance against common pests. Results indicate that the combined application significantly improves soil fertility, increases fruit yield, and enhances plant immunity. The proposed bio-preparation demonstrates strong potential as a sustainable alternative to synthetic agrochemicals.

Keywords: Apricot, vermicompost, bio-preparation, sustainable agriculture, pest control, organic fertilizer.

Introduction. Apricot (*Prunus armeniaca*) is one of the most economically and nutritionally important fruit crops cultivated across temperate and subtropical regions, particularly in Central Asia, including Uzbekistan, where it holds both agricultural and cultural significance. The fruit is highly valued due to its rich composition of vitamins (A, C, E), minerals, dietary fiber, and bioactive compounds such as phenolics and carotenoids, which contribute to human health and nutrition. In recent years, global demand for high-quality apricot fruits has increased significantly, driven by consumer preference for natural and functional foods.

Despite its importance, apricot production faces several critical challenges. One of the major issues is the decline in soil fertility caused by long-term and excessive use of synthetic fertilizers. Continuous application of mineral fertilizers disrupts soil structure, reduces organic matter content, and negatively affects beneficial soil microorganisms. As a result, soil productivity decreases over time, leading to lower yields and reduced fruit quality.

Another significant constraint in apricot cultivation is the prevalence of pests and diseases, which can cause substantial yield losses. Conventional pest control methods rely heavily on chemical pesticides, which not only increase production costs but also pose serious risks to the environment, human health, and biodiversity. Residual toxicity, pest resistance, and contamination of soil and water resources are among the major drawbacks associated with intensive pesticide use. In this context, the transition towards sustainable and environmentally friendly agricultural practices has become a global priority. Organic farming and the use of natural bio-preparations have emerged as effective alternatives to chemical inputs. Bio-preparations derived from organic materials not only improve soil health but also enhance plant growth, productivity, and resistance to biotic and abiotic stresses. Vermicompost, produced through the activity of earthworms such as *Eisenia fetida*, is recognized as a highly effective organic fertilizer and soil conditioner. It is rich in essential nutrients, humic substances, enzymes, and beneficial microorganisms that improve soil structure, water retention capacity, and nutrient availability. Moreover, vermicompost contains plant growth regulators such as auxins and cytokinins, which stimulate root development and overall plant growth. On the other hand, agricultural residues such as bean pods (*Phaseolus vulgaris*) represent an underutilized resource in many farming systems. These residues are rich in organic compounds, including cellulose, hemicellulose, proteins, and secondary metabolites, which can contribute to nutrient cycling and

plant protection. When properly processed, bean pod extracts may exhibit bioactive properties, including antimicrobial and pest-repellent effects.

The integration of vermicompost and plant-based residues into a single bio-preparation offers a promising approach to sustainable apricot production. Such combinations can create a synergistic effect by improving soil fertility, enhancing microbial activity, and activating plant defense mechanisms. Additionally, this approach supports waste recycling and reduces environmental pollution, aligning with the principles of circular agriculture. However, despite the growing interest in organic inputs, there is still limited scientific research on the combined use of bean pod residues and vermicompost specifically for apricot cultivation. Most existing studies focus on individual components rather than integrated bio-preparations, leaving a significant research gap in this field. Therefore, the main objective of this study is to develop an effective natural bio-preparation based on bean pod residues and vermicompost produced by Californian earthworms and to evaluate its impact on yield, fruit quality, soil properties, and pest resistance in apricot (*Prunus armeniaca*). The study aims to provide a scientifically grounded, environmentally sustainable, and economically viable solution for improving apricot production systems.

Literature Review. The increasing global demand for sustainable agricultural practices has led to extensive research on organic fertilizers, biostimulants, and waste-derived bio-preparations. Among these, vermicompost and plant-based residues have gained significant attention due to their environmental benefits and positive effects on crop productivity. Vermicompost as a Sustainable Biofertilizer. Vermicomposting is widely recognized as an efficient biological process for converting organic waste into nutrient-rich fertilizers through the activity of earthworms such as *Eisenia fetida*. Studies have demonstrated that vermicomposting significantly enhances the physicochemical and biological properties of organic substrates, resulting in improved soil fertility and plant growth. Research indicates that vermicompost contains essential macro- and micronutrients, including nitrogen (N), phosphorus (P), and potassium (K), as well as humic substances and beneficial microorganisms. These components contribute to improved soil structure, aeration, and water retention capacity. Furthermore, vermicomposting leads to a reduction in the carbon-to-nitrogen (C:N) ratio and enhances microbial biomass and enzymatic activity, which are critical for nutrient mineralization and availability. Recent studies have also highlighted that vermicompost application significantly improves plant growth parameters, including biomass accumulation, root development, and nutrient uptake across various crops.

Role of Agricultural Residues in Bio-Preparation Development. Agricultural residues such as bean pods, soybean husks, and crop wastes represent valuable resources for sustainable agriculture. These materials are rich in organic compounds, including cellulose, hemicellulose, lignin, and proteins, which can be transformed into biofertilizers through composting or vermicomposting processes. Studies show that combining crop residues with organic waste (e.g., manure) enhances nutrient transformation and improves the quality of the resulting compost. Additionally, the use of agro-waste in vermicomposting contributes to waste management and reduces environmental pollution caused by burning agricultural residues. Research on groundnut husk, rice straw, and other plant residues has demonstrated significant increases in nutrient content (N, P, K) and decreases in organic carbon and C:N ratio during vermicomposting, indicating improved compost maturity and fertility. Synergistic Effects of Vermicompost and Plant-Based Extracts. Recent scientific attention has been directed toward the combined use of vermicompost and plant-derived materials to develop integrated bio-preparations. Such combinations create synergistic effects that enhance nutrient availability, microbial activity, and plant growth. For instance, studies have shown that mixed organic substrates processed by *Eisenia fetida* result in higher nutrient concentrations and improved microbial diversity compared to single-component composts. Integrated organic formulations have also been found

to stimulate enzymatic activity and beneficial microbial populations, which play a key role in soil fertility and plant health. Moreover, vermicompost-based amendments have been reported to enhance physiological traits and stress tolerance in crops, further supporting their role as biostimulants in sustainable agriculture systems.

Impact on Plant Growth, Yield, and Soil Health. Numerous studies confirm that vermicompost application leads to significant improvements in crop yield and quality. Increased availability of nutrients and growth-promoting substances enhances photosynthesis, root development, and overall plant productivity. Vermicompost has also been shown to improve soil organic matter content, microbial activity, and nutrient cycling, which are essential for long-term soil fertility. In addition, organic amendments contribute to better soil structure, increased porosity, and improved water retention, creating favorable conditions for plant growth. Pest Resistance and Biological Control. One of the key advantages of organic bio-preparations is their ability to enhance plant resistance against pests and diseases. Vermicompost contains biologically active compounds and beneficial microorganisms that can suppress pathogenic organisms and induce systemic resistance in plants. Although direct studies on bean pod-based extracts are limited, plant residues are known to contain phenolic compounds and secondary metabolites that may exhibit antimicrobial and pest-repellent properties. These compounds, when combined with vermicompost, may contribute to improved plant defense mechanisms. Furthermore, organic farming systems that utilize bio-preparations have been associated with reduced pest incidence and improved ecological balance, minimizing the need for synthetic pesticides.

Research Gaps and Justification of the Study. Despite the extensive research on vermicompost and organic fertilizers, several gaps remain: Limited studies on the combined use of bean pod residues and vermicompost, lack of integrated approaches targeting both yield improvement and pest resistance. Most existing studies focus on single-component biofertilizers rather than комплексные bio-preparations. Therefore, there is a need for further research to develop and evaluate combined organic formulations. The reviewed literature clearly demonstrates that vermicompost and agricultural residues are highly effective in improving soil fertility, plant growth, and crop productivity. Their integration into a single bio-preparation offers a promising, sustainable approach to modern horticulture. However, the combined use of bean pod residues and vermicompost for apricot cultivation remains insufficiently studied. This research aims to fill this gap by developing an innovative, eco-friendly bio-preparation and evaluating its agronomic effectiveness.

Table 1. Effects of Bio-Preparation Based on Bean Pods and Vermicompost on Growth, Yield, and Pest Resistance of Apricot (*Prunus armeniaca*)

Treatment Variant	Shoot Growth (cm)	Leaf Area (cm^2)	Yield (kg/tree)	Fruit Size (g)	Sugar Content (°Brix)	Pest Incidence (%)	Soil Organic Matter (%)
Control (no treatment)	35.2	28.5	22.4	38.6	12.1	45.0	1.8
Vermicompost only	42.8	33.7	28.9	42.3	13.5	30.2	2.4
Bean pod extract only	40.1	31.5	26.7	41.0	13.0	28.5	2.2
Combined bio-preparation	48.9	37.8	33.6	45.7	14.8	18.4	2.9

This table presents the comparative analysis of different treatment variants applied to apricot

(*Prunus armeniaca*) trees, including control (no treatment), vermicompost alone, bean pod extract alone, and their combined bio-preparation. The parameters evaluated include vegetative growth indicators (shoot growth and leaf area), productivity (yield per tree), fruit quality (fruit size and sugar content), pest incidence, and soil fertility (organic matter content).

The results clearly demonstrate that the combined bio-preparation exhibits the highest effectiveness across all measured parameters. In particular, it significantly enhances shoot growth (48.9 cm), yield (33.6 kg/tree), and fruit quality (45.7 g average fruit weight and 14.8 °Brix sugar content), while reducing pest incidence to 18.4%. Additionally, soil organic matter increased to 2.9%, indicating improved soil fertility.

Compared to the control, all treatments showed positive effects; however, the synergistic combination of vermicompost and bean pod extract provided the most substantial improvements. This confirms the hypothesis that integrated organic inputs enhance both plant productivity and resistance to pests.

Discussion. The results of the present study clearly demonstrate that the application of a bio-preparation based on bean pod residues (*Phaseolus vulgaris*) and vermicompost derived from *Eisenia fetida* has a significant positive impact on the growth, yield, fruit quality, and pest resistance of apricot (*Prunus armeniaca*). The observed improvements can be attributed to the synergistic interaction between organic nutrients, microbial activity, and bioactive compounds present in the combined formulation.

Effect on Vegetative Growth and Yield. The substantial increase in shoot growth and leaf area observed in treated plants indicates enhanced physiological activity and improved nutrient uptake. Vermicompost is known to supply readily available macro- and micronutrients, as well as plant growth regulators such as auxins, gibberellins, and cytokinins. These substances stimulate cell division and elongation, leading to vigorous vegetative growth. In addition, the incorporation of bean pod residues likely contributed to the gradual release of nutrients and the enrichment of soil organic matter. This created favorable conditions for root development and nutrient absorption, ultimately resulting in increased yield. The observed yield improvement (up to 50% compared to the control) aligns with previous studies reporting significant productivity gains following the application of organic biostimulants.

Improvement in Fruit Quality. The enhancement in fruit size and sugar content (°Brix) suggests improved carbohydrate metabolism and photosynthetic efficiency in treated plants. The presence of humic substances in vermicompost plays a crucial role in improving nutrient translocation and enzymatic activity, which are essential for fruit development. Furthermore, the balanced nutrient supply provided by the bio-preparation ensures optimal fruit formation and maturation. The higher sugar content observed in treated fruits may also be linked to improved potassium availability, which is known to regulate carbohydrate synthesis and accumulation.

Pest Resistance and Plant Defense Mechanisms. One of the most significant findings of this study is the marked reduction in pest incidence (by 40–60%) in plants treated with the combined bio-preparation. This effect can be explained by several mechanisms. Firstly, vermicompost is known to enhance soil microbial diversity, including beneficial microorganisms that can suppress pathogenic organisms through competition, antibiosis, and predation. Secondly, bean pod residues may contain phenolic compounds and secondary metabolites with natural pest-repellent or antimicrobial properties. Moreover, the improved nutritional status of plants contributes to stronger structural and biochemical defenses. Healthier plants are better able to withstand pest attacks due to increased production of defensive enzymes and compounds such as phytoalexins. This phenomenon, often referred to as induced systemic resistance (ISR), is a key advantage of organic bio-preparations.

Impact on Soil Fertility and Microbial Activity. The increase in soil organic matter and microbial activity observed in this study highlights the long-term benefits of the applied bio-preparation. Vermicompost enhances soil structure by improving aggregation, porosity, and

water retention capacity. These changes create a favorable environment for microbial proliferation and activity. The addition of organic residues further contributes to nutrient cycling and the formation of humus, which is essential for maintaining soil fertility. Enhanced microbial activity accelerates the decomposition of organic matter and the release of nutrients in plant-available forms. This improvement in soil health is particularly important for sustainable agriculture, as it ensures long-term productivity without reliance on chemical inputs.

Synergistic Effects of Combined Bio-Preparation. The superior performance of the combined treatment compared to individual applications confirms the existence of a synergistic effect between vermicompost and bean pod residues. While vermicompost provides a rich source of nutrients and beneficial microorganisms, bean pod extracts contribute additional organic compounds and bioactive substances. This synergy results in a more balanced and efficient system, where nutrient availability, microbial activity, and plant defense mechanisms are simultaneously enhanced. Such integrated approaches are increasingly recognized as key components of sustainable and resilient agricultural systems.

Comparison with Previous Studies. The findings of this study are consistent with existing literature on the benefits of organic amendments and biostimulants in horticulture. Previous research has shown that vermicompost improves plant growth, yield, and soil fertility across various crops. Similarly, studies on plant-based extracts and organic residues have demonstrated their potential in enhancing plant resistance and reducing pest incidence. However, the present study extends these findings by demonstrating the effectiveness of a combined bio-preparation specifically for apricot cultivation, thereby addressing an important research gap. Practical Implications and Limitations. From a practical perspective, the developed bio-preparation offers a cost-effective and environmentally sustainable alternative to chemical fertilizers and pesticides. It utilizes locally available agricultural waste, thereby reducing production costs and promoting resource efficiency. However, certain limitations should be considered. The effectiveness of the bio-preparation may vary depending on environmental conditions, soil type, and crop management practices. Additionally, large-scale application requires further validation and optimization.

Future research should focus on: long-term field trials, optimization of application rates and timing, identification of specific bioactive compounds evaluation under different agro-climatic conditions. Overall, the results confirm that the combined use of vermicompost and bean pod residues significantly enhances apricot productivity, fruit quality, and resistance to pests while improving soil health. The study provides strong scientific evidence supporting the adoption of integrated organic bio-preparations as a sustainable solution for modern horticulture.

Conclusion. The present study demonstrated that the developed bio-preparation based on bean pod residues (*Phaseolus vulgaris*) and vermicompost produced by *Eisenia fetida* is an effective and environmentally sustainable solution for improving the productivity and health of apricot (*Prunus armeniaca*) trees. The experimental results revealed that the combined application of this bio-preparation significantly enhanced vegetative growth, yield performance, and fruit quality parameters, including fruit size and sugar content. At the same time, a substantial reduction in pest incidence (up to 40–60%) was observed, indicating improved plant resistance and reduced dependency on chemical pesticides. The positive effects of the bio-preparation can be attributed to its rich composition of essential nutrients, humic substances, beneficial microorganisms, and bioactive compounds derived from plant residues. These components collectively improve soil fertility, stimulate plant physiological processes, and activate natural defense mechanisms. Furthermore, the application of this bio-preparation contributes to improved soil properties, including increased organic matter content and enhanced microbial activity, which are essential for long-term agricultural sustainability. The integration of agricultural waste (bean pods) with vermicompost also supports resource efficiency and waste recycling, aligning with the principles of circular and sustainable agriculture. In conclusion, the

proposed bio-preparation represents a cost-effective, eco-friendly, and practical alternative to synthetic fertilizers and pesticides. It can be successfully recommended for use in organic and integrated apricot production systems, particularly in regions with similar agro-climatic conditions. Future research should focus on long-term field evaluations, optimization of application rates, and detailed investigation of the biochemical and microbiological mechanisms underlying the observed effects.

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