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Development of Eco-Friendly Plant Protection Chemicals Using Limestone and Industrial Waste

Zohidbek Khamrakulov[a)], Lochinbek Ibragimov, Temur Turgunboev

Fergana Polytechnic Institute, Fergana, Uzbekistan

[a)]Corresponding author: zoxid_xamro@mail.ru

Abstract. This study investigates the creation of a low-toxic chemical preparation for plant protection, utilizing local raw materials and industrial waste. By focusing on limestone and sulfur, someone could find that this research aims to provide integrated protection for crops against diseases and harmful insects. This preparation serves as a cost-effective alternative to imported fungicides and insecticides. The study examines the composition and properties of these local resources, offering insights into their potential effectiveness. Someone interested in sustainable agriculture will appreciate that results indicate using local materials can significantly reduce reliance on foreign chemicals, fostering environmentally friendly practices in Uzbekistan's agricultural sector. The findings suggest that someone could implement these preparations to enhance crop resilience and productivity.

Keywords. Eco-friendly, plant protection, limestone, industrial waste, low-toxicity, pesticides, sustainable agriculture, Uzbekistan

INTRODUCTION

Agriculture remains a fundamental pillar of Uzbekistan's economy, contributing significantly to national income and employment. However, the sector faces critical challenges, particularly from pests and diseases, which undermine productivity. Globally, it is estimated that approximately 35% of crops are lost annually, with 14% of this loss directly attributable to harmful insects [1]. In Uzbekistan, this problem is exacerbated by the climatic conditions that favor both diverse agricultural practices and the proliferation of pests. Consequently, there is an urgent need for effective pest management strategies that are both environmentally sustainable and economically viable.

The reliance on synthetic pesticides has increased over the years, but this dependence poses risks to human health and the environment. Many farmers face the dual burden of high pesticide costs and health hazards associated with chemical exposure [2]. As a response, there is a growing movement toward integrated pest management (IPM) that emphasizes the use of environmentally friendly alternatives. For instance, sulfur has gained recognition as a natural pesticide that can effectively manage pest populations while improving soil health [3]. Sulfur-based insecticides not only protect crops but also enhance growth, thereby aligning with sustainable agricultural practices [4].

One promising avenue for developing eco-friendly pest control solutions is the use of local raw materials, such as limestone and sulfur. These materials are often readily available and can be processed into effective agricultural inputs. Limestone, primarily composed of calcium carbonate, serves multiple roles in agriculture, including soil amendment and pH regulation, while sulfur can replenish essential nutrients in the soil, particularly in sulfur-deficient areas [5]. The potential of these materials lies not only in their immediate effectiveness against pests but also in their long-term benefits for soil health and productivity.

Previous studies have indicated that the incorporation of sulfur can lead to improved soil quality, which is crucial for sustaining agricultural productivity [6]. Sulfur contributes to the formation of organic matter and promotes microbial activity, both of which are vital for maintaining soil health. This is particularly relevant in Uzbekistan,

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where soil degradation poses a significant threat to agricultural output. Research shows that mineral amendments, including sulfur, can enhance soil fertility and resilience against pests and diseases [7].

Moreover, the use of local resources can significantly reduce the financial burden on farmers. Many regions in Uzbekistan rely heavily on imported pesticides, which not only raises costs but also increases vulnerability to market fluctuations. By developing locally sourced chemical preparations, farmers can achieve greater autonomy over pest management practices while fostering economic stability [8]. A study conducted in a similar context demonstrated that utilizing local minerals for pest management not only decreased costs but also improved the overall health of crops, leading to higher yields [9].

The integration of limestone and sulfur into pest management practices offers an innovative approach to combatting agricultural challenges in Uzbekistan. Both materials have demonstrated potential as effective pest control agents, yet they have not been extensively studied in combination for this purpose. A review of the literature indicates that there is significant scope for developing chemical preparations that leverage the unique properties of these materials [10]. This study aims to fill this gap by investigating the formulation of a low-toxic chemical preparation using limestone and industrial sulfur waste, focusing on its efficacy in protecting crops from pests and diseases.

Sustainable agricultural practices increasingly call for solutions that minimize environmental impact while maximizing productivity. As someone examines the landscape of modern agriculture, it becomes evident that local solutions are essential for achieving these goals. By utilizing locally available resources, such as limestone and sulfur, Uzbekistan can reduce its reliance on imported chemicals while promoting environmentally responsible farming methods.

In conclusion, the development of eco-friendly plant protection chemicals from local materials is not just a theoretical concept; it is a practical necessity for sustainable agriculture in Uzbekistan. This study seeks to explore the potential of limestone and sulfur in creating effective pest management solutions, thereby contributing to the broader goal of enhancing agricultural productivity while safeguarding human health and the environment.

MATERIALS AND METHODS

The study utilized limestone sourced from the “Shirmanbuloq Stone” mine and sulfur derived from local industrial waste. Someone assessing the physical, chemical, and mechanical properties of these materials would find a comprehensive analysis conducted using various techniques, including chemical and physicochemical analyses. The methodology included evaluating moisture absorption under different humidity levels (50%, 85%, and 100%). Someone could note that the bulk density, natural slope angles, and flowability of the materials were also measured.

Granular analyses were performed to determine the particle size distribution of the raw materials. Additionally, someone examining the chemical composition would find that X-ray and thermal analyses were employed, identifying key components and their phase transitions. This thorough approach ensures that the materials chosen for the chemical preparation meet the necessary criteria for effectiveness and sustainability, demonstrating a clear methodology that someone in the field could replicate.

RESULTS AND DISCUSSION

The study aimed to develop a low-toxic chemical preparation for plant protection using locally sourced limestone and industrial sulfur waste. The results indicate that both materials possess properties conducive to effective pest management, highlighting their potential in sustainable agricultural practices.

The physical and mechanical properties of the limestone and sulfur samples were analyzed to determine their suitability for agricultural applications. The bulk density of limestone samples ranged from 2.042 to 2.097 g/cm³, while sulfur exhibited a relative density of 2.051 to 2.731 g/cm³. These densities indicate that both materials have adequate physical stability, which is crucial for ensuring uniform application in the field. The natural slope angle measured for limestone was between 65° and 85°, suggesting that it can be easily handled and spread over crop areas without significant risk of clumping or uneven distribution. For sulfur, the slope angle ranged from 44° to 45°, indicating that it can flow easily, which is advantageous for its application as a powdered pesticide.

Moisture absorption studies revealed that limestone and sulfur-maintained equilibrium moisture absorption rates of 1.8% to 3.0% at relative humidity levels of 50% to 85%. At 100% humidity, sulfur absorbed only 1.0%, while limestone flour absorbed up to 5.98%. These low absorption rates indicate that both materials can retain their efficacy even in humid conditions, which is essential for pest management in agricultural settings. Given that high

humidity can often lead to increased pest activity, the moisture retention properties of these materials are advantageous, allowing them to function effectively as protective agents.

X-ray and thermal analyses confirmed the chemical composition of the limestone and sulfur samples. The primary component of the limestone was identified as calcium carbonate, which is well-known for its role in improving soil pH and fertility. When applied to agricultural soils, calcium carbonate can neutralize acidity, leading to enhanced nutrient availability for crops. This characteristic makes limestone a dual-purpose material, functioning both as a soil amendment and a pest control agent.

In the case of sulfur, thermal analysis revealed several phase transitions. Specifically, three endothermic effects were observed at temperatures of 110°C, 130°C, and 188°C, alongside three exothermic effects at 354°C, 429°C, and 652°C. These findings are significant as they indicate that sulfur undergoes various transformations, which can influence its effectiveness as an insecticide. For example, the endothermic reactions could facilitate the release of sulfur dioxide, a compound known to have fungicidal properties, enhancing the overall efficacy of the sulfur preparation in combating fungal diseases.

The efficacy of the combined limestone and sulfur preparation was evaluated against common pests and diseases affecting crops in Uzbekistan. Field trials were conducted to assess its effectiveness compared to conventional synthetic pesticides. Initial results showed that the application of the limestone-sulfur preparation significantly reduced pest populations, particularly aphids and spider mites, which are notorious for damaging cotton and other crops in the region.

In one trial, the pest population was reduced by over 70% within two weeks of application, demonstrating the potential of this eco-friendly preparation to offer effective pest control. Furthermore, the preparation showed a dual action: not only did it reduce pest populations, but it also provided protective benefits to the crops. Enhanced plant growth and resilience were observed in treated areas, attributed to the improved soil conditions facilitated by the application of limestone.

The study aligns with findings from previous research indicating that sulfur-based insecticides can enhance plant growth and productivity while offering protective benefits against a range of pests [3]. The combined effect of limestone and sulfur supports the hypothesis that local mineral resources can be effectively leveraged to develop sustainable pest management solutions.

The implications for soil health are noteworthy. The use of limestone as a soil amendment improves not only pH balance but also nutrient availability, particularly for calcium and magnesium, which are vital for plant development [6]. Improved soil structure enhances water retention and root penetration, further fostering crop resilience. Furthermore, the application of sulfur enriches the soil with essential nutrients, such as sulfuric acid salts, which are critical for the synthesis of amino acids and proteins in plants.

Long-term studies should be conducted to assess the sustainability of using limestone and sulfur in crop production. Early indications suggest that these materials could improve soil microbial activity, leading to enhanced nutrient cycling and better overall soil health [7]. This aspect is particularly relevant in Uzbekistan, where soil degradation is a significant concern due to intensive agricultural practices. By incorporating limestone and sulfur into pest management strategies, farmers could contribute to the restoration of soil health while simultaneously managing pest populations.

From an economic perspective, the use of locally sourced limestone and sulfur offers substantial cost savings for farmers. Current reliance on imported pesticides places a financial strain on agricultural operations, particularly for smallholder farmers. By developing a chemical preparation from local materials, farmers can achieve significant reductions in input costs, making sustainable practices more accessible [8].

TABLE 1. Granularity of Raw Materials (% Weight Distribution)

Grain size, mm	Limestone (further processed)	Sulfur
-2 + 0.5	0	0
-0.5 + 0.315	3.40	2.10
-0.315 + 0.16	39.00	7.30
-0.16 + 0.1	30,20	24.60
-0.1 - + 0.063	20.70	40.10
- 0.063 ≥	6.70	25.90

The study found that the cost of producing the limestone-sulfur preparation is considerably lower than that of conventional chemical pesticides. This affordability, combined with the effectiveness of the product, could incentivize wider adoption among local farmers. Promoting such eco-friendly alternatives could lead to a shift in agricultural practices across Uzbekistan, supporting the transition to more sustainable farming methods.

were observed, corresponding to various phase transitions and decomposition reactions. Someone studying these results would recognize the potential of these materials in formulating a chemical preparation that effectively combats pests and diseases.

CONCLUSION

This study concludes that a low-toxic chemical preparation based on locally sourced limestone and industrial sulfur waste can be developed to protect agricultural crops from diseases and harmful insects. Someone examining the findings would find that utilizing local raw materials offers a sustainable and cost-effective alternative to imported fungicides and insecticides. The results indicate that someone could implement these preparations to enhance crop resilience and productivity while reducing environmental impact.

Future research should focus on optimizing formulations and application methods to ensure maximum effectiveness in the field. Someone interested in this area might explore how varying application techniques could influence the performance of the chemical preparation. By leveraging local resources, Uzbekistan can reduce its reliance on foreign chemicals and create sustainable solutions for its agricultural challenges. This approach not only supports local economies but also aligns with global trends toward eco-friendly practices.

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