Pesticide Risk: A Study on the Effectiveness of Organic/Biopesticides in Sustainable Agriculture

Berk Kılıç, Ömer Aydın, Kerem Mestani, Defne Uzun

***Abstract*—**In agriculture and farming, pesticides are frequently used to kill off or fend off any pests (bugs, bacteria, fungi, etc.). However, traditional pesticides have proven to have harmful effects on both the environment and the human body, such as hazards in the endocrine, neurodevelopmental, and reproductive systems. This experiment aims to test the effectiveness of organic/bio-pesticides (environmentally friendly pesticides) compared to traditional pesticides. Black pepper and garlic will be used as biopesticides in this experiment. The results support that organic farming applying organic pesticides operates through non-toxic mechanisms, offering minimal threats to human well-being and the environment. Consequently, consuming organic produce can significantly diminish the dangers associated with pesticide intake. In this study, a method is presented to reduce pesticide-related risks by promoting organic farming techniques within organic/bio-pesticide usage.

***Keywords*—**Pesticide, garlic, black pepper, bio-pesticide.

I. Introduction

AGRICULTURE and horticulture require the extensive use of pesticides, which are chemical substances employed to eliminate various biological threats to plants and crops. Despite their effectiveness in protecting crops, these pesticides present potential health risks to consumers. These health hazards encompass concerns related to reproductive and endocrine systems, neurodevelopmental processes, and the immune system. Individuals with asthma may experience heightened reactions to certain pesticides, posing a significant risk to their well-being. Moreover, prolonged exposure to pesticides is associated with the development of chronic conditions like cancer and disruptions to hormonal balance [1]. In addition to human health, research has proven that pesticides can cause environmental damage [2]. Pesticides have the potential to contaminate soil, water, and turf while also harming various non-target insects. They pose a threat to non-target birds, fish, and plants due to their toxic nature [3]. Given the detrimental impacts of chemical pesticides on agricultural soils, water resources, human health, and the environment, there is an urgent requirement for an improved approach to managing agricultural pests. The adoption of biopesticides stands out as a prominent strategy to address these pests in an environmentally friendly manner. Biopesticides, categorized as pest control agents derived from natural products or microorganisms, present a considerable potential for effectively managing yield losses without compromising product quality. According to the Environmental Protection Agency (EPA) in the United States, biopesticides are derived from natural sources such as bacteria, plants, animals, and certain minerals [4]. Biopesticides, recognized for their capacity to decompose naturally in the environment, are becoming increasingly popular. These organic pesticides provide numerous benefits. Firstly, they do not result in contamination of consumers or plants. Additionally, they are environmentally friendly, sustainable, and more cost-effective compared to traditional pesticides. Another advantage of biopesticides is their efficiency and the use of safer approaches for managing pests. However, it is worth noting that biopesticides may require more frequent or greater application to achieve the desired effect [5].

It is surprising to learn that the global demand for food is projected to increase by 21% between 2010 and 2050, while the percentage of the population at risk of hunger is expected to rise by 17% during the same period. Climate change, coupled with population growth, significantly impacts these statistics. The anticipated surge in food demand is estimated at 32%, with the population at risk of hunger forecasted to increase to 39% [6]. To address the challenges posed by population growth and climate change, there is a need for the global adoption of novel and enhanced agricultural practices and strategies prioritizing sustainability and productivity. Improved agricultural productivity can be realized through various means, such as enhancing crop yields through the application of organic-based treatments, like biopesticides [6]. Furthermore, these projections underscore the urgency of implementing effective measures to ensure global food security in the face of escalating challenges. The intersection of climate change and population growth not only intensifies the demand for food but also exacerbates the risk of hunger among communities. This necessitates a comprehensive approach that extends beyond conventional agricultural practices. Embracing innovative strategies and technologies, with a focus on sustainability and productivity, becomes imperative. The integration of organic-based treatments, including biopesticides, represents a promising avenue for enhancing agricultural productivity while mitigating environmental impacts [7].

The wild pansy flower, scientifically known as "*Viola tricolor,*" serves as an ideal candidate for our experiment as it exhibits responsiveness to both natural and synthetic pesticides. This flower is commonly found in nature and is renowned for its reliability, making it an easy-to-cultivate plant that thrives throughout the year. The wild pansy is a petite plant with long, slender branching stems, reaching a height of up to 15 cm. Its leaves are typically oval-shaped with serrated edges. Pansies typically bloom for seven to eight months, and in warmer

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climates, they can blossom from fall through winter into early spring [8]. Wild pansy flower is selected and utilized in this project to analyze the effectiveness of traditional pesticides and bio-pesticides in terms of a sustainable agriculture pest alternative. This paper aims to address the policies that can promote countries to embrace intelligent and sustainable agricultural practices with eco-friendly, unharmful and organic practices.

II. Method

A. Material

Garlic (*Allium sativum*) and black pepper (*Piper nigrum*) powders were obtained from an online market, each packaged in packets. Distilled water was utilized for soaking the weighted powders. Muslin cloth was employed to filter the solutions, effectively removing any large residues. Flasks and chemical bottles were utilized for soaking the aqueous solutions at room temperature overnight. Labels were affixed to the solutions for identification purposes. Additionally, testing sets were prepared for each solution. Care was taken to maintain consistent concentrations of the solutions to ensure the reliability of the experiment. All apparatus used in the preparation process were sterilized to avoid contamination and ensure accurate results. The solutions were gently agitated during soaking to maximize the extraction of active compounds. To enhance comparability, control samples without any active ingredients were prepared alongside the experimental solutions. Finally, the prepared solutions were stored in a controlled environment until further analysis and application.

B. Procedure

In this study, the effects of bio-pesticides and traditional pesticides were observed on seven pansy flowers. The selected pesticides, which include traditional pesticide, black pepper, and garlic, were applied to each plant. Each selected pesticide was mixed with water to create a solution for application. For garlic and black pepper, 10 g of each was mixed with water until the solution reached 500 g by mass. However, 1 g of traditional pesticide was mixed with water until the solution became 500 g by mass (499 mL of water added) since higher amounts of traditional pesticide pose a threat to the environment. During the experimental procedure, selected pesticides were applied in the following amounts corresponding to seven pansy flowers (one of them serving as the control group) (Table I). The plants underwent weekly monitoring to assess their health, with evaluations focusing on the frequency of leaf bites and the presence of decayed leaves to gauge the overall condition of the flowers. The first group consisted of 1x, which translates to 2 mL, and the other group was 4x, which translates to 8 mL of each pesticide. Flowers were monitored every week to observe the conditions and the effects of each of the pesticides. Environmental conditions, such as temperature and humidity, were recorded during the monitoring process to account for potential external influences on plant health. Each observation session included photographic documentation to ensure visual records for comparison. Statistical analysis was performed to determine any significant differences in the effects of the pesticides across the groups. Additionally, the potential impact of the bio-pesticides on beneficial insects around the plants was carefully monitored.

TABLE I
Name of Selected Pesticides and Amounts of Each Applied to Plants

Name of Pesticide	Amount of Applied Pesticide Solution
Control group	0 mL
Traditional pesticide solution x1	2 mL
Black pepper solution x1	2 mL
Garlic solution x1	2 mL
Traditional pesticide solution x4	8 mL
Black pepper solution x4	8 mL
Garlic solution x4	8 mL

III. Discussion

In this study, garlic, and black pepper solutions were tested for their effectiveness as natural pesticides. Each time interval was recorded for the leaf bites and the presence of decayed leaves. Control of each pesticide type is performed every week, Table II gives only the specific dates during the study; however, the whole process is monitored in 90 days.

Measurements in 90 days portrayed a trend (a correlation) between the concentration of solutions, type of pesticide and the total damage. Firstly, the control group which received no pesticides had the highest count of total damage. The most successful pesticides were garlic solution (8 mL). The plant that was under the effect of garlic solution (8 mL) had a total damage of five bite marks and two rotten leaves at the end of the experimental procedure. The second most effective pesticide was the traditional pesticide solution (8 mL). The plant that was under the effect of this solution had a total damage of seven bite marks and two rotten leaves (Fig. 1).

Garlic solution (8 mL) proved to be an effective alternative to traditional pesticides. Traditional pesticides usually contain organometallic and organochlorine compounds which are hazardous to both the human health and the environment.

Garlic is followed by traditional pesticide but the increase in pesticide levels can affect environmental factors and pose health risks. Therefore, increasing the amount of pesticide may not lead to positive results in terms of feasibility and should not be interpreted as a meaningful outcome. The use of such chemicals can lead to environmental pollution, contamination of soil and water resources, decrease in biodiversity, and adverse effects on human health. Therefore, reducing pesticide use or using alternative solutions will be a more suitable approach for environmental and agricultural sustainability and human health.

In addition to the environmental and health risks associated with traditional pesticides, the overuse of these chemicals can also lead to pesticide resistance among pests. This resistance forces farmers to use even higher doses or switch to more potent chemicals, creating a vicious cycle that further threatens ecological balance and soil health. A shift toward integrated pest management (IPM) practices, which combine biological control, habitat manipulation, and careful monitoring, could serve as a viable alternative. By minimizing chemical use and focusing on sustainable practices, IPM can help maintain agricultural productivity while protecting both human health and the environment.

IV. Results

The findings of this study indicate that garlic exhibits greater efficacy than conventional pesticides when applied to specific plant species. The effectiveness of an 8 mL garlic solution can be attributed to its active compounds, such as mono sulfides and disulfides, which are toxic to herbivorous insects and play a critical role in deterring pest infestations. Additionally, garlic essential oil contains high concentrations of diallyl disulfide and diallyl sulfide, which possess well-documented repellent properties against pests. The unique chemical composition of garlic thus enables it to function as a potent, efficient, and environmentally sustainable pest control agent, outperforming traditional pesticide solutions at the same concentration.

In conclusion, garlic-based biopesticides demonstrate significant potential as eco-friendly alternatives to synthetic pesticides. Further experimental research should explore the effectiveness of garlic solutions across a range of plant species to verify their general applicability. To assess practical viability, it is especially critical to test these solutions on economically important crops, such as fruits and vegetables, under varied environmental conditions.

Experimental studies should prioritize economically important crops, such as fruits and vegetables, to determine the practical feasibility of implementing garlic-based solutions on a large scale. Moreover, it is essential to evaluate the long-term impacts of garlic biopesticides on soil health, biodiversity, and ecosystem balance. The scalability of garlic-based biopesticides should also be analyzed to ensure they are cost-effective and accessible for smallholder farmers. Governments and agricultural organizations should support the adoption of these biopesticides through training programs and awareness campaigns to educate farmers about their benefits and proper usage. Incentives for farmers adopting natural pest control methods could further accelerate this transition. Collaborative efforts between researchers, policymakers, and farmers can facilitate the integration of garlic-based pest control into Integrated Pest Management (IPM) systems. If adopted widely, these biopesticides have the potential to reduce the reliance on harmful chemical pesticides, enhance crop productivity, and promote environmental sustainability. This transition would mark a significant step toward achieving a more resilient and sustainable agricultural system. Ultimately, embracing garlic-based solutions aligns with global efforts to mitigate the adverse effects of climate change, protect natural ecosystems, and ensure food security for future generations.

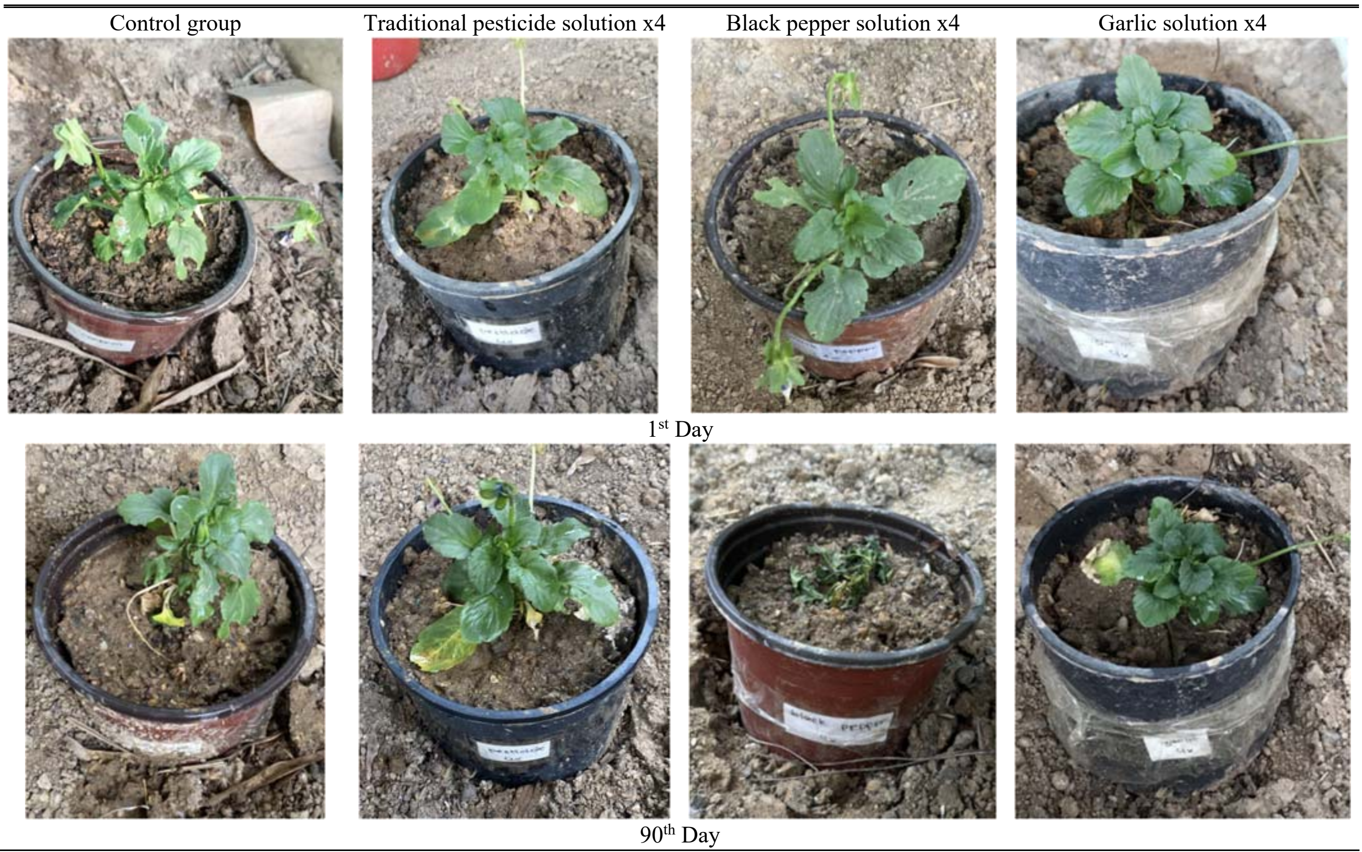

Fig. 1 Aspect of the Wild Pansy Flower (*Viola tricolor*) in the Presence of Different Pesticide Options (8 mL) in 1st and 90th Day

TABLE II
SELECTED PESTICIDE EFFICIENCIES AT DIFFERENT DATES

Date	Pesticide, 4X	Pesticide, 1X	Garlic, 4X	Garlic, 1X	Black P., 4X	Black P., 1X	Control
20.11.2023	(0_) (1**)	(0_) (2**)	(0_) (2**)	(0_) (2**)	(0_) (1**)	(0_) (1**)	(0_) (3**)
04.12.2023	(2_) (2**)	(0_)(6**)	(2_)(3**)	(0_)(7**)	(1_)(4**)	(0_)(6**)	(0_)(15**)
22.12.2023	(4**) (2_)	(7**) (0_)	(3**) (2_)	(7**) (1_)	(4**) (1_)	(6**) (0_)	(15**) (0_)
08.01.2024	(4**) (2_)	(7**) (0_)	(3**) (2_)	(7**) (1_)	(4**) (1_)	(6**) (0_)	(15**) (0_)
24.01.2024	(5**)(2_)	(7**)(1_)	(4**)(2_)	(7**)(2_)	(4**)(2_)	(8**)(1_)	(15**)(0_)
07.02.2024	(7**)(2_)	(9**)(2_)	(5**)(2_)	(7**)(6_)	(4**)(3_)	(9**)(2_)	(15**)(1_)
14.02.2024	(7**)(3_)	(9**)(3_)	(5**)(2**)	dead	dead	(9**)(2_)	(15**)(2_)

** => bite mark #; _ => rotten leaf #

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