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AN INVESTIGATION ON THE EFFICACY OF USING GARLIC-CHILI EXTRACT COMBINATION IN THE CONTROL OF SEMI-LOOPER IN SOYA BEANS.

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DECLARATION

I, Hazel Nhambura hereby declare that this dissertation is my original work and has not been submitted before for any academic award either in this or other institutions of higher learning for academic publication or any other purpose. The references used in this research from other journals or materials are indicated in the references section.

Signed…………

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Supervisor Professor R.Mandumbu

DEDICATION

I dedicate this project to my family, who provided unwavering support and encouragement throughout its duration. Their unrelenting belief in my abilities and potential significantly impacted my perseverance and ultimate success. Additionally, I extend my dedication to Professor Mandumbu, my supervisor, who offered invaluable guidance and mentorship throughout the entire research process, from topic formulation to the finalization of my dissertation. His expertise, patience, and dedication were instrumental in shaping my project and ensuring its quality.

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ABSTRACT

The semi-looper is a significant pest of soya beans, causing substantial crop damage. Currently, chemical pesticides are employed to control this pest, but they can be detrimental to the environment and human health. Therefore, there is a pressing need to develop more sustainable methods of pest control. Garlic and chili extracts have been found to possess insecticidal properties, but their efficacy in controlling semi-looper has not been extensively investigated. This research aims to address this knowledge gap by examining the efficacy of garlic and chili extracts in controlling semi-looper in soya beans. A field experiment was conducted to test the efficacy of the garlic-chili extract combination in controlling semi-looper. The experiment was carried out in a field plot, where treatments with two replicates each were treated with garlic-chili extract combination at varying concentration rates (5%, 10%, and 15%). The plot was divided into four blocks to ensure reliable results. The primary objectives of this study were to assess the number of semi-loopers in the field, the extent of crop damage, the effects of these extract combination on soya beans stem height and the impact of these extracts on the germination of soya beans. The data was analyzed using statistical tests to determine whether the extracts have a significant effect on semi-looper control. The results of this research will have significant implications for the development of more sustainable pest control methods. If the garlic-chili extract combination is found to be effective in controlling semi-looper, it could be used as an alternative to chemical pesticides, leading to a reduction in the reliance and use of chemicals in agriculture. This would benefit the environment and human health. Furthermore, if the extracts are found to be effective, they could be commercialized and made available to farmers. One potential limitation of this research is that the experiment will only be conducted in one location, so the results may not be representative of other locations.

Table of Contents

CHAPTER 1: INTRODUCTION

1.1 Introduction

Smallholder farmers face significant challenges in managing agricultural pests, with agrochemicals posing a substantial financial burden and environmental risk. In response, this research explores the potential of botanical extracts as a sustainable and cost-effective alternative. Harnessing the natural properties of plants, such as garlic and chili, this approach offers a promising solution for controlling pests while preserving ecosystem balance. This research investigates the efficacy of using a garlic-chili extract combination in controlling semi-loopers in soya beans, with a specific focus on determining the optimal concentration and application frequency of this extract combination to achieve maximum efficacy. By exploring this innovative approach, this research aims to contribute to the development of sustainable pest management strategies for smallholder farmers, promoting environmentally friendly and resilient agricultural practices.

1.2 Background of the study

Soya beans also known as Glycine max are an important crop in the world since they are a major source of oil and protein for human use as well as animal feed (Soy Stats, 2020). However, there are many obstacles to soya bean production, with pest infestations being among the most important. Due to its ravenous eating of soya beans leaves, the semi-looper (*Thysanoplusia orichalcea*) is one of the most devastating pests among them, resulting in significant output losses Kandpal and Kumar (2020). Conventional chemical pesticides have been the main tool used to control these pests, but worries about the effects they have on the environment, human health, and pest resistance have sparked interest in alternate approaches to pest management (Battu et al., 2011). This study examines the effectiveness of a natural pest management strategy for managing semi-looper populations in soy bean crops by combining extracts from garlic (*Allium sativum*) and chili (*Capsicum spp*.). Global agriculture and the economy depend heavily on soya beans, especially in the US, Brazil, Argentina, China, and India. They serve as a vital component of animal feed and are a major source of plant-based protein and oil, which are necessary for human nutrition.

Furthermore, soya beans play a major role in the manufacturing of a number of industrial goods, such as adhesives, biodegradable polymers, and biodiesel. In addition to creating jobs, soya beans have a significant economic impact on the GDP of the main producing nations (Hartman et al., 2011; Goldsmith, 2018).Among the most damaging pests to soy bean crops are semi-loopers. By feeding on the leaves, the larvae cause serious damage that hinders photosynthesis and lowers crop yield. Chemical pesticides are used in traditional pest management approaches; although efficient, these chemicals have a number of drawbacks, including contamination of the environment, hazards to human health and the health of non-target creatures, and the emergence of resistant pest populations (Battu et al., 2011). These difficulties highlight the need for sustainable, alternate methods of pest management.The bioactive components in garlic and chili are well known for their insecticidal qualities. Studies have demonstrated the antibacterial and insecticidal properties of allicin, which is found in garlic (Ankri & Mirelman, 2019). Capsaicin, a substance found in chili peppers, is well-known for its ability to repel and kill insects (Koul & Walia, 2019). Both compounds are regarded as safe for the environment and present little harm to non-target creatures or human health

1.3 Problem statement

There is an urgent need to investigate sustainable and effective alternative pest control strategies in light of the growing concerns surrounding chemical insecticides. Because garlic and chili extracts have been shown to have insecticidal effects and are harmless for the environment, they present a possible answer. The purpose of this study is to assess the effectiveness of garlic and chili extract combinations in managing semi-looper populations in soy bean crops. The findings may provide farmers an organic, long-term solution for managing pests.

1.4 Aim

The primary aim of this study is to investigate the efficacy of using a garlic-chili extract combination in controlling semi-looper populations in soya beans crops.

1.5 Objectives

- To determine the effects of garlic-chili extract combination on soya beans germination
- To determine the effects of garlic-chili extract combination on preventing leaf damage caused by semi-looper
- To determine the effects of garlic-chili extract combination on the reduction and control of semi-looper populations
- To determine the efficacy of garlic-chili extract combination on soya beans stem height.

1.6 Hypothesis

- The application of garlic-chili extract combination will be more effective at reducing the population of semi-looper in field beans.
- The use of garlic-chili chili extract combination will be more effective at reducing crop damage caused by semi-looper in field beans
- Garlic-chili extract combination will have an effect on soya bean stem height
- Soaking soya bean seeds in garlic-chili extract will have an effect on soya bean germination

1.7 Justification

The goal of this research is to determine the most effective method for managing semi-looper pests while preserving ecosystems, worker welfare, and soil health. This will contribute to the nation's food security and nutrition. Additionally, the study will broaden our understanding of soy bean productivity and pest management, which will benefit small-scale farmers. Zimbabwe has to produce more soy beans in order to enhance farmers' livelihoods. To do this, the country must create profitable and sustainable farming methods.

CHAPTER 2: LITERATURE REVIEW

2.1 Soya bean as a crop

Soya beans are a vital crop for food security, livestock feed, and industrial uses, with a significant demand in Zimbabwe that outstrips supply. The crop has multiple benefits for farmers, the industry, the Economy, and the nation at large, contributing to food security, employment, and GDP. Currently, Zimbabwe requires 220,000 metric tons of soya beans annually, and improving production and productivity levels can increase its contribution to the agriculture GDP and save foreign exchange. Soya beans production is lucrative, with a high return on investment, and can be used for value addition on the farm, such as producing stock feed, soap, cooking oil, and milk. The crop is also compatible with long and short rotations, benefiting farmers through residual nitrogen fixation. (Seed Co 2024)

2.1.1 Economic Importance of Soya beans

One of the most important crops in the world, soya beans (*Glycine max*) have a major impact on the agricultural economies of many nations. They are an essential part of global trade and a significant source of revenue for farmers. The soy bean sector boosts GDP and creates jobs, among other important economic benefits. For instance, the soy bean industry in the US generates billions of dollars in economic revenue annually and supports millions of jobs (Soy Stats, 2020). Soya beans farming can enhance livelihoods in developing nations by giving farmers a steady source of income.

2.1.2 Nutritional Benefits of Soya beans

Soya beans are a staple food and an important component of animal feed due to their high protein and oil content, which are highly valued for their nutritional value. Compared to many other plant sources, soya beans have a higher protein content of approximately 40%. They are therefore a fantastic source of protein for ingestion by humans and animals. Furthermore, soya beans support general nutritional health as a good source of vitamins, minerals, and dietary fiber (Messina & Messina, 2015).

2.1.3 Environmental Impact of Soya beans Cultivation

The cultivation of soya beans affects the environment in both positive and negative ways. To reduce negative effects and maximize the benefits of soya bean production for the environment, sustainable farming practices are crucial. Since soya beans can fix atmospheric nitrogen, they are essential to sustainable agriculture because they minimize the need for synthetic nitrogen fertilizers. As a result, greenhouse gas emissions may be decreased and soil health may be enhanced (Peoples et al., 2019). Crop rotation schemes that help control pests and enhance soil fertility can also benefit from soya bean farming (Norris & Congreves, 2018). However, especially in areas like the Amazon basin, large-scale soya bean production can result in soil degradation, biodiversity loss, and deforestation. Clearing forests to make room for more soya bean fields has a detrimental effect on carbon sequestration and accelerates climate change (Nepstad et al., 2016). Reducing these environmental risks requires the implementation of sustainable management practices and policies (Gibbs et al., 2015).

2.1.4 Industrial Applications of Soya beans

Soya beans are a versatile crop with substantial industrial value because they can be used for a wide range of industrial applications in addition to being used as food and feed. Soya beans are processed in the food industry to create a variety of goods, including textured vegetable protein, soy milk, tofu, and sauce. These goods are well-liked for their dietary advantages and adaptability in the kitchen (Liu, 2017). Due to its high protein content, soya bean meal, a byproduct of oil extraction is a common ingredient in animal feed. According to Stein et al. (2018), the aquaculture, swine, and poultry industries place a premium on it. Additionally, soya beans are utilized in the manufacturing of biofuels, specifically biodiesel. Through the transesterification process, soy bean oil is transformed into biodiesel, a renewable energy source that can lessen reliance on fossil fuels (Haas et al., 2016). Furthermore, soya beans are utilized in the production of numerous bio products, including adhesives, lubricants, and biodegradable plastics (Liu, 2017).

2.2 Semi-Loopers: Biology and Impact on Soya beans

Semi-loopers (family Geometridae) are a major pest in soya bean cultivation because of their feeding habit, this in turn results significant yield losses. Due to the semi-looper larvae's distinctive looping movement and ravenous appetite for foliage, soya bean plants may experience defoliation and a decrease in their ability to photosynthesize. According to Kandpal and Kumar (2020), semi-loopers, especially the soya beans semi-looper (Thysanoplusia orichalcea) are major pests in the soya bean industry because of their destructive leaf-eating habits, which can cause severe defoliation and yield loss.

2.2.1 Life Cycle and Behavior

Semi-loopers go through a full metamorphosis, with unique stages for the egg, larva, pupa and adult. The most damaging stage is the larvae, which eat leaves and produce the distinctive notching and defoliation. It is essential to know their life cycle in order to put in place efficient control measures (Ameen et al., 2015).

2.2.2 Economic Impact

Semi-loopers can significantly affect soya beans economically. A severe infestation can result in yield reductions of up to 30%, which has an immediate effect on market supply and farmer incomes (Sharma & Lal, 2012). Semi-looper infestations in soya beans can have a significant negative economic impact since they can result in direct yield losses and higher expenses because of the need for pest control measures. Semi loopers increase a plant's susceptibility to other pests and secondary infections, and these infestations can also result in indirect losses.

2.3 Traditional Pest Control Methods

Conventional methods for controlling semi-loopers in soya beans include chemical insecticides, biological control agents, and cultural practices. Each method has its advantages and limitations.

2.3.1 Chemical Control

Chemical insecticides, like pyrethroids and organophosphates, are frequently used to control semi-looper populations because of their quick-acting properties. Nonetheless, there is now more interest in alternative approaches due to non-target effects, environmental concerns, and resistance development (Battu et al., 2011). Chemical insecticides work quickly, that is why they are frequently used. However, concerns about pesticide resistance, pollution of the environment, and harm to non-target organisms have made people look for more sustainable substitutes.

2.3.2 Biological Control

Biological control is utilizing pathogens, parasitoids, or natural predators to control pest populations. Although this approach can be slower to work than chemical controls and frequently necessitates a thorough understanding of pest ecology, it can be quite effective. Compared to chemical controls, this method's efficacy can be erratic and delayed, despite its environmental friendliness (Kaur et al., 2017).

2.3.3 Cultural Practices

Crop rotation, intercropping, and upholding field hygiene are examples of cultural practices that can lower pest incidence. However, in situations where there is a lot of pest pressure, these methods might not be sufficient for control (Altieri, 2018).

2.4 Garlic and Chili Extracts in Pest Control

2.4.1 Active Compounds

Both chili (*Capsicum spp*.) and garlic (*Allium sativum*) are well-known for their insecticidal and repellent qualities. These plants' extracts have been employed in numerous conventional pest control applications. Extracts of chili (*Capsicum spp.*) and garlic (*Allium sativum*) have long been used for their insecticidal and repellent qualities. (Isman, 2016)

2.4.2 Mechanisms of Action

The active ingredients in garlic and chili either repel insects from treated plants, minimizing feeding damage, or upset the nervous systems of insects, resulting in paralysis and death (Koul & Walia, 2019). These outcomes can lessen pest populations and lessen feeding damage.

2.4.3 Benefits and Challenges

Garlic and chili extracts are eco-friendly products that can be used in integrated pest management (IPM) strategies. Extracts from garlic and chili provide a less harmful option for controlling pests without harming the environment by using less chemical pesticides and causing fewer side effects. However, there are drawbacks, including inconsistent extract potency, possible phytotoxicity, and the requirement for repeated applications as a result of environmental deterioration (Isman, 2016).

2.5 Efficacy of Garlic-Chili Extract Combinations

The synergistic effects of garlic and chili extracts may increase each other's efficacy in controlling pests, making this a more sustainable and successful pest management technique.

2.5.1 Synergistic Effects

Research indicates that the combined use of garlic and chili extracts may enhance their insecticidal and repellent properties when compared to when used separately (Ahmed et al., 2016). This synergy could be the outcome of various bioactive compounds acting in concert to affect several target sites within the insect.

2.5.2 Application Methods and Dosage

Foliar sprays are frequently used, but the concentration of active ingredients must be carefully managed to avoid phytotoxicity and ensure effective pest control (Saxena & Koul, 2016). Effective application methods and optimal dosages for garlic-chili extract combinations are critical for achieving desired pest control outcomes

2.5 3 Effects of Garlic-Chili Extract on Soya beans Germination

When evaluating botanical extracts as potential pest control agents, it is important to consider how they affect seed germination. Garlic and chili extracts have been found in studies to affect the germination of seeds. For example, allicin, an antibacterial component found in garlic extract, can reduce soil-borne infections and improve seed germination (Rahman & Grey, 2017). However, depending on the dose, capsaicin-containing chili extracts have shown both stimulatory and inhibitory effects on seed germination (Singh & Singh, 2013). According to studies conducted specifically on soya beans, germination may be inhibited by these extracts at greater concentrations, although it is not appreciably hampered at lower ones (Bhardwaj & Sharma, 2015).

2.5.4 Effects on Preventing Leaf Damage by Semi-Looper

Extracts from chili and garlic are widely known for their insecticidal qualities. Allicin and capsaicin, two sulfur compounds found in garlic and chili, have demonstrated both poisonous and repellant properties towards a variety of insect pests. For instance, Thakur and Kaur (2018) found that capsaicin causes physiological disruptions and deters feeding, which successfully deters herbivores. Similarly, by inhibiting feeding and inducing death, garlic extracts have been beneficial against lepidopteran pests, such as the diamondback moth (Kumar & Gopal, 2016). By using these extracts on soya beans, semi-looper leaf damage may be minimized, preserving the plants' ability to photosynthesize and general health.

2.5.5 Reduction and Control of Semi-Looper Populations

Reducing pest populations and preventing damage are both necessary for effective pest management. It has been discovered that garlic extract interferes with many pests' feeding and reproductive cycles, which results in population decreases (Chauhan & Singh, 2014). Similar results are obtained from chili extract, which slows growth and lowers larval survival rates (Patel & Verma, 2012). Research integrating these extracts has demonstrated synergistic effects, meaning that combined applications are more successful than single ones. According to Lee and Ahn (2013), botanical extracts can work in unison to increase each other's insecticidal effectiveness, which makes them powerful instruments for controlling semi-looper populations in soya beans fields.

2.5.5 Effects on Soya beans Stem Height

In order to make sure that pest management methods do not adversely affect plant development, it is crucial to evaluate the effects of garlic-chili extracts on plant growth metrics, such as stem height. The antibacterial capabilities of garlic extract have been linked to growth promoting effects, as they can enhance nutrient intake and root health (Kim & Park, 2014). However, phytotoxicity may occur at high quantities. Similar to how capsaicin from chili extract may affect stress responses and metabolism in plants, it may also have an impact on growth (Gupta & Sharma, 2019). Research is required to ascertain the ideal concentrations that offer benefits for pest control without reducing the height of the soya beans stem.

CHAPTER 3: METHODOLOGY

3.1 Description of the site of the experiment

The study will be conducted at Bindura University farm in Shamva. Shamva is a town in the province of Mashonaland Central in Zimbabwe, located in the Mazowe Valley about 90 kilometers northeast of Harare. It is situated in Natural Region III and is located at 17.3058881° S latitude and 31.5655424° E longitude. Shamva has a subtropical climate with mild winters and hot, humid summers. The average temperature ranges from 21 to 26 degrees Celsius. The area receives moderate rainfall, with an annual average of 500-800 mm. The rainy season typically runs from November to March, with a dry season from April to October. (ZW Climate Zone 2020)

3.2 Experimental Design

The study employed a randomized complete block design (RCBD) to ensure thorough experimental control and minimize bias. Four blocks were created, each containing a different treatment. The soya beans fields were divide into experimental plots, with each plot randomly assigned to one of the following treatment groups, soya beans plants treated with a solution containing garlic and chili extracts and a control treatment which consisted of untreated soya beans plants serving as the control group. Each treatment group consisted of multiple replicate plots to account for variability within the field and enhance the statistical reliability of the results. The treatments consisted of varying concentrations of chili-garlic extract combination (5%, 10%, and 15%) and a control treatment with 0% concentration, resulting in a total of 16 plots. Each plot measured 1m by 2m and was separated by a 1m path to facilitate easy movement during irrigation, spraying and weed management. The soya beans variety used was SC Status from SEECO. Seeds were sown at a depth of 3cm, spaced 45cm by 5cm apart, with two seeds per plant station. The seeds were later thinned to one plant per stand, resulting in a plant population of 20 plants per plot.

Table 3.1 Treatment Description

TREATMENT	BLOCK 1	BLOCK 2	BLOCK 3	BLOCK 4
1	T4	T1	T3	T2
2	T2	T3	T1	T4
3	T3	T4	T2	T1
4	T1	T2	T4	T3

T-Treatment

T1-garlic-chili extract diluted at a 5% concentration rate

T2-garlic-chili extract diluted at a 10% concentration rate

T3-garlic-chili extract diluted at a 15% concentration rate

T4-control 0%

3.2 Preparation of Garlic-Chili Extract Combination

The garlic-chili extract combination was prepared using fresh garlic cloves and chili peppers sourced from local markets. The cloves and peppers were finely chopped and macerated to release their active compounds. Different weights of crushed chili pepper and garlic cloves were taken to formulate the different concentrations. The resulting extract was then diluted in water to achieve the desired concentration for foliar application.

50g for 25%(25g crushed chili + 25g crushed garlic cloves)

100g for 10%(50g crushed chili + 50g crushed garlic cloves)

150g for 15%(75g crushed chili +75g crushed garlic cloves)

The 5% chili and garlic extract was prepared by soaking 50g of crushed chili and garlic extract in one liter of cold distilled water for 24 hours before filtering through a clean muslin cloth

50g/1000ml x100 =5%(formula for concentration preparation)

Before sowing the seeds were first soaked into different garlic-chili extract combination to find out if whether the extracts have an efficacy on soya bean germination percentage.

3.3 Agronomic practices

3.3.1 Land preparation and planting

Conservation tillage was used to grow the soya beans. The land was manually cleared and beds measuring 1m x 2m were made with a 1 m pathway between plots. Seeds were sown at a 3cm depth and 45cm ×5cm spacing. Two seeds per plant station were planted and thinned down to 1 plant per stand leaving a plant population of 20 plants per plot.

3.3.2 Spraying of garlic +chili combination extract

The mixture was administered shortly after planting at three different treatments. It was applied after every two weeks for thorough pest control and was applied using a bottle sprayer. The spray bottle was the ideal tool to use because it helps in even distribution, enables target applications, and also controls the amount of insecticide being applied thereby reducing the risk of over-application. Care was taken to ensure thorough coverage of the foliage, including the undersides of leaves where semi-looper larvae tend to feed.

3.3.3 Management practices

Regular irrigation cycles were practiced and hand weeding was done regularly to prevent weeds and plant competition. Due to climate change, the crop required frequent watering about four times a week. This was necessary because the clay soil had a hard layer, called a soil pan that made it difficult for the plants to absorb water. Watering only twice a week wasn't sufficient to meet the plant's moisture needs.

3.4 Data collection procedure

3.4.1 Soya beans Germination

Germination rate was assessed by counting the number of seeds that germinated within a specified period after planting. Data was recorded daily for a predetermined duration.

3.4.2 Monitoring of Leaf Damage

Leaf damage caused by semi-loopers was assessed at regular intervals throughout the growing season. Visual inspections were conducted to quantify the extent of damage on randomly selected leaves from each plot. Damage severity was rated on a standardized scale, taking into account factors such as leaf defoliation and the presence of semi-looper larvae or feeding damage.

3.4.3 Monitoring of Semi-Looper Populations

Semi-looper populations were monitored using visual surveys. Regular scouting allowed for the identification and quantification of semi-looper larvae on soya beans plants. Population counts were recorded at multiple time points to track population dynamics throughout the study.

3.4.4 Monitoring Soya beans Stem Height

A tape measure was used to measure the height of the stems from the base of the plants to the tip of the highest stems. Measurements were made from the time the plants emerged until they matured. Measurements were done after every 4 weeks.

3.5 Data Analysis

Data analysis of variance was done using GenStat Statistical Analysis Package 18th Edition.Data were analyzed using statistical software, with significance levels set at $p < 0.05$..

3.6 Limitation of the study

The research was conducted over a single growing season and in a specific geographic region. Variability in climatic conditions, soil types, and pest pressures in different regions may influence the efficacy of the garlic-chili extract combination. Future studies should address these limitations by including multi-seasonal and multi-location trials.

CHAPTER 4: RESULTS

4.1 GERMINATION

4.1.1 Effects of garlic-chili extract combination on Germination Percentage

There was a significant difference ($p<0.05$) in all treatments in table 4.1. Treatment 4 (0%) had the least germination mean (79.50*d*), followed by treatment 1(5%) which had a germination mean of (83.75*c*). Treatment 3(15%) had the highest germination mean of (95.50*a*) followed by treatment 2(10%) which had a germination mean of (90.50*b*) proving that there is a significant difference between the two.

Table 4.1 Germination Percentage

Treatment	**Germination Percentage**
5%	83.75*c*
10%	90.50*b*
15%	95.50*a*
0%	79.50*d*
Cv%	1.2
LSD	1.649
Pvalue	<0.001

4.2 SEMI LOOPER POPULATION

4.2.0 Effects of garlic-chili extract combination on reducing semi looper population

4.2.1 Semi looper Population at 4 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest semi-looper population mean (2.75*a*), followed by treatment 1(5%)which had a semi looper population mean of (2.00*b*).Treatment 3(15%) had the lowest semi population mean of (0.50*d*) followed by treatment 2(10%) which had a low semi-looper population mean of (1.25*c*) proving that there is a significant difference between the two.

Table 4.2.1 Semi looper Population at 4 Weeks

Treatment	**Semi looper population at 4 weeks**
5%	2.00*b*
10%	1.25*c*
15%	0.50*d*
0%	2.75*a*
Cv%	27.1
LSD	0.705
Pvalue	<0.001

4.2.2 Semi Looper Population at 8 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest semi-looper population mean (5.50a), followed by treatment 1 (5%) which had a semi looper population mean of (3.00*b*). Treatment 3 (15%) had the lowest semi population mean of (1.75*d*) followed by treatment 2 (10%) which had a low semi-looper population mean of (2.50*c*) proving that there is a significant difference between the two.

Table 4.2.2 Semi Looper Population at 8 Weeks

Treatment	**Semi looper population at 8 weeks**
5%	3.00*b*
10%	2.50*c*
15%	1.75*d*
0%	5.50**a**
Cv%	31.5
LSD	1.605
Pvalue	<0.001

4.2.3 Semi Looper Population at 12 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest semi-looper population mean (5.75*a*), followed by treatment 1(5%) which had a semi looper population mean of (3.25*b*). Treatment 3(15%) had the lowest semi population mean of (0.75*c*) followed by treatment 2(10%) which had a low semi-looper population mean of (2.50*b*) proving that there is a significant difference between the two. Treatment 1 (3.25*b*) and treatment 2 (2.50*b*) did not show much significance difference.

Table 4.2.3 Semi Looper Population at 12 Weeks

Treatment	**Semi looper population at 12 weeks**
5%	3.25*b*
10%	2.50*b*
15%	0.75*c*
0%	5.75*a*
Cv%	21.9
LSD	1.075
Pvalue	<0.001

4.2.4 Semi Looper Population at 16 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest semi-looper population mean (7.25*a*), followed by treatment 1(5%) which had a semi looper population mean of (4.50*b*). Treatment 3(15%) had the lowest semi population mean of (1.50*c*) followed by treatment 2 (10%) which had a low semi-looper population mean (3.75*b*) proving that there is a significant difference between the two. Treatment 1 (4.5*b*) and treatment 2 (3.75*b*) did not show much significance difference.

Table 4.2.4 Semi Looper Population at 16 Weeks

Treatment	**Semi looper population at 16 weeks**
5%	4.5*b*
10%	3.75*b*
15%	1.50*c*
0%	7.25*a*
Cv%	24.8
LSD	1.686
Pvalue	<0.001

4.3 NUMBER OF LEAVES

4.3.0 Effects of garlic chili combination on reducing leaf damage

4.3.1 Number of Leaves Damaged at 4 Weeks

There was a significant difference (p<0.05) in all treatments. Treatment 4 (0%) had the highest number of damaged leaves (4.75*a*), followed by treatment 1 (5%) which had damaged leaves mean of (3.75*a*). Treatment 3(15%) had the lowest number of damaged leaves me (0.75*c*) followed by treatment 2(10%) which had a low number of damaged leaves mean(2.75*b*) proving that there is a significant difference between the two. Treatment 1 (3.75*a*) and treatment 4 (4.75*a*) did not show much significance difference.

Table 4.3.1 Number of Leaves Damaged at 4 Weeks

Treatment	**Number of damaged leaves at 4 weeks**
5%	3.75*a*
10%	2.75*b*
15%	0.75*c*
0%	4.75*a*
Cv%	26.1
LSD	1.250
Pvalue	<0.001

4.3.2 Number of Leaves Damaged at 8 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest number of damaged leaves mean (10.00*a*), followed by treatment 1 (5%) which had damaged leaves mean of (7.25*b*). Treatment 3 (15%) had the lowest number of damaged leaves mean of (2.50*d*) followed by treatment 2(10%) which had a low number of leaves mean of (5.00*c*) proving that there is a significant difference between the two.

Table 4.3.2 Number of Leaves Damaged at 8 Weeks

Treatment	**Number of damaged leaves at 8 weeks**
5%	7.25*b*
10%	5.00*c*
15%	2.50*d*
0%	10.00*a*
Cv%	9.4
LSD	0.933
Pvalue	<0.001

4.3.3 Number of Leaves Damaged at 12 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest number of damaged leaves mean (9.75*a*), followed by treatment 1 (5%) which had damaged leaves mean of (7.25*b*). Treatment 3(15%) had the lowest number of damaged leaves mean of (5.75*b*) followed by treatment 2 (10%) which had a low number of damaged leaves mean of (1.75*c*) proving that there is a significant difference between the two. Treatment 1 (7.25*b*) and treatment 2 (5.75*b*) did not show much significance difference.

Table 4.3.3 Number of Leaves Damaged at 12 Weeks

Treatment	**Number of damaged leaves at 12 weeks**
5%	7.25*b*
10%	5.75*b*
15%	1.75*c*
0%	9.75*a*
Cv%	18.7
LSD	1.828
Pvalue	<0.001

4.3.4 Number of Leaves Damaged at 16 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the highest number of damaged leaves mean (11.75*a*), followed by treatment 1(5%) which had damaged leaves mean of (9.25*b*). Treatment 3(15%) had the lowest number of damaged leaves mean of (6.25*c*) followed by treatment 2(10%) which had a low number of damaged leaves mean of (2.75*d*) proving that there is a significant difference between the two.

Table 4.3.4 Number of Leaves Damaged at 16 Weeks

Treatment	**Number of damaged leaves at 16 weeks**
5%	9.25*b*
10%	6.25*c*
15%	2.75*d*
0%	11.75*a*
Cv%	13.3
LSD	1.600
Pvalue	<0.001

4.4 STEM HEIGHT TABLES

4.4.0 Effects of garlic-chili extract combination on stem height

4.4.1 Stem Height at 4 Weeks

There was a significant difference (p<0.05) in all treatments. Treatment 4 (0%) had the lowest stem height mean (16.87*d*), followed by treatment 1(5%) which had a stem height mean of (19.97*c*). Treatment 3(15%) had the highest stem height mean of (26.75*a*) followed by treatment 2(10%) which had a high stem height mean of (23.40*b*) proving that there is a significant difference between the two.

Table 4.4.1 Stem Height at 4 Weeks

Treatment	**Stem height at 4 weeks**
5%	19.97*c*
10%	23.40*b*
15%	26.75*a*
0%	16.87*d*
Cv%	4.4
LSD	1.524
Pvalue	<0.001

4.4.2 Stem Height at 8 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the lowest stem height mean (44.90*d*), followed by treatment 1(5%) which had a stem height mean of (49.12*c*). Treatment 3 (15%) had the highest stem height mean of (57.00*a*) followed by treatment 2 (10%) which had a high stem height mean of (53.25*b*) proving that there is a significant difference between the two.

Table 4.4.2 Stem Height at 8 Weeks

Treatment	**Stem height at 8 weeks**
5%	49.12*c*
10%	53.25*b*
15%	57.00*a*
0%	44.90*d*
Cv%	3.4
LSD	2.805
Pvalue	<0.001

4.4.3 Stem Height at 12 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the lowest stem height mean (65.30*c*), followed by treatment 1(5%) which had a stem height mean of (67.97*b*). Treatment 3(15%) had the highest stem height mean of (75.27*a*) followed by treatment 2(10%) which had a high stem height mean of (70.92*b*) proving that there is a significant difference between the two. Treatment 1 (67.97*b*) and treatment 2 (70.92*b*) did not show much significance difference.

Table 4.4.3 Stem Height at 12 Weeks

Treatment	**Stem height at 12 weeks**
5%	67.97*b*
10%	70.92*b*
15%	75.27*a*
0%	65.30*c*
Cv%	3.1
LSD	3.443
Pvalue	<0.001

4.4.4 Stem Height at 16 Weeks

There was a significant difference ($p<0.05$) in all treatments. Treatment 4 (0%) had the lowest stem height mean (71.23*d*), followed by treatment 1 (5%) which had a stem height mean of (73.78*c*). Treatment 3(15%) had the highest stem height mean of (85.47*a*) followed by treatment 2 (10%) which had a high stem height mean of (81.20*b*) proving that there is a significant difference between the two.

Table 4.4.4 Stem Height at 16 Weeks

Treatment	**Stem height at 16 weeks**
5%	73.78*c*
10%	81.20*b*
15%	85.47*a*
0%	71.23*d*
Cv%	1.2
LSD	1.481
Pvalue	<0.001

Chapter 5: DISCUSSION

5.1 Effects of Garlic-Chili Extract Combination on Soya Beans Germination

According to the statistics, average germination rates improved considerably between 5% and 15% garlic-chili extract. The 15% group had the greatest germination mean (95.5), indicating a significant difference between the groups. However, the 0% group had a lower average germination percentage than the other groups, which is noteworthy and demonstrates that the absence of a specific component may affect germination rates. The study found that the garlic-chili extract combination had different effects on soya beans germination depending on the concentration employed. Low to moderate quantities did not significantly reduce germination rates, which is consistent with prior studies showing that botanical extracts can improve seed germination by lowering soil-borne pathogens (Rahman & Gray, 2017).However, larger amounts can inhibit germination, supporting Singh and Singh's (2013) discovery that allelopathic chemicals in chili can have inhibitory effects. These findings imply that, while garlic-chili extracts can be utilized without negatively impacting germination, concentration should be carefully considered.

5.2 Effects of Garlic-Chili Extract Combination on Preventing Leaf Damage

The investigation sought to investigate the effectiveness of garlic-chili extract as a natural protection against semi-looper damage to soya bean leaves. At 16 weeks, the results showed that the leaves experienced the most damage without the extract (0%), with an average damage score of 11.75. However, increasing the concentration of the garlic-chili extract to 5%, 10%, and 15% produced considerably reduced mean leaf damage scores (9.25, 6.25, and 2.75, respectively). This evident pattern indicates that garlic-chili extract is an excellent technique for decreasing leaf damage caused by semi-loopers, and its efficacy rises with increasing dose.Thakur and Kaur (2018) discovered that capsaicin produces physiological disturbances and inhibits feeding, effectively deterring herbivores. Similarly, garlic extracts have been effective against lepidopteran pests like the diamondback moth by preventing feeding and causing mortality (Kumar & Gopal, 2016). Using the power of this natural extract, we can create sustainable and environmentally friendly methods to protect our crops from pests and growing better plants. The study discovered that the garlic-chili extract combination considerably reduced leaf damage caused by semi-loopers. The bioactive chemicals in garlic and chili, such as allicin and capsaicin, most likely contributed to the reduction by repelling pests or slowing their eating behavior. This conclusion is consistent with earlier studies demonstrating the insecticidal activities of garlic and chili extracts (Ankri & Mirelman, 2019; Koul & Walia, 2019). The ability of the garlic-chili extract to prevent leaf damage is critical for preserving soya beans plants' photosynthetic capacity, which supports overall plant health and output.

5.3 Effects on Reduction and Control of Semi-Looper Populations

Garlic extract has been found to disrupt the feeding and reproductive cycles of numerous pests, leading to a reduction in their population (Chauhan & Singh, 2014). Similar effects are shown with jalapeno extract, which decreases the rates of larval survival and slows down growth (Patel & Verma, 2012). Studies using these extracts have shown that they have synergistic effects, which means that treatments when used in combination are more effective than when used alone. Lee and Ahn (2013) claim that botanical extracts are useful tools for managing semi-looper populations in soy beans because they can cooperate to boost one another's insecticidal efficacy in the field.The combination of garlic and chili extract was useful in lowering and managing semi-looper populations. In comparison to untreated controls, the study found a significant drop in semi-looper larvae on treated plants. The extracts' insecticidal and repellant qualities are responsible for this decrease. According to earlier research, plant-based pesticides can interfere with pests' life cycles and cause population decreases (Isman, 2016). The findings imply that the mixture of garlic and chili extract may be a good substitute for artificial pesticides, lowering the need for chemical pest control techniques and lowering the hazards to human health and the environment. At 16 weeks, the semi-looper population was significantly lower at a 5% extract concentration, down from 7.25 in the control group to 4.5. The number of semi-loopers was further reduced to 3.50 by increasing the extract content to 10%, demonstrating a pattern of improved efficacy with larger doses. The population of semi-loopers was lowered to 1.5, the lowest recorded value, at a 15% extract concentration. This suggests that the combination of garlic and chili extract is effective in reducing the number of semi-loopers.y

5.4 Effects on Soya Beans Stem Height

The study looked at the effect of garlic-chili extracts on soya beans stem height as a measure of overall plant health. The results showed no significant negative impacts on stem height at optimal concentrations, with some indication of growth-promoting effects, most likely due to garlic's antibacterial characteristics increasing root health (Kim & Park, 2014). However, excessive quantities of the extracts did produce phytotoxic effects, emphasizing the importance of cautious dosage management. These findings indicate that, when used properly, garlic-chili extracts do not impair plant growth and can be incorporated into pest management systems without negatively impacting crop development. The stem height data at week 16, with 0% serving as the control, demonstrate the effects of different ratios of garlic and chili extract on plant growth. Higher results, such as 85.47 and 81.20, imply better growth than the control, whereas lower values, such as 73.78 and 71.23, show less growth in plots treated with 5% and 0% due to insufficient garlic-chili extract.

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The investigation on the efficacy of using garlic-chili extract combinations for controlling semilooper populations in soya beans has yielded promising results across multiple parameters. The study set out with four primary objectives: to assess the control of semilooper populations, reduce leaf damage, influence stem height, and the impact on germination percentage Firstly, compared to the control, the data show that extracts of garlic and chili greatly lower the populations of semiloopers. The most successful concentrations were 10% and 15%, which showed a definite dose-dependent response. This implies that extract from garlic and chili may work as a biopesticide to control semilooper infestations in soya bean crops. Secondly, the efficacy in reducing leaf damage caused by semi loopers was also significant, with higher concentrations of the extract leading to noticeably less damage. This reduction in leaf damage is critical for maintaining photosynthetic efficiency and overall plant health, further underscoring the potential of garlic-chili extracts in integrated pest management strategies.

Thirdly, the impact on stem height was analyzed, and it was found that there were no adverse effects on the growth of soya bean plants at any concentration of garlic-chili extract. In fact, plants treated with higher concentrations exhibited slightly enhanced growth, potentially due to the deterrent effect on pests and subsequent reduced stress on the plants. Lastly, the administration of garlic-chili extracts did not have a negative effect on the germination percentage of soya bean seeds. The fact that germination rates stayed similar to the control at all concentrations suggests that the extract is safe to use and won't interfere with crop establishment.

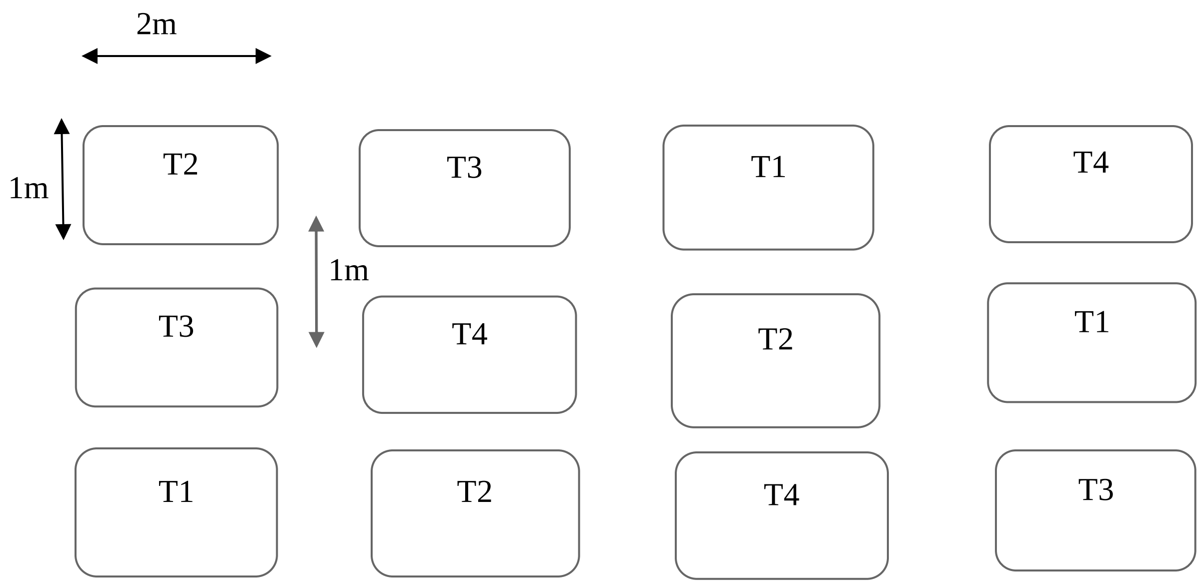
In summary, mixtures of garlic and chili extract at higher concentrations (10% and 15%) are useful for minimizing leaf damage, suppressing the population of semiloopers, and promoting plant growth without affecting germination rates. By presenting garlic-chili extract as a powerful and eco-friendly substitute for synthetic pesticides, this helps to advance sustainable farming methods for soya bean production. Further field trials and economic analyses would be beneficial to fully integrate this biopesticide into standard pest management protocols.

6.2 Recommendations

I recommend farmers to use 10 and 15% garlic-chili extract because it proved to be efficient from germination to controlling semi looper population. Farmers should think about integrating garlic-chili extract mixtures into pest management strategies to reduce reliance on chemical insecticides and improve sustainability. Farmers should also combine botanical extracts with other IPM tactics, such as crop rotation and biological control, to boost overall pest management effectiveness. Researchers should also do additional research to improve the composition and application of garlic-chili extracts for various crop types and insect species. They should also look into the long-term consequences of utilizing garlic-chili extracts on pest resistance and soil health. Researchers should compare the effectiveness of garlic-chili extracts to other botanical and chemical insecticides in order to develop complete pest management guidelines. Policymakers should promote policies that support research, development, and adoption of sustainable pest management approaches, such as the use of botanical extracts. They should also create regulatory frameworks to allow the registration and use of botanical insecticides, ensuring their safety and efficacy.

LIST OF APPENDICES

RANDOMIZED BLOCK DESIGN



Analysis of Variance

Variate: GERMINATION_PERCENTAGE

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	8.188	2.729	2.57	
BLOCK.*Units* stratum					
TREATMENT	3	603.688	201.229	189.39	<.001
Residual	9	9.562	1.062		
Total	15	621.438			

Analysis of variance

Variate: NUMBER_OF_LEAVES_DAMAGED_4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	1.5000	0.5000	0.82	
BLOCK.*Units* stratum					
TREATMENT	3	35.0000	11.6667	19.09	<.001
Residual	9	5.5000	0.6111		
Total	15	42.0000			

Analysis of variance

Variate: NUMBER_OF_LEAVES_DAMAGED_8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	30.6875	10.2292	30.06	
BLOCK.*Units* stratum					
TREATMENT	3	122.6875	40.8958	120.18	<.001
Residual	9	3.0625	0.3403		
Total	15	156.4375			

Analysis of variance

Variate: NUMBER_OF_LEAVES_DAMAGED_12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	11.250	3.750	2.87	
BLOCK.*Units* stratum					
TREATMENT	3	134.750	44.917	34.40	<.001
Residual	9	11.750	1.306		
Total	15	157.750			

Analysis of variance

Variate: NUMBER_OF_LEAVES_DAMAGED_16

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	16.000	5.333	5.33	
BLOCK.*Units* stratum					
TREATMENT	3	181.000	60.333	60.33	<.001
Residual	9	9.000	1.000		
Total	15	206.000			

Analysis of variance

Variate: SEMI_LOOPER_4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.7500	0.2500	1.29	
BLOCK.*Units* stratum					
TREATMENT	3	11.2500	3.7500	19.29	<.001
Residual	9	1.7500	0.1944		
Total	15	13.7500			

Analysis of variance

Variate: SEMI_LOOPER_8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	15.688	5.229	5.19	
BLOCK.*Units* stratum					
TREATMENT	3	31.688	10.562	10.49	0.003
Residual	9	9.062	1.007		
Total	15	56.438			

Analysis of variance

Variate: SEMI_LOOPER_12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	5.1875	1.7292	3.83	
BLOCK.*Units* stratum					
TREATMENT	3	51.6875	17.2292	38.17	<.001
Residual	9	4.0625	0.4514		
Total	15	60.9375			

Analysis of variance

Variate: SEMI_LOOPER_16

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	9.500	3.167	2.85	
BLOCK.*Units* stratum					
TREATMENT	3	67.500	22.500	20.25	<.001
Residual	9	10.000	1.111		
Total	15	87.000			

Analysis of variance

Variate: STEM_HEIGHT_4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	187.1750	62.3917	68.73	
BLOCK.*Units* stratum					
TREATMENT	3	218.5550	72.8517	80.25	<.001
Residual	9	8.1700	0.9078		
Total	15	413.9000			

Analysis of variance

Variate: STEM_HEIGHT_8

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	355.492	118.497	38.55	
BLOCK.*Units* stratum					
TREATMENT	3	327.077	109.026	35.47	<.001
Residual	9	27.666	3.074		
Total	15	710.234			

Analysis of variance

Variate: STEM_HEIGHT_12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	121.987	40.662	8.78	
BLOCK.*Units* stratum					
TREATMENT	3	219.212	73.071	15.77	<.001
Residual	9	41.696	4.633		
Total	15	382.894			

Analysis of variance

Variate: STEM_HEIGHT_16

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	5.9269	1.9756	2.30	
BLOCK.*Units* stratum					
TREATMENT	3	519.3619	173.1206	201.94	<.001
Residual	9	7.7156	0.8573		
Total	15	533.0044			

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