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Efficacy of Onion and Chilli Extracts in Controlling Aphids and Pod Borers in Cowpeas

EVERJOY MUDOTI

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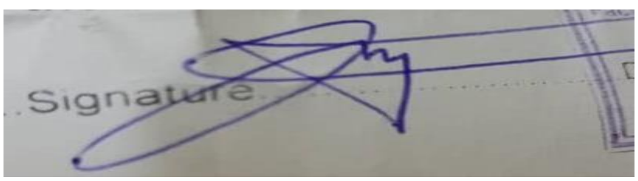
Declaration

I, Mudoti Everjoy, hereby declared that, except for references to other people's work which have been duly acknowledged, this dissertation is a result of my study and has neither in part nor in whole been presented in the education programme.

Signed: emudoti   Date: 01/07/24

(Student)

This research work was undertaken under the supervision of Professor Mandumbu. R.

Signed: 

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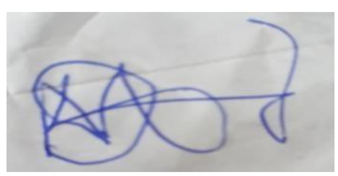
Chairperson signature:  Date: 14/07/24

Dedication

I dedicate this research paper to my daughter Angeline, my mom and my sister Evangelista

Acknowledgement

In my pursuit of profound understanding of the nitty gritties of the processes that make this company successful, I have been under the supervision of Professor Mandumbu to whom I'm so much indebted for the generous exposure accorded to me without any reservations. In this matter, I will never forget the priceless companionship from all the employees of this great institution whose interaction with me cultivated confidence and a sense of accomplishment that motivated me throughout my stay here. Last but certainly not least, I would like to express my heartfelt gratitude for the maturity I developed courtesy of the general professional environment so apparent in and around this institution and its management

Abstract

Efficient pest control is essential for optimising agricultural output. This study assessed the relative effectiveness of different pest management interventions, including as synthetic pesticides and organic methods, in controlling aphid infestations, minimising pod borer damage, and ultimately improving crop yields. A statistical analysis called analysis of variance (ANOVA) detected substantial variations in yield among the different treatment groups. The results of the post-hoc pairwise comparisons indicated that both the synthetic Lambda-Cyhalothrin + Dimethoate insecticide and the organic chilli-based treatments resulted in the highest yield improvements when compared to the untreated control. The Lambda + Dimethoate insecticide exhibited the most potent aphid suppression and led to the greatest crop output. Although the chilli and chilli + onion treatments were more effective than the control, they did not achieve the same level of yield improvement as the synthetic pesticide blend. The results indicate that the Lambda-Cyhalothrin + Dimethoate insecticide should be advised as the main strategy for pest control. The use of organic chilli-based remedies could be considered as effective supplemental choices, especially for farmers who are looking for greener solutions as part of a comprehensive pest control plan and those looking to implement integrated pest management programs.

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Chapter 1

1.1 Introduction

Cowpea, scientifically known as *Vigna unguiculata L. Walp*, is a highly important leguminous crop that is extensively farmed in the semi-arid regions of sub-Saharan Africa (Asiwe, 2009). However, the cultivation of cowpeas is sometimes hindered by insect pests, including aphids and pod borers, which can result in significant reductions in crop yield (Obeng-Ofori, 2007). Traditional synthetic pesticides, although they work well, present environmental and health hazards, which highlights the necessity for sustainable and environmentally-friendly alternatives (Aktar *et al*., 2009). This study, carried out in Gokwe South (Manoti), Zimbabwe, sought to examine the effectiveness of onion and chilli extracts as potential botanical pesticides for managing aphids and pod borers in cowpea farming.

Botanical insecticides obtained from plants have garnered growing interest because of their natural capacity to break down, less harm to unintended creatures, and reduced effect on the environment (Isman, 2006). Extracts from onion (*Allium cepa L.*) and chilli (*Capsicum annuum L.*) contain bioactive chemicals, including allicin and capsaicinoids, which have been found to have insecticidal effects against several insect pests (Shukla & Tripathi, 1987; Khakame *et al*., 2015). The study used five different treatments: onion extracts, chilli extracts, a mixture of onion and chilli extracts, the synthetic insecticide Dimethoate 40EC and Lambda Cyhalothrin as a positive control, and an untreated negative control. The effectiveness of these treatments was assessed by their capacity to reduce the population of aphids and pod borers, as well as their influence on cowpea yield.

1.2 Problem statement

In Gokwe South, Zimbabwe, cowpea farming is highly vulnerable to aphids and pod borers, which can result in lower yields and revenue losses for farmers. Even though synthetic pesticides like Lambda cyhalothrin and Dimethoate 40EC are frequently employed, there are worries about pest resistance, health risks, and environmental damage. This study will determine how well onion and chilli extracts work as long-term substitutes for controlling these pests in cowpea crops. Five treatments—onion extracts, chilli extracts, a combination of chilli and onion, a control of widely used synthetic pesticides, and a negative control will be tested for effectiveness in this study. The findings will shed light on how these botanical extracts might be used as biopesticides in the area to manage pests in a way that is both economically and environmentally sustainable.

1.3 Justification

An investigation on the efficacy of onion and chilli extracts in managing aphids and pod borers in cowpeas in Gokwe South (Manoti), Zimbabwe is strongly advised for several reasons. Aphids and pod borers pose significant challenges to cowpea cultivation in the region, leading to decreased crop productivity and financial setbacks for local farmers. Furthermore, the extensive utilisation of artificial pesticides gives rise to apprehensions regarding the pollution of the environment and the potential risks they pose to human health. Consequently, it is crucial to do research on alternative pest control methods, such as botanical extracts, in order to advance sustainable farming techniques. Moreover, the focus on onion and chilli extracts is supported by their potential insecticidal properties, as documented in previous studies. This study aims to offer valuable insights into effective and environmentally sustainable pest management strategies for cowpeas in the specified region.

1.4 Objectives

1.4.1 Main objective

This study aims to assess the efficacy of onion and chilli extracts in managing aphids and pod borers in cowpeas in Gokwe South (Manoti), Zimbabwe. The study seeks to assess the effectiveness of various treatments in terms of pest control, crop health, and yield. The study aims to provide farmers and policymakers with crucial information on sustainable and ecologically friendly methods of managing aphids and pod borers in cowpea cultivation by evaluating the effectiveness of different alternative pest management approaches.

1.4.2 Specific objectives

i. To assess the efficacy of onion extracts in managing aphid populations and pod borers in cowpeas. ii. Evaluate the effectiveness of chilli extracts in mitigating aphid and pod borer infestations in cowpeas.

iii. To investigate the combined impact of blending onion and chilli extracts on the management of aphids and pod borers in cowpeas, with a focus on their synergistic effects.

1.5 Hypothesis

The efficacy of onion and chilli extracts, Dimethoate 40EC and Lambda cyhalothrin, and untreated control therapy in reducing aphids and pod borers in cowpea crops

Chapter 2.

Literature Review

2.1 Overview

There is a rising interest in using plant extracts as substitutes for synthetic pesticides due to the increased need for sustainable and eco-friendly pest management solutions (Isman, 2006). Onion and chilli have demonstrated effective insecticidal effects against many insect pests, including those that harm cowpea crops (Khakame *et al*., 2015; Shukla & Tripathi, 1987). This literature review seeks to offer a comprehensive analysis of the significance of cowpea, including its origins and characteristics, the importance of managing aphids and pod borers, and the insecticidal qualities of onion and chilli extracts. Furthermore, it will analyse the benefits and drawbacks of utilising synthetic pesticides compared to organic extracts for controlling pests in cowpea farming.

2.2 The significance of cowpea

Cowpea is a nutritious and adaptable leguminous crop that is essential for food security and combating hunger in various regions, especially in sub-Saharan Africa (Timko & Singh, 2008). According to Jayathilake *et al*. (2018), it is an important dietary component for many people since it provides crucial plant-based protein, vitamins, and minerals. In addition to its nutritional benefits, cowpea also plays a role in promoting sustainable agricultural practices by converting atmospheric nitrogen into a form that can be used by plants, thus decreasing the need on artificial fertilisers (Boukar *et al*., 2019).

Cowpeas are a significant feed source for livestock, providing a high-protein forage choice that can be used as silage, hay, or grazing material. By utilising crop leftovers, such as stems and leaves, as livestock feed, we can enhance animal nutrition and decrease expenses associated with animal feed.

Cowpea is a prominent crop grown in semi-arid regions of Zimbabwe, providing essential sustenance and income for small-scale farmers [Asiwe, 2009]. Nevertheless, the cultivation of cowpea is frequently hindered by a range of living and non-living pressures, such as insect pests, lack of water, and poor soil quality (Kamara *et al*., 2018)]. Aphids and pod borers are significant insect pests that pose a major danger to cowpea agriculture. They cause significant reductions in crop output and do serious economic harm (Obeng-Ofori, 2007).

Furthermore, cowpeas enhance crop diversification by serving as a viable option for crop rotation with other agricultural crops. Their capacity to convert atmospheric nitrogen into a usable form in the soil improves soil fertility, which in turn benefits future crops. Cow peas exhibit a high level of tolerance towards drought, heat, and unfavourable soil conditions, rendering them highly advantageous for small-scale farmers operating in arid and semi-arid locations.

Cow peas are a significant feed source for livestock, providing a high-protein forage choice that can be used as silage, hay, or grazing material. By utilising crop wastes, such as stems and leaves, as livestock feed, it is possible to enhance animal nutrition and decrease expenses associated with animal feed.

2.3 The origins and characteristics of cowpea.

The origin of cowpea is thought to be in Africa, supported by evidence indicating its domestication and cultivation stretching back millennia (Padulosi & Ng, 1997)]. This legume is a warm-season annual plant that shows exceptional ability to thrive in many climatic situations, such as high temperatures, drought, and low soil fertility (Hall *et al*., 2003). The adaptability of the plant is due to its extensive root system, which allows it to efficiently absorb water, and its capacity to convert atmospheric nitrogen through symbiotic associations with rhizobia bacteria (Ehlers & Hall, 1997). Cowpea plants display a high level of diversity, with a wide range of types that show variations in growth patterns, seed properties, and maturity times (Timko & Singh, 2008). The vast range of agro-ecological zones, including the semi-arid regions of sub-Saharan Africa and the tropics and subtropics of Asia and the Americas, practice cultivation of cowpea due to its diversity [Singh *et al*., 2003]. The crop's ability to withstand and adapt to various conditions makes it a very important asset for small-scale farmers in these areas, playing a crucial role in ensuring food security and promoting sustainable agricultural practices (Boukar *et al*., 2019).

2.4 The importance of managing aphids and pod borers

Aphids and pod borers are very detrimental insect pests that have a significant impact on cowpea productivity [Kamara *et al*., 2018]. Aphids consume the sap of plants, leading to hindered growth, distorted leaves, and decreased photosynthetic function. Their capacity to proliferate fast and spread plant viruses worsens the harm they can inflict (Jackai & Adalla, 1997). However, certain types of insects, such as the legume pod borer (*Maruca vitrata Fabricius*) and the cowpea pod borer (*Cydia ptychora Meyrick*), specifically target the growing pods and result in substantial reductions in crop yield [Sharma *et al*., 1999].

Efficient management of these insect pests is essential to guarantee the long-term viability of cowpea cultivation and to attain food security in areas where the crop is a primary source of sustenance (Boukar *et al*., 2019). Inadequate control of these pests can lead to significant financial setbacks for small-scale farmers, who frequently have difficulties in obtaining efficient and reasonably priced pest management methods (Kamara *et al*., 2018). Moreover, the uncontrolled application of artificial pesticides can cause harmful consequences on human well-being, the ecosystem, and advantageous creatures, emphasising the necessity for alternative, environmentally friendly methods (Aktar *et al*., 2009).

2.6 Extracts derived from onions

Onion extracts consist of several compounds that contain sulphur. One of these compounds is allicin, which has been proven to have insecticidal, antifungal, and antibacterial effects (Benkeblia, 2004). Allicin is produced by the enzymatic decomposition of alliin, a non-protein amino acid found in onion tissues (Miron *et al*., 2002). Multiple research have provided evidence of the efficacy of onion extracts in combating various insect pests, such as aphids, thrips, and whiteflies (Mochiah *et al*., 2011; Mandizvidza *et al*., 2021).

Onion extracts have been discovered to be efficacious in managing aphids and pod borers in vegetable farming (Mochiah *et al*., 2011). In a study conducted by Mandizvidza *et al*. (2021), it was found that the use of onion extracts resulted in a considerable decrease in the number of sucking pests. This reduction in pests led to higher yields compared to the control group that did not receive any treatment. A study conducted by Akunne *et al*. (2015) demonstrated that the combined use of onion and neem extracts had a synergistic impact on the management of pod borers in field beans.

2.7 Extracts of chilli peppers

Chilli extracts consist of capsaicinoids, a collection of chemicals that give chilli peppers their distinct spiciness and insect-killing abilities (Michaelsen *et al*., 1995). Capsaicin, the main compound in capsaicinoids, has been discovered to have insecticidal, repellent, and antifeedant properties against many types of insect pests (Khakame *et al*., 2015).

Multiple studies have shown that chilli extracts are effective in managing insect pests in crop farming. In their study, Lale and Mustapha (2000) found that the use of chilli extracts effectively decreased the population of aphids and pod borers, resulting in higher soya bean yields. In a similar vein, the study conducted by Ofuya and Akingbohungbe in 1988 demonstrated the efficacy of chilli extracts in managing the legume pod borer (*Maruca vitrata*) infestation on pea plants.

2.8 Comparison between synthetic insecticides and organic extracts

Although synthetic pesticides have been instrumental in enhancing agricultural output and safeguarding crops against insect pests, their excessive and indiscriminate application has sparked considerable apprehension due to their adverse effects on human health, the environment, and nontarget organisms (Aktar *et al*., 2009. Synthetic pesticides refer to chemical substances that are artificially created and used to control or eliminate pests.

Synthetic pesticides are intentionally formulated to have a high level of toxicity towards specific pests. However, they can also present dangers to other living organisms, such as beneficial insects, birds, and mammals (Köhler & Triebskorn, 2013). In addition, the extensive utilisation of artificial pesticides has resulted in the emergence of resistance in insect pests, making these substances progressively ineffective (Mota-Sanchez & Wise, 2021). The presence of pesticide residues in food and water sources might have detrimental impacts on human health, such as potential carcinogenic, neurological, and reproductive outcomes (Kim *et al*., 2017). Moreover, the ecological consequences of synthetic pesticides are becoming an increasingly worrisome issue. The presence of these chemicals can lead to soil and water pollution, causing disturbances in ecosystems and impacting organisms that were not the intended target (Damalas *et al*. 2011).

Chapter 3

3.0 Methodology:

3.1 Area of study

The study was carried out at Gokwe Manoti which is located in Gokwe North. The study area falls in Natural farming region IV and experiences average temperatures of 32 ^{0}C in summer and 27 ^{0}C in winter and annual rainfall ranging from 400 – 600mm.The soils are sandy loam with a depth of 2 meters. The area is comprised of small holder farmers who are getting into vegetable production especially leaf vegetables.

3.2 Preparation of the land and planting:

The research was carried out employing a randomised complete block design. Three blocks were chosen for the experiment, with each block comprising five plots. Each plot had dimensions of 5 metres by 1 metre with a pathway 1 metre wide between plots and 2 meters between blocks. The land was prepared using conventional agricultural methods. The land was initially cleared of vegetation and refuse. Afterwards, the land was cultivated using an ox-drawn plough to loosen the soil and establish a good seedbed. The clumps of soil were further pulverised using an ox-drawn harrow in order to attain a finer tilth.

2 furrows were excavated 45cm apart on each plot. A compound D fertiliser was applied to the furrows at the application rate of 150kg/ha. The furrows were thereafter lightly covered to ensure proper integration of the fertiliser into the soil.

The cowpea seeds of variety IT 18 were planted in furrows at a depth of around 3cm and with a spacing of roughly 20cm between plants. The furrows were filled with soil, ensuring sufficient contact between the seeds and the soil to facilitate germination.

The planting technique was uniformly implemented in all plots inside the blocks to mitigate any possible discrepancies. The plots were labelled and marked to guarantee precise identification and data collection during the experiment.

3.3 Preparation of onion extract

A solution of onion extract was made by using 500 grams of red onions. Healthy red onions were chosen, screening for any indications of decay or damage. The outer layers of the onions were peeled off and discarded. The onion was then washed under flowing water to eliminate any soil particles. The onions were further diced into smaller fragments to enhance their surface area, hence promoting efficient extraction of the active chemicals. The diced onions were ground to a paste using a ceramic pestle and mortar, placed in a sterile container, and 2 litres of water were added. The concoction was delicately agitated to guarantee the uniform dispersion of the onions paste. In order to obtain the active chemicals, the mixture of onion and water was left to steep for a duration of 24 hours, ensuring ample time for the water to absorb the repellent characteristics. Following the duration of steeping, the mixture underwent filtration using a fine mesh strainer to isolate the liquid extract from the solid onion particles. The residual liquid was extracted from the onion pulp to optimise the extraction process. The obtained onion extract was gathered and preserved in a sterile, sealed plastic container, in a refrigerator to retain its effectiveness throughout the experiment.

3.4 Preparation of chilli extract

The preparation of chilli extract involved combining 100g of Birds Eye chilli peppers with 200ml of white vinegar. The Birds Eye chilli peppers were selected based on their elevated pungency and their appropriateness for extraction applications. The chilli peppers were thoroughly rinsed under a running stream of water. Subsequently, the peppers were diced in order to enhance their surface area for extraction. The diced chilli peppers were placed in a sterile container, and 200 millilitres of white vinegar were added along with 4 litres of warm water. The concoction was agitated to guarantee thorough coverage of vinegar on all the pepper fragments. The jar was tightly covered, and the combination was left undisturbed for a period of 5 days, allowing the vinegar to effectively extract the active components from the chilli peppers. Throughout this period of steeping, the mixture was intermittently agitated to enhance the extraction process.
Following the duration of steeping, the mixture underwent filtration using a fine mesh strainer to isolate the liquid extract from the solid pepper particles. The resultant liquid extract was gathered and preserved in a sterile, sealed plastic container in a refrigerator.

3.5 Extraction of a mixture of chilli and onion

The process involved the separate extraction of chilli and onion, as previously stated, followed by their blending during application.

3.6 Application of treatment

Treatments were allocated randomly to the plots to ensure impartial assessment. The application of extracts and pesticides to manage aphid infestation was carried out following a survey that showed an average aphid count ranging from 10 to 20 aphids per sampled plant. This threshold served as a signal that aphid populations had reached a point where action was necessary. Given the lack of pods on the plants at the time, the assessment did not take into account the presence of pod borers. The main emphasis was on effectively controlling the aphid infestation in order to protect the cow pea crop during its susceptible growth phase. When the cow pea plants reached an average of three pods, which showed signs of seed development, the process of searching for pod borers began. This stage initiated the process of monitoring and evaluating the occurrence and influence of pod borer infestations on the growing cow pea crop.

3.7 Data collection

Pest populations were assessed by conducting counts before application of extracts and chemicals weekly. The counting technique entailed visually examining the sampled plants and documenting the quantity of pests encountered.

3.8 Data analysis

The gathered data was examined using statistical methods to extract significant insights. The statistical procedures of Analysis of Variance (ANOVA) were performed using GENSTAT. The analysis of variance (ANOVA) was utilised to ascertain significant distinctions across several groups or treatments.

Chapter 4

24hrs before (Appendix 1):

The ANOVA showed that there were no significant differences in the 24hrs before the first application of treatments ($F = 2.11$, $p = 0.171$).

Week 4 (Appendix 2):

Based on the ANOVA, the Week 4 measurements revealed significant differences between the treatments ($F = 208.9$, $p < 0.001$). The only pairwise comparison between treatments that the LSD test showed to be significantly different was between treatments 2 and 4.

Week 6 (Appendix 3):

The ANOVA showed that in the Week 6 assessments, there were significant differences between the treatments ($F = 74.85$, $p < 0.001$). The only pairwise comparisons where the LSD test revealed a significant difference were between treatments 3 and 2, 3 and 4, and 2 and 4.

Week 8 (Appendix 4):

The Week 8 measurements revealed highly significant differences between the treatments ($F = 154.23$, $p < 0.001$). The LSD test revealed that all pairwise comparisons were significantly different, with the exception of the comparison between treatments 4 and 2.

Week 10 (Appendix 5):

The Week 10 assessments showed significant differences between the treatments, according to the ANOVA ($F = 107.14$, $p < 0.001$). The LSD test demonstrated significant differences in all pairwise comparisons, with the exception of the comparison between treatments 4 and 2.

Week 7 (Appendix 6):

($F=8.27$, $p=0.006$) The treatment effect was statistically significant.

The results of pairwise comparisons indicated a significant difference between treatments 1 and 3,

1 and 4, and 1 and 5.

Week 8 (Appendix 7):

Statistical significance was observed in the treatment effect (F=11.78, p=0.002). The results of pairwise comparisons indicated a significant difference between treatments 1 and 3, 1 and 4, 1 and 5, and 2 and 3.

Week 9 (Appendix 8):

F=18.13, p<0.001 indicated a highly statistically significant treatment effect. Pairwise comparisons revealed significant differences between treatments 1 and 3, 1 and 4, 1 and 5, 2 and 3, 2 and 4, and 2 and 5.

Week 10 (Appendix 9):

F=13.7, p=0.001 indicates a highly statistically significant treatment effect. Pairwise comparisons revealed significant differences between treatments 1 and 2, 1 and 3, 1 and 4, 1 and 5, and 2 and 4, 2 and 5.

Week 11 (Appendix 10)

The pod borers were significantly impacted by the treatment (F-value = 27.76, p < 0.001). The LSD test revealed notable variations between

There wass no discernible difference between Treatment 1 and Treatments 2, 3, 4, and 5. There is also no difference between Treatments 2 and Treatments 3, 4, and 5.

Week 12 (Appendix 11)

For Week 12, there was a significant impact of the treatment on the pod borer variable (F-value = 39.49, p < 0.001). The LSD test demonstrated significant differences between Treatment 1 and Treatments 2, 3, 4, and 5 o Treatment 2 and Treatments 3, 4, and 5. Treatments 3 vs. 4, 3 vs. 5, and 4 vs. 5 are not substantially different.

Yield (Appendix 12)

The yield data analysis reveals that the treatment had a significant effect on yield, as indicated by the ANOVA (F-value = 80.04, $p < 0.001$). Key findings from the Fisher's shielded LSD test were as follows: In terms of yield, Treatment 5 was not significantly different from Treatments 3 and 4. The yield of Treatment 5 was noticeably larger than that of Treatments 2 and 1. The yield of Treatment 3 and Treatment 4 did not differ appreciably. The yields of Treatments 3 and 4 were noticeably greater than those of Treatments 2 and 1. The yield of Treatment 2 was noticeably greater than that of Treatment 1.

Chapter 5

5.0Discussion

5.1 Aphids

As anticipated, the control group that did not receive any pest management intervention showed the most unsatisfactory outcomes, as it failed to effectively control the aphid infestation over the whole trial duration. Several of the applied treatments had significantly superior results in suppressing the aphid population, in sharp contrast to others.

The utilisation of onion-based pest management method shown its efficacy as an organic remedy, effectively restraining aphid numbers in comparison to the untreated control group. Likewise, the use of chilli pepper therapy was more effective than the control, demonstrating its efficacy as a natural technique for managing aphids. The combination of onion and chilli demonstrated a more pronounced aphid reduction effect compared to each treatment alone.

The synthetic insecticide mix of Lambda-Cyhalothrin and Dimethoate demonstrated the most effective pest control performance. The chemical treatment effectively suppressed aphid populations over the whole 8-week assessment period, surpassing the organic onion and chilli alternatives in their ability to control aphids.

Generally, the data emphasises the varying effectiveness of the pest management methods that were examined. The control group was found to be the least successful, while the Lambda + Dimethoate insecticide showed the greatest significant reduction in aphids.

5.2 Pod borers

The data analysis from the study unveiled significant disparities in the efficacy of different pest control methods in reducing pod borer populations. The control treatment, which did not receive any intervention, was the least effective approach. On the other hand, a number of the treatments that were examined showed much superior capacities in controlling pests.

The treatment using onions demonstrated encouraging outcomes by effectively reducing the population of pod borers in comparison to the control group. Likewise, the use of chilli pepper treatment showed greater efficacy compared to the control group that did not get any treatment. In addition, the combination of chilli and onion demonstrated a more pronounced inhibitory impact on the pod borer population.

The Lambda-Cyhalothrin + Dimethoate treatment stood out as the most effective pest control strategy examined. The synthetic insecticide blend effectively reduced pod borer populations during the trial period, surpassing the effectiveness of the organic onion and chilli methods.

Generally, the data shows that the control treatment was the least effective, but several pest control strategies, such as onion, chilli, their combination, and the Lambda + Dimethoate insecticide, significantly reduced the populations of pod borers throughout the study.

5.3 Yield

The statistical analysis provides a definitive assessment of the comparative efficacy of the pest control methods tested on crop output. Based on the findings, the interventions using chilli, chilli + onion, and Lambda-Cyhalothrin + Dimethoate were the most effective in increasing yields when compared to the untreated control.

These three pest management strategies had a statistically significant benefit in enhancing crop productivity compared to the control group. This implies that they possessed the highest level of competence in safeguarding the plants and optimising the potential for crop yield.

However, the use of onion-based treatment did not result in a significant improvement in crop yield compared to the control group. This suggests that the use of onion treatment was less successful in managing pest infestations and protecting crop yield compared to the alternatives of chilli-based and synthetic insecticides.

Chapter 6

Recommendations and conclusions

6.1 Conclusions

Based on the research findings about the effects of different pest control methods on aphids, pod borers, and crop yields, the following conclusions and recommendations can be made.

The study offers useful insights into the relative effectiveness of various pest management strategies. The results suggest that the combination of Lambda-Cyhalothrin and Dimethoate, both synthetic insecticides, was highly successful in managing aphid infestations and optimising crop yield. The efficacy of this treatment was superior to both the organic alternatives derived from chilli pepper and onion, as well as the untreated control.

The exceptional efficacy of the Lambda + Dimethoate insecticide indicates that it is the most dependable choice for comprehensive pest management, especially against aphids, which can result in significant reductions in crop productivity. The data indicates that this chemical treatment achieved the most effective reduction of aphids and resulted in the highest increase in crop output compared to the other interventions.

Nevertheless, the organic treatments containing chilli demonstrated potential by effectively controlling aphids and enhancing crop output, surpassing the untreated control group. Although not as potent as synthetic insecticides, these natural methods can nonetheless serve as viable alternatives, particularly for farmers who are looking for pest management solutions that are more environmentally-friendly.

Additional investigation may be necessary to examine methods for maximising the effectiveness of the chilli-based therapy. By incorporating these organic techniques alongside the Lambda + Dimethoate pesticide in a rotational or combination manner, it is possible to establish a wellrounded and environmentally-friendly integrated pest management strategy.

Based on the data, it is recommended to use the Lambda-Cyhalothrin + Dimethoate pesticide as the main approach for pest management due to its exceptional effectiveness. Nevertheless, it is important to also take into account the organic treatments that are based on chilli, as they can serve as additional choices to expand the range of pest management strategies and decrease dependence on artificial chemicals.

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Appendices

1-ANOVA Aphids 24hrs before treatment application

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	13.333	6.667	1.7	
Block.*Units* stratum					
Treatment	4	33.067	8.267	2.11	0.171
Residual	8	31.333	3.917		
Total	14	77.733			

2-ANOVA Aphids at 4 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	3.733	1.867	1.67	
Block.*Units* stratum					
Treatment	4	933.067	233.267	208.9	<.001
Residual	8	8.933	1.117		
Total	14	945.733			

3-ANOVA Aphids at 6 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	3.733	1.867	0.38	
Block.*Units* stratum					
Treatment	4	1482	370.5	74.85	<.001
Residual	8	39.6	4.95		
Total	14	1525.333			

4-ANOVA Aphids at 8 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	12.933	6.467	1.24	
Block.*Units* stratum					
Treatment	4	3218.267	804.567	154.23	<.001
Residual	8	41.733	5.217		
Total	14	3272.933			

5-ANOVA Aphids at 10 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	8.533	4.267	0.82	
Block.*Units* stratum					

Treatment	4	2221.333	555.333	107.14	<.001
Residual	8	41.467	5.183		
Total	14	2271.333			

6-ANOVA Pod Borer at 7 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.4	0.2	0.23	
Block.*Units* stratum					
Treatment	4	28.6667	7.1667	8.27	0.006
Residual	8	6.9333	0.8667		
Total	14	36			

7-ANOVA Pod Borer at 8 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.133	0.067	0.06	
Block.*Units* stratum					
Treatment	4	50.267	12.567	11.78	0.002
Residual	8	8.533	1.067		
Total	14	58.933			

8-ANOVA Pod Borer at 9 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.4	0.2	0.19	
Block.*Units* stratum					
Treatment	4	74.933	18.733	18.13	<.001
Residual	8	8.267	1.033		
Total	14	83.6			

9-ANOVA Pod Borer at 10 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	1.733	0.867	0.46	
Block.*Units* stratum					
Treatment	4	102.267	25.567	13.7	0.001
Residual	8	14.933	1.867		
Total	14	118.933			

10-ANOVA Pod Borer at 11 weeks

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	0.933	0.467	0.29	
Block.*Units* stratum					
Treatment	4	181.333	45.333	27.76	<.001
Residual	8	13.067	1.633		

Total	14	195.333

11-ANOVA Pod Borer at 12 weeks

Variate: Week_12

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	2.133	1.067	0.5	
Block.*Units* stratum					
Treatment	4	339.6	84.9	39.49	<.001
Residual	8	17.2	2.15		
Total	14	358.933			

12-ANOVA Yield

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
Block stratum	2	3.072	1.536	0.57	
Block.*Units* stratum					
Treatment	4	856.704	214.176	80.04	<.001
Residual	8	21.408	2.676		
Total	14	881.184			