BINDURA UNIVERSITY OF SCIENCE EDUCATION

FACULTY OF AGRICULTURE AND ENVIRONMENTAL SCIENCES

DEPARTMENT OF CROP SCIENCE



EFFICACY OF RABBIT URINE AS A BIOPESTICIDE IN *BRASSICA NAPUS* L.

A dissertation submitted in partial fulfilment of the requirements of the

Bachelor of Agricultural Science Honours Degree in Crop Science

written by

TAPIWA NDHLOVU B222829B

SUPERVISOR: DR T. GOCHE

SUBMISSION DATE: 26/06/2026

APPROVAL FORM

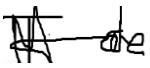
The undersigned certified that they have supervised and recommend to Bindura University of Science Education for the acceptance of the dissertation entitled **Efficacy of rabbit urine as a bio-pesticide in rape (*Brassica napus* L.) production** submitted by NDHLOVU TAPIWA in partial fulfilment of the Bachelor of Agricultural Science Honours Degree in Crop Science.

Student

Name: Tapiwa Ndhlovu Signature:  Date: 24/06/26

Supervisor

I have supervised the research project for the above-mentioned student, and I am convinced that the research can be submitted.

Dr. T Goche  24/06/26

Name: …… Signature: …….. Date: …….

Chairman

Name: Mr Mutsengi Signature: 

Date: 01/09/26

DECLARATION

I, NDHLOVU TAPIWA, registration number B222829B, do hereby declare that this dissertation is my own original work and has not been submitted to any university before for marking or supervision.

DEDICATION

I dedicate this dissertation to all smallholder farmers who are into vegetable farming.

ACKNOWLEDGEMENTS

First and foremost, I give gratitude to my parents and siblings for their support in making this a dream come true. Gratitude also goes to Dr T Goche for his patience and ensuring that my write-up became a meaningful thing. Lastly, but not least, I applaud my friends and classmates for their support during the course of this project and its write-up.

ABSTRACT

Rape (*Brassica napus* L.) is a crop of economic and nutritional importance, it is a leafy vegetable crop widely cultivated by resource-constrained farmers across Zimbabwe. However, its productivity is greatly limited by insect pest infestations, principally aphids, diamondback moths, and whiteflies which reduce the productivity and market quality of rape. Most small-scale farmers depend largely on chemical insecticides for pest control, but escalating costs, pesticide resistance, and environmental and food safety concerns have made this approach increasingly unsustainable. This study evaluated the efficacy of rabbit urine as a bio-pesticide for managing insect pests and improving the yield of rape. A field experiment was carried out at Bindura University of Science Education, Mashonaland Central, Zimbabwe.The student laid out the experiment in a Randomized Complete Block Design (RCBD) consisting of six treatments and four replications. The treatment structure included rabbit urine at 25%, 50%, 75% and 100%, a synthetic insecticide (Lambda-cyhalothrin) as a positive control and water-only plots served as the untreated control treatment. Data collected included pest incidence, number of harvestable leaves and fresh leaf yield. Analysis of variance (ANOVA) was performed using GenStat Version 18, and means were compared using the Least Significant Difference (LSD) at the 5% probability level. Results showed that all rabbit urine concentrations significantly reduced pest incidence compared to untreated control ($p \leq 0.05$). The 75% and 100% rabbit urine concentrations were statistically equivalent to Lambda-cyhalothrin in pest suppression ($p > 0.05$). The 75% concentration produced the greatest harvestable leaf count of 17.00 leaves per plant while also recording the highest fresh leaf yield of 4.7 kg per plot among rabbit urine treatments, values statistically equivalent to Lambda-cyhalothrin (19.50 leaves per plant, 5.6 kg/plot). The 100% concentration, though equally effective in pest suppression, produced lower yields than the 75% treatment due to phytotoxic leaf scorching caused by excessive nitrogenous compounds. The study concludes that rabbit urine is an effective, affordable, and environmentally friendly bio-pesticide in rape (*Brassica napus* L.). A 75% concentration is recommended as the optimal application rate for smallholder farmers in Zimbabwe.

Keywords: *Brassica napus*, bio-pesticide, rabbit urine, pest management, Zimbabwe, smallholder farming, sustainable agriculture.

TABLE OF CONTENTS

APPROVAL FORM ii

DECLARATION iii

DEDICATION iv

ACKNOWLEDGEMENTS v

ABSTRACT vi

LIST OF TABLES x

ACRONYMS xi

CHAPTER 1 1

INTRODUCTION 1

1.0 Background of the study 1

1.1 Statement of the problem 2

1.2 Justification 3

1.3 Aim of the study 3

1.4 Objectives of the study 3

1.5 Hypothesis 4

CHAPTER 2 5

LITERATURE REVIEW 5

2.0 Overview of *Brassica napus* L. production and importance 5

2.1 Important insect pests on *Brassica napus* L. 6

2.2 Bio-pesticides: classification and importance to sustainable pest management 9

2.3 The use of rabbit urine as a bio-pesticide 9

2.4 Efficacy of rabbit urine on pest incidence. 11

2.5 Dual purpose as biofertilizer and bio-pesticide 12

2.6 Current pest management strategies on *Brassica napus* L. in Zimbabwe 13

2.6.1 Chemical control and its limitations 13

2.6.2 Biological and botanical control 13

2.8 Safety evaluation and ecological impact of rabbit urine 14

2.9 Critical gaps in literature 15

CHAPTER 3 16

METHODOLOGY AND EXPERIMENTAL DESIGN 16

3.1 Study Site 16

3.2 Experimental design and field layout 16

3.3 Materials and Methodology 17

3.4 Crop husbandry practices 17

3.4.1 Land preparation and transplanting 17

3.4.2 Fertilizer application 17

3.4.3 Irrigation and weeding 18

3.5 Preparation of treatment solutions 18

3.6 Pest control/ Application of treatments 18

3.7 Data Collection 18

3.7.1 Pest incidence 18

3.8 Yield parameters 18

3.8.1 Number of harvestable leaves per plant 19

3.8.2 Fresh leaf yield (kg/plot) 19

3.9 Data Analysis 19

CHAPTER 4 20

RESULTS 20

4.1 Effects of Rabbit Urine Concentrations on Pest Incidence of Rape 20

4.3 Effects of Rabbit Urine Concentrations on Yield of Rape 20

4.3.1 Effects of rabbit urine concentrations on number of harvestable leaves of rape 20

4.3.2 Effects of Rabbit Urine Concentrations on Fresh Leaf Yield of Rape (kg/plot) 21

CHAPTER 5 23

DISCUSSION OF RESULTS 23

5.1 Effect of Rabbit Urine Concentrations on Pest Incidence of Rape 23

5.2 Effect of Rabbit Urine Concentrations on Number of Harvestable Leaves of Rape 24

5.3 Effect of Rabbit Urine Concentrations on Fresh Leaf Yield of Rape 25
5.4 Overall Efficacy of Rabbit Urine as a bio-pesticide 26
CHAPTER 6 27
CONCLUSION AND RECOMMENDATIONS 27
6.0 Conclusion 27
6.1 Recommendations 27
6.3 Study limitations 28
REFERENCES 30
APPENDICES 36

LIST OF TABLES

Table 3.1. Treatments applied on *Brassica napus* L. to study the effectiveness of rabbit urine as a bio-pesticide…… 16

Table 4.1. Effects of Rabbit Urine concentrations on pest incidence of rape ……..……20

Table 4.2. Effect of rabbit urine concentrations on number of harvestable leaves of rape……..…….21

Table 4.3. Effects of rabbit urine concentrations on the fresh leaf yield of rape in kg/plot……...23

ACRONYMS

ANOVA – Analysis of Variance

DBM – Diamondback moth

IPM - Integrated Pest Management

LSD – Least Significant Difference

WAT – Weeks After Transplanting

CHAPTER 1

INTRODUCTION

1.0 Background of the study

Brassica crops play an important role in global food production, with *Brassica napus* L. (rape) as one of the key species. Rape (*Brassica napus* L.) is a leafy vegetable crop widely grown in Zimbabwe for consumption by humans and is used as a fodder crop by livestock too (J *et al*., 2013). Despite the crop's agronomic significance in Zimbabwe and the Sub-Saharan Africa, the production of this crop is frequently hampered by the pressure of insect pests which lead to high wastage before and after harvesting.

In Zimbabwe, rape is mainly cultivated by small-scale farmers to enhance food and nutritional security. It ranks among the leading vegetables that are cultivated based on its leaves that have abundant vitamin A, thiamine and ascorbic acid (Nyakudya *et al*., 2010). Vegetable growing has become another fast-developing business due to the growing population in cities, which raise the need for vegetables (Kuntashula *et al*., 2004).

A diverse range of rape cultivars grown are in Zimbabwe, however the commonly grown are the English Giant rape and Hobson cultivars as noted by Musara & Chitamba, 2015. Both varieties have a potential of about 25-40 tonnes/ha and can be planted all year round. Although Hobson is a better version of English Giant cultivar, the latter is more desirable due to their hardiness and cooking quality (Ganya *et al*., 2018).

The most harmful insect pests in the husbandry of *B. napus* are, but not limited to, aphids (*Brevicoryne brassicae*), the diamondback moth (*Plutella Xylostella* L.) and whiteflies (*Bemisia tabaci*). These pests are reported to cause destruction of rape plants under extreme conditions of plant infestation through direct feeding, sucking out phloem sap, and spreading plant viruses, which consequently reduces crop yield by up to 80% when conditions of plant infestation are severe (Furlong *et al*., 2013). The diamondback moth has acquired a greater level of resistance to most of the synthetic pesticides which makes its control a problematic exercise to the farmers at a large scale (Zalucki *et al*., 2012).

To control and manage pest pressure on Brassica cops, a most common response has been the use of synthetic pesticides . This method is found as the most effective in controlling various insect pests but due to their temporary efficacy, their consistent and indiscriminate use has led

to a myriad of environmental, health and economic issues. Some of the issues relating to the further use of synthetic chemicals include emergence of resistance of pest population to using insecticides, destruction of non-target organisms such as useful insects and natural enemies, soil and water pollution, and accumulation of toxic residue in food crops (Aktar *et al*., 2009). Due to the over dependence on synthetic pesticides, manufacturers and retailers have acquired a right to control the prices which in many cases are not affordable to the smallholder farming industry (Mvumi & Maunga, 2018).

Due to these issues, bio-pesticides have turned out to be a far more safe and ecologically sound alternative to man-made insecticides. Isman (2006), reports that plant and animal derived substances are the most accessible and promising bio-pesticides that show pesticide effects in smallholder farming sector. Out of the already proposed bio-pesticides, the rabbit urine is found to be an ideal candidate since it is reported to have specific compounds able to confer pest avoidance. The urine of rabbits as reported by Kemunto *et al*. (2022) is made of compounds such as urea, robenidine hydrochloride and ammonium excretion. It is due to the presence of a pungent odour that insects are repelled and the ammonia in rabbit urine destroys the respiratory system of whiteflies which results in death (Mutua *et al*., 2024). It is this dual effect of repelling and killing insects which has motivated researchers to examine rabbit urine as a prospective legitimate biological pesticide with repulsive, anti-feeding and anti-pest properties (Lekamoi *et al*., 2022).

The connotation on the use of rabbit urine as a pesticide against various pests has largely been reported in part of East and West Africa by farmers (Adedire *et al*., 2004). Despite these observations, there is a lot of unavailable scientific evidence on the effectiveness and optimal application rates of rabbit urine especially on the production of *Brassica napus* L. under Zimbabwean agroecological conditions. Therefore, this study seeks to assess the efficacy of rabbit urine as a bio-pesticide against problematic insect pests of rape under field experiments at Bindura University of Science Education farm.

1.1 Statement of the problem

Brassica napus L. production in Zimbabwe is severely constrained by pest infestations especially the whiteflies (*Bemisia tabaci* and *Trialeurodes vaporariorum*), aphids (*Brevicoryne brassicae* and *Myzus persicae*) and the diamondback moth (*Plutella xylostella*). Synthetic pesticides, used extensively by vegetable farmers in Zimbabwe, to manage pest problems, however, due to their escalating prices, the environmental impact, the food

residues of pesticides as well as the emergence of pesticide resistance has rendered synthetic pesticides ineffective and unsustainable.

On the other hand, rabbit urine has been proposed to be a cheaper and ecologically sound bio-pesticide. In spite of these assertions, empirical evidence on the efficacy in combating key pests under Zimbabwean conditions is lacking. The presence of such knowledge gap inhibits the use of rabbit urine by farmers and the correct prescription by the agricultural extension services. This study aims to assess the effectiveness of rabbit urine on the *Brassica napus* L. major pests.

1.2 Justification

Rape (*Brassica napus* L.) is a vegetable crop which has both nutritional importance and economic value owing to its high content of essential vitamins and minerals, it is eaten by people who regard it as a nutritious in the winter months. Thus, any management practices that could help curb losses that are caused by pests and at the same time reduce the cost of inputs and the amount of environmental damage is helpful in direct and tangible ways to both the smallholder farmers and those of the overall agricultural system. In addition, rabbit rearing is practiced among most small scale and peri-urban farming households in Zimbabwe. This renders it easily accessible resource that would otherwise go to waste hence when proved to be effective in controlling major pests of *Brassica napus,* its application as a bio-pesticide will reduce costs and could be adopted into the current farming systems. The world sees agricultural policy frameworks that are advocating for integrated pest management strategies in an attempt to reduce the application of synthetic pesticides as well as encouraging the use of biologically and ecologically based pest control strategies (FAO, 2018). The scientific perspective of this study is that it contributes to the ever-growing body of literature in bio-pesticides research literature which is grossly underrepresented in the bio-pesticides research literature regarding agroecological setting especially in Zimbabwe.

1.3 Aim of the study

To evaluate the efficacy of rabbit urine as a bio-pesticide in managing *Brassica napus* L. pests

1.4 Objectives of the study

- To assess the effects of different rabbit urine concentrations on pest incidence in rape
- To assess the yield of rape treated with different rabbit urine concentrations

1.5 Hypothesis

H_0: Rabbit urine has no significant on rape pest incidence.

H_1: Rabbit urine has a significant effect on rape pest incidence.

H_0: Rabbit urine has no significant effect on rape yield.

H_1: Rabbit urine has a significant effect on rape yield.

CHAPTER 2

LITERATURE REVIEW

2.0 Overview of *Brassica napus* L. production and importance

Brassica napus L., a crop in the Brassicaceae family, is an economically significant crop globally. Natural cross-pollination of *Brassica oleracea* (cabbage) versus *Brassica rapa* (turnip) produced this crop plant (Diepenbrock, 2000). This species, as indicated by molecular dating, must have been formed at the most as early as 7 500 years ago. *B. napus* is the most grown leafy vegetable out of approximately 40 species that make up the genus Brassica (Muchecheti *et al*., 2012). It is officially referred/ to as rapeseed (Brassica napus L.) and accounts for almost 12% of vegetable produced oil (Nath *et al*., 2016). Besides oilseeds value, rape is usually cultivated as a protein rich leaf vegetable in the Southern and Eastern African nations where it serves as a protein nutrient rich dietary staple to rural and urban population (Nyakudya *et al*., 2010).

Brassica napus L. is characterized by a relatively shorter period of growth when compared to the other Brassica species due to high level of production and adaptability to different agroecological conditions as explained by (Musara & Chitamba, 2015). The yield of the crop is 25-40 tonnes per hectare, and the leafy vegetable is significant in food and source of income to the farmers. In Zimbabwe, the English Giant rape with its large, verdant green leaves, high growth rate and with a growing period of an estimated 90 days is the most common variety of rape that grows within the small-scale farming sector of Zimbabwe (Ganya *et al*., 2018). Rape is nutritiously abundant in minerals, roughage and vitamins used upon being cooked in its fresh or dried leaves. It provides the necessary dietary vitamins A, C and K, iron, calcium and dietary fibre to households that use it as a daily cooked vegetable (Batista *et al*., 2011; Nyakudya *et al*., 2010).

From the studies of Nyakudya *et al*., (2010), they reported that rape (*Brassica napus* L.) is normally planted during the cooler seasons which expand between April till September when the rainfall is insignificant meaning that irrigation is the primary source of water. Grown throughout all the natural crop-growing regions of Zimbabwe, the crop is significantly cultivated in the peri-urban regions, the small irrigation schemes and urban gardens of provinces including Mashonaland Central, Mashonaland East as well as in Harare Metropolitan and Midlands. This vegetable crop, which is cultivated by smallholder farmers,

is geared towards food and dietary security and is highly attainable due to the rapid growth cycle and continuous production potential of *Brassica napus* L. when under irrigation (Sibanda *et al*., 2000). This also makes it a predictable crop to provide reliable income and food to smallholder homes during the dry winter season (Muchecheti *et al*., 2012).

Nevertheless, rape (*Brassica napus* L.) production continues to be subject to multiple biotic and abiotic checks which restrict the productivity of the crop to below its genetic potential (Nyakudya *et al*., 2010). The importation of foreign crops has seen the emergence of new pest and disease issues, which in most cases are hard to control or manage further thus lead to a rapid build-up of resistance and pest resurgence. Zimbabwe's broad issues such as diminishing soil productivity, inability to acquire loans and discriminate prices of synthetic chemicals in the economic context of smallholder farmers has hampered the quality of produce as demanded by the market (Sibanda *et al*., 2000). According to (Bafana, 2019) it has been noted that many farmers have noted the need to embrace vegetable farming in a bid to stem the challenges that they are faced as a result of drought in production of the cereal crops thereby leading to urgent need to prioritize effectively and less costly pest management systems to enhance sustainable agriculture and livelihoods of the farmers.

2.1 Important insect pests on *Brassica napus* L.

Rape (*Brassica napus* L.) crops are attacked by several insect pests that belong to various orders and feeding habits (Dube *et al*., 1998; Sibanda *et al*., 2000). Although some cultural and biological control measures are being used by farmers, the most common method is the conventional use of artificial pesticides (Sibanda *et al*., 2000). Various pests of economic importance infesting brassicaceous crops in Southern African countries, such as Zimbabwe have been reported to include aphids, thrips, white flies, bagrada bug, diamondback moth and cutworms. These pests affect rape in a variety of ways with different crop growth stages (J *et al*., 2013).

For aphids, the cabbage aphid (*Brevicoryne brassicae* Sulzer) and the green peach aphid (*Myzus persicae* Sulzer) are highly stable, economically important aphids affecting rape (Shumba and Chikwanda, 2014). The mechanism used by them to attack involves colonization of the back of the leaves and growth tips, sucking phloem sap and encouraging mould growths on their honeydew excreta hence reducing palatability and market value of the crop. Aphid infestation is higher in winter because temperatures are favourable to rapid population build up than in spring or summer (Blackman & Eastop, 2000). The damage by

aphids happens at every growth stage of *B. napus* L., but severe damage is in the period of flowering and pod filling which reduces seed yield by 37% synchronous with fresh leaf yield drops due to sap sucking nymphs and adult aphids (Hull & Matthews, 2002; Kumar & Singh, 2015).

In global and local level, the DBM (*Plutella xylostella* L.) is a notorious plague on rape production. It feeds through mining the leaf mesophyll by early instars and older larvae eat the leaf tissue resulting in defoliation when infestation is at peak (Furlong *et al*., 2013). The first insect pests to be resistant to didanosine triphosphate insecticide were the paperback moths (DBM) that showed significant resistance to virtually every manufactured chemical used as a method of control over the moths (Sarfraz *et al*., 2005). The controlling of DBM is complicated due to its rapid resistance development to insecticides as argued by Grzywacz *et al*., (2010). Smallholder farmers in Southern Africa can hardly cope with the continuous pressure posed by the insect due to the inability to access effective pest management strategies and little emphasis in the effectiveness of DBM management in major research undertakings (Machekano *et al*., 2017). In Zimbabwe, the brassicaceous crops such as cabbages have been studied using many botanical extracts trying to identify affordable and sustainable alternatives than using chemical pesticides (J *et al*., 2013). A comprehensive approach must be utilized to avert resistance build-up in the pest, moving away from simply using one method to thwart DBM (Philips *et al*., 2014).

White flies (*Bemisia tabaci*) pose a significant threat to rape production particularly when the weather is hot and also in peri-urban agriculture set-up (Sibanda *et al*., 2000). Mutua *et al*. (2024) observed that white fliessignificantly reduce both yield and quality of crops, and that frequent use of chemicals has led to the development of resistance. They cause the damage by sucking sap out of phloem vessels and they are found occupying the underside of the leaves leading to chlorosis, curling of leaves subsequently weakening the plant. The cause of this damage is through both adults and nymphs. *Bemisia tabaci* does not only physically damage crops, but it is also a carrier of begomoviruses which can destroy susceptible vegetable crops such as *Brassica napus* L. and hence reduce the quantity of marketable rape leaves (Isman, 2006; Dube *et al*., 1998).

Agrotis ipsilon (cutworms) and associated species of defoliating pests are serious soil-dwelling pests, which are caterpillars and cause enormous damage during the *Brassica napus* seedling stage. The stems of rape seedlings are cut off by cutworms at or slightly below soil

surface which indicates appreciable gaps in the crop stand (Dube *et al*., 1998). The works of Dube (1998) reveal that growing rape on plots formerly under cereal production leads to comparatively more cutworm infestation due to the so-called carryover effect. Irreversible damage is greater during the seedling stage where replanting is often the only solution, which means more time taken to reach first harvests and increased costs to the farmer (Sibanda *et al*., 2000).

Frankliniella occidentalis (thrips) that digests both by scraping or grating the leaf cells of the epidermis and sap extraction is another pest of economic interest but proving to be even more cunning as a pest in brassicaceous crops. The foliage thematic of thrip destruction is characterized by silvery and gold spots and their conducive habitat is a hot and dry climate (Dube *et al*., 1998). In addition, they have been known to fly in larger populations causing rampant destruction whilst farmers are not aware and young plants are the most affected (Reitz, 2009). Thrips live on the under-leaf as well as in the crevices of the folded plant tissues making it hard to manage them using insecticides unless the systemic chemicals are sprayed (Dube ., 1998).

Occasionally, there are pests such as the Bagrada bug (*Bagrada hilaris*) of Brassica crops like *Brassica napus* L. and it seems to be becoming a threat regularly as it is written by Dube (1998). Its breeding site ranges between weeds and cruciferous plants and as it is based on the growing shoot, it is a severe threat to young plants of rape and cabbage resulting in the development of groups of small heads on the shoot apex (Gyawaly *et al*., 2020). Although it is not as devastating as aphids or DBM in the Zimbabwe vegetable production systems, the infestation by the bagrada bugs causes greater localized damage as well as restricting the ability to control the infestation due to limited efficacy of effective pesticides against the predatory bugs (Dube ., 1998).

The crops of the brassicaceous family are plagued by a plethora of insect vermin especially the order Lepidoptera that includes cutworms, whiteflies, loopers, the DBM and numerous other insects representing several orders such as thrips and aphids (Artemyeva & Kurina, 2024). These insect pests are predominantly controlled by spraying synthetic insecticides in smallholder vegetable growers in Zimbabwe since they have limited access to information on available biological control measures (Sibanda ., 2000) Such an overdependency on synthetic insecticides has proven to be expensive yet ecologically harmful and inefficient due to resistance development in major pests like *P. xylostella* and *M.persicae* (Furlong *et al*., 2013).

Based on this phenomenon, one can legitimately evaluate alternatives to conventional bio-pesticides that are cheaper and, since they are located domestically, they are more accessible.

2.2 Bio-pesticides: classification and importance to sustainable pest management

bio-pesticide is an umbrella term that describes all the natural chemicals that have insecticidal properties found in living organisms, be it plants, animals, bacteria and some minerals capable of controlling the numbers of the pests without necessarily damaging the biodiversity and the physical landscape (EPA, 2021). First of all, bio-pesticides are categorized into three groups which are microbial pesticides (entomopathogenic microbes such as *Bacillus thuringensis*) and biochemical pesticides (they include plant and animal derived substances which control pests in a non-poisonous way) and plant incorporated protectants (EPA, 2021; Isman, 2006). The utilization of bio-pesticides has many merits such as generally less toxic, target specific, highly effective in low doses, rapid degradation making them highly compatible with integrated pest management strategies due to low production costs and less opportunities to develop resistance (Orishaba, 2019). According to Isman (2006) bio-pesticides extracted out of animal substances, especially their excreta, are relatively under researched, and they show a higher potential of being utilized in the smallholder farming systems.

Existing attempt of embracing sustainable agricultural concepts has seen the increased awareness of bio-pesticides in research and policy making through the world. This is supported by Khamis *et al*. (2023) writing that the study on bio-pesticides and their product development has been deemed as being significant in ensuring sustainable development in African countries. Increased integration by using both global and local integrated pest management practices are focused on reducing the rate of application of synthetic pesticides and integration of biological management methods especially when application of the synthetic pesticides and availability of the biological control measures create the obstacles (FAO, 2018). These policies are basically imperative in Zimbabwe considering high use of multi-target pesticides by smallholder farmers and limited access to alternatives that may be safe (Sibanda *et al*., 2000).

2.3 The use of rabbit urine as a bio-pesticide

Rabbit urine application as a pest control agent in agriculture had its origin in the traditional knowledge systems in East and West Africa (Babarinde *et al*., 2011), where the usage of rabbit urine on farms has been found to be effective as a bio-fertilizer and bio-pesticide

making it a dual input that saves money and convenient to smallholder farmers (Kemunto *et al*., 2022). It has been well studied by Kenyans where farmers discovered ideal methods of collecting, storing and spraying rabbit urine on crops kale, cabbages and tomatoes (Kemunto *et al*., 2022). In western Kenya, smallholder farmers keep rabbits with the sole purpose being to collect their urine that are later used as the pesticide, bio-fertilizer, with claims filing that this is helping them to manage and control pests with efficiency at the same time saving them in terms of financial resources (Ongwae, 2018).

Cuniculture, or rabbit rearing, is considered to be an ideal investment with regard to being a less capital-intensive venture and a relatively easy-to-manage operation (Bastos *et al*., 2022; Mutai, 2020; Oseni & Lukefahr, 2014). When it comes to nutritional composition, the excreta of rabbits contain a higher level of nutrient and organic matter content as compared to the other livestock as well as to some of the commercial liquid fertilizers (Ekwere, 2024). Introducing the use of rabbit farming into the already existing smallholder agriculture systems has been shown to be a matching practice because of its dual-purpose value. In the countries where rabbit urine usage has been long-standing for example Kenya and Uganda, some farmers have innovated new ways of applying rabbit urine together with other products such as molasses, entomopathogenic microorganisms and ash to enhance its efficacy with cheaper and sustainable means as opposed to synthetic pesticides (Orishaba, 2019).

Specific chemicals composition makes the pesticide effect of the rabbit urine highly dependent (Babarinde *et al*., 2011; Kemunto *et al*., 2022). Along with high levels of nitrogen, potassium and phosphorus, the urine also contains very high proportions of ammonia and other gases containing nitrogen as by-products of protein digestion. Micro-nutrients absent in straight fertilizers, but found in rabbit urine, have further been specifically found to be 1.05% nitrogen, 0.85% potassium, 0.01% phosphorus and 0.12% calcium thus provoking pesticide ability as well as plant nutrients content (Løe, 2023).

The constituents of the approximate 100mls of urine produced by rabbits at any time are ammonia, nitrous oxide and nitrogen gas which are protein digestion by-products (Mmbaga *et al*., 2024; Okonji *et al*., 2023; Ekwere *et al*., 2023). Studies from Babarinde *et al*. (2011), and Kemunto *et al*. (2022) show that the ability to control pests such as adult white flies, winged aphids and point of lay Lepidopteran moths is caused by urea and ammonia.

Storage conditions strongly influence both the chemical makeup and pesticidal effectiveness of rabbit urine. The element nitrogen is volatile and easily lost in elevated temperatures, thus,

fresh urine tends to be more effective in pest control than the stored urine due to the presence of higher nitrogen levels as compared to the latter. It is thus recommended that farmers should ensure that they use fresh urine and not old urine to ensure that the urine pesticide effect is maximum (Kemunto *et al*., 2022; Løe, 2023).

2.4 Efficacy of rabbit urine on pest incidence.

The efficacy of rabbit urine against key *Brassica* pests has been well researched in East Africa in the past few years whilst there is little to no evidence in Southern Africa especially on *Brassica napus*. Against aphids, Løe (2023) tested rabbit against aphids on *Brassica oleracea* var. *Acephala* by inoculating with aphids and it was found that there was significant decrease in the population of aphids seven days following foliar spraying compared to controls. This was a sign that there was a presence of bio-active pesticide substances in rabbit urine. Kemunto *et al*. (2022) also tested its effectiveness on fall army-worm (*Spodoptera frugiperda*) after Mohammed (2016) had studied it on *Aphis fabae* in *Phaseolus vulgaris*. All these studies show how effective rabbit urine is against aphids and other insects in various hosts and this extends the known host range of rabbit urine. In Zimbabwe, studies on bio-pesticides conducted experiments aimed to determine the effects of botanical extracts of chilli and garlic in rape (*Brassica napus*) at Midlands state university. It also helps to establish the relevance of aphid management studies and the availability of cheaper biological alternatives locally (Shumba & Chikwanda, 2014).

Mutua *et al*. (2024) offer a more valid gauge of the efficacy of rabbit urine in white flies tomato production. They carried out their research by laying a randomized complete block design comprising of six treatments replicated four times. The study findings were that foliar sprays of urine of rabbits were found to considerably reduce the population of white flies in all life cycle stages; eggs, nymphs and adults. The best trade-offs between effective pest suppression and the safety of the plants were found in the intermediate dilutions. In this investigation the major limitation to designing application protocols was found to be phytotoxicity which highest doses ended up as the cause of scorches of the leaves and thus, reduced the overall yield.

There is a limited amount of scholarly-reviewed data on the effectiveness of rabbit urine on lepidopteran pests such as diamondback moth. The only identified study tested it on fall army worm (*Spodoptera frugiperda*) in maize crops in Kenya. Based on the second and third instar stages, (Kemunto *et al*., 2022; Løe, 2023) reported that 46-70% of the larvae remained on

untreated plants whilst 27-43% of the larvae were on the rabbit urine treated leaves thereby reducing the damage by 6.4 and 12.8 percent of the damaged leaves, respectively, after 24 hours. Though the effects are small, they do demonstrate that rabbit urine has effects on lepidopteran larvae because of repellent, via contact and odour of ammonia that suppresses larval feeding and oviposition, as the proposed mode of action (Kemunto *et al*., 2022; Løe, 2023). Nevertheless, empirical evidence is lacking on rape crop in DBM, which is a major gap in knowledge in the literature.

Combining rabbit urine with botanical bio-pesticides has shown to have a promising potential. (Lekamoi *et al*., 2022) sprayed sesame (*Sesamum indicum* L.) with a formulation of 10% *Tephrosia vogelii* and 50% rabbit urine. The results indicated a great decrease in the population of the pests and a great rise in the diversity of the natural enemies on the treated plants as compared to the untreated plants and those treated with synthetic pesticides. These findings indicate that the efficacy of botanical extracts in conservative biological control in treated crop ecosystem is promoted by rabbit urine (Matle *et al*., 2022).

2.5 Dual purpose as biofertilizer and bio-pesticide

Rabbit urine presents a twofold advantage to farmers since with one input farmers are simultaneously obtaining two benefits: the ability to control pests and an added benefit of doubling the crop nutritional benefits (Kemunto *et al*., 2022). Since rabbit urine has a dual role on plants, it has to be strictly studied under field conditions. Mmbaga *et al*. (2024) confirmed the following significant improvement in plant growth parameters when rabbit urine was used on *Brassica carinata* L., a close relative of *B. napus* on which the most effective dose was 75% of fresh urine, which was more effective compared to stored urine. The results of this closely related Brassica species are applicable directly to the present study and might offer similar results to *Brassica napus* L.

The studies on other vegetables have provided evidence in support of rabbit urine as a biofertilizer. Okonji *et al*. (2023) have found it to improve cucumber (*Cucumis sativus* L.) yield and yield components but found no improvements in yield in tomatoes whilst Indabo & Abubakar (2020) indicated that although it has received little enthusiasm in its use, research has confirmed that yield benefits have been observed with tomato, cucumber and bok choy, which utilize rabbit urine as a dual-purpose input which helps to control insect pests, but also provides fully available nutrients in a plant-available form.

2.6 Current pest management strategies on *Brassica napus* L. in Zimbabwe

2.6.1 Chemical control and its limitations

Synthetic insecticides are the main pest control tool used by Zimbabwean smallholder rape farmers. They can be categorized as pyrethroids, organophosphates, and neonicotinoids all of which are easily obtainable at urban and peri-urban agro-dealer outlets. Typical ones are lambda-cyhalothrin, cypermethrin, and dimethoate (Furlong *et al*., 2013; J *et al*., 2013; Sibanda *et al*., 2000). Although these chemicals have led to swift development of resistance towards insecticides such as diamondback moths and kill natural enemies, they continue to be a leading pest management approach on the continent (Grzywacz *et al*., 2010). To smallholder farmers in Zimbabwe, the expense of continually rebuying insecticides is prohibitive and chances of the likelihood of residue accumulation experienced by the smallholder farmers is high, as rape leaves are consumed shortly after spraying. These problems make the affordability and safety critical for smallholder farmers(Shumba & Chikwanda, 2014).

2.6.2 Biological and botanical control

Biological control interventions targeting Brassica pests (especially DBM), using entomopathogenic fungi and parasitoid have been carried out in Zimbabwe and the Southern African community (Furlong *et al*., 2013; J *et al*., 2013). From the research of Chikuvire *et al*. (2013) on diamondback moths in Zimbabwe under field conditions in cabbage, the authors found that when garlic (*Allium sativum* L.) was applied as a repellent intercrop in cabbage, it had an important impact on reducing diamondback moth populations. Added to this is microbial bio-pesticides which include but are not confined to, *Bacillus thuringiensis* formulations and mycoinsecticides derived using *Zoopthora radicans* and *Beauveria bassiana*, have shown promise as biological agents in control of DBM (Sarfraz *et al*., 2005).

Nevertheless, commercial resource constraints and high costs and underdeveloped agricultural supply chains continue to limit the massive exploitation of microbial bio-pesticides within the smallholder farming sector of Zimbabwe (Sibanda *et al*., 2000). In Ghana, Osae & Marri (2023) further indicated that, although it is true that *Beauveria bassiana* may effectively manage DBM to acceptable levels, it is not able to manage co-occurring pests such as aphids thus revealing a notable weakness. This now validates the purpose of broad-spectrum and inexpensive pest management means such as rabbit urine

which are able to control multiple pest groupings simultaneously as revealed by its efficacy data of aphids and lepidopteran pests.

2.7 Application method and phytotoxicity of rabbit urine

Rabbit urine concentration is a key factor determining both its biopesticidal efficacy and risk of phytotoxicity to crops (Løe, 2023; Mutua *et al*., 2024). In East Africa, farmers apply rabbit urine in a wide range of ratios, showing no uniform, evidence-based practices to apply to each crop species and pressure of different pests. Whereas higher concentration resulting in lower agro-ecological footprint was achieved and efficacy improved, however, at the cost of leaf scorching that can ultimately reduce overall yield and clearly indicate trade-offs between efficacy and crop safety (Mutua *et al*., 2024). According to a study on Ethiopian mustard, intermediate doses, such as 75% and 50% fresh rabbit urine, proved to be the most appropriate in increasing the growth of plants, with fresh urine showing more benefits than stored urine (Mmbaga *et al*., 2024).

Application timing is another crucial factor that determines effectiveness of rabbit urine and its suitability as a bio-pesticide. With increased temperatures, volatilization of ammonia is accelerated, making pesticides less practical and it increases the likelihood of leaves being damaged (Kangume *et al*., 2025). Consequently, spraying in areas of cooler temperatures in the day, e.g. early morning or late afternoon, can help to maximise contact time with pest populations whilst minimising the effects of phytotoxicity. With the available information at hand, it can be said that applying rabbit urine at weekly frequency can be considered to maintain the pest suppression but optimum application periods of Brassica napus in Zimbabwean conditions cannot be determined (Niyoyitungiye *et al*., 2025).

2.8 Safety evaluation and ecological impact of rabbit urine

Rabbit urine is a green urine, and poses no serious health risks to humans and animals, according to (Nyakudya *et al*., 2010). This is, more particularly, relevant to the production of leafy rapes in Zimbabwe where leaves are harvested on a regular basis and consumed fresh within a short period of time and without observable in-depth processing and storage of the product itself that might destroy the residues of synthetic pesticides. Unlike chemical pesticides, the major components of rabbit urine, such as urea, ammonia, creatinine and phosphorus are readily decomposed by soils microbes or absorbed by plant-life, leaving no left-over remnants in the soil or in the plants (Kemunto *et al*., 2022; Løe, 2023). The absence

of harvest intervals restrictions is favourable to the smallholder farmers as they harvest rape leaves in a daily or weekly without fear of food poisoning.

Although this non-toxic aspect is demonstrated, the process of gathering and spraying rabbit urine on crops has to be conducted under the safety standards. Ammonia from protein metabolism in rabbit's digestive system may irritate human's respiratory tract especially in poorly ventilated places. When spraying, protective equipment recommended by extension officers like gloves, safety shoes should be worn as rabbit urine may cause skin irritation or may harbour harmful microbes. Farmers are encouraged to adhere to safe and proper storage buildings, dilution and hygiene guidelines such as washing hands and uncovered skin post-use (Ford, 2025). Rabbit urine poses little risk to surface water and non-target organisms including pollinators and soil fauna compared with broad spectrum synthetic insecticides (Samada & Tambunan, 2020)

2.9 Critical gaps in literature

This has four major knowledge gaps that are identified in the existing literature that supports this study. To begin with, even though the effect of rabbit urine on crop plants has been studied on crops such as tomato (Mutua *et al*., 2024); kale (Løe, 2023); common beans (Kemunto *et al*., 2022), rape remains unstudied. Secondly, peer-reviewed research into rape in Zimbabwe, which focus on botanical extracts (Pahla *et al*., 2014), do not specifically assess the use of animal-based bio-pesticides, such as rabbit urine. Thirdly, the action-at-a-distance of rabbit urine against *Plutella xylostella* has no quantitative data on any Brassica crop making this pest-bio-pesticide interaction uncharted. The fourth gap to be identified is unavailability of information related to optimal concentration of rabbit urine that is effective to control major pests like aphids, DBM and white flies on *B. napus*. This study filled these gaps through a field experiment carried out at Bindura University of Science Education farm in Shamva, Mashonaland Central.

CHAPTER 3

METHODOLOGY AND EXPERIMENTAL DESIGN

3.1 Study Site

The study was carried out at Bindura University of Science Education farm, formerly known as Glen Avilin farm, located in Mashonaland Central Province in Zimbabwe. The site falls under agroecological zone IIa of Zimbabwe, characterized by moderate to high rainfall pattern which ranges from 750 to 1000 mm per annual, received predominantly in the November to March period. Red-brown clay loam soils dominate the soil type at the study site and contain moderate organic matter. The temperatures experienced at the farm range from 15^0 C to 32^0 C.

3.2 Experimental design and field layout

A Randomized Complete Block Design (RCBD) was used, with 6 treatments replicated 4 times resulting in 24 plots. Blocks were laid perpendicular to the slope of the land so that each block contained all treatments under relatively uniform conditions. Each plot measured 3 m * 1 m, separated by a distance of 0.5 m from each other. Blocks were separated by a spacing of 1m to minimize spray drift interference between plots and for ease of data collection.

Table 3.1. Treatments applied on Brassica napus L. to study the effectiveness of rabbit urine as a bio-pesticide.

Treatment symbol	Treatment description	Preparation
T1	25% rabbit urine concentration	250 ml rabbit urine + 750 ml water
T2	50% rabbit urine concentration	500 ml rabbit urine + 500 ml water
T3	75% rabbit urine concentration	750 ml rabbit urine + 250 ml water
T4	100% rabbit urine concentration	Only rabbit urine, no dilution
T5	Lambda-cyhalothrin	5% EC per 20 l water
T6	Plain water	No treatment applied

3.3 Materials and Methodology

The following materials were used for the study:

Rape variety- English Giant was selected because it is a high-yielding variety, vigorous growth and ideal for commercial production because of its cooking quality (Carol's Seedlings, 2025; Ganya *et al*., 2018).

Rabbit urine- Fresh rabbit urine was obtained from local farmers who practise cuniculture.

Synthetic Insecticide- Lambda-cyhalothrin was used since it is a widely used registered insecticide in Zimbabwe.

3.4 Crop husbandry practices

3.4.1 Land preparation and transplanting

Experimental plots were prepared by digging land with hoes to a depth of 20-25 cm, followed by harrowing to achieve a fine and uniform tilth. Raised beds were chosen to improve aeration, drainage and root penetration to encourage early root development. The plots were marked by wooden pegs and measured according to the experimental layout. Six plots were made in each of the four blocks. Each plot measured a length of 3 meters and a width of 1m for easy management.

The rape seedlings were transplanted at an inter-row spacing of 30 cm and in-row spacing of 20 cm (Carol's Seedlings, 2026). 10 rows were made out of each plot resulting in plant population of 50 plants in each plot. Transplanting was done in April coinciding with the cooler conditions which are conducive for rape growth.

3.4.2 Fertilizer application

Basal fertilizer, Compound C (6%N, 15%P, 12%), was applied during transplanting at the recommended rate of 600 kg per hectare. The fertilizer was incorporated into planting holes. For top dressing, ammonium nitrate (34.5%) was applied in two splits of 200 kg per hectare, each at two and five weeks after transplanting. Since it is acknowledged that rabbit urine at higher concentrations contributes to plant nutrition, that may disrupt separation of its fertilisation effects from its pesticidal properties (Løe, 2023). Due to this, all treatments received same fertilizer applications to ensure that results were only attributed to pest management efficacy of rabbit urine rather than nutritional differences.

3.4.3 Irrigation and weeding

Water was applied uniformly three times per week, using the flooding system within the plots to maintain adequate soil moisture for crop growth. Hand weeding was done at two-week intervals to prevent competition for resources between crops and weeds.

3.5 Preparation of treatment solutions

Rabbit urine collected within 24 hours prior to application was used for preparing the different dilutions needed for the experiments (T1-25%, T2-50%, T3-75%, T4-100%). All solutions were mixed in clean containers to avoid contamination. The synthetic insecticide, Lambda-cyhalothrin rate of 20 ml was mixed with 20 liters of water in a knapsack spray. Clean borehole water was used in preparing all the solutions, including that of the negative control.

3.6 Pest control/ Application of treatments

Foliar spray was the method used to apply all treatment concentrations, with strict cleaning of the knapsack after every treatment application to prevent cross contamination between treatments. A 20 litre capacity knapsack was used during the sprays at weekly intervals. In order to prevent volatilization of ammonia in rabbit urine and reduce phytotoxicity risk, the application was done in the late afternoon from 1600-1800hrs ((Kemunto *et al*., 2022). Spraying was done after 2 weeks from transplanting for 6 weeks, resulting in 6 total spray applications during the course of the experiment and assessments.

3.7 Data Collection

3.7.1 Pest incidence

Five random plants were randomly selected per plot for pest assessment. All visible insect pests on the plants were counted by observing three leaves per sampled plant every 7 days for 6 weeks starting at 2 weeks after transplanting (WAT) . The leaves were chosen from different canopy levels, that is, one from the lower level, one from the middle level and one from the upper layer. The total number of pests observed per plant was recorded. Totals from all sampled plants were summed to obtain the total pests per plot, and the total was divided by the sample size to give the mean pests per plot. The means were entered into a Microsoft Excel spreadsheet.

3.8 Yield parameters

The following yield parameters were assessed at four harvesting occasions conducted at two-week intervals beginning at 4 WAT.

3.8.1 Number of harvestable leaves per plant

At each harvest, fully expanded and marketable leaves were conducted on five randomly selected plants per plot. Counts from the five plants were summed and divided by five to obtain the mean number of harvestable leaves per plot.

3.8.2 Fresh leaf yield (kg/plot)

The marketable and harvestable leaves from each plot were weighed on a calibrated digital scale (0.01g precision) and the results were recorded as kilograms per plot.

3.9 Data Analysis

All the data were subjected to analysis of aariance (ANOVA) using GenStat version 18 to test for statistically significant differences exist among the treatment means for each measured variable. Where ANOVA revealed significant differences, the Least Significant Difference (LSD) test at 5% level was used to separate means.

CHAPTER 4

RESULTS

4.1 Effects of Rabbit Urine Concentrations on Pest Incidence of Rape

Rabbit urine concentration had a significant effect on pest incidence at all assessment dates ($p \leq 0.05$). Mean pest counts for the six treatments from 2 to 7 weeks after transplanting (WAT) are presented in Table 4.1. All rabbit urine treatments significantly reduced pest incidence relative to the untreated control. The untreated control consistently recorded the highest pest counts while Lambda-cyhalothrin recorded the lowest pest incidence. Rabbit urine concentrations of 75% and 100% provided pest suppression comparable to the positive control, lambda-cyhalothrin.

Table 4.1. Effects of Rabbit Urine concentrations on pest incidence of rape. Means followed by the same letter are not significantly different.

Treatment	2 WAT	3 WAT	4 WAT	5 WAT	6 WAT	7 WAT
T1:25% Rabbit urine	8.38^{b}	8.05^{b}	7.65^{b}	6.95^{b}	6.85^{b}	6.45^{b}
T3:50% Rabbit urine	8.00^{c}	7.45^{c}	6.98^{c}	6.48^{bc}	6.25^{c}	5.90^{b}
T4:75% Rabbit urine	7.18^{d}	6.68^{d}	6.05^{d}	5.25^{c}	4.35^{d}	3.80^{c}
T4:100% Rabbit urine	7.17^{d}	6.35^{d}	5.40^{e}	4.43^{d}	3.85^{e}	3.25^{c}
T5:Lambda-cyhalothrin	3.10^{e}	2.60^{e}	2.40^{f}	2.10^{e}	2.00^{f}	1.85^{d}
T6: Untreated control	9.63^{a}	10.3^{a}	11.15^{a}	12.15^{a}	12.7^{a}	13.22^{a}
Grand mean	7.3	6.9	6.6	6.23	6	5.75
P-value	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
SED	0.10	0.19	0.20	0.25	0.22	0.28
LSD	0.21	0.39	0.43	0.52	0.46	0.60
CV%	1.9	3.8	4.3	5.6	5.1	6.9

4.3 Effects of Rabbit Urine Concentrations on Yield of Rape

4.3.1 Effects of rabbit urine concentrations on number of harvestable leaves of rape

Rabbit urine concentration significantly affected the number of harvestable leaves ($p \leq 0.05$). All rabbit urine treatments produced more harvestable leaves than the untreated control. The 75% rabbit urine concentration recorded the highest number of harvestable leaves among rabbit urine treatments and performed similarly to the positive control treatment. The 100% rabbit urine concentration performed below the 75% treatment in terms of harvestable leaves

due to higher phytotoxicity associated with undiluted rabbit urine. Excessive nitrogenous compounds caused leaf scorching that reduced the number of harvestable leaves. Table 4.2 below shows the mean harvestable leaf counts per plot across treatments and harvest occasions.

Table 4.2. Effect of rabbit urine concentrations on number of harvestable leaves of rape. Means followed by the same letter are not significantly different.

Treatment	H1- 4 WAT	H2- 6 WAT	H3- 8 WAT	H4-10 WAT
T1: 25% rabbit urine	7.50^{d}	9.25^{d}	10.00^{cd}	10.50^{c}
T2: 50% rabbit urine	9.00^{c}	10.50^{c}	12.00^{c}	13.50^{b}
T3: 75% rabbit urine	10.25^{b}	12.50^{b}	14.75^{b}	17.00^{a}
T4: 100% rabbit urine	10.50^{b}	10.00^{c}	9.25^{d}	9.25^{c}
T5: Lambda-cyhalothrin	12.25^{a}	15.25^{a}	17.75^{a}	19.50^{a}
T6: untreated control	6.25^{e}	7.25^{e}	7.00^{e}	5.75^{e}
Grand mean	9.29	10.79	11.79	12.58
p-value	<0.05	<0.05	<0.05	<0.05
SED	0.36	0.46	0.92	1.31
LSD	0.76	0.99	1.96	2.80
CV%	5.4	6.1	11.0	14.7

4.3.2 Effects of Rabbit Urine Concentrations on Fresh Leaf Yield of Rape (kg/plot)

Rabbit urine concentration significantly affected fresh leaf yield of rape ($p \leq 0.05$). Rabbit urine concentrations produced higher fresh leaf yield compared to the untreated control. Fresh yield increased progressively with increasing rabbit urine concentration up to the 75% concentration level. The 75% rabbit urine concentration recorded yields comparable to those of the synthetic insecticide treatment. However, the 100% rabbit urine concentration performed below the 75% treatment level due to higher phytotoxicity associated with undiluted rabbit urine. Excessive nitrogenous compounds caused leaf scorching which reduced harvestable biomass and fresh yield. The table below presents mean fresh leaf (kg/plot) across all harvest occasions.

Table 4.3. Effects of rabbit urine concentrations on the fresh leaf yield of rape in kg/plot.Means followed by the same letter are not significantly different.

Treatment	**H1 (4 WAT)**	**H2 (6 WAT)**	**H3 (8 WAT)**	**H4 (10 WAT)**
T1:25% rabbit urine	2.10^{e}	2.60^{e}	3.00^{d}	3.20^{c}
T2:50% rabbit urine	2.40^{d}	3.00^{d}	3.50^{c}	3.80^{bc}
T3:75% rabbit urine	2.80^{c}	3.50^{c}	4.28^{b}	4.70^{ab}
T4:100% rabbit urine	3.10^{b}	3.75^{b}	3.73^{bc}	3.40^{c}
T5:Lambda-cyhalothrin	3.40^{a}	4.30^{a}	5.10^{a}	5.60^{a}
T6:Untreated control	1.60^{f}	1.73^{f}	1.68^{e}	1.27^{d}
Grand mean	2.57	3.15	3.55	3.66
p-value	<0.05	<0.05	<0.05	<0.05
SED	------	0.14	0.27	0.438
LSD	-----	0.29	0.59	0.93
CV%	0.0	6.2	11.1	16.9

CHAPTER 5

DISCUSSION OF RESULTS

5.1 Effect of Rabbit Urine Concentrations on Pest Incidence of Rape

The weekly pest incidence results presented in Section 4.2 revealed significant differences among treatments throughout the five-week monitoring period. Pest incidence increased progressively in the untreated control plots from Week 1 to Week 5, indicating continuous pest population buildup in the absence of pest control measures. In contrast, plots treated with rabbit urine, particularly the 75% and 100% concentrations, maintained consistently lower pest populations across all weeks.

The consistently low pest populations observed in 75%, 100%, and lambda-cyhalothrin treatments suggest that rabbit urine provided sustained protection against pests over time. This indicates that the active compounds in rabbit urine remained effective for relatively long periods following application. Repeated applications of organic bio-pesticides is known to improve cumulative pest suppression by maintaining active repellent compounds on plant surfaces (Pretty & Bharucha, 2015).

The gradual increase in pest incidence observed in the untreated control plots confirms the rapid reproductive capacity of insect pests under favorable field conditions. Rape crops continuously produce young succulent leaves that attract insect pests, making regular pest management necessary throughout the growing period (Mpumi *et al*., 2020).

The 25% and 50% rabbit urine concentrations reduced pest populations compared to the untreated control but were less effective than the higher concentrations. This suggests that lower concentrations may have contained insufficient active compounds to maintain strong repellence and pest suppression over extended periods. Environmental conditions such as rainfall, sunlight, and temperature may also have accelerated the breakdown or volatilization of the active compounds at lower concentrations as proposed by Isman (2020).

The similarity between the 75% rabbit urine concentration and lambda-cyhalothrin throughout the monitoring period reinforces the reliability of rabbit urine as an effective bio-pesticide. The findings support the integration of rabbit urine into integrated pest management systems where reduced reliance on synthetic chemicals is encouraged.

5.2 Effect of Rabbit Urine Concentrations on Number of Harvestable Leaves of Rape

Experimental results in Section 4.3 reveal that rabbit urine concentrations significantly influenced the number of harvestable leaves per plant. The untreated control recorded the lowest number of harvestable leaves relative to the highest values obtained from the 75% rabbit urine concentration and lambda-cyhalothrin treatment. The 100% rabbit urine concentration produced harvestable leaves lower than the 75% concentration despite maintaining low pest incidence.

The increase in harvestable leaves with increasing rabbit urine concentration up to 75% may be explained by reduced pest damage and improved plant growth. Effective pest suppression allowed plants to retain more healthy leaves, maintain photosynthetic activity, and continue vegetative growth without severe insect damage. According to (Bautze *et al*., 2022), effective pest control is crucial for maintaining leaf quality and vegetative productivity in leafy vegetables.

In addition to pest suppression, rabbit urine may also have contributed nutrients that enhanced plant growth. Rabbit urine contains nitrogen and other mineral elements that may function as a foliar nutrient source when applied in diluted form (Kemunto *et al*., 2022; Mmbaga *et al*., 2024). Nitrogen is particularly important for leaf development, chlorophyll formation, and vegetative growth (Taiz *et al*., 2018). The 75% concentration may therefore have provided both pesticidal and nutritional benefits, resulting in increased production of harvestable leaves.

The decline in harvestable leaves observed in the 100% concentration compared to the 75% treatment was likely caused by phytotoxicity. The findings in Chapter Four indicated that undiluted rabbit urine caused leaf scorching due to excessive nitrogenous compounds. High ammonia concentrations can damage plant tissues, resulting in leaf burns, chlorosis, and reduced vegetative growth (Bautze *et al*., 2022). This explains why the 100% concentration, although effective against pests, did not produce the higher leaf counts.

Statistical similarity between the 75% rabbit urine treatment and lambda-cyhalothrin demonstrates that rabbit urine can achieve crop performance comparable to synthetic insecticides when applied at appropriate concentrations. These results supports the potential use of rabbit urine as a low-cost and locally available pest management option for smallholder farmers.

5.3 Effect of Rabbit Urine Concentrations on Fresh Leaf Yield of Rape

The results in Section 4.4 showed that rabbit urine concentrations significantly increased fresh leaf yield compared to untreated control. Fresh yield increased progressively from the control treatment up to the 75% rabbit urine concentration. The 75% concentration produced yields comparable to lambda-cyhalothrin, while the 100% concentration produced slightly lower yields than the 75% treatment.

The improvement in fresh leaf yield can primarily be attributed to reduced pest incidence. Lower pest populations reduced feeding damage on leaves, thereby increasing the amount of healthy and marketable biomass harvested from treated plants. Similar observations were reported by Altieri & Nicholls (2012), who indicated that effective biological pest management contributes directly to improved vegetable yields by minimizing crop losses caused by insect pests.

The superior performance of the 75% rabbit urine concentration suggests that this concentration provided optimal pest suppression without causing phytotoxic damage to plants. At this concentration, plants likely benefited from both reduced pest attack and additional nutrients supplied by the rabbit urine. Nitrogen-rich organic substances are known to stimulate vegetative growth and improve biomass accumulation when applied at moderate concentrations (Taiz *et al*., 2018).

Although the 100% concentration maintained low pest populations, its fresh yield was lower than that of the 75% treatment. This decline confirms the negative effects of phytotoxicity associated with undiluted rabbit urine. Excessive nitrogenous compounds probably caused leaf scorching and tissue damage, reducing photosynthetic efficiency and harvestable biomass. This finding highlights the importance of proper dilution when using rabbit urine as a foliar bio-pesticide.

The untreated control recorded the lowest fresh leaf yield because high pest populations caused severe leaf damage and reduced vegetative growth. The significant differences between treated and untreated plots demonstrate the importance of effective pest management in improving rape productivity.

The comparable performance between the 75% rabbit urine concentration and lambda-cyhalothrin indicates that rabbit urine can potentially replace or supplement synthetic insecticides in sustainable vegetable production systems. This places rabbit urine as an

important input for resource-constrained farmers who may have limited financial resources to purchase commercial pesticides.

5.4 Overall Efficacy of Rabbit Urine as a bio-pesticide

The overall findings of the study demonstrate that rabbit urine is an effective bio-pesticide for the management of pests in rape production. Rabbit urine significantly reduced pest incidence while simultaneously improving yield parameters such as harvestable leaves and fresh leaf yield. The findings clearly revealed that effectiveness increased with dosage up to the 75% level.

The 75% rabbit urine concentration emerged as the optimum treatment because it consistently achieved low pest incidence, high harvestable leaves, and high fresh leaf yield comparable to the synthetic insecticide treatment. This indicates that properly diluted rabbit urine can effectively balance pesticidal activity and plant safety.

The study also demonstrated that excessive concentration may negatively affect crop performance. Although the 100% concentration effectively controlled pests, phytotoxic effects reduced plant growth and yield. This finding emphasizes the importance of determining optimum application concentrations when using organic bio-pesticides.

The findings support the principles of integrated pest control strategies, which seeks to promote the application of environmentally friendly and locally available pest control agents. Rabbit urine offers several advantages, including affordability, availability, reduced environmental contamination, and reduced dependence on synthetic pesticides. The use of rabbit urine may therefore contribute to sustainable vegetable production systems, particularly among resource-constrained smallholder farmers.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.0 Conclusion

The experimental results provides empirical scientific proof that rabbit urine applied as a weekly foliar spray is a useful bio-pesticide for managing insect pests in *Brassica napus* L. production under agroecological conditions of Mashonaland Central, Zimbabwe. Rabbit urine significantly reduced pest incidence across all tested treatments relative to the untreated control, with 75% and 100% concentrations achieving pest suppression statistically equivalent to Lambda-cyhalothrin.

The 75% rabbit urine concentration is the optimal application rate, which produced highest leaf count per plant (17.0) and highest fresh leaf yield among all rabbit urine treatments, values statistically equivalent to those recorded under synthetic insecticide management. The 100% concentration, though equally effective in pest suppression, produced inferior yield outcomes due to phytotoxic leaf scorching, indicating that increasing concentration beyond 75% does not improve the overall agronomic outcome and imposes safety costs that outweigh any additional pesticidal benefits.

Therefore, rabbit urine offers several attributes that position it as a viable, sustainable, and low-cost input in holistic pest control strategies for smallholder rape farming in Zimbabwe. The results obtained from this study lay a scientific basis for recommending 75% rabbit urine as an effective and practical pest management tool for smallholder farmers, with the potential to meaningfully reduce dependence on costly and environmentally harmful synthetic insecticides whilst maintaining the productivity and marketability of rape in Zimbabwe

6.1 Recommendations

The author recommends that rabbit urine should be used at the concentration of 75% for optimum pest suppression in rape (*Brassica napus* L.) production. This concentration consistently achieved pest suppression statistically similar to the positive control, lambda-cyhalothrin, while maintaining commercially acceptable crop yield and leaf quality. This makes it the most practically effective and non-phytotoxic application rate for vegetable farming.

Farmers should foliar spray rabbit urine during weekly intervals starting from 2 weeks after transplanting using knapsack sprayer. The best time to apply is late afternoon from 1600 to 1800 hours to prevent volatilization, phytotoxic risk and maximize residual contact activity on pest populations (Kemunto *et al*., 2022). Moreover, only rabbit urine collected within 24 hours prior to spraying is recommended because nitrogen and volatile compounds diminish significantly with storage duration thus reducing pesticidal potency (Løe, 2023). It is also recommended that farmers put on proper personal protective wear when collecting and applying rabbit urine to avoid ammonia irritation to skin and eyes.

Agricultural extensions officers in Zimbabwe should incorporate the findings of this study in their integrated pest management advisory programs for smallholder vegetable farmers. This method is low-cost, residue-free and environmentally safe alternative to synthetic insecticides within IPM frameworks. Extension service providers are urged to develop comprehensible farmer field guides in written and pictorial instructions to communicate effectively with farmers with limited formal education. The organizations should also promote cuniculture as a way of empowering farmers to reduce the costs of procuring rabbit urine, demonstration plots and farmer field days are also encouraged to give awareness to farmers on new methods and strategies to control and manage pests in a sustainable approach.

Since this study was carried out on one site and in one season, future studies should replicate the study over various sites and seasons under different agroecological conditions of Zimbabwe and Southern Africa. Future studies should conduct detailed analysis of rabbit urine chemical composition obtained from different rabbit age groups, breeds and dietary regimes to quantify the presence of compounds like ammonia, urea and other pesticidal active compounds. Another area worth paying attention to in future research is the cost-benefit analysis against synthetic pesticides to quantify the financial benefit of bio-pesticide approach in smallholder farming.

6.3 Study limitations

The study was carried out at a single site and in a one season, thus limiting the generalization of findings across a full range of agroecological regions, seasonal variability and pest population dynamics. The chemical composition of rabbit urine may vary with age, breed, health status, and diet of the source rabbits which introduces inconsistencies in treatments that could not be fully controlled by the scope of this study. The study assessed pest incidence as a combined count across all identified insect pest species which limits the ability to

conclude the efficacy of rabbit urine against specific pest species separately. Future experiments should assess each pest group individually to generate species-specific efficacy data.

REFERENCES

Adedire, C. O. ; A. J. O., Adedire, C. O., & Akinneye, J. O. (2004). Biological Activity Of Tree Marigold, Tithonia Diversifolia, On Cowpea Seed Bruchid, Callosobruchus Maculatus (Coleoptera: Bruchidae). Annals Of Applied Biology, 144(2), 185–189. https://doi.org/10.1111/J.1744-7348.2004.Tb00332.X

Aktar, W., Sengupta, D., & Chowdhury, A. (2009). Impact Of Pesticides Use In Agriculture: Their Benefits And Hazards. Interdisciplinary Toxicology, 2(1), 1–12. https://doi.org/10.2478/V10102-009-0001-7

Altieri, M. A., & Nicholls, C. I. (2012). Agroecological Diversification Strategies To Enhance Biological Pest Regulation In Horticultural Systems. Acta Horticulturae, 933, 35–42. https://doi.org/10.17660/Actahortic.2012.933.2

Artemyeva, A. M., & Kurina, A. B. (2024). Eco-Geographical And Botanical Patterns Of Resistance To Lepidoptera Insects In Brassica Rapa L. Plants, 13(5), 673. https://doi.org/10.3390/Plants13050673

Babarinde, S. A., Oyegoke, O. O., & Adekunle, A. E. (2011). Larvicidal And Insecticidal Properties Of Ricinus Communis Seed Extracts Obtained By Different Methods Against Tribolium Castaneum Herbst (Coleoptera: Tenebrionidae). Archives Of Phytopathology And Plant Protection, 44(5), 451–459. https://doi.org/10.1080/03235400903093220

Bafana, B. (2019, May 14). Zimbabwe Farmers Venture Into Vegetables To Outsmart Poor Rains | Preventionweb. Thomas Reuters Foundation. https://www.Preventionweb.Net/News/Zimbabwe-Farmers-Venture-Vegetables-Outsmart-Poor-Rains

Bastos, F. E. A., Ribeiro, S. B., Borba, A. F., Campos, L. T., Fincatto, D., & Bertoli, C. D. (2022). Use Of Rabbit Manure In Lettuce Culture: An Alternative Option. Horticultura Brasileira, 40(4), 367–372. https://doi.org/10.1590/S0102-0536-20220403

Batista, C., Barros, L., Carvalho, A. M., & Ferreira, I. C. F. R. (2011). Nutritional And Nutraceutical Potential Of Rape (Brassica Napus L. Var. Napus) And "Tronchuda" Cabbage (Brassica Oleraceae L. Var. Costata) Inflorescences. Food And Chemical Toxicology, 49(6), 1208–1214. https://doi.org/10.1016/J.Fct.2011.02.023

Bautze, D., Dietemann, L., & Singh, A. (2022). Ecological Approach To Pest And Disease Management In The Tropics | Fao. https://www.Fao.Org/Family-Farming/Detail/En/C/1637426/?Utm_Source=Chatgpt.Com

bio-pesticides | Us Epa. (N.D.). Retrieved May 3, 2026, From https://www.Epa.Gov/Pesticides/bio-pesticides

Blackman, R.L. And Eastop, V.F. (2000) Aphids On The World's Crops—An Identification And Information Guide. The Natural History Museum. John Wiley And Sons, Ltd., New York. - References - Scientific Research Publishing. (N.D.). Retrieved May 1, 2026, From https://www.Scirp.Org/Reference/Referencespapers?Referenceid=1822747

Diepenbrock, W. (2000). Yield Analysis of Winter Oilseed Rape (Brassica Napus L.): A Review. Field Crops Research, 67(1), 35–49. https://doi.org/10.1016/S0378-4290(00)00082-4

Dube, B., Gova, M., Makaya, P. R., Mutimutema, E., Savoure, P., Letheve, X., & Turner, A. (1998). Important vegetable pest and diseases in Zimbabwe - Identification and control. Weaver Press.

Ekwere, O. J. (2024). (Pdf) Evaluation of Rabbit Urine and Urea For The Growth and Yield of Okra (Abelmoschus Esculentus (L.) Moench) Grown on Intensely Cultivated Ultisols Of South Eastern Nigeria. Nigerian Journal of Agriculture, Food and Environment, 20(1), 95–102. https://www.Researchgate.Net/Publication/382912546_Evaluation_Of_Rabbit_Urine_And_Urea_For_The_Growth_And_Yield_Of_Okra_Abelmoschus_Esculentus_L_Moench_Grown_On_Intensely_Cultivated_Ultisols_Of_South_Eastern_Nigeria

English Giant Rape Seedlings - Carol's Seedlings. (N.D.). Retrieved May 23, 2026, From https://Carolsseedlings.Co.Zw/Product/English-Giant-Rape-Seedlings/

FAO. (2018). Integrated Pest Management (IPM) | Pest and Pesticide Management | Food and Agriculture Organization of the United Nations | IPM And Pesticide Risk Reduction | Food and Agriculture Organization of The United Nations. https://www.Fao.Org/Pest-And-Pesticide-Management/Ipm/Integrated-Pest-Management/En/

Ford, A. (2025). Rabbit Urine Delivers More Crops, But Sick Farmers Without Protection . https://Farmbizafrica.Com/Rabbit-Urine-Delivers-More-Crops-But-Sick-Farmers-Without-Protection/

Furlong, M. J., Wright, D. J., & Dosdall, L. M. (2013). Diamondback Moth Ecology and Management: Problems, Progress, And Prospects. Annual Review of Entomology, 58, 517–541. https://doi.org/10.1146/Annurev-Ento-120811-153605

Ganya, S., Svotwa, E., & Katsaruware, R. D. (2018). Performance Of Two Rape (Brassica Napus) Cultivars Under Different Fertilizer Management Levels in the Smallholder Sector of Zimbabwe. International Journal of Agronomy, 2018. https://doi.org/10.1155/2018/2351204

Grzywacz, D., Rossbach, A., Rauf, A., Russell, D. A., Srinivasan, R., & Shelton, A. M. (2010). Current Control Methods For Diamondback Moth And Other Brassica Insect Pests And The Prospects For Improved Management With Lepidopteran-Resistant Bt Vegetable Brassicas In Asia And Africa. Crop Protection, 29(1), 68–79. https://doi.org/10.1016/J.Cropro.2009.08.009

Gyawaly, S., Rijal, J., & Joseph, S. V. (2020). Bagrada Hilaris (Painted Bug). Cabi Compendium. https://doi.org/10.1079/Cabicompendium.8302

Hull, R., & Matthews, R. E. F. (2002). Matthews' Plant Virology / Roger Hull. https://Books.Google.Com/Books/About/Matthews_Plant_Virology.Html?Id=Bqih4ct4848c

Indabo, S. S., & Abubakar, S. S. A. (2020). (Pdf) Effect Of Rabbit Urine Application Rate As A Bio- Fertilizer On Agro-Mophorlogical Traits Of Uc82b Tomato (Lycopersicon Esculentum Mill) Variety In Zaria, Nigeria. Dutse Journal Of Pure And Applied Sciences (Dujopas), Vol. 6 No. 2 June 2020, 6(2). https://www.Researchgate.Net/Publication/342513142_Effect_Of_Rabbit_Urine_Application_Rate_As_A_Bio-_Fertilizer_On_Agro-Mophorlogical_Traits_Of_Uc82b_Tomato_Lycopersicon_Esculentum_Mill_Variety_In_Zaria_Nigeria

Isman, M. B. (2006). Botanical Insecticides, Deterrents, And Repellents In Modern Agriculture And An Increasingly Regulated World. Annual Review Of Entomology, 51, 45–66. https://doi.org/10.1146/Annurev.Ento.51.110104.151146

Isman, M. B. (2020). Botanical Insecticides In The Twenty-First Century-Fulfilling Their Promise? Annual Review Of Entomology, 65, 233–249. https://doi.org/10.1146/Annurev-Ento-011019-025010

J, C. T., Karavina, C., Parwada, C., & Maphosa, B. T. (2013). African Journal Of Agricultural Research Lantana Camara And Tithonia Diversifolia Leaf Teas Improve The Growth And Yield Of Brassica Napus. 8(48), 6220–6225. https://doi.org/10.5897/Ajar12.2173

Kangume, T., Guloba, R., Nassimbwa, F., & Byabashaija, D. (2025). The Usage, Application And Cost Effectiveness Of Rabbit Urine In Vegetable Farming In Wakiso District In Central Uganda. . International Journal Of Multidisciplinary And Current Education Research, 7(3), 429–437. https://www.Ijmcer.Com/Wp-Content/Uploads/2025/06/Ijmcer_U0730429437.Pdf

Kemunto, D., Omuse, E. R., Mfuti, D. K., Tamiru, A., Hailu, G., Rwiza, I., Belayneh, Y. T., Subramanian, S., & Niassy, S. (2022). Effect Of Rabbit Urine On The Larval Behavior, Larval Mortality, Egg Hatchability, Adult Emergence And Oviposition Preference Of The Fall Armyworm (Spodoptera Frugiperda J.E. Smith). Agriculture 2022, Vol. 12, Page 1282, 12(8), 1282. https://doi.org/10.3390/Agriculture12081282

Khamis, A. G., Ali, A. A., Ali, M. H., Nassor, A. S., Hamad, M. O., Mohammed, S. O., & Kombo, M. D. (2023). Effectiveness Of Local bio-pesticides In The Control Of Diamondback Moth (Plutella Xylostella L.) In Cabbage Production In Zanzibar, Tanzania. Acta Agriculturae Slovenica, 119(4). https://doi.org/10.14720/Aas.2023.119.4.16424

Kumar, S., & Singh, Y. P. (2015). (Pdf) Chapter 11. Insect Pests (Cabi). In S. Kumar (Ed.), Brassica Oilseeds: Breeding And Management (First, Pp. 193–232). Cab International. https://www.Researchgate.Net/Publication/316284407_Chapter_11_Insect_Pests_Cabi

Kuntashula, E., Mafongoya, P. L., Sileshi, G., & Lungu, S. (2004). Potential Of Biomass Transfer Technologies In Sustaining Vegetable Production In The Wetlands (Dambos) Of Eastern Zambia. Experimental Agriculture, 40(1), 37–51. https://doi.org/10.1017/S001447970300142x

Lekamoi, U., Kusolwa, P., & Mbega, Ernest. R. (2022). Importance Of Bio-Pesticides Formulations In Managing Insect Pests Of Sesame In Africa. International Journal Of

Biosciences, 20(2), 342–367. https://Dspace.Nm-Aist.Ac.Tz/Server/Api/Core/Bitstreams/8071f2f0-B42f-47ba-9506-5a3165bb7b89/Content

Løe, K. (2023). Rabbit Urine As A bio-pesticide And Biofertilizer [Swedish University Of Agricultural Sciences]. In Swedish University Of Agricultural Sciences. https://Stud.Epsilon.Slu.Se/19518/1/Loe-K-20230921.Pdf

Machekano, H., Mvumi, B. M., & Nyamukondiwa, C. (2017). Diamondback Moth, Plutella Xylostella (L.) In Southern Africa: Research Trends, Challenges And Insights On Sustainable Management Options. Sustainability (Switzerland), 9(2). https://doi.org/10.3390/Su9020091

Matle, A., Kusolwa, P., Philipo, M., & Mbega, E. R. (2022). Effects Of Tephrosia Vogelii And Rabbit Urine Formulation On Insect Pests And Yields Of Cowpea Singida, Tanzania. Journal Of Biodiversity And Environmental Sciences, 21(3), 63–70. https://Innspub.Net/Effects-Of-Tephrosia-Vogelii-And-Rabbit-Urine-Formulation-On-Insect-Pests-And-Yields-Of-Cowpea-Singida-Tanzania/

Mmbaga, N., Ngongolo, K., & Materu, S. T. (2024). Potential Of Rabbit Urine As Fertilizer On Growth And Production Of Brassica Carinata L. Discover Agriculture 2024 2:1, 2(1), 99-. https://doi.org/10.1007/S44279-024-00106-2

Mohammed, O. (2016). Mohammed: Management Of Black Bean Aphids (Aphis... - Google Scholar. https://Scholar.Google.Com/Scholar_Lookup?Title=Management+Of+Black+Bean+Aphids+(Aphis+Fabae)+In+Common+Beans+(Phaseolus+Vulgaris)+Using+Of+A+Mixture+Wood+Ash+And+Rabbit+Urine&Author=Mohammed,+O.&Publication_Year=2016

Mpumi, N., Machunda, R. S., Mtei, K. M., & Ndakidemi, P. A. (2020a). Selected Insect Pests Of Economic Importance To Brassica Oleracea, Their Control Strategies And The Potential Threat To Environmental Pollution In Africa. Sustainability 2020, Vol. 12, Page 3824, 12(9), 3824. https://doi.org/10.3390/Su12093824

Mpumi, N., Machunda, R. S., Mtei, K. M., & Ndakidemi, P. A. (2020b). Selected Insect Pests Of Economic Importance To Brassica Oleracea, Their Control Strategies And The Potential Threat To Environmental Pollution In Africa. Sustainability 2020, Vol. 12, Page 3824, 12(9), 3824. https://doi.org/10.3390/Su12093824

Muchecheti, F., Madakadze, I. C., & Soundy, P. (2012). Production Of Rape (Brassica Napus L.) On Soils Amended With Leguminous Tree Prunings: Yield Responses In Relation To The Chemical Composition Of The Tree Prunings. African Journal Of Agricultural Research, 7(24), 3541–3549. https://doi.org/10.5897/Ajar11.1173

Musara, C., & Chitamba, J. (2015). Growth Rate And Yield Of Brassica Napus In Response To Acacia Angustissima leaf Biomass Application. The Journal Of Animal & Plant Sciences, 25(2)(2), 510–518. https://www.Researchgate.Net/Profile/Collen-Musara/Publication/267333136_Growth_Rate_And_Yield_Of_Brassica_Napus_In_Response_To_Acacia_Angustissima_Leaf_Biomass_Application/Links/552b86e90cf2779ab7931dab/

Growth-Rate-And-Yield-Of-Brassica-Napus-In-Response-To-Acacia-Angustissima-Leaf-Biomass-Application.Pdf

Mutai, Paul. A. (2020). The Potential Use Of Rabbit Urine As A Biofertilizer Foliar Feed In Crop Production. Africa Environmental Review Journal, 4(1), 138–147. https://Scholar.Google.Com/Citations?View_Op=View_Citation&Hl=En&User=Rqljuiqaaaaj&Citation_For_View=Rqljuiqaaaaj:Uehwp8x0ceic

Mutua, E. K., Mwangi, M., & Gaoqiong, L. (2024). Effect Of Rabbit Urine Foliar Spray On The Yield And Post-Harvest Quality Of Tomato (Solanum Lycopersicum L.). International Journal Of Horticultural Science. https://doi.org/10.31421/Ijhs/30/2024/14173

Mvumi, C., & Maunga, Precious. R. (2018). Efficacy Of Lantana (Lantana Camara) Extract Application Against Aphids (Brevicoryne Brassicae) In Rape (Brassica Napus) Over Varied Periods Of Time. African Journal Of Biotechnology, 17(8), 249–254. https://Journal-Backups.Lon1.Digitaloceanspaces.Com/Uploads/Main/Article/1bfcd8956051.Pdf

Nath, U. K., Kim, H.-T., Khatun, K., Park, J.-I., Kang, K.-K., & Nou, I.-S. (2016). Modification Of Fatty Acid Profiles Of Rapeseed (Brassica Napus L.) Oil For Using As Food, Industrial Feed-Stock And Biodiesel. Plant Breeding And Biotechnology, 4(2), 123–134. https://doi.org/10.9787/Pbb.2016.4.2.123

Niyoyitungiye, L., Mbonayo, P., Kana, F., Rivuzimana, J. S., Nshimirimana, L., & Ndayisenga, D. (2025). Evaluation Of bio-pesticide Potential Of Rabbit Urine In The Control Of Spodoptera Frugiperda Larvae In Maize Cultivation. Asian Journal Of Agriculture And Allied Sciences, 8(1), 279–290. https://doi.org/10.56557/Ajaas/2025/V8i172

Nyakudya, I. W., Jimu, L., Marashe, M., & Katsvanga, C. A. T. (2010). Comparative Growth And Yield Responses Of Rape (Brassica Napus L) To Different Soil Fertility Management Amendments. Electronic Journal Of Environmental, Agricultural & Food Chemistry, 9(1), 207.

Okonji, C. J., Ajayi, E. O., Obisesan, O. I., Osundare, O. T., & Adetuyi, A. O. (2023). Performance Of Rabbit Urine On The Yield And Yield Component Of Cucumber. Badeggi Journal Of Agricultural Research And Environment, 5(1), 15–23. https://doi.org/10.35849/Bjare202301/81/002

Ongwae, E. N. (2018, July 16). Kenya: Farmers Use Rabbit Urine As Pesticide And Fertilizer : Barza Wire. Barza Wire/ Farm Radio International. https://Wire.Farmradio.Fm/Farmer-Stories/Kenya-Farmers-Use-Rabbit-Urine-As-Pesticide-And-Fertilizer/

Orishaba, P. (2019, January 30). Rabbit Urine: A Potential bio-pesticide. 1. https://Nextgeniupac2019.Wordpress.Com/2019/01/30/Rabbit-Urine-A-Potential-bio-pesticide/

Osae, M., & Marri, D. (2023). Beauveria Bassiana, Bb11, To Control The Diamondback Moth, Plutella Xylostella (L.) (Lepidoptera: Plutellidae) On Cabbage In Ghana. Accelerating Impacts Of Cgiar Climate Research For Africa. https://Hdl.Handle.Net/10568/137491

Oseni, S. O., & Lukefahr, S. D. (2014). Rabbit Production In Low-Input Systems In Africa: Situation, Knowledge And Perspectives - A Review. World Rabbit Science, 22(2), 147–160. https://doi.org/10.4995/Wrs.2014.1348

Pahla, I., Moyo, M., Muzemu, S., & Muziri, T. (2014). Evaluating The Effectiveness Of Botanical Sprays In Controlling Aphids (Brevicoryne Brassicae) On Rape (Brassica Napus L.) . International Journal Of Agronomy And Agricultural Research, 5(1), 1–6. https://www.Academia.Edu/70102257/Pahla_Et_Al_Page_1

Philips, C. R., Fu, Z., Kuhar, T. P., Shelton, A. M., & Cordero, R. J. (2014). Natural History, Ecology, And Management Of Diamondback Moth (Lepidoptera: Plutellidae), With Emphasis On The United States. Journal Of Integrated Pest Management, 5(3), D1–D11. https://doi.org/10.1603/Ipm14012

Pretty, J., & Bharucha, Z. P. (2015). Integrated Pest Management For Sustainable Intensification Of Agriculture In Asia And Africa. Insects, 6(1), 152–182. https://doi.org/10.3390/Insects6010152

Reitz, S. R. (2009). Biology And Ecology Of The Western Flower Thrips (Thysanoptera: Thripidae): The Making Of A Pest. Florida Entomologist, 92(1), 7–13. https://doi.org/10.1653/024.092.0102

Samada, L. H., & Tambunan, U. S. F. (2020). bio-pesticides As Promising Alternatives To Chemical Pesticides: A Review Of Their Current And Future Status. Online Journal Of Biological Sciences, 20(2), 66–76. https://doi.org/10.3844/Ojbsci.2020.66.76

Sarfraz, M., Keddie, A. B., & Dosdall, L. M. (2005). Biological Control Of The Diamondback Moth, Plutella Xylostella: A Review. Biocontrol Science And Technology, 15(8), 763–789. https://doi.org/10.1080/09583150500136956

Sibanda, T., Dobson, H. M., Cooper, J. F., Manyangarirwa, W., & Chiimba, W. (2000). Pest Management Challenges For Smallholder Vegetable Farmers In Zimbabwe. Crop Protection, 19(8–10), 807–815. https://doi.org/10.1016/S0261-2194(00)00108-3

Zalucki, M. P., Shabbir, A., Silva, R., Adamson, D., Liu, S. S., & Furlong, M. J. (2012). Estimating The Economic Cost Of One Of The World's Major Insect Pests, Plutella Xylostella (Lepidoptera: Plutellidae): Just How Long Is A Piece Of String? Journal Of Economic Entomology, 105(4), 1115–1129. https://doi.org/10.1603/Ec12107

APPENDICES

Appendix 1: Analysis of variance of fresh yield harvest 1

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.12000	0.04000		
BLOCK. *Units* stratum					
TREATMENT	5	8.85333	1.77067		
Residual	15	0.00000	0.00000		
Total	23	8.97333			

Appendix 2: Analysis of variance of fresh yield harvest 2

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.19125	0.06375	1.69	
BLOCK. *Units* stratum					
TREATMENT	5	16.64208	3.32842	88.17	<.001
Residual	15	0.56625	0.03775		
Total	23	17.39958			

Appendix 3: Analysis of variance fresh yield harvest 3

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.3279	0.1093	0.71	
BLOCK. *Units* stratum					
TREATMENT	5	27.1171	5.4234	35.15	<.001
Residual	15	2.3146	0.1543		
Total	23	29.7596			

Appendix 4: Analysis of variance of fresh yield harvest 4

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.4113	0.1371	0.36	
BLOCK. *Units* stratum					

TREATMENT	5	43.3287	8.6657	22.58	<.001
Residual	15	5.7563	0.3838		
Total	23	49.4963			

Appendix 5: Analysis of variance of harvestable leaves at 4 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	6.4583	2.1528	8.52	
BLOCK. *Units* stratum					
TREATMENT	5	94.7083	18.9417	74.93	<.001
Residual	15	3.7917	0.2528		
Total	23	104.9583			

Appendix 6: Analysis of variance of harvestable leaves at 6 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	3.7917	1.2639	2.94	
BLOCK. *Units* stratum					
TREATMENT	5	153.7083	30.7417	71.40	<.001
Residual	15	6.4583	0.4306		
Total	23	163.9583			

Appendix 7: Analysis of variance of harvestable leaves at 8 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	2.792	0.931	0.55	
BLOCK. *Units* stratum					
TREATMENT	5	307.708	61.542	36.26	<.001
Residual	15	25.458	1.697		
Total	23	335.958			

Appendix 8: Analysis of variance of harvestable leaves at 10 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	2.833	0.944	0.27	
BLOCK. *Units* stratum					
TREATMENT	5	521.333	104.267	30.27	<.001
Residual	15	51.667	3.444		
Total	23	575.833			

Appendix 9: Analysis of variance of pest incidence at 2 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.00125	0.00042	0.02	
BLOCK. *Units* stratum					
TREATMENT	5	99.07708	19.81542	1020.54	<.001
Residual	15	0.29125	0.01942		
Total	23	99.36958			

Appendix 10: Analysis of variance of pest incidence at 3 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.37125	0.12375	1.81	
BLOCK. *Units* stratum					
TREATMENT	5	128.11208	25.62242	374.51	<.001
Residual	15	1.02625	0.06842		
Total	23	129.50958			

Appendix 11: Analysis of variance of pest incidence at 4 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.14125	0.04708	0.58	
BLOCK. *Units* stratum					
TREATMENT	5	165.31208	33.06242	407.76	<.001
Residual	15	1.21625	0.08108		

Total 23 166.66958

Appendix 12: Analysis of variance of pest incidence at 5 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.5150	0.1717	1.42	
BLOCK. *Units* stratum					
TREATMENT	5	227.6000	45.5200	377.24	<.001
Residual	15	1.8100	0.1207		
Total	23	229.9250			

Appendix 13: Analysis of variance of pest incidence at 6 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.20333	0.06778	0.72	
BLOCK. *Units* stratum					
TREATMENT	5	276.08000	55.21600	584.64	<.001
Residual	15	1.41667	0.09444		
Total	23	277.70000			

Appendix 14: Analysis of variance of pest incidence at 7 WAT

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
BLOCK stratum	3	0.1079	0.0360	0.23	
BLOCK. *Units* stratum					
TREATMENT	5	326.6021	65.3204	410.03	<.001
Residual	15	2.3896	0.1593		
Total	23	329.0996			