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Effectiveness of local biopesticides in the control of Diamondback Moth (*Plutella xylostella* L.) in cabbage production in Zanzibar, Tanzania

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Abstract: This experiment was conducted to determine the effectiveness of different types of local biopesticides to control diamondback moth (DBM) in cabbage production in Zanzibar. The experiment was conducted in horticulture farms at Zanzibar Agricultural Research Institute. The experiment was conducted in a randomized complete block design, with 6 treatments and a control, each of which was replicated 3 times. The following plants were used as biopesticide which are garlic (T1), hot pepper (chilli) (T2), clove (T3), mixture of garlic and pepper (T4), mixture of garlic and clove (T5), synthetic insecticide (T6) and a control (T0). The parameters were evaluated by conducting initial data collection (before treatment) and final data collection (after treatment). The average number of leaves affected by DBM and yield in terms of average mass (kg) of cabbage were recorded. Results showed that T6 was significantly associated with a lowest average number of affected leaves and higher yield followed by T4 and T5. Overall, garlic-treated plots had recorded higher yield compared to the non-garlic treated plots. Therefore, garlic extract as local biopesticide can effectively repel DBM. This study recommends that garlic can be used as an alternative to using synthetic chemicals to control DBM in cabbage crop.

Key words: cabbage, biopesticide, agriculture, diamondback moth, Zanzibar, Tanzania

Učinkovitost lokalnih biopesticidov za uravnavanje kapusne sovke (*Plutella xylostella* L.) pri gojenju zelja v Zanzibarju, Tanzanija

Izvleček: Poskus je bil izveden za določitev učinkovitosti različnih lokalnih biopesticidov za nadzor kapusne sovke pri gojenju zelja v Zanzibarju. Poskus je potekal na vrtnarskih kmetijah v Zanzibarju, na Zanzibar Agricultural Research Institute. Poskus je bil izpeljan kot popolni naključni bločni poskus s šestimi obravnavanji v treh ponovitvah in kontrolo. Obravnavanja so bila sledeča: česen (T1), čili (T2), klinčki (T3), mešanica česna in paprike (T4), mešanica česna in klinčkov (T5), sintetični insekticid (T6) in kontrola (T0). Obravnavanja so bila ovrednotena z zbiranjem podatkov pred in po obravnavanjih. Pridobljeni podatki so obsegali število po sovki napadenih listov in pridelek zelja, izražen kot poprečna masa zelja (kg). Rezultati so pokazali, da je imelo obravnavanje T6 značilno najmanjše število napadenih listov in večji pridelek, temu sta sledili obravnavanji T4 in T5. Nasplošno je bil pridelk na ploskvah, kjer so sovko zatirali s česnom večji, v primerjavi s ploskvami brez česna. Iz tega lahko sklepamo, da bi lahko bili izvlečki česna uporabljeni kot učinkovit lokalni biopesticid za zatiranje kapusne sovke. Izsledki raziskave kažejo, da bi lahko uporabili česen kot alternativo sintetičnim kemičnim pripravkom za uravnavanje zeljne sovke pri pridelavi zelja.

Ključne besede: zelje, biopesticidi, kmetijstvo, kapusna sovka, Zanzibar, Tanzanija

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1 INTRODUCTION

The agriculture sector contributed an average of 25 % of the total GDP and employing the majority of the country's worksforce in Zanzibar. On average, 70 % of the population depends directly or indirectly in the agriculture sector for their livelihood. However, diseases and pests such as insect infestation in agricultural production is among a key causes of quantitative damage of the crops which finally leads to degraded in quality and quantity of food (Stathas et al., 2023).

Cabbage, *Brassica oleracea* L. ssp. *oleracea* convar. *capitata* (L.) Alef. is a green leafy vegetable with very high nutritional value and it is infested by varieties of insects. This crop is cultivated mainly by small-scale farmers in Zanzibar. The Diamondback Moth, *Plutella xylostella* (L., 1758) is one of the greatest threats to cabbage production in many parts of the world (Hill & Foster, 2000). It is a major cabbage pest that can cause a 100 % loss in yield if not well controlled and managed. In recent years, crop production in various tropical and sub-tropical countries has been largely affected by developed resistance to a wide range of synthetic chemical to control infestations. The introduction of these chemical products into the natural environment resulted in the disruption of biological balance, and poses a great threat to human, animals and environmental health (Magierowiczet al., 2020). In addition, they are known to cause cancers and abnormalities, and they remain in the environment for many years (Scholtz et al., 2002).

On the other hand, biopesticides are naturally occuring compounds or agents that are obtained from animals, plants, or microorganisms such as bacteria, and are used to control wide range of agricultural pests and pathogens (Feniboet al., 2021). The use of biopesticides to protect crops against pests has a long history in insect pest management (Moshi & Matoju, 2017). Previous literature shows that the use of biopesticides is more advantageous than the use of their conventional chemical pesticides, as they are eco-friendly and poses little threat to food safety (Khursheed et al., 2022). These opportunities coupled with increasing costs of synthetic pesticides as well as increased consumer demand of organic products have created the impetus to search for potential biopesticides.

In spite of the large number of researches conducted on effectiveness of biopesticides (Rusdi & Rusaldy, 2023), hardly any evidence, especially in Zanzibar have been conducted and published. Zanzibar has always been renowned for producing exceptionally good spices and herbs such as cloves, cinnamon, cardamon and blackpepper (Mahenya et al., 2014). Most of these products are good sources of bioactive compounds which may provide inhibitory activity against pests. In the absence of effective management options to tackle pests, there would be extensive dependence on synthetic pesticides for their management on crop, with significant negative impacts human, animal and the environment (Akutseet al., 2020). Therefore, there was a need for a research to identify specific biopesticides in the control of pests such as diamondback moth in Zanzibar. The main objective of this study was to determine the effectiveness of local biopesticides in the control of diamondback moth in cabbage production. The information obtained from this research is expected to contribute in finding solutions for for a better cabbage production among small holder farmers, especially in reducing the level of pests attack.

2 MATERIALS AND METHODS

2.1 STUDY SITE

The research was conducted in Zanzibar, Tanzania. Zanzibar is a one of the two partner states that form the United Republic of Tanzania, comprised of two main islands – Unguja and Pemba. The experiment was conducted at the horticulture farms of Zanzibar Agricultural Research Institute (ZARI) which is located at Kizimbani area. The area is about 5 kilometers from Zanzibar Town. The institute is situated at latitude 60 south, longitude 390 east and 20 m above sea level. The area receives an average rainfall of 1564 mm/annum and annual average temperature of 25.7 ^{0}C. The experiment was conducted from June to September 2021.

2.2 CABBAGE PLANTING

The chinese cabbage seeds (Michihili type) were bought from local agro-dealers directly to the field of 1000 m^2. The land was ploughed followed by harrowing on 24th June, 2021. Field measured and laid out was conducted using measuring tape, rope, a hammer and pegs to mark the planting area. On 06th July; total 63 raised planting beds of 6 x 1.5 m (length x width) were made. Each bed was separated from one another by 50 cm apart. Seeds were sown directly to the prepared seed beds on 23rd July; at a spacing of 60 cm x 30 cm. Before sowing, soils were mixed and incorporated with about 45 kg of cow dung manure per bed, whereby each plant was estimated to take 0.75 kg of manure, this was done on 14th July, 2021. Transplanting and gap filled was done on after weeding which was done three days before.

2.3 TREATMENT APPLICATIONS

There were 6 treatments which are garlic (local cultivar) water extract (T1), hot pepper (Habanero type) water extract (T2), clove (local type) water extract (T3), mixture of garlic and pepper water extract (T4), mixture of garlic and clove water extract (T5), synthetic insecticide (T6) and a control (T0). These treatments were allocated randomly in an experimental area of 33m^2 each. The number of treatments were allocated in a Randomized Complete Blocked Design (RCBD) in three replications (Rusdi & Rusaldy, 2023). 1 litre of each botanical spice water extracts was applied in 3 beds of a respective treatment for all replications in the morning before 10 o'clock using a 7 litre sprayer. Garlic, chilli pepper and cloves were separately blended and grounded respectively then mixed with water and soap to make stock solutions as previously explained (Hardiansyah & Al Ridho, 2020). In summary, 1 kg of plant materials (pepper, cloves, garlic) were diluted in 5 litres of water. For mixed biopesticides (e. g garlic and cloves/ pepper), the ratio was 1:1. During application, 1 litre of stock solution was then diluted in 5 litres of water. Biopesticide application was done after 48 hours from the time bio-pesticides prepared and were applied once for both biopesticides and synthetic. Data collection was done before application of pesticides and after application on 20th August and 30th August respectively.

2.4 DATA COLLECTION

Presence of diamondback moth attack and yields were collected before and after treatments. The data collection continued untill at harvest stage (maturity). At harvest, marketable yield (mass in kg) data were recorded for each cabbage plant. The mass (kg) of cabbage was measured obtained from a randomly selected plants in each plots. The parameters for data collection were number of total leaves, number of affected leaves per plant and yield (mass) of harvested cabbage. The level of effectiveness of the studied biopesticide treatments was calculated using the formula as follows:-

$$EI = \frac{Ca - Ta}{Ca} \times 100\%$$

Description:

EI = Insecticidal (biopesticide) efficacy (%)

Ca = Number of infested cabbage leaves in the control (without treatment biopesticide)

Ta = Number of infested cabbage leaves in the biopesticide treatment.

2.5 DATA ANALYSIS

All statistical results were considered significant if $p < 0.05$. One-Way analysis of variance (ANOVA) was performed to determine the significant differences in number of affected leaves. All analyses were performed using STATA software version 16.

3 RESULTS AND DISCUSSION

3.1 DBM INFESTATION AND EFFECTIVENESS OF BIOPESTICIDE

The intensity of DMB attacks is presented in Table 1 and Figure 1 below. This study shows that T6 (synthetic insecticide) was significantly associated with the lowest average number of affected leaves among all set of treatments followed by T4 (mixture of garlic and pepper) and T5 (Mixture of garlic and clove). With reference to the control, T3 (clove only) was significantly associated with greater average number of affected leaves in cabbage plants. As T4 and T5 are local biopesticides associated with a lower attack intensity of DBM, the significant reduction of the DBM attack on cabbage after their application was indicative of the potency of garlic extract in controlling this pests. This significant finding highlights that garlic extract can be used to control DBM and other plant pests affecting cabbages such as red flour beetle, aphids, and whiteflies (Batool Syeda & Butt, 2021).

It can be seen that all treatments provided very low level of effectiveness in controlling DBM. In comparison between treatments, T4, T5 and T6 had relatively higher efficiency compared to the rest. Meanwhile, T2 and T3 exhibited negative efficiency in controlling DMB which may implies that they are not very effective. The results reported in this study are in line with the findings reported previously using garlic extract to control plant pests (Batool Syeda & Butt, 2021; Hardiansyah & Al Ridho, 2020). For-example, garlic was intercropped with cabbage and found to have a strong repellant property against DMB (Karavina et al., 2014). Treatment of garlic is known to be a potential mean than other chemical because it provide pungent smell which plant pests do not like (Batool Syeda & Butt, 2021). Garlic belongs to same family as onion and it is known to contain similar repellent properties to insects (Elmadawyet al., 2023). Also, garlic is known to contain sulphur compounds which deter insects from feeding on plants. The use of garlic to control pests was reported to be cheaper, safer and environmentally friendly. Futher research needs to examine how much and how long the level of effectiveness of

Table 1: Average number of affected leaves per plants before and after treatments and efficiency of biopesticides in cabbage

Types of treatments	Average number of leaves			Average number of affected leaves				Efficacy (%)
	Before	After	New leaves after treatment	Before	After	Net affected leaves	*P*-value	
T_0	10.03	14.87	4.83	2.67	4.13	1.47	Reff	Reff
T_1	10.47	15.20	4.73	2.47	3.70	1.23	0.382	15.9
T_2	9.87	15.00	5.13	2.00	3.77	1.77	0.154	-20.5
T_3	8.63	13.60	4.97	1.47	3.03	1.57	0.002	-6.8
T_4	9.70	14.57	4.87	1.77	2.87	1.10	0.003	25.0
T_5	9.10	14.37	5.27	1.30	2.60	1.30	< 0.001	11.4
T_6	9.47	14.93	5.47	1.73	2.57	0.83	0.001	43.2

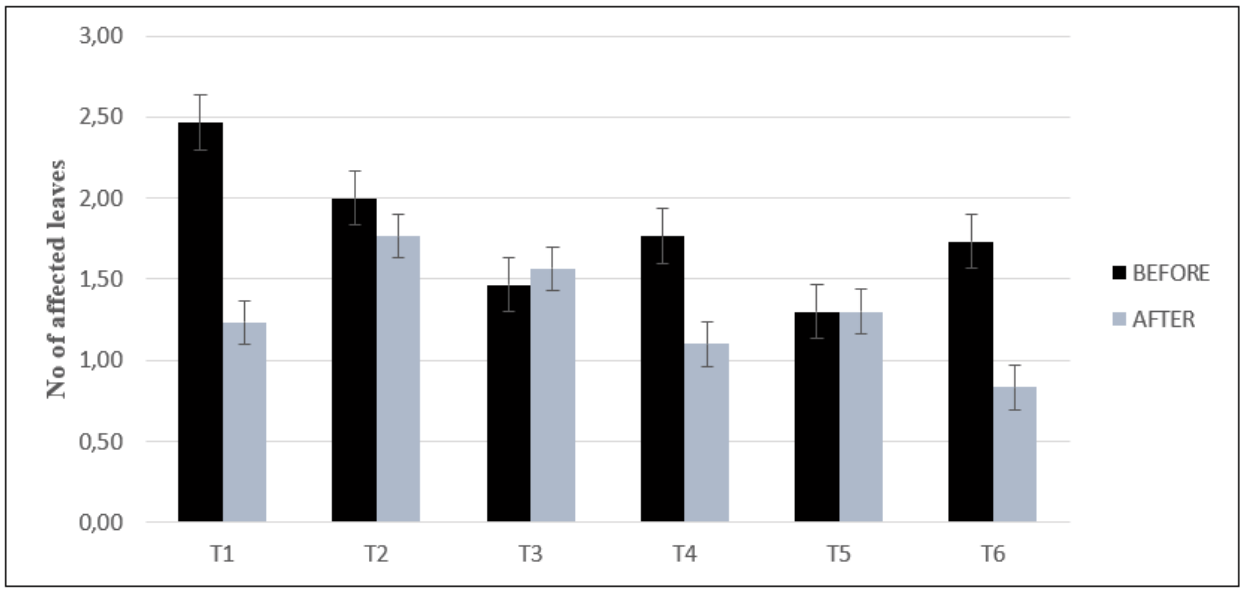

Figure 1: Average number of affected leaves per plant before and after treatment

garlic is related to the function of DBM and other pests during dry and rainy season.

3.2 YIELD OF CABBAGE

The findings concerning average mass (kg) of harvested cabbage is presented in Table 2. Result shows that the highest yield was found in T6 followed by T1 and T4. Even though the garlic extracts reduced DBM attacks, their yield performance was not comparable to the synthetic insecticide. This may be due to the fact that the active ingredient of garlic, allicin is known to degrade very fast compared to chemicals (Baidoo & Mochiah, 2016). This study showed that there was no statistically significant variations in yield among treatments ($p > 0.05$). As shown earlier, T1, T4 and T6 had significantly lower intesity of DBM attack, which may influence good growth and development of cabbages. However, data shows that the lowest yield were in T0 and T5. Further analysis revealed that there was significant difference in yield between T0 with T1 and T6, which may be attributed by the differences in the intensity of DBM infestation (Table 1). In comparison, Baidoo and Mochiah (2016) found that yield of plots sprayed with garlic were significantly higher compared to the control (Baidoo & Mochiah, 2016).

4 CONCLUSION

It can be concluded that using garlic extract as local biopesticide can effectively repel diamondback moth. Therefore, this study recommends that it can be used as an alternative to using synthetic chemicals to control

Table 2: Average mass of cabbage after harvest

Types of treatments	Mass (Kg)
T_0	0.46
T_1	0.63
T_2	0.54
T3	0.51
T4	0.58
T_5	0.47
T_6	0.64

diamondback moth in cabbage crop. Further studies are needed to confirm the effectiveness of biopesticides to control plant pests for other horticultural products in different planting seasons.

4.1 FUNDING

Funding for this study was obtained under Zanzibar Agricultural Research Institute (ZARI).

4.2 DATA AVAILABILITY

The data to support this findings are available from authors upon special request.

4.3 CONSENT FOR PUBLICATION

Not applicable.

4.4 COMPETING INTERESTS

The authors declare no conflict of interest.

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