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INSECTICIDAL POTENTIALS OF NEEM SEEDS AND *HYPTIS* LEAF FORMULATIONS FOR THE MANAGEMENT OF INSECT PESTS OF TOMATO AND CABBAGE

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Abstract

The quality and yield of tomatoes and cabbage in Nigeria are highly threatened by a complex of insect pests. Farmers spray broad-spectrum synthetic insecticides more often during the season, which poses health hazards and pollute the environment. The efficacy of plant-based pesticidal formulations of Neem seeds (*Azadirachta indica)* and African Bush Tea (*Hyptis suaveolens*) leaves against tomato and cabbage insect pests were evaluated during the 2023/2024 dry season at a field located behind the Department of Crop Protection (CPD), Ahmadu Bello University, Zaria. The plants materials were extracted using methanol and chloroform as the solvents. The extracts were used individually or in combination (Chloroform + Methanol) to formulate Emulsifiable Concentrate (EC) and Wettable Powder (WP). For each formulation, 0.5% and the checks (untreated and Lambdacyhalothrin + Dimethoate) were applied weekly and fortnightly on tomato and cabbage. Incidence, damage, and severity of insect pests were assessed weekly and yield determined at harvest. *H. armigera, M. persicae, B. tabaci, Empoasca dolichi* and *Podagrica spp*. were found to be the common insect pests. The insecticide check and the combined extract (Methanol + Chloroform) applied at 7 days intervals had the lowest insect infestation and fruit damage, with no difference in severity of damage compared to other plots sprayed fortnightly. Untreated had the highest insect incidence and percentage of fruit damage and severity. The WP had the lowest severity of fruit damage compared to the EC. The combined extract applied at 7 days intervals had the highest fruit weight and yield/ha. Insecticide check and methanol + chloroform formulation applied at 7 days had the lowest incidence and leaf damage and severity of damage on cabbage.

Keywords: Insect infestation, Tomato, Neem, Hyptis, Solvents, Management, Formulation

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INTRODUCTION

Tomato and cabbage are important vegetable crops widely grown and consumed worldwide due to their nutritional and socio-economic importance. Tomato (*Solanum lycopersicum*), a nutrient-rich vegetable with diverse culinary and nutritional application, widely cultivated and consumed globally, contributing to food security and economic development (Abraham, 2023). It ranked the 4th most produced and consumed vegetable with 186 million tons in 2022, followed by onions (111 million tons, including shallots), cucumbers (95 million tons), cabbages (73 million tons) and eggplants (59 million tons) (FAO, 2022). Nigeria ranked 10th in the world and 2nd in Africa producing 1.57 million Tons (FAOSTA, 2021). Tomato cultivation forms a significant component of Nigeria's agricultural sector, with the crop being grown across various regions of the country but major production is carried out in twelve states of Northern Nigeria (NAERLS/FARD, 2021), because the climate is well-suited for its cultivation in these areas.

In Nigeria, tomatoes are staple ingredients, featuring prominently in numerous traditional dishes whether consumed raw, cooked, or processed, and are preferred over other vegetables due to their versatility and widespread use (Adugna, 2009). Nutritionally, the fruit is a good source of vitamins, minerals and fibre to its consumers in addition to energy supply (Shahidi and Alasl, 2022). According to Hobson and Grieson (1993) tomatoes are an excellent source of vitamins A and C, iron, phosphorus, and dietary fiber with potent antioxidants, including lycopene and beta-carotene, that may help shield cells from cancerous changes. It is a rich source of vitamin A and C, minerals like iron, phosphorus and rich in dietary fibers, antioxidant like lycopene and beta-carotene content, the compounds that protect cells from cancer (Hobson and Grieson, 1993).

Cabbage (*Brassica oleracea*) is a leafy green vegetable that belongs to the Brassicaceae family (Al-Shehbaz *et al*., 2006). In Nigeria, cabbage is an important vegetable crop with a high growing demand due to its nutritional and economic value. According to (NBS, 2021), Nigeria produced about 94,555 MT in 2017 with production *increased* to 124,115 metric tons in 2020 (FAO, 2022). Cabbage is a cool weather crop that thrives in temperate and subtropical climates, adapted and well-suited for cultivation in many parts of Nigeria. The crop is mainly grown in the northern and central regions of the country, with major producing states being Plateau, Kaduna and Nasarawa (Ojo, 2019). It is also grown in other northern states of Nigeria under irrigation. Cabbage is known for its versatility, as it can be consumed raw in salads, cooked in various dishes, or even fermented into sauerkraut. The nutritional profile of cabbage is also quite impressive, as it is notable for its high content of vitamins, minerals (USDA, 2022), and antioxidants (Kumar *et al.,* 2019), particularly high in vitamin C, vitamin K, and fiber (USDA, 2022) making it a valuable addition

to a balanced diet. Beyond its direct contribution to food and income, cabbage production also has broader implications for the Nigerian agricultural sector. The cultivation of tomatoes and cabbage also has a ripple effect on the economy by stimulating growth in related sectors like food processing, logistics, and supply chain management. This, in turn, generates additional economic opportunities for farmers, traders, and local residents (Ajenifujah-Solebo *et al*., 2025). The sale of cabbage and tomato provides a steady source of income for many rural households, helping to alleviate poverty and support local economies. Thus, tomato and cabbage production in Nigeria has a significant socio-economic impact, contributing to both the livelihoods of smallholder farmers and the broader agricultural sector.

Despite being economic and nutritionally security crops, cabbage and tomato production in Nigeria faces a range of challenges that impact their yields and consequently affect socioeconomic benefit along all the value chain of their production. One of the primary concerns is the prevalence of pests and diseases. Both cabbage and tomato are severely attacked and damaged by insect pests in the field, notably *Helicoverpa armigera*, *Tuta absoluta*, *Myzus persicae, Bemisia tabaci* and *Trichoplusia ni* Ahmad and Kumar (2022); Laishram *et al*. (2014). The insects feed on the crop and affect both the quality and quantity of the harvested product which can result to significant yield and nutritional losses. Recently Oluwafemi *et al*. (2022) reported a significant damage and economic loss to tomato farmers across Nigeria by *T. absoluta*. A yield loss of between 20-80% was reported due to diamondback moth infestation, 50% due to cabbage looper and 20% by Flea beetles on cabbage (Ajayi and Afolabi, 2012; Obembe and Ojo, 2011; Oigiangbe *et al*., 2017). Attack by these insect pests can cause a significant challenge in meeting the domestic demand for the crops, with frequent shortages and fluctuations in supply.

To effectively mitigate losses due to the complex insect pests on tomato and cabbage, farmers rely on heavy application of synthetic insecticides, such as Cypermethrin, Dimethoate, Chlorpyrifos, Carbaryl, Malathion (Ajayi and Afolabi, 2012; Laishram *et al*., 2014; Oigiangbe *et al*., 2017). However, fear of residues of these insecticides in the harvested produce, human and environmental exposure to indiscriminate use of insecticides, development of resistance by the insects in addition to the cost associated with procurement of insecticide are of major concerns. There is therefore, a need for exploring an alternative effective, economical and environmentally friendly approach to the management of insect pests of cabbage and tomatoes in Nigeria. Malik *et al*. (2015) proved the effectiveness of some botanicals in management of whitefly (*Bemasia tabaci*) on tomato. Various botanicals including *Eugenia aromatica* (Baill.), *Cymbopogon citratus* (lemon grass), *Citrus sinensis* (orange peel) and *Azadirachta indica* (neem) proved effective in management of important field pests of crops (Ofuya, and Akinneye, 2010; Ojebode *et al.,* 2016; Isman, 2006). In particular, Neem extracts have shown to be effective on some insect pests related to cabbage and tomato (Ajayi and Afolabi, 2012; Kumar and Mishra, 2018). Extract from *Hyptis suaveveolens* was found to have ovicidal and larvicidal effects against insect pest (Ivoke *et al*., 2009). Giving that cabbage and tomato are host plants of insect pests, the spectrum of activity and efficacy of botanicals particularly *H. suaveveolens* and its combination with other botanicals are limited. Thus, a better formulation along with

combination (blending) of different botanicals pesticide may provide a good spectrum of activity and efficacy against the insect pest of cabbage and tomato. For instance, enhanced efficacy was observed against *Spodoptera litura* when Neem oil and pyrethrin were combined (Senthil and Kalaivani, 2019). Similarly, combination of rotenone and sabadilla (Zhang *et al*., 2019), Garlic and Citronella (Singh and Singh, 2019), provide enhanced efficacy in management of insect pests and fungal infection. Therefore, a combination of Methanol and Chloroform extracts of Neem and Hyptis plants were used to formulate Emulsifiable Concentrate (EC) and Wettable Powder (WP) and each formulation at 0.5% were applied on tomato and cabbage to determine their efficacy in the management of insect pests and damage on the crops.

MATERIALS AND METHODS

Experimental Site

The field trial was carried out in the 2023/2024 dry season at an experimental field site located behind the Department of Crop Protection (CPD), ABU, Zaria (11°9'51.456N, 7°37'56.984E).

Collection and Preparation of Neem seeds and Hyptis leaves

Dried Neem seeds were collected from within A.B.U premises; fresh matured fruits that fell from the tree were collected, depulped, and the clean seeds shade dried until complete dryness. Fresh leaves of *Hyptis suaveolens* were collected from an uncultivated land at Dan-Magaji community in Zaria, Kaduna state and shade dried to complete dryness. The dried seeds and leaves were ground into powder form separately using industrial blender/hammer mill (Hammer Mill 7.5hp) and stored in the laboratory prior to their usage.

Extraction of Neem and Hyptis extracts

The extraction of Hyptis leaves and neem seeds was carried out using the cold maceration method with methanol, as outlined by Bulus *et al*. (2024). Each pulverized sample (7 kg) was immersed in 10 L of methanol and allowed to steep at room temperature for 72 hours. The mixture was then filtered, and the resulting filtrate was concentrated under reduced pressure at 40°C using a rotary evaporator, followed by air drying. This extraction process was repeated with fresh methanol until the filtrate ran clear, indicating complete extraction. Solvent-solvent partitioning was performed by adding 500 ml of hexane to the crude extract of the Hyptis leaves and neem seeds, suspended in 2 L distilled water. After shaking and phase separation, the hexane layer was collected. This process was repeated until no further solutes were extracted into the hexane layer. The combined hexane fractions were then evaporated under reduced pressure at 40°C. This procedure was repeated with chloroform and ethyl acetate. Finally, the remaining aqueous layer was dried using a water bath and then air-dried to yield a solid residue. The percentage yield was calculated according to PAC (1996), as follows;

$$\text{Total yield of fraction} = \frac{\text{Total mass of fraction} \times 100}{\text{Total mass of sample}}$$

Preparation of Neem and Hyptis formulations:

The Emulsifiable concentrate (EC) formulation containing neem and hyptis extracts was prepared by mixing. Three concentrations (25 mg, 50 mg and 75 mg) were prepared by dissolving the respective weights in 25 ml of dimethyl sulfoxide

(DMSO) using a magnetic stirrer. Twenty-five milliliters of Tween 80 was then added and stirred. Soyabean oil (450 ml) was then added and mixed to homogeneity. The formulation was transferred to glass bottles and stored at room temperature (28±2ºC) away from direct sunlight.

The wettable powder (WP) formulation containing neem and hyptis extracts was prepared using gypsum as the base. Three concentrations (25 mg, 50 mg and 75 mg) were prepared by dissolving the respective weights in 25 ml of dimethyl sulfoxide (DMSO) using a magnetic stirrer. Twenty-five milliliters of Tween 80 was then added and stirred. Water (450 ml) was then added and mixed to homogeneity. The mixture was then poured on to 1 kg of gypsum powder and mixed. The mixture was spread out on foil paper and allowed to dry at room temperature. The formulation was ground to powder and stored at room temperature (28±2ºC) in covered plastic containers.

Raising of seedling & transplanting

The seedlings were raised in a nursery at the Department of Crop Protection, using Roma VF tomato and Nuzaka F1 cabbage obtained from agro-dealer at Samaru, Kaduna state. At 4 weeks after sowing in the nursery, both the tomato and cabbage seedlings were transplanted to the already prepared fields which were laid out into plots of 3 m x 1 m. The seedlings were transplanted at one seedling per hill into two rows, at 50 cm x 50 cm inter and intra row spacings respectively with an alleyway of 0.5m between plots.

Application of treatments

For tomato there were 14 treatments consisted of 3 Neem and Hyptis extracts of Methanol, Chloroform and combination (chloroform + methanol) at ratio 50:50, 2 formulations of Emulsifiable Concentrate (EC) and Wettable Powder (WP) and 2 frequencies of application at weekly and fortnightly interval. There were 8 treatments for cabbage consisted of 3 Neem and Hyptis extracts of Methanol, Chloroform & combination (chloroform + methanol) EC formulation at ratio 50:50, 2 frequencies of application at weekly and fortnightly interval. Synthetic insecticide (Lambdacyhalothrin (5%) + Dimethoate (20%)) and untreated control were used as checks for both the cabbage and tomato. The treatments were replicated 3 times in a Randomized complete block design (RCBD) arrangement. All the treatments were applied at 0.5% for each formulation except for the insecticide where it was applied according to the manufacturer's recommended rate of 1L per hectare. The treatments were applied according to a predetermined schedule, commenced 5 weeks after transplanting (WAT) and subsequently at weekly and fortnightly interval for 5 and 6 weeks respectively.

Agronomic Practices and Irrigation

Throughout the duration of the experiment, all recommended agronomic practices for cabbage and tomato production were observed. Irrigation was administered as needed to ensure adequate soil moisture levels for optimal plant growth and development. Irrigation schedules were adjusted based on regular monitoring of soil moisture levels, with irrigation applied promptly when soil moisture was low. NPK (15:15:15) and Urea fertilizers were applied at 300kg/ha and 200kg/ha respectively, split applied at 2 and 6 weeks after transplanting. Weeds were managed manually at 2 weeks after transplanting and subsequently whenever necessary.

Data collection

Insect pest Incidence: Five (5) consecutive plants (cabbage or tomato) in

each plot were observed for incidence of insect pest attack and related damage, 24hrs before and after the treatments at weekly interval for 6 weeks.

Percentage Damage Severity: Damage severity was scored based on scale of 1-5 were 1 is healthy leaves or fruit and 5 is completely damage leaves or fruits.

Fruit Weight/Yield: At harvest, fruits or cabbage produced per plot were weighed and converted to yield per hectare.

Data Analysis

Data obtained were Analysed using ANOVA and mean difference were separated using Student-Newman-Keuls (SNK) Test at 5% level of significant.

Acute toxicity test

This test was carried out at the Department of Veterinary Pharmacology and Toxicology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria, where the median lethal dose (LD_{50}) of the two extracts was determined in mice using a standard two-phase approach as described by Lorke (1983). The first phase involved three groups of three mice each receiving 10, 100, or 1000 mg/kg body weight of the extract. The animals were monitored for 48 hours for signs of toxicity and mortality. In the second phase, which depends on the results obtained from the first phase, three mice were divided into three groups (4, 5 and 6) of one animal each. Animals in groups 4, 5 and 6 were administered the extracts at doses of 1600, 2900 and 5000 mg/kg body weight respectively. They were then monitored for signs of toxicity and death over a period of 48 hours. Thereafter, all the animals were observed once daily for two weeks for delayed toxicity. The LD50 was determined based on dose response as described by Lorke (1983).

RESULTS

Helicoverpa armigera, *Myzus persicae*, *Bemisia tabaci* and *Podagrica spp* were the common insect pests found on tomato (Table 1). The number of *H. armigera*, *M. persicae* and *Podagrica spp* in the Methanol + Chloroform combined extract formulation and synthetic insecticide check were at par which were significantly ($P<0.05$) lower than for all the other treatments. The single Methanol or Chloroform extract of the botanicals had significantly the least number of *B. tabaci* than the combined Methanol + Chloroform extracts and all were significantly ($P<0.05$) higher than in the synthetic insecticide. The percentage fruit damage for the Methanol + Chloroform combined extract formulation and insecticide check were at par but significantly ($P<0.05$) lower than all the other treatments. The percentage of fruit damage in the untreated control was significantly ($P<0.05$) higher than all the treatments. The untreated had significantly ($P<0.05$) higher percentage damage severity than all the botanical treatments. The percentage damage severity in all the extracts were at par with the synthetic insecticide. The formulations applied at 7 days had the lowest infestation by *B. tabaci* compared to other plots sprayed fortnightly. Formulations applied at 7 days had significantly the lowest fruit damage compared to fortnightly application with no difference in severity of damage. The number of *H. amigera* in the EC formulation was significantly higher than in the WP. The WP had the lowest fruit severity damage than the EC.

Table 1: Effect of Neem seed and Hyptis leaf extract formulations on insect pests and tomatoes fruit damage

Treatment	Insect count				Fruit damage (%)	
Formulation (A)	*H. amigera*	*M. Persicae*	*B. tabaci*	*Podagrica spp*	Fruit damage	Damage severity
Untreated	1.91a	1.8a	1.6a	1.8a	7.0a	2.8a
Methanol	1.1b	1.6a	1.04b	1.0b	2.8b	1.4b
Chloroform	1.2b	1.04b	1.2bc	0.0c	3.0b	1.0b
Methanol + chloroform	0.0d	0.0c	1.5a	0.0c	1.8cb	1.1b
Insecticide	0.0d	0.0c	0.0d	0.0c	1.0c	0.1b
SE±	0.08	0.10	0.10	0.10	0.67	0.21
Spray Frequency (B)						
7 days	1.05	1.2	1.2b	1.0	1.4b	1.1
14 days	1.17	1.04	1.7a	1.02	3.7a	1.3
SE±	0.07NS	0.10NS	0.10	0.10NS	0.67	0.21NS
Formulation (C)						
EC	1.19a	1.1	1.2	1.09	4.9a	1.4a
WP	1.01b	1.1	1.1	1.01	2.4b	1.0b
SE±	0.07	0.10NS	0.10NS	0.10NS	0.67	0.21
Interaction						
A*B	NS	NS	NS	NS	NS	NS
A*C	NS	NS	NS	NS	NS	NS
B*C	NS	NS	NS	NS	NS	NS
A*B*C	NS	NS	NS	NS	NS	NS

Mean values followed by the same later in a column are not significantly different according to the Student-Newman-Keuls (SNK) test at 5% level of significant.

Table 2 shows that the Methanol + Chloroform combined extract formulation had significantly ($P<0.05$) higher number of tomato fruits and Tomato fruit Weight than all the treatments except for tomato yield where it was at par with synthetic insecticide. Untreated control had significantly the lowest number of fruits, fruit weight and yield. The WP had the highest number of fruits, however, no significant difference in terms of fruits weight and yield among the WP and EC.

Table 2: Effect of Neem seed and Hyptis leaf extract formulations on Tomato fruit yield

Treatment	**Fruit yield**		
Extract (A)	Number of fruit /plots	Fruit Weight /plot (kg)	Fruit yield Kg /ha
Untreated	49.0c	2.5c	7143c
Methanol	70.0b	4.0b	11429b
Chloroform	76.0b	4.5b	12657b
Methanol + chloroform	97.0a	5.3a	15143a
Insecticide	73.0b	4.6b	13143a
SE±	6.70	0.32	920.9
Spray Frequency (B)			
7 days	75.0	4.0	11429
14 days	63.0	4.0	11429
SE±	6.7NS	0.32NS	920.9NS
Formulation (C)			
EC	57.0b	4.0	11429
WP	74.0a	3.7	10571
SE±	6.70	0.32NS	920.9NS
Interaction			
A*B	NS	NS	NS
A*C	NS	NS	NS
B*C	NS	NS	NS
A*B*C	NS	NS	NS

Mean values followed by the same later in a column are not significantly different according to the Student-Newman-Keuls (SNK) test at 5% level of significant.

Table 3 shows that *H. armigera*, *M. persicae* and *B. tabaci* were the common insect pest on cabbage. Untreated control had significantly higher number of all the insects observed, leaf damage and damage severity. *H. amigera* was observed only on untreated control while *B. tabaci* and *M. Persicae* were present only on chloroform among the treated plots. The Methanol + chloroform extract of the botanicals and insecticide had the least

percentage of leaf damage and severity which were higher in all the other treatments. Weekly sprays had lower *B. tabaci* infestation, leaf damage and damage severity than fortnightly spray.

Table 3: Effect of Neem seed and Hyptis leaf extract formulations on insect pest and yield on Cabbage

Treatment	Insect count			Leaf damage (%)		Yield/plot
Extract (A)	*H. amigera*	*B. tabaci*	*M. Persicae*	Damage	Damage severity	Weight (kg)
Untreated	1.8a	2.6a	2.2a	35a	5.2a	0.40b
Methanol	0.0b	0.0c	0.0c	25b	3.8cd	0.51a
chloroform	0.0b	1.08b	1.2b	30b	4.0c	0.20c
Methanol + chloroform	0.0b	0.0c	0.0c	18c	4.0c	0.50a
Insecticide	0.0b	0.0c	0.0c	15c	3.9c	0.40b
SE±	0.20	0.10	0.31	2.41	0.18	0.057
Spray Frequency (B)						
7 days	1.2	1.08b	1.2	23.7b	4.0b	0.40a
14 days	1.2	1.3a	1.04	30.3a	4.6a	0.28b
SE±	0.20NS	0.10	0.31NS	2.41	0.18	0.057
Interaction						
A*B	NS	*	NS	NS	NS	*

Mean values followed by the same later in a column are not significantly different according to the Student-Newman-Keuls (SNK) test at 5% level of significant.

Table 3 indicates that the Methanol + chloroform combined formulation and methanol alone had the highest cabbage weight per plot which were significantly higher than all the other treatments. The cabbage weight per plot of synthetic insecticide and untreated was at par and were significantly higher than the Chloroform botanical extract. The botanical extract formulation applied at 7 days had significantly higher cabbage weight /plot than the fortnightly application.

The result of the acute toxicity test shows that all the animals administered with the two extracts (Neem and Hyptis extracts) at doses 10, 100, 1000, 1600, 2900 and 5000mg/kg body weight survived with no case of mortality. Based on the method of Lorke 1983, the LD_{50} of the two extracts was greater than 5000mg/kg, and is considered relatively safe since there was no mortality at that dosage. However, the clinical signs observed for the neem extract were: Cuddling together, partial paralysis of the hind limbs 5 minutes post administration. Similarly, for the Hyptis extract the clinical signs observed were: increase in respiration, cuddling together and weakness of the body.

DISCUSSION

The findings from this study demonstrate the efficacy of combining neem and Hyptis plant extract formulations as a sustainable and effective approach for managing insect pests on tomato and cabbage crops. *H. armigera, M. persicae, B. tabaci* and flea beetles were found to be the common insect pests. The results showed that the combined methanol and chloroform extract formulation exhibited similar efficacy to the standard insecticide, indicating its potential as natural alternative for pest control on tomato and cabbage. However, interestingly, methanol solvent extract outperformed the combined extract in *B. tabaci* count. This suggest that the synergistic effect may not always be beneficial and that individual solvent can be more effective under certain circumstances. This finding is supported by the work of Ogendo *et al*. (2007), who found that individual extract of *Melia azedarach* and *Azadirachta indica* were more effective against *Plutella xylostella* than their combined extract. On the other hand, the work of Kumar *et al*. (2011); Mineva *et al*. (2022) and Zhang *et al*. (2019) supported that combined plant extract are more effective than the individual plant extract. This finding highlights the importance of optimizing extraction and extraction method for specific insect and plant materials.

This study revealed that application of the Neem and Hyptis combined extract at 7-day intervals was more effective in managing *B. tabaci* infestation and fruit or leaf damage on cabbage and tomato compared to fortnightly application. In contrast, the efficacy of 7-day and fortnightly applications against *H. armigera* and *M. persicae* was comparable, with neither showing a notable advantage over the other. By implication this study may suggest that the shorter application interval may be necessary against some insects. This inconsistency may be attributed to variations in insect behavior, lifecycles or susceptibility to the botanical extracts. Similar findings have been reported in previous studies where frequency of application significantly impacted the efficacy of botanical pesticides. For instance, a study on the use of neem oil against aphids reported that weekly application was more effective than fortnightly application Kumar *et al*. (2019). Moreover, Oyedele *et al*. (2020), observed that daily application of *Hyptis suaveolens* was more effective than weekly application. These findings highlight the importance of optimizing application frequencies for specific insect and botanical type.

It is important to note that the 2 formulations (EC and WP) were only tested on tomato. This study shows that WP had more effect on *H. armigera* than *M. persicae, B. tabaci* and flea beetles. This suggests that the WP formulation may have specific insecticidal properties that are more effective against *H. armigera*. Similarly, the WP having less damage fruits compared to EC could be attributed to its adherence to the plant surface and prolong activity Jiang *et al*. (2017). Although the two formulations (EC and WP) differed in their impact on fruit damage, they produced comparable yields, suggesting that the EC formulation may have exerted control over other yield-impacting insects, thereby resulting in similar yields to the WP formulation. This study suggests that formulation selection should be based on specific insect pest species and crop requirement, an area that need to be explored more for optimizing the efficacy of this Neem-Hyptis based formulation. Overall, the combined formulation applied at 7 day had highest fruit weight and yield/ha.

The finding of this study has shown the significance of the Neem and Hyptis, especially when combined as environmentally friendly alternative to synthetic insecticide.

Leveraging on the result of acute toxicity conducted on the mammalian toxicity of this product, which was proven to be safe on mice and based on safety report of Neem and Hyptis by Kumar *et al*. (2014); NRC (1992); Oyedele (2018), it can be concluded that the botanicals used are safe for the consumers. However, more work could be done on the safety to other non-target organisms. The reduction in pest damage and better yield can contribute to famers income and improve their general livelihoods. This study informed a strategy that could be incorporated into an integrated pest management for better management of insect pest of cabbage and tomato.

CONCLUSION

In conclusion, *H. armigera, M. persicae, B. tabaci,* flea beetles and *H. amigera*, *B. tabaci, M. Persicae* were the common insect pests found in tomato and cabbage respectively in this study. The combined extract (Methanol + Chloroform) of the two plants applied at 7 days had the potential in management of insect infestation and improved tomato and cabbage yield. The WP of the combined extract (Methanol + Chloroform) proved very effective in management of insect infestation and improved tomato and cabbage yield. Thus, highlight the potential of the combined formulation as a valuable tool for minimizing tomato and cabbage losses while promoting environmental and human safety in production of these crops. Further research is needed to optimize the Neem-Hyptis formulation, exploring different concentrations and spray frequency methods according to the insect type. The experiment should be repeated to confirm the efficacy under a bigger field experiment across different locations. Furthermore, investigating the biochemical or molecular mechanism behind the insecticidal activity could provide insights for improving their efficacy.

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