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RESEARCH ARTICLE

EFFECTS OF CULTURAL PACKAGES AND CHEMICAL PESTICIDE AGAINST INFESTATION OF CABBAGE BY DIAMONDBACK MOTH (*PLUTELLAXYLOSTELLA* L.)

[1,*]Genesis Acaye, [2]Julius, C. W. Odongo and [3]David Ocan

[1] Department of Biology, Faculty of Science, Gulu University, P.O.Box 166, Gulu Uganda
[2,3] Department of Agronomy, Faculty of Agriculture and Environment, Gulu University, P.O.Box 166, Gulu Uganda

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ABSTRACT

Different cultural packages were assessed to determine their effectiveness in controlling diamondback moth (DBM) infestation on Copenhagen market cabbage variety. 'Neem leaf extract+tomatointercrop+manure+mulch'; 'Tomato intercrop+manure+mulch'; and 'Neem leafextract+manure+mulch' treatments were compared with commercial pesticide i.e. dimethoate and unsprayed treatments (control). Field experiments laid in Randomized Complete Block Design (RCBD) with three replications were carried out from August to December 2013 and July to December 2014 at Koro and Bungatira Sub-counties, respectively, in Gulu district. There were significantly ($P < 0.05$) lower number of larvae infestation in plots treated with Dimethoate; and 'Neem leaf extract+tomatointercrop+manure+mulch' as compared to other treatments. Generally, 'Neem leaf extract+tomatointercrop+manure+mulch' treatment performed close to commercial dimethoate pesticide in the control of DBM. By adopting this package, farmers will reduce pesticide sprays targeting DBM pests and gain from higher yield and chemical free products, also extra money from the tomato intercrop.

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INTRODUCTION

Cabbage (*Brassica oleracea*var*capitata*) is an important source of vitamins and minerals in maize-based diet and is grown as a cash crop by smallholder farmers in eastern and southern Africa (Munthali *et al*., 2004). Diamondback moth (DBM) *P. xylostella* (L.) (Lepidoptera: Plutellidae), is considered the most destructive pest worldwide wherever cabbage is grown and can cause as much as 100 % yield losses by lowering marketability due to destruction of leaves (Telekar and Shelton, 1993). To minimize output losses, over 98 % of vegetable farmers in Africa rely heavily on synthetic pesticides which result in high costs of production (Obopile *et al*., 2008). The use of chemical insecticides as the primary means of control for the DBM has given rise to a problem of resistance build-up in DBM populations due to their ability to quickly develop resistance to any pesticides extensively used against them (Gelernter and Lomer, 2000). This has been a blow to the farmers and their dependency on commercial insecticides and without alternatives, farmers tend to overuse chemicals shown by high quantity and spray frequency (Varela *et al*., 2003).

Corresponding author: Genesis Acaye,
Department of Biology, Faculty of Science, Gulu University, P.O.Box 166, Gulu Uganda.

There has been effort undertaken to develop and transfer innovative techniques of minimizing pesticide usage and promotion of alternative management options, this has as well been through consumers' demands and the need to comply with standards related to fresh produce export (Karungi *et al*., 2000). To reduce insecticide pollution, there is therefore, an urgent need to identify effective and affordable alternative methods that are environmentally friendly in the control of DBM (Anna *et al*., 2007). The study being reported was done to find out the effectiveness of combinations of cultural practices such as intercropping with tomato, manure application, mulching and neem leaf extract in the control of DBM infestation of cabbage production.

MATERIALS AND METHODS

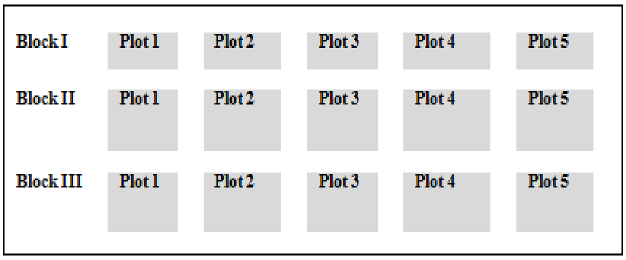
Experiments

A field experiment was conducted from August to December 2013 in Koro Sub-county located south of Gulu municipality and another similar field experiment was conducted from July to December 2014 at Bungatira Sub-county located north of Gulu municipality, Gulu district. A randomized complete block design consisting of five treatments with three replications was used.

Source: Field photo by Acaye Genesis. Date: 26/8/2014, Bungatira Sub-county, Gulu District

Figure 1. Larva of the diamondback moth, *Plutellaxylostella*

The five treatments consisted of 'Neem leaf extract+manure+mulch' (Nle+Mn+Ml); 'Tomato intercrop+Manure+Mulch' (Ti+Mn+Ml); 'Neem leaf extract+Tomatointercrop+Manure+Mulch' (Nle+Ti+Mn+Ml); Dimethoate (Dm); and Unsprayed (Usp) plots which constituted the control. The field was marked out using sisal rope, (tape measure andpegs) and was prepared using hand hoe. Each experimental plot measured 6 m x 4.2 m in size with cabbage plants spaced at 60 cm x 45 cm and tomato spaced at 60 cm x 60 cm (Jared, 2011). A distance of two (2) meters was left between the blocks and one (1) meter between the plots in order to avoid interaction effect between the different treatments.



Note:Block were spaced 2 m apart, while plots within a given block was spaced 1 m apart. The spaces constituted the walk ways

Figure 2. Field experimental layout

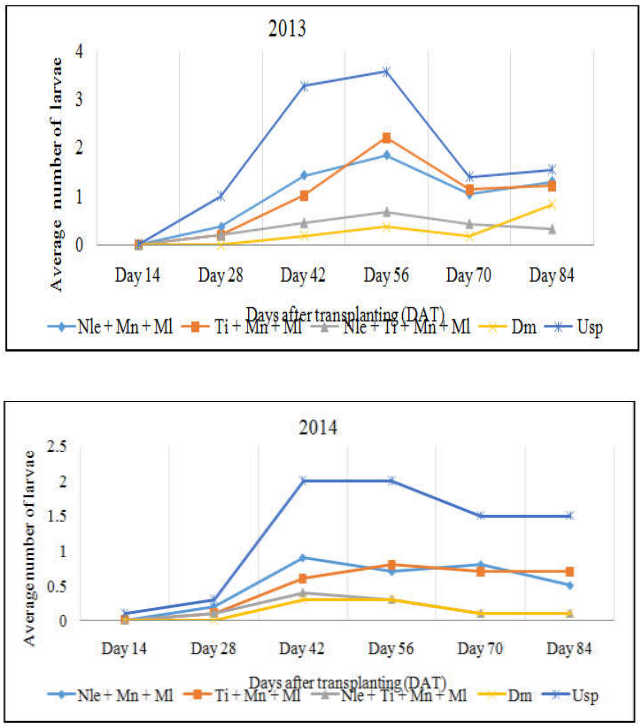
Cabbage Copenhagen market variety and Tomato variety Heinz Holland were secured from the market and sown in separate plots measuring 1 m x 1 m and sprayed with neem leaf extract, dimethoate and unsprayed (Shazia *et al*., 2006). Composted cattle manure was manually broadcasted at a rate of 2 kg/m^2 one month before transplanting (Beyene, 2007). Tomato seedlings were transplanted fifteen (15) days in the main field before cabbage seedlings were transplanted at the age of four (4) weeks after sowing in the nursery bed (Beyene, 2007). Mulching with dry grass was done one week after transplanting cabbage and maintained to a thickness of 7.5 cm until maturity (Masarirambi *et al*., 2013). Weeding was done every one (1) month until the crops were harvested. The spaces left between the plots were maintained clean by slashing and digging for easy management of the plots. One (1) kg of fresh neem leaves was soaked in water overnight and pounded gently in a mortar and five (5) liters of water were added to the pounded leaves in a bucket and strained to get a clear extract. One hundred (100) millimetres of liquid soap were added to the extract and stirred well before spraying. The liquid soap was added to aid the extract in sticking to the leaves of cabbage (Laxmitkant *et al.,* 2013). Dimethoate pesticide was acquired from local market and mixed at recommended rate of 50 ml in 20 litres of water (Karungi *et al*., 2000). Spraying was done every fourteen (14) days using plastic hand sprayer in the evening to avoid interference with the work of neem leaf extract as a result of evaporation due to sun heat. New extract was prepared for each spray interval in order to maintain its efficacy. In all cases, the upper and lower parts of the leaves were sprayed sufficiently until they were wet (Oke *et al*., 2010). Sixteen (16) cabbage plants inside the guard rows were sampled and tagged from each experimental plot for data recording every fourteen days (14) for each of the treatment (Shazia *et al*., 2006). The number of larvae were determined by direct counting with the help of identification guide according to Rogers (2005).

Data Analysis

Data were entered in spreadsheet and XLSTAT (Version 2014.5.01) was used to generate analyses of variances (ANOVA) and Dunnett (two sided) tables to aid in analysing data at the Least Significant Difference (LSD) of 5%.

RESULTS

At 14 days after transplanting (DAT), there was no infestation observed hence no significant differences among the treatments.

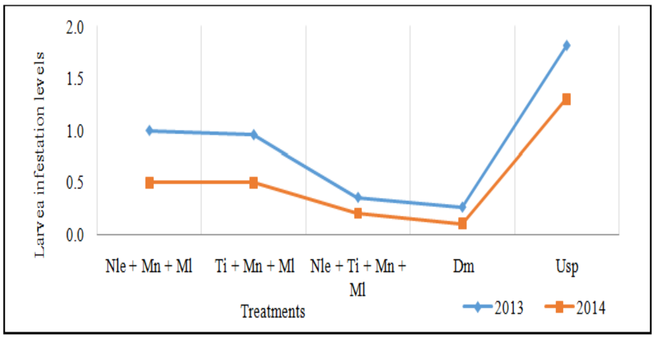


Key: Dm=dimethoate; Usp=unsprayed; Mn=manure; Ml=mulch; Nle=neem leaf extract; Ti=tomato intercrop (NOTE: Days after transplanting in the Fig (graph) should be adjusted from the legand for clear visibility)

Figure 3. Variation in the infestation levels against number of days after transplanting

In comparison to 14 DAT, this finding agreed with the finding that new generation of this insect under favourable conditions emerges every two to four weeks (Talekar and Shelton, 1993). At 28 DAT, there were significant differences (P<0.05) between all the sets of treatments except between 'Ti + Mn + Ml'vs 'Nle + Ti + Mn + Ml' in 2013 meanwhile only Dmvs Usp treatments showed significant difference (P<0.05) in 2014. At 42 DAT, there were significant differences (P<0.05) between eight sets of treatments in year 2013 meanwhile only one set of treatment Dm vs Usp showed significant difference (P<0.05) in 2014. At 56 DAT, analysis of infestation in year one and year two revealed significant differences (P<0.05) between the treatments in 2013 and 2014.From the graph (Fig. 3) above, it showed the peak of larvae infestation in all the growth stages of cabbage.

There were significant differences between Usp and all the other treatments in both year 2013 and 2014.There was no significant difference between Dm and treatment comprising 'Nle + Ti+ Mn+ Ml' in both years at this stage. There were no significant differences between 'Nle + Mn + Ml' vs 'Ti + Mn + Ml' in both years. Meanwhile, there were significant differences between 'Nle + Ti+ Mn + Ml' vs 'Ti + Mn + Ml', 'Nle + Ti + Mn + Ml' vs 'Nle + Mn + Ml', Dm vs 'Ti+ Mn + Ml' and Dm vs 'Nle + Mn+ Ml' in year 2013 and not in 2014 at the stage of plants' growth. At 70 DAT, there were significant differences (P<0.05) between the treatments in both years. At 80 DAT, there were significant differences (P<0.05) between three treatment sets in 2013 and six treatment sets in 2014. End of season analysis of the various treatments and their levels of infestation varied for both year 1 and year 2 planting as shown by the mean chart of the average end of season infestation levels.



Key: Dm=dimethoate; Usp=unsprayed; Mn=manure; Ml=mulch; Nle=neem leaf extract; Ti=tomato intercrop

Figure 4. Mean chart showing average end of season infestation levels between the different treatments in years 2013 and 2014

Table 1. Dunnett (two sided): Analysis of the differences in the infestation levels between control (Unsprayed) and the other treatments with a confident interval (CI) of 95%

Treatments	2013	2014
	Pr> Diff	Pr> iff
Usp vs Dm	0.001*	0.001*
Usp vs Nle + Ti + Mn + Ml	0.001*	0.001*
Usp vs Ti+ Mn+ Ml	0.006*	0.001*
Usp vs Nle+ Mn + Ml	0.008*	0.001*

Key: * Significant at 5% Dm=dimethoate; Usp=unsprayed; Mn=manure; Ml=mulch; Nle=neem leaf extract; Ti=tomato intercrop

Table 2. Fisher LSD grouping of the treatments basing strength to control larvae infestation in year 2013 and 2014 respectively

Treatments	2013	2014
	LSD means	LSD means
Dm	0.260[a]	0.149[a]
Nle + Ti + Mn + Ml	0.354[a]	0.198[a]
Ti + Mn + Ml	0.962[b]	0.500[b]
Nle + Mn + Ml	1.004[b]	0.517[b]
Usp	1.816[c]	1.250[c]

Key: [a] treatment ranked in the first group, [b] treatment ranked in the second group, [c] treatment ranked in the third group Dm=dimethoate; Usp=unsprayed; Mn=manure; Ml=mulch; Nle=neem leaf extract; Ti=tomato intercrop

Generally, unsprayed treatment (Usp) had the highest infestation level while dimethoate (Dm) had the lowest levels of infestation as compared to the cultural treatments. Among the cultural treatments, 'Nle + Ti + Mn + Ml' treatment had lowest level of infestation. Further comparison of the control treatment pointed that there were differences between the control (Usp) and all the other treatments in both 2013 and 2014 respectively as shown in Table 1 below;

DISCUSSION

The study demonstrated that the combination of cultural practices comprising 'Nle+ Ti+Mn+Ml' was effective in the control of DBM in cabbage production. This cultural package reduced the larvae infestation very close to the standard Dimethoate insecticide. Dm and cultural package comprising 'Nle+Ti+Mn+ Ml' were ranked in group 'a' in their strength in control of the DBM. This cultural package was ranked in the same group with Dm because of the effective positive interaction between Nle, Ti, Mn and Ml. Shazia *et al.* (2006) reported similar results in Asia.

Previous study reported effectiveness of combination of admixtures in the control of pests. It is therefore important to study the mechanism of increased effectiveness of specific combinations of cultural treatments in the control of pests (Shazia *et al.*, 2006). The present investigation indicated superiority of all the treatments over control (Usp treatment). Plots that were sprayed with neem leaf extract resulted into low counts of the DBM larvae because neem extracts are known to act on various insects; disrupting or inhibiting the development of eggs, larvae or pupae, blocking the moulting of larvae or nymphs, disrupting mating and sexual communication, repelling larvae and adults, deterring females from laying eggs, sterilizing adults, poisoning larvae and adults, deterring feeding, blocking the ability to "swallow" (that is, reducing the motility of the gut), sending metamorphosis at various stages, inhibiting the formation of chitin (Laxmitkant *et al.,* 2013). The Larvae and the adult DBM that managed to survive the Neem spray were able to survive, grow and caused damage to the plants. Brust (1993) reported that plots with mulch encouraged the association of other organisms which would help in keeping check the population of DBM larvae. Brust (1993) further reported that mulching affected oviposition as it changed the reflection from the ground. However the study did not focus on the different organisms associated with the mulch and this would require another study.

Tomatoes have a repelling effect on the insect which interferes with oviposition, hence reducing on the infestation level because few eggs were laid on the cabbage. Intercropping also interfered with the location of the right host plants (Batch and Tabashnik, 1990). Much as Tomato is known for its repelling effect by the odours that deter the moth, some of them that managed to lay their eggs in plots treated with 'Tomato intercrop+manure+mulch' were able to hatch, grow and matured to adult moth. Therefore, Tomato did not completely interfere with the hatching and growing of larvae, in agreement with Andrews *et al*., (1992).

The study revealed that planting alternate rows of tomatoes with rows of cabbage did not prevent the attack completely. This was because larvae were recorded in plots that had alternate rows of tomato planted which agreed with the finding by Andrews et al. (1992), who reported that intercropping cabbage with tomatoes had shown significant reduction of the larval density of DBM in cabbage (Andrews *et al*., 1992). The high level of infestation in unsprayed treatment was attributed to no control measures employed to suppress the different stages of DBM. The plots were left under natural conditions; this gave favourable conditions for oviposition and survival of larvae, pupae and adults DBM. In other treatments, the conditions were altered chemically or culturally to kill or interfere with the survival of this insect (Talekar and Shelton, 1993).

Infestation levels were highest between 28-56 days after transplanting when the cabbages had many leaves and were forming heads; therefore, this provided avenue for oviposition for the adult moth and the survival of the eggs and larvae. At this stage the Neem extract and the chemicals sprayed might not have easily reached the folded leaves hence more of the larvae infested the cabbage. At this stage, the plants were also vigorously growing, thus provided food for adults and the larvae (Salinas, 1986).

Decline in infestation from day 56 to 84 DAT (Fig 3) was probably because the cabbage plants were approaching maturity and perhaps were less palatable to the larvae. However, according to Bhallaa and Dubey (1986), if adult insect lays eggs, the eggs are hatched into larvae which intern result in the rise in infestation levels in the various treatments. Small scale farmers can now exploit the cultural combination of 'Nle + Ti + Mn + Ml' to produce healthy cabbage, hence relieving them from relying on chemical insecticides which are dangerous to the human health and environment in the long run (Anna *et al*., 2007).

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