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Field Evaluation on Effects of Common Spices in the Control of Diamondback Moth (*Plutella xylostella* L.) Pest of Chinese Cabbage (*Brassica campestris* L.) Commercial Cultivar

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Abstract: An experiment was carried out to assess the effectiveness of commonly used spices in controlling diamondback moth (DBM) (*Plutella xylostella* L. (Lepidoptera:Plutellidae)) field pest of Chinese cabbage (*Brassica campestris* L. sp. Perkinensis (Lour) Olson). The trial was conducted during the short rains of November to February 2004/2005 at the Horticultural field plots of Sokoine University of Agriculture, Morogoro, Tanzania. Test materials consisted of cabbage seeds; water extracts of garlic stems, fruits of hot pepper and cloves and barks of cinnamon as insecticidal pesticides. Ten treatments consisted of two controls viz., one of no pesticide and the other of standard actellic super, the rest were sole spices and their various combinations. The pesticides were applied once a week starting at seedling emergence to the completion of data collection. Treatments were laid in a Randomized Complete Block Design with three replications. Data on insect damage was recorded weekly commencing at five weeks after sowing for 3 consecutive weeks. Pest incidence decreased with time while significant treatment effects were observed for pest severity and incidence and marketable leaves. Actellic super, pepper, combination of garlic and cloves and the trio combination of garlic, pepper and cloves significantly excelled the control of no pesticide application in reducing severity and incidence of diamondback moth and having higher number and percentage of marketable leaves. Actellic super significantly excelled the other treatments in having the lowest severity and incidence of DBM. The trio combination of garlic, pepper and cloves was statistically the same as actellic super in having high number and percent of marketable leaves. Negative relationships were observed between pest severity and incidence with number and % marketable leaves. On the other hand, positive relations were observed for pest severity with incidence and number with % marketable leaves.

Key words: Actellic super, cloves, garlic, pepper, severity

INTRODUCTION

Chinese cabbage (*Brassica campestris* L. sp. Pekinensis (Lour) Olson) is an annual vegetable with nutritional, medicinal and economic benefits. It contains vitamins, minerals, protein, carbohydrates, fat and fiber. Eighty five grams of boiled vegetable contains 1.3 g protein, 1.5 g carbohydrate, 0.1 g total fat and 1.4 g fiber[1]. It is used daily in dishes as a relish and has curative benefits such as in the control of bronchitis, cataracts, diabetes, crohn's disease, diverticular diseases, heart attack and hypertension. Subsistence farmers gain revenue upon sale of the vegetable in the local markets and thus it is an important food and cash crop in the rural and urban areas in back yard culture. Among the most important production constraints of Chinese cabbage are herbivore pests that attack the edible leaves and render them unpalatable and unmarketable. Among the most important insect pests is the diamondback moth (DBM) *Plutella xylostella* L. (Lepidoptera:Plutellidae). It presents one of the greatest threats to crucifer production in the tropics causing up to more than 90% crop losses[2]. In the warm humid tropics, the pest breeds through out the year and can have more than ten generations annually. The tiny green insect originally from Europe, flourishes in the tropics where it has no natural enemies, causing over 1 billion US dollars worth of damage annually. Entire crop can be lost if control measures are not taken[3]. The pest is oligophagous with the larvae feeding specifically on membranes of the cruciferae family. Adult female moths lay their eggs on the underside of leaves. The larvae hatch and feed on the parenchyma,

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leaving the cuticle intact but as the plant grows, the cuticle tears resulting in a characteristically holey appearance on the leaf surface, rendering the vegetable unsuitable for home consumption or sale.

Control of the pest largely depends on the use of synthetic pesticides. Though originally effective, the pest has progressively developed resistance to these insecticides. Diamond back moth for instance, was the first crop pest in the world to develop resistance to the synthetic pesticide DDT[4]. To date, it has developed resistance to all modern insecticides that have been used intensively including some toxins of the bacterium *Bacillus thuringiensis* (Bt). In Mauritius for example, development of pesticide resistance by DBM has progressed rapidly from Lannate (methomyl) to Rogor (dimethoate) to Tamaron (methamidophos) to Decis (deltamethoin) to Selecron (profenols) to Tokuthion (prothiofos)[5]. In South Africa, wide spread and indiscriminate use of pesticides to DBM populations has shown resistance to synthetic pyrethroids, organophosphates and carbamates[2]. Largely because of negative environmental and health impacts of these synthetic pesticides and the increasing difficulty encountered in controlling DBM populations, much effort has been developed to finding alternative control measures for the pest. This has led to the testing of plant extracts as botanical pesticides. In most cases, the bioactive compounds of botanicals are fairly complex contrary to the more specific synthetic pesticides and thus rendering the botanicals difficult for pests to develop resistance against them[5]. Most of the botanicals are safe to prepare and apply; cheaper and relatively effective and sometimes being more effective than the synthetic pesticides[3]. The safety nature of most botanicals has been attributed to the faster decomposition in sunlight and high temperatures, leaving no residual effects in water, the crop or after cooking. They are also reported to decompose readily in the digestive track rendering them safer upon ingestion[6]. More than 80 plant species have been reported to be effective against the DBM mainly from the Meliacea (Mahogany) family and others including Asteraceae, Fabaceae and Euphorbiaceae[2]. Neem (*Azadirachta indica*), Melia (*Meliazedarach*), lemon grass (*Cymbopogon citrates*), *Lantana camara*, *Vetivera zizanoides* and *Chenopodium* spp. affected feeding adversely by making the treated host plant unpalatable to the pest larvae. Goat weed, corossol, ayapana and Indian privet affected the growth and development of larvae and pupae in different ways resulting to distorted pupae, pupal death, partial emergence of adults and deformed adults[5]. However, botanicals are not completely safe. For instance, tephrosia has been found to be toxic to fish, shrimps, crabs and highly irritating to the human user, necessitating the use of respirators and protective clothing during field application[7]. Nicotine from tobacco though has a broad spectrum effect and is highly toxic to mammals[8]. Since the safety of botanicals is largely based on their faster decomposition under ambient conditions, it is evident that they have inherent toxicity that has to be detoxified under certain conditions. It is therefore important to look for alternatives that have no such toxic potentials for a more safe application of botanicals in the field. Use of materials that are used either as food or medicine may provide a safer regime of botanicals in this regard. Such materials include spices such as garlic, pepper, cinnamon, cloves and their combinations and plant materials used in folk medicine. They are easily available and if proved effective, will provide a more sustainable approach in the control of DBM and other field pests.

The present investigation was set to research on the effectiveness of common spices available in the local premises of Tanzania in controlling DBM. Such technology if proved effective will likely provide a cheaper, cost effective and sustainable approach in combating DBM in Tanzania and else where.

MATERIALS AND METHODS

The experiment was conducted during November to February 2004/2005 cropping season at the Horticultural field plots of Sokoine University of Agriculture, Morogoro, Tanzania. The area is located at 60^0 05'S; 35^0 37'E and 525 m above sea level. Test materials consisted of cabbage seeds and garlic stems, hot pepper fruits, clove fruits and barks of cinnamon as insecticidal spices. Hundred grams of each botanical spice was ground and mixed with 1 L of water while for the mixture containing the spice combinations, the 100 g consisted of totals of the individual spices in their respective ratios. A total of 10 treatments were used consisting of two controls in which one had no protectant applied and the other was the standard synthetic pesticide, actellic super. The rest were water extract botanical spices and their various combinations and the whole set of treatments is as shown below:

T_0 : Control of no protectant
T_1 : Control of standard actellic super
T_2 : Garlic water extract
T_3 : Pepper water extract
T_4 : Clove water extract
T_5 : Mixture of T_2 and T_3 in 1:1

T_6 : Mixture of T_2 and T_4 in 1:1
T_7 : Mixture of T_3 and T_4 in 1:1
T_8 : Mixture of T_2, T_3 and T_4 in 1:1:1
T_9 : Cinnamon water extract

Seeds of the commercial variety *Brassica chinensis*, var. chihili were directly sown in raised seed beds at a spacing of 30 cm within rows and 60 cm between rows. Plots consisted of two rows and in each plot a total of 100 g seeds were sown at 15 mm depth using 6 hills per plot. During sowing in each hole compost from kraal of 237 g, was incorporated. A total of 30 plots were used in 3 replicates in which the treatments were arranged in a randomized complete block design. Thinning was done to 1 plant per hill in each plot at the 2 leaf stage. Standard actellic super of liquid formulation at recommended rate and one liter of each spice botanical water extract were applied in the 3 plots of a respective treatment for the 3 replicates once per week at late evening time using a small plastic hand sprayer. Spraying was done starting at the seedling emergence to final data collection.

Data collection started at 5 weeks after sowing on insect severity, incidence and number of marketable leaves. All leaves that were not damaged at all by the pest were counted for all 6 plants in a plot and average value per plant derived by dividing total leaves by number of plants in each plot. Similarly, the percent damage was derived by dividing the number of damaged leaves by total number of leaves in a plot and multiplied by 100. Insect damage severity was scored based on visual damage rating scale on a 0-5 in order of increasing damage[9] as shown below:

Severity scale for DBM infestation

% area of infested leaves	Scoring scale (0-5)
0-10	0
>10-20	1
>20-50	2
>50-70	3
>70-80	4
>80-100	5

The percentage incidence was scored by counting the number of plants with at least an infestation and taken as a proportion of total number in a plot and the ratio multiplied by 100. All leaves not damaged at all by insects were counted and the number divided by total number of plants to give marketable leaves per plant in a plot. The percent marketable leaves was calculated by counting the number of marketable leaves and taken as a proportion of total number of leaves and multiplied by 100.

Data for the variables was analyzed based on MSTAT-C programme[10]. Mean separation test was done using Duncan New Multiple Range Test while simple correlations were used for relationships among variables.

RESULTS

Weeks showed significant ($p \leq 0.05$) variation only in incidence of diamondback moth (Table 1). On the other hand, botanical treatments displayed significant ($p \leq 0.01$) variation in all of the studied variables viz., insect severity and incidence, number and percentage of marketable leaves. Significant interaction was observed between weeks of assessment and botanical treatments for severity and incidence of diamondback moth. There was a general decrease on the incidence of diamondback moth from the fifth to the eighth week of crop growth. This corresponds to the first and third weeks of data collection, respectively (Table 2).

Actellic super (T_1) had significantly the lowest severity (2.0) of the pest. This was followed by pepper water extract (T_3) (3.0) and a mixture of pepper and cloves water extract (T_8) (3.0). On the other hand, the control of no botanical application (T_0) resulted to the highest severity (5.0) (Table 3). The significantly lowest incidence (33%) of the pest was observed with actellic super application (T_1). This was followed by the mixture of garlic, pepper and cloves water extract (T_8) (49.7%) and pepper water extract (T_3) (51.4%). The highest incidence (89.9%) was observed with the control (T_0) of no botanical application. Actellic super (T_1) significantly resulted to the highest number of marketable leaves per plant (3.1). This was followed by the trio mixture of garlic, pepper and clove water extract (T_8) (2.6) and pepper water extract (T_3) (2.2). The latter two did not differ significantly from each other. On the other hand, the control of no botanical (T_0) had the lowest number of marketable leaves (0.6). This was followed by cinnamon water extract (T_2), mixture of garlic and pepper (T_5); mixture of garlic and cloves (T_6) and mixture of pepper and cloves (T_7) and these did not differ significantly on production of marketable leaves per plant.

Actellic super (T_1) resulted to the highest 51.7% of marketable leaves; followed by the mixture of garlic, pepper and cloves water extract (T_8) (42.7%) and these were statistically the same and they were followed by pepper water extract (T_3) (36.2%). On the contrary, the lowest percent of marketable leaves was obtained with the control of no botanical application (T_0) (10.2%). Water extracts of cinnamon, cloves and combination of pepper and cloves resulted to poor control of pest severity and

Table 1: ANOVA summary for the studied variables (Mean squares given)

Source of variation	Df	Pest severity(0-5)	Pest incidence (%)	Marketable leaves (No.)	Marketable leaves (%)
Replicates	2	0.011	22.9	0.235	23.4
Weeks	2	0.811	184.9*	1.342	299.7
Error (a)	4	0.144	21.5	0.318	105.8
Pesticides	9	9.340***	2545.6***	4.474***	1263.4***
WeekxPesticide	18	1.354***	409.6***	0.534	155.9
Error (b)	54	0.335	85.4	0.329	91.3
Total	89				

Table 2: Mean effects of weeks for the studied variables

Weeks	Pest severity (0-5)	Pest incidence (%)	Marketable leaves (no)	Marketable leaves (%)
1	4.2	69.6	2.0	32.2
2	4.1	68.6	1.6	26.6
3	3.9	64.9	1.7	26.9
x	4.1	67.7	1.8	28.6
SEx	0.069	0.846	0.103	1.88
CV (%)	14.3	13.7	32.8	33.4
LSD0.05	ns	3.61	ns	ns

Table 3: Mean effects of botanical treatments for the studied variables

Treatments	Pest severity (0-5)V1	Pest incidence(%)V2	Marketable leaves/plant (no)V3	Marketable leaves (%) V4
T_0	5.0a	89.9a	0.6e	10.2d
T_1	2.0d	33.3d	3.1a	51.7a
T_2	4.4b	75.6ab	1.4d	23.4c
T_3	3.0c	51.4c	2.2bc	36.2b
T_4	4.6ab	75.6ab	1.7cd	26.9c
T_5	4.8ab	79.3ab	1.5d	24.6c
T_6	4.3b	72.1b	1.5d	25.2c
T_7	4.8ab	79.3ab	1.6d	24.2c
T_8	3.0c	49.7c	2.6ab	42.7ab
T_9	4.6ab	75.7ab	1.3d	20.8c
x	4.1	67.7	1.7	28.6
SEx	0.193	3.080	0.191	3.184
CV (%)	14.3	13.7	32.8	33.4

Numbers within a column with same letter(s) are not significantly different at 0.05 level

Table 4: Simple correlations between variables

Variables	Pest severity	Pest incidence	Marketable leaves (No.)	Marketable leaves (%)
Pest severity	-	0.993***	-0.782***	-0.796***
Pest incidence		-	-0.772***	-0.785***
Marketable leaves (no)			-	0.988***
Marketable leaves (%)				-

*** = $p \leq 0.001$

incidence. Significant ($p \leq 0.001$) negative relationships were obtained between insect incidence and severity with number and % marketable leaves; while positive relationships were observed between pest severity with incidence and number of marketable leaves with % marketable leaves (Table 4).

DISCUSSION

The present investigation suggests the potential of spices in controlling diamondback moth of Chinese cabbage. The identified spice botanicals are water extracts of pepper; mixtures of garlic and cloves; garlic, pepper and cloves since they excelled the control of no botanical application in all of the studied variables (Table 3). Similarly, the synthetic actellic super is still the best in terms of effectiveness as it significantly excelled all other treatments in the variables under investigation. Hot pepper has been found to be an effective pesticide according to findings in Papua New Guinea that indicated the repellent nature of the spice in controlling crop pests[11]. The pesticidal properties of chili pepper have as well been reported elsewhere in the control of DBM[12]. In other studies, the repellent nature of red pepper powder has successfully been used to control worm pests in cabbage and lettuce. The pepper reduced caterpillar feeding damage sufficiently to result in high marketable yields of cabbage and lettuce according to findings of Zehnder and Griggs[13] and Zehnder *et al.*[9]. Similarly, hot pepper was among the natural pesticides that produced the highest marketable yields in cabbage against diamondback moth[3]. Ground red pepper obtained at a local supermarket has been reported as an insect repellent and more active than the control in reducing DBM

numbers in the field[13]. Hot dusts such as of chili pepper and red pepper contain capsaicin, a compound shown to repel insects[14]. Garlic water extract also gave good control on diamondback moth severity, marketable and percent marketable leaves suggesting that the spice can be used for control of the pest. Garlic has as well been reported to contain pesticidal properties[12] while Zehnder *et al.*[9] reported that garlic provides effective control of the caterpillars on lettuce and cabbage. According to Zehnder *et al.*[9] garlic and red pepper were among with equivalent or better control of cabbage worms than the karate synthetic insecticide. In other studies, garlic oil sprays have been found to have quick kill against aphids, cabbage loppers, ear wigs, June bugs, leafhoppers, squash bugs and white flies[14]. It is therefore suggested that garlic is a broad spectrum insecticide that can be used to control a number of horticultural pests. Garlic oil is reported to be a non-selective insecticide with both antibiotic and antifungal properties[15]. Combination of garlic, pepper and cloves proved to excel the control of no pesticide application in all variables suggesting that the effectiveness of the combination is basically due to positive interactions among the components of mixture. Garlic mixture that contained 1% garlic, 1% fish oil and 98% water has been found to be an insect repellent that enters the plants through stomata and moves systemically through the plant according to reports of Zehnder *et al.*[9]. The importance of admixtures in controlling pests has been reported elsewhere. Aphids have as well been repelled by spraying a mixture of hot red pepper, garlic, liquid soap and water[16]. It is therefore important to study the mechanism of increased effectiveness of specific combinations of botanicals and selectively make use of them. The present investigation indicated superiority of all treatments over the control for two variables viz., number and % marketable leaves suggesting that all the spices applied have some pesticidal control of DBM. Cinnamon oil has as well been used to control mites on edible products such as grapes, strawberry and sweet potatoes[15]. According to Bessette *et al.*[17], a pesticidal composition containing winter green oil, mineral oil and cinnamon oil was effective against insects, larval and eggs, arachnids, fungus and bacteria.

The present study therefore suggests that common spices used in horticulinary purposes viz., pepper, mixture of garlic and cloves, the trio mixture of garlic, pepper and cloves have potential in significantly reducing the DBM of Chinese cabbage. However, botanical pesticides usually breakdown fairly quickly especially on sunny, warm days rendering them less hazardous to environment and health. This characteristic makes it necessary to apply the botanicals more frequently in order to foster their effectiveness during the growing cycle. Studies are necessary to find the necessary minimum application rates and extraction methods that will provide a more effective control of DBM to economic threshold levels.

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