Original Research Papers

Effect of Biopesticides and Pheromone Traps on Major Insect-Pests and Their Natural Enemies of Cabbage

Aklima Begum[1] , Md. Abdul Latif [1], Mohammed Ali [1] , Fatima Farhana [1]*

[1] *Department of Entomology, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh*

Authors' contributions

This work was carried out in collaboration among all authors. Authors MAL and MA planned and designed the research. Author AB conducted the work on the field, collected the data and managed literature searches. Author FF performed the statistical analysis and wrote the manuscript. All authors read and approved the final manuscript.

ABSTRACT

Aims: This study is aimed to know the effect of biopesticides on insect pests, predators and yield of cabbage.
Study Design: The experiment was laid out at a randomized complete block design with four replications.
Place and Duration of Study: Central farm of Sher-e-Bangla Agricultural University, Bangladesh during the period from October 2018 to March 2019.
Methodology: The experiment was conducted with six treatments viz. T_1= Spinosad @25 ml/ha at 7 days interval , T_2= SNPV (*Spodoptera litura* nuclear polyhedrosis virus) @ 2.47/ha at 7days interval, T_3= Spodolure trap @ 1/6 plot at 14 days interval, T_4= Spodolure trap + Spinosad spray, T_5= Spodolure trap + SNPV spray and T_6= untreated control.
Results: The lowest infested leaves per five plants by flea beetle (0.33), tobacco cutworm (0.33), semi- looper (0.33), diamondback moth (1.33), aphid (7.50), was found in treatment (Spodolure trap + Spinosad).The population of natural enemies per plot was also recorded and highest population of lady bird beetle (8.00) and spider (8.60) was also observed from Spodolure trap + Spinosad treatment as compared to untreated control. The highest percentage of healthy plants (91.67), maximum weight of healthy cabbge head plant^{-1} (1.20 kg), marketable cabbage head plot^{-1} (19.48 kg) and marketable yield of healthy cabbage head (45.08 t ha^{-1}) was found with Spodolure trap + Spinosad treatment.
Conclusion: It is concluded that Spodolure trap in combination with Spinosad spray may be effective practice for the management of cabbage insect pests.

Keywords: Cabbage; Predators ; Marketable yield; SNPV; Spider; Spodolure

1. INTRODUCTION

Cabbage (*Brassica oleracea* var. *capitata* L.) is an important vegetable crop because of it has high economical and nutritional value for producers and consumers, respectively [1]. In 2015-2016, 237 thousand metric tons of cabbage was produced from an area with an average yield 75-100 ton/ha depending on selection of variety and season [[2,3]. The average yield of cabbage is due to various factors. Among, biotic factors the insect-pests play major role in reduction quantity and quality of of cabbage. The crop is attacked by a number of insect pests, *viz*. tobacco caterpillar, *Spodoptera litura*

(Fab.); diamond back moth, *Plutella xylostella* (L.); cabbage leaf webber, *Crocidolomia bionotalis* (Zell.); aphids, *Bravicornye brassicae* (L.) and *Lipaphis erysimi* (Kalt.); painted bug, *Bagrada cruciferarum* (Kirk.) and flea beetle, *Phyllotreta cruciferae* (Goeze.) etc. [4]. Among these diamond back moth, *P. xylostella* (L.) causes significant losses. to cabbage field [5]. Yield loss due to the attack of *P. xylostella* on cabbage was reported 44.6% and 53% respectively [6] [7]. Tobacco caterpillar (*Spodoptera litura* Fab.) is also an important pes cabbagecrop[8] and it can cause more than 50 % reduction e in yield [9]. The caterpillars of semi-looper feed voraciously and cause large damage by making holes on the cabbage head [10]. Flea beetle infestation leads to at least 25 % damage characterized by "shot holes" on the foliage [11].

Pesticide consumtion in vegetable crops was six times higher (1.12 kg/ha) than the rice (0.20 kg/ha) [12]. Conventional insecticides continue to be one of the most powerful weapons available for the control of pests, but their wide scale and indiscriminate application creates problems like, development of resistance and resurgence of pests; besides, leaving excessive residue on edible portions [13] [14]. Now the people have become more aware about health, which has opened doors for production of organic vegetable and use of green chemistry insecticides for pest management. Therefore, now the basis of vegetable production has been shifted from quantity to quality and food safety. The increased demand of residue free vegetables will definitely motivate vegetable growers to use safe pesticides for pest management. It has been observed that effective management of *Spodoptera litura* can be ensured with the mass trapping of *Spodoptera litura* by pheromone traps along with 2-3application of SNPV [15]. In Bangladesh, scientists of different public research institutes and universities have already developed bio-pesticides based pest management packages against several destructive insect pests and diseases of different crops. Keeping this view in mind, the research was undertaken to test the efficacy of bio-pesticides (pheromone traps) for succession of insect pests and their natural enemies in cabbage ecosystem.

2. MATERIALS AND METHODS

2.1 Experimental site

The research work was conducted during the period of October 2018 to March 2019, at the central farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The location of the site is $23^0$74/N latitude and $90^0$35/E longitude with an elevation of 8.2 meter from sea level.

2.2 Climate and soil

The experimental site was subtropically characterized by high temperature, high humidity and heavy rainfall in Kharif season (April to September) and scanty of rainfall in Rabi season (October to March). The soil was having a texture of silty clay with pH and organic matter 5.8 and 1.16%, respectively. The results showed that the soil composed of 27% sand, 43% silt and 30% clay [16].

2.3 Experimental treatment and design

The seed of cabbage variety was BARI cabbage-2 (Agradut) which was raised without any plant protection measures. The nine treatments, viz. T_1 (Spinosad @ 25 ml/ha at 7 days interval), T_2 (SNPV (Spodoptera litura nuclear polyhedrosis virus) @ 2.47/ha at 7days interval), T_3 (Spodolure @ 1/6 plot at 14 days interval), T_4 (Spodolure + Spinosad), T_5 (Spodolure + SNPV) and T_6 (Untreated Control) were used. The experiment was laid in a Randomized Complete Block Design (RCBD) with four replications with plot 2.4 × 1.8 m. The distance was maintained between replications and plots 1.0 m and 0.5 m, respectively.

2.4 Crop husbandry

The seed was sown on the seedbed on October 20, 2018. . The crop was raised with standard dosages of cowdung and fertilizers as recommended by BARC Fertilizer Recommendation Guide-2020[17]. Cowdung, urea, TSP and MoP were applied @ 10000, 370, 250 and 250 kg ha-1, respectively . The 28 days old seedlings were transplanted in the main field in third week of November. After one week of transplanting all plots were checked for any missing hill, which was filled up with extra seedlings of the same source whenever required.

2.5 Data collection

Five plants were randomly selected from each unit plot for the recording of necessary data.The data of different parameters was collected as well as recorded twice in week starting from 10 days after transplanting the seedlings from seedbed to the main field. The data on crop characters like the number of healthy and infested leaves no. of healthy and infested head, Number of insect pest plant^{-1}, the weight of individual head; length and diameter of cabbage heads; yield (t ha^{-1}) were recorded. Only the fully compact and marketable heads were harvested at the time of harvesting.

2.6 Statistical package

Collected data were analyzed following ANOVA techniques by using MSTAT computer package program. Mean values were ranked and compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance [18].

3. RESULTS AND DISCUSSION

3.1 Incidence of insect pest during cabbage cultivation

Five major insect pests named flea beetle (*Phyllotreta* spp.), aphid (*Brevicoryne brassicae*), semi-looper (*Trichoplusia* spp.), diamondback moth (*Plutella xylostella*) and tobacco cutworm (*Spodoptera litura*) were found in the cabbage field during the experimental period.

3.1.1 Population of cabbage flea beetle

Among the identified insect pests, flea beetle is the only insect thats adult stage attacked cabbage leaves and caused damage by feeding leaf lamina in the form of small hole. Significant variation was observed on flea beetle population among diffrent treatments (Fig. 1). The lowest flea beetle population (0.33) was found from T_4 (Spodolure + Spinosad) whereas the highest number of cabbage flea beetle (5.28) was found from control plots. Under treated plot, the highest number of cabbage flea beetle (3.00) was found from T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval). Islam et al. 2017 reported more or less simiar result in the same crop [19].

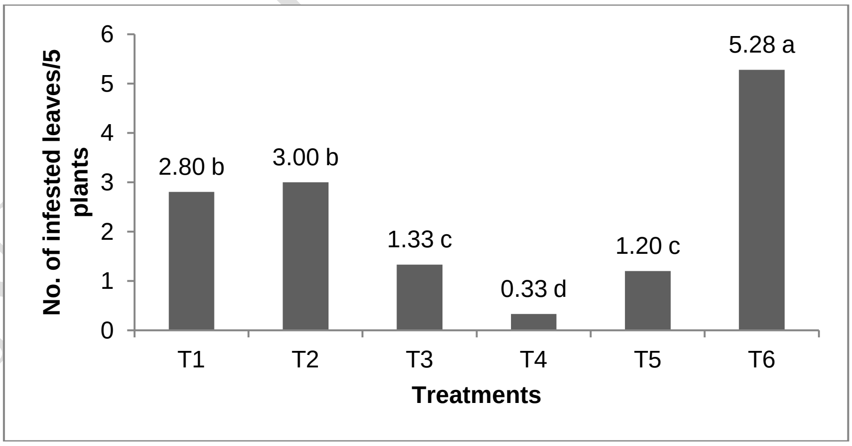

Fig.1. Population of flea beetle by number in cabbage field treated by different treatments

T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.1.2 Population of cabbage aphid

Aphid at its adult and nymphal stages attacked cabbage leaves and damage caused by sucking cell sap from the tender leaves resulting weaken of the plants. Significant variation was observed on Aphid incidence in number among the treatments (Fig. 2). Results revealed that the lowest number of Aphid (7.50) was found from T_4 (Spodolure + Spinosad) treatment whereas the highest number of Aphid (26.44) was found from control treatment T_6. Under treated plot, the highest number of Aphid

(23.60) was found from T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval). Bhavani and Punnaiah (2006) also found the more or less similar result using some botanicals and biopesticides [20].

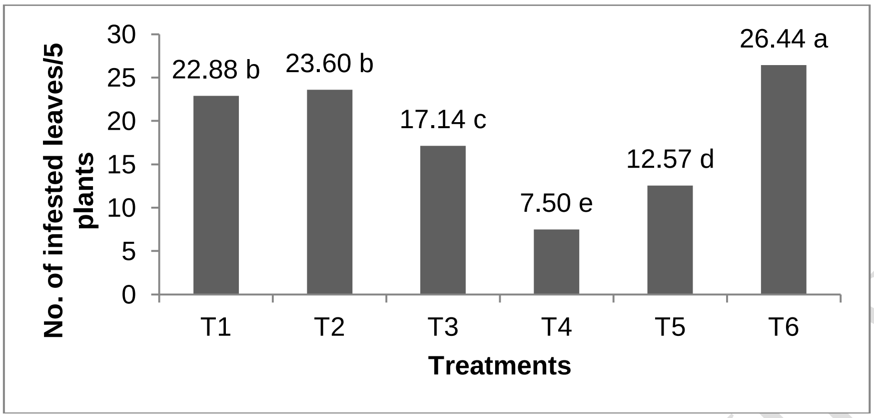

Fig. 2. Population of aphid by number in cabbage field treated by different treatments
T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.1.3 Population of cabbage semi-looper

The semi-looper only at its larval stage attacked cabbage leaves and damage caused by feeding leaf lamina in the form of irregular hole. Significant variation was observed on Semi-looper in number among the treatments (Fig. 3). Results revealed that the lowest number of Semi-looper (0.33) was found from T_4 (Spodolure + Spinosad) treatment whereas the highest number of Semi-looper (4.36) was found from control treatment T_6. Under treated plot, the highest number of Semi-looper (2.50) was found from T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval) and T_3 (Spodolure @ 1/6 plot at 14 days interval). This result was supported by Iqbal et al. 2015 [21].

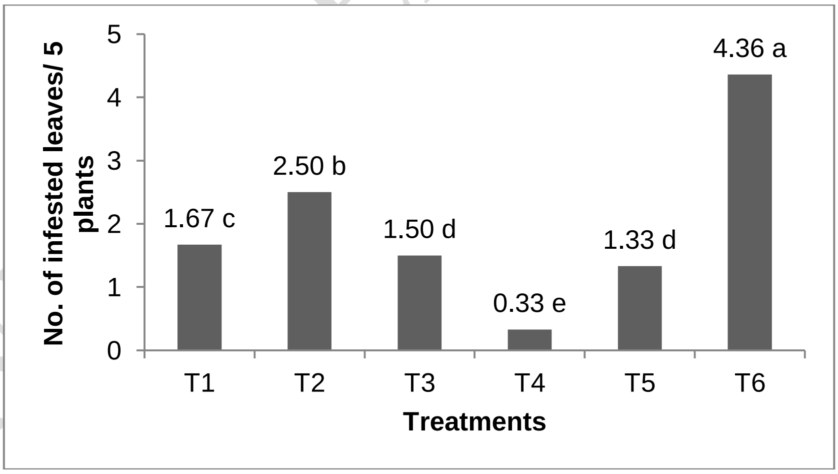

Fig.3. Population of semi-looper by number in cabbage field treated by different treatments
T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.1.4 Population of cabbage diamondback moth

The diamond back moth only at its larval stage attacked cabbage leaves and damage caused by upper epidermis of leaf in the form of irregular hole and net like appearance. Significant variation was observed on Diamondback moth in number among the treatments (Fig. 4). Results revealed that the lowest number of Diamondback moth (1.33) was found from T_4 (Spodolure + Spinosad) treatment whereas the highest number of Diamondback moth (6.33) was found from control treatment T_6. Under treated plot, the highest number of Diamondback moth (4.00) was found from T_2 (SNPV; *Spodoptera* *litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval). Goud *et al.* reported the similar result in diamondback moth incidence in 2006 [22].

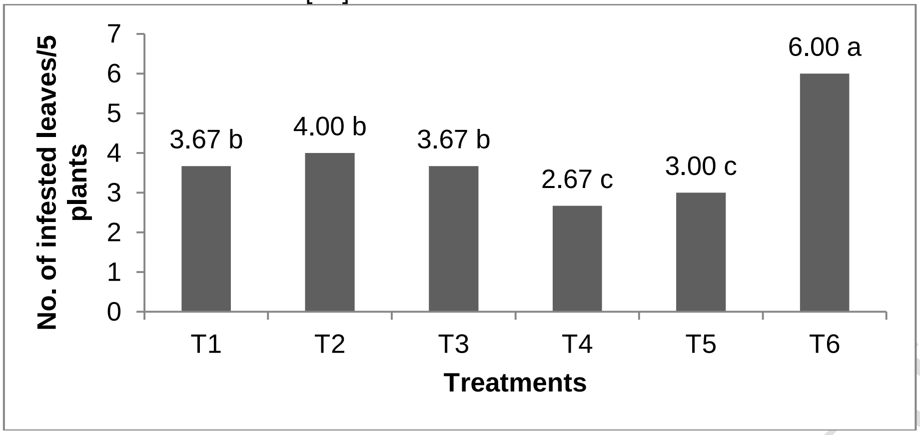

Fig.4. Population of diamondback moth by number in cabbage field treated by different treatments

T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.1.5 Population of cabbage tobacco caterpillar

The tobacco caterpillar only at its larval stage attacked cabbage leaves and head, and damage caused by voracious feeding of upper epidermis of leaf and head in the form of regular hole. Significant variation was observed on Tobacco cutworm in number among the treatments (Fig. 5). Results revealed that the lowest number of Tobacco cutworm (0.33) was found from T_4 (Spodolure + Spinosad) treatment whereas the highest number of Tobacco cutworm (5.28) was found from control treatment T_6. Under treated plot, the highest number of Tobacco cutworm (3.00) was found from T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval). More or less similar result was obtained by Reddy et al. in 2017 [23].

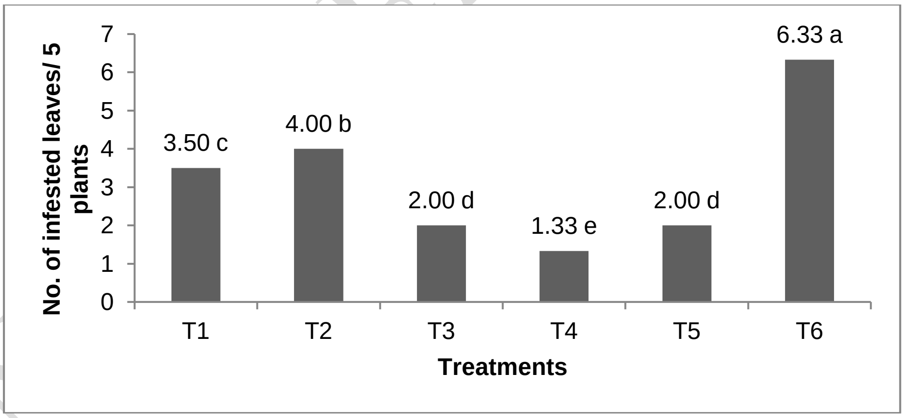

Fig.5. Incidence of cutworm by number in cabbage field treated by different treatments

T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.2 Effect on natural enemies

3.2.1 Population of lady bird beetle

Significant variation was observed on lady bird beetle in number among the treatments (Fig. 6). Results revealed that the highest number of lady bird beetle (8.00) was found from T_4 (Spodolure + Spinosad) treatment whereas the lowest number of lady bird beetle (6.50) was found from control treatment T_6. Under the treated plot, the lowest number of lady bird beetle (6.75) was found from T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval).

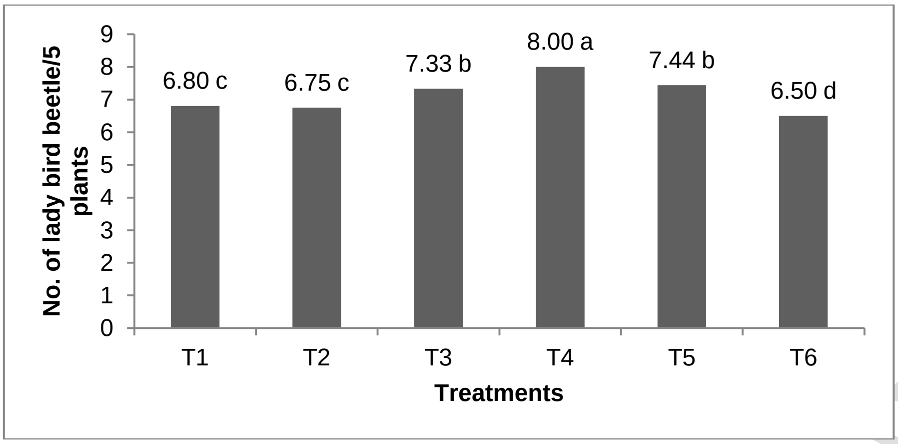

Fig.6. Population of lady bird beetle per plant in cabbage field treated by different treatments

T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.2.2 Population of spider

Significant variation was observed on spider in number among the treatments (Fig. 7). Results revealed that the highest number of spider (8.60) was found from T_4 (Spodolure + Spinosad) treatment whereas the lowest number of spider (6.80) was found from control treatment T_6. Under treated plot, the lowest number of spider (7.48) was found from T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval).

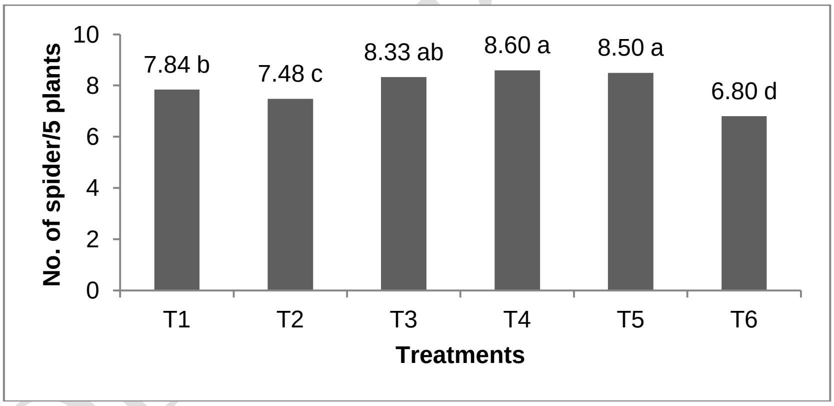

Fig. 7. Population of spider per plant in cabbage field treated by different treatments

T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.3 Effect of management practices

3.3.1 Healthy plants

The data on percent (%) number of healthy plants showed significant variation at different days of crop duration (Table 1). Results indicated that the highest percent (%) number of healthy plants (100, 97.22, 94.44, 93.06 and 91.67% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_4 (Spodolure + Spinosad) treatment the lowest percent (%) number of healthy plants (90.28, 79.17, 69.44, 59.72 and 52.78% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T_6. But under treated plants the lowest percent (%) number of healthy plants (91.67, 84.72, 77.7, 73.61 and 70.83% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval) at the time of harvest.

Table 1. Effect of bio-pesticides on percent (%) number of healthy plants plot^{-1} in cabbage field at different DAT

Treatments	Percent (%) number of healthy plants				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T_1	93.06 bc	86.11 c	79.17 c	76.39 cd	73.61 d
T_2	91.67 c	84.72 c	77.78 c	73.61 d	70.83 d
T_3	94.44 bc	87.50 bc	81.94 c	79.17 c	77.78 c
T_4	100.00 a	97.22 a	94.44 a	93.06 a	91.67 a
T_5	97.22 ab	90.28 b	87.50 b	86.11 b	81.94 b
T_6	90.28 c	79.17 d	69.44 d	59.72 e	52.78 e
LSD	0.76	0.73	0.79	0.63	0.72
CV(%)	4.97	7.07	6.52	9.57	8.98

In a column, means followed by same latter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting, T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.3.2 Infested plants

The data on percent (%) number of infested plants showed significant variation at different days of crop duration (Table 2). Results indicated that the lowest percent (%) number of infested plants (0, 2.78, 5.56, 6.94 and 8.33% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_4 (Spodolure + Spinosad) treatment the highest percent (%) number of infested plants (9.72, 20.83, 30.56, 40.28 and 47.22% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T_6. Under treated plants the highest percent (%) number of infested plants (8.33, 15.28, 22.22, 26.39 and 29.17% at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment which was statistically identical with T_1 (Spinosad @ 25 ml/ha at 7 days interval) at the time of harvest.

Table 2. Effect of bio-pesticides on percent (%) number of infested plants plot^{-1} in cabbage field at different DAT

Treatments	Percent (%) number of infested plants				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T_1	6.94 bc	13.89 b	20.83 b	23.61 bc	26.39 b
T_2	8.33 ab	15.28 b	22.22 b	26.39 b	29.17 b
T_3	5.56 c	12.50 bc	18.06 b	20.83 c	22.22 c
T_4	0.00 e	2.78 d	5.56 d	6.94 e	8.33 e
T_5	2.78 d	9.72 c	12.50 c	13.89d	18.06 d
T_6	9.72 a	20.83 a	30.56 a	40.28 a	47.22 a
LSD	0.36	0.73	0.79	0.63	0.72
CV(%)	8.55	6.47	9.93	10.57	7.37

In a column, means followed by same latter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting T_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.3.3 Healthy leaves plant^{-1}

The data on healthy leaves at 30 DAT, no significant variation was found on number of healthy leaves plant^{-1} (Table 3). But at 50, 70, 90 DAT and at harvest, significant variation was found due to different management practices against insect pest of cabbage (Table 4). Results revealed that the highest number of healthy leaves plant^{-1} (14.36, 18.99, 20.70, 19.88 and 17.35 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_4 (Spodolure + Spinosad) treatment. The lowest number of healthy leaves plant^{-1} (13.48, 14.90, 15.40, 14.63 and 12.68 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T_6. But under treated plants the lowest number of healthy leaves plant^{-1} (13.85, 16.05, 16.85, 16.13 and 14.23 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment.

Table 3. Effect of bio-pesticides on number of healthy leaves plant^{-1} of cabbage field at different DAT

Treatments	Number of healthy leaves plant^{-1}				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T_1	13.73	16.48 d	17.58 d	17.04 d	14.98 c
T_2	13.85	16.05 d	16.85 e	16.13 e	14.23 d
T_3	13.55	17.17 c	18.35 c	17.92 c	15.43 c
T_4	14.36	18.99 a	20.70 a	19.88 a	17.35 a
T_5	14.25	18.10 b	19.33 b	18.90 b	16.27 b
T_6	13.48	14.90 e	15.40 f	14.63 f	12.68 e
LSD	1.72^{NS}	0.63	0.53	0.57	0.58
CV(%)	3.98	8.45	6.93	7.18	9.54

In a column, means followed by same latter(s) do not differ significantly at 5% level by LSD DAT= Days After TransplantingT_1 = Spinosad, T_2 = SNPV (Spodoptera litura nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.3.4 Infested leaves plant^{-1}

The data on infested leaves at 30, 50, 70, 90 DAT and at harvest, significant variation was found number of infested leaves plant^{-1} due to different management practices against insect pest of cabbage (Table 4). Results showed that the lowest number of infested leaves plant^{-1} (0.88, 1.05, 1.70, 2.18 and 2.63 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_4 (Spodolure + Spinosad) treatment. the highest number of infested leaves plant^{-1} (3.43, 4.10, 4.63, 5.38 and 6.38 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in control treatment T_6. But under treated plants the highest number of infested leaves plant^{-1} (2.80, 3.25, 3.50, 4.25 and 4.75 at 30, 50, 70, 90 DAT and at harvest, respectively) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment.

Table 4. Management of major insect pest by bio-pesticides on number of infested leaves plant^{-1} of cabbage

Treatments	Number of infested leaves plant^{-1}				
	30 DAT	50 DAT	70 DAT	90 DAT	At harvest
T_1	2.40 bc	2.75 bc	3.05 bc	3.50 c	3.88 c
T_2	2.80 ab	3.25 b	3.50 b	4.25 b	4.75 b
T_3	1.80 cd	2.43 cd	2.87 cd	3.25 cd	3.63 cd
T_4	0.88 e	1.05 e	1.70 e	2.18 e	2.63 e
T_5	1.55 de	2.03 d	2.38 d	2.75 d	3.25 d
T_6	3.43 a	4.10 a	4.63 a	5.38 a	6.38 a
LSD	0.75	0.62	0.61	0.56	0.46
CV(%)	4.41	7.84	8.25	10.48	7.53

In a column, means followed by same latter(s) do not differ significantly at 5% level by LSD DAT= Days After Transplanting T_1 = Spinosad, T_2 = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

3.4 Effect of management practices on yield

3.4.1 Weight of healthy cabbage head plant^{-1}

Different treatments on weight of healthy cabbage head plant^{-1} showed significant variation (Table 5). Results indicated that the highest healthy cabbage head plant^{-1} (1.20 kg) was found in T_4 (Spodolure + Spinosad) treatment. the lowest healthy cabbage head plant^{-1} (0.88 kg) was found in control treatment $T_{6,\ B}$ut under treated plants the lowest healthy cabbage head plant^{-1} (0.97 kg) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus) treatment which was statistically similar with T_1 (Spinosad @ 25 ml/ha at 7 days interval).

In terms of % increase of healthy head weight plant^{-1} over control, the highest % increase (36.36%) was found in T_4 (Spodolure + Spinosad) whereas the lowest % increase (10.23%) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment. This result was supported by Dey et al. [24].

3.4.2 Weight of infested cabbage head plant^{-1}

Different treatments on weight of infested cabbage head plant^{-1} showed significant influence (Table 5). Results indicated that the lowest infested cabbage head plant^{-1} (0.52 kg) was found in T_4 (Spodolure + Spinosad) treatment which was significantly different from other treatment. The highest infested cabbage head plant^{-1} (0.92 kg) was found in control treatment T_6 whereas under treated plants the highest infested cabbage head plant^{-1} (0.66 kg) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment.
In terms of % decrease of infested head weight plant^{-1} over control, the highest % decrease (43.48%) was found in T_4 (Spodolure + Spinosad) followed by T_5 (Spodolure + SNPV) whereas the lowest % decrease (28.26) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment.

3.4.3 Marketable cabbage head plot^{-1}

Different treatments on marketable cabbage head plot^{-1} (kg) showed significant variation (Table 5). Results indicated that the highest marketable cabbage head plot^{-1} (19.48 kg) was found in T_4 (Spodolure + Spinosad) treatment. The lowest marketable cabbage head plot^{-1} (8.30 kg) was found in control treatment T_6. but under treated plants the lowest marketable cabbage head plot^{-1} (12.34 kg) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment.

3.4.4 Marketable cabbage head ha^{-1}

Different treatments on marketable cabbage head ha^{-1} (kg) showed significant variation (Table 5). Results indicated that the highest marketable cabbage head ha^{-1} (45.08 t) was found in T_4 (Spodolure + Spinosad) treatment whereas the lowest marketable cabbage head ha^{-1} (19.24 t) was found in control treatment T_6. but under treated plants the lowest marketable cabbage head ha^{-1} (28.57 t) was found in T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval) treatment. Simiar trend of yield was found by other authors using chemical insecticides [25]. As using biopesticides is better and safer than chemical insecticides, then is wise to use the biopesticides.

Table 5. Effect of bio-pesticides on yield and yield contributing characters of cabbage

Treatments	Yield parameters					
	Wt.of healthy cabbage head plant^{-1} (kg)	**% increase of healthy head plant^{-1} over control**	**Wt. of infested cabbage head plant^{-1} (kg)**	**% decrease of infested head plant^{-1} over control**	**Cabbage yield plot^{-1} (Marketabl) (kg)**	**Cabbage yield ha^{-1} (Marketabl) (t)**
T_1	1.03 bc	17.05	0.80 b	13.04	13.68 d	31.65 d
T_2	0.97 cd	10.23	0.66 c	28.26	12.34 e	28.57 e
T_3	1.10 ab	25.00	0.60 d	34.78	15.35 c	35.54 c
T_4	1.20 a	36.36	0.52 e	43.48	19.48 a	45.09 a
T_5	1.18 a	17.05	0.55 e	40.22	17.38 b	40.23 b
T_6	0.88 d	--	0.92 a	--	8.31 f	19.24 f
LSD	0.12	--	0.05	--	1.29	2.99
CV(%)	7.49	--	8.94	--	5.94	6.94

In a column, means followed by same latter(s) do not differ significantly at 5% level by LSD, T_1 = Spinosad, T_2 = SNPV (*Spodoptera litura* nuclear polyhedrosis virus), T_3 = Spodolure, T_4 = Spodolure + Spinosad, T_5 = Spodolure + SNPV, T_6 = Control

CONCLUSION

It was found that among the different treatments T_4 comprised of Spodolure trap along with Spinosad spray gave the highest performance where the lowest performance was obtained by control treatment. On the other hand, the lowest performance among the treated plots was achieved by T_2 (SNPV; *Spodoptera litura* nuclear polyhedrosis virus @ 2.47/ha at 7days interval).

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