➔DOI : 10.15740/HAS/AJBS/10.1/48-56
e ISSN-0976-8343 | ■ Visit us : *www.researchjournal.co.in*

ASIAN JOURNAL OF BIO SCIENCE
Volume **10** | Issue 1 | April, 2015 | 48-56

RESEARCH PAPER

Development of suitable integrated pest management module for major lepidopteran insect pests of cabbage (*Brassica oleracea* var. *capitata*)

SOMNATH DESHMUKH, **H.V. PANDYA**, S.D. PATEL, M.M. SAIYAD AND P.P. DAVE

Department of Entomology, ASPEE College of Horticulture and Forestry, Navsari Agriculture University, NAVSARI (GUJARAT) INDIA
Email : hvpandya@nau.in

Article Info : Received : 09.12.2014; Revised : 16.02.2015; Accepted : 01.03.2015

Investigation on development of suitable integrated pest management module for major insect pest of cabbage (*Brassicae oleracea* var. *capitata*) was carried out in experimental field of Navsari Agricultural University, Navsari, Gujarat. In case of larval population of *C. binotalis, S. litura, P. xylostella* and *H. armigera* was found in sole synthetic insecticide module M_3 (0.23, 0.35, 1.61 and 1.78/ plants, respectively) followed by eco-friendly pest management module M_1 (0.23, 0.98, 1.50 and 1.51/ plants, respectively) and botanicals bio-pesticides module M_2 (0.30, 0.99, 1.62 and 1.65/ plants, respectively). As far as yield and economics is concerned, module M_3 recorded highest yield of cabbage heads (28322.0 kg/ha) and consequently higher net gain over control (122050 Rs./ha) and higher net BCR (1:41.01). However, its effect in destructing natural fauna, polluting environment and causing residual problem should not be overlooked. Eco-friendly pest management module and botanicals and bio-pesticides module was next effective module in recording yield and net profit besides any adverse effect on natural fauna and did not leave any toxic residue.

Key words : IPM modules, Insect pests, Cabbage

How to cite this paper : Deshmukh, Somnath, Pandya, H.V., Patel, S.D., Saiyad, M.M. and Dave, P.P. (2015). Development of suitable integrated pest management module for major lepidopteran insect pests of cabbage (*Brassica oleracea* var. *capitata*). *Asian J. Bio. Sci.*, **10** (1): 48-56.

INTRODUCTION

Cabbage is locally known as *Kobij, Kobi, Bandh Kobi* and *Karam Kala* which is a native of Western Europe and the Mediterranean Sea. In 1984, the Food and Agriculture Organization (FAO) of the United Nations listed cabbage as a top twenty vegetable and an important food source sustaining world population (Anonymous, 2005). The area under cabbage cultivation was around 372.4 hectares with an annual production of 8534.2 MT in India during 2012-13 out of which in Gujarat, cabbage occupies an area of about 30.92 hectares with the total head production of 663.53 MT (Anonymous, 2013).

The productivity of cabbage is much lower than its potential attributing to many causes and among them insect pests are major constraints. According to Sachan and Srivastava (1972), the cabbage crop having infestation of multiple insect pests complex suffers appreciable damage. It is attacked by various important insect pests *viz*., diamond back moth, *Plutella xylostella* Linnaeus, cabbage butterfly, *Pieris brassicae* Linnaeus, army worm, *Spodoptera litura* Fabricius, head eating caterpillar, *Helicoverpa armigera* Hubner and leaf webber, *Crocidolomia binotalis* Zeller. For the management of these insect pests, farmers usually solely depend on chemical insecticides intensively either singly or in a mixture throughout the growing season. This not only justifies the economic losses but also causes ecological disturbance and creates many problems like destruction of natural enemies and development of resistance to chemical insecticides. Apart from this, it may also leave excessive toxic residue on edible portion and increases insecticidal load in the environment that may in the long run prove to be hazardous to human health and consumer point of view.

To overcome these drawbacks, now-a-days emphasis has been given on alternative method of controlling the insect pests of cabbage, which are effective, eco-friendly and acceptable to farmers *viz.*, integrated pest management (IPM). Srinivasan and Krishna (1991) suggested Indian mustard as a trap crop in cabbage for effective management of diamondback moth. Minimum number of diamondback moth larvae was recorded in cabbage when mustard was used as a trap crop (Pawar and Lawande, 1995). Application of NSKE at 4 per cent (Srinivasan and Krishna, 1991) effectively checked the population of diamondback moth. Similarly, *Bacillus thuringiensis* is one of the most important microbial agent which is used effectively to manage major insects of cabbage (Panchabhavi and Sudhindra, 1994). Sheikh and Kushwaha (1994) reported that *B. thuringiensis* recorded 58.37 and 38.22 per cent of *S. litura* @ 4.40 x 10^8 and 2.20 x 10^8 viable spores/ml, respectively.

Pawar *et al*. (1981) recorded mortality in two major lepidopteran crop pests *viz*., *Helicoverpa armigera* and cabbage looper, *T. nee* by using NPV. Mallapur *et al.* (1994) evaluated calendar based spray and need based spray for the control of cabbage pests and found that total four sprays were required in calendar based spray, while six sprays were required in need based spray.

The information on the IPM practices for the management of major insect pests is scanty and needs to be updated. Keeping this in mind, the present investigation has been under taken.

Research Methodology

Field experiment was conducted with cabbage var. “Golden acre” in the experimental field of N.M. College of Agriculture, N.A.U., Navsari during *Rabi* season. The experiment was laid out in a Randomized Block Design (RBD) with four modules including untreated control and five replications. The crop was raised with recommended agronomic practices with plot size of 20×20 M for each module at 60×45 cm spacing.

Time and methods of application of treatment :

M_1: Modules 1 :

Eco-friendly management module comprised of trap cropping with mustard (one row of mustard was sown on the border of experimental plot), application of neem based formulation neemazol 3000 ppm @ 0.0004%, application of *B. thuringiensis* @ 1.5 kg per ha, spraying of *Ha*NPV @ 450 LE/ha, release of *Chrysoperla* @ 10,000 larvae/ha.

M_2: Module 2:

Sole application of botanicals and bio-pesticides module comprised of application of neem based formulation, neemazol 3000 ppm @ 0.0004%, application of *Bacillus thuringiensis* @1.5 kg per ha, spraying *Ha*NPV @ 450 LE/ha.

M_3: Module 3 :

Sole synthetic insecticide module (on need base) comprised of for lepidopterous larvae: spraying of spinosad 0.002 per cent, emamectin benzoate 0.001per cent and endosulfan 0.075 per cent.

M_4: module 4:

Untreated control the biocontrol component was incorporated by releasing *Chrysoperla* larvae. The larvae of *Chrysoperla* acquired from the Bio-control Laboratory, Department of Agricultural Entomology, NAU, Navsari were utilized for this purpose. The first instar *Chrysoperla* larvae were released with the help of camel hair brush uniformly in the entire plot @ 10,000/ha. The releases were made as and when required.

To study the incidence of major insect pests of cabbage, weekly observations were recorded throughout the crop season. For this purpose, ten plants per plot were selected randomly. The diamond back moth incidence was assessed on the basis of number of larvae present on ten randomly selected and tagged plants from each replication. The number of diamond back moth larvae was recorded from the entire plant at weekly interval.

For head eating caterpillar, the observations were recorded at weekly interval by observing randomly selected ten plant and numbers of larvae per plant were recorded. For army worm, the observation was recorded at weekly interval by observing randomly selected ten plant and number of larvae per plant was recorded. For leaf webber, observations were recorded in the same way as described in army worm.

The data on population of larvae of diamondback moth, head eating caterpillar, army worm and leaf webber were analyzed after due square root transformation using Randomized Block Design. For judging overall performance of modules, the data pooled analysis of data over different intervals was also carried out.

Research Findings and Analysis

The pest management modules *viz.*, eco-friendly pest management module (M_1), botanical and bio-pesticides pest management module (M_2) and sole synthetic insecticide module (M_3) were compared with untreated module (M_4) for the management of major insect pests of cabbage *viz.*, leaf webber, *Crocidolomia binotalis* Zeller, army worm, *Spodoptera litura* Fabricius, diamondback moth, *Plutella xylostella* Linnaeus and head eating caterpillar, *Helicoverpa armigera* Hubner.

Efficacy of various modules on major insect pests :
Leaf webber, Crocidolomia binotalis Zeller :

The data indicated that leaf webber appeared at 4 WAT. The mean number of larvae did not differ significantly among different treatments modules at 5 WAT (Table 1).

At 7 and 8 WAT, lower number of larvae was recorded in module M_3 (0.06 and 0.04/plant, respectively) followed by module M_1 (0.10 and 0.004/plant, respectively) and module M_2 (0.20 and 0.10, respectively).

At 9 and 10 WAT, lower number of larvae was recorded in module M_1 (0.20 and 0.34/plant, respectively) followed by module M_3 (0.22 and 0.40/plant, respectively) and module M_2 (0.26 and 0.44, respectively), whereas the highest number of larvae was recorded in untreated control module (0.84 and 0.90/plant, respectively).

At 11 and 12 WAT, maximum number of larvae was recorded in untreated control (1.04 and 0.78/plant, respectively). Minimum number of larvae was recorded in sole synthetic insecticides module (0.30 and 0.24/plant, respectively) which was at par with eco-friendly pest management module (0.34 and 0.26/plant, respectively) and botanical and bio-pesticides module (0.42 and 0.32 / plant, respectively).

The pooled analysis of data indicated that different treatment modules exhibited their significant influence on number of larvae

Minimum number of larvae was recorded in sole synthetic insecticide module M_3 and eco-friendly pest management module M_1 (0.23/plant) followed by botanical and bio-pesticides module (0.30/plant), while maximum number of larvae was recorded in untreated control (0.75/plant).

The present findings are in collaboration with the findings of Mallapur *et al*. (1994) who reported that calendar based spray and need based spray of insecticides effectively controlled cruciferous leaf webber population. According to Bhavani and Punnaiah (2004), endosulfan 35 EC recorded highest reduction of larval population. The results of present investigation agree with past report

Table 1 : Mean population of leaf webber, *Crocidolomia binotalis* Zeller on cabbage in different treatment module at Navsari

Treatments (Module)	No. of leaf webber								Pooled
	5 WAT	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	12 WAT	
T_1 (M_1)	0.84 (0.22)	0.93 a (0.36)	0.77 a (0.10)	0.73 a (0.04)	0.83 a (0.20)	0.91 a (0.34)	0.91 a (0.34)	0.87 a (0.26)	0.86 a (0.23)
T_2 (M_2)	0.82 (0.18)	0.96 a (0.46)	0.83 a (0.20)	0.77 a (0.10)	0.87 a (0.26)	0.96 a (0.44)	0.95 a (0.42)	0.90 a (0.32)	0.89 a (0.30)
T_3 (M_3)	0.80 (0.14)	0.97 a (0.46)	0.75 a (0.06)	0.73 a (0.04)	0.85 a (0.22)	0.94 a (0.40)	0.89 a (0.30)	0.85 a (0.24)	0.85 a (0.23)
T_4 (M_4)	0.83 (0.20)	1.19 b (0.94)	1.16 b (0.86)	0.97 b (0.46)	1.15 b (0.84)	1.16 b (0.90)	1.23 b (1.04)	1.12 b (0.78)	1.11 b (0.75)
GM	0.82	1.01	0.88	0.80	0.92	0.99	0.99	0.93	0.92
S.E. ± (T)	0.05	0.06	0.04	0.04	0.04	0.05	0.06	0.06	0.02
C.D. (P=0.05) (T)	NS	0.19	0.10	0.13	0.13	0.18	0.20	0.19	0.054
S.E. ± (P×T)	–	–	–	–	–	–	–	–	0.05
C.D. (P=0.05) (P×T)	–	–	–	–	–	–	–	–	–
C.V. (%)	14.09	13.82	9.01	11.92	10.46	13.45	14.47	15.12	13.10

NS= Non-significant WAT=Weeks after transplanting

Figures in parenthesis are original values and those outside are $\sqrt{x + 0.5}$ transformed value wherein endosulfan was used.

Srinivasan and Krishna (1991) reported that Indian mustard was used a trap crop for the management of cabbage leaf webber. Further, application of Bt var. *kurstaki* 0.2 per cent was effective treatment for the control of leaf webber (Sailaza and Krishnnaiah, 2003). Similarly, Rabindra and Jayaraj (1988) reported that treatment of Bt effectively reduced the larval population of leaf webber at 24 and 48 hrs after the treatment. In present investigation also, mustard was used as a trap crop and Bt was used as bio-pesticide in eco-friendly management module which effectively suppressed the larval population. Thus, the present findings are in confirmation with the past reports.

Army worm, Spodoptera litura (*Fabricius*) :

The army worm larvae started appearing at 6 WAT. All the pest management modules were significantly superior over the untreated module at 6 WAT (Table 2).

At 7 WAT, the lowest number of larvae was found in M_3 (0.12/plant) and it was at par with M_1 (0.14/plant) and M_2 (0.18/plant). Significantly the highest number of larvae was recorded in untreated module (1.04/plant). At 8 WAT, difference in number of larvae in different treatments was found to be non-significant. The data obtained on number of larvae at 9 WAT, 10 WAT, 11 WAT and 12 WAT revealed that minimum larvae of army worm recorded in module M_3 (0.26, 0.38, 0.38 and 0.30/plants, respectively) followed by module M_1 (0.58, 0.78, 0.58 and 0.30/plants, respectively) and module M_2 (0.62, 0.68, 0.62 and 0.44/plants, respectively). The highest number of larvae was recorded in untreated control module (2.28, 2.06, 2.34 and 1.54/plants, respectively).

The pooled analysis of data on mean number of larvae as affected by various treatment modules revealed that all the three modules were significantly superior over untreated control, wherein lowest number of larvae was recorded in synthetic chemical insecticides module which was at par with eco-friendly pest management module. Botanical and bio-pesticides module was next in the order of effectiveness. The highest number of larvae was recorded in untreated control.

The results of present investigation talliy with the findings of Ambekar *et al*. (2009), wherein they reported that the highest mortality of second and fourth instar larvae of *Spodoptera litura* was observed in the treatment of endosulfan 0.04 per cent. Similarly, the effectiveness of endosulfan 35 EC @ 0.07 per cent was proved by Bhavani and Punnaiah (2004). Verma *et al.* (1971) also reported that endosulfan 0.1 per cent was effective against *Spodoptera litura.*

Eco-friendly pest management module and botanical and bio-pesticide pest management module also proved their effectiveness in reducing the number of *Spodoptera litura* larvae. Bt @ 0.2 per cent was effective treatment for the control of *S. litura* as reported by Sailaza and Krishnayya (2003). Karmarkar and Bhole (2000) reported that the treatment of neem based insecticides neemark 2 per cent was effective for the larvae of *S. litura*. Thus, the findings of present study are in confirmation with the past reports.

Diamondback moth, *Plutella xylostella* (Linnaeus) :

Larvae of diamondback moth appeared at 4 WAT.

Table 2 : Mean population of army worm, *Spodoptera litura* Fabricius on cabbage in different treatment modules at Navsari

Treatments (Module)	No. of army worm							Pooled
	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	12 WAT	
T_1 (M_1)	0.86 a (0.26)	0.80 a (0.14)	1.01 (0.54)	1.03 a (0.58)	1.13 b (0.78)	1.03 a (0.58)	0.89 a (0.30)	0.98 ab (0.45)
T_2 (M_2)	0.91 a (0.34)	0.82 a (0.18)	1.00 (0.52)	1.05 a (0.62)	1.07 ab (0.68)	1.04 a (0.62)	0.95 a (0.44)	0.99 b (0.49)
T_3 (M_3)	0.93 a (0.38)	0.78 a (0.12)	1.05 (0.64)	0.87 a (0.26)	0.93 a (0.38)	0.93 a (0.38)	0.89 a (0.30)	0.92 a (0.35)
T_4 (M_4)	1.11 b (0.74)	1.24 b (1.04)	1.22 (1.00)	1.66 b (2.28)	1.60 c (2.06)	1.68 b (2.34)	1.43 b (1.54)	1.44 c (1.57)
GM	0.95	0.91	1.07	1.15	1.18	1.17	1.04	1.08
S.E. ± (T)	0.06	0.03	0.06	0.06	0.06	0.06	0.05	0.04
C.D. (P=0.05) (T)	0.17	0.09	NS	0.18	0.19	0.21	0.17	0.12
S.E. ± (PxT)	–	–	–	–	–	–	–	0.06
C.D. (P=0.05) (PxT)	–	–	–	–	–	–	–	0.16
C.V. (%)	12.91	7.15	12.54	11.03	11.93	13.13	12.20	11.90

NS= Non-significant WAT=Weeks after transplanting

Figures in parenthesis are original values and those outside are $\sqrt{x+0.5}$ transformed value

The data on number of larvae of diamondback moth are presented in Table 3. The number of larvae did not differ significantly among different treatment modules at 4 and 5 WAT. At 6 and 7 WAT, lower number of larvae was recorded in module M_3 (1.50 and 1.34/plant, respectively) followed by module M_1 (2.40 and 1.42/plant, respectively) and module M_2 (2.52 and 1.56, respectively). At 8 and 9 WAT, lower number of larvae was recorded in module M_3 (1.46 and 1.88/plant, respectively) followed by module M_1 and module M_2. At 10, 11 and 12 WAT, lower number of larvae was found in module M_3 (2.32, 2.02 and 1.96/ plant, respectively) followed by module M_1 (2.58, 2.16 and 1.90/plant, respectively) and module M_2 (3.40, 2.92 and 2.72/plants, respectively).

The pooled data revealed that minimum number of larvae was recorded in sole synthetic insecticide module (1.61/plant) which was at par with eco-friendly pest management module (1.75/plant) and botanical and bio-pesticides module (2.13/plant). Maximum number of larvae (4.33/plant) was recorded in untreated control.

It is evident from the above results that all the three modules were effective in reducing number of the diamondback moth larvae. Thus, results of present investigation are in confirmation with the findings of Mahalakshmi *et al*. (2002), who reported that spinosad 0.01 per cent was most superior treatment in reduction of larval population of diamondback moth. Similarly, effectiveness of spinosad 25 EC @ 15 g a.i./ha in reducing the larval population of diamondback moth was reported by Walunj *et al.* (2001). While, Suganya Kanna *et al.*

Table 3 : Mean population of diamondback moth, *Plutella xylostella* Linnaeus on cabbage in different treatment modules at Navsari

Treatments (Module)	No. of diamondback moth									Pooled
	4 WAT	5 WAT	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	12 WAT	
T_1 (M_1)	0.80(0.14)	1.40(1.46)	1.69bc(2.40)	1.38a(1.42)	1.41a(1.50)	1.63a(2.22)	1.74ab(2.58)	1.62a(2.16)	1.52a(1.90)	1.50a(1.75)
T_2 (M_2)	0.83(0.20)	1.46(1.64)	1.73b(2.52)	1.42a(1.56)	1.39a(1.48)	1.78a(2.70)	1.97b(3.40)	1.85a(2.92)	1.79a(2.72)	1.62a(2.13)
T_3 (M_3)	0.91(0.34)	1.47(1.68)	1.41a (1.50)	1.34a(1.34)	1.39a(1.46)	1.52a(1.88)	1.67 a(2.32)	1.58a(2.02)	1.55a(1.96)	1.45a(1.61)
T_4 (M_4)	1.00(0.52)	1.51(1.80)	1.75c (2.62)	1.96b(3.34)	2.41b(5.30)	2.60b(6.26)	2.80c(7.34)	2.55b(6.02)	2.51b(5.80)	2.20b(4.33)
GM	0.88	1.46	1.65	1.53	1.65	1.88	2.04	1.90	1.84	1.64
S.E. ± (T)	0.07	0.05	0.09	0.07	0.07	0.12	0.08	0.08	0.11	0.07
C.D. P=0.05) (T)	NS	NS	0.26	0.21	0.22	0.38	0.28	0.24	0.36	0.21
S.E. ± (P×T)	–	–	–	–	–	–	–	–	–	0.09
C.D.(P=0.05) (P×T)	–	–	–	–	–	–	–	–	–	0.24
C.V. (%)	16.57	7.61	11.58	9.95	9.89	14.51	9.83	8.98	14.04	11.63

NS= Non-significant WAT=Weeks after transplanting

Figures in parenthesis are original values and those outside are $\sqrt{\mathbf{x + 0.5}}$ transformed value

Table 4 : Mean population of head eating caterpillar, *Helicoverpa armigera* Hubner on cabbage in different treatment modules at Navsari

Treatments (Module)	No. of head eating caterpillar							Pooled
	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	12 WAT	
T_1 (M_1)	1.13 a (0.78)	1.34 a (1.30)	1.63 a (2.22)	1.67 a (2.34)	1.70 a (2.46)	1.55 a (1.94)	1.44 a (1.60)	1.51 a (1.81)
T_2 (M_2)	1.19 a (0.96)	1.40 a (1.50)	1.81 a (2.78)	1.78 a (2.70)	1.97 a (3.40)	1.70 a (2.44)	1.53 a (1.86)	1.65 a (2.23)
T_3 (M_3)	1.12 a (0.78)	1.33 a (1.30)	1.74 a (2.58)	1.54 a (1.92)	1.72 a (2.50)	1.52 a (1.82)	1.43 a (1.56)	1.50 a (1.78)
T_4 (M_4)	1.74 b (2.56)	1.96 b (3.34)	2.10 b (3.94)	2.54 b (5.98)	2.58 b (6.18)	2.75 b (7.10)	2.64 b(6.50)	2.36 b (5.09)
GM	1.30	1.50	1.82	1.88	1.99	1.88	1.76	1.73
S.E. ± (T)	0.07	0.06	0.10	0.11	0.09	0.07	0.08	0.06
C.D. (P=0.05) (T)	0.21	0.21	0.29	0.32	0.28	0.23	0.24	0.18
S.E. ± (PxT)	–	–	–	–	–	–	–	0.08
C.D. (P=0.05) (PxT)	–	–	–	–	–	–	–	0.24
C.V. (%)	12.04	10.10	11.67	12.51	10.14	8.68	9.95	10.82

NS=Non-significant WAT=Weeks after transplanting

Figures in parenthesis are original values and those outside are $\sqrt{\mathbf{x + 0.5}}$ transformed value

(2005) reported that application emamectin 5 SG @ 10 g a.i./ha effectively reduced the larval population of diamondback moth over the rest of the treatment. While, Muthukumar *et al*. (2007) indicated that spinosad 75 g a.i./ha and emamectin benzoate 10 g a.i./ha were the effective treatments for the control of lepidopterous insect pest of cauliflower. While, the effectiveness of spinosad emamectin benzoate and endosulfan against diamondback moth was reported by Mala (2006). Bansode (2003) found that sequential spraying of quinalphos 0.05 per cent, profenophos 0.07 per cent, malathion 0.05 per cent and endosulfan 0.07 per cent was effective for the control of diamondback moth.

Eco-friendly pest management module which comprises trap cropping, application of neem based insecticides and Bt also proved its effectiveness in controlling the diamondback moth larvae. In past, Srinivasan and Krishna (1991) reported that growing of mustard as a trap crop effectively checked the number of diamondback moth larvae. Similarly, the significant effect of mustard as trap crop for the attraction of diamondback moth was reported by Pawar and Lawande (1995). Singh *et al*. (2006) indicated that intercropping of mustard in cabbage recorded minimum activity of diamondback moth larvae in cabbage. According to Panchabhavi and Sudhindra (1994), Bt based insecticide halt 0.3 kg was the effective treatment for the control of diamondback moth. Justin *et al*. (1990) also reported that Bt effectively reduced the larval population of diamondback moth. According to Pawar and Pokharkar (1995) Bt @ 1 lit./ha was the most effective treatment for the control of diamondback moth. Ojha and Singh (2003) reported minimum number of larvae of diamondback moth, semilooper and head borer in cauliflower intercropped with Indian mustard. Thus, the present findings are in agreement with the past reports.

Head eating caterpillar, *Helicoverpa armigera* Hubner :

The larvae of head eating caterpillar, *Helicoverpa armigera* appeared at 6 WAT and the data are given in Table 4.

Minimum number of larvae (0.78/plant) was observed in eco-friendly pest management module (M_1) as well as sole synthetic insecticide module (M_3) which were at par with botanicals and bio-pesticides module M_2 (0.96/plant). The maximum number of larvae was recorded in untreated module (2.56/plant). Similar trend of effectiveness of different modules was observed at 7 and 8 WAT, wherein number of larvae ranged from (1.30

Table 5 : Yield and economics of different treatments modules on cabbage at Navsari

Sr. No.	Treatments (Modules)	Yields (kg/ha)	Increased yield over control (kg/ha)	*Cost of treatments (Rs./ha)	Gross realization over control (Rs./ha)	Net gain over control (Rs./ha)	Gross BCR	Net BCR
1	2	3	4	5	6	7	8	9
1.	Eco-friendly pest management module (M_1)	26239.5 a	10412.5	7105	104125	97020	01:13.7	1:12.7
2.	Botanical and bio-pesticides pest management module (M_2)	19159.0 a	3332	3980	33320	29340	01:07.4	1:6.4
3.	Sole synthetic insecticide module (M_3)	28322.2 a	12495	2900	124950	122050	01:42.9	1:41.1
4.	Untreated module (M_4)	15827.0b	–	–	–	–	–	–
	S.E.±	0.12						
	C.D. (P=0.05)	0.36						
	C.V.(%)	10.83						

Total cost of insecticides used including two labour per hectare for each spray @ Rs. 100 per day prevailing market price of cabbage = 5 Rs./kg

Insecticide/seed	Price Rs. per kg or lt
Spinosad	2000
Endosulfan	350
Emamectin benzoate	10300
Dimethoate	320
Bt	2030
*Ha*NPV	250 per 100 LE
Neemazol	450
C. carnea	30 per 100 eggs card
Mustard seed	25 per 1 kg

to 3.34 and 2.22 to 2.58 per plant, respectively). At 9 WAT it was indicated that minimum number of larvae was found in module M_3 (1.92/plant) and was at par with module M_1 (2.34/plant) and module M_2 (2.70/plant). Similar trend of effectiveness of different modules was observed at 10 WAT.

At 11 and 12 WAT, the highest number of larvae was recorded in untreated control (7.10 and 6.50/plant), while the lowest number of larvae was found in module M_3 (1.82 and 1.56/plant, respectively) and it was at par with module M_1 (1.94 and 1.60/plant, respectively) and module M_2 (2.44 and 1.86/plant, respectively). The pooled analysis of data over periods indicated that different treatment modules exhibited significant influence on the number of larvae. The lowest number of larvae was recorded in sole synthetic insecticides module (1.78/plant) which was at par with eco-friendly pest management module (1.81/plant) and botanical and bio-pesticides module (2.23/plant), whereas the highest number of larvae (5.09/plant) recorded in untreated control.

In past, Bansode (2003) found that sequential application of quinalphos 0.05 per cent, profenophos 0.07 per cent, malathion 0.05 per cent and endosulfan 0.07 per cent effectively controlled larval population of *Helicoverpa armigera*. Thus, results of present investigation are in confirmation with the findings of past workers.

Pawar *et al.* (1981) reported that NPV recorded effective mortality of *Helicoverpa armigera*. In present study, eco-friendly pest management module which included trap cropping with mustard, Bt and HaNPV was also effective. Thus, the present finding tallies with past report.

Effect of various modules on yield and economics :

Yield :

The data on yield of cabbage heads are presented in Table 5. Statistical analysis of data revealed that all the three pest management modules proved their superiority in increasing yield of cabbage heads by recording significantly higher yield as compared to untreated control. Sole synthetic insecticides module recorded higher yield (28322.0 kg/ha) than rest of the treatments and it was at par with eco-friendly pest management module (26239.5 kg/ha) and botanicals and bio-pesticides module (19159.0 kg/ha). Significantly the lowest yield (15827.0 kg/ha) was recorded in untreated control module.

Components incorporated in sole synthetic insecticides module suppressed the insect pest population, which ultimately helped to increase the cabbage head production. The components such as dimethoate for the control of sucking insect pests and components such as spinosad, endosulfan and emamectin benzoate for the control of lepidopterous pests caused significant effect in reducing the damage caused by various insect pests and ultimately increased the yield. Eco-friendly pest management module was the next effective treatment in recording the yield of cabbage heads which was followed by the sole botanicals and bio-pesticide module. The present findings are more or less similar with those reported by earlier workers. Suganya Kanna *et al.* (2005) reported that the highest yield (30.36 t/ha) of cabbage was obtained by application of newer molecule emamectin benzoate 5 SG @ 10 g a.i./ha.

Economics :

The net gain over control in different treatments was workout by deducting the cost of treatment from the gross realization over control of each treatment and is presented in Table 5. It can be clearly seen from the table that the highest gross realization over control was obtained in sole synthetic insecticides module (124950 Rs./ha) followed by eco-friendly pest management module (104125 Rs./ha) and botanicals and bio-pesticides module (33320 Rs./ha). Similar trend was observed while considering the net gain over control in different modules. Higher net gain was obtained from sole synthetic insecticide module (122050 Rs./ha) followed by eco-friendly pest management module (97020 Rs./ha) and botanicals and bio-pesticides module (29340 Rs./ha).

The data on net benefit to cost ratio (BCR) indicated that sole synthetic insecticide module M_3 highest net BCR (1:41.1) followed by eco-friendly pest management module M_1 (1:12.7) and botanical and bio-pesticides module M_2 (1: 6.4).

LITERATURE CITED

Ambekar, N.M., Bhole, S.R. and Patil, R.S. (2009). Efficacy of some insecticides alone and in combination with neem product against second and fourth instar larvae of *Spodoptera litura*. *Pestol.*, **33**(3) : 46-49.

Anonymous (2005). Interesting facts of cabbage. *Crop care*. Jan.-March : 59-60.

Anonymous (2013). *Indian Horticulture Database*, Pub. by National Horticulture Board, Ministry of Agriculture, Govt. of India. pp. 139-140.

Bansode, G.M. (2003). Integrated management of diamondback moth (*Plutella xylostella* L.) on cauliflower. M.Sc. (Ag.) Thesis, Navsari Agricultural University, Navsari, GUJARAT (INDIA).

Bhavani, B. and Punnaiah, K.C. (2004). Comparative efficacy of selected insecticides against major pests of cabbage. *Pestology*, **28**(8) : 20-27.

Justin, C.G.L., Rabindra, R.J. and Jayaraj, S. (1990). *Bacillus thuringiensis* Berliner and some insecticides against the diamondback moth, *Plutella xylostella* L. on cauliflower. *J. Biol. Control,* **4**(1) : 40-43.

Karmarkar, M.S. and Bhole, S.R. (2000). Studies on efficacy of some Neem products against second and fourth instar larvae of *Spodoptera litura* Fabricus. *Pestology*, **14**(8): 56-57.

Mahalakshmi, M.S., Arjun Rao, P. and Ramachandra Rao, G. (2002). Efficacy of some newer insecticides against *Plutella xylostella* infesting mustard. *Andhra Agric. J.,* **49**(1-2) : 65-68.

Mala R.K. (2006). Studies on biology, population dynamics and chemical control of diamondback moth, *Plutella xylostella* L. on cabbage. M.Sc. (Ag.) Thesis, Navsari Agricultural University, Navsari, GUJARAT (INDIA).

Mallapur, C.P., Bhat, N.S. and Lingappa, S. (1994). Control of cabbage pests by insecticides. *J. Maharashtra Agric. Univ.,* **19**(2): 259-261.

Muthukumar, M., Sharma, R.K. and Sinha, S.B. (2007). Field efficacy of biopesticides and new insecticides against major insect pests and their effect on natural enemies in cauliflower. *Pesticide Res. J*., **19**(2) : 190-196.

Panchabhavi, K.S. and Sudhindra, M. (1994). Bacillus thuringiensis in the IPM of cabbage diamondback moth. *Pestology*, **18**(9) : 28-30.

Pawar, D.B. and Lawande, K.E. (1995). Effects of mustard as a trap crop for diamondback moth on cabbage. *J. Maharashtra Agric. Univ*., **20**(2) : 185-186.

Pawar, V.M., Waghmare, U.M. and Bilapate, G.G. (1981). Studies on nuclear polyhedrosis virus infection in *Heliothis armigera* Hubner and *Trichoplusia ni* Fabricus. *J. Ent. Res*., **5**(2) : 147-151.

Prithwiraj, Pramanik and Chatterjee, M.L. (2003). Efficacy of some new insecticides in the management of diamond back moth *Plutella xylostella* Linnaeus in cabbage. *Indian J. Plant Prot.,* **31**(2) : 42-44.

Rabindra, R.J. and Jayraj, S. (1988). Control of cabbage webworm *Crocidolomia binotalis* Zell. on mustard with Bt and other insecticides. *J. Bio. Control.,* **2**(1): 56-57.

Sachan, J.N. and Srivastava, B.P. (1972). Studies on the seasonal incidence of insect pest of cabbage. *Indian J. Ent.*, **34**(2): 123-129.

Sailaza, K. and Krishnayya, P.V. (2003). Efficacy of *Bacillus thuringiensis* var. *kurstaki* as influenced by neem against insect pests of cauliflower. *Plant Protec. Bull.,* **55**(12) : 27-29.

Sheikh, A.G. and Kushwaha, K.S. (1994). Synergistic interaction of *Bacillus thuringiensis* Berliner with some insecticides against tobacco caterpillar, *Spodoptera litura* Fabricius on cauliflower. *J. Bio. Control,* **8**(2) : 98-101.

Singh, I.P., Singh, R. and Singh, P. (2006). Influence of intercrops on the major pests in cabbage. *Indian J. Ent.*, **68**(2) : 18-186.

Srinivasan, K. and Krishna, M. (1991). Development and adoption of integrated pest management for major pests of cabbage using Indian mustard as a trap crop. *Trop. Pest Mgmt.,* **37**: 26-28.

Suganya Kanna, S., Chandra Sekaran, S., Regupathy, A. and Lavanya, D. (2005). Emamectin 5 SG (Proclaim) – A new insecticide for diamondback moth, *Plutella xylostella* L. management in cabbage. *Pestology*, **29**(3) : 24-27.

Varalakshmi, P., Arjun Rao, P., Madhumati, T., Krishnayya, P.V. and Srinivasa Rao, V. (2007). Efficacy of some eco-friendly and conventional insecticidal treatment against *Lipaphis erysimi* (Kalt.) infesting cauliflower. *Andhra Agric. J.*, **54**(1-2) : 60-62.

Verma, A.N., Verma, N.D. and Singh, R. (1971). Chemical control of *Prodenia litura* (Fab.) (Lepidoptera: Noctuidae) on cauliflower. *Indian J. Hort.*, **28** : 240-243.

Walunj, A.R., Pawar, S.A. and Darekar, K.S. (2001). Evaluation of new molecule, spinosad 2.5 SC for the control of DBM (*Plutella xylostella*) on cabbage. *Pestology*, **25**(9):56-57.