Indian Journal of Agricultural Sciences **91** (12): 1742–6, December 2021/Article
https://doi.org/10.56093/ijas.v91i12.120796

Plant protection module on management of diamondback moth, *Plutella xylostella* and other lepidopteran pests in cabbage

RAJENDRA PRASAD[1]*, B S MANJUNATH[2], B SAVITA S M[1] and MALLIKARJUNA GOWDA A P[2]

Krishi Vigyan Kendra, Ramanagara, UAS, Bengaluru 560 065, India

Received: 16 June 2020; Accepted: 20 July 2021

ABSTRACT

The diamondback moth (DBM), *Plutella xylostella* (L.) is the most destructive insect pest of cruciferous crops throughout the world. The use of trap crops, pheromones, botanicals, bio-agents and safer insecticides for pest control promises to be an important integrated approach in the management of DBM and other lepidopteran pests which helps to solve major environmental and human health problems. A study was designed and carried out at Ramanagara and Bengaluru Rural district during 2017–18 and 2018–19 to understand the effectiveness of IPM module, recommended practices and farmers' practice in cabbage fields.The results revealed that 15 days prior to cabbage transplanting, sowing of Indian mustard (2 rows after 25 rows of cabbage) attracted DBM moths for oviposition, 7 days after transplanting (DAT), installation of WOTA-T traps @ 5 Nos./acre helped in monitoring and mass trapping of DBM moths. The spraying of botanicals, bioagents and safer insecticides as per the schedule, viz. neem soap (10 g/l) after 15 DAT, Spinosad 2.5 SC (1.25 ml/l) after 18 DAT, Emamectin benzoate 5SG (0.5 gm/l) after 21 DAT, Bt (Dipel) (1 g/l) after 35 DAT, Chlorfenapyr 10 SC (1.5 ml/l) after 50 DAT, Spinosad 2.5 SC (1.25 ml/l) after 65 DAT and Emamectin benzoate 5 SG (0.5 gm/l) after 80 DAT, effectively reduced the damage caused by DBM in cabbage fields. The pest incidence in IPM module was negligible resulted in fetching higher yields, quality heads and better returns compared to farmers' practice. Farmers can adopt IPM module as an alternative to insecticides as it is ecologically safe, economically viable and socially well acceptable.

Keywords: Bioagents, Botanicals, Cabbage, DBM, Safer insecticides

Cabbage (*Brassica oleracea* var. *capitata* L.) is a commercially important cruciferous vegetable. In Karnataka, cabbage occupies an area of about 11.11 thousand ha with the total head production of 238.15 MT (Anonymous 2017). The productivity of cabbage is much lower than its potential attributing to many causes and among them insect pests are major constraints. The diamondback moth, *Plutella xylostella* (L.) (Lepidoptera: Plutellidae) can cause more than 90% crop loss and only few fourth stage larvae on a cabbage can make it unacceptable in the market (Verkerk and Wright 1996). Management of insect pests, farmers 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 prove in the long run to be hazardous from consumer's point of view.

Recent studies suggested Indian mustard as a trap crop in cabbage for effective management of diamondback moth (Hooks and Johnson 2003). Pulverised neem seed powder extract (PNSPE) and pulverised neem seed powder formulation (PNSPF) treatments recorded significantly less DBM than other botanicals and chemical insecticides except spinosad (Prasannakumar *et al.* 2013). Similarly, *Bacillus thuringiensis* is one of the most important microbial agents which are used effectively to manage major insects of cabbage (Panchabhavi and Sudhindra 1994). The information on IPM practices for the management of major insect pests is scanty and needs to be updated. Keeping this in mind, the principal focus of this study was to compare different modules along with combination of bio-agents, deterrents and attractants for eco-friendly and efficient management of lepidopteran pests for better yield and high returns.

MATERIALS AND METHODS

The experiment was conducted with cabbage hybrid Unnati at the experimental field of Ramanagara and Bangalore Rural district during 2017–19. The experiments were laid out in simple randomized block design (RBD)

Present address: [1]Krishi Vigyan Kendra, Ramanagara, UAS, Bengaluru; [2]Krishi Vigyan Kendra, Bengaluru Rural, UAS, Bengaluru. *Corresponding author e-mail: rajendrayadav007@gmail.com.

and replicated seven times. The crop was raised with recommended agronomic practices with plot size of 25 × 20 m for each module at 60 cm × 45 cm spacing. Crop was raised under similar agronomic situations and the schedule of management practices were followed as per the modules for two consecutive crop seasons.

Time and methods of application of treatment: *M_1: Modules 1*: Synthetic chemical management, viz. Flubendiamide 39.35 SC (0.05%), Emamectin benzoate 5 SG (0.05%), Spinosad 2.5 SC (0.15%), Fipronil 5 SC (0.15%), Rynaxypyr 20 SC (0.025%), Novaluron 10 EC (0.15%), Chlorofenapyr 10 SC (0.10%), Chloropyriphos 20 EC (0.20%) – Farmers practice.

M_2: Module 2: Intercropping with mustard (25:2), spray the crop with 5% NSKE– recommended by University of Agricultural Sciences, Bengaluru (UAS, B).

M_3: Module 3: Intercropping with mustard (trap crop) (25:2), Installation of WOTA-T traps (DBM traps), Use of sticky traps, Spray of Bt (1 g/l), Neem soap (10 g/l), Entomopathogenic fungi (*Beauveria bassiana*) (0.20%), Emamectin benzoate 5 SG (0.05%), Chlorfenapyr 10 SC (0.10%), Spinosad 2.5 SC (0.15%) – recommended by Indian Institute of Vegetable Research, Varanasi (IIVR, Varanasi).

To study the incidence of major insect pests, viz. DBM and webworm of cabbage, weekly observations were recorded throughout the crop season. Ten plants were selected randomly to record the observations from each plot. The DBM and cabbage webworm incidence was assessed on the basis of number of larvae present on 10 randomly selected plants from each module. The number of DBM and cabbage webworm larvae was recorded from the entire plant at weekly interval. The effectiveness in terms of yield was recorded from the whole plot as total weight of marketable crop. The marketable heads were classified and graded into three groups according to the local practice. Class A heads had no visible damage; class B had slight feeding damage (heads marketable after peeling-off three to four leaves), class C had severe damage (heads only marketable after removal of more than four leaves).

Statistical analysis: The data on population of DBM and cabbage webworm larvae were analyzed after due square root transformation. The data were also statistically analyzed by ANOVA (Cochran and Cox 1957) and the differences among means were tested by using critical differences (CD) values at 5% level of probability. For judging overall performance of modules, the pooled analysis of data over different intervals was also carried out. Overall efficacy and economics of modules in managing the insect pests was analysed using the mean pest incidence, cabbage yield, additional net income and benefit-cost (B:C) ratio as;

$$\text{C:B ratio} = \frac{\text{Additional income over farmers practice}}{\text{Additional cost over farmers practice}}$$

RESULTS AND DISCUSSION

Effect of various modules on DBM incidence, yield and economics: The pest management modules, viz. UAS,

Table 1 Mean larval population of DBM, cabbage webworm and yield of cabbage in different treatment modules during 2017-19

Treatment	Observations on DBM incidence (No. of larvae/10 plants)											Average DBM incidence	Average webworm incidence	Yield (t/ha)
	Pre count	3 WAT	4 WAT	5 WAT	6 WAT	7 WAT	8 WAT	9 WAT	10 WAT	11 WAT	12 WAT			
M_1	2.47	2.34	3.62	4.48	6.33	8.48	9.57	9.82	10.17	9.05	8.10	6.77 $(2.70)^b$	0.44 $(0.97)^b$	35.12^b
M_2	2.47	3.15	5.88	6.87	8.06	9.34	11.03	11.49	11.50	10.97	10.53	8.30 $(2.97)^a$	0.58 $(1.04)^a$	33.22^c
M_3	2.55	0.92	1.09	1.33	1.57	2.04	2.14	2.31	1.89	1.46	1.48	1.71 $(1.49)^c$	0.27 $(0.88)^c$	42.20^a
SEm±						---						0.22	0.06	0.64
CD (P=0.05)						---						0.52	0.13	1.88
CV %						---						13.08	13.54	16.33

WAT=Weeks after transplanting. *Figures in parenthesis are square root transformed values; **Figures followed by letters in the column differ significantly by DMRT (P=0.05); M_1- Farmers' practice; M_2–UAS recommended practice; M_3–IPM module.

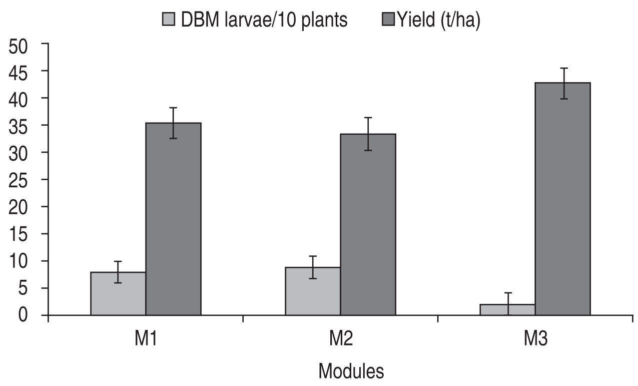

Fig 1 Influence of modules on DBM incidence and yield in cabbage. [a] Figures within a column followed by different letters are significantly different, P<0.05; M_1-Farmers' practice; M_2–UAS recommended practice; M_3–IPM module.

Bengaluru recommended technology (M_2) and IIVR, Varanasi IPM technology (M_3) were compared with Farmers' practice (M_1) for the management of major insect pests of cabbage, viz. diamondback moth, *P. xylostella* and cabbage webworm, *H. undalis.* All the modules showed damage symptom by *P. xylostella* larvae but differed measurably from other modules. The data on number of diamondback moth larvae are presented in Table 1. The number of larvae did not differ significantly among different modules till 2 weeks after transplanting (WAT). At 3 WAT onwards lower number of larvae was recorded in module M_3 followed by module M_1 and M_2. The pooled data revealed that minimum number of larvae was recorded in IPM module (M_3) (1.71/10 plants) which was superior to farmers practice (M_1) (6.77/10 plants) and recommended practice (M_2) (8.30/10 plants) (Fig 1). Cabbage webworm webs the leaves and bore into the stem, stalks or leaf veins. The pooled data revealed that minimum number of cabbage webworm larvae was recorded in IPM module (M_3) (0.27/10 plants) which was statistically superior to farmers' practice (M_1) (0.44/10 plants) and recommended practice (M_2) (0.58/10 plants) (Table 1). Statistical analysis of data on yield of cabbage heads revealed that IPM module M_3 (42.20 t/ha) evidenced highest increase in yield of cabbage heads by recording significantly higher yield as compared to M_1 (35.12 t/ha) and M_2 (33.22 t/ha) (Fig 1).

The marketable yield was analysed based on distribution percentage of cabbage heads in three grading classes. The data showed that 89% of class A of total marketable heads in IPM module (M_3) and was statistically significant in comparison with farmers practice (M_1 - 76%) and recommended practice (M_2-69%) (Fig 2). The marketable heads in IPM module increased by 1.17 and 1.29 times as compared to farmers' practice and recommended practice, respectively. A relatively high number of class B and class C cabbage heads were harvested in recommended practice. The numbers of plant protection sprays during cropping period were less in IPM module (7 nos.) compared with farmers' practice (11 nos.) and recommended practice (9 nos.) (Table 2). Thus, results of present investigation are in confirmation with the findings of Mallapur *et al.* (1994).

Economics: The net income in different modules was calculated by deducting the gross cost of module from the gross income (Table 2). It can be clearly seen that the highest net returns was obtained in IPM module-M_3 (458832 ₹/ha) followed by farmers practice-M_1 (345370 ₹/ha) and recommended practice-M_2 (327406 ₹/ha). The additional income over farmers practice was positive in IPM module-M_3 (113462 ₹/ha), whereas there was negative in recommended practice (-17964 ₹/ha) compared to farmers practice. However, net benefit to cost ratio (BCR) indicated that IPM module-M_3 obtained highest net BCR (1:5.50) followed by recommended practice-M_2 (1:3.96) and farmers practice-M_1 (1 : 3.88). Hence, schedules of technology application for effective and efficient management of DBM and other lepidopteran pests in cabbage have been developed and thus, residue free produce can be obtained. This schedule is found to be more eco-friendly, environmentally compatible and safe for human health as well as agro-ecosystem.

It is evident from the above results that IPM module (M_3) was effective in reducing diamondback moth infestation. Eco-friendly pest management module which comprises trap cropping, sex pheromone traps, application of neem based insecticides, Bt and green molecules proved its effectiveness in controlling the diamondback moth. Thus, growing of two rows of mustard after every 25 rows of cabbage as a trap crop reduced 80-90% of DBM population and other pests. (One row of mustard is sown 15 days before cabbage planting and a second row 25 days after planting of cabbage). DBM larvae colonized on mustard, sparing the main cabbage crop and results of present investigation are in confirmation with Srinivasan and Krishnamoorthy

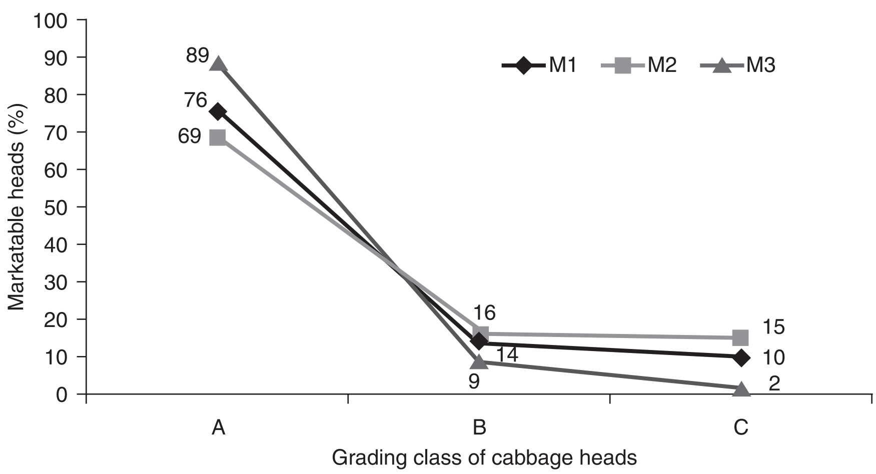

Fig 2 Distribution (%) of marketable cabbage heads in grading class. M_1- Farmers' practice; M_2–UAS recommended practice; M_3–IPM module.

Table 2 Pooled data on yield and B: C ratio on cabbage in different treatment modules during 2017-2019 at Ramanagara and Bengaluru Rural district

Technology assessed	Yield (t/ha)	No. of sprays during crop period	Cost of chemical sprays/ha (includes labour)	Gross cost	Gross income	Net income	Additional income over farmers practice	B:C ratio
M_1	35.12	11	46075	119825	465195	345370		3.88
M_2	33.22	09	31675	110450	437856	327406	- 17964	3.96
M_3	42.20	07	25450	101950	560782	458832	113462	5.50

Avg. cost per kg – ₹13.13/-; M_1-Farmers practice; M_2–UAS recommended practice; M_3–IPM module.

(1992). Bansode (2003) reported minimum number of larvae of diamondback moth, semi-looper and head-borer in cauliflower intercropped with Indian mustard.

Lepidopteran insect males find the females by following the smell of the sex pheromone and then they mate. The mode of action of the pheromone is to affect the mating of DBM resulting in population reduction. The communication disruption technique using DBM sex pheromones is quite useful in reducing the population density when applied on a field. Botanicals affect the colonization and feeding through deterrent actions. Microbial pesticides (Bt) offer high potential for delaying the development of resistance. These are more effective when used in combination with chemical insecticides. Entomopathogenic bacteria paralyze or kill their host by adversely affecting growth and development of host insects. The present findings are in conformation with Mohan and Gujar (2000) Bt @ 1 l/ha was the most effective treatment for the control of diamondback moth. Sheikh and Kushwaha (1994) reported that *B. thuringiensis* recorded 58.37 and 38.22% of *S. litura* @ 4.40×10^8 and 2.20×10^8 viable spores/ml, respectively.

Insect growth regulators cause blockage, disruption or inhibition from biosynthesis, storage, release, transport and reception to disturb behavioural or physiological activities which may ultimately prove lethal to insects. However, newer insecticides are safer to ecological system which can efficiently manage the incidence of DBM. The present results are in agreement with Mahalakshmi *et al.* (2002), who reported that spinosad 0.01% was most superior treatment in reduction of larval population of diamondback moth. While, Muthukumar *et al.* (2007) indicated that spinosad and emamectin benzoate were the effective in controlling lepidopterous insect pests in cauliflower. However, Somnath *et al.* (2015) opined that sole synthetic insecticide module performed better with DBM incidence and yield. However, its effect in destructing natural fauna, polluting environmentand causing residual problem should be overlooked. Eco-friendly pest management module and botanicals and bio-pesticides module was also effective in recording yield and net profit besides without adverse effect and did not leave any toxic residue. Gautam *et al.* (2018) reported that the novel insecticides in conjunction with other IPM approaches may play a pivotal role in devising effective management strategy against diamondback moth.

Based on the present studies, it can be concluded that IPM module has proven its outstanding efficacy for the control of insecticide-resistant DBM populations and other lepidopteran pests. IPM module is a valuable alternative to insecticides as it is ecologically safe, economical and socially satisfactory as well.

ACKNOWLEDGEMENTS

Authors are highly grateful to Agricultural Technology Application Resources Institute (ATARI), Indian Council of Agricultural Research, Zone XI India for encouragement and financial support to the research work..

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