Formulation and Validation of organic insect pest management module for pests of cabbage and cauliflower in valley and foot hills region, Manipur

ABSTRACT

During the rabi seasons from 2017 to 2020 in the valley and foothill regions of Imphal, Manipur, a study was conducted to design and test three different organic insect pest management modules for cabbage and cauliflower. The focus was on three major pests: cabbage butterfly, diamondback moth, and cabbage aphid. Module three (M-3) emerged as the most effective strategy, incorporating various organic practices. This included seed treatment with *Trichoderma harzianum* at 10g/kg seed and soil drenching in nursery plots at 25g/100 m^2, intercropping with mustard, application of anonnin extract at 5 ml/litre, Spinosad 45% SC (biopesticide) at 3ml/10 litres, and *Verticillium lecanii* at 10 ml/litre. Additionally, the module incorporated the installation of yellow sticky traps for aphids and pheromone traps for diamondback moths for monitoring and mass trapping. The results indicated that Module 3 performed well than other modules and the control group in reducing insect pest incidence on cabbage and cauliflower. Moreover, it contributed to an increased yield, demonstrating its superiority in organic insect pest management for both valley and foothill regions. This underscores the effectiveness of a holistic and integrated approach to pest management in organic farming practices.

Keywords: Cabbage, Cauliflower, Cabbage butterfly, Diamond back moth, Cabbage aphids, organic insect pest management, Manipur

1. INTRODUCTION

Cole crops are widely cultivated for their nutritional benefits. In 1984, the FAO recognized cabbage as one of the top twenty vegetables, highlighting its crucial role in sustaining the global population's food needs [1]. Traditionally grown during the rabi season, these crops are now cultivated year-round. In India during 2012-13, cabbage occupied an area of approximately 372.4 hectares, yielding 8534.2 MT, while cauliflower covered 402.2 hectares with an annual production of 7886.7 MT [2]. Despite their significance, the productivity of cole crops falls short of expectations due to various biotic factors, with insect pests, notably, causing substantial economic losses [10].

Cole crops faces attacks from several pests, including the diamond black moth (DBM) (*Plutellaxylostella*), cabbage caterpillar (*Peiris brassicae*), and cabbage leaf webber (*Crocidolomiabinotalis*). The yield loss from these major pests ranges from 48.5-51.6% for cabbage leaf webber, 69.2% for cabbage caterpillar, and 77.4-99.1% for the diamond black moth [15]. Consequently, the use of chemical pesticides has been a conventional practice in pest management, though often applied in high quantities and unscientific patterns. Over the past six decades, chemical applications have played a crucial role in pest control, but there is growing evidence of potential risks to the ecosystem and human health [5].

In Manipur, pesticide consumption reaches 26-30 Mt/acre, leading to concerns such as the depletion of natural enemies, environmental pollution, resurgence, residue problems, and the development of insecticide resistance in the diamond black moth against various insecticides [19]. As a result, organic pest management has garnered widespread recognition globally, with Manipur emerging as a hub for organic vegetables. In this region, farmers have achieved a cabbage yield of approximately 245 q/hectare in a single season, excluding profits generated during the off-season. This underscores the growing importance and success of organic farming practices, particularly in promoting sustainable and environmentally friendly approaches to agriculture. This study aims to identify alternative, environmentally friendly pest management methods compatible with eco-friendly pest management programs. With this perspective in mind, the present research plans to synthesize three different organic pest management modules and compare them with an untreated control group.

2. MATERIAL AND METHODS

The research experiment was conducted at the Entomology farm, ICAR-RC-NEH Region, Manipur centre, spanning both the Lamphel and Langol farms in Lamphelpat, Manipur, India. This initiative took place during the rabi season across the years 2017-18, 2018-19, and 2019-20. Employing a Randomized Block Design (RBD), the experiment comprised four modules, including an untreated control, and each module had three replications. The crops were cultivated using recommended agronomic practices, with a plot size of 3x3 m for each module and a spacing of 50x50 cm. The selected varieties for cabbage and cauliflower were Rareball and Candid Charm, respectively.

Time and methods of application of treatment:

M1 (Module 1): Seed treatment with *Trichoderma harzianum* @ 10g /Kg seed. One row of marigold was sown on the border of experimental plot as trap crop. Application of Neem seed kernel extract (NSKE) @ 75 ml/ litre as preventive spray after 15 days of transplanting. Installation of yellow sticky trap (for aphids) and pheromone traps for diamond back moth for monitoring and mass trapping. Spray of *Beauveria bassiana* (biopesticide) @ 10g / litre for cabbage butterfly and diamond back moth. Spraying of *Verticillium lecanii* @ 10 ml/ litre for management of cabbage aphids.

M2 (Module 2): Soil drenching in nursery plots with *Trichoderma harzianum* @ 25g / 100m^2. One row of mustard was sown on the border of experimental plot as trap crop. Application of karanjin extract @ 2ml/litre as preventive spray after 15 days of transplanting. Installation of yellow sticky trap (for aphids) and pheromone traps for diamond back moth for monitoring and mass trapping. Spray of *Bacillus thuringiensis* (biopesticide) @ 2 g/litre for cabbage butterfly and diamond back moth. Spraying of *Verticillium lecanii* @ 10 ml/ litre for management of cabbage aphids.

M3 (Module 3): Seed treatment with *Trichoderma harzianum*@ 10g /Kg seed and Soil drenching in nursery plots with *Trichoderma harzianum*@ 25g / 100m^2. Intercrop of mustard was sown on the border and after every two row of main crop of experimental plot. Application of anonnin extract @ 5 ml/litre as preventive spray after 15 days of transplanting. Installation of yellow sticky trap (for aphids) and pheromone traps for diamond back moth for monitoring and mass trapping. Spray of Spinosad 45% SC (biopesticide) @ 3ml/ 10 litre for cabbage butterfly and diamond back moth. Spraying of *Verticillium lecanii* @ 10 ml/ litre for management of cabbage aphids.

M4 (Module 4): Untreated control. Crop was sprayed only with water.

To assess the incidence of major pests affecting cabbage and cauliflower, weekly observations were meticulously documented throughout the crop season. Data collection involved examining five randomly selected plants from each replication. The presence of Diamondback moth and cabbage butterfly was evaluated based on the number of larvae found on five randomly selected plants in each replication. Aphids were quantified by counting them on five randomly selected plants in each replication. The aphid observations were recorded by assessing one square inch leaf area from two leaves per plant, examining both sides of the leaves at weekly intervals until the crops reached maturity. This process was facilitated by using a cardboard template.

As part of the pest management strategy, the first application of botanicals was administered 15 days after transplanting as a preventive measure, and biopesticides were applied after the 4th or 5th week post-transplanting. If necessary, a second spray was conducted after the 8th or 9th week, depending on the pest population observed on the crops. Regular monitoring was conducted throughout the entire crop period to ensure timely intervention. The data on the larval population of Diamondback Moth, Cabbage butterfly, and the aphid population were analyzed after applying the square root transformation in the context of the Randomized Block Design (RBD). To assess the overall performance of the modules, a pooled analysis of data over different intervals was also carried out.

3. RESULTS AND DISCUSSION

The pest management modules were compared with untreated module (control) for the management of major insect pests of cabbage and cauliflower viz., Cabbage butterfly, Aphids and Diamond back moth.

Efficacy of various modules on major insect pests:

Cabbage butterfly: The data revealed that cabbage butterflies emerged shortly after the transplanting of cabbage and cauliflower. The mean number of larvae per plant exhibited significant differences among various treatment modules. During the first and second weeks after transplanting (WAT), a lower number of larvae were observed in module 3, and this was comparable to the larval counts in module 1 and module 2. In the subsequent 3rd and 4th WAT, module 3 recorded the lowest larval numbers, followed by module 2 and module 1, respectively. Throughout the 5th to 8th WAT, module 3 consistently showed lower larval counts, equivalent to module 2. However, by the 9th and 10th WAT, the untreated control (module 4) exhibited the highest larval numbers.Upon pooling the data over three years, module 3 demonstrated the lowest cabbage butterfly population, averaging 0.07 larvae per plant. Consequently, module 3 yielded the most favorable outcomes and was on par with module 2, both in the valley and foothill regions (Table 1).

Table 1: Mean population of cabbage butterfly on cabbage and cauliflower in different module

Treatments (Modules)	Mean number of cabbage butterfly larvae/ plant (Pooled from 3 years data)			
	Lamphel		Langol	
	Cabbage	Cauliflower	Cabbage	Cauliflower
M1	0.26 (0.87)	0.39 (0.93)	0.21 (0.84)	0.53 (1.00)
M2	0.12 (0.78)	0.11 (0.78)	0.08 (0.76)	0.10 (0.77)
M3	0.07 (0.75)	0.08 (0.76)	0.08 (0.76)	0.11 (0.78)
M4	3.12 (1.86)	3.44 (4.02)	2.76 (1.75)	3.22 (1.88)
LSD at 5%	0.10	0.09	0.08	0.10

Diamond back moth: The data revealed that diamondback moths appeared one week after the transplanting of cabbage and cauliflower. The mean number of larvae per plant exhibited significant differences among different treatment modules after 2 weeks after transplanting (WAT). During the 3rd and 4th WAT, a lower number of larvae were recorded in module 3, which was comparable to the larval counts in module 1 and module 2. Throughout the 5th, 6th, and 7th WAT, lower numbers of larvae were observed in module 2 and 3, and these were at par with module 1. By the 8th, 9th, and 10th WAT, lower numbers of larvae were recorded in module 3, and it was at par with module 2. However, by the 9th and 10th WAT, the untreated control (Module 4) exhibited the maximum number of larvae.Upon pooling the data over three years, module 3 demonstrated the lowest diamondback moth population, averaging 0.06 larvae per plant. Consequently, module 3 yielded the most favorable results and was on par with module 2, both in the valley and foothill regions (Table 2).

Table 2: Mean population of Diamond back moth on cabbage and cauliflower in different module

Treatments (Modules)	Mean number of DBM larvae (Pooled from 3 years data)			
	Lamphel		Langol	
	Cabbage	Cauliflower	Cabbage	Cauliflower
M1	0.13 (0.79)	0.16 (0.81)	0.11 (0.78)	0.14 (0.80)
M2	0.07 (0.75)	0.06 (0.75)	0.05 (0.74)	0.06 (0.75)
M3	0.06 (0.75)	0.06 (0.75)	0.04 (0.74)	0.05 (0.74)
M4	0.80 (1.13)	0.90 (1.17)	1.02 (1.21)	1.19 (1.27)
LSD at 5%	0.07	0.07	0.07	0.08

Aphids (No of aphid / square inch leaf area): The data revealed that cabbage aphids made their appearance 5 weeks after the transplanting of cabbage and cauliflower. The mean number of aphids per square inch leaf area showed significant variations among different treatment modules. At 6, 7, 8, 9, and 10 weeks after transplanting (WAT), a lower number of aphids per square inch leaf area were recorded in module 3, and this was comparable to module 2. By the 9th and 10th WAT, the untreated control (Module 4) exhibited the maximum number of aphids.Upon pooling the data over three years, module 3 demonstrated the lowest cabbage aphid population, averaging 0.23 aphids per square inch leaf area. Therefore, module 3 yielded the most favorable results and was on par with module 2, both in the valley and foothill regions (Table 3).

Table 3: Mean population of cabbage aphids on cabbage and cauliflower in different module at lamphel farm (Number of aphids / square inch leaf area)

Treatments (Modules)	Mean number of cabbage aphids (Pooled from 3 years data)			
	Lamphel		Langol	
	Cabbage	Cauliflower	Cabbage	Cauliflower
M1	0.91 (1.16)	1.02 (1.21)	0.63 (1.04)	1.01 (1.20)
M2	0.48 (0.84)	0.37 (0.91)	0.31 (0.84)	0.22 (0.84)
M3	0.23 (0.97)	0.47 (0.97)	0.21 (0.89)	0.26 (0.86)
M4	4.64 (2.25)	4.96 (2.31)	4.41 (2.20)	5.00 (2.33)
LSD at 5%	0.20	0.17	0.13	0.10

Furthermore, the results indicate that Module 3 recorded the highest Benefit-Cost (BC) ratio, while Module 1 exhibited the lowest (Table 4). Importantly, all modules demonstrated better results compared to the untreated control.

Table 4: Effect organic pest management modules (Treatments) on yield of cabbage and cauliflower

Treatments (Modules)	Lamphel (Pooled from 3 year data) BC ratio		Langol (Pooled from 3 year data) BC ratio	
	Cabbage	Cauliflower	Cabbage	Cauliflower
M1 (Module 1)	1:8.0	1:3.9	1:8.2	1:3.5
M2 (Module 2)	1:10.8	1:5.3	1:11.1	1:5.1
M3 (Module 3)	1:12.4	1:6.39	1:12.7	1:6.41
M4 (Module 4)	-	-	-	-

The obtained results on the superior performance of spinosad in suppressing the butterfly larvae align with Rangad*et al*.'s (2014)[11] findings, where spinosad was reported to kill the maximum number of larvae after fifteen days of application. Singh *et al*. (2006)[17] demonstrated that intercropping mustard with cabbage resulted in minimal activity of diamondback moth larvae in cabbage. Similarly, Ojha and Singh (2003)[8] reported the minimum number of larvae of diamondback moth, semilooper, and head borer when intercropped with Indian mustard. The current investigation aligns with the findings of Shukla and Kumar (2006) [16], who advocated for the incorporation of Azadirachtin at 2.0 liters/ha in pest management modules, highlighting it as the optimal component for reducing larval populations and maximizing yield. The efficacy of *Bacillus thuringiensis var. kurstaki* in combination with neem as a successful component of Integrated Pest Management (IPM) was also validated by Sailaza and Krishnayya (2003)[13]. Bhardwaj *et al*. (2017)[3] tested various IPM modules, including botanicals and biopesticides, and found them effective in managing pests of cabbage crops, leading to increased yields.The efficacy of microbial products against cabbage butterfly on cabbage was also supported by studies using spinosad[7] , *B. thuringiensis* [6,9], and *B. bassiana*[12]. Singh *et al*. (2015)[18] tested these microbials along with novel organic biopesticides and found them effective in managing both cabbage butterfly and diamondback moth. Deshmukh *et al*. (2015)[4] and Shashni (2015)[14] also reported similar results with the use of biopesticides.In summary, the present findings harmonize with a combination of past reports related to sustainable pest management in cabbage. This study serves as an initial step toward constructing a location-specific IPM module for cabbage.

4. CONCLUSION

The present findings highlight that Module 3, incorporating seed treatment with *Trichoderma harzianum* at 10g/kg seed, soil drenching in nursery plots at 25g/100m^2, intercropping with mustard, application of anonnin extract at 5 ml/litre, Spinosad 45% SC (biopesticide) at 3ml/10 litres, and *Verticillium lecanii* at 10 ml/litre, coupled with the installation of yellow sticky traps (for aphids) and pheromone traps for diamondback moths for monitoring and mass trapping, proved to be the most effective in organic insect pest management of cabbage and cauliflower. This approach presents a promising strategy for pest management without reliance on chemical solutions. Importantly, it contributes to maintaining ecological balance by preserving natural enemies, microflora, and fauna, thereby suppressing insect pests at a natural level.These modules are environmentally friendly, non-toxic to humans and animals, and do not harm the ecosystem. Therefore, the adoption of these modules can assist farmers in reducing the pesticide load on crops, effectively managing pests, and providing a high remunerative value for their produce. This approach promotes sustainable and ecologically responsible agricultural practices.

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