Reflex of Different Pest Management Modules against Sucking Insect-pests and Pod Borer for the Safety of Beneficial Insects in Vegetable French Bean (*Phaseolus vulgaris* L.)

Hongal Shivanand[1], H.P. Maheswarappa[2], Gurav Shrishail Gopal[1], S.B. Gurumurthy[1], R. Raghunatha[1]
K.S. Raghavendra[1], T.V. Sowjanya[1], Divya S. Bhat[1], Phatak Rahul[1], N. Ashoka[1]
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ABSTRACT

Background: Natural farming (NF) is a farming system that uses environmentally friendly pest and disease management practices. In contrast to chemical farming, it avoids use of synthetic fertilizers, pesticides and fungicides and hence, offers an alternative way for the eco-friendly pest management for the sustainable crop production. French bean crop is ravaged by wide array of insect pests wherein, sucking insect-pests like aphids, leaf miner and pod borer causing considerable damage. To manage these pests, farmers are spraying both recommended and non-recommended synthetic chemical pesticides having adverse effects on environment and human beings.

Methods: Field experiment was conducted to evaluate the pest management strategies against sucking insect-pests and pod borer infesting French bean over a period of three years from 2019-20 to 2021-22 at College of Horticulture, Sirsi, Uttar Kannada (Hill Zone of Karnataka) during summer season. Four pest management modules *viz*., farmers practice, organic farming, natural farming (NF) and recommended package of practices (RPP) were evaluated to manage the pests in an eco-friendly manner. The field experiment was laid out in a randomized block design with five replications comprising of four treatments. The standard protocol was followed for recording observations.

Result: Among the different modules tested, farmers practice recorded lowest population of aphids, leaf miner and pod borer and was at par with recommended package of practices. Whereas, Organic farming and natural farming recorded moderate level of pest infestation and quite safe for maintaining the predators like Coccinellids, *Chrysoperla carnea* and spider population for natural predation. The cost of plant protection measures was also least in these modules which indicates the socially and economically acceptable farming practices which may be adopted for safer French bean production.

Key words: Brahmastra, Natural farming (NF), Neemastra, Organic farming.

INTRODUCTION

French bean, (*Phaseolus vulgaris* L.) is an important legume vegetable belonging to family Fabaceae also known as Rajmash, Snap bean, Kidney bean and Garden bean. It is an important source of protein for many developing countries. It approximately accounts to 90 per cent of total bean production (Voysest and Dessert, 1991). In India, French bean as a legume vegetable plays a major role in nourishment of human population with a proteinaceous diet which supplies protein (1.8 g). The crop has more social and economic significance than other legume vegetable crops (Ashoka *et al*., 2021). Due to high protein content (21.1%), French bean plays a strategic role against protein calorie malnutrition in India (Kumar *et al*., 2006).

Leguminous crops are susceptible to many abiotic and biotic stresses. Pest and disease problems are the major constraints to the productivity of the common bean, particularly in the tropics (Graham and Vance, 2003). Worldwide, yield losses due to insect pests alone have been estimated to the tune of 35 to 100 per cent annually (Singh and Schwartz, 2011). The major insect and mite pests infesting French bean are bean stem fly, aphids, mites, whitefly, leaf miner, pod borers and bean gall weevil and Acarina (spider mites) under open field conditions (Mondal *et al*., 2018). Several workers *viz*., Singh (2013); Noor *et al.* (2014) and Singh and Singh (2015) have reported insect pests of French bean from various regions of India. The larvae of leaf miner (*Liriomyza trifolii* Burgess) feed on the

[1]Natural Farming Project, College of Horticulture, University of Horticultural Sciences, Sirsi-581 401, Karnataka, India.
[2]University of Horticultural Sciences, Bagalkote-587 104, Karnataka, India.

Corresponding Author: Gurav Shrishail Gopal, Natural Farming Project, College of Horticulture, University of Horticultural Sciences, Sirsi-581 401, Karnataka, India. Email: shrishailagri@gmail.com

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leaf parenchyma, which reduces the photosynthetic leaf area and provides entry points for foliar pathogens. Infested and injured leaves become necrotic and may drop prematurely, leading to poor yields. Aphids (*Aphis craccivora* Koch) suck the sap from stem, leaves and pods leading to shrivelling and crinkling. While, pod borer *Maruca vitrata* (fabricius) bore holes into the pods and feed on internal content causing complete damage of beans.

Economic significance of the French bean compelled the farmers to use more frequent applications of recommended for suppressing the insect pest population which leads to residue problems and the elimination of beneficial insects. Within the farming systems, beneficial insects especially parasitoids, predators and pollinators contribute to reinforce the ecological stability of the cropping eco-system and thereby increasing the crop yield (Nuessly *et al*., 2004; Landis *et al*., 2005; Kasina *et al*., 2006). In the recent years, pest management strategies have receiving greater attention across the globe for their utilization as eco-friendly and sustainable approach and hence, there is a need to develop indigenous pest management modules for the safer and healthier production of vegetable crops. With this brief background, the present experiment was conducted on evaluation of pest management modules against sucking insect-pests and pod borer for the safety of beneficial insects in vegetable French bean.

MATERIALS AND METHODS

Bio-efficacy study

The experiment was conducted to evaluate different management practices *viz*., farmers practice, organic practice, NF and recommended package of practice approaches in management of insect pests infesting French bean. The experiment was conducted at College of Horticulture, Sirsi, Uttar Kannada, India (Hilly Zone of Karnataka) and laid out in randomized block design (RBD) with four treatments and five replications during 2019-20 to 2021-22. The French bean Arka Sharath variety used with spacing of 30 × 45 cm. Plants were well maintained with all the agronomic practices as per package of production UHS, Bagalkot suggests that 25 ton of farm yard manure, recommended dose of fertiliser like nitrogen, phosphorus and potash were 63:100:75 kg/ha, respectively. Plant protection measures were chosen based on previous reviews against insect pest and diseases. For each treatment, five plants per replication were tagged with red ribbons and further observations were recorded.

Treatment imposition in different practices

The conventional chemical pesticides *viz*., Imidacloprid 17.8% SL, Abamectin 1.9% EC, Dimethoate 30% EC, Emamectin benzoate 5% SG and Azadirachtin 3000 PPM (neem oil) were obtained from local market and the neemastra and agniastra are prepared by using locally available materials as given below. The treatments were imposed when the pest incidence was noticed and pest incidence was recoded at 3, 5 and 7 days after spray. The spraying was done using Knapsack sprayer @ 500 lit/ha.

Neemastra

Around 200 lit water capacity barrel or tank was taken and 10 lit cow urine+2 kg cow dung + 10 kg neem leaves (small chaffed leaves) were added in the barrel. Then, daily for around two to three times the content stirring with wooden stick was carried out in clock wise direction and covered it with gunny bag and placed under shadow for 48 hrs so that the alkaloids present in the solution get dissolved. The stirring of content was done in morning and evening hours for 1 minute. Then the solution was filtered by using muslin cloth (Maru *et al*., 2021).

Brahmastra

Around 40-50 lit capacity barrel was taken wherein 20 lit of cow urine+2 kg neem leaf paste+2 kg *Pongamia pinnate* leaf paste/*Lantana camera*+ 2 kg datura leaf paste/2 kg custard apple paste + 2 kg castor leaf paste/2 kg custard apple leaf paste was added. The solution was boiled for 4-5 times in mud or steel pot under low flame for 1 hr, continuous stirring was done while boiling the contents and covered with lid. Then the solution was allowed to cool for 48 hrs where all alkaloids will dissolve in it. Daily morning and evening hours stirring was carried out for 1 minute and content was filtered by using muslin cloth (Maru *et al*., 2021).

Observations

The standardised protocol was followed for recording observations as follows. The data on leaf damage by leaf miner as mining per leaves were recorded by counting the total number of healthy and damaged leaf per plant from five randomly selected plants. Aphid population was counted on five randomly selected plants from each plot. The population of French bean pod borer was recorded from randomly and marked five plants per replication. The per cent pod borer damage was recorded by counting damaged pods and total pods per plant. The observations on population of insect pest were recorded at 24 hours before spray as pre treatment count while post treatment observations were recorded at 3, 5 and 7 days after imposition of treatment. The observations on natural enemies' *viz*., lady bird beetle, green lace wing flies, hymenopteran parasitoids and spiders were recorded from five plants per replication per modules and the three years data was averaged.

Statistical analysis

The data on number of leaf miner, aphids' population and pod borer and natural enemies' *viz*., coccinellids, chrysoperla and spiders were subjected to square root transformation. The data on per cent pod borer damage was subjected to arc sine transformation. The data associated with the experiment conformed to the assumptions of the analysis of variance (single factor ANOVA), based on normality and homogeneity of variances through WASP software®

(developed by ICAR Research complex, Goa, India) and means were compared at < 5% probability using Duncan's multiple range test (DMRT) (Duncan, 1951).

RESULTS AND DISCUSSION

Effect of different management practices on French bean aphids

The mean data of three years (Table 1) indicates that, at a day before first spray, population of aphids varied from 28.33±0.33 to 32.27±1.14 indicating uniform distribution among various treatments. Number of aphids per plant was significantly less in all the treatments over to pre-treatment count at 3rd, 5th and 7th days after imposition of treatment.

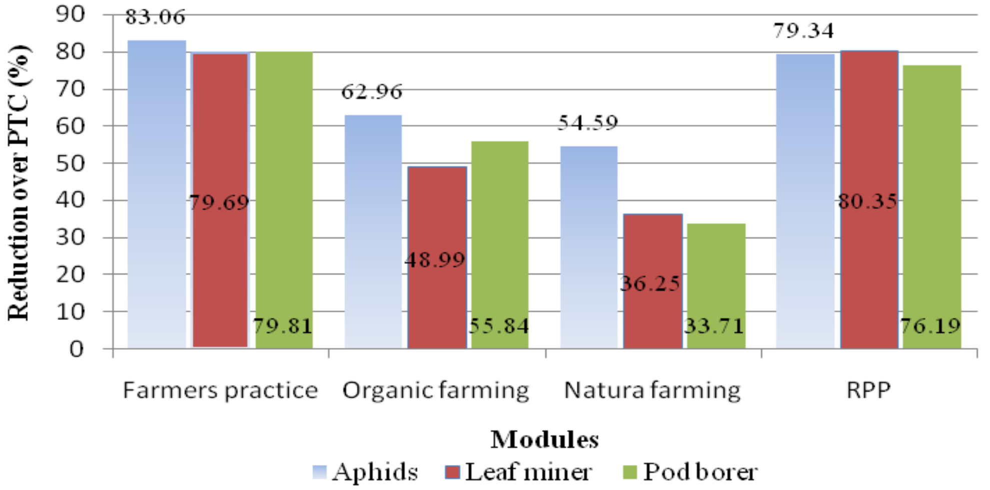
At 7 Days after first spray, significantly least population of aphids was noticed in plots treated with imidacloprid 17.8 SL @ 0.25 ml/l (T_1) (5.47±0.43 no./five leaf) with 83.06 per cent reduction of aphids' population over pre-treatment count and it was on far with T_4 (Dimethoate 30 EC @ 1.7 ml/l) (6.27±0.76 no./five leaf) with 79.34 per cent population reduction. The natural farming plot treated with neemastra recorded 12.87±0.79 aphids with 54.59 per cent reduction over pre-treatment count and was at par with organic plots treated with azadirachtin 3000 PPM @ 5 ml/l (11.53±0.43 no/five leaf) with 62.96 per cent reduction (Fig 1).

Farmers practice and RPP recorded significantly least population of French aphids and were superior treatments throughout the experimental period. It might be attributed to long term action of synthetic chemical pesticides. The present findings are in conformity with the findings of Kaniuczak and Matosz (1998) who revealed that new insecticide imidacloprid has considerable potential in faba bean IPM programs. Meena *et al*., (2020) revealed that, imidacloprid and thiamethoxam were most effective with maximum population reduction over untreated control (75.97

Table 1: Evaluation of different management practices on the population of French bean aphid, *Aphis craccivora* (Koch) at Sirsi.

Treatments	Spray details	Mean no. of aphids (five plants)*			
		DBS	3 DAS	5 DAS	7 DAS
T_1: Farmers practice	Imidacloprid 17.8SL @ 0.25 ml	32.27±1.14 (5.68)	19.33^a±1.81 (4.37)	11.93^a±1.40 (3.44)	5.47^a±0.43 (2.33)
T_2: Organic farming	Azadirachtin 3000 PPM @ 5 ml/l	31.13±1.56 (5.58)	26.00^b±0.79 (5.10)	20.40^b±0.72 (4.52)	11.53^b±0.43 (3.40)
T_3: Natural farming	Neemastra @ 30 ml/l	28.33±0.33 (5.32)	27.20^b±0.56 (5.21)	19.00^b±0.64 (4.35)	12.87^b±0.79 (3.58)
T_4: Recommended POP	Dimethoate 30 EC @ 1.7 ml/l	30.33±1.21 (5.50)	20.53^a±0.52 (4.53)	13.07^a±1.41 (3.59)	6.27^a±0.76 (2.48)
S.Em±		-	0.13	0.21	0.11
CD @ 5%		NS	0.34	0.48	0.31

Note: DBS: Day before spray/application, DAS: Day after spray/Application. NS- Non significant.
Figures in the parentheses are $\sqrt{(x + 1)}$ transformed values, * - Pooled data of three years.



RPP: Recommended package of practice, ROPTC: Per cent reduction over Pre-treatment count (PTC) = ((PTC-T) /PTCC)*100

Fig 1: Per cent reduction of population over pre-treatment count in different modules.

and 72.92%, respectively). Similar results were also reported by Bora *et al*. (2016) against cowpea aphids, Aslam and Ahmad (2001, 2002) against mustard and turnip aphid.

Neem (*Azadirachta indica*), binds to acetylcholine receptors thereby disrupting the nervous system and has different chemical properties *viz*., repellence, feeding deterrence, inhibition of oviposition, egg hatching and moulting (Grdisa and Grsic, 2013). Repellent, antifeedant, ovipositional deterrent and growth regulator actions of neem on pests have been attributed in controlling aphid and head borer (Prasannakumar *et al*., 2013). Azadirachtin, a tetranortritarpinoid, is a major active ingredient isolated from neem, which is known to disrupt the metamorphosis of insects (Tomlin *et al*., 2007). The effectiveness of neem-based products and neem oil against various aphids are also studied by different research persons (Shennag *et al*., 2014).

Effect of different management practices on French bean leaf miner

The pooled data of three years (Table 2) on population of French bean leaf miner indicates that, at a day before first spray, population varied from 15.27±0.90 to 17.07±1.43 indicating uniform distribution among various treatments. At 7 Days after first spray, significantly least population of leaf miner was noticed in plots treated with Dimethoate 30 EC @ 1.7 ml/l (T_4) (3.00±0.42 no./five plant) with 80.35 per cent reduction of leaf miner population over pre-treatment count and it was on far with T_1 (Abamectin 1.9 EC @ 1ml/l) (3.47±0.31 no./five plant) with 79.69 per cent population reduction. The organic plots (T_2) treated with Azadirachtin 3000 PPM @ 5 ml/l recorded moderate level of leaf miner (8.40±0.58) with 48.99 per cent reduction over pre-treatment count. Natural farming plot treated with neemastra recorded 10.20±0.29 leaf miner with 36.25 per cent reduction over pre-treatment count (Fig 1).

Neem based insecticides containing secondary metabolites like azadirachtin possess antioxidant, insecticidal and antimicrobial activities (Charapale *et al*. 2021) have a significant pest controlling ability and act in various ways. Azadirachtin based formulations seems to have some superiority over synthetic pesticides in view of their role as environment friendly as they degrade rapidly Akbar *et al*. (2012). Additionally, they are environment friendly, highly degradable and have low persistency as well as residual effects. Application of neemastra and commercial formulation of neem Azadirachtin 3000 PPM @ 5 ml/l have recorded moderate level of leaf miner infestation on French bean in the present study. Similar findings were also reported by Adilakshmi *et al*. (2008); (Ahmed *et al*., 2007) and Gandhi *et al*. (2006).

Effect of different management practices on French bean pod borer

The pre-treatment counts on per cent pod borer damage at a day before spray indicates that, damage varied from 11.87±0.77 to 13.87±0.64 indicating uniform distribution of French bean pod borer population among various treatments (Table 3). At 7 days after first spray, significantly least per cent pod borer damage was noticed in plots treated with Emamectin benzoate 5% SG @ 0.3 g/l (T_1) (2.80±0.40%) with 79.81 per cent reduction of aphids population over pre-treatment count and it was on far with T_4 (Dimethoate 30 EC @ 1.7 ml/l) (3.00±0.37%) with 76.19 per cent population reduction. The organic plots (T_2) treated with Azadirachtin 3000 PPM @ 5 ml/l recorded moderate level of per cent pod borer damage (5.80±0.37) with 55.84 per cent reduction over pre-treatment count. Natural farming plot treated with Brahmastra @ 30 ml/l recorded 7.87±0.44 pod borer damage with 33.71 per cent reduction over pre-treatment count (Fig 1).

Emamectin benzoate is an ananalog of abamectin, belongs to Avermectins *i.e*., insecticidal compounds derived from the soil bacterium *Streptomyces avermitilis*. This compound acts as an insecticide by interfering with the nervous system of insect and causes the insect to become

Table 2: Evaluation of different management practices on the population of French bean leaf minor, *Lyriomyza* spp at Sirsi.

Treatments details	Spray details	Live leaf minors per five plants*			
		DBS	3 DAS	5 DAS	7 DAS
T_1: Farmers practice	Abamectin 1.9 EC @ 1 ml/l	17.07±1.43 (4.12)	11.13^a±0.48 (3.34)	7.27^a±0.27 (2.69)	3.47^a±0.31 (1.85)
T_2: Organic farming	Azadirachtin 3000 PPM @ 5 ml/l	16.47±0.65 (4.05)	15.00^b±0.35 (3.88)	11.07^b±0.36 (3.33)	8.40^b±0.58 (2.89)
T_3: Natural farming	Neemastra @ 30 ml/l	16.00±0.60 (3.99)	14.67^b±0.55 (3.82)	12.93^c±0.61 (3.59)	10.20^c±0.29 (3.20)
T_4: Recommended POP	Dimethoate 30 EC	15.27±0.90 (3.90)	11.53^a±0.51 (3.40)	7.20^a±0.36 (2.68)	3.00^a±0.42 (1.72)
S.Em±		-	0.09	0.07	0.11
CD @ 5%		NS	0.23	0.19	0.29

Note: DBS: Day before spray/Application, DAS: Day after spray/Application. NS- Non-significant.

Figures in the parentheses are $\sqrt{(x + 1)}$ transformed values.

* - Pooled data of three years.

paralyzed. Emamectin benzoate 5 % SG is both a stomach and contact insecticide effective against legume pod borer (Prasadkumar and Devappa, 2006; Shivaraju, 2011; Mahalakshmi *et al*., 2012 and Parmar, 2015). Organo-phosphate compound Profenophos (0.05%) was found to be most effective in reducing the larval population of *M. vitrata* (Sonune, 2010).

In the present study, NF and organic farming recorded moderate level of aphids, leaf miner and pod borer damage and agniastra showed increased efficacy at second treatment imposition during 2020-21 indicating increased action of those plant-based botanicals. It might be due to insects getting resistance against chemical pesticides due to their repeated application. The chances of getting resistance against plant-based pesticides are very less because of different target sites in the insects and due to different components (alkaloids) present in them. The common bioactive compounds in botanical pesticides are majorly secondary metabolites such as steroids, alkaloids, tannins, terpenes, phenols, flavonoids and resins that possess antifungal, antibacterial, antioxidant or insecticidal properties (Ahmed *et al*., 2017).

Brahmastra and Agni Astra contain different plant and cow-based products having different mode of action. Cow urine can be used in pest control strategy either single or in combination with plant parts and neem-based commercial products have shown significant synergistic effect to enhance product toxicity resulting in pest mortality (Gahukar, 2013). The present findings showed that all the plant leaf extract, cow urine and their combination in the aginastra proved their superiority in reducing the pest population. The present experimental findings indicated effectiveness of NF treatment is in accordance with the several workers *viz*. mustard aphid (Gupta 2005), tea mosquito bug (Deka *et al.,* 2016). Benson *et al*. (2017) reported that *Allium indica*, *Piper guineense* and *Allium sativum* are insecticidal by inhibiting reproduction and development of the pest of okra. Pongamia plants contains

Table 3: Evaluation of different management practices on the population of French bean pod borer, *Maruca vitrata* (Fabricius) at Sirsi.

Treatments	Spray details	Per cent pod borer damage*			
		DBS	3 DAS	5 DAS	7 DAS
T_1: Farmers practice	Emamectin benzoate 5% SG @ 0.3 g/l	13.87±0.64 (21.85)	6.80^a±0.90 (14.97)	4.73^a±0.48 (12.50)	2.80^a±0.40 (9.55)
T_2: Organic farming	Azadirachtin 300 PPM	13.13±0.58 (21.22)	12.13^b±0.50 (20.36)	9.07^b±0.48 (17.51)	5.80^b±0.37 (13.91)
T_3: Natural farming	Brahmastra @ 30 ml/l	11.87±0.77 (20.10)	10.27^b±0.41 (18.67)	9.67^b±0.55 (18.08)	7.87^c±0.44 (16.26)
T_4: Recommended POP	Melathion 50 EC	12.60±0.80 (20.76)	8.07^a±0.62 (16.46)	5.13^a±0.72 (12.97)	3.00^a±0.37 (9.90)
S.Em±		-	0.67	0.61	0.49
CD @ 5%		NS	1.91	1.93	1.50

Note: DBS: Day before spray/application, DAS: Day after spray/Application. NS- Non-significant.
Figures in the parentheses are arc transformed values, * - Pooled data of three years.

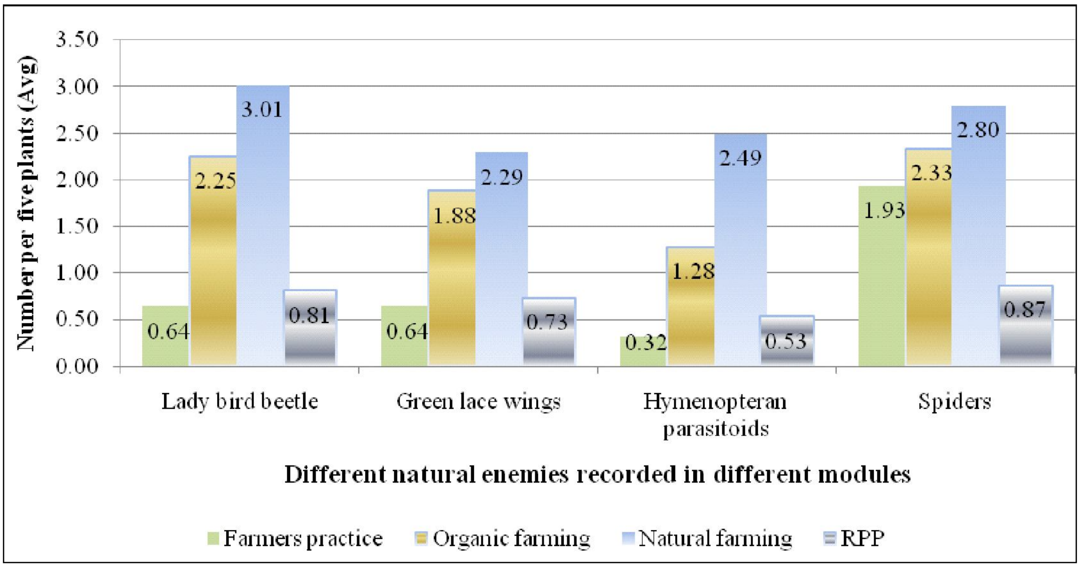


Fig 2: Influence of different modules on natural enemy population (Average of three years).

furanoflavone group including karanjin and pongamin, the major flavonoid having larvicidal activity.

The use of plant extracts with insecticidal properties has the potential of reducing the effects of insect pests of agricultural crops. The significant reduction in pest's numbers on the treated plants was an indication that they can be used as an alternative to chemical insecticides.

Influence of different modules on the population of different natural enemies

Observations on natural enemies were recorded at the time of crop harvesting as shown in the Fig 2 indicated that, significantly highest number of natural enemies *viz*., lady bird beetles, green lace wing flies, hymenopteran parasitoids and spiders were observed in natural farming (3.01, 2.29, 2.49 and 2.80, *respectively*) as compared to other modules and was at par with organic farming (2.25, 1.88, 1.28 and 2.33, *respectively*). The farmer's practice (0.64, 0.64, 0.32 and 1.93, respectively) and recommended package of practice (0.81, 0.73, 0.53 and 0.87, respectively) recorded least natural enemy population which might be due to ill effect synthetic chemical pesticides on natural enemies.

Insecticides used for the pest management can be detrimental to natural enemies that are naturally present or released in the agro-ecosystems. Besides the direct mortality, they also cause sub-lethal effects such as reduction in fecundity, fertility, predation/parasitism rates of predators and parasitoids (Bueno *et al*., 2017; Carvalho *et al*., 2019). Contrary to these ill effects of chemical pesticides, application of botanical and/or microbial pesticides represent a potential control approach to be adopted against insect pests which would decrease the detrimental side effects on non-target beneficial arthropods typically exhibited by hazardous pesticides (Mansour and Biondi, 2021). Botanical insecticide and natural enemies can be a potential combination for pest management against insect pest of tomato and selective to natural enemies (Soares *et al*., 2019). Botanicals pesticides are often categorized as safe to non-target organisms and environmentally friendly are crucial in optimizing ecosystem services.

CONCLUSION

The various groups of conventional insecticides are being used since last five decades. The neuro-active chemicals which have played a major role in management of insect pests in vegetables, Their indiscriminate usage has led to resurgence of new pest in ecosystem and they will create resistance, long residue period on crops and hazardous to environment. Hence, the indigenous techniques involving use of cow-based products and plant-based pesticides and green labelled pesticide are very effective and eco-friendly too. They will also enhance the natural enemies in the eco-system which in turn prevent build up of resistance in the target pest. Organic farming and natural farming practices are low input demanding, energy efficient and holistic production systems which play a crucial role in sustainability in agricultural production.

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Conflict of interest

All authors declared that there is no conflict of interest.

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