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Evaluation of IPM modules for the management of thrips on coriander (*Coriandrum sativum* L.) under semi-arid conditions

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Abstract

Three species of thrips *viz*., *Frankliniella schultzei* Trybom, *Thrips tabaci* Lind., and *Caliothrips indicus* Bag. (Thysanoptera: Thripidae) causes major damage to coriander crop under favourable environmental conditions. Thrips infestation initiated on coriander crop at 20 days after seed germination with very few in numbers and then gradually population increased to its maximum at 45 to 50 days after seed germination. In this study, eight strategically developed IPM modules were evaluated against thrips population, amongst them, IPM module M-5 consisted with imidacloprid 600FS @ 3ml kg^{-1} (Seed treatment) followed by foliar application of ker (*Capparis decidua*) extract @ 10ml $lit.^{-1}$, *Verticillium lecani* ($1x10^{8}$cfu g^{-1}) @ 6g $lit.^{-1}$, and fipronil 5%SC @ 0.035% at definite interval, given effective management of thrips (96.39 and 94.88% mortality in thrips population in 2018-19 and 2019-20, respectively) with relative safety to natural enemies, and pollinators, and lower the pesticide load for pest management practices. Two years study data were also revealed the effectiveness of IPM modules M-5 correlated with higher seed yield (2709 kg ha^{-1}), economics (Rs.1.50 Lakh) and B: C ratio (4.9:1). Subsequently, it recommends that IPM modules consisted with botanical product, entomopathogenic fungi based bio-pesticides and insecticides exhibited sustainable management module for thrips on coriander and comparatively safer to natural enemies.

Keywords: Coriander, thrips, management, IPM modules, Economics

Introduction

Coriander (*Coriandrum sativum* L.) is also known as '*Dhania*' belongs to the family *Apiaceae* (*Umbelliferae*), chromosome number 2n=12 is an important seed spice crop. Its is considered to be a native of Europe to south western Asia and now it has been distributed over the world includes India, Morocco, Pakistan, Romania, France, Iran, Iraq, Syria, Isreal, Sri Lanka, Spain, Italy, Egypt, Argentina, Russia, Australia and Canada. In India, it is mainly grown in the states of

Rajasthan, Madhya Pradesh, Andhra Pradesh. It grown in an area of 7.106 Lakh hectare with a production of 973973 million tonnes of seed during 2022-23 (Anonymous, 2024). Coriander leaves and seeds are primarily used for flavouring, seasoning and imparting aroma in variety of food items and beverages. Besides importance in food industry, it has medicinal properties and used in various pharmaceutical preparations and also in cosmetic industry (Malhotra and Vashishtha, 2008). Many insect- pests, *viz*., aphids, *Myzus persicae* (Araujo, 1986), *Hyadaphis coriandri* Das (Jain and Yadav, 1988), *Aphis gossypii* Glover, thrips, jassids, *Empoasca kerri* (Pruthi), whitefly, *Bemisia tabaci* (Genn.), seed wasp*, Systole albipennis* (Walker) (Singh and Baswana, 1984), pod borer, *Heliothis armigera* (Hub.), *Spodoptera litura*, bugs, termite and leaf folders are causing medium to heavy damage to coriander crop. Among them, thrips species *Frankliniella schultzei* Trybom, *Thrips tabaci* Lind., and *Caliothrips indicus* Bag. (Thysanoptera: Thripidae) have been reported as a major insect of coriander crop (Meena *et al.,* 2017). It was estimated from the earlier study that sucking pests including thrips caused a yield loss in coriander up to 43.28 per cent (Ghadage *et al.,* 2010 and Meena & Meena, 2020).

These thrips species are geographically distributed all over the world, considered as international in habitat. In India this thrips is particularly important on coriander, cumin, fennel, chillies, tomato, onion, and many other host plants. Thrips infestation initiated in early growth stage about 20 days after germination and cause damage on coriander Meena *et al*., 2017; Meena and Kumar 2011), okra, cotton, eggplant (Abang *et al*., 2018), cumin (Meena *et al*., 2018) and several other field, horticultural crops and weed plants year-round. The immature stages (nymphal stages) and adult thrips feed on plants. After hatching, the nymphs feeding on plant juice by lacerating the leaf tissues and later on stem and shoot by rasping and sucking type of mouth parts and suck the out coming sap (Meena *et al*., 2019). Thrips suck the sap from leaves of plant causing yellowing and drying of leaves; higher populations cause drying of whole plants (Kant *et al*., 2024). Infested plant parts show discoloration in patches and stunted growth. Thrips is very difficult by only the use of single insecticide and repeated use of chemical pesticides and this management practice has resulted in resistance to insecticides and mortality of natural enemies. Frequently use of insecticides also created pesticide residue in harvested coriander seeds. Hence integrated pest management is an alternate way for sustainable management of thrips on coriander. Keeping above objectives in view, the present study was carried out to develop a suitable IPM module using cultural, mechanical, botanicals, bio-control agents and chemical insecticides in a compatible manner for development of eco-friendly and cost effective IPM module for thrips management and pesticide free coriander produce.

Materials and methods

Field trials were conducted at Research Farm of ICAR-National Research Centre on Seed Spices, Tabiji, Ajmer (Rajasthan) in rabi season for two consecutive years 2018-19 and 2019-20. Experimental location is surrounded by Aravalli hill range, lying under the coordinates between 74^{0} 35' 39" to 74^{0} 36' 01" E longitude and 26^{0} 22' 12" to 26^{0} 22' 31" N latitude with an altitude of 486 m (Meena *et al*., 2019). The study area falls under semi-arid region of the country; where summers are extreme hot and winters are cold. Area receives annual average rainfall of 300-550 mm, whereas, relative humidity was ranged from 60-80 per cent (Meena *et al*., 2018).

The experiments were designed to find out the effectiveness of strategically developed eight different IPM modules for thrips management in coriander under field conditions. The trials were laid out in randomized block design (RBD) with three replications. The seeds of coriander variety ACr-2 were sown in well prepared split plots sized of 5 x 4 meters keeping 30 x 15 cm row to row and plant to plant crop geometry. All recommended package of practices of coriander were applied to the plants for healthy growth and better-quality production. Eight different IPM modules consisted with cultural practices (uprooting weeds- an alternate host of thrips), mechanical means, botanical products, bio-control agents, and chemical insecticides in the form IPM module were evaluated under four application schedules at different intervals. The details of each IPM modules are given in table 1. In application schedule, first application of each IPM module was applied as seed treatment as well as soil application at the time of seed sowing; second treatment at 35 days after germination and third and fourth treatment applications were applied at 70 and 85 days after germination, respectively when sufficient thrips population was observed.

Observations on thrips population were recorded right from 10 days after germination to 50 days after germination at 10 days interval by visual counting of thrips on 5 randomly selected and tagged plants per plot in all replications. Initially whole plant was taken into account for observations but in later vegetative growth stages, three branches/plant were considered for the observations. Pre treatment population was recorded 1 day prior to third and fourth applications of treatments and the post treatment data were recorded at 1, 3, 7 and 10 days after each spray application and then per cent reduction in thrips population was worked out. Yield data was recorded from individual plot of each replication, harvested separately for each IPM module. Economics of each IPM modules was also worked out based on two years pooled yield.

Data analysis

The reduction percentage of thrips population was calculated by using Abott (1925) formula:

$$P = \frac{T - C}{100 - C} \times 100$$

Where,

P = Corrected per cent mortality; T = Observed per cent mortality in treatment; C = Percent mortality in control.

IPM module-wise marketable seed yield of each year was recorded, and converted in to kg per ha. The data collected was subjected to statistical analysis as randomized block design after suitable transformations. The corrected per cent mortality so obtained were analyzed after converted into arc sin values and tabulated to statistically analysis to determine the various treatment effects. The mean separation of number of thrips till 50 days after germination and per cent mortality in thrips in third and fourth applications and seed yield was performed using Duncan's Multiple Range test DMRT ($P \leq 0.05$). The statistical analysis was performed using the SPSS statistical software.

Results and discussion

Efficacy against thrips

In 2018-19, results showed that, all IPM modules significantly maintained the thrips population ($P \leq 0.05$, Duncan's Multiple Range test DMRT) under check over untreated control at 10, 20, 30, 40 and 50 d after germination in first and second applications (Table 2). In first application, no thrips population was recorded under all treatment application except control plots, wherein, 0.2 thrips plant^{-1} were recorded in M-8 (control) at 10 days after germination. Further at 20, and 30 days after germination, there was an increase in its infestation in all the treatments ($P \leq 0.05$), but significantly less than the control. At 30 days after germination, no thrips infestation was recorded in IPM module M-5 and M-7 in which imidacloprid 600 FS and thiamethoxam 25 WG were applied as seed treatment, respectively. The next effective models were M-3, M-4, and M-1 with soil application of caster cake (0.27 thrips plant^{-1}), seed treatment with neem oil 3% (1.2 thrips plant^{-1}) and cultural practices (1.2 thrips plant^{-1}), respectively. No information was available on effect of these chemical as seed and soil treatment against thrips on coriander, however, seed treatment with imidacloprid 600 FS @ 5 ml kg^{-1} seed in cumin was found effective against thrips (Meena *et al.*, 2021), leafhopper and thrips on cowpea with highest gross and net returns (Anusha *et al.*, 2016). Sujatha and Bharpoda (2017) reported that seed treatment of moongbean with thiamethoxam 25WG (0.01%) was found to be more effective against the sucking pests are evident to the present finding. In second application made on 35 days after germination and thrips population was recorded at 40 and 50 days after germination, showed that there was an increase in thrips infestation in all the treatments with lowest infestation in M-5 ($P \leq 0.05$), but significantly less than to control. At 50 days after germination, all tested IPM modules were found significantly superior over untreated control in thrips management in coriander. The minimum thrips population (0.2 thrips plant^{-1}) was recorded in IPM module M-5 (ker plant extract @ 10ml lit^{-1}) followed IPM module M-7 (azadirachtin 0.03 EC) with 1.4 thrips plant^{-1} mean population and statistically differed with each other. Meena *et al.* (2016) reported that foliar application of ker plant extract @ 10ml lit.$^{-1}$, was found effective against aphid on coriander are conformity with present findings. *Capparis decidua*

Edgew (Forssk.) plants contain insecticidal compounds Tetrahydropyran-2-one and triacontanol shown enormous insecticidal activity against a wide range of insect pests (Upadhyay 2012; Upadhyay 2013). The next effective IPM modules were M-3 (2.4 thrips plant^{-1}), M-6 (3.4 thrips plant^{-1}) and M-4 (4.4 thrips plant^{-1}), whereas IPM module M-2 was performed least effective module followed by M-1 at this stage in management of thrips on coriander (Table 2).

The mortality per cent in thrips population due to third and fourth applications of IPM modules (Table 3) showed that all treatments were significantly reduced the thrips populations ($P \leq 0.05$, Duncan Multiple Range Test) in all replications as compared to control at 1, 3, 7, and 10 days after treatments. There was a significant increase in per cent mortality of thrips till 7 days after third treatment application, and then decreased at 10 days after treatment. At 7 days after treatment, thrips populations were reduced in all treatment applications in comparison with the control. The highest mortality (75.11%) in thrips population was recorded on plants treated with IPM module M-5 (*Verticillium lecanii* @6g lit.$^{-1}$) followed by 72.56% mortality in M-7 (*Metarrhizium anisopliae* @6g lit.$^{-1}$) and both the treatments were statistically on par. Fungal strain *Verticilium lecani* (CS-625) was reported to cause 95% mortality in aphids after 10 days of treatment when applied as filtrate (Javed *et al.*, 2019). The next effective IPM modules were M-3 (tumba fruit extract @ 10ml lit^{-1}), M-6 (*Beauveria bassiana* @6g lit^{-1}) and M-4 (Coccinella larvae @5000/acre) reduced 71.58, 70.70 and 70.18 per cent thrips population, respectively and statistically on par with each other. Cucurbitacin E glycoside content of *Citrullus colocynthis* shows insecticidal effect on aphids (Torkey *et al.*, 2009). Fresh tumba fruit extract @ 10ml lit^{-1}, found effective in management of aphid in coriander (Meena *et al.*, 2016) and thrips in fennel under integrated organic farming system (Meena *et al.*, 2019) support the present result. The remaining IPM modules were recorded least effective module in management of thrips on coriander. A similar trend of mortality in thrips population was recorded in fourth application, where all IPM modules were found significantly superior over control in management of thrips on coriander (Table 3). At 7 days after treatment, the highest mortality (96.39%) in thrips population was recorded with IPM module M-5 (fipronil as last treatment application) followed by M-7 (acetamiprid as last treatment application) reduced 93.33 per cent thrips population. Both modules were found statistically on par with each other in their efficacy. Fipronil @ 2ml l^{-1} was also found effective in reduction of whitefly population on tomato (Meena and Raju, 2014) support the present finding. IPM modules M-1 was recorded least effective module followed by M-2 in management of thrips and were statistically on par with each other.

The same IPM modules were also evaluated against thrips in second year during 2019-20 and relevant data on thrips population and per cent population reduction in third and fourth treatment applications were present in table 4 and 5. At 10, 20, 30, 40 and 50 days after germination, the thrips population was recorded significantly lower to control in all IPM modules ($P \leq 0.05$). In first treatment, at 10 days after seed germination, there was no thrips population recorded in all IPM module, whereas, 0.2 thrips plant^{-1} were recorded in control (M-8). Similar results were also obtained at 20 days after seed germination, wherein 1.0 thrips plant^{-1} was recorded in IPM module M-4 and 2.2 thrips plant^{-1} were recorded in control plots. The remaining treatments (IPM modules) escaped coriander plants from thrips infestation at this stage. At 30 days after germination, thrips infestation increased in range between 0.4 to 3.6 thrips plant^{-1} wherein, lowest population (0.4 thrips plant^{-1}) was in M-3 and highest (3.6 thrips plant^{-1}) in control. IPM modules M-5 (imidacloprid 600 FS as ST), and M-7 (Thiamethoxam 25 WG as ST) showed zero thrips infestation (Table 4). In second treatment application, thrips infestation was recorded in the range of 2.2 to 5.4 thrips plant^{-1}, wherein 2.2 thrips plant^{-1} were recorded in IPM module M-3 and maximum 5.4 thrips plant^{-1} were recorded in control (M-8). The plots treated with IPM module M-5 and M-7 were found free thrips infestation at 40 days after germination. At 50 days after germination, IPM module M-5 showed zero infestation, proved most effective module against thrips. However, thrips infestation in control plots steadily increased from 0.2 thrips plant^{-1} at 10 days after germination to 7.8 thrips branch^{-1} at 50 days after germination. IPM modules M-7, M-3 and M-4 were found middle order of effectiveness against thrips up to 50 days after germination. One day prior to treatment of third application, per plant thrips populations were ranged from 4.6 to 19.6 thrips $plant^{-1}$ in all modules, showed significant difference in population due to treatment effect of first and second applications. Mortality in thrips population at 1, 3, 7, and 10 d after application showed that all IPM modules were found significantly better in reduction of thrips population over control, whereas highest reduction percentage in thrips population was recorded at 7 d after treatment (Table 5). At 7^{th} day after third treatment application of IPM module, M-5 recorded highest mortality (72.75%) in thrips population followed by M-7 (70.13%) and both were on par with each other. The next effective IPM module was M-3 reduced 66.50% thrips population followed by M-4 and M-6 reduced 63.08 and 61.75% thrips population IPM module M-4 and M-6 were statistically on par with each other. IPM module M-1 was found least effective in management of thrips on coriander followed by M-2. In fourth application, all IPM modules consistently showed higher per cent reduction in thrips population than the control and IPM modules M-5 at 1, 3, and 7 d after treatment, reduced 68.37, 76.14 and 94.88% thrips population, respectively and was on par to M-7 at all intervals (Table 5). Other IPM modules were recorded as middle order of effectiveness in management of thrips on coriander under field conditions.

Yield

Based on two years study pooled data of 2018-19 and 2019-20, it was found that all IPM modules were performed better in the management of thrips on coriander under field conditions. The coriander seed yield was harvested significantly higher in all IPM modules over untreated control (Fig. 1). IPM module M-5 recorded the higher seed yield of 2709 kg per ha, which was significantly superior over rest of the IPM modules. The next most effective IPM module was M-7 which recorded coriander seed yield 2467 kg per ha and this IPM module was significantly superior over rest of the module and rated as second best effective module against thrips. The next efficient IPM modules were M-3 and M-4 recorded 2346 and 2289 kg per hectare with significant yield difference. The untreated control recorded the lowest 1736 kg per ha seed yield (Fig. 1).

Economics

The loss assessment due to thrips and economics of IPM modules was worked out and data presented in Table 6 revealed that the highest yield 973 kg ha^{-1} was increased in IPM module M-5 followed by M-7 (470 kg ha^{-1}) over untreated control due to treatments. Likewise lowest avoidable loss recorded in same modules. The highest gross return (Rs. 189630), net return (Rs. 150680) was recorded in IPM module M-5 followed by IPM module M-7 (gross return Rs. 172690; net return Rs. 132380) and M-3 (gross return Rs. 164220; net return Rs. 117470). These treatments found more effective in controlling thrips in coriander. The highest B: C ratio 1: 4.90 was also obtained in M-5 than M-7 (1: 4.3), whereas, the lowest gross return (Rs. 147700) was recorded with IPM module M-1 and net return (Rs. 94620) was recorded in M-2, proved least effective modules in management of thrips on coriander (Table 6).

Conclusion

Thrips is one of the major sucking insects, cause damage in early crop growth stage and only insecticidal control kill the insect as well as its natural enemies. Hence the present study conclude that IPM module M-5 consisted by seed treatment with imidacloprid 600FS @ 3ml kg^{-1} seed followed by foliar applications of ker plant extract @ 10ml lit^{-1} + *Verticillium lecani* ($1x10^8$cfu g^{-1}) @ 6g lit^{-1} + fipronil 5%SC @ 0.035% at 35, 70 and 85 days after germination, significantly reduced thrips population on coriander in semi-arid region. The IPM module M-5 was also recorded highest seed yield (2709 kg ha^{-1}), net return (Rs. 150680) and B: C ratio (4.9:1).

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Conflict of interest

The authors declare no conflicts of interest.

Table 1. Details of IPM modules applied for the management of thrips on coriander in 2018-19 and 2019-20.

IPM Module	Treatment combination
M-1	Cultural method (weeding)+ yellow sticky trap @25 traps acre^{-1} + ker plant extract @ 10ml lit^{-1} + acetamiprid 20%SP @0.025%
M-2	Neem cake @500kg ha^{-1} (SA) + cultural method + NSKE (5%)+ fipronil 5%SC @ 0.035%
M-3	Castor cake @ 300kg ha^{-1} (SA) + azadirachtin 0.03 EC @ 3ml lit^{-1} + tumba fruit extract @ 10 ml lit^{-1} + thiacloprid 240 SC @0.025%
M-4	Neem oil 3% @ 5 ml lit^{-1} (ST) + yellow sticky trap 25 Acre^{-1} + *Coccinella* larvae @5000 acre^{-1} + imidacloprid 17.8 SL @ 0.003%
M-5	Imidacloprid 600FS @ 3ml kg^{-1} seed (ST) + Ker plant extract @ 10ml lit^{-1} + *Verticillium lecanii* (1x108cfu g^{-1}) @ 6g lit^{-1} + fipronil 5%SC @ 0.035%
M-6	*Trichoderma viride* @6g kg^{-1} seed (ST) + *Coccinella* larvae @ 5000 acre^{-1} + *Beauveria bassiana* @ 6g lit^{-1} + fipronil 5%SC @ 0.035%
M-7	Thiamethoxam 25 WG @ 5g kg^{-1} seed (ST) + *Azadirachtin* 0.03EC @ 5ml lit^{-1} + *Metarhizium anisopliae* @ 6g lit^{-1} + acetamiprid 20 SP @0.025%
M8	Control (Untreated)

+ Two local wild plants: Ker plant is botanically known as *Capparis decidua* (Forssk.) Edgew., and tumba plant (*Citrullus colocynthis* Lin.), SA- soil application, ST- seed treatment

Table 2. Field efficacy of first & second applications of different IPM modules against thrips on coriander in rabi 2018-19

IPM module	Thrips population (No. of thrips plant^{-1} up to 40 DAG and per branch at 50 DAG)				
	1st Application			IInd Application	
	10 DAG	20 DAG	30 DAG	40 DAG	50 DAG
M_1	0#	0.4^b	1.2^c	3.4^b	5^c
M_2	0	0^d	2^b	3^d	6.8^b
M_3	0	0^d	0.27^d	1.4^f	2.4^f
M_4	0	0.2^c	1.2^c	3.2^c	4.4^d
M_5	0	0^d	0^e	0^g	0.2^h
M_6	0	0^d	2^b	2^e	3.4^e
M_7	0	0^d	0^e	0.2^g	1.4^g
M_8	0.2	1^a	3.2^a	5.4^a	8.2^a

*Mean of 15 plants from three replications.
In column, means followed by common letters are not significantly different at ($P \leq 0.05$) by Duncan's Multiple Range test (DMRT). # Observations contains zero pest infestation need not to compare by DMRT

Table 3. Field efficacy of third & fourth applications of different IPM modules against thrips on coriander in rabi 2018-19.

IPM module	PTC	Per cent mortality in thrips population				Per cent mortality in thrips population			
		IIIrd Application				IVth Application			
		1 DAT	3 DAT	7 DAT	10 DAT	1 DAT	3 DAT	7 DAT	10 DAT
M_1	9.20	49.55 (44.72)^{c}	53.52 (46.99)^{d}	64.56 (53.44)^{c}	51.55 (45.87)^{d}	53.28 (46.85)^{c}	64.33 (53.31)^{c}	76.28 (60.83)^{d}	63.41 (52.75)^{c}
M_2	11.40	48.48 (44.11)^{c}	54.19 (47.38)^{cd}	65.43 (53.97)^{c}	52.30 (46.30)^{cd}	54.92 (47.81)^{c}	65.39 (53.94)^{c}	77.83 (61.90)^{d}	65.84 (54.21)^{c}
M_3	8.60	50.19 (45.09)^{bc}	57.22 (49.13)^{c}	71.58 (57.76)^{b}	56.26 (48.58)^{b}	58.72 (50.00)^{bc}	72.29 (58.22)^{b}	89.00 (70.63)^{c}	70.44 (57.04)^{b}
M_4	10.80	51.75 (45.99)^{bc}	56.86 (48.92)^{c}	70.18 (56.88)^{b}	55.42 (48.09)^{bc}	58.14 (49.67)^{bc}	70.45 (57.05)^{b}	87.50 (69.27)^{c}	69.83 (56.66)^{b}
M_5	3.40	56.22 (48.56)^{a}	67.89 (55.47)^{a}	75.11 (60.06)^{a}	60.11 (50.82)^{a}	64.56 (53.44)^{a}	77.00 (61.33)^{a}	96.39 (79.12)^{a}	74.78 (59.84)^{a}
M_6	7.60	52.40 (46.35)^{bc}	63.57 (52.85)^{b}	70.70 (57.21)^{b}	58.76 (50.02)^{ab}	57.07 (49.07)^{c}	69.73 (56.60)^{b}	86.61 (68.52)^{c}	69.65 (56.57)^{b}
M_7	4.80	53.56 (47.03)^{ab}	66.56 (54.65)^{a}	72.56 (58.40)^{ab}	61.33 (51.53)^{a}	63.22 (52.65)^{ab}	75.44 (60.27)^{a}	93.33 (75.04)^{b}	72.89 (58.61)^{ab}
M_8	14.20	0.00 (0.00)^{d}	0.00 (0.00)^{e}	0.00 (0.00)^{d}	0.00 (0.00)^{e}	0.00 (0.00)^{d}	0.00 (0.00)^{d}	0.00 (0.00)^{e}	0.00 (0.00)^{d}

*Mean of 15 plants from three replications.
PTC = Pre treatment count; DAT = days after treatment, values in parentheses are angular transformed values.
In PTC, the difference in thrips population between treatments is due to the impact of first & second applications of different IPM modules.
In column, means followed by common letters are not significantly different at ($P \leq 0.05$) by Duncan's Multiple Range test (DMRT).

Table 4. Field efficacy of first & second applications of different IPM modules against thrips on coriander in rabi 2019-20

IPM module	Thrips population (No. of thrips plant $^{-1}$ up to 40 DAG and per branch at 50 DAG)				
	1st Application			IInd Application	
	10 DAG	20 DAG	30 DAG	40 DAG	50 DAG
M1	0#	0#	1^{d}	3^{cd}	5.4^{b}
M2	0	0	2^{b}	3.4^{b}	4.8^{c}
M3	0	0	0.4^{f}	2.2^{f}	3^{e}
M4	0	1	1.6^{c}	2.8$^{c\ e}$	4.2^{d}
M5	0	0	0^{g}	0^{g}	0^{g}
M6	0	0	0.6^{e}	3^{c}	5^{c}
M7	0	0	0^{g}	0^{g}	0.4^{f}
M8	0.2	2.2	3.6^{a}	5.4^{a}	7.8^{a}

*Mean of 15 plants from three replications.
In column, means followed by common letters are not significantly different at ($P \leq 0.05$) by Duncan's Multiple Range test (DMRT). # Observations contains zero pest infestation need not to compare by DMRT

Table 5. Field efficacy of third & fourth applications of different IPM modules against thrips on coriander in rabi 2019-20

IPM module	PTC	Per cent mortality in thrips population				Per cent mortality in thrips population			
		III[rd] Application				IV[th] Application			
		1 DAT	3 DAT	7 DAT	10 DAT	1 DAT	3 DAT	7 DAT	10 DAT
M_1	11.60	49.07 (44.45)[e]	51.55 (45.87)[d]	58.18 (49.68)[d]	53.55 (47.01)[d]	50.79 (46.30)[c]	63.25 (52.66)[c]	73.47 (58.98)[e]	60.29 (50.92)[e]
M_2	13.00	50.75 (45.41)[de]	52.40 (46.35)[d]	59.80 (50.64)[d]	54.21 (47.39)[d]	52.30 (46.32)[c]	63.70 (52.93)[c]	75.44 (60.27)[e]	61.89 (51.86)[e]
M_3	7.20	56.82 (48.90)[bc]	61.64 (51.71)[b]	66.50 (54.62)[bc]	60.41 (50.99)[b]	61.85 (51.83)[b]	70.74 (57.23)[b]	88.05 (69.76)[c]	70.30 (56.96)[c]
M_4	9.00	52.21 (46.25)[cde]	58.14 (49.67)[bc]	63.08 (52.57)[cd]	57.78 (49.46)[bc]	53.68 (47.09)[c]	65.71 (54.14)[c]	81.39 (64.43)[d]	67.56 (55.26)[cd]
M_5	4.60	61.41 (51.59)[ab]	68.37 (55.76)[a]	72.75 (58.51)[a]	67.19 (55.03)[a]	68.37 (55.76)[a]	76.14 (60.74)[a]	94.88 (77.05)[a]	82.32 (65.12)[a]
M_6	14.40	54.45 (47.53)[cd]	56.75 (48.87)[c]	61.75 (51.77)[cd]	56.52 (48.73)[cd]	54.32 (47.45)[c]	64.65 (53.51)[c]	79.87 (63.32)[d]	65.33 (53.91)[d]
M_7	5.20	62.13 (52.00)[a]	66.98 (54.91)[a]	70.13 (56.92)[ab]	65.17 (53.81)[a]	65.80 (54.19)[a]	75.47 (60.38)[a]	92.21 (73.81)[b]	78.52 (62.39)[b]
M_8	19.60	0.00 (0.00)[f]	0.00 (0.00)[e]	0.00 (0.00)[e]	0.00 (0.00)[e]	0.00 (0.00)[d]	0.00 (0.00)[d]	0.00 (0.00)[f]	0.00 (0.00)[f]

*Mean of 15 plants from three replications.
PTC = Pre treatment count; DAT = days after treatment, values in parentheses are angular transformed values.
In PTC, the difference in thrips population between treatments is due to the impact of first & second applications of different IPM modules.
In column, means followed by common letters are not significantly different at ($P \leq 0.05$) by Duncan's Multiple Range test (DMRT).

Table 6. Cost economics of IPM modules against thrips of coriander

IPM Module	Seed yield (kg ha^{-1})	Increase in yield over control (kg ha^{-1})	Total avoidable loss (kg ha^{-1})	Value of increased yield (Rs.)	Treatment cost (Rs.)	Total cost of production (Rs ha^{-1})	Gross returns (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C Ratio
M1	2110	374	599	12230	11380	46880	147700	100820	3.2
M2	2151	415	558	21050	20450	55950	150570	94620	2.7
M3	2346	610	363	11670	11250	46750	164220	117470	3.5
M4	2289	553	420	7430	6830	42330	160230	117900	3.8
M5	2709	973	0	4230	3450	38950	189630	150680	4.9
M6	2218	482	491	7510	6730	42230	155260	113030	3.7
M7	2467	731	242	5830	4810	40310	172690	132380	4.3
M8	1736	0	973	-	0	35500	121520	86020	3.4

Gross return = Yield x Market price of coriander seed (Rs. 70 kg^{-1}); Net returns = Gross return - Total cost; B: C ratio = Gross returns / Total cost.

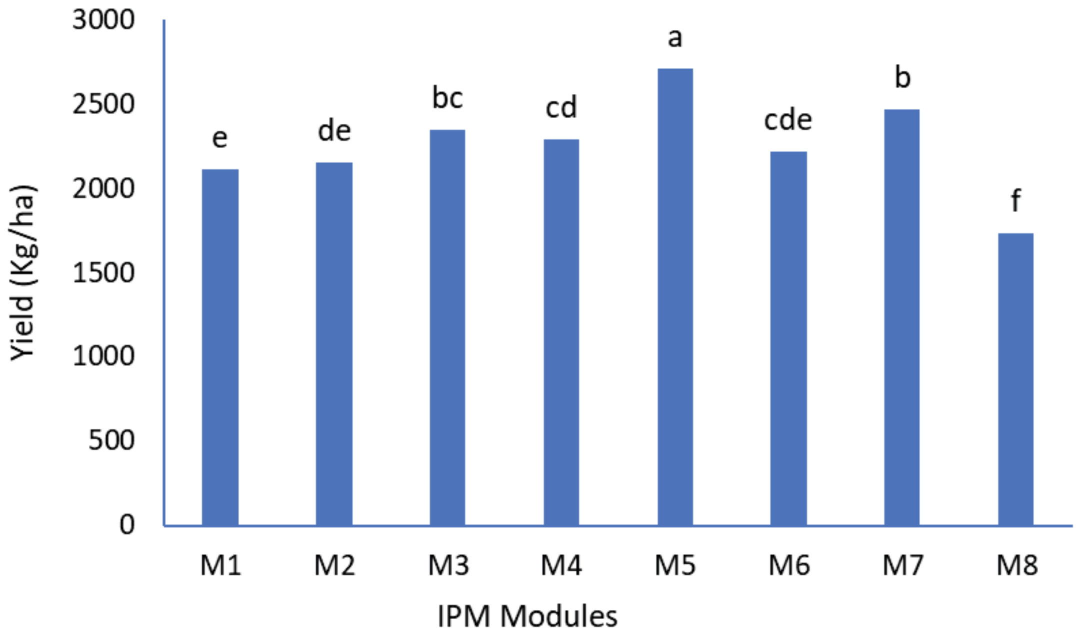

Figure 1. Coriander seed yield (kg ha^{-1}) in different IPM modules in rabi season (2018-19 -2019-20 pooled)

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