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Studies on Integrated Pest Management of Tomato Pin worm, *Phthorimaea absoluta* (Meyrick) under Naturally Ventilated Polyhouse condition

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ABSTRACT: The studies on evaluation of IPM modules for the management of pin worm, *Phthorimaea absoluta* (Meyrick) were carried out on tomato cultivar, Arka Abhedh. The experiment was carried out under naturally ventilated polyhouse condition during 2021-22 at College of Horticulture, Mudigere. The experiment was laid out in Randomized Complete Block Design, comprising four treatments with five replications. Observations were recorded at 10 days intervals. Module 1 consisting of seed treatment with imidacloprid 48 % FS @ 7g/kg of seeds, seedling dip with imidacloprid 17.8 SC @ 0.5 ml/l, collection and destruction of infested leaves, installation of sticky traps at 30/1000 m^2 area, installation of sex pheromone traps 20/1000 m^2 area and spraying of chlorantraniliprole 18.5 SC @ 0.3 ml/l, spinoteram12 SC @ 1.25 ml/l followed by flubendiamide 480 SC @ 0.3 ml/l proved to be better in reducing tomato pin worm population under naturally ventilated polyhouse condition.

Keywords: IPM, tomato pin worm, contact and stomach insecticides, polyhouse.

INTRODUCTION

Tomato is one of the economically important vegetable crop and widely cultivated throughout the world. Tomato belongs to Solanaceae family and is native of Peru and México. Tomato production is constrained by diverse biotic and abiotic stresses. Among the biotic stresses, pests and diseases reduce the yield as well as the quality of marketable fruits. The major insect pests of tomato are fruit borer, *Helicoverpa armigera* (Hubner), tomato pin worm, *Phthorimaea absoluta* (Meyrick), tobacco leaf eating caterpillar, *Spodoptera litura* (Fab.), American serpentine leaf miner, *Liriomyza trifolii* (Burgess), thrips, *Thrips tabaci* Lind., two spotted red spider mite, *Tetranychus urticae* (Koch.) and whitefly, *Bemisia tabaci* (Gennadius). Recently, the South American tomato borer, *P. absoluta* has emerged as one of the most devastating pests of tomato crop in South America (Saad *et al*., 2020).

Chang and Metz (2021) reinstated the name as *Phthorimaea absoluta*, earlier it was called as *Tuta absoluta*. *P. absoluta* (Meyrick) (Gelechiidae: Lepidoptera) is commonly known as tomato borer, tomato moth and South American tomato pin worm. After hatching, larvae penetrate the leaf or fruit epidermis and bore galleries in the plant tissues and fruits making them unfit for marketing. Larvae can form extensive galleries in the stems which damage the development of the plant. Severe damage by larvae may result in complete defoliation and drying of plants. Potential yield loss can reach 100 per cent, if the pest is not managed (Sridhar *et al*., 2016). Due to its high capability to develop resistance to synthetic insecticides, and its concealed feeding behaviour, the management of this insect has become a challenging task. Various approaches of insect pest management in tomato are the use of resistant cultivars, botanicals and chemicals. The integration of cultural, mechanical, chemical and biological control components will reduce the pest population. So, the present investigation was carried out.

MATERIALS AND METHODS

The studies on evaluation of IPM modules for the management of tomato pin worm were carried out on tomato cultivar, Arka Abhedh. The experiment was carried out under naturally ventilated polyhouse condition during 2021-22 at College of Horticulture, Mudigere. The experiment was laid out in Randomized Complete Block Design (RCBD). There were four treatments with five replications. Tomato cultivar Arka Abhedh seedlings, were transplanted in the main field with a plot size of 30 m × 1.5 m and spacing of 75 × 60 cm. Seedling root dip was imposed while transplanting and the other treatments were imposed according to the schedule. Observations were made from 45 DAT to 125 DAT after imposition of treatments.

Treatment details of evaluation of IPM modules against tomato pin worm

Module 1:

1. Seed treatment with imidacloprid 48 % FS @ 7g/kg of seeds
2. Seedling dip with imidacloprid 17.8 SC @ 0.5 ml/l (10-15 minutes)
3. Collection and destruction of infested leaves (up to 2 months)
4. Installation of sticky traps at 30/1000 m^2 area
5. Installation of sex pheromone traps 20/1000 m^2 area at 15 days after transplanting (replacing lures at every 30 days interval)
6. Spraying of chlorantraniliprole 18.5 SC @ 0.3 ml/l, spinoteram12 SC @ 1.25 ml/l followed by flubendiamide 480 SC @ 0.3 ml/l @ 15 days interval (two to two and half month after transplanting)

Module 2:

1. Seed treatment with azadirachtin 10,000 ppm of 5 ml/l
2. Seedling dip with azadirachtin 10,000 ppm of 5 ml/l
3. Collection and destruction of infested leaves (up to two months)
4. Installation of sticky traps at 30/1000 m^2 area
5. Installation of sex pheromone traps 20/ 1000 m^2 area at 15 days after transplanting (replacing lures at every 30 days interval)
6. Application of azadirachtin 10000 ppm @ 3 ml/l followed by *Metarhizium anisopliae* @ 3 g/l *i.e.*, 1 × 10^8 CFU/ g @ 15 days interval followed by *Bacillus thuringenesis* @ 2 g/l *i.e.*, 1 × 10^8 CFU/ g (two to two and half month after transplanting).

Module 3:

1. Seed treatment with imidacloprid 48 % FS @ 7g/kg of seeds
2. Seedling dip with imidacloprid 17.8 SC @ 0.5 ml/l (10-15 minutes)
3. Collection and destruction of infested leaves (up to two months)
4. Installation of sticky traps at 30/1000 m^2 area
5. Installation of sex pheromone traps 20/ 1000 m^2 area at 15 days after transplanting (replacing lures at every 20 days interval)
6. Spray of spinoteram 12 SC @ 1.25 ml/l followed by *Metarhizium anisopliae* @ 3 g/l *i.e.*, 1 x 10^8 CFU/ g followed by *Bacillus thuringenesis* @ 2g/l (two to two and half month after transplanting)

Module 4:

RPP (chlorantraniliprole 18.5 SC @ 0.3 ml/l, spinoteram12 SC @ 1.25 ml/l - recommended by KSNUAHS and IIHR package)

In case of tomato pin worm, from each treatment and replication, five plants were selected randomly and number of mines per leaf were counted on fully opened, randomly selected three leaves and for calculating per cent fruit damage, hundred fruits were selected randomly, the number of damaged fruits were counted at each harvest. The observations were recorded at ten days intervals starting from 45 DAT to 125 DAT after the imposition of treatments.

Per cent fruit damage

$$= \frac{\text{Number of pin worm infested fruits}}{\text{Total number of fruits observed}} \times 100$$

Cost-effectiveness of each module was assessed based on net returns. Net returns of each treatment were worked out by deducting the total cost of each module from the gross returns. Total cost of production includes both cultivation as well as plant protection charges.

RESULTS AND DISCUSSION

Influence of IPM modules against tomato pin worm, *Phthorimaea absoluta*

The overall mean indicated that among the modules, significantly lower incidence of mines per 3 leaves was observed in M_1 (0.30). The next module which received moderate number of mines per 3 leaves were M_4 and M_3 (0.43 and 0.55, respectively). Whereas, significantly higher number of mines per 3 leaves was recorded in M_2 (0.66) (Table 1).

Table 1: Evaluation of IPM modules against tomato pin worm (*Phthorimaea absoluta*) on tomato.

Module No.	Mean no. of mines/ 3 leaves									Overall mean
	45 DAT	55 DAT	65 DAT	75 DAT	85 DAT	95 DAT	105 DAT	115 DAT	125 DAT	
M_1	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.52 (1.00)	0.48 (0.98)	0.56 (1.02)	0.86 (1.16)	0.46 (0.97)	0.30 (0.89)
M_2	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.12 (0.78)	1.00 (1.22)	1.12 (1.27)	1.32 (1.34)	1.40 (1.37)	1.00 (1.22)	0.66 (1.07)
M_3	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.10 (0.77)	0.74 (1.11)	0.89 (1.17)	1.00 (1.00)	1.24 (1.31)	0.98 (1.21)	0.55 (1.02)
M_4	0.00 (0.70)	0.00 (0.70)	0.00 (0.70)	0.08 (0.76)	0.60 (1.04)	0.76 (1.12)	0.86 (1.16)	0.90 (1.18)	0.70 (1.09)	0.43 (0.96)
S.Em ±	0.00	0.00	0.00	0.01	0.04	0.05	0.05	0.02	0.03	0.03
C.D. @5%	0.00	0.00	0.00	0.03	0.12	0.15	0.15	0.06	0.09	0.10

Note: Values in the parenthesis are $\sqrt{x+0.5}$ transformed; DAT – Days After Transplanting; DAT- Days after Transplanting

The present findings are in line with Sridhar *et al*. (2016) who reported that the most efficacious insecticides identified effective against *P. absoluta* were spinetoram 12 SC @ 1.25ml/ l, cyantraniliprole 10 OD @ 1.8 ml/ l, flubendiamide 480 SC @ 0.3ml/ l and spinosad 45 SC @ 0.3ml/ l, both on leaf and fruits. The present findings are also in line with Sridhar *et al*. (2019) who reported that among the various entomopathogens, egg parasitoids, *T. pretiosum* and among synthetic chemicals, spinetoram 12 SC@

1.25ml/l were found very effective for the management of *P. absoluta*. Yellow light traps were found as an effective component for integrated management of *P. absoluta*. In the present study, M_1 was found to be effective against tomato pin worm mainly because of these treatments imposed with newer group of insecticides *viz.,* spinoteram 12 SC, chlorantraniliprole 18.5 SC and flubendiamide 480 SC @ 0.3 ml/ l which possess broad-spectrum contact and stomach poisons with translaminar action and it is a good larvicide and it also includes cultural practices such as collection and destruction of infested leaves, it reduces the early build-up of the pest population and mechanical practices like installation of pheromone traps which attracts the pin worm population and reduce the pest infestation.

Influence of IPM modules on the per cent fruit damage by tomato pin worm, *Phthorimaea absoluta.* The overall mean indicated that among the modules, M_1(6.52) recorded significantly lower per cent fruit damage. The next best module, which received significantly moderate per cent fruit damage was M_4 (8.92). However, M_2 (12.92) recorded significantly higher per cent fruit damage than M_3 (11.02) (Table 2). The present investigation is in line with Kumar *et al*. (2020) who reported that, the reduction in the fruit damage by *P. absoluta* and good yields is due to the integrated management strategy taken up by installing pheromone traps 2 weeks after transplanting by which awareness on timely spraying of azadirachtin 1500ppm @ 5ml/l or combination of azadirachtin with chlorantraniliprole 18.5% SC @ 0.3 ml or flubendiamide 480 SC @ 0.3ml or indoxacarb 14.5% SC @ 1.75ml. The present investigation is in conformity with Saad *et al*. (2020) who revealed that, the pesticide consequence model indicated that (emamectin benzoate, chlorantraniliprole, flubendiamide, chlorfenapyr) gave the highest percent reduction of *P. absoluta* on the fourth model in the first season of 2017. While, (chlorantraniliprole, emamectin benzoate, chlorfenapyr, flubendiamide) gave the highest pest mean reduction on the third model in the second season of 2018. Flubendiamide followed by chlorfenapyr gave the highest percent reduction of *P. absoluta*. In the present study, M_1 was found to be effective against tomato pin worm mainly because of these treatments imposed with newer group of insecticides *viz.,* spinoteram 12 SC, chlorantraniliprole 18.5 SC and flubendiamide 480 SC @ 0.3 ml/ l which possess broad-spectrum contact and stomach poisons with translaminar action and it is a good larvicide and it also includes cultural practices such as collection and destruction of infested leaves, it reduces the early build-up of the pest population and mechanical practices like installation of pheromone traps which attracts the pin worm population and reduce the pest infestation.

Table 2: Evaluation of IPM modules against per cent fruit damage by tomato pin worm (*Phthorimaea absoluta*) on tomato.

Module No.	Per cent fruit damage									Overall mean
	45 DAT	55 DAT	65 DAT	75 DAT	85 DAT	95 DAT	105 DAT	115 DAT	125 DAT	
M_1	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.96 (8.05)	9.56 (18.01)	9.16 (17.62)	9.80 (18.24)	12.20 (20.44)	16.00 (23.58)	6.52 (14.79)
M_2	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.20 (10.30)	12.90 (21.05)	13.80 (21.81)	23.18 (28.78)	28.20 (32.08)	35.00 (36.27)	12.92 (21.07)
M_3	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.50 (9.10)	10.80 (19.19)	12.90 (21.05)	18.80 (25.70)	24.18 (29.45)	30.00 (33.21)	11.02 (19.39)
M_4	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.60 (7.27)	9.32 (17.78)	10.10 (18.53)	15.10 (22.87)	20.16 (26.68)	24.00 (29.33)	8.92 (17.38)
S.Em ±	0.00	0.00	0.00	0.14	0.19	0.24	0.29	0.69	0.70	0.58
C.D. @5%	0.00	0.00	0.00	0.42	0.60	0.75	0.90	2.14	2.15	1.80

Note: values in the parenthesis are angular transformed; DAT- Days After Transplanting; DAT- Days After Transplanting

Per cent fruit damage and Marketable fruit yield/ 500 m^2. In the present investigation, lower per cent fruit damage was recorded in the module M_1 (7.60). Whereas, M_2 (13.40) had recorded significantly higher per cent fruit damage. With respect to yield, higher yield was recorded in the module M_1 (4.72 tons/ 500m^2). Whereas, significantly lower yield was recorded in the module M_2 (4.10 tons/ 500m^2) (Table 3). The present study is in line with Dilipsundar and Srinivasan (2019) who reported that in the laboratory100 per cent mortality was observed in case of chlorantraniliprole 18.5 SC @ 0.5 ml/l, spinosad 45 SC @ 0.4 ml/l and flubendiamide 480 SC @ 0.25 ml/l after 96 hours of treatment. In field evaluation maximum reduction in larval population was recorded in case of chlorantraniliprole 18.5 SC @ 40g *a.i.*/ha (90.35 per cent) followed by spinosad 45 SC @ 73g *a.i.*/ha (87.58 per cent) and flubendiamide 480 SC @ 48g *a.i.*/ha (84.10 per cent). Fruit yield was higher in plots treated with chlorantraniliprole 18.5 SC (22.6 t/ha) followed by spinosad 45 SC (22.2 t/ha) and flubendiamide 480 SC (21.4 t/ha). In the present study lower per cent fruit damage and higher yield was recorded in the module M_1. This may be due to the treatment was imposed with newer molecules. Further, the insect pests which are exposed to these molecules may not have developed any resistance.

Table 3: Performance of IPM modules for tomato pin worm fruit damage and yield after imposition of the treatments.

Module No.	Per cent fruit damage	Yield (tons/ 500 m^2)	Yield (tons/ acre)
M_1	7.60 (16.00)	4.72	37.76
M_2	13.40 (21.47)	4.10	32.80
M_3	11.50 (19.82)	4.30	34.40
M_4	9.20 (17.66)	4.52	36.16
S.Em ±	0.60	0.05	0.60
C.D. @5%	1.82	0.15	1.81

Note: Values in the parenthesis are angular transformed

Cost economics. The highest cost of protection, gross returns and net returns were recorded in M_1 (640.00, 1,41,600.00 and 1,01,360.00Rs./ 500m^2, respectively). Further, lowest gross returns and net returns was recorded in M_2 (1,23,000.00 and 82,845.08 Rs./ 500m^2, respectively). Finally, the benefit cost ratio (B: C) was higher in M_1 (3.52: 1) followed by M_4 (3.36: 1) and M_3 (3.21: 1). However, lowest B: C ratio was obtained in M_2 (3.06: 1) (Table 4). The present study is in line with Nitin *et al*. (2018) who reported that Module 7 (Pheromone traps @20/ha, *M. anisopliae* @ 3 ml/l, spinosad (45% SC @ 0.2 ml/l) and azadirachtin (1 EC @ 2 ml/l) followed by standard check (indoxacarb (14.5SC @ 0.75 ml/l), flubendiamide (480SC @ 0.2 ml/l), cyantraniliprole (10.26 OD @ 0.3 ml/l), spinetoram (11.7 SC @0.75 ml/l) and module 6 (pheromone traps @20/ha, *M. anisopliae* (3 ml/l), azadirachtin (1 EC @ 2 ml/l) and spinosad (45 SC @0.2 ml/l) were found effective in reducing *P. absoluta*. The highest yield (59.31 t/ha) and C: B ratio (1:3.25) was obtained in Module 7.

Table 4: Cost economics of IPM modules against tomato pin worm under polyhouse condition.

Module No.	Yield (tons / 500 m^2)	Cost of protection (Rs. / 500 m^2)	Total cost of production (Rs. / 500 m^2)	Gross returns (Rs. / 500 m^2)	Net returns (Rs. / 500 m^2)	B: C ratio
M_1	4.72	640.00	40,240.00	1,41,600.00	1,01,360.00	3.52:1
M_2	4.10	554.92	40,154.92	1,23,000.00	82,845.08	3.06:1
M_3	4.30	535.32	40,135.32	1,29,000.00	88,864.68	3.21:1
M_4	4.52	480.00	40,080.00	1,35,600.00	95,520.00	3.36:1

Fruit price = Rs. 30/ Kg

CONCLUSION

From the present investigation, it could be concluded that Module 1 consisting of seed treatment with imidacloprid 48 % FS @ 7g/kg of seeds, seedling dip with imidacloprid 17.8 SC @ 0.5 ml/l , collection and destruction of infested leaves, installation of sticky traps at 30/1000 m^2 area, installation of sex pheromone traps 20/1000 m^2 area and spraying of chlorantraniliprole 18.5 SC @ 0.3 ml/l, spinoteram12 SC @ 1.25 ml/l followed by flubendiamide 480 SC @ 0.3 ml/l proved to be better in reducing tomato pin worm population under naturally ventilated polyhouse condition.

FUTURE SCOPE

The future studies need to be carried out on IPM of tomato pin worm under open field conditions.

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Conflict of Interest. None.

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