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Field assessment on management of South American pin worm, *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) in tomato

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Abstract
Field trials were conducted for three years during *kharif* season of 2014, 2015 and 2016 to evaluate the integrated pest management (IPM) module against pinworm (*Tuta Absoluta*) in tomato in comparison with farmer's practice. Seasonal incidence studies revealed that population increased gradually from September and touched its peak during December (28.00 adults/trap). The insect was found to be higher at the fruit maturity stage and infestation found decreased with increase in temperature. IPM module reduced the cost of cultivation by Rs. 9615.66 ha-1 and the net returns were increased by Rs. 53282.00 per hectare. The average benefit cost ratio was improved with 2.39 in treatment compared to farmers practice 1.92. The results based on pooled data showed that reduction in the fruit damage by *Tuta 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/lt 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 carried in practicing farmers field based on ETL level of adult catches and burning of infested plants and remnants of the crop immediately after the fruits have been harvested also found effective in managing the pest.

Keywords: Tomato, pinworm, IPM module, pheromone traps, economics

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most important commercial and commonly consumed nutritious vegetable grown in India with the production of 22.3 million tonnes from an area of 0.8 million hectors [1]. As fruits of tomato are tender and soft, is more susceptible to pest and disease attack. Accidental introduction of South American tomato leafminer or tomato pin worm, *T. absoluta* (Meyrick) (Lepidoptera: Gelechiidae) occured due to movement of infested fruits and packing material between countries. Since the initial detection, this has become the most serious pest causing severe damage to tomato in many areas [2]. Such introduced pests exploit the surrounding conditions and in the absence of their natural enemies cause severe damage to the crops. The pest is native to Peru, where it is a serious pest on solanaceous vegetables [3], its infestation is being noticed both in protected and open fields. It is solanaceous oligophagous pest, primary host is tomato although potato, brinjal, common bean and other wild solanaceous family plants are also convenient hosts [4]. High reproductive potential of pest, short generation time, multivoltine character and its aggressive nature are the reasons for its easy adaptability in the new locations [5].
In India, it was noticed for the first time on tomato at the Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bengaluru, Karnataka, during the Rabi season of 2014 and then from Pune and then in Malnad and in Hyderabad - Karnataka region [4] .
For the prevalence of the pest, conducted extensive field surveys in tomato growing mandals Inderavelly, Gudi Hathnoor and Thosam Mandals and other parts of district of the Adilabad district and confirmed its incidence in tomato growing areas. Farmers are mainly depending on synthetic pesticides to manage the pest and their indiscriminate use resulting in development of resistance in target pests [3] and harmful pesticide residues in fruits.
Hence, on farm trials was made for inculcating knowledge on the pest identification, proper use and adoption of pest management modules against tomato leaf miner in the farmers' fields

as it directly enables to conduct demonstrations at the farmer's fields which inturn helps to learn information related to the technology.

Materials and Methods

Assessment on management of tomato leaf miner carried out in the farmers fields of operational area of KVK, Adilabad in tomato cultivating mandals Indervelly, Gudihathnoor, Thosam Mandals and other parts of district for three consecutive years *i.e.* 2016, 2017 and 2018 during *kharif* and *rabi* in an area of 6 acres in 6 selected farmers' fields with an intention to increase knowledge on pest identification and field evaluation on management of leaf miner in tomato.

The selection of farmers was done on basis of farmers participatory mode by KVK Scientists in tomato growing mandals for implementing of management modules against pest in the field. They were trained on the package of practices recommended by SHU (State Horticultural University) from sowing till harvesting like the quality seeds, seed treatment with bio control agents (*Trichoderma*), recommended dose of fertilizers, mulching, integrated pest management practices in tomato. The conventional practices were taken as a control.

Table 1: Details of practices on Management of Pin worm (*Tuta Absoluta*) in Tomato

S. No	IPM FLD	Farmers Practice
1	Installation of Pheromone traps @ 10/acre for mass trapping.	Not installing pheromone traps
2	Need based approaches based on trap catches i.e., when < 10moths/trap/week - Azadirachtin 1500ppm @ 5ml/lt. When >10moths/trap/week -Azadirachtin 1500ppm @ 5ml/lt + conventional chemicals. Need Based chemicals: Chlorantraniliprole 18.5% SC @ 0.3 ml or flubendiamide 480 SC @0.3ml or Indoxacarb 14.5% SC @ 1.75ml when incidence is severe.	Applying Acephate @ 1.5 g/lt, Acetamiprid @ 0.2 g/lt, Flonicamid @ 0.3 g/lt , Chlorfenapyr @ 1.5 ml/lt and Spinosad @ 0.3ml/lt

Monitoring of moths: Moth population was monitored starting from transplanting using sex pheromone traps (Pheromone chemicals Ltd). Five traps were installed 0.5 m above ground level and adjusted to canopy height at weekly interval. Sex pheromone dispensers were renewed every four weeks and the number of moths captured per trap was recorded weekly throughout crop growth period. Insecticides *viz*., flubendiamide or chlorantraniliprole or spinosad were chosen at recommended doses based on the ETL for management of leaf miner as and when need arise.

The data on the pest incidence in IPM and non IPM plots were recorded. The data on fruit damage was recorded from ten randomly selected plants from each field and calculated percentage of fruit infestation was calculated

The data of yield, pest management, production cost and returns were collected by KVK, scientists with frequent field visits during 2016-2018 from demonstration plots and farmers practice plot (control plot) and finally calculations were done as per formula suggested by Samui *et al*. (2000) [6].

$$\text{Per cent increase in yield} = \frac{\text{Demonstration yield - farmers practice yield}}{\text{Farmers practice yield}} \text{ X } 100$$

Results and Discussion

Table 2: Seasonal incidence of leaf miner (*Tuta obsoluta*) under field conditions during 2016-17

Month	Leaf infestation (%)	Fruit damage (%)	Trap catches (No.)
July	0.00	0.00	0.00
August	0.33	0.00	3.13
September	1.67	5.25	8.80
October	3.54	8.53	14.38
November	10.26	16.43	23.12
December	13.24	20.72	28.00
January	8.65	11.33	14.68
Mean	5.10	8.89	13.73

The data presented in table 2 reveal that the incidence of leaf miner on tomato initiated during vegetative stage in the month of August with 0.33% Leaf infestation and reached at peak level in the month of December with 13.24% infestation. The mean per cent leaf damage was 5.10% throughout the crop growth period.

The infestation of fruits was noticed in the month of September and per cent infestation levels throughout the crop period ranged from 5.25- 20.72% with mean 8.89 per cent fruit infestation. The maximum of 20.72% damaged fruits was recorded during December when the trap catches was at its peak with 28.00 adults/ trap. The insect was found to be higher at the fruit maturity stage and infestation found decreased with increase in temperature.

Figure 2. Number of captured tomato leaf miner moths in an open-field tomato crop at Haramaya in 2014.

The moth catches were began in the month of July and continued till final harvest of the crop. The number of moths varied from 3.13 to 28.00 numbers per trap. The population increased gradually from September and touched its peak with a mean of 28.00 adults per trap during December. Thereafter, pest population declined gradually and reached 14.68 trap catches per trap in the month of January. Results are in consonance with the findings of Nayana *et al*., 2018 and Portakaldali *et al*., 2013.

Table 3: Correlation between incidence of tomato leaf miner with weather parameters during 2016 under field condition

Parameter	Correlation Coefficient (r)					
	Tmax	Tmin	RH1	RH2	BSSH	Rain fall (mm)
Fruit damage (%)	-0.35	0.78	-0.78	-0.37	0.09	0.43
Trap catches (No.)	-0.44	0.89	-0.86	-0.08	-0.46	-0.73

Correlation between percent fruit damage and trap catches of pinworm with weather parameters presented in table 3 indicated that R.H (r =-0.178 and-0.210) exerted significant positive correlation with minimum temperature (r= 0.78 and 0.89) and strong negative relationship with morning relative humidity (-0.78 and -0.86).The findings of authors [9, 4] are in association with the present results.

Table 4: Comparative C: B analysis of tomato under IPM FLD and farmers practice

Year	Variety	No. of farmers	Area (ha)	Average yield (t/ha)		Per cent increase	B:C ratio		Fruit damage (%)	
				Demo	Check		T1	T2	Demo	Check
2016	US-440	6	0.6	40.62	37.5	8.32 %	2.50:1	2.24:1	7.23	15.45
2017	US-440	6	0.6	38	34.5	10.14 %	2.93:1	2.09:1	4.21	10.73
2018	US-440	6	2.4	39.16	34.83	12.42 %	1.73:1	1.44:1	6.33	18.24

A comparison of productivity levels between IPM practices in demonstration trials and farmers practices is shown in Table 4. The results indicate that relying singly on pesticides cannot control the pest and adoption of integrated pest management start strategies were effective in reducing the fruit damage caused by *tuta obsoluta* as there is increase in yields in demonstration plots over farmers practice.

During 2016, the per cent fruit damage in IPM plot was 7.23, whereas in the farmers practice, it was 15.45 per cent. The tomato fruit yield in the IPM plot was 40.62 t ha-1 with 8.32 per cent increase in yield when compared to farmers practice i.e., 37.5 t ha-1. During 2017, the per cent fruit damage in IPM plot and farmers practice was 4.21 and 10.73 per cent with fruit yields of 38 and 34.5 t ha-1, respectively. Recorded 10.14 per cent increase in yield when compared to farmers practice. In the year 2018, per cent pinworm damage was 6.33 and 18.24 recorded in IPM plot and farmers practice, respectively. The tomato fruit yield in the IPM plot was 39.16 t ha-1 with 12.42 per cent increase in yield when compared to farmers practice 34.83 t ha-1.

Results indicate that reduction in the fruit damage by *Tuta absoluta* and good yields is due to the integrated management strategy taken up by installing pheromone traps 2 weeks after transplanting by which Monitoring & behavioural manipulation of insect can be done and minimize the male adults. The results were in accordance with the findings of Megido *et al*., 2013 and Braham *et al*., 2014 who reported pheromone trap data give early warning of the infestation and also will alert the user to low level of populations before they become serious.

Awareness on timely spraying of Azadirachtin 1500ppm @ 5ml/lt followed by combination of Azadirachtin with Chlorantraniliprole 18.5% SC @ 0.3 ml or Flubendiamide 480 SC @0.3ml or Indoxacarb 14.5% SC @ 1.75ml in practicing farmers field based on ETL level of adult catches, burning of infested plants and remnants of the crop immediately after the fruits have been harvested also found effective in managing the pest reduced infestation. Earlier workers have also reported that implementation of IPM module through front line demonstrations reduced the pest load and chemical pesticide usage in tomato crop [12, 13], brinjal [14] and chilli [15].

Table 5: Comparative cost economics analysis of tomato under IPM FLD and farmers practice

Year	Economics of demonstration (Rs./ha)				Economics of check (Rs./ha)			
	Gross Cost	Gross Return	Net Return	BCR (R/C)	Gross Cost	Gross Return	Net Return	BCR (R/C)
2016	133205	334500	201295	2.50:1	140605	315000	174395	2.24:1
2017	131000	384750	253750	2.93:1	143105	299250	156145	2.09:1
2018	135612	235000	99387	1.73:1	144954	209000.0	64045	1.44:1
Mean	133272	318083	184810	2.39:1	142888	274416	131528	1.92:1

Effect of IPM module on economics

The economics of tomato crop under demonstration (IPM) and farmers' practice were estimated and presented in Table 5, on an average in all the three years, the cost of cultivation was reduced by Rs. 9615.66 ha-1 and the net returns were increased by Rs. 53282.00 per hectare. The average benefit cost ratio was improved with 2.39 in treatment compared to 1.92 in farmers practice.

Net profit in IPM module was relatively higher (Rs. 184810/ha) than farmer's practice (Rs. 131528/ ha). The IPM module registered the maximum benefit cost of 2.39 as compared to farmer's practice (1.92). The results obtained in the study are similar with the previous workers [16, 17] who have also reported that IPM module provided higher net returns, yield and benefit cost ratio over the farmer's practices in tomato.

Conclusion

Chemical insecticides are the only method applied as control strategies against pinworm by the tomato growers which increased cost of cultivation and poor quality produce. Thus, the pinworm management strategies followed reduced the indiscriminate use of insecticides as monitoring of pest population done by pheromone traps which in turn helped correct timing of pesticide application.

The trials conducted in Adilabad district by KVK, Adilabad on tomato crop provided efficient management of leaf miner as it attacks all parts of the crop from vegetative to fruiting stage. The farmers were educated various aspects like identifying the pest, symptoms, right method and time of control significantly increased the income of the farmers by reducing the losses due to leaf miner, *Tuta obsoluta* in tomato.

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