Pest Management in Horticultural Ecosystems
Vol. 26, No.2 pp 214-221 (2020)

Efficacy of selected chemicals for the management of melon fruit fly, *Zeugodacus cucurbitae* (Coquillett) (Diptera: Tephritidae) on tomato

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ABSTRACT: Tomato is an important vegetable crop widely cultivated in India**.** Recent years, melon fruit fly, *Zeugodacus cucurbitae* is becoming a serious threat to tomato crop resulting severe yield and economic loss to growers but unfortunately its incidence and damage is not reported in Karnataka earlier. Efficacy of selected chemicals against tomato fruit fly revealed that deltamethrin 2.8% EC @ 1ml/l and spinosad 45% SC @ 0.2ml/l were found superior in controlling fruit fly infestation followed by cypermethrin 25% EC @ 0.5ml/l. Flubendiamide 39.35% SC @ 0.3ml/l, lambda-cyhalothrin 5% EC @ 0.5ml/l and dimethoate 30% EC @ 1.75ml/l were only moderately effective in reducing fruit fly infestation. Quinalphos 25% EC @ 2ml/l was the least effective insecticide among the different chemicals evaluated.

Keywords: Chemicals, fruit fly, tomato, *Zeugodacus cucurbitae*

INTRODUCTION

Tomato is one of the most important vegetable crops being grown in almost all parts of the world including India and many other countries. In Karnataka, it is extensively cultivated in Kolar and Chikkaballapur Districts with production of 4.81 lakh tonnes and 1.42 lakh tonnes, respectively (Anonymous, 2017). Many insect pests attack tomato starting from germination to harvesting resulting in reduction in yield and fruit quality as well. The major pests attacking tomatoes are fruit borer, *Helicoverpa armigera* (Hubner), tomato leaf miner, *Tuta absoluta* (Meyrick), serpentine leaf miner, *Liriomyza trifolii* (Burgess), leaf eating caterpillar, *Spodoptera litura* (Fabricius), thrips, *Thrips tabaci* Lindeman, whiteflies, *Bemisia tabaci* (Gennadius) and the fruit fly (Afreen *et al.,* 2017). The fruit flies are major insect pests of solanaceous and cucurbit crops and losses are as high as 80 per cent in tomato and 100 per cent in cucurbit crop harvests (Philippe *et al.,* 2010). Among the important species of fruit flies, the melon fly, *Zeugodacus cucurbitae* and pumpkin fly, *Z. tau* have wide distribution throughout South-East Asia and attack number of crops which belong to *Cucurbitaceae* and *Solanaceae* family (Pinero *et al*., 2006).

In recent years, the melon fruit fly, *Z. cucurbitae* is becoming a serious threat to tomato crop resulting in severe yield and economic loss ranging from 24 to 62% fruits damage among different tomato hybrids grown in Kolar and Chikkaballapur districts (Vijay, 2020).

Many tomato growers are not able to notice the melon fly infestation till the liquid oozes out from the ripened fruits at harvest or when fruits start rotting on the plants due to its peculiar mode of infestation in tomato, as adult female fly starts laying eggs underneath the pedicel of the fruit. So, protection of fruits with environment friendly approaches without harming the consumers from chemical residual toxicity are the main concerns in tomato crop production (Anonymous, 1986). Since the melon fly infestation appears during harvesting stage of the fruit, its incidence often goes unnoticed. With this back ground, probable potential threat to tomato production by melon fruit fly in the coming days, the present investigation on efficacy of different chemicals against tomato fruit fly was carried out.

MATERIALS AND METHOD

Two field trials were conducted during September and December 2019 at Beemaganapalli village (13.585059^{o} N,78.215720^{o} E) Srinivasapur Taluk, Kolar District of Karnataka to ascertain the relative efficacy of different insecticides against melon fruit fly on tomato. Randomised block design method with eight treatments including untreated control was carried out (Table 1). Each treatment had three replications. Each replication was maintained with the plot size of 3×5 metre. Since our studies are the first report on fruit fly infestation causing economic damage in Karnataka and South India, there were no insecticides recommendation for fruit

Table 1. Efficacy of selected chemicals against fruit fly, *Z. cucurbitae* on tomato (Trial -I)

Treatment	Pre-treatment count	Number of infested fruits Mean ± SD		
		5 DAS	10 DAS	15 DAS
Cypermethrin 25% EC @ 0.5ml/l	10.53	(3.07±0.42)^{b}	(2.20±0.35)^{b}	(1.27±0.12)^{b}
Deltamethrin 2.8% EC @ 1ml/l	11.47	(2.27±0.12)^{a}	(1.00±0.35)^{a}	(0.47±0.23)^{a}
Lambda-cyhalothrin 5% EC @ 0.5ml/l	12.33	(4.13±0.23)^{c}	(3.47±0.31)^{c}	(2.53±0.50)^{d}
Dimethoate 30% EC @ 1.75ml/l	11.27	(5.00±0.80)^{d}	(4.53±0.64)^{d}	(2.73±0.58)^{d}
Quinalphos 25% EC @ 2ml/l	11.67	(5.20±0.20)^{d}	(4.87±0.12)^{d}	(3.47±0.12)^{e}
Spinosad 45% SC @ 0.2ml/l	12.53	(2.47±0.12)^{ab}	(1.20±0.20)^{a}	(0.67±0.12)^{a}
Flubendiamide 39.35% SC @ 0.3ml/l	11.67	(3.87±0.64)^{c}	(3.20±0.72)^{c}	(1.93±0.12)^{c}
Control (untreated)	10.93	(12.00±0.40)^{e}	(12.40±0.20)^{e}	(12.87±0.12)^{f}
F-test	NS	*	*	*
Sem±	0.62	0.25	0.25	0.18
CD		0.76	0.77	0.55
CV	NS	9.17	10.64	9.72

*Significant at 5% level. NS- Non significant. DAS- Days after spray. Figures in each column followed by same alphabet are not significantly different.

fly control in tomato. So, chemicals with less waiting period and relatively safe to the human beings were selected for the chemical trials. The waiting period of different chemicals selected for the evaluation against fruit fly are; Cypermethrin (2-4 days), Deltamethrin (3-5 days), Lambda-cyhalothrin (4 days), Dimethoate (7days), Quinalphos (6-7 days), Spinosad (1-3 days), Flubendiamide (5 days) (Anonymous, 2012 & Anonymous, 2020).

The selection of insecticides for evaluation against fruit fly infestation on tomato was based on either earlier literature on chemical recommendations on other crops against melon fly. The chemicals like flubendiamide, lambda cyhalothrin which are having short waiting period on tomato, cost effective and less persistent were also included in this experiment, which are relatively safe for both consumers as well as farmers while spraying.

The insecticide treatment details are mentioned in Table 1. Fruit fly infestation in each experimental plot was considered as uniform and before treatment imposition, number of infested fruits from five randomly selected plants was recorded by destructive sampling method and treated as pre-count in each plot. Then the plants other than those which are examined while taking pre-count were labelled and different chemical treatments were imposed on experimental plots using high volume knapsack sprayer. After treatment imposition, data on number of fruits infested was recorded by destructive

Table 2. Efficacy of selected chemicals against fruit fly, *Z. cucurbitae* (Trial -II)

Treatment	Pre-treatment count	Number of infested fruits Mean ± SD		
		5 DAS	10 DAS	15 DAS
Cypermethrin 25% EC @ 0.5ml/l	8.73	(2.13±0.23)^{b}	(1.87±0.23)^{b}	(1.27±0.23)^{b}
Deltamethrin 2.8% EC @ 1ml/l	8.53	(1.60±0.20)^{a}	(0.87±0.31)^{a}	(0.40±0.20)^{a}
Lambda-cyhalothrin 5% EC @ 0.5ml/l	8.80	(2.93±0.31)^{c}	(2.53±0.31)^{c}	(2.13±0.31)^{c}
Dimethoate 30% EC @ 1.75ml/l	8.57	(3.47±0.42)^{d}	(3.40±0.20)^{d}	(2.27±0.23)^{c}
Quinalphos 25% EC @ 2ml/l	8.83	(3.80±0.40)^{d}	(3.73±0.12)^{d}	(2.73±0.12)^{d}
Spinosad 45% SC @ 0.2ml/l	8.73	(1.60±0.20)^{a}	(0.93±0.31)^{a}	(0.40±0.20)^{a}
Flubendiamide 39.35% SC @ 0.3ml/l	8.53	(2.87±0.12)^{c}	(2.60±0.53)^{c}	(2.13±0.31)^{c}
Control (untreated)	8.73	(9.07±0.31)^{e}	(9.80±0.40)^{e}	(10.33±0.31)^{e}
F-test	NS	*	*	*
Sem±	0.25	0.18	0.19	0.15
CD	NS	0.54	0.59	0.46
CV		8.94	10.48	9.60

*Significant at 5% level. NS- Non significant. DAS- Days after spray. Figures in each column followed by same alphabet are not significantly different.

sampling method at five, ten and fifteen days after treatment imposition.

The mean number of fruits infested by *Z. cucurbitae* in tomato was worked out and values were then subjected to single factor Analysis of Variance (ANOVA) given by Gomez and Gomez (1984). The critical difference (CD) at 5% probability level was used as the test criterion. To compare the efficacy of different chemicals, the per cent reduction in fruit fly infestation over control was calculated using Henderson and Tilton's formula (1955).

Per cent reduction in fruit infestation over control=

$$1-\left[\frac{Ta}{Tb}\times\frac{Cb}{Ca}\right]\times 100$$

Where,

T_a= Population in treated plot after spray or treatment

T_b = Population in treated plot before spray or treatment

C_a = Population in control plot after spray or treatment

C_b = Population in control plot before spray or treatment

RESULTS AND DISCUSSION

Efficacy of selected chemicals against tomato fruit fly, *Z. cucurbitae* (Trial I)

The data on the efficacy of selected insecticides against *Z. cucurbitae* infesting tomato crop are presented in Table 1. The pre-treatment count of mean number of fruits infested ranged from 10.53 to 12.53.

Five days after treatment imposition, all the seven treatments were found significantly superior over control. Amongst, deltamethrin (2.27) and spinosad (2.47) were

found best treatments and equally effective in reducing the mean number of fruits infestation by tomato fruit fly over control. These were followed by cypermethrin (3.07). The next best chemicals in minimizing the fruit fly infestation are flubendiamide (3.87) and lamda-cyhalothrin (4.13) which were on par with each other. Dimethoate (5.00) and quinalphos (5.20) were the least effective among chemical treatments against fruit fly but were statistically superior over control in reducing the mean number of fruits infested by fruit fly five days after post treatments.

The observations recorded at ten days post treatment revealed that all the treatments were significantly superior over control. Deltamethrin (1.00) and spinosad (1.20) were the most and equally effective chemicals in reducing the mean number of fruits infestation compared to other treatments. These were followed by cypermethrin (2.20). The next best treatments in reducing the mean number of fruits infested by fruit fly were flubendiamide (3.20) and lamda-cyhalothrin (3.47) and on par with each other. Dimethoate (4.53) and quinalphos (4.83) were found least effective in efficacy compared to all other chemical treatments but were significantly superior over control in reducing the mean number of fruit infestation.

The results at fifteen days after treatments revealed that all the seven chemical treatments were significantly superior over control. Among them, deltamethrin (0.47) and spinosad (0.67) were highly effective chemicals in reduction of mean number of fruits infestation by tomato fruit fly and were on par with each other, followed by cypermethrin (1.27). The next best treatment in minimizing the number of fruit infestation was flubendiamide (1.93). Lamda-cyhalothrin (2.53) and dimethoate (2.73) were on par with each other in reducing the mean number of fruits infestation by tomato fruit fly. Quinalphos (3.47) was least effective in reducing fruit fly infestation but was significantly superior over the control.

Efficacy of selected chemicals against tomato fruit fly, *Z. cucurbitae* (Trial-II)

The pre-treatment values on mean number of tomato fruits infested by fruit fly ranged between 8.53 to 8.83 fruits per plant and are presented in Table 2. Five days after post treatments, all the treatments were found significantly effective over control. Among them deltamethrin (1.60) and spinosad (1.60) were found best treatments in reducing mean number of fruit infestation by fruit fly and both are on par with each other. These were followed by cypermethrin (2.13). The next best treatments in reducing the fruit fly infestation were flubendiamide (2.87) and lambda-cyhalothrin (2.93) which were on par with each other. Dimethoate (3.47) and quinalphos (3.80) were on par with each other in reducing the mean number of fruits infestation by fruit fly and were found superior over control but these treatments were least effective when compared with other chemical treatments.

At ten days post treatments, all the seven treatments were found significantly superior over control. Deltamethrin (0.87) and spinosad (0.93) recorded the highest reduction in mean number of fruits infestation compared to all other treatments and were on par with each other. These treatments were followed by cypermethrin (1.87). Lambda-cyhalothrin (2.53) and flubendiamide (2.60) were next best effective treatments against tomato fruit fly infestation and were found on par with each other. Dimethoate (3.40) and quinalphos (3.73) were least effective in reducing the mean number of fruits infestation by fruit fly and were on par with each other.

At fifteen days after treatments imposition, the observations revealed that all the chemical treatments were significantly superior over control. Deltamethrin (0.40) and Spinosad (0.40) were emerged as the best chemical treatments in reducing mean number of tomato fruit infestation by fruit fly and were on par with each other. These were followed by cypermethrin (1.27). The next best effective treatments against fruit fly infestation were lambda-cyhalothrin (2.13), flubendiamide (2.13), dimethoate (2.27) and were on par with each other. Quinalphos (2.73) was least effective chemical treatment in reducing fruit fly infestation but was significantly superior over control.

Pooled data

The pooled data on the efficacy of selected chemicals against fruit fly infesting on tomato are presented in Table 3. The pre-treatment count on mean number of fruits infested by fruit fly ranged between 9.63 to 10.63. The analysis of the pooled data showed that the chemicals efficacy trend was similar to that in both the trials. The per cent reduction in fruit fly infestation over control is also presented in Figure 1.

Five days after treatments imposition, it was found that all the seven treatments were found significantly superior over control in reduction of mean number of fruits infested by fruit fly. Deltamethrin (1.93) and spinosad (2.03) were the best treatments in reducing fruit fly infestation in tomato. However, these treatments were on par with each other. These were followed by cypermethrin (2.60). Flubendiamide (3.37) and lamda-cyhalothrin (3.53) were the next effective insecticides and

Table 3. Efficacy of selected chemicals against fruit fly, *Z. cucurbitae* (Pooled data)

Treatment	Pre-treatment count	Number of infested fruits Mean ± SD		
		5 DAS	10 DAS	15 DAS
Cypermethrin 25% EC @ 0.5ml/l	9.63	(2.60±0.26)^{b}	(2.03±0.06)^{b}	(1.27±0.15)^{b}
Deltamethrin 2.8% EC @ 1ml/l	10.00	(1.93±0.15)^{a}	(0.93±0.32)^{a}	(0.43±0.06)^{a}
Lambda-cyhalothrin 5% EC @ 0.5ml/l	10.57	(3.53±0.21)^{c}	(3.00±0.20)^{c}	(2.33±0.38)^{cd}
Dimethoate 30% EC @ 1.75ml/l	9.77	(4.23±0.60)^{d}	(3.97±0.40)^{d}	(2.50±0.36)^{d}
Quinalphos 25% EC @ 2ml/l	10.23	(4.50±0.26)^{d}	(4.30±0.10)^{d}	(3.10±0.10)^{e}
Spinosad 45% SC @ 0.2ml/l	10.63	(2.03±0.06)^{a}	(1.07±0.23)^{a}	(0.53±0.06)^{a}
Flubendiamide 39.35% SC @ 0.3ml/l	10.10	(3.37±0.29)^{c}	(2.90±0.20)^{c}	(2.03±0.15)^{c}
Control (untreated)	9.83	(10.53±0.21)^{e}	(11.10±0.26)^{e}	(11.60±0.10)^{f}
F-test	NS	*	*	*
Sem±	0.37	0.18	0.15	0.13
CD	NS	0.54	0.45	0.39
CV		7.47	7.06	7.47

*Significant at 5% level. NS- Non significant. DAS- Days after spray. Figures in each column followed by same alphabet are not significantly different.

on par with each other. Dimethoate (4.23) and quinalphos (4.50) were the least effective among different chemicals against tomato fruit fly infestation but were on par with each other and significantly superior over control.

At ten days after post treatments, deltamethrin (0.93) and spinosad (1.07) were the most effective chemicals against fruit fly. These were followed by cypermethrin (2.03). Flubendiamide (2.90) and lambda-cyhalothrin (3.00) were the next best treatments in reducing the mean number of fruits infested by fruit fly and were on par with each other. The least effective chemicals in reducing the mean number of fruits infestation were dimethoate (3.97) and quinalphos (4.30) and were on par with each other but significantly superior over control.

At fifteen days post treatments, deltamethrin (0.43) and spinosad (0.53) were found best in reducing fruit fly infestation among all the treatments and both the treatments on par with each other. These treatments were followed by cypermethrin (1.27). The next best treatments in reducing the mean number of fruits infestation were flubendiamide (2.03) and lambda-cyhalothrin (2.33) which were on par with each other. These were followed by dimethoate (2.50). Quinalphos (3.10) was also found superior over control but this was the least effective against fruit fly infestation when compared with all other treatments.

As the fruit fly, *Z. cucurbitae,* is one of the emerging pests in tomato ecosystem, if unnoticed in the initial stages it may cause serious damage to the yield. Infestation of the fly is mainly during fruit ripening stage, so farmer has to take at most care while opting for chemical control measures. Since tomatoes were harvested once in 3–4 days interval, consumers will get affected if pesticides with long residual activity used to manage fruit fly. Keeping these things in mind, in the current chemical

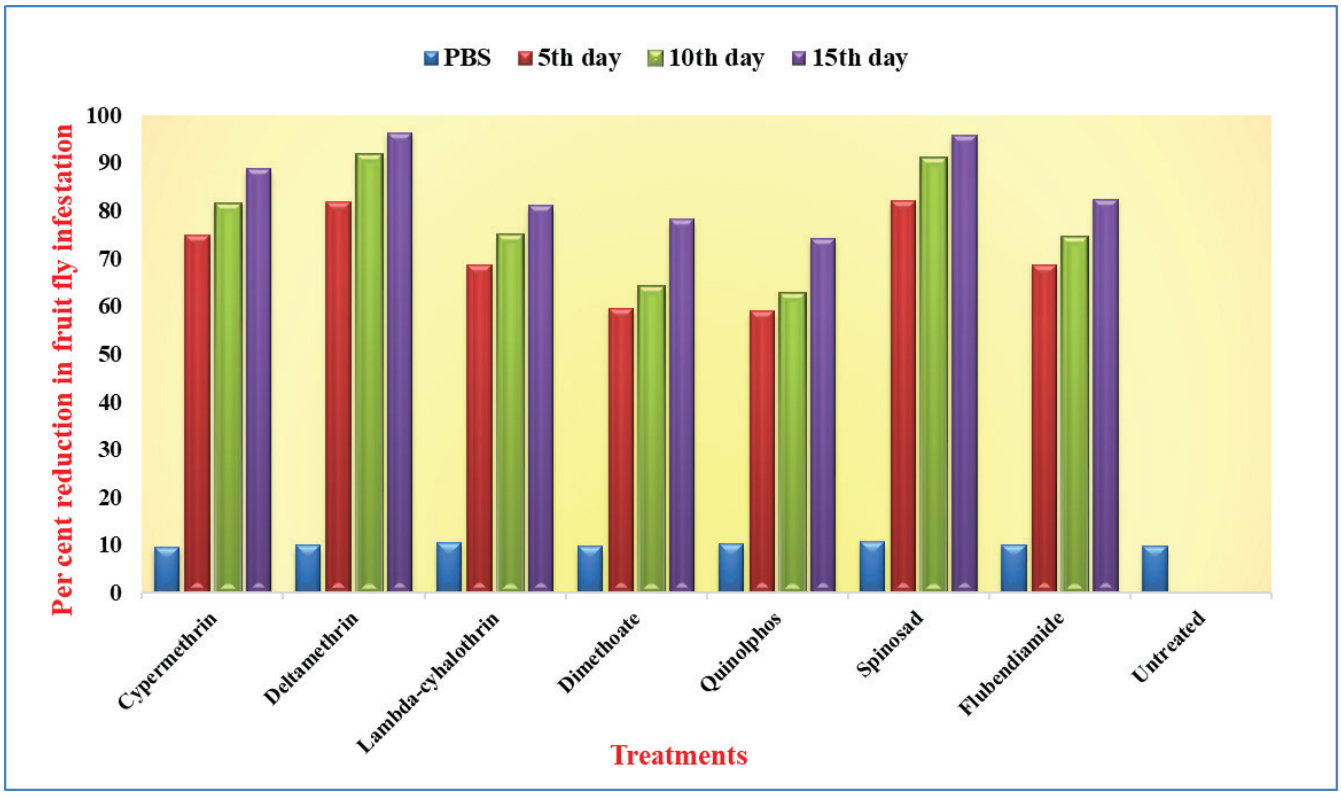

Fig. 1. Reduction in fruit fly infestation on tomato after different insecticidal treatments

evaluation studies, chemicals with less waiting period on tomato were selected.

In the study among seven different chemical treatments evaluated, deltamethrin 2.8% EC @ 1ml/l and spinosad 45% SC @ 0.2ml/l were found superior among all the treatments in controlling the fruit fly infestation. These findings were supported by Vinutha and Kotikal (2018), who found that fruit fly infestation in oriental pickling melon was lowest in plots treated with deltamethrin 2.8 EC (0.5 ml/l) and spinosad 45 SC (0.3 ml/l). Sawai *et al*. in 2014 also reported that deltamethrin (0.0025 %) was the most effective insecticide in management of fruit fly with highest marketable yield in ridge gourd.

The efficacy results of spinosad 45% SC @ 0.2ml/l of the current study was also supported by the studies of Nehra *et al*. (2019) and Bhowmik *et al.* (2014), who reported that spinosad 45 SC (0.4 ml/l) was the most effective chemical in the management of fruit fly in round gourd and bitter gourd respectively. The reports of Srinivas *et al.* (2018) on cucumber treated with spinosad 45 SC (0.15 ml/l) had lowest number of ovipositional punctures (0.72 and 0.98 /fruit), lowest number of maggots (8.0 and 8.93 /fruit), lowest per cent fruit infestation (14.92 and 17.90 %) in both *kharif* and summer seasons respectively.

In the present investigation, it was also found, the next best treatment is cypermethrin 25% EC @ 0.5ml/l. These results are comparable with the findings of Sharma *et al*. (2016) who observed the lowest fruit fly infestation of cucumber in the plot treated with cypermethrin. Sood and Sharma (2004) also found significantly less number of fruits infestation by cucurbit fruit fly in treatments with pyrethroids (deltamethrin, cypermethrin and fenvalerate) in comparison to malathion.

Further, in the current study lambda-cyhalothrin 5% EC @ 0.5ml/l was found moderately effective against fruit fly. This is contrary to some of the earlier workers findings on lambda-cyhalothrin efficacy against fruit fly. Abrol *et al*. (2019) reported that lambda-cyhalothrin (0.004%) was more effective insecticide against fruit fly in bottle gourd followed by spinosad (0.002%) and deltamethrin (0.0028%). The findings of Balas *et al.* (2018) showed that lambda-cyhalothrin 5 EC (0.005 %) was the most effective insecticide in management of fruit flies in cucumber. Meena (2011) also reported that Lambda cyhalothrin (0.04%) and spinosad (0.002%) proved best in managing fruit fly infestation in tomato.

In the present study, it was found that quinalphos 25% EC @ 2ml/l was the least effective against fruit fly infesting tomato compared to other chemicals treatments. However, 3.10 mean number of fruits infestation when

converted to mean per cent fruit infestation reduction, accounts 68.47 per cent reduction is also good efficacy level of quinalphos against fruit fly infestation. These results were supported by the findings of Bhatnagar and Yadava (1992) who reported that quinalphos (0.02%) was moderately effective insecticide against fruit fly in bottle gourd, sponge gourd and ridge gourd.

The farmers growing tomato during June to December period need to monitor regularly by observing fruits for fruit fly infestation more particularly at the ripening stage. The infestation may occur when there are good rains. If infestation is noticed, there is a need for insecticide application for effective control of fruit fly. Considering the chemical evaluation results from the present investigation, though deltamethrin showed good efficacy against fruit fly, application of spinosad 45% SC @ 0.2ml/l or cypermethrin 25% EC @0.2ml/l may be advocated since deltamethrin is recently grouped under prohibited chemicals by the Government of India. Further, spinosad usage can be suggested compared to cypermethrin, since former insecticide is a bio-molecule with green label and is relatively safe for the farmers (while applying the chemicals) as well as to the consumers. Timely application of these insecticides at the initial stages of pest infestation would be the most effective method in controlling the pest in a tomato ecosystem.

ACKNOWLEDGEMENT

Authors are thankful to farmers Mr. Gopala Reddy and Mr. Murali Reddy, Beemaganapalli Village, Marasanapalli Post, Srinivasapur Tq., Kolar District, their co-operation and allowing the first author to carry out this research study. The above research findings are the part of first author's M. Sc. thesis research.

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MS Received: 22 November 2020
MS Accepted: 30 November 2020