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ARTICLE

Development and Evaluation of IPM Modules for the Management of Guava Fruit Fly

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ABSTRACT

Field studies were carried out during kharif 2016 and summer 2017 at Udyanagiri, UHS, Bagalkot, Karnataka, India to evaluate IPM modules against fruit fly in an already established guava orchard of variety Sardar (L-49). Among four modules, the mean fruit damage was significantly the lowest in M3 (0.68%) followed by M2 (1.19%) and M1 (2.21%) and were on par with each other during kharif 2016. During summer 2017, M3 recorded significantly lowest damage (0.59%) followed by M2 (0.92%) and M1 (2.41%) but were on with each other. The highest per cent protection was afforded by M3 (95.76 and 96.76, respectively) during 2016 and 2017. The average fruit yield over the years of experimentation revealed significantly the highest fruit yield (8.13 t/ha) from M3 followed by M2 (7.32 t/ha) and M1 (5.31 t/ha). Among the four modules, highest B:C was from M3 (7.65) followed by M2 (6.67) and M1 (4.91).

1. Introduction

The guava, botanically known as Psidium guajava L. belongs to the family of Myrtaceae. It is one of the most common fruits grown in India. The fruits are very rich in vitamin C (100-260 mg/100 g pulp). Fruits are also rich in minerals like Calcium, Phosphorous, acidity (2.4%), carbohydrates (9-10%), total soluble sugars (13%), Vitamin A, B2 pantothenic acid, riboflavin, thiamin, niacin and pectin. In India, the total area under guava cultivation is 2.60 lakh hectares with an annual production of 38.26 lakh metric tonnes [1]. About 80 species of insects have been recorded on guava [2] and [3] affecting yield and quality of fruits. Spiraling whitefly, guava kajji bug and fruit fly are the major constraints. Among the fruit flies the Oriental fruit fly, Bactrocera dorsalis Hendel (Diptera: Tephritidae) is the most important and destructive pest associated with guava [4] and [5].

In general, fruit flies are very difficult to manage as they are polyphagous, multivoltine and adults having high mobility and fecundity. Conventionally farmers are applying various types of chemical insecticides to control. Eggs and maggots remain protected in the host tissues, pupae in the soil and thus most insecticidal applications are ineffective. The unscientific use of synthetic insecticides, besides leading to the residual problems, also results in resistance development in fruit flies, outbreak of secondary pests, undesirable effect on non target organisms and

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serious environment pollution. To manage these fruit flies, it is important to look for different eco friendly options particularly because high export potential for guava which demands production of residue free fruit this has prompted to take up this study with an objective of developing alternate methods for management of fruit flies.

2. Materials and Methods

Field studies were carried out during kharif 2016 and summer 2017 at Udyanagiri, UHS, Bagalkot to evaluate three IPM modules against fruit fly in an already established guava orchard of variety Sardar (L-49) and 6 year old over an area of one acre. Three different IPM modules along with untreated control were evaluated viz., Module I- Organics, Module II- Integrated, Module III- Recommended package of practices of [6] and Module IV- Untreated control (Table 1). The crop spacing was 6 m x 6 m. Total 15 plants were selected for each module and were replicated five times. Area for each treatment was 10 guntas. The spray was done with the help of knapsack sprayer. The insecticides were applied at flowering and fruit initiation stage, based on the ETL.

Table 1. Treatment details of IPM Modules against guava fruit fly

Modules	Treatments
M_1: Organic module	(a) Application of neem cake to soil @ 250 kg/ac (b) Spraying of neem oil @ 1% (c) Installation of fruit fly traps- methyl eugenol @ 2% and malathion 50 EC @ 1.0 ml/l (10 traps/ac) (d) Collection and destruction of affected fruits
M_2: Integrated module	(a) Raking of soil around the tree and drenching with chlorpyriphos @ 4.0 ml/l (b) Alternative bait spray (malathion 50 EC @ 2 ml + 10 g jaggery per l and Azadiracthin 10000 ppm @ 1.0 ml/l during fruiting stage (c) Installation of methyl eugenol bottle traps @ 10 traps/ac (d) Collection destruction of affected fruits
M_3: RPP-recommended POP	Spraying with dimethoate 30 EC @ 1.70 ml along with 10 g jaggery per l (UHS, POP)
M_4	Untreated control

Note: POP=Package of practices

3. Statistical Analysis

Observations on fruit damage and oviposition punctures were recorded on 7th and 14th days after treatment starting from fruit initiation stage from five plants Fruit infestation was recorded by selecting 25 fruits from each plants randomly from each treatment at each harvest based on oviposition punctures made by the fruit flies. The yield of fruit per plant was taken from all the harvests of guava. Treatment wise yield of healthy fruits was recorded at each harvest and extrapolated into t per ha. The data thus obtained were statistically analysed. Economics of treatment was worked out based on yield data, cost of treatments, net profit and Cost Benefit Ratio.

4. Results

The data obtained on efficacy of treatments in IPM modules against fruit fly in the field trial during kharif 2016 are given in Table 2 and Figure1. On 7th day after first treatment, M3 [(a. Spraying of dimethoate 30 EC @ 1.70 ml/l along with 10 g jaggery (UHS, POP)] recorded no fruit damage (0.00%). The next best treatment was M2 [a) Raking of soil around the tree and drenching with chlorpyriphos @ 4.0 ml/l b. Alternative bait spray (malathion 50 EC @ 2 ml/l + 10 g jaggery) and Azadiracthin 10000 ppm @ 1.0 ml/l during fruiting stage c. Installation of methyl eugenol water bottle traps @ 10 traps/acre d. Collection destruction of affected fruits)] which recorded significantly lowest fruit damage (0.10%) followed by M1 [(a. Application of neem cake to soil, b. Spraying of neem

Table 2. Effect of IPM modules against guava fruit fly (2015-16)

Modules	Fruit infestation (%)								Over all mean fruit infestation (%)	Protection over control (%)
	1st treatment		2nd treatment		**3rd treatment**		**4th treatment**			
	7 DAT	**14 DAT**	**7 DAT**	**14 DAT**	**7 DAT**	**14 DAT**	**7 DAT**	**14 DAT**		
M_1: Organic module	0.23 (1.47)b	1.09 (3.75)b	0.47 (2.67)b	0.60 (1.37)b	1.68 (7.39)b	2.82 (9.58)b	4.48 (12.20)b	6.34 (14.22)b	2.21 (7.61)b	86.24
M_2: Integrated module	0.10 (1.04)b	0.40 (1.82)b	0.51 (1.87)b	0.58 (2.19)b	1.32 (6.49)b	1.50 (6.95)c	3.82 (11.24)b	1.32 (4.93)c	1.19 (5.67)b	92.59
M_3: RPP-recommended POP	0.00 (0.28)b	0.00 (0.28)b	0.00 (0.28)b	0.38 (1.81)b	0.99 (5.66)b	1.07 (5.91)c	1.14 (6.11)c	1.86 (5.98)c	0.68 (3.75)b	95.76
M_4: Untreated control	4.24 (10.27)a	4.02 (11.52)a	6.86 (13.01)a	7.66 (15.08)a	11.20 (19.48)a	13.50 (21.52)a	36.20 (36.97)a	44.93 (42.05)a	16.07 (22.36)a	-
S. Em ±	1.77	1.46	2.09	2.08	0.70	0.43	0.46	1.63	1.36	-
CD at 5 %	5.54	4.50	6.42	0.94	2.15	1.32	1.44	5.01	4.05	-

Notes: Means followed by same alphabet do not differ significantly (0.05) by DMRT (p=0.05)

Figures in the parenthesis are arc sine transformed values

DAT- Days after treatment

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oil @ 1% c. Installation of fruit fly traps- methyl eugenol @ 1 ml and malathion 50 EC @ 1.0 (10 traps/acre), d. Collection and destruction of affected fruits)] recording fruit damage of 0.23 per cent being on par with each other. M4 (untreated control) recorded significantly the highest fruit damage (4.24%).

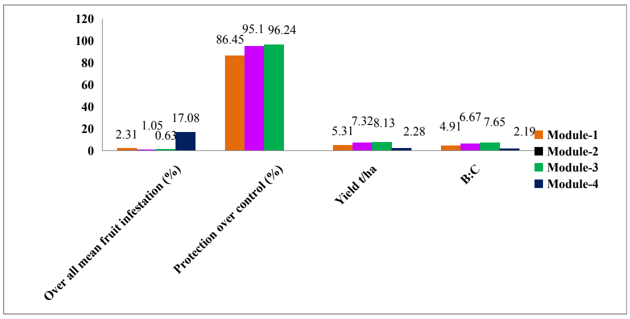

Figure 1. Effect of IPM modules against guava fruit fly 2015-16 and 2016-17

On the 14th day after first treatment, M3 recorded no fruit damage (0.00%). The next best treatment was M2 which recorded significantly lowest fruit damage (0.40%) followed by M1 (1.09%) and were on par with each other. M4 (untreated control) recorded significantly highest fruit damage (4.02%). On the 7th day after second treatment, M3 recorded no fruit damage (0.00%). The next best treatment was M2 which recorded significantly the lowest fruit damage (0.51%) followed by M1 recording fruit damage of 0.47 per cent and these two modules were on par with M3. M4 (untreated control) recorded significantly highest fruit damage (6.86%). On the 14th day after second treatment, M3 recorded significantly the lowest fruit damage (0.38%). The next best treatment was M2 that recorded significantly the lowest fruit damage (0.58%) followed by M1 (0.60%) and these two modules were on par with M3. M4 (untreated control) recorded significantly highest fruit damage (7.66%).

On the 7th day after third treatment, M3 recorded significantly the lowest fruit damage (0.99%). The next best treatment was M2 which recorded significantly lowest fruit damage (1.32%) followed by M1 (1.68%) and these two modules were on par with M3. M4 (untreated control) recorded significantly highest fruit damage (11.20%). On the 14th day after third treatment, M3 recorded significantly the lowest fruit damage (1.07%). On the 7th day after fourth treatment, also M3 recorded significantly the lowest fruit damage (1.14%). The next best treatments were M2 (3.82%) and M1 (4.48%) and these two modules were on par with each other. M4 (untreated control) recorded significantly highest fruit damage (36.20%). On the 14th day after fourth treatment, M2 recorded significantly the lowest fruit damage (1.32%) followed by M3 with fruit damage of 1.86 per cent and were on par. The next best treatment was M1 (6.34%). M4 (untreated control) recorded significantly highest fruit damage (44.93%). Until 7th day of 3rd treatment there was no influence of treatments, though appeared better than control. After that organic module could not compete with the IPM and POP. However, overall efficacy indicated no significant difference among treatments. Among four modules, the mean fruit damage was the lowest in M3 (0.68%) followed by M2 (1.19%) and M1 (2.21%) and were on par with each other, and superior over M4 (untreated control) which recorded significantly highest fruit damage (16.07%).

The highest per cent protection was noticed in M3 (95.76%). M2 and M1 also recorded significantly higher protection over control (92.59 and 86.24%, respectively). Until 7th day of 3rd treatment, there was no difference between treatments though looked better than control. After that organic module could not compete with the IPM and POP. However, overall efficacy indicated no difference among treatments.

The data obtained on efficacy of IPM modules against fruit fly in the field trial of summer 2017 are presented in Table 3. At 7th day after first treatment, M1 recorded significantly lowest fruit damage (0.10%) followed by M2 (0.20%) and M3 (0.48%) and these modules were on par with each other. M4 (untreated control) recorded significantly highest fruit damage (6.62%). On the 14th day after first treatment, M3 recorded significantly lowest fruit damage (0.54%) followed by M2 (0.66%) both being on par. M1 also recorded significantly lowest fruit damage (2.55%) than M4 (untreated control) which recorded significantly highest fruit damage (8.72%). On the 7th day after second treatment, M2 was free from fruit damage (0.00%). The next best treatments were M1 (0.20%) and M3 (0.33%) and were on par with each other. M4 (untreated control) recorded significantly highest fruit damage (13.85%). On the 14th day after second treatment, M2 and M3 suffered no fruit damage (0.00%). M1 also recorded significantly lowest fruit damage (1.68%) than M4, which recorded significantly highest fruit damage (15.92%). On the 7th day after third treatment, M3 recorded significantly lowest fruit damage (0.26%) on par with M2 (0.29%) and M1 (0.76%). M4 (untreated control) recorded significantly highest fruit damage (20.53%). On the 14th day after third treatment, M3 recorded significantly lowest fruit damage (1.07%) on par with M2 (1.64%) and M1 (2.62%). M4 (untreated control) recorded significantly highest fruit damage (15.14%).

Table 3. Effects of IPM modules against guava fruit fly (2016-17)

Modules	Fruit infestation (%)								Over all mean fruit infestation (%)	Protection over control (%)
	1st treatment		2nd treatment		3rd treatment		4th treatment			
	7 DAT	14 DAT	7 DAT	14 DAT	**7 DAT**	**14 DAT**	**7 DAT**	**14 DAT**		
M_1: Organic module	0.10 $(1.04)^b$	2.55 $(9.04)^b$	0.20 $(1.37)^b$	1.68 $(7.37)^b$	0.76 $(3.31)^b$	2.62 $(8.30)^b$	5.50 $(11.82)^b$	5.94 $(14.05)^b$	2.41 $(7.87)^b$	86.67
M_2: Integrated module	0.20 $(1.37)^b$	0.66 $(4.52)^c$	0.00 $(0.28)^b$	0.00 (0.28)c	0.29 $(1.62)^b$	1.64 $(4.68)^b$	2.46 $(10.54)^b$	2.12 $(8.24)^c$	0.92 $(4.45)^b$	94.91
M_3: RPP-recommended POP	0.48 $(0.28)^b$	0.54 $(3.27)^c$	0.33 $(1.70)^b$	0.00 $(0.28)^c$	0.26 $(1.55)^b$	1.07 $(5.25)^b$	0.58 $(5.20)^b$	1.46 $(6.83)^c$	0.59 $(3.99)^b$	96.73
M_4: Untreated control	6.62 $(14.51)^a$	8.72 $(17.12)^a$	13.85 $(21.68)^a$	15.92 $(23.11)^a$	20.53 $(26.67)^a$	15.14 $(22.10)^a$	17.06 $(24.89)^a$	46.81 $(43.17)^a$	18.08 $(24.35)^a$	-
S. Em ±	1.13	0.97	1.12	1.34	1.94	2.74	2.25	0.58	1.41	-
CD at 5 %	3.50	2.99	3.46	4.13	5.97	8.43	6.92	1.81	4.16	-

Notes: Means followed by same alphabet do not differ significantly (0.05) by DMRT (p=0.05)

Figures in the parenthesis are arc sine transformed values

DAT- Days after treatment

On the 7th day after fourth treatment also M3 showed significantly lowest fruit damage (0.58%) but on par with M2 (2.46%) and M1 (5.50%). The M4 (untreated control) recorded significantly highest fruit damage (17.06%). On the 14th day after fourth treatment, M3 recorded significantly lowest fruit damage (1.46%) followed by M2 (2.12%) and both being on par. The next best treatment was M1 that recorded fruit damage of 5.94 per cent. M4 (untreated control) recorded significantly highest fruit damage (46.81%).

Among the four modules tested, the over all mean fruit damage in M3 was significantly lowest (0.59%) followed by M2 (0.92%) and M1 (2.41%) and were on with M3. M4 (untreated control) recorded significantly highest fruit damage (18.08%). The highest per cent protection was afforded by M3 (96.73%). M2 and M1 (94.91 and 86.67%, respectively) were the next best modules and significant over untreated control. In the Second year, performance was similar to the previous year in general, however the organic module showed superiority over IPM and POP modules. The average fruit yield over the years of experimentation was 8.13 t per ha from M3 followed by M2 (7.32 t/ha) and M1 (5.31 t/ha). Significantly lowest fruit yield was recorded in M4 (untreated control) (2.28 t/ha).

The economics of each module was worked out based on yield of marketable fruits obtained in experiment during the year 2015-16 and 2016-17 as presented in Table 4. Among different modules, maximum gross income was obtained from M3 fetching Rs. 4,06,500/ha, followed by M2 with Rs. 3,66,000 per ha. The next best treatment was M1 with Rs. 2,65,500 per ha. M4 (untreated control) recorded grass returns of Rs. 1,14,000 per ha. M3 provided maximum net profit Rs. 3,53,377 per ha, followed by M2 with Rs. 3,11,146 per ha. The next best treatment in obtaining high net return was M1 recording Rs. 2,11,498 per ha. M4 (untreated control) recorded low net returns (Rs. 62,000). Cost benefit ratio (B:C) was worked out for each module. Among the four modules, highest B:C was from M3 (7.65) followed by M2 (6.67) and M1 (4.91). Relatively low B:C of 2.19 was seen in M4 (untreated control).

Table 4. Economics of IPM modules against guava fruit fly (2015-16 and 2016-17)

Modules	**Yield (t/ha)**	**Grass return (Rs/ha)**	**Total cost (Rs/ha)**	**Treatment cost (Rs/ha)**	**Net returns (Rs/ha)**	**B:C**
M_1: Organic module	5.31	265500	54002	2002	211498	4.91
M_2: Integrated module	7.32	366000	54854	2854	311146	6.67
M_3: RPP-recommended POP	8.13	406500	53123	1123	353377	7.65
M_4: Untreated control	2.28	114000	52000	-	62000	2.19

Notes: Market price: Rs 50 Rs/ Kg

Gross return = Yield x Market price

Net Returns = Gross return-Total Cost of cultivation

B:C ratio = Gross Returns/Total Cost of cultivation

5. Discussion

Though repeated application of bait spray proved effective, the residual effects of dimethoate which is having a systemic nature cannot be ignored. So, bait spray during initial period followed by neem based commercial insecticides or relying upon neem or spray integrated with methyl eugenol pheromone traps could be good option to reduce residue problem and high pest pressure situation. [7] also assessed the effectiveness of a locally recommended IPM package that comprised of weekly removal of fall-

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en fruits tri weekly inter-trees ploughing and raking and three fortnightly cover sprays of insecticide. Cost- benefit returns were dependent on the level of pest pressure, and in years of low pressure the package may not recover its costs, necessitating a threshold approach. According to [8] field sanitation (weeding and pruning of dead branches), use of methyl eugenol (sex pheromone traps), and bagging of fruits increased the yield of fresh fruits of guava. Clean culture, orchard sanitation or removal and destruction of the insect infested fruits either by burning or deep burying and ploughing around the trees have been proved to be an effective tool in the management of fruit flies. M3 has given higher protection might be attributed to reduction in pupae in the soil and reduction in fruit fly population by methyl eugenol traps and chemicals used in the components. [9] indicated that IPM module consisting of raking of soil under the tree, collection and destruction of fallen fruits (Sanitation), MAT and BAT resulted in high yield of fruits (24.5 t/ha). In the present study M3 has produced higher yield which might be attributed to lower infestation by the fruit fly and repeated timely application.

According to the reports of [10], hoeing under the tree canopy at 15 days interval along with collection of fallen fruits and burying deep in the soil and spray of spinosad was found most effective in reducing the fruit fly infestation (6% and 6.3% for the year 2013 and 2014, respectively) with cost benefit ratio of 1: 14.7, followed by the treatment comprising of hoeing and sanitation along with the spray Diptrex 80% WP @ 150 gm/100 liter of water (CBR= 1: 14.85). Hoeing under tree canopy alone proved to be least effective with average fruit fly infestation 16.67 and 15.85 per cent for the year 2013 and 2014 respectively with lowest CBR. The highest net returns and B:C in M3 might be attributed to lower cost of insecticide and higher yield compared to other modules. This particular module could be the choice by the farmer. However, M2 with integrated approach reduces dependency on the insecticide based bait which would be detrimental by way of residues especially when applied at delayed pest build-up situations. Hence, M2 appears to be the most viable option with respect to harvesting of yield on par with M3 and off course with slightly lower B:C ratio.

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