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COST EFFECTIVE IPM MODULES FOR THE MANAGEMENT OF MORINGA FRUIT FLY, *Gitona distigma* (Meigen) (DIPTERA : DROSOPHILIDAE)

C. SELVI and N. MUTHUKRISHNAN

Department of Agrl Entomology, Agricultural College and Research Institute, Madurai-625 104, Tamil Nadu, India
E-mail : selviento@yahoo.com

ABSTRACT : Five IPM modules were evaluated at Nadupatti area of Dindigul District, Tamil Nadu during *kharif* 2006 for their effectiveness against moringa fruit fly, *Gitona distigma* (Meigen). Among them, suggestive module 1 (SM 1) consisting of soil application of thiamethoxam 25 WG @ 200 g a.i. ha^{-1} on 150, 180 and 210 days after sowing, use of fermented tomato in a trap, collection and destruction of fruit fly damaged fruits at weekly interval and foliar spray of spinosad 45 SC @ 56 g a.i. ha^{-1} and profenofos 50 EC @ 250 g a.i. ha^{-1} on 165 and 195 DAS was found to be the best module in minimizing fruit damage and pupae in the soil and increasing fruit yield and cost benefit ratio.

Key words : IPM, *Gitona distigma*, moringa fruit fly

INTRODUCTION

Moringa (*Moringa oleifera)* (Lam.) is one of the most popular vegetables in South India, and is grown in an area of 4639 ha with an annual production of 231950 tonnes of tender fruits (Anonymous, 2003). The moringa fruit fly, *Gitona distigma*, (Meigen) a palaearctic species was reported for the first time in India by Ragumoorthi and Subba Rao (1997). Ragumoorthi (1996) reported that G. *distigma* caused 70 per cent yield loss and attained a major pest status in poorly managed moringa crop. Economic injury level (EIL) was worked out as 15 per cent of affected fruits (Ragumoorthi *et al.*, 1998). Farmers also expressed that yield would be substantially increased if cost effective and feasible IPM modules for fruit fly were formulated. Therefore a few cost-effective IPM modules were evaluated to mitigate moringa fruit fly in the present investigation.

MATERIALS AND METHODS

Field trials were conducted to evaluate six IPM modules (Table 1) for the management of moringa fruit fly during *kharif* 2006 in a randomized block design (RBD) with four replications. The experiment was laid out at Nadupatti, Dindigul district (Tamil Nadu, south India) with moringa cv. 'Nadupatti local type'. The treatments were imposed during fruit setting stage when the incidence of fruit fly crossed economic threshold level (ETL). Spraying of the

Table 1. Details of IPM modules used in the study

Suggestive Module 1 (SM 1)	Suggestive module 2 (SM 2)	Suggestive module 3 (SM 3)	TNAU module (TM)	Farmer's module
Soil application of thiamethoxam 25 WG @ 200 g a.i. ha^{-1} on 150, 180 and 210 days after Sowing (DAS)	Soil application of thiamethoxam 25 WG @ 100 g a.i. ha^{-1} on 150, 180 and 210 DAS	Soil drenching with chlorpyriphos 20 EC @ 400 g a.i. ha^{-1} on 150, 180 and 210 DAS	Ranking soil and applying lindane 1.3D @ 163 g a.i. ha^{-1} on 150, 180 and 210 DAS	Soil application of neem cake @ 500 kg ha^{-1} on 150, 180 and 210 DAS
Use of fermented tomato pulp	Use of fermented moringa pulp or fruit	Use of fermented brinjal pulp	Use of fermented grape juice	Skipping irrigation during peak period of Infestation
Collection and destruction of fruit fly damaged fruits at weekly interval	Collection and destruction of fruit fly damaged fruits at weekly interval	Collection and destruction of fruit fly damaged fruits at weekly interval	Foliar spray of dichlorvos 76 WSC @ 380 g a.i. ha^{-1} followed by fenthion 100 EC @ 750 g a.i. ha^{-1} on 165 and 195 DAS	Foliar application of Polytrin C 44 EC @ 440 g a.i. ha^{-1} followed by malathion 50 EC @ 500 g a.i. ha^{-1}
Foliar spray of spinosad 45 SC @ 56 g a.i. ha^{-1} and profenofos 50 EC @ 250 g a.i. ha^{-1} on 165 and 195 DAS	Foliar spray of imidacloprid 17.8 SL @ 27 g a.i. ha^{-1} followed by spinosad 45 SC @ 56 g a.i. ha^{-1} on 165 and 195 DAS	Foliar spray of imidacloprid 17.8 SL @ 27 g a.i. ha^{-1} followed by spinosad 45 SC @ 56 g a.i. ha^{-1} on 165 and 195 DAS		

TNAU – Tamil Nadu Agricultural University liquid formulations was made with a knapsack sprayer during morning hours. Ten litres of spray fluid was used per plot of 8 x 6 m size, which had 12 trees. The dust formulation was applied using a muslin cloth bag (15x30cm). The required quantity of dust was taken in a bag and tied loosely at the tip of a wooden pole (2 m). Dusting was done in the morning hours on the soil to have uniform coverage. For soil application of granular insecticides, the control plots were applied with soil to arrive at the quantity required for broadcasting. For each treatment, 10 kg soil was taken in a plastic tray and mixed with calculated quantity of insecticides and broadcasted.

Observations were recorded on total number of fruits and number of infested fruits (with rotting symptom and white coloured eggs in the grooves) per tree and expressed as percentage. Similarly, soil samples (for each sample 250g of soil in one square feet area up to 10cm depth) under the trees at 20 places were collected and observed for the presence of pupae and expressed as number per sample. Number of adults attracted in the bait traps were observed and expressed as numbers/ trap (Ragumoorthi, 1996). Observations on the extent of damage due to fruit fly were recorded on 3, 5, 7 and 15 days after applications. Collection of soil samples and trap catches were made at weekly interval. In this study, soil application was done from 150 DAS to 210 DAS at monthly interval and foliar spray was given from 165 DAS to 195 DAS at 15 days interval. Bait traps were placed from 150 DAS and bait materials were changed once in a week.

Statistical analysis of data was done through ANOVA of randomized block design (RBD). The per cent fruit damage data were subjected to arcsine transformation. The data based on numbers were transformed by using the formulae $\sqrt{x}$ or $\sqrt{x} + 0.5$. Mean values of treatments were compared by Duncan's multiple range test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The pretreatment (150 DAS) count of fruit damage ranged from 28.5 to 30.1 per cent. However, after first soil application on 157 DAS, suggestive module 1 (SM1) recorded lowest fruit damage (16.9%). The TNAU module (TM) (20.9%), suggestive module 3 (SM3) (22.7%), suggestive module 2, (SM2) (23.4%) and farmers module (FM) (27.8%) were next best modules in registering lower fruit damage, when compared to control (39.3%). On 165 DAS, however, in increase in fruit damage was noticed in all treatments (26.8 to 42.8%). Hence first foliar spray of insecticides was imposed in the respective plots. After first foliar spray on 168 DAS, SM1 resulted in the lowest fruit damage (16.8%) followed by other modules *viz.*, SM4 (20.8%), SM2 (22.4%), FM (26.8%) and TM (33.4%) which were statistically on par with each other in their efficacy and superior to control (48.0%). On five days after first spray (172 DAS) also the per cent fruit damage by fruit fly was low in SM1 (11.5%) compared to other modules (14.9 to 21.4%). Due to the first soil application and foliar spray of insecticides, there was a decline in fruit damage till 180 DAS (9.68 to 19.0%) in all the treated plots.

Second soil application of insecticides was done at 180 DAS against fruit fly. Seven days after second soil application, decrease in fruit damage was noticed which ranged from 18.5 to 29.9 per cent than control in which fruit damage was maximum (52.5%). However, fruit damage was higher on 195 DAS (22.8 to 55.0%). Hence, second foliar spray was imposed on 195 DAS in respective IPM module plots. Three days (198 DAS) after second spray, per cent fruit damage was 13.1 per cent in SM1 followed by other IPM modules (16.7-26.2%). Five days after second spray (202 DAS) also the per cent fruit damage was less in SM1 (9.2%) followed by TM (12.0%) which was significantly on par with other modules (17.1-20.6%).

Table 2. Effect of IPM modules on fruit damage due to *G. distigma* in annual moringa (local type) during *kharif* 2006)

IPM Modules	fruit damage % on pre and post treatment														
	I Soil application			I Foliar spray + II Soil application					II Foliar spray + III Soil application					Over all mean	% reduction over control
	150 DAS *	157 DAS	165 DAS**	168 DAS	172 DAS	180 DAS*	187 DAS	195 DAS**	198 DAS	202 DAS	210 DAS*	217 DAS	225 DAS		
SM 1	30.1	16.9^{a}	26.8^{a}	16.8^{a}	11.5^{a}	9.68^{a}	18.5^{a}	22.8^{a}	13.1^{a}	9.2^{a}	8.5^{a}	20.7^{a}	21.4^{a}	17.6^{a}	63.81
SM 2	28.9	23.4^{bc}	30.1^{a}	22.9^{ab}	19.1^{b}	15.6^{ab}	26.6^{b}	34.0^{a}	21.6^{bcd}	17.1^{bc}	16.5^{b}	24.2^{ab}	26.2^{ab}	23.6^{b}	51.48
SM 3	29.4	22.7^{b}	31.6^{a}	33.4^{ab}	19.2^{ab}	15.9^{ab}	25.1^{ab}	33.7^{a}	20.7^{c}	17.1^{bc}	16.0^{b}	24.6^{ab}	26.7^{a}	23.6^{b}	51.48
TNAU module	28.8	29.9^{b}	29.1^{a}	20.8^{ab}	14.9^{ab}	12.1^{ab}	21.8^{ab}	24.3^{a}	16.7^{ab}	12.0^{ab}	10.5^{a}	22.2^{a}	23.5^{ab}	20.0^{a}	58.88
Farmers' module	29.1	27.8^{c}	33.1^{a}	26.8^{b}	21.4^{b}	19.0^{b}	29.9^{b}	37.3^{a}	26.2^{d}	20.6^{c}	20.6^{b}	31.4^{b}	37.3^{b}	28.1^{b}	42.22
Control	28.5	39.3^{d}	42.8^{b}	48.0^{c}	43.4^{c}	48.7^{c}	52.5^{c}	55.0^{b}	49.5^{e}	54.5^{d}	59.4^{c}	64.8^{c}	63.9^{c}	48.7^{d}	
SEd±	**NS**	**1.22**	**2.17**	**3.50**	**2.90**	**2.75**	**2.18**	**4.52**	**1.54**	**2.17**	**1.90**	**2.35**	**3.74**	**2.05**	
CD (P=0.05)		**2.60**	**4.62**	**7.47**	**6.19**	**5.87**	**4.65**	**9.63**	**3.29**	**4.63**	**4.05**	**5.01**	**7.97**	**4.37**	

*Days after soil application SM – Suggestive Module

** Days after foliar spray

DAS - Days after sowing

Table 3. Effect of IPM modules on the number of pupae of *G. distigma* infesting annual moringa local type (*kharif* 2006)

IPM Modules	No of pupae on pre and post treatment / 250g of soil									Over all mean	% reduction over control
	I Soil application			I Foliar spray + II Soil application			II Foliar spray + III Soil application				
	150 DAS*	157 DAS	165 DAS**	180 DAS*	187 DAS	195 DAS**	210 DAS*	217 DAS	225 DAS		
Suggestive module 1	3.4	2.1[a]	2.5[a]	2.5[a]	1.4[a]	1.6[a]	2.2[a]	0.5[a]	2.0[a]	2.1[a]	76.66
Suggestive module 2	3.5	3.0bc	3.0ab	3.1a	2.4b	2.2a	3.3bc	2.5b	3.1b	3.0bc	66.66
Suggestive module 3	3.5	3.0bc	3.2ab	3.2a	2.4ab	2.1a	3.4bc	2.8b	3.2b	3.0bc	66.66
TNAU* module	3.4	2.5ab	2.6ab	2.6a	2.0ab	1.7a	3.0b	1.1a	2.5a	2.3ab	74.44
Farmers' module	3.5	3.4c	3.9bc	3.5a	3.0b	3.0a	4.1c	3.1b	3.5b	3.5c	61.11
Control	3.4	5.2d	5.6c	7.1b	8.5c	8.8b	9.6d	10.5c	10.8c	9.0d	
S Ed±	**NS**	**0.12**	**0.20**	**0.17**	**0.15**	**0.29**	**0.09**	**0.16**	**0.11**	**0.10**	
CD (P=0.05)		**0.29**	**0.42**	**0.38**	**0.33**	**0.63**	**0.20**	**0.35**	**0.25**	**0.22**	

*Days after soil application * TNAU = Tamil Nadu Agricultural University (TM)

** Days after foliar spray

DAS - Days after sowing

Table 4. Effect of bait materials on attraction of moringa fruit fly, *G. distigma*

Source	Fermented tomato	Fermented grape juice	Fermented brinjal	Fermented moringa pulp
Range	20-26	17.22	12-16	4-6
Mean ± SD	24.7 ± 1.49	20.3 ± 0.67	13.1 ± 0.87	5 ± 0.69

N = 10

Table 5. Economics of IPM modules used against moringa fruit fly, *G. distigma*

Module	Cost of implementation of IPM modules (Rs. / ha)	Total cost of cultivation (Rs. / ha)	Mean yield (t/ha)	Per cent increase in yield over control	Gross returns (Rs. / ha)	Net returns (Rs. / ha)	C :B ratio
Suggestive module 1 (SM1)	2875	15760	16.2	55.55	64800	49040	1:3.1
Suggestive module 2 (SM2)	5075	17960	12.0	40.00	48000	30040	1:1.6
Suggestive module 3 (SM3)	5560	18440	11.7	38.46	47200	29160	1:1.5
TNAU module (TM)	3075	15960	14.9	51.67	59760	43800	1:2.7
Farmers module (FM)	7505	21390	10.2	29.41	40800	19410	1:1.0
Control	-	3120	7.2	-	8880	5760	1:0.3

The per cent fruit damage ranged from 8.5 to 59.4 due to third soil application of insecticides on 210 DAS. Seven days after third soil application, fruit damage ranged from 20.7 to 64.8 per cent including control. Due to second foliar spray and third soil application of insecticides, a decrease in fruit damage (21.4 to 37.3%) was noticed up to 225 DAS.

Mean data on fruit damage after two foliar sprays and three soil applications revealed that the SM1 registered the lowest fruit damage of 17.6 per cent compared to other five modules (20.0 to 28.1%) and control (48.7%). The treatment, SM1 was statistically on par with TM by recording lesser fruit damage of 20.0 per cent. The next best modules were SM3 (23.6%) and SM2 (23.6%) and FM (28.1%). Similar trend was observed in per cent reduction over control, where highest per cent reduction of fruit damage was in SM1 (63.81%) followed by TM (58.88%), SM3 and SM2 (51.48%) and FM 42.22%) modules.

Number of pupae in soil ranged from 3.4-3.5 and was not significantly different in all the plots before imposing the treatments. After first soil application (157 DAS), the number of pupae significantly decreased. The minimum number of pupae was recorded in SM1 (2.1) followed by TM (2.5) and SM2 modules which were significantly on par (3.9) with SM3 (3.0) and FM. However, an increase in the population of pupae was noticed up to 165 DAS (2.5 to 5.6). Hence, first foliar spray and second soil application was given on 180 DAS. Seven days after second application (187 DAS), all the IPM modules (1.4 to 3.0) were significantly superior over untreated check (8.5). Increase in trend on pupae, however was observed 15 days after second soil application (195 DAS). So second foliar spray and third soil application were done on 210 DAS. Immediately after third soil application and second foliar spray, maximum reduction of pupae was observed in SM1 (2.2), which was followed by SM2, SM3 and TM (2.5 to 3.1) modules, whereas control registered highest number of pupae (10.5).

Mean data revealed that number of pupae was minimum in SM1 (2.1) compared to other five modules evaluated (2.3 to 3.5). Similarly, highest percentage reduction over control was recorded in SM1 (76.6%) followed by FM (61.6%), SM2 and SM3 (66.6%) and TM (74.4%) modules.

Among the four attractants (fermented tomato, fermented brinjal, fermented grape juice and fermented moringa pulp) used, trap containing fermented tomato in SM1 registered more flies (25 flies / trap / fortnight) followed by fermented grape juice, which was placed in TM plot (20 flies / trap / fortnight) and fermented brinjal, placed in SM3 (13 flies / trap / fortnight) (Table 4). Only few number of flies were attracted (5 flies / trap / fortnight) due to fermented moringa pulp, that was placed in SM2 plot. Among the four attractants tested against fruit fly, fermented tomato was most effective in attracting more number of fruit flies per trap.

Based on the cost benefit ratio, the IPM modules were ranked (Table 5). Suggestive module 1 (SM1) resulted in the highest benefit cost ratio of 3.1 compared to other modules. While considering effectiveness and economics, TNAU module (TM) ranked next to SM 1(2.7). The other IPM modules in the order of economics and efficiency were SM2 (1.6), SM3 (1.5) and FM (1.0).

The foliar application of spinosad and profenofos (SM1) was found to be effective in reducing the fruit fly infestation followed by fenthion and dichlorovos (SM2) which ultimately increased the moringa yield. The application of dichlorovos (0.04%) and fenthion (0.05%) (Anjaneya Murhty, 1985) and fenthion (0.04%) (Ragumoorthi, 1996) was effective in managing *G. distigma*, because of their quick knock down effect. The efficacy of spinosad and profenofos against sorghum shootfly, *A. soccata* in sorghum was also reported by Sharma *et al.*, (1996). Soil application of NSKE (2 litres / tree) and lindane

10D (200g / tree) during 50 per cent fruit set was found to reduce the moringa fruit fly *G. distigma* incidence (Ragumoorthi, 1996). A total of four attractants were tested to attract fruit fly on Naduppati local. Among these, fermented tomato @ 20 g/ trap was highly effective followed by fermented grape juice @ 20 g/ trap. Drosophilids are attracted more towards the fermented products. This may be attributed to the fact that moringa fruit flies were trapped more in fermented tomato and grapevine. Present findings are in conformity with those of Ragumoorthi (1996) and Stalin Dhanaraj (2002).

Based on these findings, it can be summarized that, among the five IPM modules evaluated, the suggestive module 1 (SM 1) consisting of soil application of thiamethoxam 25 WG @ 200 g a.i. ha^{-1} on 150, 180 and 210 days after sowing, use of fermented tomato in a trap, collection and destruction of fruit fly damaged fruits at weekly interval and foliar spray of spinosad 45 SC @ 56 g a.i. ha^{-1} and profenofos 50 EC @ 250 g a.i. ha^{-1} on 165 and 195 DAS was found to be the best module in minimizing fruit damage, and increasing fruit yield thus resulting in higher returns.

REFERENCES

Anjaneya Murthy, J.N. 1985. Studies on seasonal incidence and insecticidal control of fruit fly, *Gitona* sp., leaf eating caterpillar, *Noorda blitealis* Walk. and legume aphid, *Aphis craccivora,* Koch. On annual moringa. M.Sc. (Ag.). Thesis, Tamil Nadu Agric. Univ., Coimbatore, Tamil Nadu, India. 70p.

Anonymous. 2003. *Horticultural Statistics.* Directorate of Horticulture and Plantation Crops, Chepauk, Chennai. 120p.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research.* Wiley International Science Publications, John Wiley and Sons, New York. 680p.

Ragumoorthi, K.N. 1996. Bio-ecology, host plant resistance and management of moringa fruit fly *Gitona distigma* Meigen (Diptera: Drosophilidae), Ph.D. Thesis, Tamil Nadu Agric. University, Coimbatore, Tamil Nadu, India, 180 p.

Ragumoorthi, K.N. and Rao, P.V.S. 1997. First report of a palaearctic species of moringa fruit fly, *Gitona distigma* (Meigon) in India. *Pestology,* **21**(9): 50-53.

Ragumoorthi K.N., Selvaraj, K.N and Subba Rao, P.V. 1998. Assessment of economic injury level (EIL) for moringa fruit fly, *Gitona distigma* (Meigon) (Diptera: Drosophilidae). In: Advances in IPM for Horticultural Crops, (eds.), Parvatha Reddy *et al.*, AAPMHE: Bangalore, pp: 137-139.

Sharma, M., Kapoor, K.N and Bharaj, G.S. 1996. Effect of seed treatment of sorghum with some new insecticides for control of shoot fly. *Crop Research,* **11** (1): 90-92.

Sivagami, R. and David, B.V. 1968. Some insect pests of moringa (*Moringa olifera). South Indian Horticulture,* **16**: 69-71.

Stalin Dhanaraj. 2002. Preliminary investigation on the pest management in drumstick. M.Sc. (Ag.). Thesis, Tamil Nadu Agricultural. University, Coimbatore, Tamil Nadu, India. 107p.