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Development and validation of IPM modules against major sucking insect-pests of groundnut

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ABSTRACT

Five different IPM modules were designed and tested for the management of insect-pests in groundnut including farmer practices during 2013 to 2016 at Junagadh, Gujarat. Data were recorded for the incidence of major sucking pests, *i.e.* thrips (*Caliothrips indicus*) and leaf hoppers (*Balclutha hortensis*). It was observed that synthesized IPM Modules significantly reduced insect-pest incidence on groundnut and enhanced the yield over farmers' practices (FP). The population of thrips and leaf hoppers were recorded to be lowest in module T_5 and varied from 0.46 to 1.09 thrips/plant and 0.47 to 4.0 leafhoppers/plant, respectively. The module T_5 was significantly superior to Farmer Practice during both *Kharif* and *Rabi*-summer seasons.

Key words: *Balclutha hortensis, Caliothrips indicus,*Groundnut, Modules, IPM.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.), an important oilseed and supplementary food crop of the world is attacked by more than 100 insect-pests right from planting stage to its storage (Nandagopal, 1992). The annual yield loss in groundnut due to insect-pests is approximately 15 per cent *i.e.*, 1.6 million tones of produce worth Rs 25,165 million (Dhaliwal *et al.*, 2010; Jasrotia *et al.*, 2016). Among the insect-pests inflicting damage to groundnut, the defoliators such as, the groundnut leaf miner (GLM), the red-headed hairy caterpillars (RHC), the tobacco caterpillar, the gram pod borer and the Bihar hairy caterpillar are the most important in India. Aphids, leafhoppers, thrips are the major sap-sucking pests reported on groundnut. Mealy bugs are the potential pests of groundnut in warm and humid areas.

In groundnut, two species of leafhoppers, *Balclutha hortensis* Lindberg and *Empoasca kerri* (Pruthi) (Nandagopal and Reddy, 1987; Nandagopal, 2004; Harish *et al.*, 2015) and four species of thrips, *Scirtothrips dorsalis* Hood, *Frankliniella schultzei* Trybom, *Thrips palmi* Karny and *Caliothrips indicus* (Bagnall) (Nandagopal and Vasanta, 1991; Rao and Wightman, 1993) are reported as major sucking insect-pests. These insect-pests suck the plant sap from the underside of the leaves, young shoots and floral parts. It has been observed that excessive application of nitrogenous fertilizers by the farmers aggravates the incidence of sucking insect-pests and maximize the yield loss. When infestation occurs during the early stages of crop growth *i.e.*, vegetative and flowering stages, the yield reduction is reported to be up to 22 per cent due to leafhoppers (Amin,1980;Vyas,1984) and up to 40 per cent due to thrips (Ghewande, 1987).

The increasing problems due to continued usage of pesticides and failure of individual IPM components to check the pest population necessitates the development of IPM modules that involves the synergistic integration of IPM components. Application of chemical insecticides is still regarded as the most preferred pest management strategy among the farmers and their indiscriminate application have serious adverse effect on beneficial insects, human health and surrounding environment. Some of the insecticides are not yielding the desired level protection against sucking insect-pests due to the development of insecticide resistance. Considering the adverse effect of insecticides, management of the insect pests of groundnut through IPM strategies is gaining importance in the recent years. Due to increasing development of resistance to conventional insecticides in sucking insects, research is being carried out to identify the alternative means of pest management. Keeping the above perspective in view, the present study was planned to synthesize five different IPM modules and compare them with the farmers' practice and later validate best module on the farmers' fields.

MATERIALS AND METHODS

The experiment was conducted in experimental area of Plant Pathology section of ICAR-DGR in Randomized Block Design with four replications. Five different IPM

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Table 1: Details of IPM modules evaluated against major insect-pests of groundnut

Practice	IPM module/Treatment				
	T1	**T2**	**T3**	**T4(Farmers' Practice)**	**T5**
Cultural	Deep summer ploughing-8 inches depth; Border crop (3-4 rows of bajra); Trap crop (3-4 rows of castor @ 250 g/ha); Soil amendments (castor cake or neem cake @ 250 kg/ha)	Deep summer ploughing-8 inches depth; Border crop (3-4 rows of bajra); Trap crop (3-4 rows of castor @ 250 g/ha); Soil amendments (castor cake or neem cake @ 250 kg/ha)	Deep summer ploughing-8 inches depth; Border crop (3-4 rows of bajra); Trap crop (3-4 rows of castor @ 250 g/ha); Soil amendments (castor cake or neem cake @ 250 kg/ha)	Mancozeb @ 3.0 g/kg	Ploughing upto 8 inches and soil solarisation with polythene sheet (50 µm); Border crop (3-4 rows of bajra); Trap crop (3-4 rows of castor @ 250 g/ha); *Trichoderma* enriched FYM (50kg with 4 kg *Trichoderma* /ha) 20 days before sowing applied in seed furrow+ NSKE @ 5% at 20-30 DAS
Seed treatment	(*Trichoderma harzianum* @ 10 g/kg seed and Imidacloprid 600 FS @ 1 mL/kg	Seed treatment (*Trichoderma harzianum* @ 10 g/kg seed and Imidacloprid 600 FS @ 1 mL/kg	Mancozeb @ 3.0 g/kg		Mancozeb 3g/kg seeds + Imidacloprid 600 FS @ 1 ml/kg seeds + Rhizobium @ 625 g/ha seed
Soil treatment	*Trichoderma harzianum* @ 4 kg mixed with 50 kg well rotten FYM	*Trichoderma harzianum* @ 4 kg mixed with 50 kg well rotten FYM	*Trichoderma harzianum* @ 4 kg mixed with 50 kg well rotten FYM		*Trichoderma harzianum* @ 4 kg mixed with 50 kg well rotten FYM
Physical Practices	Light trap; Hand picking of egg masses/ gregarious larvae	Light trap; Hand picking of egg masses/ gregarious larvae	Pheromone traps @ 10 traps /ha for lepidopterous pests; Hand picking of egg masses/ gregarious larvae		Pheromone trap as mass trapping (@25 traps/ha for lepidopterous pests); Hand picking of egg masses/ gregarious larvae
Chemical Control	Hexaconazole @ 1 mL/L at 45 & 60 DAS for effective management of major diseases of groundnut	Hexaconazole @ 1 mL/L at 45 & 60 DAS for effective management of major diseases of groundnut; Application of Spinosad 45 SC @ 150 mL/ha	Hexaconazole @ 1 mL/L at 45 & 60 DAS; Need based spray of Acephate @ 0.05% (10 g/15 L) and a single spray of Flubendiamide 480 SC @ 100 mL /ha		Difenoconazole 1 ml/lit (application only if ELS/LLS/Rust scores crosses 3 rating scale)

modules were synthesized for the management of insect-pests and pathogens in groundnut including farmers' practices after reviewing the literature and available resources/ technologies. The detailed description of developed modules is given in Table 1.These modules comprised of cultural, biological and chemical practices for the management of insect-pests and pathogens in groundnut. Although, the modules both for diseases and insect-pests of groundnut were tested but here only the findings about incidence of insect-pests have been provided. The modules were evaluated for two *Kharif* seasons of 2013 and 2014 and two *Rabi*-summer seasons of year 2014 and 2015.The validation of best modules was conducted for one *Kharif* 2015 season and one *Rabi*-summer 2016 season.The groundnut variety GG-20 was sown during *Kharif* seasons and TG-37A during *Rabi*-summer seasons. The plot size was kept 5x5 m^2.

Observations were recorded on incidence of major insect-pests i.e. thrips (*C. indicus*) and leaf hoppers (*B. hortensis*) during both the seasons. A weekly observation schedule was followed for recording the incidence of insect-pests. Ten plants were randomly selected from each plot. The population of sucking pests (thrips and leafhoppers) was recorded by counting number of nymphs and adults present in top three opened leaves of a plant at a spot out of 10 plants. Thrips infestation was noted by counting the number of plants with feeding patches while for leafhoppers, the number of plants with yellowing was counted. The other pests of groundnut like aphids, *Spodoptera, Helicoverpa* and leaf miner are occasional pests in Saurashtra region of Gujarat. After harvesting, pod and fodder yields were recorded from each plot.

All analyses were performed at the 0.05 significance level. Statistical analysis was done by using SAS Software (SAS, 2005).

RESULTS AND DISCUSSION

(i) Evaluation of modules: The evaluation of five modules (T_1 to T_5) was carried out in two seasons; *Kharif* 2013 and 2014 and two *Rabi*-summer seasons; *Rabi*-summer 2014 and 2015.

Insect population build-up: The population of sucking pests; thrips and leafhopper varied significantly in the tested modules. During *Kharif*-2013, the lowest population of thrips was recorded in T_5 (0.46 thrips/plant) module followed by T_2 (0.97 thrips/plant) and highest in T_4 (3.18 thrips/plant) module. Leafhopper population was significantly higher in T_4 (1.53 leafhoppers/plant) as compared to module T_5 (0.64 leafhopper/plant). Similar trends were observed in population recorded during *Kharif*-2014 (Table 2).

During *Rabi*-summer 2014, the population of thrips and leafhoppers was highest in T_4 module i.e. 3.54 thrips/ plant and 1.06 leafhoppers/plant, respectively. Similarly during *Rabi*-summer 2015, the mean population of thrips varied from 1.09 to 2.81 thrips/plant. The population was maximum in T_4 module (2.81 thrips/plant) and minimum in T_5 module (1.09 thrips/plant). The mean population of leafhopper was highest (1.66 leafhoppers/plant) in T_2 and lowest in T_5 (0.81 leafhoppers/plant) (Table 2).

Plant infestation: The highest thrips infestation levels were recorded in T_4 module (FP) i.e. 28.8, 32.1, 34.3, and 29.3 per cent during *Kharif*-2013, *Rabi*-summer-2014, *Kharif*-2014 and *Rabi*-summer-2014, respectively as compared to lowest infestation levels of 9.0, 13.6, 15.5, and 12.0 per cent in T_5 during same seasons, respectively. The per cent plant infestation by leafhopper was recorded highest in T_4 module. It was 12.5, 12.9, 8.2 and 8.0 per cent during *Kharif*-2013, *Rabi*-summer-2014, *Kharif*-2014 and *Rabi*-summer-2014, respectively as compared to highest infestation levels of 26.3, 23.3, 20.1 and 27.3 per cent in T_4 during same seasons, respectively (Table 3).

Yield: The highest pod yield during *Kharif* season(pooled 2013 & 2014) was obtained in module T_5 (1496.2 kg ha^{-1}) and lowest in T_4 (1055 kg ha^{-1}). Also, fodder yield was recorded maximum (3995 kg ha^{-1}) with BC of 1.8 in module T_5 and minimum (2730 kg ha^1) in T_4 (FP) module with BC 1.4. Similar trends of yield variation were seen in *Rabi*-summer 2014 and 2015. The BC ratio and ICBR was highest in Module T_5 i.e. 1.8 and 5.3, respectively in *Kharif*-2013 and *Kharif*-2014. Similarly, in *Rabi*-summer the BC ratio

Table 2: Effect of IPM modules (treatments) on population of sucking pests of groundnut.

Treatment	Insect population per plant							
	***Kharif*-2013**		***Rabi*-Summer-2014**		***Kharif*-2014**		***Rabi*-Summer-2015**	
	Thrips	**Leafhopper**	**Thrips**	**Leafhopper**	**Thrips**	**Leafhopper**	**Thrips**	**Leafhopper**
T1	1.47 (1.21)	0.48(0.69)	1.17(1.08)	0.30(0.55)	0.85(0.92)	0.54(0.73)	1.68(1.30)	0.93(0.96)
T2	0.97(0.98)	1.03(1.01)	1.69(1.30)	0.71(0.84)	1.73(1.31)	0.43(0.66)	1.50(1.22)	1.66(1.29)
T3	1.15(1.07)	1.10(1.05)	2.30(1.51)	0.96(0.98)	1.30(1.14)	0.49(0.70)	1.41(1.19)	1.36(1.17)
T4	3.18(1.78)	1.53(1.24)	3.54(1.88)	1.06(1.03)	1.79(3.20)	1.41(1.19)	2.81(1.67)	1.43(1.20)
T5	0.46(0.68)	0.64(0.80)	0.97(0.98)	0.47(0.68)	0.62(0.79)	0.50(0.71)	1.09(1.05)	0.81(0.66)
LSD at 5 %	0.70	0.87	0.54	0.47	0.60	0.58	0.49	0.51

Figures in the parenthesis are square root transformed values

Table 3: Effect of IPM component (treatments) on infestation of sucking pests of groundnut.

Treatment	Percent Plant Infestation							
	Kharif-2013		*Rabi*-Summer-2014		*Kharif*-2014		*Rabi*-Summer-2015	
	Thrips	Leafhopper	Thrips	Leafhopper	Thrips	Leafhopper	Thrips	Leafhopper
T1	19.0 (25.8)	19.7(26.3)	14.2(22.1)	13.1(21.2)	18.5(25.4)	10.0(18.4)	22.0(28.0)	14.7(22.5)
T2	10.3(18.7)	19.3(26.0)	18.1(25.1)	16.7(24.1)	28.1(32.0)	9.0(17.4)	18.7(25.6)	20.7(27.1)
T3	19.4(26.1)	17.1(24.4)	25.5(30.3)	13.7(21.7)	26.1(30.6)	12.4(24.6)	20.0(26.6)	19.3(26.0)
T4	28.8(32.4)	26.3(30.8)	32.1(34.5)	23.3(28.8)	34.3(35.8)	20.1(26.6)	29.3(32.8)	27.3(31.5))
T5	9.0(17.4)	12.5(20.7)	13.6(21.6)	12.9(21.3)	15.5(23.1)	8.2(16.6)	12.0(20.3)	8.0(16.4)
LSD at 5 %	10.4	13.3	10.3	9.8	11.3	11.4	11.32	11.18

Figures in the parenthesis are arcsine transformed values

and ICBR were highest in Module T_5 i.e. 2.5 and 9.1, respectively (Table 4).

(ii) Validation of modules: The best module found in terms of insect-pest abundance and plant infestation level, module T_5 was validated along with module T_4 (FP) for comparison on farmers' fields for validation during single season of *Kharif* 2015 and *Rabi*-summer 2016.

In *Kharif* 2015, the module T_5 harboured significantly lower number of thrips (1.0 thrips/plant) and leafhoppers (3.0 leafhoppers/plant) as compared to T_4 module that recorded 2.3 thrips per plant and 5.0 leafhoppers per plant. The percent plant infestation caused by thrips and leafhoppers was also lower in T_5 module than T_4 module. The plant infestation caused by thrips was 1.0% and 3.0% in T_5 and T_4, respectively. Similarly, plant infestation by leafhopper was 2.0% and 4.0% in T_5 and T_4, respectively (Table 5).

The pod yield in *Kharif* 2015 was highest in IPM module T_5 (1319 kg ha^{-1}) and lowest in FP (1184 kg ha^{-1}). Also, fodder yield was recorded maximum (4040 kg ha^{-1}) and minimum (3960 kg ha^{-1}) in FP module. The highest pod yield during *Rabi*-summer 2016 season was obtained in T_5 (1397 kg ha^{-1}) and lowest in FP (1126.5 kg ha^{-1}) The BC ratio and ICBR was highest in Module T_5 i.e. 1.7 and 1.4, respectively during *Kharif*-2015. Similarly, during *Rabi*-summer 2016, the BC ratio and ICBR were highest in Module T_5 i.e. 1.6 and 2.9, respectively (Table 6).

The overall mean impact of IPM modules after implementing the modules revealed module T_5 harbored lesser insect-pests and recorded more yields as compared to other tested modules. The findings of present studies are in line with previous investigations carried out on similar research. Karuppuchamy (2016) validated a IPM module against thrips and aphids of groundnut consisting of seed treatment with imidacloprid 70 FS 5 ml/kg followed by spraying with thiamethoxam 25 WG at 0.4 ml/l at 30 DAS (or) seed treatment with imidacloprid 70 FS at 5 ml/kg of seed followed by spraying with neem seed kernel extract (NSKE) 5% at 30 DAS + placing yellow sticky trap at 25/ha at 30 DAS + raising cow pea as trap crop + release of green lace wing predator *Chrysoperla zastrowi* at 30 DAS @ 2500 / ha.

Soil solarization which was the part of IPM module T_5 has been found in reducing the diseases and insect-pest incidence in various cropping systems. The underlying mechanism of action is based on the increased soil temperature (commonly in the range of 45–55°C) at soil depth of 5-cm underneath transparent polyethylene sheets

Table 4: Effect of IPM modules (treatments) on yield of groundnut and bajra.

	Kharif 2013 and *Kharif* 2014 (Pooled)					*Rabi*-Summer-2014 and *Rabi*-Summer-2015 (Pooled)				
Treatment	Pod Yield kgha^{-1}	Fodder Yield kgha^{-1} Groundnut	Fodder Yield kgha^{-1} Bajra	BC ratio	ICBR	Pod Yield kg ha^{-1}	Fodder Yield kg ha^{-1} Groundnut	Fodder Yield kg ha^{-1} Bajra	BC ratio	ICBR
TI	1353.3	3587.5	2691.0	1.6	3.6	1721.5	2977.5	2345.0	2.1	5.4
T2	1213.6	3500.0	2484.0	1.5	2.5	1623.0	2802.3	2390.0	2.1	5.0
T3	1413.4	3608.8	2328.8	1.7	3.9	1646.8	2849.3	2895.0	2.1	5.0
T4	1055.4	2730.0	0.0	1.4	0.0	1443.3	2729.5	0.0	1.7	0.0
T5	1496.2	3995.0	2328.8	1.8	5.3	1977.0	3152.5	2800.0	2.5	9.1
C.D. at 5 % Yield	70.69	407.50	203.71			106.42	NS	966.09		
C.D. at 5 % Yield x Treatment	145.19	257.72	128.84			67.31	545.43	NS		
C.D. at 5 %	241.39	576.29	288.10			NS	331.07	417.00		

Table 5: Effect of IPM component (treatments) on population and infestation of sucking pests of groundnut.

Treatment	*Kharif* 2015				*Rabi*-Summer-2016			
	Insect population per plant		Percent plant infestation		Insect population per plant		Percent plant infestation	
	Thrips	Leafhopper	Thrips	Leafhopper	Thrips	Leafhopper	Thrips	Leafhopper
T4(FP)	2.3(1.5)*	5.0(2.2)	3.0(9.9)**	4.0(11.5)	4.6(2.1)*	8.0(2.8)	6.0(14.1)**	6.0(14.1)
T5	1.0(1.0)	3.0(1.7)	1.0(5.7)	2.0(8.1)	3.0(1.7)	4.0(2.0)	2.0(8.1)	4.0(11.5)
LSD at 5 %	0.80	1.02	1.11	1.34	1.75	1.98	1.78	1.56

*Figures in the parenthesis are square root transformed values
**Figures in the parenthesis are arcsine transformed values

Table 6: Effect of IPM modules (treatments) on yield of groundnut and bajra.

Treatment	*Kharif* 2015					*Rabi*-Summer-2016				
	Pod Yield kg ha^{-1}	Fodder Yield kg ha^{-1}		BC ratio	ICBR	Pod Yield kg ha^{-1}	Fodder Yield kg ha^{-1}		BC ratio	ICBR
		Groundnut	Bajra				Groundnut	Bajra		
T4 (FP)	1184.0	3960.0	-	1.7	0.0	1126.5	2595.0	-	1.5	0.0
T5	1319.0	4040.0	3200.0	1.7	1.4	1397.0	2890.0	3230.0	1.6	2.9
C.D. at 5 %	74.34	402.34				76.89	223.78			

causes plant pathogens mortality (Katan, 1981). Besides the reduction in soil-borne pathogens, soil solarization also leads to increased growth response (IGR) of plants (Katan, 1981; Horiuchi, 1984). Soil solarization also integrates well with other techniques such as mulching, and soil amendments to enhance its overall effectiveness against pests and, increase crop yield (D'Addabbo *et al.,* 2010). Seed treatments with imidacloprid @ 2.0 to 5.0 g a. i. kg^{-1} were found most effective in reducing the thrips and leafhopper population in groundnut. However, seed treatment with imidacloprid @ 2.0 g a. i. kg^{-1} may be included in integrated pest management (IPM) package for groundnut from environmental safety point (Nataraja *et al.*, 2016).

Mondal *et al.*, (2017) found IPM consisting of deep ploughing, Carbofuran 3G@ 25 kg/ha, Delta traps@ 100/ ha, *Bacillus thuringiensis* var. kurstaki, 90-120 billion spores /g@ 500g per hectare, Imidacloprid 17.8 SL @0.05 per cent was most effective against sucking pests of French bean in Jammu. Developing of the IPM modules and its adoption by the farmers can only ensures the successful management of insect-pests. In a study carried out in Bikaner district of Rajasthan with 180 sample sizes to find out adoption level of farmers about integrated pest management Practices against red hairy caterpillar (*Amsacta moorei* Butler) infesting groundnut. The study revealed that majority of farmers adopted the cultural practices such as summer deep ploughing, sanitation of fields, manual weeding, inter cropping and inter row earthing up. Also, majority of respondents had low level of adoption for the use of pheromone/light traps, destruction of alternative host plants and setting up of light traps, whereas a high majority of respondent were adopting practices neem based botanicals (Bagenia and Meena, 2017).

The present finding revealed that IPM module consisting of deep ploughing, soil solarization with polythene sheet (50 µm); Border crop (3-4 rows of bajra); Trap crop (3-4 rows of castor @ 250 g/ha); application of *Trichoderma* enriched FYM (50 kg with 4 kg *Trichoderma*/ha) 20 days in seed furrow and NSKE application @ 5 per cent at 20-30 DAS was found most effective against sucking pests of groundnut. The use of Integrated Pest Management modules is believed to be a promising strategy in managing sucking insect-pests in the groundnut. With the adoption of IPM modules, farmers can reduce the pesticide pressure on crops and effectively manage the insect pests of crops.

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