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Evaluation of IPM modules against major sucking insect pests of groundnut (*Arachis hypogaea*)

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ABSTRACT

Groundnut (*Arachis hypogaea* L.) is one of the major oilseed crops, contributing 45% of oilseed production in India. Being a cash crop, groundnut helps farmers to support themselves and their families. Additionally, it gives farm families access to nutrient-dense groundnut kernels, which are high in protein and energy and it also provides nutritious fodder (haulms) to livestock. Insect pest menace is one of the few essential biotic stresses contributing towards lower yield. The sucking pests like aphids, leafhoppers and thrips are the major biotic constraints for a crop like groundnut. Currently, farmers are accustomed to using synthetic insecticides to control their infestation. Unregulated insecticide use may also endanger farm-friendly insects. This practice must be replaced with some other methodologies such as integrated pest management modules. Therefore, present study was carried out to evaluate 11 different IPM modules including untreated (control) against sucking insect pests of groundnut during rainy (*kharif*) season of 2020 and 2021 at Sri Karan Narendra Agriculture University, Jobner, Rajasthan. The maximum per cent reduction in sucking insect pests populations was observed in module M_{10} (farmer practices-imidacloprid) and mentioned as effective IPM module. The maximum pod yield of 27.08 q/ha was also obtained in the module M_{10}. On the basis of cost benefit (B:C) ratio the module M_{10} gave the highest ratio (25.62) followed by M_7 (12.35) and M_1 (12.15).

Keywords: Groundnut, IPM modules, Sucking pests

Groundnut (*Arachis hypogaea* L.) also known as peanut is an important food and cash crops of India, and ranks second among oilseed crops (DACNET 2021). India is the second largest producer of groundnut in the world with a contribution of about 37%. However, the crop is plague with low productivity which can be attributed to several abiotic and biotic factors. Insect pests are major threat to groundnut cultivation leading to yield loss of about 15%, which totals to about 1.6 million tonnes of produce worth ₹25,165 million (Dhaliwal *et al.* 2010, Jasrotia *et al.* 2018). Sucking pests are the major biotic constraints in groundnut production. Sucking pests like aphids suck the sap from the tender plant parts such as shoots and twigs causing the whole plant or parts of plant dry up. Aphids also mediated the cause of viral diseases such as rosette disease in groundnut (Vijayalakshmi 1994, Naidu *et al.* 1998). Leafhoppers prefer the first three terminal leaves and suck the sap from the leaves and petioles. Infestation of sucking pests induces yellowing of foliage (hopper burn) that begins at the tip. The leafhoppers can cause up to 22% of yield loss in groundnut (Vyas 1984). Thrips mainly feed by lacerating and sucking the sap from leaves and caused yield loss from 17 to 40% (Ghewande 1987). The peanut stripe virus (PStV) carried by the thrips cause peanut bud necrosis disease (PBND).

The uncontrolled usage of insecticides on insect-pests has led to insecticide resistance in their body. Some insecticides are no longer providing the appropriate level of protection. Additionally, reports of the negative consequences of chemical insecticides are well documented. Crop protection measures are currently aimed at reducing insect pest populations well below the economic threshold level rather than eradication, for which IPM is more suited than any single component. Thus, the integration of different methods, like application of biological agents, entomopathogenic fungi, mixed and border crop, usage of neem-based pesticides with precise dose of popular insecticides appears to be effective and eco-friendly management of sucking insect pests of groundnut. In this context, an attempt was made to develop and evaluate IPM module based on myco-insecticide for groundnut production.

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MATERIALS AND METHODS

The experiment was conducted in a simple randomized block design with 11 IPM modules including untreated (control) and each were replicated thrice. The groundnut variety RG-510 was sown on 8^{th} July and 5^{th} July during 2 consecutive seasons i.e. *kharif,* 2020 and 2021, respectively at Sri Karan Narendra Agriculture University, Jobner, Rajasthan. The plot size was 3.0 m × 2.0 m with row to row and plant to plant spacing of 40 cm and 15 cm, respectively. The recommended package of practices of the zone was followed to raise the crop except insecticidal application, which was followed as per schedule.

IPM modules and their applications: All the modules comprising three sprays i.e. first of entomopathogenic fungus, second of newer and biorational insecticides and third of NSKE 5%. Pre-calibrated knapsack sprayer was used for spraying the insecticides on the crop and care was taken to check the drift of insecticides by putting polythene sheet screen around each plot during spraying. Total three sprays were applied first at initiation of sucking insect pests and subsequently two applications at 20 days intervals.

Details of IPM modules evaluated

S. No.	IPM Modules
M_1	Sequential spray of *Beauveria bassiana,* diafenthiuron and NSKE 5%
M_2	Sequential spray of *Beauveria bassiana*, chlorantraniliprole and NSKE 5%
M_3	Sequential spray of *Beauveria bassiana,* spiromesifen and NSKE 5%
M_4	Sequential spray of *Metarhizium anisopliae*, diafenthiuron and NSKE 5%
M_5	Sequential spray of *Metarhizium anisopliae,* chlorantraniliprole and NSKE 5%
M_6	Sequential spray of *Metarhizium anisopliae,* spiromesifen and NSKE 5%
M_7	Sequential spray of *Lecanicillium lecanii*, diafenthiuron and NSKE 5%
M_8	Sequential spray of *Lecanicillium lecanii,* chlorantraniliprole and NSKE 5%
M_9	Sequential spray of *Lecanicillium lecanii,* spiromesifen and NSKE 5%
M_{10}	Farmer practices (Imidacloprid)
M_{11}	Untreated control

The population of major sucking insect pests, viz. aphid, leafhopper and thrips were recorded at one day before application (pre-treatment population) and one, three, seven and ten days after application (post-treatment population) in different IPM modules. The samples of 3 leaves from 5 tagged plants raised in each plot at weekly interval, preferably in the early morning.

The Per cent reduction in population was calculated using formula given by Henderson and Tilton (1955) which is modification of Abbott's formula (1925).

$$\text{Per cent reduction in population} = 100 \times 1 - \frac{T_a \times C_b}{T_b \times C_a}$$

where T_a, Number of insects in treated plots after treatment; T_b, Number of insects in treated plots before treatment; C_a, Number of insects in untreated control after treatment; C_b, Number of insects in untreated control before treatment.

The pod yield per plot expressed into quintal per hectare and transformed the percentage data into angular transformation values for statistical analyses (Gomez and Gomez 1976). The economics of each modules was also worked out by computing the purchase cost of insecticides as well as their cost of manual application. The gross income was worked out by multiplying the pod yield with the wholesale price of groundnut prevailing in the market at the time of threshing.

RESULTS AND DISSCUSSION

Aphid: Based on the overall mean of pooled data, the mean per cent reduction in aphid population was maximum (82.00%) in module M_{10} (farmer practices-imidacloprid) and it was significantly superior over all the modules (Table 1). Next to M_{10} the maximum reduction was recorded in modules M_7 followed by M_1 and M_9 (60.48, 58.54 and 58.31%, respectively). Although these modules were effective but found to be statistically non-significant relatively. The minimum per cent reduction in aphid population was recorded in module M_5 (41.88%) and it was significantly different. The modules M_2 and M_8 registered 45.56 and 47.32% reduction, respectively and both were comparatively at par. Modules M_6 (52.18%), M_4 (53.69%) and M_3 (54.18%) differed non-significantly with each other and were found moderately effective IPM modules.

Leafhopper: According to the overall mean of pooled data, the maximum mean per cent reduction in (81.39) leafhopper population was observed in module M_{10} (farmer practices-imidacloprid) (Table 2) and it was significantly superior over all the applied modules. Next to it, the maximum reduction was recorded in modules M_7 followed by M_1 and M_9 i.e. 60.33, 58.30 and 58.09, respectively. These three modules were statistically non-significant when compared among themselves. The minimum per cent reduction in leafhopper population was recorded in module M_5 (41.68%) and it was statistically significant. The modules M_2 and M_8 registered 44.78 and 46.98% reduction, respectively and both were comparatively at par. The modules M_6 (51.93%), M_4 (53.84%) and M_3 (54.15%) differed non-significant from each other and these were moderately effective IPM modules.

Thrips: The maximum mean per cent (81.04) reduction in the thrips population was observed in module M_{10} (farmer practices-imidacloprid) (Table 3) and it was significantly superior over all the applied modules. Next to it, the maximum population reduction was recorded in modules M_7 followed by M_1 and M_9 with per cent reduction of 59.48, 58.58 and 58.47, respectively. These three modules can be grouped as effective modules but are statistically

Table 1 Evaluation of IPM modules against aphid in groundnut in *kharif,* 2020 and 2021 (Pooled)

IPM Module	Perc ent reduction in aphid population days after spray															Overall mean
	First spray					Second spray					Third spray					
	One	Three	Seven	Ten	Mean	One	Three	Seven	Ten	Mean	One	Three	Seven	Ten	Mean	
M_1	34.89	37.38	45.33	35.35	38.24	82.87	91.09	79.32	71.93	81.30	57.19	63.61	55.39	48.08	56.07	58.54
	(36.21)	(37.69)	(42.32)	(36.48)	(38.20)	(65.55)	(72.63)	(62.95)	(58.01)	(64.38)	(49.13)	(52.90)	(48.09)	(43.90)	(48.49)	(49.91)
M_2	29.76	32.87	39.67	29.71	33.00	58.75	65.86	57.13	47.93	57.41	48.16	52.88	44.78	39.26	46.27	45.56
	(33.06)	(34.98)	(39.04)	(33.02)	(35.06)	(50.04)	(54.25)	(49.10)	(43.81)	(49.26)	(43.95)	(46.65)	(42.00)	(38.79)	(42.86)	(42.45)
M_3	31.50	33.86	38.98	31.70	34.01	75.31	79.12	73.25	68.80	74.12	55.34	61.46	53.69	47.17	54.41	54.18
	(34.14)	(35.58)	(38.63)	(34.26)	(35.67)	(60.21)	(62.81)	(58.85)	(56.04)	(59.42)	(48.07)	(51.62)	(47.12)	(43.38)	(47.53)	(47.40)
M_4	28.35	32.86	36.58	30.71	32.12	77.90	81.99	75.28	66.78	75.49	54.25	60.18	52.31	47.07	53.45	53.69
	(32.16)	(34.97)	(37.22)	(33.65)	(34.53)	(61.96)	(64.89)	(60.19)	(54.80)	(60.32)	(47.44)	(50.87)	(46.32)	(43.32)	(46.98)	(47.11)
M_5	24.21	28.41	33.69	25.29	27.90	56.72	64.93	51.72	42.82	54.04	45.28	51.18	42.39	35.89	43.69	41.88
	(29.47)	(32.21)	(35.48)	(30.19)	(31.88)	(48.86)	(53.68)	(45.98)	(40.87)	(47.32)	(42.29)	(45.68)	(40.62)	(36.80)	(41.37)	(40.32)
M_6	28.64	33.13	37.77	31.18	32.68	74.10	78.25	71.93	64.64	72.23	53.67	60.67	48.70	43.54	51.64	52.18
	(32.35)	(35.14)	(37.92)	(33.94)	(34.86)	(59.41)	(62.20)	(58.01)	(53.51)	(58.20)	(47.10)	(51.16)	(44.25)	(41.28)	(45.94)	(46.25)
M_7	38.24	43.58	49.68	39.81	42.82	83.06	91.89	80.75	73.75	82.36	57.39	65.36	55.26	47.00	56.25	60.48
	(38.20)	(41.31)	(44.81)	(39.12)	(40.87)	(65.70)	(73.47)	(63.98)	(59.18)	(65.17)	(49.25)	(53.95)	(48.02)	(43.28)	(48.59)	(51.05)
M_8	33.67	39.44	45.56	34.65	38.33	60.54	67.15	57.92	47.23	58.21	46.67	52.63	44.49	37.87	45.41	47.32
	(35.46)	(38.90)	(42.45)	(36.06)	(38.25)	(51.08)	(55.03)	(49.55)	(43.41)	(49.72)	(43.09)	(46.50)	(41.83)	(37.98)	(42.37)	(43.46)
M_9	36.50	41.06	49.56	37.10	41.06	78.90	85.69	76.12	70.24	77.73	57.27	64.70	55.69	46.96	56.15	58.31
	(37.16)	(39.85)	(44.75)	(37.52)	(39.85)	(62.65)	(67.80)	(60.74)	(56.94)	(61.84)	(49.18)	(53.55)	(48.27)	(43.26)	(48.53)	(49.79)
M_{10}	83.66	90.62	80.29	75.13	82.43	82.22	92.22	81.19	75.72	82.84	81.77	90.75	78.19	72.23	80.73	82.00
	(66.16)	(72.17)	(63.64)	(60.09)	(65.21)	(65.06)	(73.80)	(64.30)	(60.48)	(65.53)	(64.74)	(72.30)	(62.16)	(58.20)	(63.97)	(64.89)
M_{11}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
S.Em. ±	0.40	0.47	0.50	0.46	0.47	0.71	0.75	0.69	0.62	0.68	0.57	0.62	0.55	0.54	0.59	0.50
CD (P=0.05)	1.14	1.35	1.42	1.32	1.33	2.03	2.14	1.97	1.78	1.94	1.62	1.77	1.57	1.54	1.69	(1.44

Treatment details are given under Materials and Methods.

Table 2 Evaluation of IPM modules against leafhopper in groundnut in *kharif,* 2020 and 2021 (Pooled)

IPM Module	Per cent reduction in leafhopper population days after spray															P
	First spray					Second spray					Third spray					
	One	Three	Seven	Ten	Mean	One	Three	Seven	Ten	Mean	One	Three	Seven	Ten	Mean	
M_1	33.14	39.04	45.23	35.41	38.20	82.19	91.22	78.18	71.92	80.87	56.24	62.94	54.41	49.70	55.82	58.30
	(35.14)	(38.67)	(42.26)	(36.51)	(38.18)	(65.04)	(72.76	62.15)	(58.00)	(64.07)	(48.59)	(52.50)	(47.53)	(44.83)	(48.34)	(49.78)
M_2	28.66	31.47	38.93	27.05	31.53	58.43	66.85	55.93	46.48	56.92	46.87	53.77	45.35	37.65	45.91	44.78
	(32.37)	(34.12)	(38.60)	(31.34)	(34.16)	(49.85)	(54.85)	(48.40)	(42.98)	(48.98)	(43.20)	(47.16)	(42.33)	(37.85)	(42.65)	(42.01)
M_3	30.73	34.37	40.46	31.65	34.30	76.49	79.92	74.43	66.88	74.43	54.24	60.26	51.97	48.46	53.73	54.15
	(33.66)	(35.89)	(39.49)	(34.23)	(35.85)	(61.01)	(63.39)	(59.64)	(54.87)	(59.63)	(47.43)	(50.92)	(46.13)	(44.12)	(47.14)	(47.38)
M_4	28.96	32.67	36.29	29.94	31.96	76.81	82.65	74.72	66.47	75.16	54.74	61.66	53.22	47.93	54.39	53.84
	(32.56)	(34.85)	(37.04)	(33.17)	(34.43)	(61.21)	(65.40)	(59.81)	(54.61)	(60.11)	(47.72)	(51.74)	(46.84)	(43.81)	(47.52)	(47.20)
M_5	23.72	27.25	33.75	24.18	27.22	56.93	63.61	52.68	43.28	54.12	44.23	52.28	41.49	36.76	43.69	41.68
	(29.14)	(31.47)	(35.51)	(29.45)	(31.45)	(48.99)	(52.90)	(46.54)	(41.13)	(47.37)	(41.68)	(46.31)	(40.10)	(37.32)	(41.37)	(40.21)
M_6	27.88	33.01	37.93	31.26	32.52	72.25	78.14	70.49	64.47	71.33	52.88	61.68	49.19	44.00	51.94	51.93
	(31.87)	(35.07)	(38.02)	(33.99)	(34.77)	(58.21)	(62.12)	(57.10)	(53.41)	(57.63)	(46.65)	(51.75)	(44.54)	(41.55)	(46.11)	(46.11)
M_7	36.09	45.10	50.97	39.25	42.85	82.65	90.90	79.90	74.17	81.90	57.40	64.68	54.53	48.36	56.24	60.33
	(36.92)	(42.19)	(45.55)	(38.78)	(40.89)	(65.39)	(72.44)	(63.36)	(59.45)	(64.82)	(49.26)	(53.54)	(47.60)	(44.06)	(48.59)	(50.96)
M_8	34.12	38.99	45.37	31.56	37.51	60.95	66.35	58.28	46.95	58.13	47.72	52.99	43.83	36.63	45.29	46.98
	(35.74)	(38.64)	(42.34)	(34.18)	(37.77)	(51.33)	(54.55)	(49.77)	(43.25)	(49.68)	(43.69)	(46.71)	(41.45)	(37.24)	(42.30)	(43.27)
M_9	37.42	40.90	49.75	38.24	41.58	78.04	84.09	75.48	68.07	76.42	58.04	63.88	55.18	48.03	56.28	58.09
	(37.71)	(39.76)	(44.85)	(38.20)	(40.15)	(62.06)	(66.50)	(60.32)	(55.59)	(60.95)	(49.62)	(53.06)	(47.97)	(43.87)	(48.61)	(49.66)
M_{10}	81.10	91.24	79.36	73.72	81.35	81.66	90.74	79.81	75.66	81.97	81.77	92.27	77.78	71.63	80.86	81.39
	(64.24)	(72.78)	(62.99)	(59.17)	(64.42)	(64.65)	(72.30)	(63.30)	(60.44)	(64.87)	(64.72)	(73.86)	(61.89)	(57.84)	(64.06)	(64.45)
M_{11}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
S.Em.±	0.58	0.64	0.69	0.60	0.63	1.00	1.08	0.97	0.91	0.99	0.80	0.88	0.77	0.71	0.79	0.57
CD (P=0.05)	1.66	1.84	1.96	1.72	1.79	2.86	3.09	(2.78	2.59	2.82	2.28	2.52	2.19	2.04	2.26	1.63

Treatment details are given under Materials and Methods.

Table 3 Evaluation of IPM modules against thrips in groundnut in *kharif,* 2020 and 2021 (Pooled)

IPM Module	Perc ent reduction in thrips population days after spray															
	First spray					Second spray					Third spray					Overall mean
	One	Three	Seven	Ten	Mean	One	Three	Seven	Ten	Mean	One	Three	Seven	Ten	Mean	
M_1	33.14	36.49	44.98	34.92	37.38	83.26	90.87	80.54	71.56	81.56	58.62	63.42	56.83	48.31	56.79	58.58
	(35.15)	(37.16)	(42.12)	(36.22)	(37.69)	(65.85)	(72.41)	(63.82)	(57.77)	(64.57)	(49.96)	(52.78)	(48.93)	(44.03)	(48.90)	(49.94)
M_2	28.16	33.16	39.63	29.88	32.71	59.76	65.31	57.68	47.41	57.54	48.78	53.63	44.96	36.32	45.92	45.39
	(32.05)	(35.16)	(39.01)	(33.13)	(34.88)	(50.63)	(53.92)	(49.42)	(43.51)	(49.34)	(44.30)	(47.08)	(42.11)	(37.06)	(42.66)	(42.35)
M_3	30.90	34.99	40.90	31.61	34.60	76.97	79.37	73.86	68.51	74.68	56.28	60.77	54.66	48.44	55.04	54.77
	(33.77)	(36.26)	(39.76)	(34.20)	(36.03)	(61.36)	(63.04)	(59.30)	(55.88)	(59.82)	(48.61)	(51.22)	(47.67)	(44.11)	(47.89)	(47.74)
M_4	27.67	30.40	36.13	28.66	30.71	78.26	83.63	76.19	68.93	76.75	55.27	59.07	52.98	44.83	53.03	53.50
	(31.73)	(33.46)	(36.95)	(32.37)	(33.65)	(62.23)	(66.13)	(60.81)	(56.13)	(61.18)	(48.02)	(50.22)	(46.71)	(42.03)	(46.74)	(47.01)
M_5	25.51	29.36	33.89	25.17	28.48	58.87	63.18	52.63	43.36	54.51	44.13	52.50	42.44	36.22	43.82	42.27
	(30.33)	(32.80)	(35.60)	(30.10)	(32.25)	(50.11)	(52.64)	(46.51)	(41.18)	(47.59)	(41.63)	(46.43)	(40.65)	(37.00)	(41.45)	(40.55)
M_6	27.90	31.21	37.49	29.12	31.43	72.58	76.77	70.62	65.91	71.47	54.74	60.93	46.85	40.94	50.86	51.25
	(31.88)	(33.96)	(37.75)	(32.66)	(34.10)	(58.42)	(61.18)	(57.17)	(54.28)	(57.71)	(47.72)	(51.32)	(43.19)	(39.78)	(45.49)	(45.72)
M_7	35.46	40.65	49.24	38.92	41.06	82.37	91.27	80.11	72.66	81.60	53.17	66.26	56.44	47.30	55.79	59.48
	(36.54)	(39.61)	(44.56)	(38.59)	(39.85)	(65.20)	(72.81)	(63.54)	(58.49)	(64.62)	(46.83)	(54.49)	(48.70)	(43.45)	(48.33)	(50.47)
M_8	31.78	36.22	44.28	32.98	36.31	58.37	66.39	55.20	48.07	57.01	51.27	53.88	47.65	35.82	47.15	46.82
	(34.31)	(37.00)	(41.71)	(35.05)	(37.06)	(49.82)	(54.57)	(47.98)	(43.89)	(49.03)	(45.72)	(47.22)	(43.65)	(36.76)	(43.37)	(43.18)
M_9	36.30	40.77	48.78	38.40	41.06	78.87	85.22	76.93	71.24	78.06	58.22	63.26	55.85	47.77	56.27	58.47
	(37.05)	(39.68)	(44.30)	(38.29)	(39.85)	(62.63)	(67.39)	(61.29)	(57.57)	(62.07)	(49.73)	(52.69)	(48.36)	(43.72)	(48.60)	(49.87)
M_{10}	78.86	89.87	76.22	71.43	79.09	84.74	92.10	82.43	74.49	83.44	80.88	90.59	78.22	72.64	80.58	81.04
	(62.63)	(71.44)	(60.81)	(57.69)	(62.79)	(67.01)	(73.67)	(65.22)	(59.71)	(66.00)	(64.07)	(72.14)	(62.18)	(58.46)	(63.85)	(64.19)
M_{11}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.000
S.Em.$\pm$	0.58	0.63	0.68	0.59	0.62	1.01	1.08	0.98	0.91	0.99	0.80	0.88	0.76	0.70	0.78	0.57
CD (P=0.05)	1.66	1.79	1.94	1.69	1.77	2.87	3.08	2.79	2.60	2.83	2.29	2.51	2.18	1.99	2.24	1.62

Treatment details are given under Materials and Methods.
Figures in parentheses are angular transformed values.

non-significant. The minimum per cent reduction in thrips population was recorded in modules M_5 (42.27%). The M_2 and M_8 modules expressed their effectiveness with 45.39 and 46.82% reduction, respectively and both were comparatively at par. The modules M_6 (51.25%), M_4 (53.50%) and M_3 (54.77%) differed from each other non-significantly and were considered moderately effective modules.

The mean per cent population reduction of studied pests, viz. aphid, leafhopper and thrips was maximum in module M_{10} followed by M_7, M_1 and M_9. These were found effective IPM modules. The minimum per cent reduction in sucking insect pests population was recorded in the modules M_5 followed by M_2 and M_8 and can be judged as least effective IPM modules. The modules M_6, M_4 and M_3 were moderately effective IPM modules in controlling sucking insect pests of groundnut.

Biradar and Hegde (2016) evaluated different IPM modules against thrips and leafhopper in groundnut and reported that the Module III (cowpea as a conservative crop was grown along the border and the biopesticides like *Lecanicillium lecanii* @6 g/ L, *Beauveria bassiana* @6 g/ L and Sl NPV @100 LE/ acre) recorded significantly lowest sucking pest population compared to other modules. Their results partially corroborates with present findings of this study. Satpathi *et al.* (2016) reported that the pesticides-based management modules proved better as compared to the biopesticides based modules in managing the attack of sucking pests in cowpea which again support the present results. Karuppuchamy (2016) and Sharmah and Rahman (2017) also done similar type of work which partially support the present investigation. Jasrotia *et al.* (2018) also reported that the population of thrips and leafhopper were recorded lowest in the module T_5 (ploughing up to 8 inches and soil solarisation with polythene sheet, border crop, trap crop, *Trichoderma* enriched FYM, NSKE 5% + seed treatment with mancozeb, imidacloprid and *rhizobium* + soil treatment by *Trichoderma harzianum* + pheromone trap+ difenoconazole spray) which supports the present results in reference to NSKE 5%.

Effect of IPM modules on pod yield of groundnut: The pooled data revealed that all the treated plots have highest pod yield over untreated control. The maximum pod yield was obtained in the module M_{10} (27.08 q/ha) and it was significantly superior over all the modules. Further, the maximum pod yield was recorded in M_7 (25.92 q/ha) followed by M_1 (25.59 q/ha) and M_9 (25.25 q/ha). These three modules can be considered in a non-significant group of modules with respect to yield gain. The minimum pod yield was obtained in the M_5 (15.09 q/ha) followed by M_2 (15.68 q/ha) and M_8 (16.93 q/ha) which differed from each other non-significantly. The modules M_6, M_4 and M_3 recorded 20.41, 20.90 and 21.58 q/ha, pod yield respectively and found non-significant when compared with each other. Present findings corroborates with the results presented by Jasrotia *et al*. (2018) where the most effective module gave highest pod yield and benefit cost ratio. Satpathi *et al*. (2016) revealed that the yield of healthy pods varied significantly amongst different treatment modules. Significantly the highest pod yield was obtained in the module T_4 [Vermicompost during first top-dressing at 25 DAS + Neem oil 90% (2 ml/litre) once during vegetative stage + Flubendiamide 480 SC (0.1 ml/litre) once during reproductive stage (Pesticide based IPM- II)] (9.85 t/ ha) which was statistically at par with the modules T_3 [Vermicompost during first top-dressing at 25 DAS + Neem oil 90% (2 ml/litre) once during vegetative stage + Malathion 50 EC once during reproductive stage (Pesticide based IPM-I)] and T_1 [(Profenofos 40 EC + Cypermethrin 4 EC) (1 ml/litre) twice during vegetative and reproductive stage (Farmer's practice)]. Amongst the biointensive management modules the treatment module T_6 [Vermicompost + Tobacco decoction twice during vegetative and reproductive stage (Biointensive management-II)] provided the lowest yield (6.33 t/ha) which was statistically identical to the pod yield recorded from other biointensive module T_5 [Vermicompost during first top-dressing at 25 DAS + Neem oil 90% twice during vegetative and reproductive stage (Biointensive management-I)] and control. Sharmah and Rahman (2017) reported the similar results in their studies.

Various individual pest control strategies have been applied in the past but none of them found effective alone. A combination of various methods can be a good strategy in crop protection. In this study, we designed 10 modules involving different combinations of mycoinsecticide, insecticide with crop management practices. It has been found that farmer practice of imidacloprid was successful in controlling major sucking pests of groundnut and helpful in gaining the maximum yield also.

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