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Management of major sucking pests in okra, *Abelmoschus esculentus* using different management modules

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Abstract
The present study was carried out to evaluate various management modules against major sucking pest of okra. The module M-III (azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC) and M-IV (neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC) was found effective against aphids as well as leafhopper for keeping down the pests population throughout the crop growth. The whitefly population in okra can be effectively manage by using the module M-IV (neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC was most effective) and module M-III (azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC) found most effective; however, these module does not differ statistically to each other. The modules M-IV(Neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC lit was found most effective management for suppressing spider mites and it does not differ statically than mites in module M-III. The management module M-III, azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC was the most effective module for shoot and fruit borer management recording significantly least fruit damage of 15.63 per cent followed by M-IV which resulted least fruit damage by 19.16 percent and which yielded higher marketable yield there modules were on par to each other.

Keywords: Management, modules, okra, pest, sucking

Introduction

Vegetables are an essential part of our diet, which supplying vitamins, carbohydrates and minerals needed for a balanced diet. Their value is important especially in developed and developing countries like India, where malnutrition abounds (Khan *et al.* 2001) [7]. One of the most popular vegetable Okra, *Abelmoschus esculentus* (L.) Moench (okra) is a flowering plant in the Malvaceae. Even though it is a native of tropical Africa, and widely cultivated in India and Subtropical regions around the world, such as Southeast Asia. In India, it is grown both in *summer* and *kharif* season (Lal and Sinha, 2005) [12]. This crop is suitable for cultivation as a kitchen garden crop as well as on large high- tech commercial farms. One of the important limiting factors in the cultivation of okra is insect pests. Many of the pests occurring on cotton are found to ravage okra crop. As high as 112 species of insects have been recorded on okra (Ardhendu chakraborty, 2014) [2]. India and listed the most destructive insect pests as leafhopper, *Amrasca biguttula biguttula* (Ishida), aphid, *Aphis gossypii* (Glover), whiteflies, *Bemisia tabaci* (Gennadius), fruit borer, *Helicoverpa armigera* (Hubn.), *spotted bollworm*, *Earias vittella* (Fabricius) and *Earias insulana* (Boisd.) (Mandal, *et al*., 2006) [13] and (Mane, *et al*., 2010) [14]. The several insecticides are being used for the control these pests. Even though chemical control is easiest and best method of pest control in okra but injudicious, indiscriminate and repeated use of same pesticide has created the problems like environmental pollution, insecticidal resistance, pesticide hazards and resurgence. In okra frequent pickings done, If chemical control are used in okra to control the pests residual effect of insecticides on fruit therefore, chemical control is limiting factor for management of this pests.

Hence, the research workers have wanted researching out the more effective, eco-friendly and persistence formulation of botanical insecticides which may keep the crop pest below ETL. Therefore, an experiment planned with effective management module by using botanicals, biopesticides and insecticides and in combination with botanicals. To find out the right selection of management module for management of major sucking pest in okra for increasing the yield.

Material and Methods

Study areas: The sucking pests like aphids, leafhoppers and whitefly constitute the major group of insect pest on okra at initial stage of crop growth, while in later stage shoot and fruit borer attack the crop which needs to be managed below the level of economic damage. The experiment was conducted at the field of Department of Agricultural Entomology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* 2017.

Layout: The field experiments were laid out in randomized block design (RBD) consisting of six treatments including control during *kharif* season 2017. Okra (Cultivar: Akola bahar) was raised in the plots size of Gross plot size 4.8 m x 2.7m and Net plot size: 3.6 m × 1.8 m with the spacing of 60 x 45 cm. Cultural practices like preparatory tillage, hoeing, weeding, thinning, gap filling, fertilizer applications, etc. were done as per the university recommendations.

Treatment details: The various management modules evaluated in the present study were composed of three sprays in management module M-I and M-II and four sprays in management module M-III, M-IV and M-V; the module M-VI was untreated control. Management modules used as M-I-(Neem seed kernel extract 5%, dimethoate 30 EC @ 20 ml/10 lit and thiamethoxam 25 WG @ 1.5 g/10 lit), M-II-(Neem seed kernel extract 5%, Lecanicillium lecanii 2 x 108 cfu 40 g /10 lit and azadirachtin 300 ppm @ 50 ml / 10 lit), M-III-(Azadirachtin 300 ppm @ 50 ml / 10 lit, dimethoate 30 EC @ 20 ml/10 lit, thiamethoxam 25 WG @ 1.5 g/10 lit and quinalphos 25 EC @ 20 ml /10 lit), M-IV-(Neem seed kernel extract 5%, dimethoate 30 EC @ 20 ml/10 lit, thiamethoxam 25 WG @ 1.5 g/10 lit and quinalphos 25 EC @ 20 ml /10 lit), M-V-(Neem seed kernel extract 5%, Lecanicillium lecanii 2 x 108 cfu @ 40 g /10 lit, azadirachtin 300 ppm @ 50 ml / 10 lit and dimethoate 30 EC @ 20 ml/10 lit), M-VI-(Untreated control).

Method of application: The sprays in various management modules were undertaken from 15 days after emergence of crop and were continued at an interval of 10 days at 15, 25, 35 and 45 days after emergence (DAE). As per management module; overall four sprays were undertaken for management of major pests of okra. Pre-treatment observations were taken 24 hours before first spray. Sprayings were done using knapsack sprayer with solid cone nozzle early in morning hours to avoid the mid-day heat. Care was taken to wash the pump with water while switching on from one pesticide treatment to another and covering all plants parts thoroughly while spraying.

Observations: The observations were recorded on various major sucking pests *viz.*, aphid, leafhopper, whitefly, red spider mites. Pre treatment observations on sucking pests *viz.*, aphids, leafhoppers and whiteflies, were taken 24 hrs before spray and post treatment observations were recorded at 3, 7 and 10 days after each spray. For shoot and fruit borer damage, number of healthy and damaged fruits due to borer were recorded at 5, 10, 14, 19, 24, 29, 34 and 38 days after fourth spray in each plot. At the time of every picking damaged fruits and healthy fruits were counted on number basis to workout percent infestation of shoot and fruit borer.

Data analysis: The data of sucking pest *viz*., aphids, leafhoppers, whiteflies, red spider mites was recorded at 3, 7 and 10 days after each spray and transformed to square root values and per cent fruit damage data was transformed arc sine values and subjected to statically analysis (Gomez and Gomez, 1984) [3].

Results and Discussion

A. Effect of management modules on pests of Okra

i. *Aphis gossypii:* First spray: Effective control of aphids were recorded with azadirachtin 300 ppm (M-III) and it was followed in neem seed kernel extract 5% (M-II, M-III, M-IV, M-I); however, all these treatments were at par with each other and minimum population than in untreated control. Similar trends of effectiveness of management modules for control of aphids in okra after 10 DAFS.

Second spray: The population of *A. gossypii* data at, 3 DASS stated that the lowest population of aphids was recorded in dimethoate 30 EC in (M-I, M-III and M-IV) with1.37, 1.37 and 1.40 aphids / leaf, respectively and all these were on par to each other and aphids in dimethoate spray were significantly least than in *Lecanicillium lecanii* 2×10^8 cfu and untreated control. Populations of *A. gossypii* at, 7 DASS lowest were recorded in module sprays M-III, M-I and M-IV which were composed of dimethoate 30 EC (1.78, 1.83 and 1.87 aphids / leaf) and all these were at par with each other. At, 10 DASS minimum aphids were noted in dimethoate 30 EC, sprays *i.e.* M-IV, M-III and M-I recording, respectively 2.20, 2.27 and 2.35 aphids / leaf and these were at par to each other.

Third spray: At, 3 DATS lowest population of *A. gossypii* was recorded in modules M-III, M-IV and M-I which were thiamethoxam 25 WG spray recording 1.60, 1.67 and 1.70 aphids / leaf, respectively and all these were at par with each other. It was followed in azadirachtin 300 ppm spray (M-V and M-II) noting 3.38 and 3.42 aphids / leaf, and were at par with each other. At, 7 DATS significant differences were noted in aphid population on par population of aphid was recorded in modules *viz.*, M-IV, M-I and M-III which were thiamethoxam 25 WG spray (2.38, 2.58 and 2.93 aphids / leaf, respectively) and these populations were significantly less than in azadirachtin (M-II and M-V). At, 10 DATS minimum aphids were noted in M-IV, M-I and M-III consisted of thiamethoxam 25 WG spray and aphids in these were at par to each other and significantly less than aphids in azadirachtin 300 ppm @ 50 ml / 10 lit spray (M-II, 7.33 and M-V, 7.57).

Fourth Spray: Management modules (M-III and M-IV) were found to be effective in *A. gossypii* management in okra during fourth spray Aphid population was ranged from 3.12 to 9.42 /leaf (Table 2).

Cumulative effect: The overall effect of insecticide sequential sprays in the form of modules 3 days after each module spray showed that there were significant differences in *A. gossypii* population. The management module M-III, azadirachtin 300 ppm, dimethoate 30, thiamethoxam 25 WG, quinolphos 25 EC was found effective for keeping down the aphids throughout the crop growth. The management module M-III was on par to management module M-IV; however, later does not differ statistically than than mean aphid population in module M-V, neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu, azadirachtin 300 ppm, dimethoate 30 EC (Fig 1).

Our recorded observation revealed that the minimum aphids were noted in M-III, azadirachtin 300 ppm @ 50 ml / 10 lit (2.68 / leaf); however, it was at par to M-IV, M-V, M-II and M-I which were neem seed kernel extract 5% sprays with 3.33, 3.55, 3.60, 3.77 aphids / leaf and aphids in these all were at par to each other. Present finding are in agreement with some previous workers viz. Naik *et al.* (2012) [15], (Kabir and Mia 1987) [6], (Konar *et al.* 2013) [8] who reported effectiveness of neem seed kernel extract 5% & dimethoate 30 EC was effective against aphids on okra. Our recorded observation stated that the minimum aphids were noted in M-IV, M-I and M-III consisted of thiamethoxam 25 WG (3.90, 4.48, 4.50 /leaf). Similarly (Anita and Nandihalli, 2009) [1] reported that thiamethoxam@25 WG was found effective against aphids in okra. The effectiveness of management modules in ascending order against aphids in okra as M-III > M-IV> M-V> M-I> M-II> M-VI.

ii. *Amarasca biguttula biguttula*: First spray: At, 3DAFS data revealed that all modules were significantly superior over untreated control. Most effective module was M-III, azadirachtin 300 ppm spray (0.68 leafhoppers / leaf) followed by neem seed kernel extract 5% spray M-II, M-IV and M-V 0.82, 0.85 and 0.85 leafhoppers / leaf, respectively and all neem seed kernel extract 5% spray modules were on par to Azadirachtin 300 ppm sprays and significantly minimum leafhoppers than untreated control. Similar trends at 7 &10 DAFS was found and effectiveness of modules placed in ascending order as M-IV, M-III, M-II, M-V and M-I against the leafhopper in okra.

Second spray: *A. biguttula* population was ranged from 1.32 to 6.32 / leaf and were significant 3, 7 and 10 days after second spray (DASS). Significantly minimum and on par *A. biguttula* were noted in dimethoate 30 EC module spray (M-III, M-IV, M-I) 3, 7 and 10 days after second spray and it was significantly rest than in *Lecanicillium lecanii* 2×10^8 cfu (M-II and M-V) and untreated control. The *Lecanicillium lecanii* 2×10^8 cfu spray was effective than untreated control in which leafhoppers were 4.63 to 6.32 per leaf.

Third spray: Significantly, minimum *A. biguttula* were noted in thiamethoxam than in azadirachtin 300 ppm spray (M-II, M-V) 3, 7 and 10 days after spray in which significantly least *A. biguttula* were noted than in untreated control.

Fourth spray: The population of *A. biguttula* was significantly least in M-III, M-IV and M-V and was on par to each other 3, 7 and 10 days after fourth spray. However, leafhoppers in module M-I and M-II were not differed to leafhoppers in untreated control no spray of insecticides included in these modules. (Table 3).

Cumulative effect: At, 3DAS data revealed that the management module M-IV was found most effective for keeping down the *A. biguttula* throughout the crop growth which had 1.94 average leafhoppers. At, 7 DAS data stated that management module M-III and module M-IV noted lower *A. biguttula* (2.57 and 2.73 / leaf), respectively being on par to each other. The management module M-V was next effective module recording, 3.76 leafhopper / leaf and at par to M-I management modules. At, 10 DAS stated that management module M-III (3.33/ leaf) was most effective and M-IV, (3.41/leaf) were most effective and were at par with each other. Whereas, management module M-V, was next best management module which noted 4.58 leafhoppers per leaf as against 8.49 *A. biguttula* observed in untreated control (M-VI) (Fig 2).

Our recorded data revealed that Minimum population of leafhopper was noted in module azadirachtin 300 ppm; however, statistically equal results were noted with neem seed kernel extract 5% spray (M-IV, M-I, M-V and M-II). Our results in line with the results of (Kumar *et al.* 2001) [14] & (Naik *et al.* 2012) [15] which stated that neem seed extract was effective against the leafhopper in okra crop.

Our recorded observation stated the effectiveness of dimethoate 30 EC against the leafhopper which was supported by the report of (Kumar *et al.* 2001) [10] and (Kumar and Kumar 2017) [11]. Thiamethoxam 20 G was next effective against the leafhopper. These findings are confirmed by findings of (Jayarao *et al.* 2016) [5], (Gosalwad *et al.* 2008) [4], (Preetha *et al.* 2009) [16], (Sinha and Sharma 2008) [18] & (Kumar *et al.* 2001) [10] who reported effectiveness of thiamethoxam against leafhopper in okra cropping system.

iii. *Bemisia tabaci*: First spray: Data recorded stated that the management module M-I and management module M-III was found most effective for *B. tabaci* management. However, both these modules were equally effective with management module M-IV.

Second spray: observation data revealed that management module M-I, M-II and M-IV was observed most effective for *B. tabaci* suppression 3, 7 and 10 days after spray.

Third spray: Comparatively lowest population of *B. tabaci* recorded in all the management modules over untreated control. Neonecotinoid, thiamethoxam emerged as most effective insecticide composed in third spray as module component included in management module M-IV, M-III and M-I. Hence these modules do not differ statistically at 3, 7 and 10 days after spray.

Fourth spray: Lowest *B. tabaci* recorded in management module M-V 1.80, 2.35 and 2.93 whiteflies / leaf 3, 7 and 10 days after spray, respectively. However, *B. tabaci* in this module does not differ statistically than in management modules M-IV and M-III which were composed of quinolphos 25 EC @ 20 ml /10 lit spray and noted 1.88, 2.83, 2.93 and 2.77, 2.80, 3.17 per leaf, respectively. The management module M-I and M-II were not effective over untreated control (M-VI) recording respectively 5.08, 5.45, 6.85 and 4.88, 5.62, 7.17 whiteflies per leaf (Table 4).

Cumulative effect: Overall data showed that none of the modules *B. tabaci* data not crossed ETL (6 whitefly/ leaves) and it was found in the range between (1.54-3.99 whitefly/leaf) except modules VI (untreated control) (4.59-5.96 whitefly/leaf). Overall data stated that effectiveness of modules in ascending order as M-VI <M- II<M- I < M-V < M-IV<M- III (Fig 3).

Our recorded observation showed that dimethoate 30 EC used in various modules found effective against the whiteflies, these findings are confirmed by findings of (Kumar and Kumar 2017) [15] who noticed dimethoate 30 EC effective for whitefly management of okra. However, the module with M-III composed of neem cake flonicamid 50 WG, neemzol TS

5%, dinotefuran 20 SG, flubendiamide 35.59 SC, chlorfluazuron 5.4 EC, emamectin benzoate 5 SG, reported effective against whiteflies on okra. Similar observation recorded by (Roy and Sarkar 2017) [17] stated that due to use of flonicamid 50 WG, neemzol TS 5%, dinotefuran 20 SG, flubendiamide 35.59 SC, chlorfluazuron 5.4 EC, emamectin benzoate 5 SG reduction of 51.45 per cent of whitefly in okra done.

iv. *Tetranychus spp*: The incidence of *T. spp* initiated 28 days after emergence and hence the reaction of insecticides on spider mites expressed second spray onwards in each module;

Second spray: Recorded data revealed significant differences amongst various modules at 3, 7 and 10 days after second spray (DASS). Minimum population was recorded in management module M-III and M-IV. The spray of Lecanicillium lecanii ,(M-II and M-V) was less effective for management of spider mites but effective over control.

Third spray: It was observed that the thiamethoxam 25 WG was the one of the component in management module M-IV, M-III and M-I and it was found most effective for suppressing the *Tetranychus spp* population 3, 7 and 10 days after third spray. The thiamethoxam 25 WG and azadirachtin 300 ppm which was included in management module M-II, neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu, azadirachtin 300 ppm and M-V, neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu, azadirachtin 300 ppm, dimethoate 30 EC and these modules represents as next effective over untreated control (M-VI).

Fourth spray: Lowest population was recorded in management module M-V and recorded 3.3, 5.43, 6.3 /cm^2 leaf at 3,7,10 DAFS, respectively followed by M-IV 3.70, 5.88, 6.27 / cm^2 leaf at 3,7,10 DAFS. However, management modules M-III, M-IV and M-V were found equally effective over control and management module M-I and M-II (Table 5).

Cumulative effect: The data on *Tetranychus spp* 3 days after spray (mean of three sprays) showed that there was significant difference in mites and the population range was 2.10 to 6.40 per leaf. *Tetranychus spp* in all the management modules (M-VI) were lowering than the mites in untreated control. The management module M-IV, neem seed kernel extract 5%, dimethoate 30 EC , thiamethoxam 25 WG & quinalphos 25 EC (2.10, 3.13, 3.52), respectively was found most effective management for suppressing spider mites and it does not differ statistically than mites (4.98, 6.21, 7.41) in management module M-II, neem seed kernel extract 5%. Modules IV & III effect against *Tetranychus spp* was superior over rest of the modules tested. Due to want of literature on specific module on spider mites, discussion could not done. Our results showed that effectiveness of management modules in ascending order M-VI <M-II<M-I<M-V<M-III<M-IV (Fig 4).

The management module M-IV, neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC was found most effective management for suppressing spider mites followed by management module M-II, neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu, azadirachtin 300 ppm. Both these module's effect against spider mites was superior over rest of the modules tested. However other remaing management modules given as per effectiveness against red spider mites as M-V>M-I>M-II>M-VI.

V. Fruit damage due to *Earias vittela and E. insulana* and effects of management modules:

Mean recorded data revealed that the management modules MIII, azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG & quinalphos 25 EC was the most effective for *E.vittela and E. insulana* management recording significantly least fruit damage of 15.63 per cent followed by management module M-IV, in neem seed kernel extract 5%, dimethoate 30 EC, quinalphos 25 EC & thiamethoxam 25 WG where 19.16 per cent fruit damage recorded and there modules were on par to each other. The later does not differ stastically in per cent fruit damage than management module M-V (21.63), M-I (24.60), M-II (26.13) per cent fruit damage respectively, as against 31.89% in untreated control (M-VI) (Fig 5) (Table 6).

In present study, module-III, azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC found most effective for shoot and fruit borer management on okra. Our results agreement with results of (Roy and Sarkar 2017) [17] stated that 83.07 per cent fruit damage reduction over untreated control by using neem cake, flonicamid 50 WG, neemzol TS 5%, dinotefuran 20 SG, flubendiamide 35.39 SC, chlorfluazuron 5.4 EC, emamectin benzoate 5 SG. Literature on similar type modules on fruit damage of okra was unavailable hence the present study results are not discussed in details.

C. Effect of various management modules on yield: The significant differences were noted in marketable okra fruit yield in various management modules. The management module M-III, azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC emerged as most effective for insect pest management and recording highest marketable fruit yield of 56.65 qtl/ha followed by management module M-IV recorded 53.04 qtl/ha yield and these yield data were on par to each other. The later module i.e. M-IV does not differ stastically in yield than module M-V, which yield which were registered 48.28 and 46.06 qtl/ ha, respectively. The management module M-II, neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu , azadirachtin 300 ppm noted 43.94 qtl/ha which was significant than yield in untreated control (33.52 qtl / ha); however, yield in management module M-II was equal to yield in M-I, and M-V (Fig 6).

Our recorded data revealed that maximum yield of okra recorded in M-III (56.65 qtl/ha) followed by M-IV (53.04 qtl/ha). The other remaining management modules gives marketable yield in ascending order as M-V>M-I>M-II>M-VI (Fig 6). However, our results are agreement with the results of (Roy and Sarkar 2017) [17] who stated that highest yield of tender marketable fruits i.e. 13.69 tonnes/ ha was noted in management module composed of neem cake, flonicamid 50 WG, neemzol TS 5%, dinotefuran 20 SG, flubendiamide 35.39 SC, chlorfluazuron 5.4 EC & emamectin benzoate 5 SG in okra cropping system. However, (Roy and Sarkar, 2017) [17] observed highest incremental cost benefit of 1:4.77 for management module composed of neem cake, flonicamid 50 WG, neemzol TS 5%, dinotefuran 20 SG, flubendiamide 35.39 SC, chlorfluazuron 5.4 EC, emamectin benzoate 5 SG in okra cropping system. Due to want of literature on specific module on the yield of okra, the discussion of this aspect could not be done.

Table 1: Details of management modules used for pest's management in okra

Module	Management module
M-I	Neem seed kernel extract 5%, dimethoate 30 EC @ 20 ml/10 lit and thiamethoxam 25 WG @ 1.5 g/10 lit
M-II	Neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu 40 g /10 lit and azadirachtin 300 ppm @ 50 ml / 10 lit
M-III	Azadirachtin 300 ppm @ 50 ml / 10 lit, dimethoate 30 EC @ 20 ml/10 lit, thiamethoxam 25 WG @ 1.5 g/10 lit and quinalphos 25 EC @ 20 ml /10 lit
M-IV	Neem seed kernel extract 5%, dimethoate 30 EC @ 20 ml/10 lit, thiamethoxam 25 WG @ 1.5 g/10 lit and quinalphos 25 EC @ 20 ml /10 lit
M-V	Neem seed kernel extract 5%, *Lecanicillium lecanii* 2 x 10^8 cfu @ 40 g /10 lit, azadirachtin 300 ppm @ 50 ml / 10 lit and dimethoate 30 EC @ 20 ml/10 lit
M-VI	Untreated control

Table 2: Effects of different management module on aphid's population on okra

Module	Number of Aphids/leaf															
	First Spray (15 DAE)				Second spray (25 DAE)			Third Spray (35 DAE)			Fourth Spray (45 DAE)			Cumulative effect		
	1 DBS	3 DAFS	7 DAFS	10 DAFS	3 DASS	7 DASS	10 DASS	3 DATS	7 DATS	10 DATS	3 DAFS	7 DAFS	10 DAFS	3 DAS	7 DAS	10 DAS
M-I	4.08 (2.02)*	2.13 (1.46)	3.25 (1.77)	3.77 (1.93)	1.37 (1.16)	1.83 (1.33)	2.35 (1.45)	1.70 (1.26)	2.58 (1.60)	4.48 (2.11)	8.42 (2.90)	9.67 (3.10)	10.33 (3.21)	3.40 (1.84)	4.33 (2.08)	5.23 (2.28)
M-II	4.05 (2.01)	1.83 (1.35)	3.28 (1.79)	3.60 (1.89)	2.45 (1.56)	3.00 (1.72)	3.98 (1.99)	3.42 (1.84)	6.25 (2.47)	7.57 (2.74)	8.10 (2.84)	10.25 (3.18)	10.67 (3.26)	3.93 (1.99)	5.70 (2.38)	6.45 (2.54)
M-III	4.33 (2.08)	1.82 (1.34)	2.53 (1.50)	2.68 (1.60)	1.37 (1.16)	1.78 (1.31)	2.27 (1.42)	1.60 (1.24)	2.93 (1.69)	4.50 (2.12)	3.27 (1.80)	3.35 (1.83)	5.07 (2.23)	2.01 (1.42)	2.65 (1.61)	3.63 (1.90)
M-IV	2.87 (1.65)	2.10 (1.45)	3.17 (1.76)	3.33 (1.80)	1.40 (1.18)	1.87 (1.35)	2.20 (1.40)	1.67 (1.25)	2.38 (1.54)	3.90 (1.96)	3.48 (1.86)	4.33 (2.06)	4.38 (2.09)	2.16 (1.47)	2.94 (1.70)	3.45 (1.85)
M-V	2.58 (1.58)	1.92 (1.38)	3.25 (1.77)	3.55 (1.86)	2.53 (1.57)	2.95 (1.71)	3.98 (1.99)	3.38 (1.83)	6.73 (2.59)	7.33 (2.70)	3.12 (1.76)	3.50 (1.76)	4.03 (2.01)	2.72 (1.65)	4.11 (2.02)	4.73 (2.17)
M-VI	3.90 (1.97)	2.78 (1.66)	4.78 (2.19)	5.93 (2.43)	3.65 (1.90)	4.15 (2.01)	6.03 (2.45)	5.98 (2.37)	9.27 (3.04)	10.43 (3.23)	9.42 (2.92)	10.62 (3.24)	11.27 (3.28)	5.46 (2.32)	7.18 (2.68)	8.42 (2.90)
F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.14	0.06	0.11	0.15	0.09	0.08	0.15	0.14	0.12	0.10	0.24	0.20	0.22	0.07	0.08	0.09
CD at 5%	-	0.18	0.32	0.46	0.28	0.24	0.44	0.44	0.35	0.29	0.71	0.61	0.66	0.22	0.23	0.26
CV (%)	14.83	8.37	11.80	15.86	12.95	9.95	16.32	17.90	10.75	7.83	20.13	16.11	16.34	8.29	7.42	7.64

DBS- Days before spray, DAFS- Days after first spray, DASS- Days after second spray, DATS- Days after third spray, DAFS- Days after fourth spray, DAS- Days after spray, *Figures in parentheses are square root transformed values.

Table 3: Effects of different management module on leafhopper population in okra

Module	Number of Leafhopper/leaf															
	First Spray (15 DAE)				Second spray (25 DAE)			Third Spray (35 DAE)			Fourth Spray (45 DAE)			Cumulative effect		
	1 DBS	3 DAFS	7 DAFS	10 DAFS	3 DASS	7 DASS	10 DASS	3 DATS	7 DATS	10 DATS	3 DAFS	7 DAFS	10 DAFS	3 DAS	7 DAS	10 DAS
M-I	1.92 (1.34)	0.90 (0.94)	1.97 (1.40)	2.12 (1.41)	1.52 (1.22)	1.73 (1.28)	2.28 (1.51)	2.17 (1.46)	2.68 (1.63)	3.70 (1.92)	7.33 (2.68)	9.12 (3.01)	11.82 (3.42)	2.97 (1.71)	3.88 (1.97)	4.98 (2.23)
M-II	2.03 (1.42)	0.82 (0.90)	1.63 (1.28)	2.13 (1.46)	2.98 (1.70)	3.43 (1.81)	3.95 (1.97)	5.20 (2.22)	4.98 (2.22)	5.93 (2.43)	6.67 (2.57)	9.05 (3.00)	10.20 (3.19)	3.92 (1.96)	4.78 (2.18)	5.55 (2.35)
M-III	1.12 (1.02)	0.68 (0.79)	1.57 (1.25)	2.00 (1.38)	1.32 (1.14)	1.50 (1.21)	2.25 (1.50)	2.10 (1.45)	2.88 (1.68)	3.33 (1.79)	3.80 (1.93)	4.95 (2.22)	5.75 (2.39)	1.98 (1.40)	2.73 (1.65)	3.33 (1.82)
M-IV	1.40 (1.18)	0.85 (0.92)	1.53 (1.23)	2.05 (1.40)	1.40 (1.18)	1.50 (1.17)	2.50 (1.56)	2.18 (1.47)	2.78 (1.66)	3.34 (1.82)	3.32 (1.82)	4.45 (2.09)	5.74 (2.37)	1.94 (1.39)	2.57 (1.60)	3.41 (1.83)
M-V	1.83 (1.35)	0.85 (0.92)	1.83 (1.34)	2.03 (1.42)	3.03 (1.72)	3.37 (1.83)	4.47 (2.11)	5.42 (2.29)	5.05 (2.24)	6.28 (2.51)	3.37 (1.83)	4.78 (2.18)	5.53 (2.31)	3.17 (1.77)	3.76 (1.93)	4.58 (2.14)
M-VI	1.78 (1.33)	1.42 (1.19)	3.45 (1.83)	4.77 (2.16)	4.63 (2.15)	5.38 (2.32)	6.32 (2.51)	7.63 (2.75)	7.18 (2.66)	9.03 (3.00)	7.83 (2.71)	10.27 (3.10)	13.50 (3.59)	5.38 (2.30)	6.57 (2.55)	8.49 (2.90)
F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.12	0.07	0.09	0.16	0.10	0.16	0.09	0.14	0.13	0.13	0.19	0.23	0.24	0.07	0.07	0.10
CD at 5%	-	0.20	0.28	0.49	0.30	0.46	0.29	0.44	0.40	0.39	0.56	0.69	0.73	0.23	0.22	0.30
CV (%)	18.12	14.33	13.26	21.13	13.00	19.25	10.43	15.23	13.06	11.56	16.50	17.67	16.81	8.57	7.27	8.95

Table 4: Effects of different management module on whitefly population in okra

Module	Number of Whitefly/leaf															
	First Spray (15 DAE)				Second spray (25 DAE)			Third Spray (35 DAE)			Fourth Spray (45 DAE)			Cumulative effect		
	1 DBS	3 DAFS	7 DAFS	10 DAFS	3 DASS	7 DASS	10 DASS	3 DATS	7 DATS	10 DATS	3 DAFS	7 DAFS	10 DAFS	3 DAS	7 DAS	10 DAS
M-I	2.85 (1.69)	1.07 (1.02)	2.18 (1.47)	1.73 (1.29)	1.12 (1.05)	1.30 (1.11)	1.58 (1.23)	1.63 (1.28)	1.73 (1.31)	1.88 (1.36)	5.08 (2.25)	5.45 (2.32)	6.85 (2.60)	2.23 (1.49)	2.67 (1.63)	3.01 (1.73)
M-II	3.12 (1.77)	1.42 (1.18)	1.82 (1.34)	2.02 (1.42)	2.72 (1.64)	3.50 (1.85)	3.38 (1.81)	2.78 (1.66)	2.78 (1.66)	3.38 (1.83)	4.88 (2.18)	5.62 (2.36)	7.17 (2.65)	2.95 (1.72)	3.43 (1.85)	3.99 (1.99)
M-III	2.92 (1.70)	1.33 (1.11)	1.53 (1.24)	1.57 (1.22)	0.90 (0.95)	1.43 (1.18)	1.50 (1.20)	1.58 (1.23)	1.73 (1.31)	1.83 (1.35)	2.77 (1.61)	2.80 (1.65)	3.17 (1.77)	1.65 (1.28)	1.88 (1.37)	2.02 (1.42)
M-IV	2.25 (1.49)	1.47 (1.20)	1.83 (1.35)	2.23 (1.49)	1.00 (1.00)	1.32 (1.13)	1.58 (1.23)	1.82 (1.34)	1.67 (1.29)	2.02 (1.40)	1.88 (1.36)	2.83 (1.68)	2.93 (1.70)	1.54 (1.24)	1.91 (1.38)	2.19 (1.48)
M-V	2.25 (1.45)	1.45 (1.19)	1.97 (1.39)	2.13 (1.45)	2.65 (1.63)	3.00 (1.72)	3.38 (1.81)	3.15 (1.77)	2.78 (1.66)	3.48 (1.86)	1.80 (1.34)	2.35 (1.52)	2.93 (1.70)	2.26 (1.50)	2.53 (1.59)	2.98 (1.72)
M-VI	2.85 (1.69)	3.38 (1.82)	3.57 (1.86)	4.78 (2.17)	4.42 (2.09)	5.25 (2.28)	5.58 (2.36)	4.98 (2.23)	4.98 (2.23)	5.70 (2.38)	5.58 (2.34)	6.73 (2.53)	7.77 (2.75)	4.59 (2.14)	5.13 (2.26)	5.96 (2.44)
F' test	NS	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.09	0.13	0.09	0.14	0.08	0.14	0.16	0.09	0.10	0.07	0.17	0.17	0.16	0.05	0.05	0.07
CD at 5%	-	0.39	0.28	0.41	0.25	0.41	0.49	0.26	0.29	0.21	0.50	0.52	0.50	0.14	0.15	0.21
CV (%)	11.28	20.45	12.75	18.08	11.93	17.82	20.11	10.73	12.14	8.39	18.00	17.14	15.02	5.97	6.12	7.72

Table 5: Effects of different management module on red spider mites population in okra

Module	Number of Spider mites/ cm^2 leaf											
	Second spray (25 DAE)			Third Spray (35 DAE)			Fourth Spray (45 DAE)			Cumulative effect		
	3 DASS	7 DASS	10 DASS	3 DATS	7 DATS	10 DATS	3 DAFS	7 DAFS	10 DAFS	3 DAS	7 DAS	10 DAS
M-I	0.75 (0.86)	1.37 (1.17)	1.13 (1.06)	1.88 (1.33)	2.18 (1.47)	3.47 (1.86)	8.72 (2.94)	10.42 (3.20)	12.20 (3.45)	3.73 (1.93)	4.66 (2.15)	5.60 (2.36)
M-II	1.07 (1.03)	2.40 (1.53)	2.53 (1.59)	5.12 (2.21)	6.08 (2.42)	7.08 (2.65)	8.93 (2.99)	10.57 (3.25)	12.60 (3.50)	4.98 (2.22)	6.21 (2.48)	7.41 (2.71)
M-III	0.55 (0.73)	1.13 (1.06)	1.07 (1.03)	1.82 (1.34)	2.17 (1.45)	3.33 (1.80)	4.03 (2.01)	6.18 (2.32)	6.47 (2.53)	2.10 (1.45)	3.16 (1.77)	3.62 (1.90)
M-IV	0.77 (0.87)	1.27 (1.12)	0.97 (0.98)	2.03 (1.41)	2.25 (1.49	3.32 (1.76)	3.70 (1.91)	5.88 (2.33)	6.27 (2.49)	2.10 (1.44)	3.13 (1.73)	3.52 (1.87)
M-V	1.10 (1.04)	2.30 (1.50)	2.28 (1.50)	5.12 (2.21)	5.95 (2.37)	8.03 (2.83)	3.30 (1.81)	5.43 (2.29)	6.30 (2.50)	3.09 (1.75)	4.56 (2.12)	5.54 (2.35)
M-VI	1.42 (1.19)	4.27 (1.82)	4.18 (2.04)	7.65 (2.76)	8.58 (2.92)	10.78 (3.27)	10.42 (3.22)	11.62 (3.39)	13.58 (3.66)	6.40 (2.53)	8.16 (2.85)	9.52 (3.08)
F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	0.05	0.07	0.06	0.18	0.15	0.20	0.11	0.26	0.29	0.07	0.12	0.12
CD at 5%	0.14	0.22	0.19	0.53	0.46	0.59	0.33	0.78	0.89	0.22	0.36	0.35
CV (%)	9.86	10.68	9.24	18.85	15.03	16.64	8.78	18.52	19.54	7.90	11.22	9.88

Table 6: Mean percent fruit damage by shoot and fruit borer on okra

Module	Fruit damage due to shoot and fruit borer days after fourth spray (%)								Mean Fruit damaged (%)
	5 DAFS	10 DAFS	14 DAFS	19 DAFS	24 DAFS	29 DAFS	34 DAFS	38 DAFS	
M-I	23.01 (28.66)*	23.58 (29.58)	26.09 (30.69)	25.18 (30.10)	24.71 (29.68)	24.29 (29.68)	25.21 (30.13)	24.71 (29.68)	24.60 (29.30)
M-II	23.68 (29.68)	25.12 (30.03)	27.35 (31.53)	27.80 (31.82)	26.30 (30.84)	25.96 (30.51)	26.57 (31.01)	26.30 (30.84)	26.13 (30.74)
M-III	10.17 (17.91)	12.30 (20.00)	14.45 (25.27)	15.97 (23.04)	16.04 (22.83)	17.07 (20.84)	18.59 (25.51)	20.48 (26.89)	15.63 (23.24)
M-IV	16.28 (23.71)	14.22 (21.63)	19.69 (27.08)	19.79 (26.38)	20.02 (26.55)	20.03 (25.82)	21.26 (27.44)	21.99 (27.85)	19.16 (25.63)
M-V	16.56 (23.71)	19.79 (26.30)	23.13 (28.60)	22.49 (28.17)	23.67 (28.93)	21.25 (27.44)	22.49 (28.17)	23.67 (28.93)	21.63 (27.65)
M-VI	25.04 (30.02)	28.46 (32.20)	31.58 (34.05)	32.67 (34.86)	34.28 (34.90)	33.68 (28.17)	34.49 (35.94)	34.96 (35.38)	31.89 (34.38)
F' test	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.
SE (m)±	1.72	2.03	2.41	1.58	2.04	1.47	1.16	1.58	0.85
CD at 5%	5.20	6.10	7.26	4.76	6.15	4.42	3.50	4.76	2.57
CV (%)	13.52	15.26	16.76	10.87	14.02	10.14	7.83	10.52	5.96

*Figures in parentheses are arc sine values, DAFS – Days after fourth spray

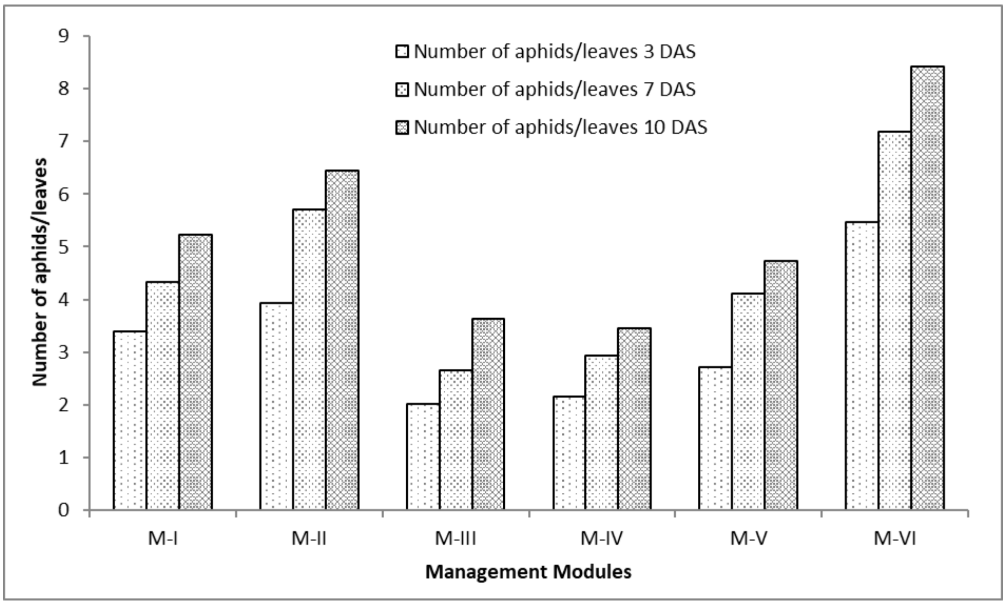

Fig 1: Cumulative effect of management modules on Aphids on okra

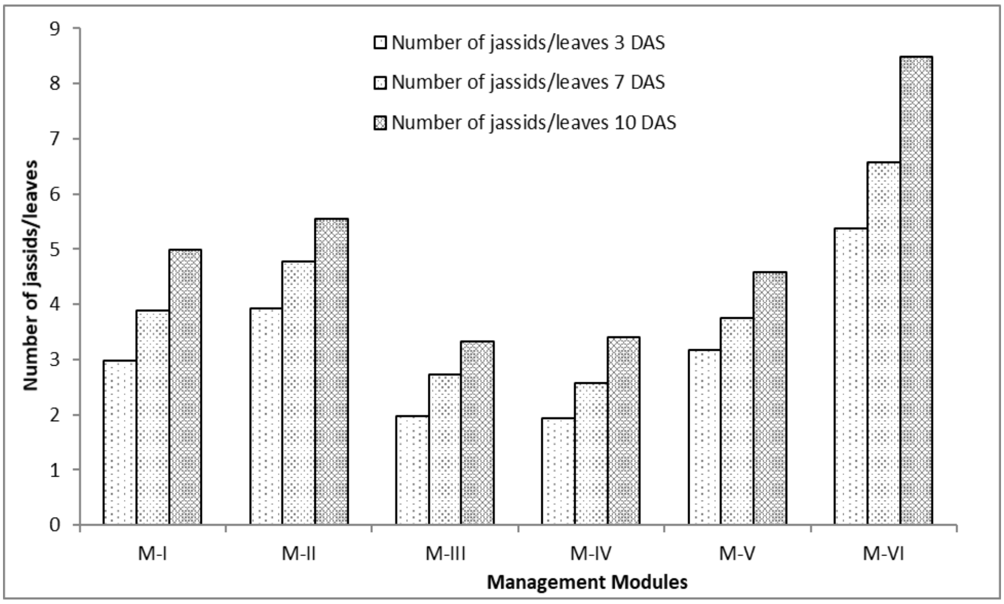

Fig 2: Cumulative effect of management modules on Leafhopper on okra

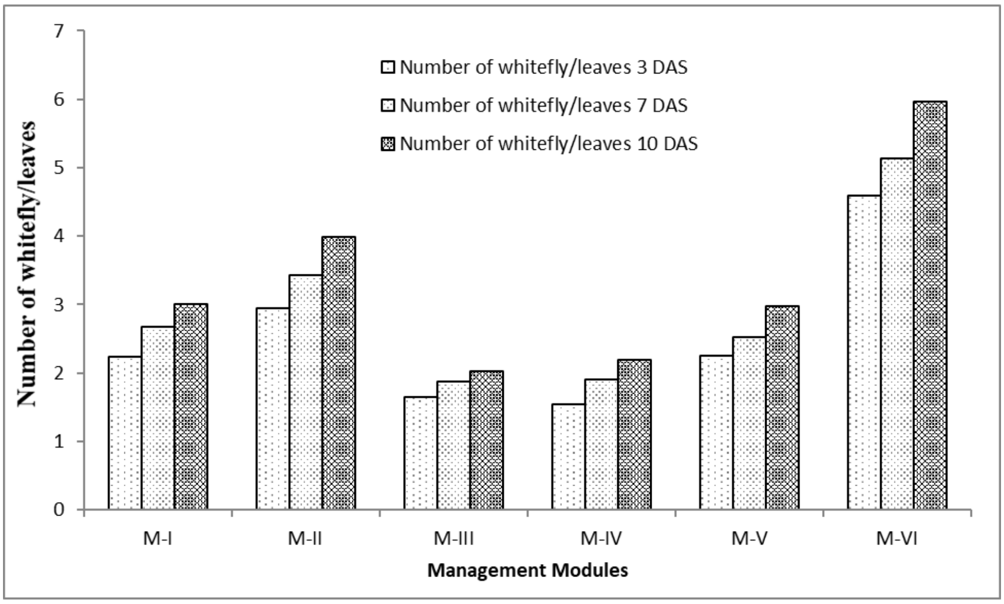

Fig 3: Cumulative effect of management modules on Whitefly on okra

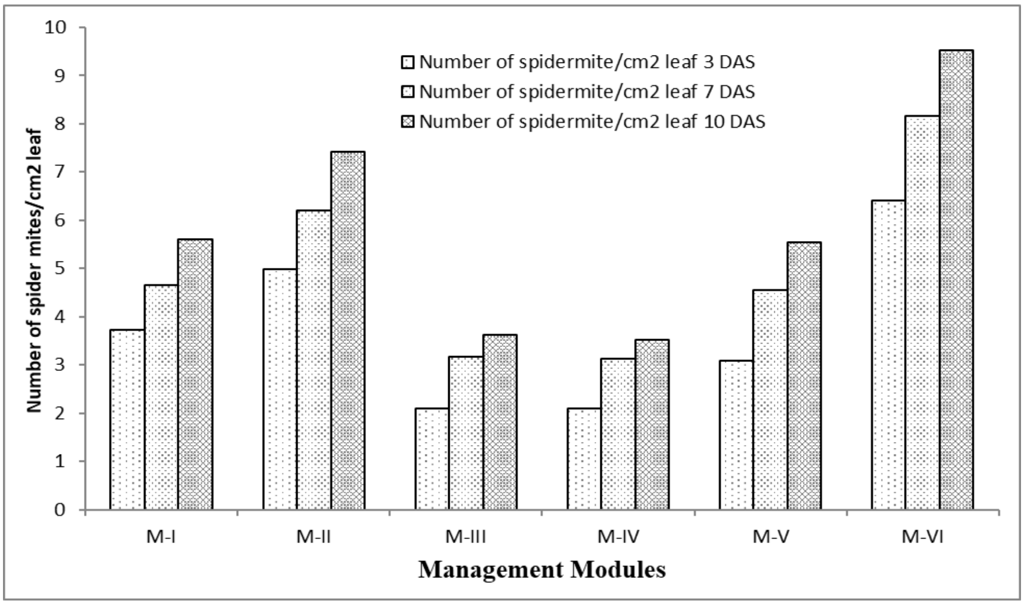

Fig 4: Cumulative effect of management modules on red spider mites on okra

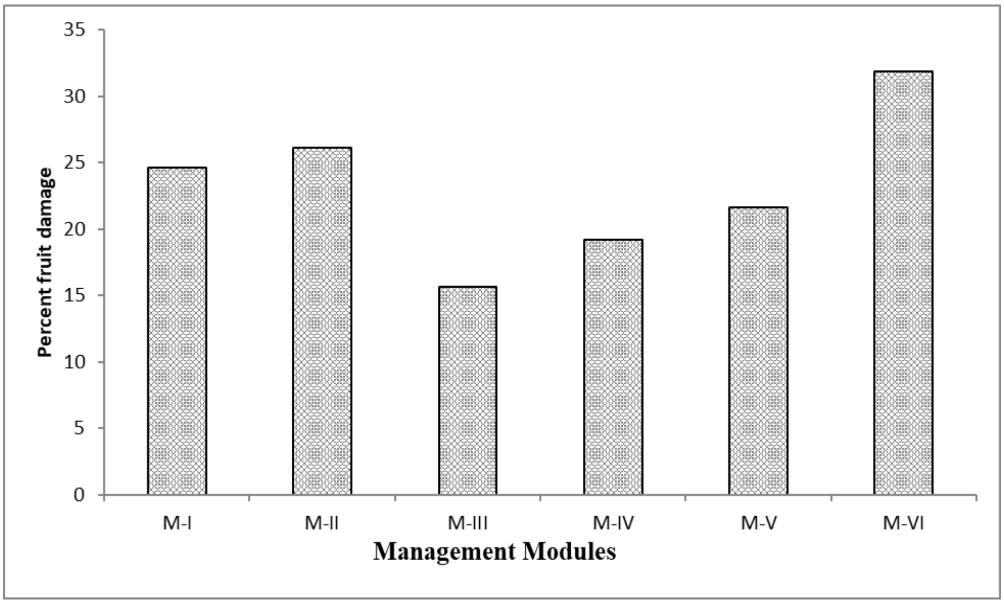

Fig 5: Mean percent fruit damage by fruit & shoot borer in okra

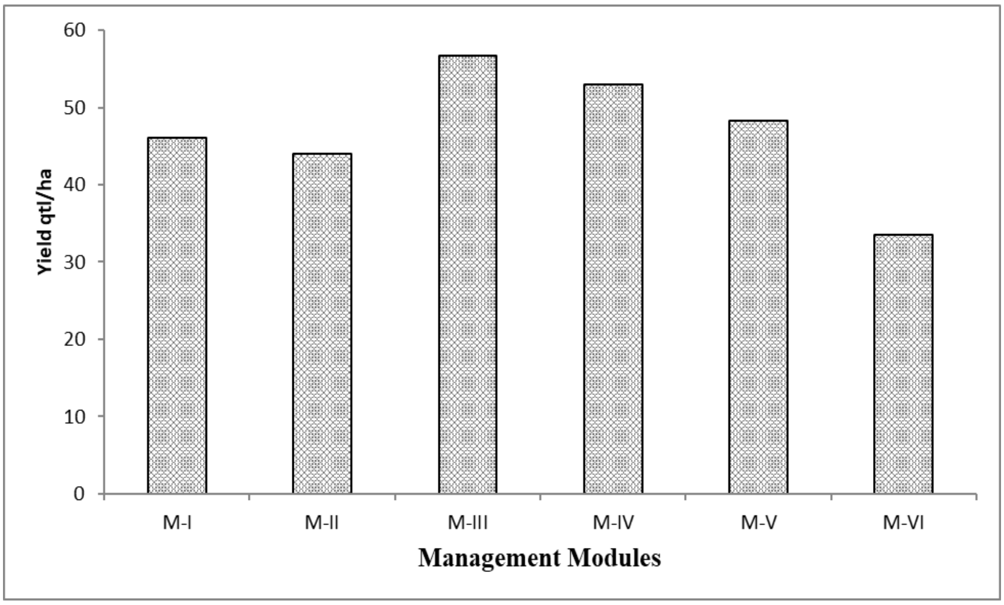

Fig 6: Marketable fruit yield of okra in various management modules

Conclusion

Aphid and jassids in okra effectively manage by using the management module M-III (Azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC) and M-IV (Neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC) were most effective for keeping down pests population throughout the crop growth and were at par with each other. Whitefly population in okra can be effectively manage by using module M-IV (neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC was most effective) and module M-III (azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinolphos 25 EC) found most effective; however, these module does not differ statistically to each other. The modules M-IV(Neem seed kernel extract 5%, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC lit was found most effective management for suppressing spider mites and it does not differ statically than mites in module M-III. For effective management of shoot and fruit borer module M-III (Azadirachtin 300 ppm, dimethoate 30 EC, thiamethoxam 25 WG, quinalphos 25 EC) was the most effective module which recorded least fruit damage (15.63) per cent followed by M-IV (19.16) percent fruit damage and both modules yielded higher marketable yield and on par to each other.

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