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EFFICACY OF BIOPESTICIDES AGAINST MAJOR ARTHROPOD PESTS AND THEIR NATURAL ENEMIES ON OKRA

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ABSTRACT

Efficacy of six biopesticides against insect pest of okra was evaluated in terms of population reduction over control during *kharif*, 2016 and 2017. Four foliar applications were provided to the crop and results revealed that all the treatments were effective over control. Neem-baan was most effective treatment at 3rd and 7th day in all the sprays against whitefly, (65.25, 28.80), (64.35, 27.88), (64.82, 27.71), (63.65, 26.54) and leafhopper, (64.08, 26.35), (64.09, 27.20), (64.45, 27.44), (64.39, 27.35), respectively. Neem baan was also effective at 3rd and 7th day against red spider mite during 4th spray and brought significant reduction in the shoot and fruit borer infestation up to 62.67%. Biopesticides treatments did not show any detrimental effect on the coccinellids and spiders' populations under field conditions. However, in laboratory experiments Neem based pesticides brought significant reduction when treated aphid (*A. gossypii*) fed to both species of coccinellids viz., *C. septempunctata* and *C. sexmaculata*. 3 per cent Neem oil reported highest feeding reduction (28.05%) for *C. septempunctata* while *C. sexmaculata* recorded 34.74% reduction in same treatment.

Key words: Okra, biopesticides, sucking pests, whitefly, leafhopper, mite, fruit and shoot borer, natural enemies, coccinellids, spiders,

Vegetables occupy an important status in Indian agriculture. Among them okra *Abelmoschus esculentus* (L.) Moench is an important vegetable crop grown all over India and tropical and subtropical parts of the world. Besides various reasons for low productivity, heavy damage inflicted by insect pests is a key limiting factor. As many as 72 insect species have been recorded on okra (Srinivasa and Rajendra, 2003). The insect pests creating bottleneck in higher production of okra are leafhopper (*Amrasca* (*Sundapteryx*) *biguttula*) whitefly (*Bemisia tabaci*) and shoot and fruit borer (*Earias vittella*). Kanwar and Ameta (2007) recorded 48.97% reduction in okra fruit yield due to attack by the insect pests. Indiscriminate use of insecticides in vegetable production is creating various health hazards in consumers, export quality concern and also creating environmental problems by causing disturbances in the pest-natural enemy balance. Arthropod fauna belonging to coccinellids and spiders have been widely represented a generalist predators group in agro-ecosystem and they play important role in to maintain pest populations of those belonging to pest category especially soft bodied insects (Rajeswarn, et al., 2005).

In modern intensive system of agriculture exert the unavoidable and explicit or implicit detrimental impacts on such bio-agents may be irrational use of chemical insecticides (De Bach and Rosen, 1991) and to avoid such effects modern integrated pest management tactics generally more inclined towards biopesticides to avoid the harmful impact of chemical based insecticides. Biopesticides may or may not be completely safe towards natural enemies they can influence beneficial insects directly or indirectly by host feeding behaviour in diverse agro-ecosystem (Swaminathan et al., 2010). For generalist predators in agroecosystem, reduced feeding behaviour or negative influence on biology might influence the overall health of biocontrol programme. Realizing the above facts, the present studies were undertaken to evaluate various eco-friendly pesticides against insect pests of okra and also study the impact on natural enemies in field and laboratory condition.

MATERIALS AND METHODS

The field experiment was conducted at the Instructional Farm of Division of Entomology, Indian Agricultural Research Institute, New Delhi (located at 28º38'23''N latitude; 77º09'27''Elongitude; 228.61m above mean sea level) during *kharif,* 2016 and 2017. The trial was laid out in plots measuring 5m x 3m in Randomized Block Design in seven treatments with three replications as detail given below. The row to row distance and plant to plant spacing for okra were

60 and 45cm, respectively. Sowing of the recommended variety of okra (*Arka Anamika*) was conducted in the first week of July, 2016 and 2017 as sole crop with required agronomic practices. Four sprays of following bio-pesticide were made at fortnightly interval *viz.,* T_1 Torpedo (Plant extract of *Sophora* & *Stemona* species @1ml/ltr), T_2 Pongamia oil (*Pongamia pinnata* crude oil @3%), T_3 Varunastra (*Verticillium lecanii* 2% A.S. @ 2.5ml/ltr (CFU – 2 X 10^8 per ml)),T_4 Neem oil (*Azadirachta indica* crude oil @ 3%), T_5 Lastraw (Potassium salts of fatty acid @ 5ml/ltr), T_6 Neem-baan (Azadirachtin 0.15% E.C. @ 3ml/ltr) and T_7 Control.

Observations were recorded for the leaf hoppers, whiteflies and mites on 3 leaves (upper, middle and lower) by the visual count technique during early hours of the day from 5 plants per replication selected at random and tagged. Population of red spider mites on the selected leaves was recorded by placing a card board sheet which had a window of 1 cm^2 on ventral surface of the leaf. Counting of mites was done with the help of a hand lens (10x) and natural enemies recorded per five plants from each replication one day before making the treatments and 3^{rd} and 7^{th} days after the treatment with biopesticides. The fruits infested with shoot and fruit borer were recorded at each picking and their weight also noted. The weights of healthy and infested fruits were taken separately and per cent infestation due to fruit borer was worked out for each treatment. The reduction in sucking pests as a result of the spray treatments was computed by comparing with the pre-treatment population and expressed as % (Henderson and Tilton, 1952). The data were subjected to ANOVA.

Evaluation against coccinellids under laboratory condition was done in RBD and each treatment was replicated four times. Following treatments were applied*viz.,* T_1 Torpedo (Plant extract of *Sophora* & *Stemona* species @1ml/ltr), T_2 Pongamia oil (*Pongamia pinnata* crude oil @3%), T_3 Varunastra (*Verticillium lecanii* 2% A.S. @ 2.5ml/ltr (CFU – 2 X 10^8 per ml)),T_4 Neem oil (*Azadirachta indica* crude oil @ 3%), T_5 Lastraw (Potassium salts of fatty acid @ 5ml/ltr), T_6 Neem-baan (Azadirachtin 0.15% E.C. @ 3ml/ltr) T_7 Myco-Jaal, [*Beauveria bassiana* 1.15% S.C. (CFU – 1 X 10^8 per ml) @ 2.5ml/ltr.] andT_8 Nimbecidine (Azadirachtin 0.03% E.C.@ 3 ml/ltr.) T_9 Control. Thus, total eight, botanical as well as fungal based biopesticides were made available.

The experiment was conducted in two separate arenas for grubs of coccinellids viz., *Coccinella septempunctata* L. and *Cheilomenes sexmaculata* (F.) and they were fed with pre-counted aphids (*Aphis gossypii* Glover) treated with biopesticides. In order to evaluate the impacts of biopesticides on the grubs of dominant coccinellids, the 2^{nd} instar larvae were collected from the field and starved for 6 hours. Thereafter, known numbers of treated prey (150) were provided them as food for 24hrs and maintained in glass jars (500ml capacity) separately for each treatment. Four replicates for each treatment were made and three grubs per replication consisting 150 aphids (*A. gossypii*) as prey were made available. The glass jars were covered with a muslin cloth secured with rubber bands and placed in the laboratory at ambient conditions of temperature and humidity. After 24 hours of exposure with the treated prey-food, the data on mortality and feeding reduction over control were recorded. Further, the surviving grubs were provided with fresh counted numbers of untreated prey till they pupate. Later, the adult emergence was noted to work out the impacts of biopesticides on treatments. The adults so emerged were paired and allowed to mate. The eggs laid were recorded and further carefully maintained to observe the egg hatchability (%), as methodology adopted by Swaminathan et al., (2010).

RESULTS AND DISCUSSION

Table 1 reveals that all treatments showed significant reduction in whiteflies and red spider mite population 3^{rd} and 7^{th}day after sprays (DAS) over untreated okra. Pooled data of per cent reduction over control (PROC) two years (*kharif*, 2016 and 2017) revealed that at 3^{rd} and 7^{th} DAS, maximum mean reduction in the population of whiteflies was recorded inT_6-Neem-baan(65.25, 28.80), (64.35, 27.88), (64.82, 27.71) and (63.65, 26.54) followed by T_4-Neem oil during first, second, third and fourth sprays respectively. However, it was minimum T_3-*Vertilcillium lecanii* where PROC at 3^{rd} DAS was 38.92, 42.78, 40.83 and 39.39% and at 7^{th} DAS, PROC was minimal in treatment, T1-Torpedo viz; 16.21, 17.01, 16.53 and 15.73% in subsequent sprays. Population of red spider mite was recorded only during last spray and maximum PROC at 3 and 7 DAS for red spider mite was observed in T_6 (63.28, 29.88) followed by T_4 (55.75, 26.59) whereas, T_3 (42.99) at 3 DAS and T_1 (17.05) were observed least effective among different treatments.

Likewise, as given in Table 2, highest PROC for leaf hopper at 3 and 7 DAS was recorded in Neem-baan, T_6 (64.08, 26.35), (64.09, 27.20), (64.45, 27.44)

Table 1. Efficacy of biopesticides against whitefly and red spider mite on okra (pooled data, *kharif* 2016 and 2017)

	Treatments#	% reduction of over control (PROC)									
		Whitefly								Red spider mite	
		I Spray		II Spray		III Spray		IV Spray		IV Spray	
		3DAS	7DAS	3DAS	7DAS	3DAS	7DAS	3DAS	7DAS	3DAS	7DAS
T_1	Torpedo	46.15 (42.79)	16.21 (23.74)	46.15 (42.72)	17.01 (24.33)	46.99 (43.27)	16.53 (23.98)	44.46 (41.83)	15.73 (23.35)	46.16 (42.82)	17.05 (24.35)
T_2	Pongamia oil	56.07 (48.58)	22.12 (28.00)	51.13 (45.67)	20.61 (26.53)	54.67 (47.72)	22.76 (28.48)	54.52 (47.63)	22.08 (28.04)	52.31 (46.35)	23.53 (29.02)
T_3	Varunastra	38.92 (38.60)	22.59 (28.22)	42.78 (40.81)	21.32 (27.50)	40.83 (39.71)	22.49 (28.26)	39.39 (38.88)	21.42 (27.57)	42.99 (40.99)	23.87 (29.19)
T_4	Neem oil	60.11 (50.88)	24.48 (29.67)	57.90 (49.59)	23.52 (29.01)	57.27 (49.21)	24.27 (29.52)	57.45 (49.31)	24.05 (29.38)	55.75 (48.33)	26.59 (31.05)
T_5	Lastraw	48.66 (44.25)	18.63 (25.45)	47.69 (43.69)	18.44 (24.93)	48.02 (43.86)	18.92 (25.67)	46.24 (42.87)	17.88 (25.00)	46.97 (43.28)	19.54 (26.23)
T_6	Neem-baan	65.25 (54.05)	28.80 (32.31)	64.35 (53.41)	27.88 (31.84)	64.82 (53.66)	27.71 (31.76)	63.65 (52.96)	26.54 (30.96)	63.28 (52.73)	29.88 33.12)
T_7	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
S.Em. ±		2.60	1.54	2.34	2.08	2.46	1.33	1.34	0.93	0.59	0.95
CD at 5%		8.10	4.79	7.28	6.48	7.67	4.14	4.18	2.91	1.84	2.97

#Torpedo @ 1ml/ltr, Pongamia oil (3%), Varunastra (*Verticillium lecanii* 2% A.S) @ 2.5ml/ltr, Neem oil (3%), Lastraw @ 5ml/ltr, Neem-baan (Azadirachtin 0.15% E.C) @ 3ml/ltr were sprayed on fortnightly interval after date of sowing; DAS= Days after spray; Figures in parentheses angular transformed values

Table 2. Efficacy of biopesticides against leafhopper and fruit borer on okra (pooled data, of *kharif* 2016 and 2017)

	Treatments[#]	% reduction of over control (PROC) Leaf hopper								Fruit and shoot borer (*E. vittella*) Fruit infestation (%)		Reduction in infestation over control (%)	
		I Spray		II Spray		III Spray		IV Spray					
		3DAS	7DAS	3DAS	7DAS	3DAS	7DAS	3DAS	7DAS	No. basis	Wt. basis	No. basis	Wt. basis
T_1	Torpedo	45.06 (42.17)	15.72 (23.34)	44.49 (41.85)	17.11 (24.45)	45.12 (42.22)	16.78 (24.19)	44.97 (42.12)	16.20 (23.74)	30.48 (33.52)	30.40 (33.48)	26.90	26.12
T_2	Pongamia oil	54.46 (47.59)	22.79 (28.52)	51.61 (45.95)	22.09 (28.02)	52.61 (46.52)	22.56 (28.36)	52.69 (46.57)	21.27 (27.44)	23.46 (28.98)	23.07 (28.72)	43.75	43.93
T_3	Varunastra	38.12 (38.15)	22.29 (28.18)	40.21 (39.37)	22.03 (28.00)	39.96 (39.23)	22.06 (27.99)	36.99 (37.47)	21.11 (27.35)	16.93 (24.29)	16.63 (24.06)	59.38	59.58
T_4	Neem oil	57.20 (49.18)	23.84 (29.22)	55.49 (48.19)	23.62 (29.08)	56.64 (48.84)	23.19 (28.77)	54.72 (47.73)	23.58 (28.98)	18.90 (25.78)	18.62 (25.58)	54.67	54.74
T_5	Lastraw	47.67 (43.68)	19.86 (26.47)	47.90 (43.82)	19.50 (26.21)	46.40 (42.95)	18.86 (25.67)	46.81 (43.15)	18.56 (25.39)	26.89 (31.25)	26.62 (31.07)	35.51	35.30
T_6	Neem-baan	64.08 (53.25)	26.35 (30.90)	64.09 (53.23)	27.20 (31.43)	64.45 (53.44)	27.44 (31.60)	64.39 (53.39)	27.35 (31.53)	15.78 (23.40)	15.36 (23.07)	62.16	62.67
T_7	Control	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	41.69 (40.24)	41.14 (39.92)	N/A	N/A
S. Em. ±		1.33	0.67	1.17	0.67	0.77	0.98	1.42	1.33	0.13	0.16	-	-
CD at 5%		4.15	2.09	3.65	2.08	2.39	3.04	4.43	4.16	0.39	0.49	-	-

[#] Torpedo @ 1ml/ltr, Pongamia oil (3%),Varunastra (*Verticillium lecanii* 2% A.S) @ 2.5ml/ltr, Neem oil (3%), Lastraw @ 5ml/ltr, Neem-baan (Azadirachtin 0.15% E.C) @ 3ml/ltr were sprayed on fortnightly interval after date of sowing; DAS= Days after spray; Figures in parentheses angular transformed values; N/A = Not Applicable

Table 3. Impact of biopesticides on *C. septempunctata* and *C. sexmaculata*

Treatments[#]	Aphid prey provided (No.)	Prey consumed (Mean/ 24hr)*		Feeding reduction over control (%)		Adult emergence (%)		Egg hatchability (%)	
		C. septempunctata	*C. sexmaculata*	*C. septempunctata*	*C. sexmaculata*	*C. septempunctata*	*C. sexmaculata*	*C. septempunctata*	*C. sexmaculata*
T_1	150	120.4	104.3	7.62	2.46	91.68 (81.23)	100.00(90.05)	97.52 (81.12)	97.67 (81.28)
T_2	150	113.3	93.8	13.09	12.28	91.68 (81.23)	91.68 (81.23)	98.52 (85.17)	97.02 (80.26)
T_3	150	120.0	99.8	7.90	6.67	91.68 (81.23)	91.68 (81.23)	97.35 (80.79)	97.77 (82.69)
T_4	150	93.8	69.8	28.05	34.74	83.35 (72.41)	83.35 (72.41)	96.56 (79.59)	98.73 (85.47)
T_5	150	115.9	90.8	11.07	15.09	91.68 (81.23)	100.00 (90.05)	97.16 (81.63)	98.89 (87.01)
T_6	150	105.8	85.5	18.84	20.00	75.03 (63.58)	66.68 (58.71)	97.36 (82.06)	96.57 (79.54)
T_7	150	120.8	101.6	7.33	4.92	91.68 (81.23)	91.68 (81.23)	97.29 (82.21)	97.82 (82.71)
T_8	150	112.9	95.3	13.37	10.88	83.35 (72.41)	75.03 (63.58)	96.91 (80.37)	96.65 (79.57)
T_9	150	130.3	106.9	N/A	N/A	91.68 (81.23)	100.00 (90.05)	98.50 (83.95)	98.41 (83.77)
SEm±	-	0.66	0.69	-	-	9.642	8.146	1.92	1.87
CD at 5%	-	1.93	2.01	-	-	NS	NS	NS	NS

[#]T_1 -Torpedo (Plant extract of *Sophora* & *Stemona* species) @ 1ml/ltr, T_2- Pongamia oil (3%), T_3 – Varunastra (*Verticillium lecanii* 2% A.S) @ 2.5ml/ltr, T4 -Neem oil (3%), T_5 - Lastraw (Potassium salts of fatty acid) @ 5ml/ltr, T_6 - Neem-baan (Azadirachtin 0.15% E.C.) @ 3ml/ltr, T_7 - Myco-Jaal (*Beauveria bassiana* 1.15% S.C.) @ 2.5ml/ltr, T_8 - Nimbecidine (Azadirachtin 0.03% E.C.) @3ml/ltr.; Figures in parentheses angular transformed values NS= Non significant, * = 3 grubs provided/150 aphids (*A. gossypii*)/treatment; N/A = Not Applicable and (64.39, 27.35) followed by T_4 Neem oil, during four sprays respectively. The least PROC at 3rd DAS i.e. (38.12), (40.21), (39.96) and (36.99) was found in treatment, T_3 –Varunastra while least PROC at 7th DAS was recorded against leafhoppers in T_1-Torpedo. Based on the observation, it is imperative that Neem based biopesticides have strong repellent impact on insects which is close in agreement with Mordue and Nisbet (1998). The present results was conformity to the findings of Mohanasundaram et al., (2012); Naik et al., (2012); Janghel et al., (2015) and Sarkar et al., (2015). The present results also corroborate the findings of Mamun et al., (2015) who found that Neem, Karanj and Torpedo were effective against red spider mite (*Oligonychus coffeae*) laboratory. Similarly, Chandler (2005) found that *V. lecanii*was significantly effective against *T. urticae* on tomato leaves in laboratory.

As far as shoot and fruit borer infestation is concerned, all the the treatments are significantly superior over control. The percent infestation on weight basis varied from 15.36 - 30.40% while it was 41.41% in case of control. The least per cent fruit was recorded in treatment- Neem baan (T_6) followed by Varunastra (T_3). Neem baan resulted maximum reduction of fruit infestation on weight basis i.e. 62.67% followed by Varunastra (59.58 %) while Torpedo (T_1) was minimum i.e.26.12 over control. Our findings are in close agreement with the findings of Pachole et al., (2017) who proved effectiveness of Neem oil @3%, and *V. lecanii* against shoot and fruit borer, *E. vittella.* The overall efficacy of the bio-pesticides indicated that Neem based pesticides were significantly effective in causing the maximum population reduction of sucking pests and minimum fruit infestation in okra after the four sprayings.

The biopesticide treatments in overall did not show any adverse effect on natural enemies (coccinellids and spiders) populations under field conditions which were statistically non significant during all four sprays. The population of coccinellids ranged from 1.67-3.50 while spider population ranged from 1.33- 4.17 among different biopesticide treatments. The present investigation was in conformity with earlier findings of Mohanasundaram et al., (2012); Bade et al., (2017). But, Kumar et al., (2015) found relatively higher doses of biopesticides (Neem oil, pongamia oil, NSKE) have detrimental effects on the population of natural enemies (coccinellids, rove beetles and spiders) in okra.

From the laboratory studies, it was observed that maximum feeding reduction (28.05%) for adult *C. septempunctata* and 34.74% for *C. sexmaculata* of prey (*A. gossypii*) recorded in 3 per cent Neem oil (T_4) followed by T_6 Neem-baan (Azadirachtin 0.15% E.C.) causing 18.84 and 20.00 % reduction for both species, respectively. Although biopesticides did not show any show any significant role in per cent adult emergence and egg hatchability in both coccinellids (Table 3). From the laboratory experiments on coccinellids, it was inferred that Neem based biopesticides presented significant reduction in prey feeding behaviour and also some extent but insignificant on biology of both coccinellids. These findings were in close conformity with the results of Swaminathan et al., (2010) who evaluated the side effects of botanicals on coccinellid and found 72 % maximum reduction in feeding in 10% NSKE followed 68 per cent for 5% Neem oil. In contrast, Ahmad et al., (2003) reported detrimental effects (hatching, larval mortality, reduction in prey consumption) of Neem and its derivatives on the early instar larvae of *C. septempunctata.* Moreover, Kraiss and Cullen, (2008) revealed that both azadirachtin and Neem seed oil reduced the development time survival to adulthood of *H. axyridis* but fecundity not affected. Neem and its derivatives generally safe to beneficial arthropods (Schmutterer, 1999) but higher doses may be cause detrimental impacts (Swaminathan et al., 2010)

Results reveal that entomopathogenic fungal based biopesticides did not have significant impacts on coccinellids and the results are in line of Pingel and Lewis (1998) who observed that fourth instars of *Coleomegilla maculate* when exposed by direct contact with a granular formulation of *B. bassiana* containing 1.1 X 10^8 conidia per gram did not show any mortality. Similarly, Thungrabeab and Tongma (2007) also found *B. bassiana* as non-pathogenic to larval *C. septempunctata.* Present study envisages the use of biopesticides in managing insect pest of okra since it has no detrimental effects on natural enemies. However, new vistas require attention to study the impacts of biopesticides on natural enemies especially spiders.

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