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Research Article

Studies on seasonal incidence and relative safety of pesticides against coccinellid beetles in okra ecosystem

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ABSTRACT: Field experiments were conducted to study the seasonal incidence and relative safety of pesticides to the coccinellid beetles, *Coccinella septempunctata* Linnaeus and *Menochilus sexmaculatus* (Fabricius) on okra during *Kharif*, 2002 and 2003. The appearance of the beetles started from the first week of August (1.8 and 1.7 beetles / plant) and reached its maximum (6.2 and 6.4 beetles / plant) in the first week of October in both the years. Weather parameters (minimum temperature and relative humidity) showed significant negative correlation (r = -0.7029 and r = -0.7207 in 2002 and r = -0.5932 and r = -0.6489 in 2003) with coccinellid population, whereas, maximum temperature had non-significant positive (r = 0.0716 and r = 0.4913) and rainfall had non-significant negative correlation (r = -0.2740 and r = -0.2380) with coccinellid population in both the years. Use of *Bt* (Dipel) 0.012% alone was found to be least toxic to the coccinellid beetles on okra followed by NPV 0.10% and azadirachtin (5ml / lit.). Monocrotophos (0.04%) proved highly toxic followed by acephate (0.0375%), whereas imidacloprid (0.006%), endosulfan (0.05%) and endosulfan+*Bt* (0.05+0.006%) were moderately toxic to the coccinellid predators in okra ecosystem.

KEY WORDS: Seasonal incidence, safety, pesticides, coccinellid beetles, okra

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INTRODUCTION

Abelmoschus esculentus (L.) Moench commonly known as okra or lady's finger (*Bhindi*) is a most popular vegetable over the world. India is the leading vegetable producing country in the world, occupying 6.76 million hectare area with an annual production of 101.43 million tonnes (Rai and Pandey, 2007), of which, okra has an area of 0.36 million hectare with annual production of 3.42 million tonnes (Anonymous, 2003). The crop is infested by numerous insect pests from germination to last picking (Choudhary and Dadheech, 1989).

It was estimated that if insecticidal umbrella was not provided, there would be a net yield loss of 54.04% (Choudhary and Dadheech, 1989) to 76% (Hafeez and Rizvi, 1994). Knowledge of seasonal incidence of natural enemies of insect pests of okra is necessary for adopting sustainable management practices against these pests. *Trichogramma brasiliensis* (Ashmead) and *Bracon hebetor* Say were reported as potential parasitoids, whereas *Coccinella septempunctata* Linn., *Menochilus sexmaculatus* (Fab.), *Chrysoperla carnea* (St.) and *Syrphus* sp. were the potential predators in okra ecosystem (Stansty *et al*., 1997). In order to conserve natural enemies in okra ecosystem, use of safe insecticides and organic method of pest management should be emphasized. The insecticides, bio-pesticides and their combinations applied on target pests also influence the non-target insects such as parasitoids and predators prevailing in natural ecosystems. Studies were, therefore, carried out for two years to determine the seasonal fluctuations in coccinellid populations and effect of pesticides on them in okra ecosystem in semi-arid region of Rajasthan (India).

MATERIALS AND METHODS

Studies on seasonal incidence of coccinellids, *Coccinella septempunctata* Linnaeus and *Menochilus sexmaculatus* Fabricius in okra ecosystem and relative safety of insecticides, bio-pesticides and their combinations to them were conducted in field experiments during *Kharif*, 2002 and 2003 at Horticulture farm, S. K. N. College of Agriculture (Rajasthan Agricultural University), Jobner, Rajasthan under irrigated conditions. Two separate field experiments were laid out in randomized block design with ten treatments including untreated control, and each treatment was replicated three times. The seeds of okra variety, Prabhani Kranti were sown on different dates (21st July and 19th July, respectively) in both the years in plots measuring 3 x 2.25 m (6.75m^2) having 45 cm and 30 cm row to row and plant to plant spacing, respectively. The crop in one experiment was maintained by adopting the recommended package of practices and kept completely free from any insecticide or herbicide use to record the seasonal incidence of the coccinellids and their relative pest population. Observations on the population of *C. septempunctata* and *M. sexmaculatus* along with pest infestation were recorded at weekly intervals starting from the first week of August and continued up to the last picking of okra fruits during both the years. Initially, the whole plant was taken as a single unit and later on three leaves/plant (top, middle and bottom canopy of the plants) were selected. Five plants from each plot were selected at random (Rawat and Sahu, 1973). Maximum and minimum temperature, relative humidity and rainfall were recorded at the experimental location at weekly intervals. Data on pest population, coccinellid beetles and weather factors were correlated and statistically analysed.

All the treatments were imposed by using pre-calibrated high volume knapsack sprayer @ 500 litres of spray solution / ha against the jassid, *Amrasca biguttula biguttula* (Ishida), whitefly, *Bemisia tabaci* (Genn.) and shoot and fruit borer, *Earias* sp. and coccinellids. The formulation and concentration of treatments are given in Table 1. The crop received totally four sprays and the first spray was given 30 days after sowing in August when there was sufficient build-up of insect population on okra. The remaining three sprays were given at an interval of 15 days during both the years. To assess the efficacy of these treatments, the population count of *C. septempunctata* and *M. sexmaculatus* (larva and adult) were recorded regularly on five randomly selected and tagged plants in each treatment one day before and 1, 3, 7, and 15 days after each spray application. The data on survival of coccinellid population at definite time intervals thus collected were transformed ($\sqrt{x + 0.5}$) and subjected to analysis of variance for 2002 and 2003 separately and in pooled randomized block design. The mean population of predators in all the treatments, sprays and their interactions were compared after calculating the relevant critical difference.

RESULTS AND DISCUSSION

Seasonal incidence

Coccinella septempunctata and *M. sexmaculatus* were observed on okra crop and their activity coincided with the fluctuation of *A. biguttula biguttula*, *B. tabaci* and *Earias* sp. The appearance of the coccinellids started from the first week of August with a mean population of 1.8 and 1.7 beetles per plant in 2002 and 2003, respectively. The population of coccinellids was 3.1 beetles per plant (range 1.3 – 6.2 beetles / plant) in the 1st year and 3.22 beetles per plant (range 1.7 – 6.4 beetles / plant) in the 2nd year. The maximum coccinellid population (6.2 beetles / plant and 6.4 beetles / plant) was recorded in the first week of October in both the years and the population gradually decreased and lasted up to harvest of the crop. The present results partially corroborate the findings of Dakha and Pareek (2007) who reported that the coccinellid predators on many crop pests were active during May-November.

Table 1. Insecticides used, their formulations and concentration

Common name	Trade name	Formulation	Concentration (%) / Dose
Imidacloprid	Confidor	17.8 SL	0.006
Acephate	Asataf	75 SP	0.0375
Endosulfan	Thiodan	35 EC	0.05
Monocrotophos	Nuvacron	36 WSC	0.04
Azadirachtin	Nimbecidine	0.03 EC	5ml/lit.
Bacillus thuringiensis (B.t.)	Dipel	8 L	0.012
Nuclear Polyhedroses Virus (NPV) *	–	LE	0.10
Acephate + B.t.	–	75 SP + 8 L	0.0375 + 0.006
Endosulfan + B.t.	–	35 EC + 8 L	0.05 + 0.006
Control	–	–	–

*Source: Agricultural Research station, Sri Ganga Nagar (Rajasthan)

Correlation between coccinellid population and weather parameters

The incidence of coccinellid beetles appeared on the 31 SMW when the temperature was 38.8°C (maximum) and 26.7°C (minimum), relative humidity 74.5% and 3.00 mm rainfall during the year 2002 and at 33.4°C (maximum) and 24.3°C (minimum) temperature, relative humidity 76.5% and 13.4 mm rainfall during 2003. The maximum coccinellid population (6.2 beetles / plant) was recorded at 36.3°C maximum and 18.3°C minimum temperature and 37% relative humidity in the 1st year and at 37°C maximum and 20.3°C minimum temperature and 46% relative humidity in the 2nd year. Minimum temperature (r = –0.7029) and relative humidity (r = –0.7207) showed significant negative correlation, whereas maximum temperature (r = 0.0716) and rainfall (r = –0.2740) had non-significant positive and negative correlation, respectively with the coccinellid population in 2002 (Table 2). Negative significant effect of minimum temperature (r = -0.5932) and relative humidity (r = –0.6489), whereas positive non-significant correlation of maximum temperature (r = 0.4913) and negative non-significant effect of rainfall (r = –0.2380) on coccinellid population were observed during 2003 (Table 2). The present results are in conformity with that of Kumar *et al*. (1996) who found significant negative correlation between weather parameters (minimum temperature and relative humidity) and coccinellid population.

Correlation between coccinellid beetles and pest population

The incidence of jassids (2.0 and 2.4 jassids / plant) on okra started on the 31 SMW (15 DAS) and reached its maximum (16.4 and 15.2 jassids / plant) on 38 SMW in both the years. Coccinellid population had statistically non-significant negative correlation (r = –0.0520 and r = –0.2581) with jassid population during 2002 and 2003, respectively (Table 3). The infestation of whitefly also started from the first week of August (15 DAS) (initial mean population was 0.80 and 1.20 whiteflies per plant) in year 2002 and 2003, respectively. Thereafter, the whitefly population increased and reached its maximum (6.20 and 8.60 per plant) in the fourth week of September in both the years. The present findings are akin to the observations of Kumawat *et al.* (2000), who reported the maximum population of whitefly (7.33 / plant) in the fourth week of September. The appearance of coccinellid beetles was non-significant and negatively correlated (r = –0.1140 and r = –0.1271) with the whitefly population in both the years (Table 3).

Table 2. Correlation coefficient of weather parameters with the population of coccinellids on okra

Weather parameters	Coccinellids	
	2002	2003
Maximum Temperature (°C)	0.0716 (NS)	0.4913 (NS)
Minimum Temperature (°C)	–0.7029* (*P* = 0.05)	–0.5932* (*P* = 0.05)
Relative Humidity (%)	–0.7207* (*P* = 0.05)	–0.6489* (*P* = 0.05)
Rain fall (mm)	–0.2740 (NS)	–0.2380 (NS)

*Significant at 5% level; NS: non-significant

Table 3. Correlation coefficient between pest population and coccinellids in okra ecosystem during 2002 and 2003

Year	Pests population	Coccinellids	Significant
2002			
1	Jassids	-0.0520	NS
2	Whitefly	-0.1140	NS
3	Shoot and fruit borer	0.6908*	*P*=0.05
2003			
1	Jassids	-0.2581	NS
2	Whitefly	-0.1271	NS
3	Shoot and fruit borer	0.7027*	*P*=0.05

*Significant at 5% level; NS: non-significant

Table 4. Efficacy of pesticides against coccinellids feeding on insect pests of okra under field conditions at one- and three-day intervals during 2002 and 2003 (Pooled)

Treatment	Conc. (%) / Dose	Population of coccinellids* per plant after one day of spray				Mean	Population of coccinellids* per plant after three days of spray				Mean
		I	II	III	IV		I	II	III	IV	
Imidacloprid	0.006	1.34	1.94	1.77	1.77	1.70	0.90	1.80	1.67	1.60	1.49
17.8 SL		(1.35)	(1.56)	(1.50)	(1.50)	(1.48)	(1.18)	(1.51)	(1.47)	(1.44)	(1.40)
Acephate	0.0375	1.04	1.54	1.37	1.37	1.33	0.70	1.40	1.43	1.27	1.20
75 SP		(1.22)	(1.43)	(1.36)	(1.36)	(1.34)	(1.09)	(1.38)	(1.39)	(1.33)	(1.29)
Endosulfan	0.05	1.37	2.17	2.00	1.90	1.86	1.03	1.90	1.77	1.80	1.62
35 EC		(1.36)	(1.63)	(1.57)	(1.55)	(1.53)	(1.24)	(1.54)	(1.50)	(1.51)	(1.45)
Monocrotophos	0.04	1.00	1.40	1.30	1.24	1.23	0.57	1.27	1.27	1.17	1.07
36 WSC		(1.22)	(1.35)	(1.34)	(1.31)	(1.31)	(1.02)	(1.33)	(1.32)	(1.29)	(1.24)
Azadirachtin	5 ml/lit.	2.30	3.44	3.20	2.63	2.89	1.27	3.00	2.40	2.30	2.24
0.03 EC		(1.67)	(1.98)	(1.92)	(1.77)	(1.83)	(1.33)	(1.87)	(1.70)	(1.67)	(1.64)
Bt	0.012	2.80	4.07	3.50	3.70	3.52	1.50	3.44	3.30	3.70	2.98
8 L		(1.82)	(2.14)	(2.00)	(2.05)	(2.00)	(1.41)	(1.98)	(1.95)	(2.05)	(1.85)
N.P.V.	0.10	2.67	3.90	3.27	3.50	3.33	1.37	3.36	3.20	3.07	2.75
LE		(1.78)	(2.10)	(1.94)	(2.00)	(1.95)	(1.36)	(1.96)	(1.92)	(1.88)	(1.78)
Acephate+*Bt*	0.0375 + 0.006	1.43	1.87	1.64	1.50	1.61	0.87	1.70	1.63	1.50	1.42
		(1.39)	(1.53)	(1.45)	(1.41)	(1.45)	(1.16)	(1.48)	(1.45)	(1.41)	(1.38)
Endosulfan+*Bt*	0.05 + 0.006	1.50	2.37	2.24	1.97	2.02	1.14	2.10	1.90	1.90	1.76
		(1.41)	(1.69)	(1.65)	(1.56)	(1.58)	(1.27)	(1.60)	(1.55)	(1.54)	(1.49)
Control	–	5.90	6.20	5.70	4.40	5.55	3.70	5.60	5.10	4.30	4.68
		(2.52)	(2.58)	(2.42)	(2.18)	(2.42)	(2.05)	(2.42)	(2.34)	(2.16)	(2.24)
Mean		2.13	2.89	2.60	2.40	2.50	1.30	2.56	2.37	2.26	2.12
		(1.57)	(1.80)	(1.71)	(1.67)	(1.69)	(1.31)	(1.71)	(1.66)	(1.63)	(1.58)
		Treat.	Spray	Treat. x Spray			Treat.	Spray	Treat. x Spray		
SEM ±		(0.038)	(0.024)	(0.075)			(0.037)	(0.023)	(0.074)		
CD (P = 0.05)		(0.087)	(0.067)	(0.213)			(0.085)	(0.066)	(0.208)		

*Mean of three replications; Figures in parentheses are " x + 0.5 values

Table 5. Efficacy of pesticides against coccinellids feeding on insect pests of okra under field conditions at seven- and fifteen-day intervals during 2002 and 2003 (Pooled)

Treatment	Conc. (%) / Dose	Population of coccinellids* per plant after one day of spray				Mean	Population of coccinellids* per plant after three days of spray				Mean
		I	II	III	IV		I	II	III	IV	
Imidacloprid	0.006	0.83	1.07	1.50	1.30	1.17	1.57	1.64	1.23	1.20	1.41
17.8 SL		(1.15)	(1.25)	(1.41)	(1.34)	(1.29)	(1.43)	(1.46)	(1.31)	(1.30)	(1.38)
Acephate	0.0375	0.40	0.87	1.10	1.00	0.84	1.10	1.17	1.10	0.93	1.07
75 SP		(0.94)	(1.17)	(1.26)	(1.22)	(1.15)	(1.26)	(1.29)	(1.26)	(1.19)	(1.25)
Endosulfan	0.05	0.90	1.17	1.57	1.40	1.26	1.67	1.77	1.44	1.34	1.55
35 EC		(1.18)	(1.29)	(1.43)	(1.37)	(1.32)	(1.47)	(1.50)	(1.39)	(1.35)	(1.43)
Monocrotophos	0.04	0.27	0.47	0.84	0.90	0.62	0.80	1.13	0.97	0.74	0.91
36 WSC		(0.87)	(0.98)	(1.15)	(1.18)	(1.04)	(1.12)	(1.27)	(1.20)	(1.11)	(1.18)
Azadirachtin	5 ml/lit.	1.10	1.70	2.00	1.90	1.68	2.67	2.20	1.77	1.60	2.06
0.03 EC		(1.26)	(1.47)	(1.58)	(1.54)	(1.46)	(1.78)	(1.64)	(1.50)	(1.45)	(1.59)
Bt	0.012	1.30	2.10	2.50	2.60	2.13	4.13	2.50	2.07	1.90	2.65
8 L		(1.34)	(1.61)	(1.73)	(1.76)	(1.61)	(2.15)	(1.73)	(1.60)	(1.55)	(1.76)
N.P.V.	0.10	1.27	2.14	2.30	2.53	2.06	3.90	2.40	2.00	1.80	2.53
LE		(1.33)	(1.62)	(1.67)	(1.74)	(1.59)	(2.09)	(1.69)	(1.57)	(1.51)	(1.72)
Acephate + *Bt*	0.0375 + 0.006	0.70	0.94	1.30	1.20	1.03	1.50	1.40	1.14	1.00	1.26
		(1.09)	(1.20)	(1.34)	(1.30)	(1.23)	(1.41)	(1.38)	(1.27)	(1.22)	(1.32)
Endosulfan + *Bt*	0.05 + 0.006	0.97	1.27	1.67	1.50	1.35	1.80	1.80	1.54	1.37	1.63
		(1.20)	(1.33)	(1.46)	(1.41)	(1.35)	(1.51)	(1.51)	(1.42)	(1.36)	(1.45)
Control	–	3.10	4.50	4.60	3.30	3.88	4.80	4.70	3.73	3.17	4.10
		(1.89)	(2.23)	(2.22)	(1.93)	(2.06)	(2.29)	(2.26)	(2.05)	(1.89)	(2.12)
Mean		1.08	1.62	1.94	1.76	1.60	2.39	2.07	1.70	0.00	1.54
		(1.23)	(1.41)	(1.52)	(1.48)	(1.41)	(1.65)	(1.57)	(1.46)	(0.00)	(1.17)
		Treat.	Spray	Treat. x Spray			Treat.	Spray	Treat. x Spray		
SEM ±		(0.034)	(0.021)	(0.067)			(0.052)	(0.033)	(0.104)		
CD (P = 0.05)		(0.078)	(0.060)	(0.190)			(0.121)	(0.093)	(0.295)		

*Mean of three replications; Figures in parentheses are " x + 0.5 values

Shoot and fruit borer infestation started in the second and first week of August during 2002 and 2003 and continued throughout the crop period in both the years. Initially the shoot borer infestation was 1.0 and 0.66 per cent, which gradually increased and reached its maximum (23 and 25%) in the third week of October during 2002 and 2003. The coccinellid population showed significantly positive correlation (r = 0.6908 and r = 0.7027) with shoot and fruit borer infestation in both the years (Table 3).

Relative safety of pesticides to coccinellids

The effects of insecticides, bio-pesticides and its combinations on coccinellid beetles on okra are presented in Table 4 and 5. Pooled data on the effect of different insecticides on the population of coccinellid beetles revealed that all the treatments were significantly more toxic in comparison to untreated control (6.20 beetles / plant) under field conditions during both the years. The treatment of *Bt* (Dipel) 0.012% alone was found to be the least toxic (4.07 beetles / plant) followed by NPV 0.10% (2.67 beetles / plant), both being on par with each other and significantly safer than the rest of the treatments. The present findings agree with the results reported by Bozsik Andras (2006) and Nadaf and Goud (2007) who concluded that *Bt* formulation was comparatively safe to immature and adult stages of coccinellids. Microbial formulations are slow acting primarily due to their mode of action.

The other treatments in the lower order of toxicity were azadirachtin (5ml lit^{-1}), endosulfan + *Bt* (Dipel) (0.05 + 0.006%) and endosulfan (0.05%). Endosulfan + *Bt* (Dipel) and endosulfan were statistically on par with each other, but significantly differed with azadirachtin. These results are consistent with those of Rao *et al*. (1990), who reported low population of coccinellid predators in plots treated with neem products and this may be due to its repellent action and low persistence rather than toxicity. Combination of insecticides and bio-pesticides (endosulfan + *Bt*) against these predators on okra has not been documented, therefore, the results could not be compared and discussed. Makar and Jadhav (1981) and Dhingra *et al*. (1995) reported that endosulfan (0.02– 0.07%) was less toxic to coccinellids on different crops which broadly corroborate the findings of the present study.

Monocrotophos (0.04 %) was found most toxic (1.40 beetles/plant) followed by acephate 0.0375% (1.54 beetles/plant) to the predators in present investigation, akin to the findings of Ali (1994), who reported monocrotophos as highly toxic to coccinellids. Imidacloprid (0.006%) and acephate + *Bt* (0.0375 + 0.006%) were categorized as moderately toxic to coccinellid beetles (1.94 and 1.87 beetles / plant, respectively) in the present investigation, in accordance with Srinivasa Babu and Sharma (2003), who found imidacloprid as safer insecticide to coccinellid predators. The significant difference between sprays and the interaction between treatments and sprays indicated significant toxic effect of insecticides at all intervals (Table 4 and 5).

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