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Efficacy and economics of biopesticide and insecticide combinations against okra pests

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ABSTRACT
Studies on the combinations of commercial formulation of *Bacillus thuringensis* (B.t.) @ 500 g ha^{-1} with lower concentration of insecticides viz., Cartap 50 SP @ 130 g ha^{-1}, Acephate 75 SP @ 300 g ha^{-1}, Chlorpyriphos 20 EC @ 175 g ha^{-1}, Endosulfan 35 EC @ 250 g ha^{-1}, Amrutguard 0.5% and B.t. @ 500 g ha^{-1} as well as Monocrotophos 36 EC @ 400 g ha^{-1} alone against Jassid, *Amrasca biguttula biguttula* Ishida and shoot and fruit borer *Earias vittella* Fabricius were conducted at the University Apiary, Rajendra Agricultural University, Pusa Farm during summer of 2000 and 2001. The treatment combinations of B.t. + Endosulfan and Bt + Acephate recorded minimum Jassid population (7.94 and 7.97/ 30 leaves), per cent shoot infestation (9.10 and 9.46) and per cent fruit damage based on fruit number (17.35 and 19.50) and fruit weight (16.3 and 17.13) as well as the larval population per hundred fruits (24.23 and 27.61). These treatments also maximized the crop yield 123.14 and 117.52 q ha^{-1}, respectively and proved to be most effective treatments, while B.t. alone was found to be the least effective treatment. Monocrotophos proved profitable in monetary term with the maximum cost benefit ratio (1:5.21) followed by B.t. + Endosulfan (1:2.96).

Key words : Biopesticide, Okra, Jassid, Shoot and fruit borer, Insecticide.

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) is an important vegetable crop and grown widely in various parts of India throughout the year. It is considered to be native of India and is grown extensively in South-East Asian countries. One of the major constraints for low productivity and poor qualificative in India is that the crop is attacked by as many as 45 species of pests belonging to different orders on okra Nair (1981). Out of numerous pests that infest the okra crops, the Jassid, *Amrasca bigutulla biguttula* Ishida and shoot and fruit borer, *Earias vittella* Fabricius, are the most serious pests and a major limiting factor in okra cultivation. Krishnaiah (1980) estimated the loss due to Jassid and shoot and fruit borer incidence to be in the order of 40-56 and 49-79 per cent, respectively in untreated plot. After the introduction of hybrid varieties of okra with broader leaves, the pests have become a thrust to okra cultivation in India. To control the pest ravages, farmers use many insecticides during crop growth period. But frequent and enormous use of synthetic pyrethroids, organophosphate insecticides has posed the resistance problem and resurgence of pest(s) (Mehrotra, 1990). Moreover, in okra the shorter interval between pluckings of fruits poses the residue hazards to the consumers when the chemical insecticides are used. The pests were also found to develop resistance to insecticides (Kabir *et al*., 1994). Microbial insecticides particularly those derived from bacterium, *Bacillus thuringensis* Berliner (Colloquially called B.t.) offer great promise for management of various pests in vegetables. However, the biopesticides are not as effective as conventional insecticides. Delfin WG (B.t. kurstaki) was used alongwith lower concentration of insecticides in the present study and the efficacy of combinations against the pests are discussed in this paper.

MATERIALS AND METHODS

The field experiment was conducted at the University Apiary, Rajendra Agricultural Univeristy, Pusa Farm, Samastipur, Bihar during summer, 2000 and 2001 to assess the efficacy of biopesticide and insecticide combinations on the pests incidence. The experiment was laid out in a randomized block design with three replications in a plot size of 3 m x 2 m. The okra (cv. Pusa Sawani) seeds were sown on 16^{th} February in both the years with a spacing of 30 cm x 30 cm. All the crop management practices except the insecticide applications were followed for maintaining healthy crop growth. There were 8 treatments including untreated control (Table 1).

Spraying was done late in the afternoon with high volume knapsack sprayer (ASPEE make) and a through coverage of leaf area, tender shoots and fruits was ensured. Sprays were done @ 200-500 L of water ha^{-1}, depending on the height of the crop. First foliar spray was done on 3^{rd} April after 20 days of the crop emergence on 25^{th} March followed by second and third foliar sprays on 15^{th} April and 6^{th} May after 40 and 60 days of the crop emergence, respectively in both the years (2000 and 2001).

Observation on population density of pests :

Jassid :

Observations on the pest activity were recorded in each plot of the replicates, a day preceding and 3 and 7 days following the foliar treatments in both the years. Jassid nymphs as well as adults population were observed from three leaves consisting of 2^{nd}, 3^{rd} and 4^{th} each of the 10 randomly selected tagged plants in each of the replicates after Krishnaiah *et al*. (1979). Both the Jassid nymphs and adults were counted on lower surface of leaves in boarder area of plots in the early morning (7 AM to 9 AM), the time during which the Jassids were found inactive. The population of Jassids counts in all the replicates were taken together and average population per 30 leaves per 10 plants was worked out and transformed into square root, $x + 0.5$ value for analysis of variance.

Shoot and fruit borers :

All the plants in a plot were considered for recording shoot and fruit borer incidence. Harvesting of okra fruits was done at weekly interval. Observations on the pest incidence, viz., shoot damage (total number of shoots and damaged shoots) and fruit damage (total number and total weight of healthy and damaged fruits) were recorded on weekly basis and ultimately pooled together, separately for the respective parameters after tabulating replication wise at each observation to worked out mean value of the pest incidence calculated by unitary method by using the following formula:

$$\text{(i) Per cent shoot damage} = \frac{\text{No. of damaged shoots}}{\text{Total no. of (healthy + damaged) shoots}} \times 100$$

$$\text{(ii) Per cent fruit damage by no.} = \frac{\text{No. of damaged fruits}}{\text{Total no. of (healthy + damaged) fruits}} \times 100$$

$$\text{(iii) Per cent fruit damage by wt.} = \frac{\text{Wt. of damaged fruits}}{\text{Total wt. of (healthy + damaged) fruits}} \times 100$$

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Larval population :

The larval population of *E. vittella* per hundred fruits was taken at each picking. Larvae were either crawling on the infested fruits or were present inside the infested fruits of okra. The larvae in infested fruits were counted by cutting them longitudinally. Larval population were counted at each weekly pickings and average population per hundred fruits was worked out.

Shoot and fruit infestation (number and weight basis of fruits) and larvae per hundred fruits were transformed into Arc Sin transformation in replication wise. Data were subjected to statistical analysis by bifurcating them into crop(s) and insecticide(s) for the purpose of data interpretation and drawing conclusion pertaining to their respective influence independently on reduction of the pest incidence.

The yield data of marketable fruits were recorded at weekly picking and converted into quintal per hectare. Thus, the data were taken subjected to statistical analysis.

Cost benefit ratio was calculated by considering additional cost (cost of insecticide and operational charge) and benefit (compared to untreated control) in the respective treatments.

RESULTS AND DISCUSSION

During two summer seasons of 2000 and 2001, almost all the combinations and alone treatments were found to be significant in reducing the Jassid and shoot and fruit borer incidence over untreated control (water treatment).

Jassid :

Results (Table 1) revealed that the commercial formulation of B.t. alone and in combinations with B.t. + insecticides significantly reduced Jassid population over untreated control. The minimum Jassid population (7.94/30 leaves) was recorded in the combinations of B.t. + Endosulfan. This was found at par with other combination treatments of B.t. + Acehate (7.97/30 leaves) and B.t. + Chlorpyriphos (8.11/30 leaves). Such synergistic effect of B.t. with sublethal dose of safer insecticides had significant effect as compared to B.t. alone when sprayed thrice at different growth stages of the crops. This is also in conformity with the findings of Jayraj (1985) and Puri *et al*. (1988).

The application of B.t. alone was also effective in reducing the Jassid population (8.93/30 leaves) and it was found at par with monocrotophos (8.31/30 leaves). Ghosh *et al*. (1999) inferred that the B.t. (1 g/L) recorded 32.14 per cent mortality of Jassids on okra while effectiveness of monocrotophos was demonstrated earlier by Rathore *et al*. (1974, Radadia and Patel (1993).

***Shoot and fruit borer* :**

The pest incidence was measured interms of per cent shoot and fruit infestation (by number and weight) as well as the larval population per hundred fruits for each treatments (Table 1) and discussed below :

Shoot infestation :

On the basis of pooled means of shoot infestation (Table 1), all the combinations and alone treatments were significantly superior over untreated control. The treatment combination of B.t. with Endosulfan was most effective and showing least shoot infestation of 9.10 per cent and proved to be the best. It was however, followed by B.t. + Acephate (9.46%), B.t. + Cartap (10.52%), B.t. + Amrut guard (10.94%) and B.t. + Chlorpyriphos (11.09%). Treatment with B.t. alone recorded maximum of 11.39 per cent shoot infestation and was also found to be effective. Although, it was at par with monocrotophos (11.95%).

Fruit infestation :

The pooled means of data revealed that the commercial formulation of B.t. alone and in combination with B.t. + Insecticides significantly reduced fruit infestation over untreated control (Table 1). Amongst the combination treatments, B.t. + Endosulfan was found to be most effective exhibiting least fruit infestation both by number (17.35%) and weight (16.03%). The next best combination of B.t. + Acephate was also found effective in reducing per cent fruit infestation by number (19.50%) and also by weight (17.13%). The other combination treatments viz., B.t. + Cartap, B.t. + Chlorpyriphos and B.t. + Amrutguard were found effective in order of treatment and not significantly different to each other in reducing per cent fruit infestation by number (22.19, 22.99 and 23.58) and by weight (19.27, 19.08 and 19.55), respectively. B.t. and recommended insecticides as monocrotophos alone were found least effective treatments and recorded maximum per cent of fruit infestation by number (27.67 and 26.10) and weight (23.45 and 22.18). Although they were found statistically at par with each other.

Table 1 : Efficacy of biopesticide and insecticide combinations against the pests of okra (Pooled mean, 2000 and 2001)

Sl. No.	Treatment [Kg/%(conc.)/ha]	*Mean number of Jassids/ 30 leaves	**Mean percentage of shoot infestation	**Mean percentage of fruit in festation by		**Mean number of larvae/ 100 fruits	Average Marketable fruit yield (q ha^{-1})	Percent increase in yield over untreated control
				Number	Weight			
1.	B.t.+Cartap 50SL (500g + 150g)	8.32 (68.86)	10.52 (3.37)	22.19 (14.32)	19.27 (10.98)	30.94 (26.63)	115.16	43.44
2.	B.t. + Acephate 75SP (500g + 300g)	7.97 (63.06)	9.46 (2.69)	19.50 (11.18)	17.13 (8.72)	27.61 (21.80)	117.52	46.38
3.	B.t. + Chlorpyriphos 20EC (500g + 250g))	8.11 (65.32)	11.09 (3.72)	22.99 (15.32)	19.08 (10.79)	30.56 (25.92)	110.69	37.87
4.	B.t. + Endosulfan 35 EC (500g + 250g)	7.94 (62.59)	9.10 (2.56)	17.35 (8.91)	16.03 (7.66)	24.23 (16.97)	123.14	53.38
5.	B.t. + Amrutguard (500 g + 0.5%)	8.56 (72.92)	10.94 (3.62)	23.58 (16.10)	19.55 (11.32)	33.17 (30.03)	105.70	31.66
6.	B.T. alone 500g)	8.93 (79.40)	11.39 (3.92)	27.67 (21.69)	23.45 (15.92)	37.45 (37.00)	96.07	19.66
7.	Monocrotophos 36 SL (400 g)	8.91 (78.95)	11.95 (4.28)	26.10 (19.48)	22.18 (14.34)	34.64 (32.38)	97.54	21.49
8.	Untreated control (Water treatment)	10.94 (119.21)	12.34 (4.55)	33.48 (30.49)	32.87 (29.52)	40.62 (42.42)	80.28	-
	SEm	0.063	0.072	0.570	0.457	0.491	0.850	-
	CD (P=0.05)	0.182	0.214	1.906	1.314	1.412	2.446	-

B.t.= Bacillus thuringiensis Kurstaki; *Square root transformed values ;
**Arc Sin transformed values; Figures in the parentheses original values

Larval population :

The pooled means of the larval population in various treatments ranged from 24.23 to 37.45 per hundred fruits as against 40.62 per hundred fruits in untreated control (Table 1). All the combination and alone treatments were significantly superior over untreated control. The combination treatment with B.t. + Endosulfan was found to be most effective exhibiting minimum larval population (24.23 per hundred fruits) and proved to be the best. It was however, at par with B.t. + Acephate (27.61). The other combination treatments viz., B.t. + Cartap, B.t. + Chlorphyriphos and B.t. + Amrutguard recorded 30.94, 30.56 and 33.17 larval population per hundred fruits, respectively and these treatments were at par with each other (Table 1). B.t. and monocrotophos alone treatments recorded maximum of 37.45 and 34.64 larvae per hundred fruits, respectively and found to be least effective.

Thus, the treatment with three sprays of B.t. + Endosulfan @ 500 g + 250 g/ha and B.t. + Acephate @ 500 g + 300 g/ha proved most effective showing least per cent of shoot and fruit infestation as well as minimum larval population per hundred fruits. Such synergistic effect of B.t. with sublethal dose of safer insecticides persist longer period in the crops. Patil and Sarode (1976) also reported the effect of synergistic character of B.t. with sublethal dose of the recommended insecticides viz., endosulfan 0.06%, quinalphos 0.05%, monocrotophos 0.06% and fenverlate 0.012% against the bollworm infestation (*Earias* spp.).

B.t. @ 500 g/ha and the recommended insecticide as monocrotophos @ 400 g/ha were also found effective over untreated control. In earlier Tomar (1998) reported that Dipel alone gave better control of *E. vitella* resulting in least shoot and fruit infestation by number and also by weight. Similarly, effectiveness of monocrotophos against the pest was reported by Balasubramani and Swamiappan (1993). Slight variation in the efficacy of B.t. and insecticides might be due to location specific pest incidence, crop variety and interval of applications employed in the investigations.

Yield of marketable fruits :

The yield data (Table 2) indicated that all the combinations and alone treatments were significantly superior (96.07 to 123.14 q/ha) to untreated control (80.28 q/ha). The treatment combination of B.t. with endosulfan gave highest yield (123.14 q/ha) and was at par with B.t. + Acephate (117.52 q/ha). The combination B.t. + Cartap (115.16 q/ha), B.t. + Chlorpyriphos (110.69 q/ha) and B.t. Amrutguard (105.70 q/ha) were next in order of producing yield of marketable fruits, while B.t. recorded less yield (96.07 q/ha) and at par with monocrotophos (97.54 q/ha). In the present study B.t. + Endosulfan and B.t. + Acephate combinations effectively reduced Jassid population and per cent shoot as well as fruit infestation resulting in higher yield. Ahmad (1998) and Tomar (1998) also reported that the combination of B.t. + Endosulfan was most effective against *E. vittella* and consequently gave the maximum yield of okra fruits.

Yield increase over untreated control :

The data on increase in okra fruit yield over untreated control due to the control of Jassid and shoot and fruit borer in different treatments showed that yield increased from 19.66% to 53.38%. The highest (53.38%) increase in yield over untreated control was obtained with three spraying of B.t. + Endosulfan followed by B.t. + Acephate (46.38%), B.t. + Cartap (43.44%), B.t. + Chlorpyriphos (37.87%), B.t. + Amrutguard (31.66%), Monocrotophos (21.49%) and B.t. alone (19.66%).

Table 2 : Economics of biopesticide and insecticide combinations against the pests of okra (Pooled mean, 2000 and 2001)

Sl. No.	Treatment [kg%(Conc.)/ha]	Marketable fruit yield (q ha^{-1})	Increase in yield over untreated control (q ha^{-1})	Gross income (Rs. ha^{-1})	Cost of Treatment (Rs. ha^{-1})	Net income (rs ha^{-1})	Cost benefit ratio
1.	B.t.+Cartap 50SL (500g + 150g)	115.16	34.88	14824.00	4927.50	9896.50	1:2.00
2.	B.t. + Acephate 75SP (500g + 300g)	117.52	37.24	15827.00	4923.00	10904.00	1:2.21
3.	B.t. + Chlorpyriphos 20EC (500g + 250g))	110.69	30.41	12924.25	4594.30	8329.95	1:1.81
4.	B.t. + Endosulfan 35 EC (500g + 250g)	123.14	42.86	18215.50	4590.00	13625.50	1:2.96
5.	B.t. + Amrutguard (500 g + 0.5%)	105.70	25.42	10803.50	4882.50	5921.00	1:1.21
6.	B.T. alone 500g)	96.07	15.79	6710.75	4410.00	2310.75	1:0.52
7.	Monocrotophos 36 SL (400 g)	97.54	17.26	7335.50	1180.00	6155.50	1:5.21
8.	Untreated control (Water treatment)	80.28	-	-	-	-	-

Market price of okra marketable fruits @ Rs. 425/q (during 2000 and 2001)

Cost benefit ratio :

The comparison of fruit yields in commercial formulation of B.t. alone and in combination with B.t. + Insecticides were applied thrice at different crop growth stages showed low yield of unprotected okra crop in comparison to crop protected at different crop growth stages. Thus benefit due to Jassid, shoot and fruit borer control was high and CBR ranged from 1:6.52 (B.t.) to 1:5.21 (Monocrotophos) in crop protected at different stages with different insecticides. The descending order of CBR was observed as 1:5.21, 1:2.96, 1:2.21, 1:2.00, 1:1.81, 1:1.21 and 1:0.52 for monocrotophos; B.t. + Endosulfan, B.t. + Acehate, B.t. + Cartap, B.t. + Chlorpyriphos, B.t. + Amrutguard and B.t. alone, respectively.

Thus, from this study, it can be concluded that application of thrice spraying of B.t. + Endosulfan after 20, 40 and 60 days of the crop emergence gave better protection to okra crops against Jassids, shoot and fruit borer with higher marketable fruit yield.

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