JOURNAL OF PLANT PROTECTION RESEARCH Vol. 52, No. 1 (2012)
DOI: 10.2478/v10045-012-0006-7

COMPARATIVE POTENTIAL OF DIFFERENT BOTANICALS AND SYNTHETIC INSECTICIDES AND THEIR ECONOMICS AGAINST *LEUCINODES ORBONALIS* IN EGGPLANT

Sharma Deepak Kumar, Haseeb Masarrat, Qamar Muntaha*

Department of Plant Protection, Faculty of Agricultural Sciences
Aligarh Muslim University, Aligarh- 202002, Uttar Pradesh, India

Received: March 18, 2011
Accepted: August 9, 2011

Abstract: The field experiment was conducted to evaluate the potential of two botanicals viz; ozoneem and neem seed kernel extract (NSKE) and three chemical insecticides viz; imidacloprid, alphamathrin, chlorpyriphos 50% EC + cypermethrin 5% EC against *Leucinodes orbonalis*, during the years from 2008 to 2009. Botanicals were tested alone and in combination with cultural practices. On the basis of the pooled means, the results revealed that three sprays of chlorpyriphos + cypermethrin @ 0.01% active substance (a.s.) in 15 days intervals was found to be the most economical, resulting in minimum shoot (2.15%) and fruit (12.95%) infestation respectively, followed by alphamathrin @ 0.01% a.s. with a highest marketable yield of 87.77 q/ha. Maximum marketable yield was received from the treatment with alphamathrin, but due to high costs involved in the use of this chemical, it took second place. Three sprays of NSKE @ 5 ml/lt. recorded a maximum of shoot (3.91%) and fruit (24.49%) infestation, respectively. However, shoot and fruit infestation was brought down and marketable yield increased to some extent, when these treatments were combined with cultural methods. It is therefore, suggested that the combination of chlorpyriphos 50% EC + cypermethrin 5% EC, being the most effective and economically viable insecticide, can be utilized as a valuable chemical component in Integrated Pest Management to manage the *L. orbonalis* in eggplant crop.

Key words: *Leucinodes orbonalis*, botanicals, synthetic insecticides, marketable yield, eggplant

INTRODUCTION

Eggplant (*Solanum melongena*) is one of the most important vegetable crops in the Indian subcontinent (Srinivasan and Huang 2008). That accounts for almost 50% of the world's area under its cultivation (Alam *et al*. 2003). However, in India, the area is estimated as 7.5% of the total area of vegetables with 8% of the total production of vegetables (Indian Horticulture Data Base 2009). Insect pests viz; *Leucinodes orbonalis* Guen, *Aphis gossypii, Epilachna* spp., *Amarasca bigutulla bigutulla,* have been considered as important pests of eggplant (Butani and Jotwani 1984; Bhadauria *et al.* 1999). Among these insect pests, *L. orbonalis* is most destructive. Over 90% of fruits can be infested in high pest pressure years (Dhandhapani *et al*. 2003). Fruit infestation by this pest ranges from 20.70 to 88.70% in various parts of India (Raju *et al.* 2007; Haseeb *et al.* 2009). Insecticides have been reported effective against this pest but it is observed that this pest defies all the chemical control measures (Kumar *et al.* 2006) because once the caterpillar gains entry into the fruit or shoot, it is beyond the reach of almost all chemicals applied on the surface. Also, excessive dependence on huge quantities of insecticides, alone and in combination, to control *L. orbonalis* is causing ecological pollution and pest resistance (Ali 1994). Such management tools made its cultivation uneconomical and also caused residual toxicity. It has become necessary to use preparations which are safe, effective, cheap and fit into an integrated pest management strategy. With the above facts in mind, the present studies were carried out to evaluate the comparative efficacy and the Cost: Benefit ratio of botanicals and synthetic insecticides against *L. orbonalis* in field conditions.

MATERIALS AND METHODS

Location and site attributes

The field experiment was conducted in the Department of Plant Protection, Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh-India. The area is situated in the land between the Ganga and Yamuna rivers, at 27° 54′ N latitude and 78° 05′ E longitudes. The climate is hot and dry in summer, cold and dry in winter with an intervening rainy season. Cultivated land is sandy loam (67% sand, 13% silt, 18% clay, 2% organic matter, pH – 7.6) soil.

Experimental design and treatments

The present investigation was carried out on the Navkiran variety of eggplant. Eggplant seeds were sown

*Corresponding address:
dksharma_amu@rediff.com

in the last week of May, 2008 and forty day old, vigorous seedlings were selected from the nursery and transplanted in the experimental field on 7th July, 2008 at a distance of 75 (Row to Row) x 60 (Plant to Plant) cm in each plot which was the size of 3.75x1.80 m. There were three replicates for each treatment and the plots were randomized using a randomized block design. Botanicals *viz.*, T_1 (treatment) – ozoneem (1,500 ppm) @ 3 ml/lt water and T_2 – NSKE (alcoholic extract) @ 5 ml/lt water, were used alone and in combination with cultural practices *viz.*, T_3 – NSKE (alcoholic extract) @ 5 ml/lt water + NSKP (for urea coating) @1 kg/32.60 kg urea, T_4 – ozoneem (1,500 ppm) @ 3 ml/lt water + removal and destruction of infested twigs/fruits and fallen leaves twice a week and T_5 – NSKE (alcoholic extract) @ 5 ml/lt water + removal and destruction of infested twigs/fruits and fallen leaves twice a week. However, synthetic insecticide *viz.*, T_6 – imidacloprid @ 0.015% active substance (a.s.), T_7 – chlorpyriphos 50% EC + cypermethrin 5% EC @ 0.001% a.s. and T_8 – alphamathrin @ 0.001% a.s. were used. The first spray of different treatments commenced 50 days after transplanting: @ 750 liter solution/ha with the help of hand atomizer sprayer and repeated three times at 15 days intervals. Parallel control plots were sprayed with normal water. In all the treatments, a half dose of the recommended (130.4 kg urea/ha equivalent to 60 kg N/ha.) nitrogenous fertilizer was used as the basal dressing at the time of field preparation for transplanting of seedlings. The remaining half was used as top dressing at 30 days after transplanting (DAT), except in case of treatment T_3, in which remaining half dose of urea (65.2 kg urea equivalent to 30 kg N) was applied into two splits of 32.60 kg/ha each, after coating with NSKP @1 kg/32.60 kg urea, first split applied at 30 DAT and second at 60 DAT.

Observations on shoot and fruit infestation

After application of treatments the observations were recorded on infested shoots and fruits caused by *L. orbonalis* from 5 randomly selected plant/treatment/replicate. Observations were recorded at the time of each picking (5th, 9th and 14th day) after each of the three sprays. The healthy and damaged shoots from each treatment were counted, and per cent of shoot damage was calculated. However, assessment of fruit infestation was made by balancing of infested and healthy fruits of each plot at each picking separately. Thus, the data obtained from each treatment were pooled and calculated in per cent fruit damage.

Assessment of marketable yield and the Cost: Benefit Ratio

The yield of healthy fruits taken at each picking in each treatment were added as average yield/plant and converted into marketable yield (quintal/ha) by multiplying with respective number of plants/ha at adopted spacing between plant-plant and row to row. The Cost: Benefit Ratio was worked out from the yield of eggplant fruits and the cost of treatments incurred in the application, in order to find out an economically viable treatment for the management of *L. orbonalis* in eggplant. The market price of eggplant fruits, government rate of insecticides, labor cost, and insecticide spray charges were taken into account to compute the Cost: Benefit Ratio using the following formula:

$$\text{Cost: Benefit Ratio} = \frac{\text{Value of yield over the control } (R_s/\text{ha})}{\text{Total cost of plant protection } (R_s/\text{ha})}$$

Statistical analysis

Data were subjected to analysis of variance (ANOVA) by using Statistical package R, version 2.8.0 (2008-10-20). The means were separated through the pair wise comparison procedure by using the (Tukey's test). These procedures were done so that the efficacy of different treatments against *L. orbonalis* could be compared to each other and their relative efficacy could be adjusted.

RESULTS AND DISCUSSION

Effect on shoot infestation

On the basis of pooled means (average of means of % infestation at 5th, 9th and 15th day) of shoot infestation, all the treatments; botanicals (T_1 to T_3), botanicals + cultural practice (T_4 to T_5) and chemical insecticides (T_6 to T_8) were found to be significantly (df – 2, 16, LSD – 0.69, $p < 0.05$) superior over the control (Fig. 1). T_7 – chlorpyriphos 50% EC + cypermethrin 5% EC @ 0.001% a.s. was found most effective, with least shoot damage: 2.15±0.23 per cent, and proved to be the best. While T_2 – NSKE (alcoholic extract) @ 5 ml/lt. recorded the maximum of 3.91±0.22 per cent mean shoot infestation, and was found to be the least effective treatment.

T_7 – chlorpyriphos 50% EC + cypermethrin 5% EC @ 0.001% a.s. and T_8 – alphamathrin @ 0.001% a.s. with 2.15±0.23 and 2.37±1.24 per cent shoot infestation were found significantly (df – 2,16, LSD – 0.69, $p < 0.05$) superior over treatments; T_1 – Ozoneem (1500 ppm) @ 3 ml/l, T_2 – NSKE (alcoholic extract) @ 5 ml/l, T_3 – NSKE (alcoholic extract) @ 5 ml/lt. + NSKP (for coating urea) @ 1 kg/32.60 kg urea, T_4 – ozoneem (1,500 ppm) @ 3 ml/l + weekly removal and destruction of infested twigs/ fruits and fallen leaves and T_5 – NSKE (alcoholic extract) @ 5 ml/l + weekly removal and destruction of infested twigs/fruits and fallen leaves with 3.37±0.23, 3.91±0.22, 3.82±0.23, 3.14±0.25 and 3.60±0.41 per cent mean shoot infestation respectively, except T_6 – imidacloprid @ 0.015% a.s. with 2.62±0.38 per cent shoot infestation found non- significant over T_4 with 3.14±0.25 per cent shoot infestation, respectively.

The neem based treatments (T_1, T_4 and T_5) with 3.37±0.23, 3.91±0.22 and 3.82±0.23 per cent and (T_2 and T_3) with 3.14±0.25 and 3.60±0.41 per cent mean shoot infestation respectively, were found non-significant over each other. The same as with the chemical treatments (T_6, T_7 and T_8) with 2.62±0.38, 2.15±0.23 and 2.37±1.24 per cent mean shoot infestation respectively, were also found non-significant over each other.

Effect on fruit infestation

All the treatments (T_1 to T_8) were found significantly (df – 2, 16, LSD – 0.69, $p < 0.05$) superior over the control. The pooled means of fruit damage in different treatments (Fig. 1) ranged from 12.95±0.21 percent mean fruit infestation in T_7 to 24.49±0.54 per cent mean fruit infestation in T_2 as against 31.68±0.87 per cent mean fruit infestation in the control.

Chemical treatments; T_6, T_7 and T_8 with 14.43±0.54, 12.95±0.21 and 13.79±0.46 per cent fruit infestation were to be found significantly (df – 2, 16, LSD – 1.69, $p < 0.05$) superior over neem based treatments; T_1, T_2, T_3, T_4, and T_5 with 23.98±0.44, 24.49±0.54, 21.73±0.46, 22.62±1.165 and 23.07±0.23 per cent fruit infestation but found non-significant over each other.

Neem based treatments; T_3 and T_4, were found significantly different (df – 2, 16, LSD – 1.69, $p < 0.05$) over T_1 and T_2, but T_5 was found non-significantly different with all the neem (T_1, T_2, T_3 and T_4) based treatments.

Marketable yield of eggplant fruit in different treatments

It is indicated that the two treatments; T_1 and T_2 with 70.22±0.70 and 71.11±0.38 q/ha (Fig. 1) marketable yield respectively, were found non-significant over each other and the control with 69.77±1.30 q/ha marketable yield. While T_3, T_4, T_5, T_6, T_7 and T_8 with 73.11±0.56, 75.77±0.96, 73.99±1.14, 85.55±0.79, 86.88±1.96 and 87.77±1.39 q/ha marketable yield respectively, were significant (df – 2,16, LSD – 0.42, $p < 0.05$) over each other and the control. On the basis of marketable yield, these treatments could be arranged in a descending order as; T_8 (87.77±1.39) > T_7 (86.88±1.96) > T_6 (85.55±0.79) > T_4 (75.77±0.96) > T_5 (73.99±1.14) > T_3 (73.11±0.56) > T_2 (71.11±0.38) > T_1 (70.22±0.70) and T_9 (69.77±1.30) q/ha.

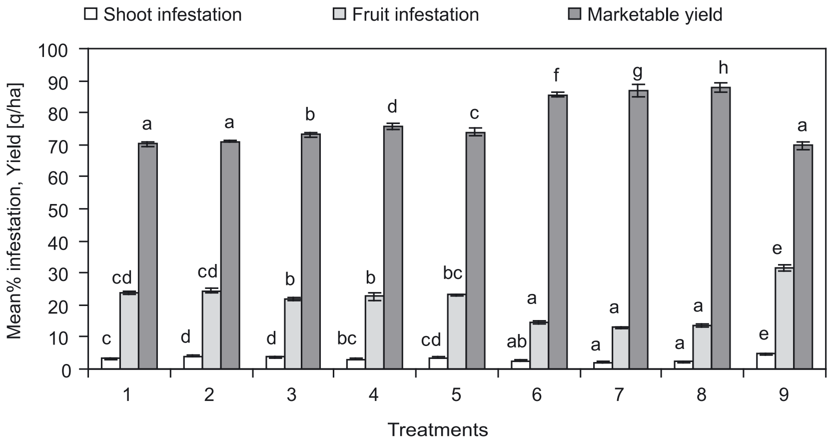

Fig. 1. Comparative potential of botanical and synthetic insecticides against *L. orbonalis*. Histogram bars followed by similar letter (s) are not significantly different ($p > 0.05$, Tukey's HSD) from each other

Similar results were obtained by various workers. Singh (2000) reported that neem oil treated plots were at par with neem cake treated eggplant plants. Neem oil treatments were found effective against the borer but not much more profitable than chemical insecticides. Likewise, Murugesan and Murugesh (2009) reported that neem oil and nimbecidine were moderately effective against this pest and gave higher yields than the standard check. Marketable yield increased to some extent when neem products were combined with removal and destruction of infested shoots. Similarly, other workers reported that prompt removal and destruction of EFSB infested shoots at regular intervals, either weekly (Alam *et al.* 2003; Miller *et al.* 2003) or fortnightly (Rahman *et al.* 2002; Srinivasan and Hung 2008) is an important component of the Fruit and Shoot Boser Integrated Post Management (FSB IPM) strategy. Jat *et al.* (2001) evaluated nine insecticides and one neem product (nimbecidine) out of which the highest yield was obtained with cypermethrin followed by carbaryl and endosulfan, while nimbecidine was found least effective against *L. orbonalis*, resulting in the lowest yield. Duara *et al.* (2003), Singh and Singh (2003), Rahman *et al.* (2006), Deshmukh and Bhamare (2006) also reported the best efficacy of cypermethrin against the *L. orbonalis*. Islam *et al.* (1999) reported the highest Benefit: Cost Ratio BCR of 37.77 in plots treated with Shobicron (mixture of cypermethrin and profenofos) against *L. orbonalis*.

Cost: Benefit Ratio of different treatments

Two treatments (T_1 and T_2) had a non-significant effect on the crop yield increase over the control (Table1). The remaining treatments, however, showed some gain in marketable yield. The highest yield (18 q/ ha) was obtained in the treatment (T_8) alphamathrin @ 0.001%, but the highest net profit (13,002.00 Rs/ha) was registered in the treatment (T_7) chlorpyriphos 50 % EC + cypermethrin 5% EC @ 0.001 % and could be adjusted as the most profitable treatment (CBR, 1:18.95). The lowest CBR (1:–0.75) was obtained in the treatment of Ozoneem (1500 ppm) @ 3 ml/lt. Based on the CBR, the tested treatments could be arranged in the descending order as, T_7 (CBR, 1:18.95) > T_8 (CBR, 1:9.16) > T_6 (CBR, 1:2.82) > T_3 (CBR, 1:0.65) > T_4 (CBR, 1:0.45) > T_5 (CBR, 1:0.01) > T_2 (CBR, 1:–0.29) > T_1 (CBR, 1:–0.75). From these results, it can be concluded that chlorpyriphos 50% EC + cypermethrin 5% EC@ 0.001 per cent was found as the most economical treatment to control the *L. orbonalis*, but two treatments (T_1 and T_2) were found to be highly uneconomical, as less return per rupee invested was obtained. This was mainly due to the high costs involved in preparations, and the higher concentrations used which jointly increased the total cost of treatment/ha. up to the level where profit could not be achieved. The literature on the Cost: Benefit Ratio of control measurements against *L. orbonalis* is limited. Islam *et al.* (1999) reported the highest BCR of 37.77 in plots treated with shobicron (mixture of cypermethrin and pro-

Table 1. Cost: Benefit Ratio of the treatments

S. No.	Treatments	No. of sprays	Dose/% concentration	Outputs			Inputs			Net profit/ha [Rs.]	Cost: Benefit ratio
				yield of healthy fruits [q/ha]	increased yield over the control [q/ha]	price of increased yield [Rs.]	cost of insecticide formulation	labour charges [Rs.]	total [Rs.]		
T_1	Ozoneem (1500 ppm)	3	3 ml/l	70.22	0.45	360	1,044	450	1,494	–1,134	1:–0.75
T_2	NSKE (alcoholic extract)	3	5 ml/l	71.11	1.34	1,072	1,080	450	1,530	–458	1:–0.29
T_3	NSKE (alcoholic extract) + NSKP (for urea coating)	3	5 ml/l + 1kg/32.60 kg urea	73.11	3.34	2,672	1,160	450	1,610	1,062	1:0.65
T_4	T1 + weekly R & D of infested twigs/fruits and fallen leaves	3	3 ml/ l	75.77	6	4,800	1,044	2,250	3,294	1,506	1:0.45
T_5	T2 + weekly R & D of infested twigs/fruits and fallen leaves	3	5 ml/l	73.99	4.22	3,376	1,080	2,250	3,330	46	1:0.01
T_6	Imidacloprid	3	0.015% a.s.	85.55	15.78	12,624	2,850	450	3,300	9,324	1:2.82
T_7	Chlorpyriphos 50% EC + Cypermethrin 5% EC	3	0.001% a.s.	86.88	17.11	13,688	236	450	686	13,002	1:18.95
T_8	Alphamathrin	3	0.001% a.s.	87.77	18	14,400	967	450	1,417	12,983	1:9.16
T_9	Untreated Check	3	–	69.77	–	–	–	–	–	–	–

R & D = Removal and Destruction; Labour charge @ Rs. 75.0/day; Sale of brinjal fruits @ Rs. 800.0/q
a.s. – active substance

fenofos). Deshmukh and Bhamare (2006) reported that, among conventional insecticides, cypermethrin 25 EC @ 0.006% proved superior in terms of efficacy and yield. The incremental Cost: Benefit Ratio (ICBR) showed that cypermethrin was economically the most viable treatment (1:27.02) against this pest. Our results also showed that the highest CBR was obtained in treatment of cyclone (mixture of chlorpyriphos + cypermethrin) as also reported by the other workers.

ACKNOWLEDGEMENTS

The authors are thankful to the Department of Plant Protection, Aligarh Muslim University for providing the facilities to conduct this research work.

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