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Bio-rational and cost-effective control of shoot and fruit borer incidence on Brinaj

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Abstract
Field studies were undertaken during winter 2012-13 at Bhubaneswar (Odisha) to reveal the impact of indigenous products and bio-nutrients along with reduced levels of fertilizers on the incidence of insect pests of brinjal cv. Blue star. The fruit damage on number (36.4 to 37.2%) and weight (39.6 to 40.2%) basis varied non- significantly with respect to the nutrient level tested. Six sprays of spinosad 45 SC effectively restricted the fruit damage within 28.0 % as against 36.8 - 42.1 % in untreated control and this was followed by carbosulfan 25 EC (32.2 – 34.9%). The benefit cost ratio was appreciable when the crop was raised with 50%RDF + Bio-NPK and protected with carbosulfan 25EC(3.44:1) and spinosad 45SC (2.20:1). None of the indigenous products proved effective against shoot and fruit borer incidence.

Keywords: brinjal, indigenous products, bio-nutrients, reduced fertilizers, shoot & fruit borer

1. Introduction
Brinjal (*Solanum melongena* L.) is considered as one of the top ten vegetables in the world (Srinivasan, 2009). The economic importance of brinjal in India is well documented (Anil and Sharma, 2010). In the tropics, cultivation of brinjal is severely constrained due to infestation by several insect pests. As brinjal is a common man's vegetable grown in almost all over India and after potato it ranks as the second highest consumed vegetable in the country along with tomato [10] indiscriminate use of insecticides on such vegetable crop may cause concern to the consumers owing to the risk of pesticide residues. Therefore, the search for alternative pest control strategies is receiving attention worldwide in recent years. The use of reduced rate of chemical insecticide and chemical fertilizers compensated with bio-fertilizers, not only reduces the cost of inputs, but also improves the soil quality and this might keep the pest incidence under check. Moreover, the traditional practices supplemented with modern science could also bring sustainability in agriculture and showed the possibilities to bring ecological and economic benefits to the farmers. Therefore, the IPM with conventional nonchemical methods of pest control as components is thought to avert the risk of pesticide and make the IPM more farmers' and eco- friendly. In view of this, the present studies were undertaken to reveal the possible impact of bio-nutrients with reduced levels of recommended dose of fertilizers and a few safe insecticides on the incidence of fruit and shoot borer of brinjal.

2. Materials and Methods
The field experiment was conducted at the Central Research Station, OUAT, Bhubaneswar during 2012-13. The soil type of the experimental area is red laterite with average pH of 6.5. Three weeks old seedlings of brinjal cultivar 'Blue star' were planted on 10.10.12 in plots of size 3×4 m ($12m^2$) with inter- and intra- row spacing of 60 and 50 cm, respectively. Recommended dose of fertilizers (RDF) *i.e.* N: P_2O_5: K_2O @ 125:80:100 Kg/ha and 50% RDF + Bio-NPK were taken as main plot treatments. The bio-NPK procured from the local market includes azospirillum, phosphate solublising microbes, potash mobilizing bacteria and before application it were mixed with 30 kg of FYM and incubated overnight. The above nutrients were applied to the main plots following agronomic package of practices.
While, the treatments in sub-plots were viz., (1) Mixture of cow urine (10%) + cow dung (10%) + neem leaves (5%), (2) Mixture of **c**ow urine+ cow dung (10%) + karanj leaves (5%) **(**3) Pot mixture of botanicals, (4) Spinosad 45 SC (1ml/lit water) (5) Carbosulfan 25 EC (2ml/lit. water) and (6) Untreated control. Thus, there were 12 treatments in all and these were replicated thrice in split-plot design.

The spray able formulation of botanicals was prepared by soaking 300 g each of neem and karanj leaf powder in 600 ml of cow urine (CU) and 600 gm of cow dung (CD) separately for three days. At the lapse of three days the solution was strained and diluted with water to make the final volume up to six liters. The pot mixture of botanicals (T_3) is prepared by mixing cow urine (5lit) with jaggery (50g) and to this fresh cow dung (1kg), karanj leaves (1kg) and calotropis leaves (1kg) were added. The pot with this mixture was kept for a week to get a fermented liquid which after straining and diluting with water @ 20 ml/ was utilized for spraying. The crop received a total of 6 sprayings at 10 days intervals with the first spraying being done at 30 days after transplanting (DAT) of brinjal.

Periodical observations were recorded on the incidence of shoot and fruit borer, *Leucinodes orbonalis.* The number of plants showing shoot damage in ratio to the total plants in middle three rows was taken as criterion for assessment of shoot damage. At fruiting stage of the crop, the fruit damage both on number and weight basis was assessed. The fruit damage in percentage was calculated from the total and infested fruits cumulative of six pickings during the crop period. The marketable fruit yield cumulative of six pickings was converted on hectare basis and such data was utilized for comparing the treatment effects. The data on the incidence of insect pests, and fruit yield were analyzed statistically by following standard statistical procedure suggested by Gomez and Gomez, (1984).

3. Results and Discussion

The shoot damage by the shoot and fruit borer during the vegetative stage of brinjal cv. Blue star varied from 1.0 to 5.2 and from 14.5 to 19.6 in response to nutrient levels in main plots and control strategies in subplots (Table-1). Comparatively low shoot damage of 14.5% was recorded in plots applied with recommended dose of fertilizer (125:100:80 kg/ha of N, P_2O_5 and K_2O) as against 19.6% in plots applied with 50% RDF + bio-NPK. Similarly among the subplot treatments significantly low shoot damage of 1.03 % was recorded in plots treated with insecticide carbosulfan 25 EC (2ml / liters of water). Irrespective of nutrient level tested, the treatments with indigenous materials (T_1, T_2 and T_3) showed 3.1-5.2% shoot infestations which was at par with that of untreated control (3.1%). Therefore, cow urine and cow dung based strategies were found as ineffective against borer infestation in the brinjal. However, it has been reported that cow urine alone or in combination with NSKE showed insecticidal properties in various crops [2, 8].

The fruit damage on number and weight basis with respect to the nutrient level tested i.e. RDF and 50% RDF + Bio-NPK also varied non- significantly from 36.4 to 37.2 and 39.6 to 40.2%, respectively. However on number basis such variation (27.2 to 44.4%) in fruit damage was found significant with respect to the control strategies. Among the treatments spinosad recorded lowest fruit damage of 27.2 percent and this was followed by the treatment with carbosulfan 25 EC (32.2%). None of the ITK based treatment proved affective on the basis of fruit damage on number basis (37.2 to 44.4 %) as compared to untreated control (36.8%). Similar trend was noticed with the ITK based treatments when fruit damage on weight basis was taken into account. On the contrary, insecticides were found to be most effective in restricting the fruit damage within 35% as against 42.1% in untreated control. While, the ITK based treatments showed high fruit infestation ranging from 39.7 to 48.3% as compared with 42.1% in untreated control. Thus, it was concluded that six sprays of either spinosad 45 SC or carbosulfan 25 EC was quite effective over the ITK based treatments in reducing the shoot and fruit borer infestation.

Although it has been reported that plant products fermented in animal dung and urine acted as pest repellent [14, 15, 22] and such animal waste had enhanced the insecticidal property of various botanicals [13] but botanicals like neem and karanj fermented in cow urine and cow dung did not show any effectiveness against the shoot and fruit borer infestation in the present investigation. It's also opined that cow urine fermented karanj and neem leaves at 10% concentration were ineffective against the shoot and fruit borer [18].

Table 1: Shoot infestation and fruit damage by shoot & fruit borer in brinjal cv. Blue star in response to nutrient levels and control strategies

Treatment	Shoot & fruit borer infestation (%) to		
	Shoot	Fruit	
		No. basis	Wt. basis
Nutrient levels:			
RDF	14.5(1.9)[1]	36.4(37.0)[2]	39.6(38.8)[2]
50%RDF + Bio NPK	19.6(1.6)	37.2(37.8)	40.2(39.1)
SE(m)±	0.05	0.3	0.7
CD (P=0.05)	0.3	ns	Ns
Control strategies:			
1.CU+CD+NL	3.1(1.9) [a]	43.2(41.1)[d]	46.5(42.9)[d]
2.CU+CD+KL	3.2(1.9) [a]	44.4(41.7)[d]	48.3(43.9) [d]
3.Pot mixture	5.2(2.4)[b]	37.2(37.5)[c]	39.7(39.0)[c]
4.Spinosad 45 SC	1.3(1.2) [a]	27.2(31.4)[a]	27.8(31.7)[a]
5.Carbosulfan 25 EC	1.03(1.2)[a]	32.2(34.5)[b]	34.9(36.1)[b]
6.Control	3.1(1.9) [ab]	36.8(37.3)[c]	42.1(40.2) [c]
SE(m) ±	0.11	0.6	0.7
CD (P=0.05)	0.9	1.8	2.2
Interaction:			
SE(m)±	0.2	0.8	1.6
CD(P=0.05)	0.6	2.3	Ns

[1]Figs.in parentheses are sq.root transformed values; [2]Figs.in parentheses are in corresponding angular values; RDF: Recommended dose of fertilizers; Bio NPK: (PSM + *Azospirillum* +Potash mobilizing microbes + Compost); CU: cow urine; CD: cow dung; NL: neem leaves; KL: karanj leaves; Pot mix: Mixture of NL, KL, Calotropis, CU & CD.

As such in okra it was found that repeated spray of cow dung and cow urine was not effective against the borers viz. *Earias vitella*, *Helicoverpa armigera*. [9] Similar report of ineffectiveness of cow urine against borer species was also evidenced [4, 17]. Thus, it was concluded from the present findings that spinosad 45 EC was most effective in restricting fruit damage within 28.0 % as against 36.8 - 42.1 % in untreated control. The present findings on the effectiveness of spinosad against *L. orbonalis* corroborates with early findings of some scientists [1, 5, 12, 19].

The marketable fruit yield of brinjal cv. Blue star did not vary significantly (112.02 to 112.73 q/ha) with respect to RDF (112.12 q/ha) and 50%+Bio-NPK (112.73 q/ha), but such yields were found superior over untreated control plots in which only 77.86 q/ha of fruits have been harvested (Table-2). It is therefore, suggested that economical use of chemical fertilizer was possible as 50% of recommended fertilizer dose can be supplemented with bio-fertilizer which not only maintain better soil conditions, but also cut down the cost of chemical fertilizer. However, there was significant variation in fruit yield (77.86 - 167.26 q/ha) with respect to the control

strategies tested. The treatment comprising of neem and karanj leaves fermented with animal waste (cow urine and cow dung) showed low fruit yields of 89.91 and 96.09 q/ha, respectively and found reasonably better than untreated control (77.86 q/ha).

Table 2: Maketable fruit yield of brinjal cv. Blue star

Treatment	Fruit yield (q/ha)
Nutrient levels:	
RDF	112.12
50%RDF + Bio NPK	112.73
SE(m)±	2.18
CD (P=0.05)	Ns
Control strategies	
1.CU+CD+NL	89.91[d]
2.CU+CD+KL	96.09[cd]
3.Pot mixture	104.06[c]
4.Spinosad 45 SC	167.26[a]
5.Carbosulfan 25 EC	139.34[b]
6.Untreated Control	77.86[e]
SE(m)±	3.78
CD(P=0.05)	11.10
Interaction:	
SE(m)±	1.5
CD(P=0.05)	Ns

RDF: Recommended dose of fertilizers; Bio NPK (PSM+ Azospirillum + Potash mobilizing microbes + Compost); CU: cow urine; CD: cow dung; NL: neem leaves; KL: karanj leaves; Pot mix: Mixture of NL, KL, Calotropis, CU & CD

In contrast with present findings Wange and Kale [23] revealed that reducing N to 50 kg while using bio-fertilizer did not help in achieving yield at par with recommended N per ha and only 25% N could be saved through the use of bio-fertilizer. It was reported highest fruit yield of 31.7 tons / ha in brinjal cv annamalai was obtained under rain fed situation with the application of FYM at 25 t / ha along with 100 % NPK and bio-fertilizer [16]. Higher yields with spinosad 45 SC as evidenced in present findings was also in support with early findings [5, 11, 19]. Thus, spinosad 45 SC can be considered as most effective insecticide for brinjal. Carbosulfan 25 EC being the second most effective insecticide in terms of fruit yield can also be considered for application to control the shoot and fruit borer infestation in brinjal. It is also opined that carbosulfan gave highest yield of 24.6 t / ha followed by spinosad (21.5 tonn/ ha) as against 9.2 t / ha in untreated control [20]. Thus, the above two insecticides i.e. spinosad and carbosulfan were found as most suitable for the management of shoot and fruit borer in brinjal.

The benefit cost ratio in respect to nutrient levels (RDF and 50%RDF + Bio-NPK) and control strategies have been worked out and presented in Table 3. It was evidenced that the treatment with neem leaves and karanj leaves fermented with cow dung and cow urine could not yield better benefits as low yields were recorded with these treatments. Among the control strategies, spinosad 45 SC application in plots with recommended dose of fertilizer was found as most effective in yielding appreciable benefit cost ratio of 2.65:1. On the contrary better benefit cost ratio was also noticed with the treatments like pot mixture (1.60:1) and carbosulfan (3.44:1) in plots fertilized with 50% RDF and bio-NPK. Thus, when bio-NPK with 50% RDF was used treatments like pot mixture, carbosulfan 25 EC and spinosad 45 SC were found better in terms of benefit cost ratio. It is also reported highest return with 5 sprays of spinosad [6]. In contrast with present findings Shailaja *et al.* reported better benefit cost ratios with the treatments like karanj leaves and neem leaves fermented in cow urine [18].

Table 3: Benefit: Cost ratio as generated with respect to control strategies under recommended dose of fertilizer (RDF) and bio-nutrients with 50% RDF

Treatments		Fruit yield (q/ha)	Yield benefit over control (q/ha)	Cost of produce (Rs)	Total cost of input (Rs)	Profit (+) / Loss (-)	Benefit cost ratio
Nutrient levels	**Control strategies**						
RDF	1 CU+CD+NL	85.11	6.65	6650=00	11281=00	-4631=00	-0.41: 1
	2 CU+CD+KL	98.50	20.04	20040=00	11281=00	+8759=00	0.78: 1
	3 Pot mixture	101.19	22.73	22730=00	11281=00	+11449=00	1.01: 1
	4 Spinosad45SC	173.48	95.02	95020=00	26029=00	+68991=00	2.65: 1
	5 Carbosulfan25EC	135.97	57.51	57510=00	14593=00	+42917=00	2.94: 1
	6 Untreated control	78.46	-	-	-	-	-
Mean	-	112.12	-	-	-	-	-
50% RDF + Bio NPK	1 CU+CD+NL	94.71	17.45	17450=00	11416=00	+6034=00	0.53: 1
	2 CU+CD+KL	93.69	16.43	16430=00	11416=00	+5014=00	0.44: 1
	3 Pot mixture	106.94	29.68	29680=00	11416=00	+18264=00	1.60: 1
	4 Spinosad45SC	161.05	83.79	83790=00	26164=00	+57626=00	2.20: 1
	5 Carbosulfan25EC	142.72	65.46	65460=00	14728=00	+50732=00	3.44: 1
	6 Untreated control	77.26	-	-	-	-	-
Mean	-	112.73	-	-	-	-	-

RDF: Recommended dose of fertilizers; Bio NPK (PSM+ Azospirillum + Potash mobilizing microbes + Compost); CU: cow urine; CD: cow dung; NL: neem leaves; KL: karanj leaves; Pot mix: Mixture of NL, KL, Calotropis, CU & CD; Cost of inputs: Spinosad(Tracer): Rs 136 / 7ml; Carbosulfan (Marshal) Rs594/lit.; Azospirillum: Rs 45/packet; Phosphate solubilising microbes: Rs 45/packet; Potash solublising bacteria: Rs45/packet; Cost of brinjal: Rs.1000/q; Laborer cost for spraying included.

4. Conclusion

The present study suggests the effectiveness of the bio-rational compounds and chemicals like spinosad and carbosulfan in managing shoot and fruit borer of brinjal.

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