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Efficacy of Biorational and eco-friendly control strategies in brinjal against *Epilachna* beetle, jassids and whiteflies

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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 jassid population was unaffected with nutrient levels tested, while application of 50% recommended dose of fertilizers (125:100:80 kg/ha of N, P and K) (RDF) with Bio-NPK showed significantly high population of whiteflies (3.65/3 leaves) as against 3.05/3 leaves in plot receiving RDF. The leaf damage by *Epilachna* beetle, fruit damage (both on number and weight basis) and marketable fruit yield were however, found unaffected by the nutrient sources tested. 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).

Keywords: Brinjal, indigenous products, bio-nutrients, reduced fertilizers, *Epilachna* beetle, carbosulfan 25 EC, Spinosad 45 SC

1. Introduction
Brinjal (*Solanum melongena* L.), also known as Aubergine or Eggplant is a solanaceous member which is native to India and is considered as one of the top ten vegetables in the world [24]. The economic importance of brinjal in India is well documented [3] and in Odisha, the crop is grown throughout the year as an assured source of income and cultivation of this indispensable vegetable crop is considered as highly remunerative because of its high demand throughout the state. These are rich source of potassium, magnesium, calcium and iron. In the tropics, cultivation of brinjal is severely constrained due to infestation by several insect and mite 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 [11] 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 *Epilachna* beetle and sucking insect pests of brinjal like jassid and whitefly.

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 jiggery (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/liter 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 *Epilachna* beetle *Epilachna vigintioctopunctata* (Fabricius), jassids *Amrasca biguttula biguttula* (Ishida) and whitefly *Bemisia tabaci* (Gennadius). The incidence of leaf damage caused by *Epilachna* beetle has been assessed by observing the top five leaves of five randomly selected plants in each treatment. The jassid and whitefly population were recorded by examining the lower surface of the leaves (top, middle and bottom) of five randomly selected plants. 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, (1976).

3. Results and Discussion

In brinjal cv. Blue star it was observed that nutrient levels (RDF and 50%+Bio-NPK) tested did not have any significant impact on population of jassids and it varied non-significantly from 13.3 to 14.6 / 3 leaves. Similarly, in case of whiteflies 50% RDF + Bio-NPK treated plots recorded significantly higher population of 3.65 / 3 leaves as against 3.05 / 3 leaves in plots treated with RDF (Table-1). However, in response to control strategies the jassids and whitefly population varied significantly from 12.75 to 16.55 and from 3.00 to 4.05/3 leaves respectively. Despite significant variation in population density of above insects, none of the control strategies tested was found effective in reducing the population of sucking pests.

Thus, it was evident from above observation that both nutrient level and control strategies were ineffective against whitefly and jassids and it was felt essential that some additional strategy like use of yellow sticky traps could have restricted sucking insects effectively.

Table 1: Population density of sucking insects and damage to leaves by *Epilachna* beetle in brinjal cv. Blue star in response to nutrient levels and control strategies

Treatment	Mean No./3leaves of		Leaf damage* by *Epilachna* beetle (%)
	Jassid	White fly	
Nutrient levels			
RDF	13.28(3.40)	3.05(1.87)	19.1(4.3)
50%RDF + Bio NPK	14.63(3.50)	3.65(1.96)	18.6(4.3)
SE(m)+	0.05	0.02	0.04
CD (P=0.05)	ns	0.06	ns
Control Strategies			
1.CU+CD+NL	13.95(3.43)^{a}	3.25(1.85)^{a}	18.2(4.3)^{b}
2.CU+CD+KL	13.70(3.43)^{a}	3.00(1.80)^{a}	18.3(4.3)^{b}
3.Pot mixture	13.15(3.45)^{a}	3.80(1.98)^{b}	22.1(4.7)^{c}
4.Spinosad45SC	13.65(3.35)^{a}	3.05(1.80)^{a}	22.0(4.7)^{c}
5.Carbosulfan25EC	16.55(3.77)^{b}	4.05(2.18)^{c}	12.0(3.4)^{a}
6.Control	12.75(3.28)^{a}	3.25(1.88)^{ab}	20.2(4.5)^{bc}
SE(m)+	0.08	0.04	0.07
CD(P=0.05)	0.23	0.12	0.20
Interaction			
SE(m)+	0.11	0.06	0.1
CD(P=0.05)	0.32	0.18	0.3

* Data average of 4 observations; Figs.in parentheses are sq. root transformed 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

Comparatively higher population of jassids (14.63) and whiteflies (3.65 / 3leaves) was found in plots applied with 50% RDF + Bio-NPK and this might be due to enhanced crop growth which attracted these insect pests. As such it is in dicated that jassids preferred the plant which received higher level of nitrogen [7]. However it was reported that application of neem cake at 0.5 tons per ha +50% RDF followed by application of four indigenous materials like NSKE (5%), vermiwash 2%, garlic and chilli extract were effective in reducing most insects in brinjal including the sucking pests like whiteflies and leaf hoppers [13]. Similarly in Odisha it was reported that application of neem cake @100 kg per ha after

transplanting followed by installation of pheromone traps @ 25 per acre, mechanical clipping of infested shoot at weekly interval and spraying of multi-neem @ 1500 ml per acre @ 10-12 days interval reduced the shoot and fruit borer in brinjal [19].

The observations on leaf damage due to *Epilachna* beetle averaged over four observations during early vegetative stage of crop showed no distinct variation (18.6-19.1%) with respect to nutrient level tested, but they varied significantly from 12.0 - 22.1% with respect to control strategies. The lowest leaf damage of 12.0% was recorded with carbosulfan 25% EC which was followed by ITKs based treatments like CU+CD+NL (18.2%) and CU+CD+KL (18.3 %). Suresh, *et al*. while studying the eco-friendly management of spotted beetle in brinjal in dicated that the treatment involving FYM + biofertilizers + neem cake recorded high per cent reduction of *Epilachna* beetle in festation [25]. It was reported that four sprays of spinosad were effective in reducing the leaf hopper population which contradicts with the present findings [14].

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

Treatment	Fruit yield (q/ha)
Nutrient levels	
RDF	112.02
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.Spinosad45SC	167.26^{a}
5.Carbosulfan25EC	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

The marketable fruit yield of brinjal cv. Blue star did not vary significantly (112.02 to 112.73 q/ha) with respect to RDF (112.02 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).The highest yield (167.26 q/ha) was recorded with Spinosad 45 SC.

In contrast with present findings it was 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 [27]. 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 [18]. Higher yields with spinosad 45SC as evidenced in present findings was also in support with early findings [5, 12, 22]. 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. 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 [23].

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 45SC 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 [21].

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, bio-NPK like PSM, Azospirillum, Potash mobilizing microbes, Compost and reduced level of chemicals like spinosad and carbosulfan in managing *Epilachna* beetle, jassids and whiteflies of brinjal.

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