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Plant products and microbial formulation in the management of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee.)

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ABSTRACT

Oxymatrine (1.2 EC @ 0.2 per cent) and spinosad (45 SC @ 225 g a.i. /ha) were found to be effective against brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guenee.). Oxymatrine was effective at early vegetative stage. Highest per cent reduction of shoot damage was observed in oxymatrine and it is on par with spinosad Spinosad was effective at fruiting stage. Maximum per cent reduction of fruit damage was recorded in spinosad and it was on par with oxymatrine.

Key words: Brinjal shoot and fruit borer, Plant products, Microbial formulations.

INTRODUCTION

Brinjal or eggplant is an important vegetable crop in many countries particularly in India, China, South East Asia, South East Europe and several African countries (Lovelock, 1972). In India, during the year 2005 it is cultivated in an area of 5,10,000 hectares with a production of 8,200,000 metric tonnes (www.fao.org). The per capita production of vegetables in India is 135g per day much lower than what is recommended by the dieticians (300g for a balanced diet). The brinjal production in India is to be increased to meet the requirements of our growing population (Satya Vart Dwivedi *et al.*, 2003). This cash earning crop is damaged by more than 36 insect pests, even from the nursery stage to harvest (Reghupathy *et al.*, 1997). Among the insect pests the most important and serious pest is shoot and fruit borer, *Leucinodes orbonalis* Guenee. (Lepidoptera: Pyralidae) and it is considered to be a limiting factor in brinjal cultivation. The yield loss was reported to be as high as 70 - 92 per cent (Krishnaiah and Vijay, 1975; Nair, 1995). The larva attacks shoot in the early stages of the crop and later on fruit formation, it damages the fruits. The loss caused by this pest varies from season to season depending up on environmental factors as reported by Gangwar and Sachan (1981) and Patel *et al.* (1988).As the fruits are being consumed, development of a eco-friendly and safe pest management recommendation is felt very much essential. Therefore it was programmed to test the bio-efficacy of some of the botanical oils, like oils of pungam (*Pongamia pinnata* L.) (Syn. *Pongamia glabra* Vent.), and iluppai (*Madhuca indica*), a cold desert plant seed- based botanical insecti cide namely oxymatrine, and neem seed kernel extract (NSKE), product of actinomycetes *Saccharopolyspora spinosa* (spinosad), in comparison with chemical insecticides like acephate, carbaryl and wettable sulphur.

MATERIALS AND METHODS

The field experiments with nine treatments were laid out in a Randomized Block Design (RBD) with three replications during February 2005 - August 2005 and February 2006 - May 2006. Seedlings were raised in a raised nursery bed; the seeds (Alankar var.) were sown in 10 cm lines apart with 1 cm depth during January 2005 and December 2005 for first and second crops respectively. Forty days old seedlings were transplanted on the ridges adopting a spacing of 60 cm between rows and 75 cm between plants in a 5x 4 m (20m^2) plot size. Both the trials were carried out in the Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, Union Territory of Pondicherry. Standard horticultural practices were followed as per the "Crop Production Techniques of Horticultural Crops" (Anon, 2004) except the plant protection. The borer infestation was recorded on shoot and fruits (number basis) on randomly selected five plants from each treatment per plot. *Pongamia pinnata* (L) (PPO) (2%), *Madhuca indica* (J.F.Gonel) oil (MIO) (2%), PPO +MIO in 1:1 (2%), oxymatrine 1.2 EC (0.2%) (M/S. Jasmine Biological Pvt. Ltd., Hyderabad), spinosad 45 SC (225 g.a.i./ ha), acephate 75 SP (750 g.a.i./ha), carbaryl 50 WP + wettable sulphur 50 WP (1:1), neem seed kernel extract (NSKE 5%) along with untreated check were used as treatments.

The insecticides used in the management study were applied as foliar sprays with a spray fluid of 500 l/ha using hand operated knapsack sprayer with double cone jet swirl nozzle and forwarded at 45^o angle with spray bottom upwards moving the lance straight in the inter row to ensure good coverage on the under surface of the leaves also. No spray was given in the unprotected crop plot. The treatments were imposed at an interval of 15 days commenced from 20 days after transplanting (DAT). Totally five sprays were taken up in each crop season. A precount was taken before the first spray. Pest damage was assessed at 7th and 14th days after spraying (DAS).The 14th day count was taken as precount for the subsequent spraying.

The borer damage in shoot was assessed on five tagged plants by counting the number of damaged shoots per plant to total number of shoots of the plant and expressed in percentage. Finally damaged shoots were taken alone for estimation. Shoot damage by *L. orbonalis* was assessed by recording total number of shoots observed as well as affected shoot from each treatment and the percentage of damage was worked out.

Fruit borer incidence was estimated by recording the total number as well as weight of the affected and unaffected fruits from each plot separately at every picking and the cumulative per cent damage was worked out. The percentage data for the damaged shoots and fruits were converted into its angular transformation. If zero values were recorded, the per cent damage was transformed to square root transformation for statistical analysis.

RESULTS AND DISCUSSION

Shoot damage

The result obtained on 15th day after each spraying during 2005 is presented in Table1. The treatment oxymatrine highly reduced shoot damage (89.02%) followed by spinosad (87.02 per cent). Both oxymatrine and spinosad were on par with standard chemical carbaryl (79.67 per cent). The standard chemical was also on par with pungan oil plus iluppai oil (1:1) treatment (76.5 per cent). The order of toxicity expressed as the percentage reduction over control for the five sprays as follows: Oxymatrine > Spinosad > Carbaryl + Wettable Sulphur > Pungam oil + Iluppai oil > Acephate > Iluppai oil > Pungam oil > Neem seed kernel extract.

Observation of 2006 study reveals that the efficacy of botanicals and chemicals on the shoot damage percent of brinjal shoot and fruit borer was studied by applying five foliar sprays (Table 2). An overall reduction of 87.33 per cent over control was observed after five sprays in oxymatrine treated plot. The reduction in shoot damage was higher in in three sprayings *viz*., first, second and fourth. However the reduction was higher in third and fifth sprayings in spinosad treated plots. Both oxymatrine and spiosad were on par with each other in all the five sprayings and they were on par with recommended chemical carbaryl with wettable sulphur. The order of overall toxicity expressed as per cent reduction over control after five foliar sprays are as follows: Oxymatrine > Spinosad > Carbaryl + Wettable Sulphur > Acephate > Pungam oil + Iluppai > Neem seed kernel extract > Iluppai oil > Pungam oil.

The results of the first field experiment (2005) on shoot damage by *L.orbonalis* indicated that among the treatments, oxymatrine reduced the shoot damage by *L.orbonalis*, effectively and the reduction over control ranged from 82.33 to 91.95 per cent, during five rounds of foliar application and the natural source insecticide spinosad was on par with oxymatrine. The effectiveness of oxymatrine was observed at seventh and fourteen DAT. The next round of foliar application was given on 15th DAT after each application. In the second field experiment (2006) also similar results were obtained. In this experiment Oxymatrine cent reduced the shoot damage by *L. orbonalis* effectively and the reduction over control ranged from 85.04 to 91.89 per cent over control.

From these field experiments it was clear that among the botanicals, a newer plant derived insecticide, oxymatrine and the natural source insecticide, spinosad reduced the shoot damage significantly and the treatments were found to be superior to the control and the standard check carbaryl + wettable sulphur. The results obtained in the field experiments were in accordance with earlier works of Tabassum and Maruthi Ram (2004) who reported that this new insecticide oxymatrine has been effectively used for the control of shoot and fruit borer infestation in brinjal. The next best treatments following oxymatrine were spinosad and carbaryl + wettable sulphur. The per cent reduction of shoot damage ranged between 84.36 and 93.82 in spinosad and 75.41 and 85.38 in carbaryl + wettable sulphur. Sparks *et al*. (1995) reported that spinosad has relatively broad spectrum activity and has been effectively used for the control of many species of insect pests in the order of lepidoptera in various crop systems. This adds strength to the present findings that spinosad was effective against many species of insect pests in the order of Lepidoptera.

Fruit damage

The data obtained on consolidating the eight pickings implied that the per cent fruit damage fluctuated between 5.07 and 54.59 with the minimum damage recorded in spinosad (5.07%) followed by oxymatrine (6.28%) and carbaryl + wettable sulphur (11.62%) with a per cent reduction of 90.71, 88.49 and 78.71 respectively (Table 3). Oxymatrine was on a par with spinosad. The order of over all toxicity expressed as per cent reduction over control after five sprays ranged as follows: Spinosad > Oxymatrine > Carbaryl + Wettable Sulphur > Acephate > Pungam oil > Pungam oil + Iluppai oil > Neem seed kernel extract > Iluppai oil.

The data obtained during 2006 on consolidating the eight pickings implied that the per cent fruit damage fluctuated between 7.06 and 53.55 with the minimum damage recorded in spinosad (7.06%) followed by oxymatrine (9.65%) and carbaryl + wettable sulphur (11.69%) with a per cent reduction of 86.81, 81.97 and 78.16. Oxymatrine was on a par with spinosad (Table 4). The order of over all toxicity expressed as per cent reduction over control after five sprays ranged as follows: Spinosad > Oxymatrine >

Table 1. Efficacy of botanicals and chemicals on shoot damage (%) by *L. orbonalis* during five foliar applications in brinjal (Crop I- 2005)

Treatments	1st Foliar Spray		2nd Foliar Spray		3rd Foliar Spray		4th Foliar Spray		5th Foliar Spray		Over all mean
	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduc Sprays	
Pungam oil	5.89 (13.91)[b]	51.75	4.40 (12.01)[c]	68.16	3.09 (10.04)[b]	69.53	2.76 (9.56)[b]	72.99	276(9.56)[e]	68.71	3.78(11.13)[d]
Iluppai oil	4.94(12.67)[b]	59.17	3.51(10.64)[c]	74.60	2.67(9.39)[b]	73.67	2.44(8.89)[ab]	76.13	2.45(8.97)[de]	72.22	3.20(10.26)[cd]
Pungam oil +Iluppai oil	4.10(11.64)[ab]	66.11	2.76(9.56)[bc]	80.02	2.31(8.68)[b]	77.22	1.87(7.78)[ab]	81.70	1.94(7.96)[cd]	78.00	2.59(9.25)[bcd]
Oxymatrine	2.15(8.25)[a]	82.23	1.21(6.05)[a]	91.24	1.09(5.96)[a]	89.25	0.89(4.37[a]	91.29	0.71(4.82)[a]	91.95	1.21(6.14)[a]
Spinosad	2.41(8.89)[a]	80.08	1.77(7.49)[ab]	87.19	1.16(6.15)[a]	88.56	1.03(4.69)[ab]	89.92	0.80(5.10)[a]	90.93	1.43(6.78)[ab]
Acephate	4.95(12.79)[b]	59.09	3.92(11.26)[c]	71.63	2.71(9.35)[b]	73.27	2.06(8.19)[ab]	79.84	1.46(6.93)[bc]	83.45	3.02(9.89)[cd]
Carbaryl + Wettable sulphur	3.52(10.75)[ab]	70.90	3.02(9.90)[bc]	78.14	2.12(8.29)[ab]	79.09	1.40(6.65)[ab]	86.30	1.16(6.18)[ab]	86.85	2.24(8.38)[abc]
Neem seed kernel extract	6.01(14.12)[b]	50.33	4.27(11.73)[c]	69.10	3.45(10.53)[b]	65.98	2.79(9.49)[b]	72.70	2.53(9.14)[de]	71.32	3.81(11.24)[d]
Control	12.10(20.27)[c]		13.82(21.74)[d]		10.14(18.51)[c]		10.22(18.63)[c]		8.82(17.25)[f]		11.02(19.30)[e]
CD value	3.19**		2.47**		2.34**		4.26**		1.30**		2.37**

Values in parentheses are arcsin transformed values. Means followed by a common letter are not significantly different at the 5% level by DMRT, ** Significant at 1% level

Table 2. Efficacy of botanicals and chemicals on shoot damage (%) by *L. orbonalis* during five foliar applications in brinjal (Crop- 2006)

Treatments	Shoot damage (%)											
	1st Foliar Spray		2nd Foliar Spray		3rd Foliar Spray		4th Foliar Spray		5th Foliar Spray		over all Mean	% over control
	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction		
Pungam oil	8.44 (16.63)[d]	42.62	6.19(13.80)[b]	52.78	4.62(12.41)[c]	64.54	3.59(10.90)[c]	59.27	2.94(9.85)[c]	71.57	5.16(13.00)[c]	57.08
Iluppai oil	7.12(15.41)[d]	51.60	5.16(12.27)[b]	60.64	4.15(11.73)[bc]	68.17	2.87(9.70)[bc]	67.43	2.36(8.80)[bc]	77.17	4.33(11.73)[bc]	63.92
Pungam oil + I luppai oil (1:1)	6.17(14.35)[cd]	58.06	4.35(11.95)[ab]	66.82	3.23(10.35)[bc]	75.20	2.37(8.78)[abc]	73.14	2.06(8.22)[bc]	80.10	3.64(10.94)[bc]	69.75
Oxymatrine	1.97(7.88)[a]	86.61	1.70(7.33)[a]	87.03	1.81(7.65)[a]	86.12	1.32(6.51)[a]	85.04	0.84(5.20)[ab]	91.89	1.53(7.03)[a]	87.33
Spinosad	2.10(8.27)[a]	85.72	1.84(7.78)[a]	85.96	1.79(7.68)[a]	86.25	1.38(6.63)[a]	84.36	0.64(3.66)[a]	93.82	1.55(6.88)[a]	87.08
Acephate	4.40(11.97)[bc]	70.09	3.64(10.98)[ab]	72.23	3.37(10.56)[bc]	74.13	2.29(8.67)[abc]	74.05	1.68(7.33)[bc]	83.77	3.08(10.07)[abc]	74.42
Carbaryl Wettable sulphur	3.60(10.86)[ab]	75.53	2.95(9.85)[ab]	77.50	2.73(9.48)[ab]	79.04	2.17(8.40)[ab]	75.41	1.51(6.99)[abc]	85.38	2.59(9.14)[ab]	78.42
NSKE	5.92(14.05)[cd]	59.76	5.11(12.92)[b]	61.02	4.38(12.07)[c]	66.41	3.45(10.67)[bc]	60.86	2.37(8.79)[bc]	77.08	4.25(11.85)[bc]	64.67
Control	14.71(22.53)[e]		13.11(21.20)[c]		13.04(21.05)[d]		8.82(17.24)[d]		10.35(18.64)[d]		12.01(20.24)[d]	
CD value	2.95**		4.32**		2.19**		2.20**		3.24**		3.18**	

Values in parentheses are arcsin transformed values; Means followed by a common letter are not significantly different at the 5% level by DMRT ** Significant at 1% level

Table 3. Efficacy of botanicals and chemicals on fruit damage (%) by *L.orbonalis* during eight pickings in brinjal (Crop 1- 2005) (Number basis)

Treat-ments	Fruit damage (%)																over all mean	% reduction
	1st picking		2nd picking		3rd picking		4th Picking		5th Picking		6th Picking		7th Picking		8th Picking			
	Mean .	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction	Mean	% reduction		
Pungam oil	19.16 (25.93)^{cd}	63.33	20.09 (26.56)^{c}	60.60	12.43 (20.62)^{bc}	78.21	11.41 (19.74)^{cd}	77.84	24.34 (29.52)^{cd}	60.58	18.60 (25.54)^{bc}	73.21	18.50 (25.47)^{bc}	66.79	10.74 (19.11)^{cd}	71.79	16.50 (24.25)^{cd}	69.04
Iluppai oil	24.02 (29.33)^{d}	54.03	21.26 (27.43)^{c}	58.30	22.06 (28.00)^{e}	61.33	18.68 (25.60)^{e}	63.73	27.49 (31.61)^{d}	55.48	23.49 (28.99)^{d}	66.17	16.63 (24.06)^{b}	70.14	12.14 (20.38)^{d}	68.11	2.72 (27.06)^{d}	62.04
Pungam oil + Iluppai oil (1:1)	21.43 (27.55)^{cd}	58.99	18.26 (25.28)^{c}	64.18	19.53 (26.22)^{de}	65.76	15.27 (23.00)^{de}	70.35	21.48 (27.57)^{cd}	65.21	19.86 (26.44)^{bcd}	71.39	19.69 (26.34)^{bc}	64.66	8.49 (16.90)^{bc}	77.70	17.50 (24.70)^{cd}	67.94
Oxyma trine	9.58 (17.71)^{a}	81.66	3.56 (10.80)^{a}	93.01	8.50 (16.79)^{ab}	85.10	7.73 (16.08)^{ab}	84.99	8.76 (17.21)^{a}	85.81	4.65 (12.40)^{a}	93.30	3.89 (11.34)^{a}	93.01	3.63 (10.98)^{a}	90.46	6.28 (14.49)^{a}	88.49
Spino sad	8.91 (17.29)^{a}	82.95	2.90 (9.79)^{a}	94.31	7.27 (15.34)^{a}	87.25	5.21 (12.45)^{a}	89.88	6.35 (14.57)^{a}	89.71	2.65 (9.32)^{a}	96.18	4.93 (12.81)^{a}	91.15	2.35 (8.65)^{a}	93.82	5.07 (13.00)^{a}	90.71
Acep hate	15.80 (23.39)^{bc}	69.76	12.21 (20.35)^{b}	76.05	12.10 (20.35)^{bc}	78.79	10.54 (18.94)^{bc}	79.53	20.07 (26.59)^{c}	67.49	21.79 (27.82)^{cd}	68.62	24.03 (29.35)^{d}	56.86	10.92 (19.28)^{cd}	71.32	15.93 (23.41)^{c}	70.81
Carbaryl + Wettable sulphur	11.26 (19.54)^{ab}	78.45	9.54 (17.98)^{b}	81.29	10.57 (18.92)^{abc}	81.47	6.08 (14.28)^{a}	88.19	14.31 (22.22)^{b}	76.82	15.83 (23.32)^{b}	77.20	18.41 (25.30)^{bc}	66.95	7.00 (15.24)^{b}	81.61	11.62 (19.92)^{b}	78.71
NSKE	19.34 (26.07)^{cd}	62.99	19.06 (25.87)^{c}	62.62	15.15 (22.84)^{cd}	73.44	16.59 (24.01)^{e}	67.79	23.14 (28.75)^{cd}	62.52	19.06 (25.88)^{bcd}	72.55	21.69 (27.74)^{cd}	61.06	11.17 (19.52)^{d}	70.66	18.15 (25.20)^{cd}	66.75
Control	52.26 (46.29)^{e}		50.99 (45.56)^{d}		57.05 (49.05)^{f}		51.51 (45.86)f		61.75 (51.88)^{e}		69.44 (56.48)^{e}		55.71 (48.29)^{e}		38.08 (38.10)		54.59 (47.63)^{e}	
CD value	3.95**		3.21**		3.71**		3.47**		3.80**		3.12**		2.78**		2.33**		2.78**	

Values in parentheses are arcsin transformed values. Means followed by a common letter are not significantly different at the 5% level by DMRT ** Significant at 1% level
Mean of three replications

Table 4. Efficacy of botanicals and chemicals on fruit damage (%) by *L. orbonalis* during seven pickings in brinjal (Crop II - 2006) (Number basis)

Treatments	1st picking Mean	1st picking % reduction	2nd picking Mean	2nd picking % reduction	3rd picking Mean	3rd picking % reduction	4th Picking Mean	4th Picking % reduction	5th Picking Mean	5th Picking % reduction	6th Picking Mean	6th Picking % reduction	7th Picking Mean	7th Picking % reduction	over all mean	% reduction
Pungam oil	23.32 (28.86)^{def}	60.41	10.54 (18.89)^{b}	80.24	15.93 (23.43)^{c}	71.70	10.30 (18.70)^{bc}	73.65	19.17 (25.96)^{bc}	59.22	13.85 (21.69)^{ab}	79.02	15.01 (22.73)^{ab}	72.26	15.44 (23.13)^{cd}	71.16
Iluppai oil	27.38 (27.47)^{e}	53.51	24.38 (31.55)^{f}	54.29	24.78 (29.58)^{d}	55.97	12.00 (29.85)^{d}	69.30	22.65 (20.25)^{c}	51.84	19.21 (28.41)^{c}	70.90	18.65 (25.97)^{b}	65.53	21.29 (25.55)^{b}	60.24
Pungam oil + Iluppai oil	19.98 (26.53)^{cde}	66.08	18.59 (25.53)^{c}	65.14	23.69 (29.07)^{d}	57.92	18.61 (25.52)^{d}	52.41	16.26 (23.77)^{b}	65.41	21.02 (26.28)^{b}	68.16	13.01 (21.03)^{ab}	75.95	18.73 (25.64)^{de}	65.02
Oxy matrine	12.53 (20.72)^{ab}	78.73	7.37 (15.64)^{b}	86.17	9.19 (17.63)^{b}	83.67	7.58 (15.93)^{ab}	80.61	11.34 (19.64)^{a}	75.88	10.01 (18.32)^{ab}	84.83	9.59 (17.36)^{a}	82.28	9.65 (18.02)^{ab}	81.97
Spinosad	8.30 (16.73)^{a}	85.89	3.90 (11.22)^{a}	92.68	6.18 (14.39)^{a}	89.02	5.12 (13.07)^{a}	86.89	9.29 (17.69)^{a}	80.24	7.01 (14.88)^{a}	89.38	9.62 (17.82)^{a}	82.22	7.06 (14.85)^{a}	86.81
Acephate	17.76 (24.82)^{bcd}	69.85	10.27 (18.63)^{b}	80.74	17.75 (24.89)^{c}	68.46	15.58 (23.21)^{d}	60.16	19.52 (26.17)^{bc}	58.49	17.33 (24.49)^{ab}	73.74	12.92 (20.97)^{ab}	76.11	15.87 (23.47)^{cd}	70.36
Carbaryl + Wettable sulphur	15.26 (22.83)^{bc}	74.09	8.30 (16.73)^{b}	84.43	11.87 (20.13)^{b}	78.91	8.09 (16.44)^{b}	79.31	16.16 (23.62)^{b}	65.63	11.15 (19.21)^{ab}	83.11	11.03 (18.90)^{a}	79.60	11.69 (19.94)^{bc}	78.16
NSKE	25.03 (30.00)^{ef}	57.50	21.91 (27.89)^{cd}	58.93	22.36 (28.22)^{d}	60.27	9.49 (17.86)^{bc}	75.74	20.12 (26.63)^{bc}	57.21	19.19 (25.40)^{b}	70.93	14.61 (22.30)^{ab}	72.99	18.95 (25.79)^{de}	64.61
Control	58.91 (50.17)^{g}		53.36 (46.93)^{e}		56.30 (48.62)^{e}		39.12 (38.71)^{e}		47.03 (43.29)^{d}		66.02 (54.39)^{c}		54.12 (47.37)^{c}		53.55 (41.03)^{f}	
CD value	4.24**		3.22**		2.79**		2.90**		3.01**		9.39**		5.83**		3.52**	

Values in parentheses are arcsin transformed values. Means followed by a common letter are not significantly different at the 5% level by DMRT, ** Significant at 1% level. # Mean of three replications

Carbaryl + Wettable Sulphur > Pungam oil > Acephate > Pungam oil + Iluppai oil > Neem seed kernel extract > Iluppai oil.

The results on the mean per cent fruit damage by *L.orbonalis* in first (2005) and second (2006) trials indicated that among the treatments tested, irrespective of both the trials, spinosad was found to be effective in checking the fruit damage. Higher per cent reduction of fruit damage over control was observed in spinosad treated plants, which were recorded 90.71 per cent during 2005 and 86.81 per cent during 2006. It could be inferred from these two trials that spinosad effectively reduced the fruit damage. Oxymatrine and carbaryl + wettable sulphur were found to be the next best treatments.

The results on effectiveness of spinosad in the present findings were in accordance with the earlier reports of Dandale *et al.* (2001). He reported that spinosad was found to be effective in suppressing the bollworm complex damage in green fruiting bodies in cotton up to14 DAT. In both the seasons the effectiveness of spinosad persisted up to 7 and 14 DAT and next round of application was taken up subsequently. The excellent insecticidal property of spinosad against bollworm complex was already reported by Banerjee *et al.* (2000), Patil *et al.* (1999), and Holloway and Forrester (1998), which add strength to the present findings. The effectiveness of oxymatrine was in accordance with reports of Tabassum and Maruthi Ram (2004) who reported that oxymatrine was found to be more effective in controlling brinjal shoot and fruit borer, *L. orbonalis* incidence.

Tabassum and Maruthi Ram (2004) concluded that oxymatrine 1.2 EC @ 1 ml and 1.5 ml / lit of water dose are more economical and gave higher yields with best CBR and thus farmers could use those doses for effective managements of brinjal shoot and fruit borer and Red spider mite. Oxymatrine did not exhibit phytotoxicity when sprayed on brinjal and it could be used safely on brinjal crop for effective management of pests. In general plant-based products have been used to control this pest along with the chemicals (Mishra *et al.*, 2004). .

Economics of different treatments

The benefit cost ratio depicted that Oxymatrine was found to be the best effective treatment recording higher benefit cost ratio *i.e.*, 1: 4.37. Although the Spinosad derived from the actinomycetes, *Saccharopolyspora spinosa* was effective in suppression of fruit borer population, it recorded benefit cost ratio of 1: 4.01 followed by acephate (1:3.25), carbaryl + wettable sulphur (1 : 1.266), pungam oil + illupai oil (1 : 1.244), pungam oil (1 : 1.74), NSKE (1 : 1.85), control (1: 1.79) and illupai oil (1 : 1.74). Plant-based products/extracts are having potential role in regulating the pest and also increase the horticulture crop production as mentioned by Gahukar (2006).

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