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COMPARATIVE EFFICACY OF MICROBIAL, BOTANICAL AND CHEMICAL INSECTICIDES AGAINST LEPIDOPTERAN PESTS IN CASTOR

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ABSTRACT

Studies were conducted to evaluate the efficacy of microbial [combination formulation of *Beauveria bassiana* + *Bacillus thuringiensis* var. *kurstaki* (*Btk*), indigenous and commercial formulations of *Btk*], botanical (karanj oil and neem seed kernel extract) and chemical (profenofos) insecticides against semilooper (*Achaea janata*) and capsule borer (*Conogethes punctiferalis*) in castor. In laboratory bioassay, *Btk* (Delfin®) @ 1g/L, combination formulation of *B. bassiana* + *Btk* @1.25 ml/L and 2 ml/L effected 100% mortality in third instar larvae of semilooper 48h after treatment as compared to 100% mortality by profenofos @ 1ml/L at 24h after treatment. *Btk* @1g/L and combination formulation of *B. bassiana* + *Btk* @ 2ml/L were found effective in reducing semilooper population (97.5% and 91.0% larval reduction over untreated control) and at par with profenofos (100% reduction over control) in field trial. However, their efficacy in reducing capsule borer damage (39.2 and 27.8% reduction over control, respectively) and seed yield obtained (1897 and 1836 kg/ha, respectively) was significantly lower than profenofos (53.6% reduction in capsule damage and seed yield of 2036 kg/ha) but superior over botanicals. Cocoons of larval parasitoid of semilooper, *Snellenius* (*Microplitis*) *maculipennis* were more in numbers in microbial and botanical treatments compared to profenofos. The microbial formulations *viz*., combination formulation of *B. bassiana* + *Btk* and *Btk* can be opted for inclusion as a component in the Integrated Pest Management in castor.

KEY WORDS
Castor
Lepidopteran pests
Profenofos, *Bacillus thuringiensis*, *Beauveria bassiana*, Combination formulation

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INTRODUCTION

Castor (*Ricinus communis* L.) is the most important non-edible oilseed crop of India. Its seed oil has multifarious applications in production of wide industrial products including medicine, cosmetics, lubricants, paints, biopolymers and biodiesel. The current castor production in the country is 22.95 lakh tonnes from 14.53 lakh hectares with a productivity of 1560 kg/ha (DAC, 2013). One of the major constraints in exploiting higher productivity in castor is the damage due to insect pests *viz*., semilooper, *Achaea janata* L. (Lepidoptera: Noctuidae) and capsule borer, *Conogethes* (*Dichocrosis*) *punctiferalis* Guen. (Lepidoptera: Pyralidae). Incidence of *A. janata* is generally noticed from vegetative to early reproductive phase of the crop (Lakshminarayana and Raoof, 2005). Over 50% defoliation is common in certain years due to semilooper. Infestation of *C. punctiferalis* starts from flowering stage onwards and the larvae web the tender capsules, bore inside, and feed on the kernels. The loss in seed yield due to capsule borer is upto 50% in recent years. So far, the use of synthetic insecticides has been the major approach for controlling these pests. The recommended insecticides are unsafe to *Snellenius* (*Microplitis*) *maculipennis* Zepligate, a potential and unique larval parasitoid of semilooper, which is parasitizing more than 75% of larvae in the field (Basappa and Lingappa, 2005). Microbial and botanical insecticides can provide an alternative eco-friendly option to manage these insect pests and conserve natural enemies (Vanlaldiki *et al*., 2013; Dhingra *et al*., 2012; Lakshminarayana, 2010). The present investigations were, therefore, undertaken to evaluate the efficacy of indigenous combination formulation of *Beauveria bassiana* + *Bacillus thuringiensis* and *Bacillus thuringiensis* formulations developed at Directorate of Oilseeds Research (DOR, 2012) along with commonly used microbial, botanical and chemical insecticides against the lepidopteran pests in castor under laboratory and field conditions.

MATERIALS AND METHODS

Test insects and host plants

Laboratory culture of semilooper, *Achaea janata* maintained on castor leaves following Bhadauria *et al*. (2002) at ambient conditions (27$\pm$2ºC, 60-70% RH) was used for the experiment. Castor plants of cv. VP1 raised in field without exposure to insecticides were used for the laboratory bioassays.

Laboratory bioassay of microbial, botanical and chemical insecticides against semilooper

Leaf dip bioassay method described by Shelton *et al*. (1993) was used to determine the efficacy of four microbial [Combination formulation of *Beauveria bassiana* 3.85×10^{8} conidia/ml + *Bacillus thuringiensis* var. *kurstaki* (*Btk*) 0.38g/mL at 1.25 and 2 mL/L, *Bacillus thuringiensis*-1 at 1g/L, *Bacillus thuringiensis*-5 at 1g/L and commercial formulation of *Bacillus thuringiensis* var. *kurstaki* (Delfin WG™) at 1g/L], two botanicals (karanj oil at 2mL/L and NSKE 5%) and a chemical (profenofos 50EC at 1mL/L) insecticide against third instar larvae of semilooper. The experiment was conducted in Completely Randomized Design. Unsprayed castor leaves (cv. VP1) along with the petiole collected from the field were surface sterilized with 0.5 per cent sodium hypochlorite, rinsed in sterile water and shade dried. These leaves were dipped in solutions of respective treatments for about 30 seconds and the excess fluid was drained off. Leaves treated with distilled water served as control. The leaf with the petiole immersed in water in a vial and allowed for shade drying. Each vial having the treated castor leaf was kept separately in a plastic jar (30 cm x 15cm) and third instar larva of semilooper was released. Ten larvae were released per replication. Likewise three replications were maintained for each treatment. The plastic jars were covered with muslin cloth and kept at ambient conditions (27±2°C, 60-70% RH). Observations on the mortality of the larvae were taken at 24, 48 and 72 hours after treatment.

Field evaluation of microbial, botanical and chemical insecticides against semilooper and capsule borer in castor

A field trial was conducted at Research Farm, Directorate of Oilseeds Research, Rajendranagar, Hyderabad (latitude 17.53°N, longitude 78.27°E, altitude 545 m a.s.l.) to evaluate efficacy of microbial, botanical and chemical insecticides against semilooper (*A. janata*) and capsule borer (*C. punctiferalis*) in castor hybrid DCH-519 during *kharif* 2012-13. The experiment was conducted in a Randomized Block Design with a plot size of 5.4 x 4.5 m with three replications following a spacing of 90 x 90 cm. All agronomic practices were followed as per the recommendations except for insect-pest management. Bioefficacy of two microbial [Combination formulation of *B. bassiana* 3.85×10^8 conidia/mL +*B. thuringiensis* 0.38g/mL at 1.25 and 2 ml/L and commercial formulation of *Bacillus thuringiensis* var. *kurstaki* (Delfin WG™) at 1g/L], two botanical (karanj oil @ 2mL/L and NSKE5%) and a chemical (Profenofos 50EC@1mL/L) insecticides was determined against semilooper and capsule borer along with untreated control. Two sprays were imposed using high volume knapsack sprayer (500L/ha) during vegetative and capsule development (in secondary and tertiary spikes) stage against semilooper and capsule borer, respectively. Observations on semilooper larvae were recorded from five randomly selected plants from each replication at one day before and 3, 7 and 14 days after spraying and the mean larvae per plant worked out. Observations on the cocoon of larval parasitoid of semilooper, *S. maculipennis* were also recorded. Number of capsules damaged by the capsule borer was recorded from five randomly selected plants from each treatment at one day before and 7 and 14 days after spraying and then per cent capsule damage was worked out. Finally the yield was recorded on the net plot area basis which was later converted to kg/ha and subjected to statistically analysis. The economics of treatments was worked out based on the yield and cost of protection.

Statistical methods

For laboratory bioassays, the per cent mortalities were transformed to arcsine percentage and subjected to statistical analysis adopting CRD. In the RBD analysis, the percentage values were transformed to arcsine percentage and numbers to square root transformation and subjected to statistical analysis using Agres statistical software. Following ANOVA, differences between datasets were determined using least significant difference at P = 0.05 in all instances.

RESULTS AND DISCUSSION

Laboratory bioassay of microbial, botanical and chemical insecticides against semilooper

Leaf dip bioassay revealed that profenofos @ 1 mL/L was found to be highly effective against semilooper causing 100% larval mortality at 24h after treatment followed by *Btk* (Delfin) @1g/L, combination formulation of *B. bassiana* + *B. thuringiensis* @ 1.25 ml/L and 2 ml/L caused 100% mortality at 48h after treatment. Indigenous Bt-1 and Bt-5 formulations effected 100%

Table 1: Effect of microbial, botanical and chemical insecticides on semilooper (*A. janata*) and its larval parasitoid (*S. maculipennis*) in castor (*kharif* 2012-13)

Treatment	Semilooper (Larva/plant)						Semilooper parasitoid (*S. maculipennis*) cocoon/plant			
	PTC	3DAT	7DAT	14DAT	Mean	% reduction over control	3 DAT	7 DAT	14DAT	Mean
B. bassiana + *B. thuringiensis*@1.25ml/L	1.6	0.4 (0.94) ^{b}	0.3(0.86) ^{ab}	0.1(0.79) ^{ab}	0.27	77.9	0.47 (0.98)^b	0.33 (0.91)^b	0.33(0.91)^{bc}	0.38
B. bassiana + *B. thuringiensis*@2ml/L	1.7	0.3(0.85) ^{ab}	0.1 (0.74) ^{a}	0.0(0.70) ^{a}	0.11	91.0	0.53 (1.01)^b	0.27(0.88)^b	0.20(0.84)^{bc}	0.33
B. thuringiensis var. *kurstaki* @ 1g/L	2.1	0.1(0.79) ^{ab}	0.0 (0.70) ^{a}	0.0(0.70) ^{a}	0.03	97.5	0.40 (0.95)^b	0.20(0.84)^{bc}	0.20(0.83)^{bc}	0.27
NSKE 5%	1.9	0.5(0.97) ^{b}	0.3 (0.87) ^{ab}	0.1(0.79) ^{ab}	0.29	76.2	0.93 (1.19)^a	0.33(0.91)^b	0.40(0.94)^{ab}	0.56
Karanj oil @ 2ml/L	2.1	0.4(0.94) ^{b}	0.4 (0.92) ^{b}	0.3(0.86)^b	0.36	70.5	0.87 (1.16)^a	0.40(0.95)^b	0.33(0.91)^{bc}	0.53
Profenofos @1ml/L	2.0	0.0(0.70) ^{a}	0.0 (0.70) ^{a}	0.0(0.70) ^{a}	0.0	100	0.20 (0.84)^c	0.07(0.75)^c	0.13(0.80)^c	0.13
Untreated control	1.7	2.1(1.61) ^{c}	0.9 (1.19) ^{c}	0.6(1.04)^c	1.22	-	1.07 (1.25)^a	0.80(1.14)^a	0.67(1.07)^a	0.84
S.E. m±	-	0.11	0.12	0.09	-	-	0.05	0.06	0.07	-
CD (P=0.05)	NS	0.23	0.27	0.21	-	-	0.11	0.12	0.15	-
CV(%)	-	13.2	20.2	18.4	-	-	5.9	7.5	9.3	-

Figures in parentheses are square root transformed values, PTC – Pre treatment count, DAT - Days after treatment; In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

Table 2: Effect of microbial, botanical and chemical insecticides on capsule borer (*C. punctiferalis*) and yield and economics in castor (*kharif* 2012-13)

Treatment	Capsule damage (%) PTC	7 DAT	14DAT	Mean	% reduction	Yield (kg/ha) over control	Increase in yield over control (%)	Increase in yield over control (kg)	*Cost of increased yield (Rs)	#Cost of Treatment (Rs)	Net Profit (Rs)	ICBR (Rs)
B. bassiana + *B. thuringiensis*@1.25mL/L	9.2	8.3(16.7)^{cd}	8.2(16.6)^{cd}	8.3	14.4	1720^{bc}	7.8	124	3596	1278	2318	1:1.81
B. bassiana + *B. thuringiensis*@2mL/L	8.5	7.2(15.5)^{bc}	6.7(15.0)^{b}	7.0	27.8	1836^{abc}	15.0	240	6960	1662	5298	1:3.19
B. thuringiensis var. *kurstaki* @ 1g/L	7.1	5.5(13.4) ^{ab}	6.3(14.5)^{b}	5.9	39.2	1897^{ab}	18.9	301	8729	3840	4889	1:1.27
NSKE 5%	7.7	8.0(16.4)^{cd}	7.4(15.8)^{bc}	7.7	20.6	1758^{bc}	10.2	162	4698	2140	2558	1:1.19
Karanj oil @ 2mL/L	10.1	9.5(17.9)^{de}	8.4(16.8)^{cd}	9.0	7.2	1643^{bc}	3.0	47	1363	1136	227	1:0.19
Profenofos @1mL/L	7.9	4.7(12.5)^{a}	4.3(11.9)^{a}	4.5	53.6	2036^{a}	27.6	440	12760	1344	11416	1:8.49
Untreated control	8.1	10.6 (19.0) ^{e}	8.8(17.2)^{d}	9.7	-	1596^{c}	-	-	-	-	-	-
S.E. m±	-	1.0	0.6	-	-	119	-	-	-	-	-	-
CD (P=0.05)	NS	2.2	1.4	-	-	259	-	-	-	-	-	-
CV(%)	-	7.9	4.9	-	-	8.2	-	-	-	-	-	-

*Cost of castor seed- Rs. 29/kg #Labour charges included; Figures in parentheses are arc sin transformed values, PTC - Pre treatment count, DAT - Days after treatment; In a column, means followed by a common letter(s) are not significantly different by LSD (P=0.05)

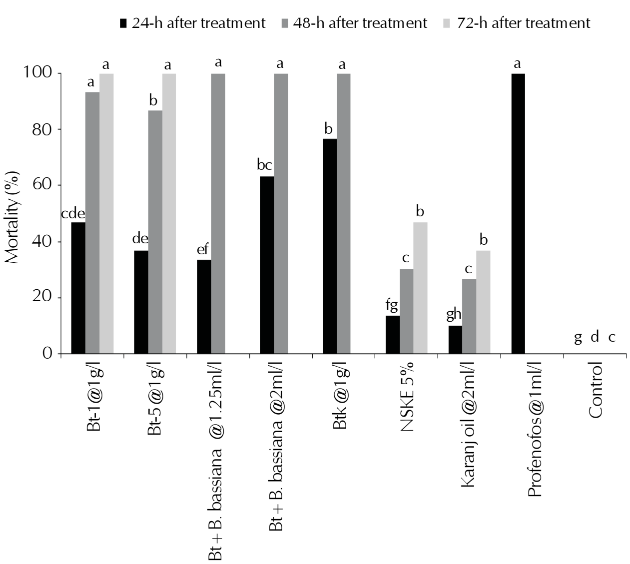

Figure 1: Laboratory evaluation of microbial, botanical and chemical insecticides against 3rd instar larvae of semilooper (*A. janata*)

mortality at 72h after treatment and were significantly higher than NSKE5% (46.7%) and karanj oil @ 2mL/L (36.7%) (Fig. 1).

Field evaluation of microbial, botanical and chemical insecticides against semilooper and capsule borer in castor

The mean population of semilooper larvae in different treatments before and at different intervals after spray is presented in Table 1. The incidence of semilooper before spraying ranged from 1.6 to 2.1 larvae/plant. There was a significant reduction in semilooper population after spraying of the microbial, botanical and chemical insecticides over untreated control. Profenofos @1mL/l recorded significantly lower infestation of semilooper (nil larval population up to 14 days after spray) over other treatments. Efficacy of *Btk* @1g/L and combination formulation of *B. bassiana* + *B. thuringiensis* @2mL/L were at par with profenofos in reducing semilooper population (0.0 to 0.1 and 0.0 to 0.3 larvae/plant, respectively) and superior over botanicals and untreated control. The results from the pooled mean data after spray revealed that profenofos @1mL/L was superior and effected 100% reduction in larval population of semilooper over untreated check followed by *Btk* (97.5%) and combination formulation of *B. bassiana* + *B. thuringiensis* @ 2mL/L (91.0%).

The effect of spray treatments on the semilooper larval parasitoid, *S. maculipennis* recorded at different intervals after spray revealed that all the botanical and microbials treatments were safer and recorded significantly higher numbers of cocoons of the larval parasitoid compared to profenofos (Table 1). The pooled mean data on the effect of treatments on the larval parasitoid also revealed more numbers of parasitoid cocoons in untreated control (0.84/plant), NSKE 5% and karanj oil 2ml/L treatments (0.56 and 0.53/plant) followed by combination formulations of *B. bassiana* + *B. thuringiensis* (0.33 to 0.38/plant) and *Btk* (0.27/plant) over profenofos treated plots (0.13/plant).

The per cent capsule damage due to capsule borer before imposing treatments ranged from 7.1 to 10.1%. Capsule damage recorded at different intervals after spray revealed that the treatment profenofos significantly excelled over microbials and botanicals in reducing the damage (Table 2). Profenofos registered lower infestation of 4.3 to 4.7% capsule damage, which was followed by *Btk* @1g/L (5.5 to 6.3%) and combination formulation of *B. bassiana* + *B. thuringiensis* @2mL/L (6.7 to 7.2%). Botanicals *viz.*, NSKE5% and karanj oil 2ml/L treated plots registered maximum of 7.4 to 9.5% capsule damage and were on par with untreated control (8.8 to 10.6%). The pooled mean data showed that the treatment profenofos effected a maximum reduction of 53.6% in damage over control and found superior in bringing down the level of infestation of capsule borer over microbials (14.4 to 39.2%) and botanicals (7.2 to 20.6%). Profenofos 50EC @1 mL/L recorded highest yield of 2036 kg/ha, which was followed by *Btk* @1g/L (1897kg/ha) and combination formulation of *B. bassiana* + *B.

thuringiensis @2mL/L (1836kg/ha). Further, increasing yield over control was higher in profenofos 50EC (27.6%) followed by *Btk* @1g/L (18.9%) and *B. bassiana* + *B. thuringiensis* @2mL/L (15.0%) over botanical treatments (3 to 10.2%). Net profit over untreated control was maximum in case of profenofos (Rs.11416/ha) followed by combination formulation of *B. bassiana* + *B. thuringiensis* @2mL/L (Rs.5298/ha) and *Btk* @1g/L (Rs. 4889/ha). The cost effectiveness of profenofos was high with incremental cost-benefit ratios of 1: 8.49, followed by *B. bassiana* + *B. thuringiensis* @2mL/L (1: 3.19), *B. bassiana* + *B. thuringiensis* @1.25mL/L (1: 1.81) and *Btk* (1: 1.27) (Table 2).

The results of the laboratory and field experiments distinctly revealed that profenofos 50EC@1mL/L followed by *Btk* @1g/L and combination formulation of *B. bassiana* + *B. thuringiensis* @2mL/L were effective in management of semilooper as compared to botanicals. Earlier workers have demonstrated the effectiveness of profenofos (Bassappa and Lingappa, 2002) and *Bt* (Vimala Devi and Hari, 2010) against semilooper. The information on the efficacy of combination formulation of *B. bassiana* + *B. thuringiensis* against *A. janata* is lacking to compare with present investigations. Similar to present findings, combination formulation of *B. bassiana* + *B. thuringiensis* were found to be effective against *H. armigera* on sunflower and on par with conventional insecticides (DOR, 2013). All these reports were in conformity with the present findings. The results on the safety of botanicals and microbials to semilooper larval parasitoid, *S. maculipennis* over profenofos under field conditions are in accordance with the findings of Basappa and Lingappa (2005).

Profenofos 50EC @ 1mL/L alone gave significantly better results in reducing the capsule borer damage over microbial and botanical treatments. This is consistent with the reports of Rajabaskar and Regupathy (2013), who found that profenofos 0.05% was found effective against *C. punctiferalis* over neem formulations in cardamom. Furthermore, the lower persistence of botanicals and microbials under field condition due to photodegradation (Haddad *et al.*, 2005; Selvanarayanan and Karthikeyan, 2013) might not be sufficient to give better protection against the internal feeding capsule borer as that of chemical insecticides.

Chemical insecticides probably continue to be the most effective control strategy to date. However, their detrimental effects are a cause of public concern, which calls for rationalized use of insecticides and reorientation of protection strategies towards ecologically sound pest management. The present study thus revealed that combination formulation of *B. bassiana* + *B. thuringiensis* and *Bacillus thuringiensis* var. *kurstaki* were promising against semilooper coupled with safety to its larval parasitoid, *S. maculipennis*, and can be opted for inclusion as component in the Integrated Pest Management in castor.

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