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RESEARCH **P**APER

Laboratory evaluation of entomopathogenic fungus alone or in combination with edible oils on progeny adult build-up of lesser grain borer on stored paddy

P. JYOTHI[1], N. SAMBASIVA RAO[2] **AND** R. LAKSHMIPATHY[3]

[1]Department of Entomology, Agricultural College Campus, BAPATLA (A.P.) INDIA
[2]Post Harvest Technology Centre, Agricultural College Campus, BAPATLA (A.P.) INDIA
[3]Microbiology Laboratory, Agricultural College Campus, BAPATLA (A.P.) INDIA

The entomopathogenic fungi, *Beauveria bassiana* (2 x 10^6conidia/g), *Metarhizium anisopliae* (1 x 10^9 conidia/g) and *Lecanicillium lecanii* (2 x 10^7 conidia/g) @ 5 g/l as bag treatment and 5g/kg of paddy as grain treatment alone, their interactions and the compatibility of entomopathogenic fungi @ 5g/kg with two vegetable oils (2 ml/kg) *viz.*, sunflower oil and groundnut oil were tested against the progeny build-up of lesser grain borer, *R. dominica.* In the grain treatment, least progeny of 122.33 was observed with *B. bassiana* followed by *M. anisopliae* (130.67) which were at par at 180 DAT. Among the bag treatment, *M. anisopliae* recorded the lower progeny of 266.33 followed by *B. bassiana* (291.00) and *L. lecanii* (298.67) which were at par with each other but were significantly different from control (366.33). In the study of interaction effects, *Beauveria* + *Metarhizium* + *Lecanicillium* had recorded least progeny of 119.67 followed by *Beauveria* + *Metarhizium* (122.00) and were superior over all other treatments. In the study of compatibility of entomopathogenic fungi with edible oils, progeny build up recorded at 180 DAT was found to be less with *Beauveria* + Groundnut oil (118.33) followed by *Metarhizium* + Groundnut oil (121.33) compared to oils alone, sunflower (307.67) and groundnut (252.33) but were significantly different from control (517.00).

Key words : *Beauveria, Lecanicillium, Metarhizium, Rhyzopertha dominica,* Sunflower oil

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INTRODUCTION

Paddy is the most important staple food crop of India. Indian population of about 65 per cent is dependent on rice for food stuff. After harvesting, unprocessed paddy will be stored for various lengths of time at producers, wholesalers and millers level. While in storage, paddy is at risk to infestation by a wide range of stored product insects like rice moth (*Corcyra cephalonica* Stainton), rice weevil (*Sitophilus oryzae* Linn.) and lesser grain borer (*Rhyzopertha dominica* Fabricius) and mites (Wakefield, 2006). Lesser grain borer, *R. dominica* is a major insect pest of many stored grains, including rice (Arthur *et al.*, 2007). The infestations of *R. dominica* cause loss of biomass (Swaminathan, 1977), decrease in grain quality through feeding damage (Williams *et al.*, 1981). Losses due to this pest have been estimated at 15 per cent or more of total grains stored each year (Batta, 2005).

Application of insecticides is one of the preventing measures to reduce losses during storage period. The continuous use of chemical insecticides for control of storage grain pests has also resulted in serious problems such as resistance to the insecticides, pest resurgence, elimination of economically beneficial insects, and toxicity to humans and wildlife (Padin *et al.*, 2002). These problems and the demand for pesticide free foods have triggered efforts to find alternative management options (Padin *et al*., 2002). Microbial pesticides are one such alternative to tackle insecticide problems. Several reports are available on efficacy of entomopathogenic fungi like *Beauveria bassiana* (Balsamo) Vuiillemin, *Metarhizium anisopliae* (Metschnikoff) Sorokin and *Lecanicillium lecanii* Zimmerman on storage insect pests. Zimmermann (2007a and b) reported that *B. bassiana* and *M. anisopliae* are considered to be safe with minimal risks to vertebrates,

humans and the environment. In the present study, the effect of entomopathogenic fungi, *B. bassiana*, *M. anisopliae* and *L. lecanii*, their interaction and the compatibility of entomopathogenic fungi with vegetable oils on progeny build-up of lesser grain borer, *R. dominica* of paddy were reported.

RESEARCH METHODOLOGY

The experiment was conducted at Post Harvest Technology Center, Agricultural College, Bapatla, Guntur district, Andhra Pradesh during the year 2011-12. The fungal isolates of *B. bassiana*, *M. anisopliae* and *L. lecanii* were procured from Plant Pathology laboratory, Directorate of Oilseeds Research, Rajendranagar, Hyderabad, Andhra Pradesh. The paddy variety BPT 5204 (Sambamashuri) was procured from Rice Research Unit, Bapatla, Guntur District, Andhra Pradesh. The three entomopathogenic fungi, *B. bassiana*, *M. anisopliae* and *L. lecanii* were further tested for their purity by plating them on Martin Rose Bengal agar medium. The pure cultures of these fungi were maintained and preserved on Potato dextrose agar (PDA) (potato – 250 g, agar- 16 g, dextrose – 20 g) plants at refrigerated condition for further studies. Further, these cultures were mass multiplied by inoculating into the flask containing sterilized Potato Dextrose Broth (PDB) under aseptic conditions in Laminar Air Flow (LAF) chamber. After inoculation, the flasks were incubated at 32°C in a bacteriological incubator till the profused sporulation was attained. Then the mycelia mat along with spores was thoroughly macerated in a sterile pestle and mortar. The macerated material was then transferred to sterile conical flasks under aseptic conditions. The suspension of the fungi was mixed to the sterile talc powder at the rate of 1: 4 (250 ml/kg of carrier material). The population of the fungi in the talc powder formulation was determined by standard dilution technique by using MRBA and the populations of the fungi were 2 $x10^6$, 1 x 10^9, and 2 x 10^7/g in *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, respectively.

Adults of lesser grain borer, *R. dominica* were collected from the stock culture of Entomology laboratory, Post Harvest Technology Centre, Agricultural College, Bapatla and were transferred into 250 g of disinfested paddy grains (BPT 5204) in a plastic jar of 1 L capacity. The released adults were allowed for 20 days to lay sufficient eggs in culture jars, later the adults were removed and the jars were kept for progeny adult emergence. The jars were regularly observed for adult emergence after 30 days of release. The newly emerged adults were used for experimental purpose.

Bag treatment and grain treatment :

For bag treatment 5 g of each fungal formulation *B. bassiana*, *M. anisopliae* and *L. lecanii* was mixed with 1 L of water and 2-3 drops of surfactant (Tween 80) was added to the mixture. Then the jute bags were immersed in the water mixture till the bags are completely wet, later the bags were taken out and dried under shade till they dry completely. The treated bags were filled with 250 g of paddy grain and five pairs of freshly emerged adults (0-24 h old) were released into the bags and kept in 1 L capacity plastic jars covered with muslin cloth to prevent the escape of adults from the bags. For grain treatment, 1.25 g of fungal dust formulation was directly added to 250 g of paddy grain and mixed thoroughly till all the dust distributed uniformly on the grain. Later the treated grain was kept in 0.5 L plastic jar, five pairs of freshly emerged adults (0-24 h old) were released and covered with muslin cloth for aeration. Three replications were maintained for both bag treatment and grain treatment.

Interaction treatments of entomopathogenic fungi against progeny build-up of lesser grain borer :

The fungal formulations of 1.25 g each of *B. bassiana*, *M. anisopliae* and *L. lecanii*, 0.625 g each of *B. bassiana* + *M.anisopliae*, *B.bassiana* + *L. lecanii* and *M. anisoplea* + *L. lecanii* and 0.3125 g each of *B. bassiana* + *M. anisoplea* + *L. lecanii* were added to 250 g of paddy separately in each replication and mixed the grain thoroughly till all the dust distributed uniformly on the grain.

Compatibility treatments of entomopathogenic fungi with the edible oils :

Sunflower oil (0.625 ml), groundnut oil (0.625 ml), *B. bassiana* in sunflower oil (1.25 g + 0.625 ml), *B. bassiana* in groundnut oil (1.25 g + 0.625 ml), *M. anisopliae* in sunflower oil (1.25 g + 0.625 ml), *M. anisopliae* in groundnut oil (1.25 g + 0.625 ml), *L. lecanii* in sunflower oil (1.25 g + 0.625 ml) and *L. lecanii* in groundnut oil (1.25 g + 0.625 ml) were added to 250 g of paddy separately in each replication and mixed the contents with grain thoroughly till all the contents were distributed on it. Later the treated grain was kept in 0.5 L plastic jar, five pairs of freshly emerged adults (0-24 h old) were released and covered with muslin cloth for aeration. Three replications were maintained for each treatment. The experiment was conducted under ambient conditions. Observations were recorded for six months on the progeny build-up from 30 DAT to 180 DAT at fortnight interval. The progeny build-up was transformed into square root values and was subjected to Complete Randomized Design (CRD) analysis.

RESEARCH FINDINGS AND ANALYSIS

The findings of the present study as well as relevant discussion have been presented under the following heads :

Effect of entomopathogenic fungi on progeny build-up of lesser grain borer under bag and the grain treatment :

The results in Table 1 revealed that the observations

recorded on 30 DAT showed that the bag treated with *M. anisopliae* recorded a progeny of 20.33 followed by *B. bassiana* (20.67) and *L. lecanii* (22.00) which were at par with each other and were not significantly different from control (22.67). Among the grain treatment *B. bassiana* was most effective and caused less progeny of 6.67 which was at par with *M. anisopliae* (7.33) and *L. lecanii* (9.00).

The observations recorded on 60 DAT on progeny adult build-up indicated that the grain treated with *M. anisopliae* showed less progeny of 32.00, which was at par with *B. bassiana* (36.00) and *L. lecanii* (38.33) and were significantly different from all other treatments. Among the bag treatment, *M. anisopliae* and *B. bassiana* recorded equal progeny of 85.67 which were at par with *L. lecanii* (89.67). Based on the data it was evident that grain treatment showed better results than bag treatment. All the treatments were significantly different from control (193.00).

The observations on 90 DAT showed that grain treated *B. bassiana* recorded less progeny of 59.00 which was at par with *M. anisopliae* (65.33) and *L. lecanii* (69.00) and were significantly different from all other treatments. Among the bag treatment *M. anisopliae* recorded 208.33 progeny adults followed by *B. bassiana* (209.00) and *L. lecanii* (217.33) which were at par with each other and were not significantly different from control (285.33).

The observations at 120 DAT indicated that the grain treated with *B. bassiana* and *M. anisopliae* recorded equal progeny of 74.67, which were at par with *L. lecanii* (88.00) and were significantly different from all other treatments. Among the bag treatment, *M. anisopliae* showed the progeny of 209.67 which was at par with *B. bassiana* (236.33) and *L. lecanii* (238). All the treatments were significantly different from control (484.33).

The data recorded on 150 DAT showed that grain treated with *B. bassiana* was most effective and caused less progeny of 90.33 which was at par with *M. anisopliae* (95.00) and was significantly different from *L. lecanii* (128.00) and other treatments. Among the bag treatment *M. anisopliae* recorded 231.00 progeny adults which was at par with *B. bassiana* (239.67) and *L. lecanii* (250.00). All these treatments were significantly different from the control (459.00). The data recorded on 180 DAT showed less progeny development in *B. bassiana* treated grain (122.33) which was at par with *M. anisopliae* (130.67) and both were significantly different from

Table 1 : Effect of entomopathogenic fungi against the progeny build-up of lesser grain borer under the bag and grain treatment

Treatments	Dosage	Progeny adult build-up (No.)										
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	150 DAT	165 DAT	180 DAT
Beauveria bassiana(bag treatment)	5 g/L	20.67 (4.59) a	38.67 (6.23)bc	85.67 (9.27) b	169.00 (13.01) a	209.00 (14.45) a	217.00 (14.74) a	236.33 (15.39) b	235.33 (15.35) b	239.67 (15.49) b	267.33 (16.36) b	291.00 (17.07) b
Metarhizium anisopliae (bag treatment)	5g/ L	20.33 (4.55) a	37.00 (6.12)bc	85.67 (9.28) b	167.33 (12.91) a	208.33 (14.44) a	212.33 (14.58) a	209.67 (14.48) b	219.33 (14.81) b	231.00 (15.19) b	251.67 (15.87) b	266.33 (16.32) b
Lecanicillium lecanii (bag treatment)	5g/ L	22.00 (4.74) a	49.67 (7.07) b	89.67 (9.49) b	181.67 (13.50) a	217.33 (14.75) a	230.67 (15.20) a	238.00 (15.44) b	246.33 (15.71) b	250.00 (15.82) b	277.00 (16.66) b	298.67 (17.28) b
Beauveria bassiana (grain treatment)	5g/k g	6.67 (2.65) b	19.33 (4.45) c	36.00 (6.03) c	40.33 (6.37) b	59.00 (7.71) b	68.00 (8.27) b	74.67 (8.64) c	96.33 (9.83) c	90.33 (9.53) d	96.33 (9.84) d	122.33 (11.08)d
Metarhizium anisopliae (grain treatment)	5g/k g	7.33 (2.79) b	20.33 (4.56) c	32.00 (5.70) c	40.33 (6.36) b	65.33 (8.10) b	69.67 (8.36) b	74.67 (8.66) c	101.33 (10.09)c	95.00 (9.76) cd	107.33 (10.37) d	130.67 (11.45) d
Lecanicillium lecanii (grain treatment)	5g/k g	9.00 (3.06) b	23.67 (4.91) c	38.33 (6.22) c	50.00 (7.09) b	69.00 (8.34) b	82.67 (9.11) b	88.00 (9.40) c	114.67 (10.72)c	128.00 (11.33) c	143.33 (11.98) c	168.67 (13.00) c
Control		22.67 (4.81) a	132.67 (11.34)a	193.00 (13.48)a	249.00 (15.42) a	285.33 (16.54) a	356.67 (18.39) a	484.33 (21.92) a	521.00 (22.79) a	459.33 (21.38)a	405.33 (20.13) a	366.33 (19.14)a
S.E. ±		0.21	0.61	0.93	1	1	1.19	0.61	0.46	0.55	0.34	0.33
C.D. (P = 0.05)		0.64	1.85	2.84	3.03	3.03	3.62	1.85	1.39	1.66	1.03	1.01

DAT- Days After Treatment, The values in parentheses are transformed values
In each column values with similar alphabet do not vary significantly at 5%

L. lecanii (168.67). Among the bag treatment, *M. anisopliae* recorded less progeny of 266.33 which was at par with *B. bassiana* (291.00) and *L. lecanii* (298.67). All the treatments were significantly different from control (366.33).

The present results are in agreement with Rice and Cogburn (1999) who reported F_1 progeny of 6.5 and 41.3 of *R. dominica* and *S. oryzae*, respectively at 1 x 10^6 conidia/ml on long grain rough rice. The emergence of adult rice weevil progeny was reduced by 86.2 per cent with *B. bassiana* (3.9 x 10^7) mixed with rice (Sheeba *et al.*, 2001). Throne and Lord (2004) reported that the no. of *Oryzaephilus surinamensis* progeny adults produced was reduced by 38 - 67 per cent in whole oats at 10 mg of *B. bassiana* conidia/kg and there was no effect of the fungus on insects developing on cracked oats. Application of *M. anisopliae* @ 8 x 10^6 conidia/kg resulted in less progeny in *R. dominica* (12.1) and *S. oryzae* (31.7) after 2 months of treatment (Kavallieratos *et al.*, 2006). Pedrini *et al.* (2010) demonstrated than *B. bassiana* strain GHA (1 x 10^8) caused a progeny reduction of 37.5 per cent for *T. castaneum* after 3 months in wheat. Hafez (2011) reported less progeny of *T. confusum* between untreated and treated wheat as 204.33 and 57.28 with *B. bassiana* (1% w/w) after 2 months of treatment. Less progeny of *R. dominica* in wheat (39.67) was recorded with *B. bassiana* at 2.23 x 10^9 conidia/kg after 2 months of treatment (Tahira *et al.*, 2011). El-Sebai (2011) demonstrated that less F_1 progeny of *R. dominica* (16) was recorded with *B. bassiana* (1% w/w) in wheat.

Interaction effects of entomopathogenic fungi against the progeny build-up of lesser grain borer :

The data pertaining to the interaction effects of entomopathogenic fungi against the progeny of *R. dominica* are presented in Table 2. The observations recorded on 30 DAT showed that *Beauveria* + *Metarhizium* + *Lecanicillium* and *Beauveria* were most effective and recorded equal progeny of 4.3 and were at par with *Metarhizium* (5.0), *Beauveria*+ *Metarhizium* (5.3), *Beauveria* + *Lecanicillium* (5.7) and *Metarhizium* + *Lecanicillium* (6.7) but was significantly different from *Lecanicillium* (8.3). All these treatments were significantly different from control (26.0) (Table 2).

The data at 60 DAT showed less progeny with *Beauveria* + *Metarhizium* + *Lecanicillium* (18.3) which was at par with *Beauveria* + *Metarhizium* (20.7), *Metarhizium* (27.3), *Beauveria* (29.9) and *Beauveria*+ *Lecanicillium* (29.9). The highest progeny was recorded with *Lecanicillium* (42.0) and *Metarhizium* + *Lecanicillium* (38.3) which was at par with each other. All the treatments were significantly different from control (319.0) (Table 2).

At 90 DAT lowest progeny was recorded with *Beauveria* + *Metarhizium* + *Lecanicillium* (40.7) followed by *Beauveria* + *Metarhizium* (48.3), *Beauveria* (50.3), *Beauveria* +

Table 2 : Interaction effects of entomopathogenic fungi against the progeny adult build-up of lesser grain borer, *R. dominica*

Treatments	Dosage (g/kg)	Progeny adult build-up (No.)										
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	150 DAT	165 DAT	180 DAT
Beauveria bassiana	5	4.33 (2.19)c	14.67 (3.87) c	29.94 (4.81) bc	49.67 (7.08) b	50.33 (7.11) b	61.33 (7.85) bc	72.33 (8.51) bc	74.33 (8.64) c	103.67 (10.19) cd	118.00 (10.87) c	133.33 `(11.55)bc
Metarhizium anisopliae	5	5.00 (2.34)bc	17.67 (4.22) bc	27.33 (5.21) bc	51.67 (7.22) b	60.33 (7.80) b	80.33 (8.98) bc	76.67 (8.77) bc	82.33 (9.10) c	110.00 (10.50) c	125.00 (11.20) c	144.00 (12.00) c
Lecanicillium lecanii	5	8.33 (2.96) b	27.00 (5.24) b	42.00 (6.52) b	53.33 (7.33) b	69.00 (8.33) b	91.67 (9.57) b	96.67 (9.86) b	108.00 (10.40) b	139.33 (11.82) b	157.67 (12.58) b	175.67 (13.27) b
Beauveria + Metarhizium	2.5 +2.5	5.33 (2.41) bc	14.33 (3.83) c	20.67 (4.60) c	42.33 (6.54) b	48.33 (6.98) b	62.33 (7.91) bc	63.00 (7.97) c	67.00 (8.21) c	93.00 (9.67) cd	103.67 (10.19) c	122.00 (11.06) d
Beauveria + Lecanicillium	2.5 +2.5	5.67 (2.44) bc	19.02 (4.71) bc	29.94 (4.81) bc	50.33 (7.12) b	52.00 (7.23) b	78.33 (8.85) bc	74.33 (8.65) bc	80.00 (8.96) c	99.33 (9.98) cd	118.00 (10.87) c	137.67 (11.74) bc
Metarhizium+Lecanicillium	2.5 +2.5	6.67 (2.68) bc	25.33 (5.08) b	38.33 (6.21) bc	56.67 (7.56) b	57.33 (7.60) b	84.67 (9.23) b	77.67 (8.83) bc	86.00 (9.30) bc	106.67 (10.35) c	123.00c (11.11)	138.67 (11.79) bc
Beauveria + Metarhizium + Lecanicillium	1.67+1.67 + 1.67	4.33 (2.18) c	14.00c (3.79)	18.33c (4.32)	41.00b (6.43)	40.67 (6.38) b	50.00 (7.10) c	63.00 (7.97) c	64.67 (8.07) c	88.33 (9.42) d	104.00c (10.22)	119.67 (10.95) d
Control		26.00 (5.11) a	131.33 (11.42) a	319.00 (17.76) a	428.33 (20.63) a	514.33 (22.58)a	537.67 (23.11) a	530.00 (22.96) a	530.67 (23.01) a	462.67 (21.52) a	409.00 (20.22) a	398.67 (19.98) a
S.E. ±		0.24	0.40	0.58	0.48	0.62	0.59	0.51	0.40	0.27	0.37	0.34
C.D. (P = 0.05)		0.73	1.21	1.74	1.43	1.86	1.78	1.54	1.20	0.81	1.10	1.03

DAT – Days After Treatment

The values in parentheses are transformed values, In each column values with similar alphabet do not vary significantly at 5%

Lecanicillium (52.0), *Metarhizium* + *Lecanicillium* (57.3). The highest progeny were recorded with *Lecaniciilium* (69.0) followed by *Metarhizium* (60.3). All the treatments were at par with each other and were significantly different from control (514.3) (Table 2). Similar trend was observed at 120 DAT with less progeny adult build up was recorded in *Beauveria* + *Metarhizium* + *Lecanicillium* (63.0) and *Beauveria* + *Metarhizium* (63.0) which were at par with *Beauveria* (72.3), *Beauveria* + *Lecanicillium* (74.3), *Metarhizium* (76.7) and *Metarhizium* + *Lecanicillium* (77.7) and were significantly different from *Lecanicillium*. All the treatments were significantly different from control (530.0) (Table 2).

The results with regard to effect of treatments after 150 days of treatment showed less progeny build up with *Beauveria* +*Metarhizium* + *Lecanicillium* (88.3) which was at par with *Beauveria* + *Metarhizium* (93.0), *Beauveria*+ *Lecanicillium* (99.3) and *Beauveria* (103.7) and was significantly different from *Metarhizium* + *Lecanicillium* (106.7) and *Metarhizium* (110.0). All the treatments were significantly different from *Lecanicillium* (139.3) that showed least significance but was significantly different from control (462.7).

The observations recorded at 180 DAT indicated that *Beauveria* +*Metarhizium* + *Lecanicillium* was superior among all treatments with less progeny of 119.7 that was at par with *Beauveria* +*Metarhizium* (122.0) and was significantly different from all other treatments. *Beauveria* (133.3), *Beauveria* + *Lecanicillium* (137.7), *Metarhizium* + *Lecanicillium* (138.7). Highest progeny was recorded with *Lecanicillium* (175.7) followed by *Metarhizium* (144). All the treatments were significantly different from control (398.7) (Table 2).

Compatibility effect of entomopathogenic fungi with edible oils against the progeny build-up of lesser grain borer :

Among the treatments at 30 DAT, *Metarhizium* + groundnut oil recorded less progeny adults of 5.33 which was at par with *Lecanicillium* + groundnut oil (5.67), *Lecanicillium* + sunflower oil (6.00), *Beauveria* + groundnut oil (6.00), *Beauveria* + sunflower oil (6.00) and *Metarhizium* + sunflower oil (6.67). Highest progeny was recorded with sunflower oil (9.33) followed by groundnut oil (8.33) which were at par with each other. All the treatments were significantly different from control (15.00) (Table 3).

The data recorded on 60 DAT showed less progeny build up with *Beauveria* + groundnut oil (35.33) which was at par with *Metarhizium* + groundnut oil (37.67), *Beauveria* + sunflower oil (39.33), *Lecanicillium* + sunflower oil (47.00), *Metarhizium* + sunflower oil (52.00), *Lecanicillium* +

Table 3 : Compatibility effect of entomopathogenic fungi with edible oils against the progeny build-up of lesser grain borer

Treatments	Dosage (g +ml /kg)	Progeny adult build-up (No.)										
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	120 DAT	135 DAT	150 DAT	165 DAT	180 DAT
Sunflower oil	2.5 ml/kg	9.33	57.00	135.67	155.00	165.67	266.00	258.67	267.33	273.00	293.33	307.67
		(3.13) b	(7.58) b	(11.66) b	(12.47) b	(12.89) b	(16.27) b	(16.02) b	(16.30) b	(16.48) b	(17.10) b	(17.53) b
Groundnut oil	2.5 ml/kg	8.33	51.33	113.67	133.00	134.33	198.33	176.67	177.00	190.67	199.67	252.33
		(2.96)bc	(7.18) b	(10.68) b	(11.55) b	(11.60) b	(14.06) b	(13.25) b	(13.26) c	(13.78) c	(14.06) c	(15.89) b
Beauveria +	5 +2.5	6.00	31.67	39.33	46.33	63.33	88.33	81.00	94.67	103.67	116.33	136.67
Sunflower oil		(2.55) c	(5.67)cde	(6.28) c	(6.83) cd	(7.98) c	(9.42) c	(9.02) c	(9.74) de	(10.20) de	(10.81) e	(11.71) d
Beauveria +	5 +2.5	6.00	24.33	35.33	36.00	52.67	71.00	57.67	68.00	87.00	97.67	118.33
Groundnut oil		(2.54) c	(4.84) e	(5.97) c	(6.03) d	(7.28) c	(8.43) c	(7.59) c	(8.27) f	(9.35) e	(9.90) e	(10.90) d
Metarhizium +	5 +2.5	6.67	38.67	52.00	60.00	75.00	83.67	89.00	109.00	112.67	126.67	148.00
Sunflower oil		(2.67)bc	(6.26)bcd	(7.25) c	(7.78) c	(8.66) c	(9.17) c	(9.46) c	(10.45)cde	(10.63) de	(11.28) de	(12.19) d
Metarhizium +	5 +2.5	5.33	23.33	37.67	39.67	53.00	73.67	56.67	82.67	87.00	107.00	121.33
Groundnut oil		(2.39) c	(4.94) de	(6.17) c	(6.33) d	(7.31) c	(8.44) c	(7.55) c	(9.10) de	(9.35) e	(10.37) e	(11.03) d
Lecanicillium +	5 +2.5	6.00	43.67	47.00	64.00	71.00	70.67	82.00	97.00	104.00	116.33	141.33
Sunflower oil		(2.53) c	(6.63) bc	(6.88) c	(8.02) c	(8.43) c	(8.34) c	(9.06) c	(9.87) de	(10.22) de	(10.80) e	(11.90) d
Lecanicillium +	5 +2.5	5.67	43.00	52.33	53.00	82.33	103.00	100.33	134.00	157.67	172.67	196.67
Groundnut oil		(2.47) c	(6.59) bc	(7.27) c	(7.31) cd	(9.09) c	(10.17) c	(10.03) c	(11.57) cd	(12.54) cd	(13.14) cd	(14.02) c
Control		15.00	86.33	287.67	318.00	379.33	559.00	561.33	572.33	541.67	484.00	517.00
		(3.93) a	(9.22) a	(16.90) a	(17.76) a	(19.32) a	(23.38) a	(23.45) a	(23.71) a	(23.15) a	(21.94) a	(22.67) a
S.E. ±		0.17	0.42	0.46	0.45	0.69	1.08	0.99	0.94	0.76	0.67	0.57
C.D. (P = 0.05)		0.52	1.24	1.37	1.35	2.05	3.22	2.93	2.80	2.27	1.99	1.70

DAT- Days After Treatment, The values in parentheses are transformed values, In each column values with similar alphabet do not vary significantly at 5%

groundnut oil (52.33) and were significantly different from groundnut oil (113.67) and sunflower oil (135.67), but all were significantly different from control (287.67) (Table 3).

The data recorded on 90 DAT recorded less progeny with *Beauveria* + groundnut oil (52.67) which was at par with *Metarhizium* + groundnut oil (53.00), *Beauveria* + sunflower oil (63.33), *Lecanicillium* + sunflower (71.00), *Metarhizium* + sunflower oil (75.00) and *Lecanicillium* + groundnut oil (82.33). Highest progeny was recorded with sunflower oil (165.67) followed by groundnut oil (134.33) which were significantly different from control (379.33) (Table 3). Similar trend was observed at 120 DAT where less progeny build up was recorded with *Metarhizium* + groundnut oil (56.67), which was at par with *Beauveria* + groundnut oil (57.67), *Beauveria* + sunflower (81.00), *Lecanicillium* + sunflower oil (82.00), *Metarhizium* + sunflower oil (89.00), and *Lecanicillium* + groundnut oil (100.33). Highest progeny was recorded with sunflower oil (258.67) followed by groundnut oil (176.67), but was significantly different from control (561.33).

The data at 150 DAT showed that *Beauveria* + groundnut oil and *Metarhizium* + groundnut oil have recorded less progeny of 87.00 which were on par with *Beauveria* + sunflower (103.67), *Lecanicillium* + sunflower oil (104.00) and *Metarhizium* + sunflower oil (112.67). The next better was *Lecanicillium* + groundnut oil (157.67) that was on par with groundnut oil (190.67). All these treatments were significantly different from sunflower oil (273.00) that has shown less efficacy but was significantly different from the untreated control (541.67) (Table 3).

At 180 DAT *Beauveria* + groundnut oil had recorded less progeny of 118.33 which was at par with *Metarhizium* + groundnut oil (121.33), *Beauveria* + sunflower (136.67), *Lecanicillium* + sunflower oil (141.33), *Metarhizium* + sunflower oil (148.00) and were significantly different from *Lecanicillium* + groundnut oil (196.67). Highest progeny was recorded with sunflower oil (307.67) followed by groundnut oil (252.33). All the above treatments were significantly different from control (517.00) (Table 3). Similar results were obtained by Khalequazzaman *et al.* (2007) who reported the less progeny of *Callasobruchus chinensis* with Groundnut oil (1% and 5.35% at 30 and 60 days) and sunflower oil (37% and 68% at 30 and 60 days) at 1ml/kg. Sabbour and shadia (2007) reported that mustard oil (0.05%) + *Paceilomyces fumosoroseus* (4.25×10^7) caused 74.5 and 93 per cent reduction in oviposition and adult emergence, respectively against broad bean beetle, *B. rufimanus* after 4 months of treatment.

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