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Research Article

Compatibility of vegetable oils with entomopathogenic fungi against lesser grain borer, *Rhyzopertha dominica* (F.) in paddy

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ABSTRACT: Compatibility of entomopathogenic fungi, *Beauveria bassiana* (2 x 10^6 conidia/g), *Metarhizium anisopliae* (1 x 10^9conidia/g) and *Lecanicillium lecanii* (2 x 10^7conidia/g) @ 5 g/kg with vegetable oils (2 ml/kg) *viz.* sunflower oil and groundnut oil were studied against lesser grain borer, *Rhyzopertha dominica* in paddy. The highest adult mortality of *R. dominica* was recorded with *Metarhizium* + groundnut oil (81.57%) followed by *Beauveria* + groundnut oil (78.54%) when compared to groundnut oil (65.28%) alone at 15 DAT. 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) when compared to control (517.00) and were superior over all other treatments. Similarly, less per cent weight loss was recorded with *Beauveria* + groundnut oil (17.59%) followed by *Metarhizium* + groundnut oil (19.01%) when compared with control (50.09 %) at 180 DAT. High per cent reduction in progeny was recorded with *Beauveria* + groundnut oil (77.11%) followed by *Metarhizium* + groundnut oil (76.53%) when compared to control. The next better were recorded with *Beauveria* + sunflower oil (73.56%), *Lecanicillium* + sunflower oil (72.66%) and *Metarhizium* + sunflower oil (71.37%) when compared to control at 180 DAT. High per cent reduction in weight loss was recorded with *Beauveria* + groundnut oil (64.88%) followed by *Metarhizium* + groundnut oil (62.05%). The next better were recorded with *Beauveria* + sunflower oil (60.03%), *Metarhizium* + sunflower oil (56.50%), and *Lecanicillium* + sunflower oil (51.61%) when compared to control at 180 DAT.

KEY WORDS: *Beauveria bassiana, Metarhizium anisopliae, Lecanicillium lecanii*, sunflower oil, groundnut oil, *Rhyzopertha dominica*

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INTRODUCTION

Paddy is the most important staple food crop of India. About 65% of Indian population is dependent on paddy for food stuff. After harvesting, unprocessed rice (paddy) will be stored for various lengths of time by producers, wholesalers and millers level. While in storage, paddy is at risk of infestation by a wide range of stored product insects like rice moth (*Corcyra cephalonica* Stainton), rice weevil (*Sitophilus oryzae* Linn.), lesser grain borer (*Rhyzopertha dominica* Fabricius) and mites (Wakefield, 2006). In India, upto 12% of post harvest losses were caused by insect pests (Mohan, 2003). 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% 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 the control of storage grain pests has also resulted in serious problems such as resistance to the insecticides, pest resurgence, elimination of economically important 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 the efficacy of entomopathogenic fungi like *Beauveria bassiana* (Balsamo) Vuiillemin*, Metarhizium anisopliae* (Metschnikoff) Sorokin and *Lecanicillium lecanii* (Zimmerman) on storage insect pests (Batta, 2005; Buba, 2010 and Hafez, 2011). Vimala Devi and Prashanth (2009) reported that the effectiveness of entomofungal pathogens was found to increase when formulated in oils. Several vegetable oils such as sunflower, ground nut, safflower and cotton seed have been used for formulating conidia of the various entomopathogenic fungi. Zimmermann (2007a & 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 compatibility of vegetable oils with entomopathogenic fungi were tested against *R. dominica* in paddy.

MATERIALS AND METHODS

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.

Preparation of fungal formulation

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 (MRBA) [(K_2HPO_4 - 0.5 g, KH_2PO_4 - 0.4 g, $MgSo_4$ - 0.4 g, Dextrose – 10 g, peptone – 5 g, yeast – 0.5 g, Rose Bengal – 50 mg, streptomycin- 30 mg)]. The pure cultures of these fungi were maintained and preserved on Potato Dextrose Agar (PDA) [(potato – 250 g, Agar- 16 g, dextrose – 20 g)] slants 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 profused sporulation was attained. The mycelia mat along with spores was thoroughly macerated in a sterile pestle & 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 were 2 x10^6, 1 x 10^9, and 2 x 10^7/g in *B. bassiana*, *M. anisopliae* and *L. lecanii* formulations, as determined by MRBA technique respectively.

Collection and rearing of the test insect

The experiment was conducted at Post Harvest Technology Center, Agricultural College, Bapatla, Guntur district, Andhra Pradesh during the year 2011-12. Adults of *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.

Grain treatment with fungal formulation

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 on adult mortality at 7 DAT and 15 DAT. The progeny buildup and per cent weight loss was recorded from 30 DAT to 180 DAT at fortnightly interval. Mortality assessment was made by counting dead and live adult insects and percentage of adult mortality was calculated for treated and untreated paddy grains. To calculate the per cent corrected mortality the following Abbott's formula was used (Abbott, 1925).

$$\text{Abbott's formula} = \frac{\text{\% test mortality - \% control mortality}}{\text{100 - \% control mortality}} \times 100$$

Progeny adult emergence was determined by counting the number of all visible dead and live adults found in paddy at the time of observation. The dead insects were discarded after counting and live adults were reintroduced into their respective jars for further build up. Per cent weight loss of paddy grain due to damage by lesser grain borer was also determined after excluding all insect stages, frass and dust from the grain. The per cent weight loss was calculated by the following formula (Adams and Schulten, 1978).

$$\text{Per cent weight loss} = \frac{(U.Nd) - (D.Nu)}{U\,(Nd+Nu)} \times 100$$

Where,

U = weight of undamaged grains

Nu = number of undamaged grains

D = weight of damaged grains

Nd = Number of damaged grains.

The adult mortality and per cent weight loss were transformed into arcsine values and the progeny build-up was transformed into square root values and were subjected to Complete Randomized Design (CRD) found to be analysis.

RESULTS AND DISCUSSIONS

Effect on Adults Released

At 7 days after treatment DAT, the data indicated that the highest per cent mortality was recorded with *Metarhizium*+ groundnut oil (59.35%) which was on par with *Beauveria* + groundnut oil (56.02%), *Beauveria* + sunflower oil (48.15%) and groundnut oil (43.15%). *Lecanicillium* + sunflower (35.65%), *Metarhizium* + sunflower oil (33.24%), sunflower oil (32.31) and *Lecanicillium* + groundnut oil (28.61%) are at par with each other and have recorded the less per cent mortality. All the treatments were significantly different from control (Table 1).

At 15 DAT, *Metarhizium* + groundnut oil was found to be superior and recorded the highest adult mortality of 81.57%. The next best was *Beauveria* + groundnut oil (78.54%) followed by *Beauveria* + sunflower oil (73.67%), *Lecanicillium* + sunflower oil (68.98%), *Metarhizium* + sunflower oil (68.98%), groundnut oil (65.28%). The lowest mortality was recorded with sunflower oil (56.17%) followed by *Lecanicillium* + groundnut oil (60.65%). All the treatments were on par with each other, but were significantly different from control (Table 1).

Inglis *et al.* (1996) reported that the oils allow the entomopathogenic fungi to penetrate into the host cuticle by replacing epicuticular lipids by aqueous phase, followed by aqueous cuticular fluids covering the surface with water droplets which enhances conidial germination. The present results are in agreement with Hidalgo *et al.* (1998) who reported that rapeseed oil containing $1x10^{10}$ conidia of *B. bassiana* gave 100% mortality of *Sitophilus zeamais* in maize. Smith *et al*. (1999) reported 96-100% mortality of larger grain borer, *Prostephanus truncatus Horn* with *B. bassiana* + Rapeseed oil. Malsam*et al.* (2002) reported 100% mortality of white fly, *Trialeurodes vaporariorum* (Westwood) with *M. anisopliae* + Sunflower oil Biol 174. Sabbour & Shadia (2007) reported 74.2 and 60.1% mortality of broad bean beetle, *Bruchus rufimanus (Boheman)* with mustard oil and nigella oil, respectively in cowpea.

Table 1. Compatibility of entomopathogenic fungi with vegetable oils against

Treatments	Dosage (g +ml/kg)	Mortality (%)	
		7th day	15th day
Sunflower oil	2.5 ml/kg	32.31 (33.93)c	56.17 (48.59)a
Groundnut oil	2.5 ml/kg	43.15 (40.98)abc	65.28 (54.63)a
Beauveria + sunflower oil	5 + 2.5	48.15 (43.96)abc	73.67 (59.65)a
Beauveria + groundnut oil	5 + 2.5	56.02 (48.50)ab	78.54 (62.14)a
Metarhizium+ sunflower oil	5 + 2.5	33.24 (35.06)bc	68.98 (56.31)a
Metarhizium+ groundnut oil	5 + 2.5	59.35 (50.42)a	81.57 (64.95)a
Lecanicillium+ sunflower oil	5 + 2.5	35.65 (35.86)bc	68.98 (56.31)a
Lecanicillium+ groundnut oil	5 + 2.5	28.61 (31.75)c	60.65 (51.48)a
Control**		0.00	0.00
Em ±		4.59	5.47
P = (0.05)		13.63	16.25

DAT- Days After Treatment
Means in a column with the same letter are not significantly different
The values in parentheses are Arcsine transformed values
**The corrected per cent mortality at 7th& 15th day was calculated using Abbott's formula when actual mortality in control was 10 & 13.33%, respectively

Effect on Progeny Build-Up

Among the treatments at 30 DAT, *Metarhizium* + groundnut oil recorded less progeny adults of 5.33 which was on 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 on par with each other. All the treatments were significantly superior than control (15.00) (Table 2).

At 45 DAT, high per cent reduction in progeny was recorded with *Metarhizium* + groundnut oil (72.98%) followed by *Beauveria* + groundnut oil (71.82%) when compared with control. The next better were *Beauveria* + sunflower oil (63.32%), *Metarhizium* + sunflower oil (55.21%) and *Lecanicillium* + groundnut oil (50.19%) when compared with control. Less per cent reduction in progeny was recorded with Sunflower oil (33.97%) followed by groundnut oil (40.54%) and *Lecanicillium* + sunflower oil (49.42%) when compared to control (Fig 1).

The data recorded on 60 DAT showed less progeny build up with *Beauveria* + groundnut oil (35.33) which was on par with *Metarhizium* + groundnut oil (37.67), *Beauveria* + sunflower oil (39.33), *Lecanicillium* + sunflower oil (47.00), *Metarhizium* + sunflower oil (52.00), *Lecanicillium* + 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 2).

The data recorded on 90 DAT recorded less progeny with *Beauveria* + groundnut oil (52.67) which was on par with *Metarhizium*+ groundnut oil (53.00), *Beauveria* + sunflower oil (63.33), *Lecanicillium* + sunflower (71.00),

Table 2. Compatibility of vegetable oils with entomopathogenic fungi against the progeny adult build up of *Rhyzopertha dominica*

Treatments	Dosage (g +ml /kg)	Progeny adult build-up (No.)					
		30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
Sunflower oil	2.5	9.33 (3.13)^{b}	135.67 (11.66)^{b}	165.67(12.89)^{b}	258.67(16.02)^{b}	273.00 (16.48)^{b}	307.67 (17.53)^{b}
Groundnut oil	2.5	8.33 (2.96)^{bc}	113.67 (10.68)^{b}	134.33 (11.60)^{b}	176.67 (13.25)^{b}	190.67 (13.78)^{c}	252.33 (15.89)^{b}
Beauveria + Sunflower oil	5 +2.5	6.00 (2.55)^{c}	39.33 (6.28)^{c}	63.33 (7.98)^{c}	81.00 (9.02)^{c}	103.67 (10.20)^{de}	136.67 (11.71)^{d}
Beauveria + Groundnut oil	5 +2.5	6.00 (2.54)^{c}	35.33 (5.97)^{c}	52.67 (7.28)^{c}	57.67 (7.59)^{c}	87.00 (9.35)^{e}	118.33 (10.90)^{d}
Metarhizium+ Sunflower oil	5 +2.5	6.67 (2.67)^{bc}	52.00(7.25)^{c}	75.00 (8.66)^{c}	89.00 (9.46)^{c}	112.67 (10.63)^{de}	148.00 (12.19)^{d}
Metarhizium+ Groundnut oil	5 +2.5	5.33 (2.39)^{c}	37.67 (6.17)^{c}	53.00 (7.31)^{c}	56.67 (7.55)^{c}	87.00 (9.35)^{e}	121.33 (11.03)^{d}
Lecanicillium+ Sunflower oil	5 +2.5	6.00 (2.53)^{c}	47.00 (6.88)^{c}	71.00 (8.43)^{c}	82.00 (9.06)^{c}	104.00 (10.22)^{de}	141.33 (11.90)^{d}
Lecanicillium+ Groundnut oil	5 +2.5	5.67 (2.47)^{c}	52.33 (7.27)^{c}	82.33 (9.09)^{c}	100.33 (10.03)^{c}	157.67 (12.54)^{cd}	196.67 (14.02)^{c}
Control		15.00 (3.93)^{a}	287.67 (16.90)^{a}	379.33 (19.32)^{a}	561.33 (23.45)^{a}	541.67 (23.15)^{a}	517.00 (22.67)^{a}
SEm ±		0.17	0.46	0.69	0.99	0.76	0.57
P = (0.05)		0.52	1.37	2.05	2.93	2.27	1.70

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

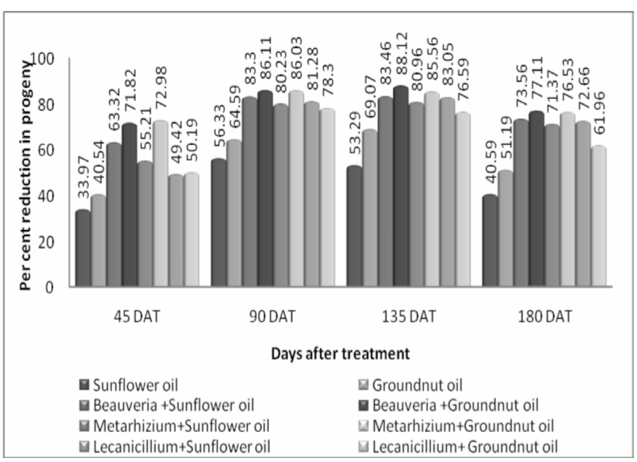

Fig. 1. Compatibility of vegetable oils with entomopathogenic fungi on per cent reduction of *Rhizopertha dominica* progeny when compared to control at different periods of storage.

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 2). High per cent reduction in progeny was recorded with *Beauveria* + groundnut oil (86.11%) followed by *Metarhizium* + groundnut oil (86.03%). The next best was *Beauveria* + sunflower oil (83.30%), *Lecanicillium* + sunflower oil (81.28%), *Metarhizium* + sunflower oil (80.23%) and *Lecanicillium*+ groundnut oil (78.30%) when compared to control. Less per cent reduction in progeny was recorded with sunflower oil (56.33%) followed by groundnut oil (64.59%) when compared with control (Fig 1). Similar trend was observed at 120 DAT where less progeny build up was recorded with *Metarhizium* + groundnut oil (56.67), which was on 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).

At 135 DAT, high per cent reduction in progeny was recorded with *Beauveria*+ groundnut oil (88.12%) followed by *Metarhizium* + groundnut oil (85.56%). The next better were recorded with *Beauveria* + sunflower oil (83.46%), *Lecanicillium* + sunflower oil (83.05%) and *Metarhizium* + sunflower oil (80.96%) when compared to control. Less per cent reduction in progeny was recorded with sunflower oil (53.29%) followed by groundnut oil (69.07%) and *Lecanicillium* + groundnut oil (76.59%) when compared to control (Fig 1).

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 2).

At 180 DAT *Beauveria* + groundnut oil has recorded less progeny of 118.33 which was on 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 2). High per cent reduction in progeny was recorded with *Beauveria*+ groundnut oil (77.11%) followed by *Metarhizium* + groundnut oil (76.53%). The next better treatments were recorded with *Beauveria* + sunflower oil (73.56%), *Lecanicillium* + sunflower oil (72.66%) and *Metarhizium* + sunflower oil (71.37%) when compared to control. Less per cent reduction in progeny was recorded with sunflower oil (40.59%) followed by groundnut oil (51.19%) and *Lecanicillium* + groundnut oil (61.96%) when compared with control (Fig 1).

Similar results were obtained by Khalequazzaman *et al.* (2007) who reported the less progeny of *Callasobruchus chinensis* with groundnut oil (1% & 5.35% at 30 & 60 days) and sunflower oil (37% & 68% at 30 & 60 days) at 1ml/kg. Sabbour and Shadia (2010) reported that mustard oil (0.05%) + *P. fumosoroseus* (4.25 x 10^7) caused 74.5 and 93% reduction in oviposition and adult emergence, respectively against broad bean beetle, *B. rufimanus* after 4 months of treatment.

Effect on per cent weight loss

At 45 DAT, high per cent reduction in weight loss was recorded with *Beauveria* + groundnut oil (77.67%) followed by *Metarhizium* + groundnut oil (75.00%). The next better were *Lecanicillium* + groundnut oil (67.96%), *Beauveria* + sunflower oil (53.64%) and *Metarhizium* + sunflower oil (44.90%) when compared to control. Less per cent reduction in weight loss was recorded with sunflower oil (11.16%) followed by groundnut oil (24.27%) and *Lecanicillium* + sunflower oil (28.16%) when compared with control (Fig 2).

The data recorded on 60 DAT showed less per cent weight loss with *Beauveria*+ groundnut oil (1.83%) which was on par with *Metarhizium* + groundnut oil (2.22%), *Beauveria* + sunflower oil (2.17%), *Lecanicillium* + sunflower oil (2.73%). The next best was *Metarhizium* +

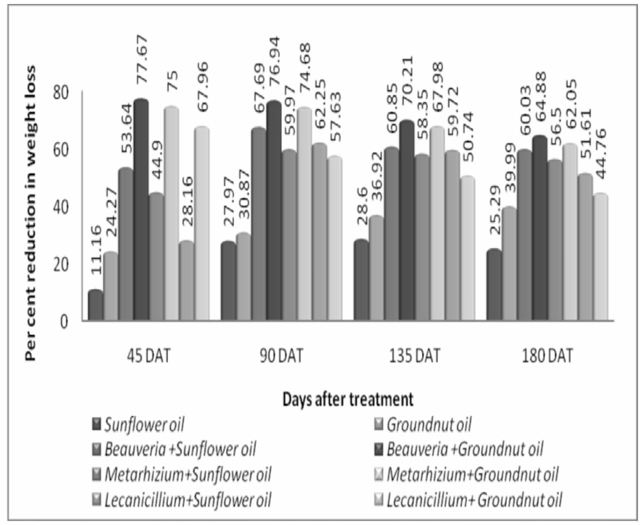

Fig. 2. Compatibility of vegetable oils with entomopathogenic fungi on per cent reduction in weight by lessergrain borer at different periods of storage.

sunflower oil (3.24%) which was on par with *Lecanicillium* + groundnut oil (3.38%), groundnut oil (4.03%) & sunflower oil (4.36%) that has recorded highest progeny. All the treatments were significantly different from control (7.90%) (Table 3).

At 90 DAT *Beauveria* + groundnut oil has recorded less per cent weight loss of 3.99 which was on par with *Metarhizium* + groundnut oil (4.38%) and *Beauveria* + sunflower oil (5.59%). The next best was *Lecanicillium*+ sunflower oil (6.53%), which was on par with *Metarhizium* + sunflower oil (7.08%) and *Lecanicillium* + groundnut oil (7.33%). High per cent weight loss was recorded with sunflower oil (12.46%) followed by groundnut oil (11.96%). All the treatments were significantly different from control (17.30%) (Table 3). High per cent reduction in weight loss was recorded with *Beauveria* + groundnut oil (76.94%) followed by *Metarhizium* + groundnut oil (74.68%). The next better treatments were recorded with *Beauveria* + sunflower oil (67.69%), *Lecanicillium* + sunflower oil (62.25%), *Metarhizium* + sunflower oil (59.97%) and *Lecanicillium* + groundnut oil (57.63%) when compared to control. Less per cent reduction in weight loss was recorded with sunflower oil (27.97%) followed by groundnut oil (30.87%) when compared to control (Fig 2).

Data recorded at 120 DAT revealed that *Beauveria* + groundnut oil has caused less per cent weight loss of 8.03 which was on par with *Metarhizium* + groundnut oil (8.93%), *Beauveria* + sunflower oil (11.30%), *Lecanicillium* + sunflower oil (11.70%), *Metarhizium* + sunflower oil (12.66%) and *Lecanicillium* + groundnut oil (14.08%). High per cent weight loss was recorded with

Table 3. Compatibility of vegetable oils with entomopathogenic fungi against weight loss (%) by *Rhyzopertha dominica*

Treatments	Dosage (g +ml / kg)	Weight loss (%)				
		60 DAT	90 DAT	120 DAT	150 DAT	180 DAT
Sunflower oil	2.5	4.36(12.04) [b]	12.46(20.68) [b]	23.19 (28.60) [b]	29.88(33.04)[ab]	37.42(37.69) [b]
Groundnut oil	2.5	4.03(11.57)[bc]	11.96 (20.23) [b]	20.65 (27.01)[bc]	25.93 (30.60)[bc]	30.06(33.26)[bc]
Beauveria + Sunflower oil	5 +2.5	2.17 (8.47) [de]	5.59 (13.68) [de]	11.30 (19.64) [d]	15.11(22.84) [de]	20.02 (26.54) [e]
Beauveria + Groundnut oil	5 +2.5	1.83 (7.43) [e]	3.99 (11.48) [f]	8.03(16.18) [d]	12.11 (20.29) [e]	17.59 (24.70) [e]
Metarhizium+ Sunflower oil	5 +2.5	3.24(10.35)[bcd]	7.08 (15.44) [cd]	12.66(20.78) [d]	12.86 (21.00) [e]	21.79 (27.77) [de]
Metarhizium+ Groundnut oil	5 +2.5	2.22 (8.55) [de]	4.38(12.06)[ef]	8.93 (17.26) [d]	12.11 (20.29) [e]	19.01(25.82) [e]
Lecanicillium+ Sunflower oil	5 +2.5	2.73 (9.49)[cde]	6.53 (14.81) [cd]	11.70 (19.89) [d]	15.96 (23.51) [de]	24.24(29.49)[cde]
Lecanicillium+ Groundnut oil	5 +2.5	3.38 (10.52)[bcd]	7.33(15.71) [c]	14.08 (22.04) [cd]	20.35(26.82) [cd]	27.67(31.74) [cd]
Control		7.90(16.30) [a]	17.30(24.57) [a]	32.47(34.38) [a]	35.84(36.65) [a]	50.09(45.05) [a]
SEm±		0.75	0.55	2.01	1.60	1.56
P=(0.05)		2.22	1.64	5.98	4.77	4.63

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

sunflower oil (23.19%) followed by groundnut oil (20.65%). All these treatments were significantly different from control (32.47%) (Table 3).

At 135 DAT, high per cent reduction in weight loss was recorded with *Beauveria* + groundnut oil (70.21%) followed by *Metarhizium* + groundnut oil (67.98%). The next best was recorded with *Beauveria* + sunflower oil (60.85%), *Lecanicillium* + sunflower oil (59.72%), *Metarhizium* + sunflower oil (58.35%) and *Lecanicillium* + groundnut oil (50.74%) when compared to control. Less per cent reduction in weight loss was recorded with sunflower oil (28.60%) followed by groundnut oil (36.92%) when compared to control (Fig 2).

The data on 150 DAT showed that the grain treated with *Beauveria* + groundnut oil and *Metarhizium* + groundnut oil recorded less per cent weight loss of 12.11 which has shown significant results and were on par with *Metarhizium* + sunflower oil (12.86%). The next better were *Beauveria* + sunflower oil (15.11%) which was on par with *Lecanicillium* + sunflower oil (15.96%) and were significantly different from control (35.84%). High per cent weight loss was recorded with sunflower oil (29.88%) which was not significantly different from control & was on par with groundnut oil (25.93%) that was significantly different from control (Table 3).

The observations on 180 DAT showed that the grain treated with *Beauveria* + groundnut oil was found to be best and recorded the less per cent weight loss of 17.59 which was on par with *Metarhizium* + groundnut oil (19.01%) and *Beauveria*+ sunflower oil (20.02%), *Metarhizium* + sunflower oil (21.79%) and *Lecanicillium* + sunflower oil (24.24%) (Table3). High per cent weight loss was recorded with sunflower oil (37.42%) followed by groundnut oil (30.06%) and *Lecanicillium* + groundnut oil (27.67%) which has shown less significance. All the treatments were significantly different from control (50.09%). High per cent reduction in weight loss was recorded with *Beauveria* + groundnut oil (64.88%) followed by *Metarhizium* + groundnut oil (62.05%). The next best was recorded with *Beauveria* + sunflower oil (60.03%), *Metarhizium* + sunflower oil (56.50%), and *Lecanicillium* + sunflower oil (51.61%) when compared to control. Less per cent reduction in weight loss was recorded with sunflower oil (25.29%) followed by groundnut oil (39.39%) and *Lecanicillium* + groundnut oil (44.76%) when compared to control (Fig 2).

Khalequazzaman *et al.* (2007) reported less per cent weight loss with groundnut oil (1.5 & 0.80% at 30 & 60 days) and sunflower oil (3.7% & 9% at 30 & 60 days) against *C. chinensis*. Sabbour and Shadia (2007) reported less per cent weight loss of 17 and 22% with mustard and Nigella oil against Broad bean beetle*, B. rufimanus*. From this study it was concluded that grain treatment of paddy with *Metarhizium* + groundnut oil and *Beauveria* + groundnut oil proved effective in causing highest adult mortality, reduction in progeny adults and per cent weight loss when compared with other treatments tested.

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