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Bio-efficacy of biocontrol agents against Fall armyworm *Spodoptera frugiperda* (J. E. Smith) under laboratory conditions

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Abstract
Laboratory bioefficacy of six test bioagents *viz*., entomopathogenic fungi (*Metarhizium anisopliae, Nomjraea rileyi, Beauveria bassiana*), entomopathogenic bacteria *Bacillus thuringiensis*, entomopathogenic nematode *Steirnerernema carpocapsae* and botanicals *Azardirachtin* were evaluated against 1st, 3rd, 5th instar larva of fall armyworm at 1st, 3rd 5th and 7th days after treatment. Among all evaluated bioagents treatment with *Bt* showed the highest mortality *i.e* 85.92%, 64.44% and 50.00% against 1st, 3rd, and 5th instar larvae, respectively. The next best treatment was *Nomurea rileyi* showed 71.48%, 57.04% and 36.68% mortality against 1st, 3rd and 5th instar larvae respectively. In present study Bioefficacy depicted as *Bt> N. rileyi> M. anisopliae* and Azardiractin >*S. carpocapsae* and *B. bassiana* against 1st, 3rd and 5th instar larvae of fall armyworm.

Keywords: entomopathogenic fungi, entomopathogenic bacteria, entomopathogenic nematode, botanicals, fall armyworm *Spodoptera frugiperda*

Introduction

The Fall armyworm *Spodoptera frugiperda* is an economically important pest native to tropical and subtropical America has recently invaded India, causing more damage to maize and sorghum. It is a notorious pest with high dispersal ability, wide host range and high fecundity makes the fall armyworm one of the severe economic pest. Pest management in agriculture is a challenging task in the context of increasing agricultural productivity without upsetting the ecological balance and deteriorating the environment. Chemical insecticides in agriculture are useful for protecting crop against pests and play the significant role to boost the production. To obviate the effects of chemical insecticides, there has been increased demand for the alternative and selective pest control agents particularly bioagents that in turn are silent workers from nature. Biological control is regarded as more beneficial than pesticide-based control due to their target specificity, eco-safety, reduced number of applications, yield and quality improvement, higher acceptability and export value of produce and suitability for rural areas. Several biopesticides with novel mode of action are now available in the market and therefore, it is necessary to use safe, effective, ecologically sound biocontrol agents. Due to the seriousness of the pest problem and relative paucity of information regarding pest management the present investigations were conducted with objective to study bioefficacy of different biocontrol agents against *S. frugiperda* under laboratory conditions.

Materials and Methods

The efficacy of test bioagents were evaluated on larvae by adopting the leaf dip method (Ahmad *et al*., 1995). Tender succulent maize leaves were brought and after thorough cleaning with water. The leaves were dipped in requisite concentration of bioagents for 10 seconds. The leaves were air dried under ceiling fan for 4 hr and then the leaves were placed in each plastic container. Ten larvae were randomly selected from nucleus culture and then were placed in each plastic container. Larval mortality was recorded after every 1, 3, 5 and 7 DAT. The moribund larvae were considered as dead. Mean larval mortality was computed for larval instar. The data were subjected to the arc sin transformation and statistical analysis thereafter.

Table 1: Bioefficacy of test bioagents against first instar larvae

TN	Treatments	Per cent Mortality at Days After Treatment			
		1 DAT	3 DAT	5 DAT	7 DAT
T_1	*Metarhizium anisopliae* @ (1 x 10^8 cfu/ml) 5g / l	3.33 (8.06)*	13.33 (21.14)	42.59 (40.69)	67.77 (55.42)
T_2	*Beauveria bassiana* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)	6.67 (13.25)	31.85 (34.21)	38.89 (38.31)
T_3	*Nomuraea rileyi* @ (1 x 10^8 cfu/ml) 5g / l	3.33 8.06)	17.41 (24.05)	53.33 (46.92)	71.48 (57.80)
T_4	*Bacillus thuringiensis* @ (3.5% ES) 2ml / l	16.67 (23.86)	26.37 (31.00)	71.48 (39.26)	85.92 (68.16)
T_5	*Steinernema carpocapsae* @ (10,0000 IJs) 4ml / l	0.00 (2.87)	10.00 (18.43)	39.26 (38.77)	46.29 (42.87)
T_6	*Azadirachtin* @ (10,000 ppm) 2ml / l	10.00 (18.43)	13.33 (21.14)	46.30 (42.87)	58.52 (49.91)
T_7	Untreated check	3.33 (8.85)	3.33 (8.06)	6.67 (13.25)	6.67 (13.25)
CD at 5%		-	4.83	9.03	9.32
SE (m) ±		3.45	3.39	2.97	3.07

*Figures in parentheses are the arc sin transformed values.

Bioefficacy of test bioagents against 1st instar larva

At 1 DAT, all the six test bioagents were found to be statistically non-significant with the untreated check exhibiting meager effect.

At 3 DAT, *Bt* (26.37%) was found to be significantly superior over rest of the treatments. *N. rileyi* (17.41%), Azardirachtin (13.33%) and *M.anisopliae* (13.33%) were observed to be the next best treatments which were on par. In the descending order of preference was *S. carpocapsae* (10%) followed by *B. bassiana* (6.67%).

At 5 DAT, *Bt* (71.48%) remained to be promising recording higher mortality over rest of treatments. *N. rileyi* (53.33%), Azardirachtin (46.30%), *M. anisopliae* (42.59%) and *S. carpocapsae* (39.26%) stood next best treatments which were on par with each other. *B. bassiana* (31.85%) was found to be least effective.

At 7 DAT, *Bt* (85.92%) was found the most promising treatment and in the order of merit next treatments were *N. rileyi* (71.48%), *M. anisopliae* (67.77%) and Azardirachtin (58.52%) which were on par. *S. carpocapsae* (46.29%) and *B. bassiana* (38.89%) recorded lower mortality and were at par with each other.

Bioefficacy of test bioagents against 2nd instar larva

At 1 DAT, all the test bioagents were found to be non-significant with the untreated check exhibiting no harmful effect.

At 3 DAT, *B. thuringiensis* (20%) and *N. rileyi* (13.70%) were found to be the most effective treatments which were on par, followed by Azardirachtin (10%) and *M. anisopliae* (6.67%) which were on par followed by *S. carpocapsae* (3.33%) and *B. bassiana* (0.00%) and were at par with each other.

At 5 DAT, *Bt* (57.04) remain to be significantly superior over rest of the treatment followed by *N. rileyi* (35.56%), Azardirachtin (27.41%), *M. anisopliae* (31.85%) and *S. carpocapsae* (24.81%) which were on par. Comparatively *B. bassiana* (17.41%) was observed to be the least effective treatment.

At 7 DAT, *Bt* (64.44%), *N. rileyi* (57.04%) and *M. anisopliae* (53.33%) were found superior over rest of the treatments which were at par with each other followed by Azardirachtin (46.30%) followed by *S. carpocapsae* (46.30%) and *B. bassiana* (24.81%) which were on par.

Table 2: Bioefficacy of test bioagents against third instar larvae

TN	Treatments	Per cent Mortality at Days After Treatment			
		1 DAT	3 DAT	5 DAT	7 DAT
T_1	*Metarhizium anisopliae* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)*	6.67 (13.25)	31.85 (34.21)	53.33 (46.92)
T_2	*Beauveria bassiana* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)	0.00 (2.87)	17.41 (24.05)	24.81 (29.82)
T_3	*Nomuraea rileyi* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)	13.70 (21.49)	35.56 (36.59)	57.04 (49.05)
T_4	*Bacillus thuringiensis* @ (3.5% ES) 2ml / l	10.00 (18.43)	20.00 (26.07)	57.04 (49.05)	64.44 (53.71)
T_5	*Steinernema carpocapsae* @ (10,0000 IJs) 4ml / l	0.00 (2.87)	3.33 (8.06)	24.81 (29.32)	31.85 (34.21)
T_6	*Azadirachtin* @ (10,000 ppm) 2ml / l	6.67 (13.25)	10.00 (18.43)	27.41 (31.51)	46.30 (42.87)
T_7	Untreated check	3.33 (8.85)	3.33 (8.06)	6.67 (13.25)	6.67 (13.25)
CD at 5%		-	5.47	9.29	8.19
SE(m)±		2.77	3.45	3.06	2.70

*Figures in parentheses are the arc sin transformed values

Bioefficacy of test bioagents against 5th instar larva

At 1 DAT, all the test bioagents were found to be non-significant with the untreated check exhibiting no harmful effect.

At 3 DAT, *Bt* (10.37%) was found to be the most superior treatment followed by Azardirachtin (6.67%), *N. rileyi* (3.33%) and *M. anisopliae* (3.33%) which were on par followed by *S. carpocapsae* and *B. bassiana* which were at par with each other.

At 5 DAT, *Bt* (24.07%) was found most significantly superior treatment. Next treatments in the order of merit were *N. rileyi* (20.74%), *M. anisopliae* (17.04%) and Azardirachtin (13.33%) which were found at par, followed by *S. carpocapsae* (6.67%) and *B. bassian*a (6.67%) which were on par with each other.

At 7 DAT, *Bt* (50.00%) and *N. rileyi* (36.68%) were observed to be the most promising treatments which were on par followed by *M. anisopliae* (30.00%), Azardirachtin (24.07%), *S. carpocapsae* (20.00%) and *B. bassiana* (17.04%) and were at par with each other.

Table 3: Bioefficacy of test bioagents against 5th instar larva

TN	Treatments	Per cent Mortality at Days After Treatment			
		1 DAT	3 DAT	5 DAT	7 DAT
T_1	*Metarhizium anisopliae* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)*	6.67 (13.25)	17.04 (24.20)	30.00 (33.21)
T_2	*Beauveria bassiana* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)	0.00 (2.87)	6.67 (13.25)	17.04 (24.20)
T_3	*Nomuraea rileyi* @ (1 x 10^8 cfu/ml) 5g / l	0.00 (2.87)	6.67 (13.25)	20.74 (27.08)	36.68 (37.22)
T_4	*Bacillus thuringiensis* @ (3.5% ES) 2ml / l	6.67 (13.25)	10.37 (18.78)	24.07 (29.30)	50.00 (45.00)
T_5	*Steinernema carpocapsae* @ (10,0000 IJs) 4ml / l	0.00 (2.87)	3.33 (8.06)	6.67 (13.25)	20.00 (26.57)
T_6	*Azadirachtin* @ (10,000 ppm) 2ml / l	3.33 (8.06)	3.33 (8.06)	13.33 (21.49)	24.07 (29.30)
T_7	Untreated check	3.33 (8.85)	3.33 (8.06)	3.33 (8.06)	3.33 (8.06)
CD at 5%		-	5.04	7.58	10.51
SE(m)±		2.77	4.72	4.31	2.50

*Figures in parentheses are the arc sin transformed values

Conclusions

Laboratory bioefficacy of six test bioagents were evaluated against 1st, 3rd and 5th instar larva. In first instar larva, the trend of bioefficacy of bioagents at 3 DAT, exhibited as *Bt*>*N. rileyi,* Azardiractin and *M. anisopliae*>*S. carpocapsae*>*B. bassiana*. At 5 DAT, shown as *Bt*>*N. rileyi*, Azardiractin, *M. anisopliae* and *S. carpocapsae*>*B. bassiana*. At 7 DAT, presented as *Bt*>*N. rileyi*, *M. anisopliae* and Azardiractin>*S. carpocapsae* and *B. bassiana*. In third instar larva, the trend of bioefficacy of bioagents at 3 DAT, presented as *Bt* and *N. rileyi*>Azardiractin and *M. anisopliae*>*S. carpocapsae* and *B. bassiana*. At 5 DAT, shown as *Bt*>*N. rileyi*, Azardiractin, *M. anisopliae* and *S. carpocapsae*>*B. bassiana*. At 7 DAT, exhibited as *Bt*, *N. rileyi*, *M. anisopliae*>Azardiractin >*S. carpocapsae* and *B. bassiana*. In fifth instar larva, the trend of bioefficacy of bioagents at 3 DAT, unveiled as *Bt*>Azardiractin, *N. rileyi and M. anisopliae*>*S. carpocapsae* and *B. bassiana*. At 5 DAT, shown as *Bt*>*N. rileyi*, Azardiractin, *M. anisopliae*>*S. carpocapsae* and *B. bassiana*. At 7 DAT, presented as *Bt* and *N. rileyi*>*M. anisopliae*, Azardiractin, *S. carpocapsae* and *B. bassiana*.

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