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Bio efficacy of certain entomopathogenic fungus against major insect pests of *Brassica campestris* var. Toria

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Abstract
Field experiment was conducted in Instructional-Cum-Research (ICR) farm, Assam Agricultural University, Jorhat during *rabi* 2018-19 to evaluate the bio-efficacy of certain entomopathogenic fungus against major insect pests of *Brassica campestris* var. *toria*. Results of efficacy of entomopathogenic fungus against mustard aphid and sawfly revealed that, lowest mean population of aphid and sawfly was observed in dimethoate 30 EC @ 2 ml/lit treated plots after the spray followed by *Lecanicillium lecanii* (NBAIR) and highest population was observed in Azadirachtin @ 2 ml/lit treated plot, but in case of flea beetle, lowest mean population was observed in dimethoate 30 EC @ 2 ml/lit treated plots followed by *L. lecanii* (NBAIR) and highest was observed in *Metarhizium anisopliae* (AAU-culture) treated plot. The efficacy of treatments against *C. transversalis* revealed that after the spray, highest mean population was observed in Azadirachtin @ 2 ml/lit treated plots followed by *L. lecanii* (AAU-culture), whereas highest mean population of *D. rapae* was observed in Azadirachtin @ 2 ml/lit treated plots followed by *M. anisopliae* (AAU-culture).

Keywords: Mustard, BIPM, entomopathogenic fungus, *Brassica campestris*

Introduction
Oilseeds have been the backbone of agricultural economy of India since ancient time. India accounts for 14.8% of rapeseed mustard production at global level and occupies prime position in the World [1]. Mustard, *Brassica juncea* (Linnaeus) belongs to the family Cruciferae and it was originated in China. Later on, it was introduced into North Eastern India [2]. From India, it has been spread in to Afghanistan via Punjab. In India, the *Brassica* crop is widely cultivated in Uttar Pradesh, Rajasthan, Madhya Pradesh, Assam, Bihar, Orissa, Haryana, Punjab, Gujarat and West Bengal [3]. Afterwards its cultivation has been spread to non-traditional States such as Maharashtra, Andhra Pradesh, Tamil Nadu and Karnataka.

Among different factors responsible for the low yield of mustard, damage inflicted by various insect pests is an important cause; Rai [4] had enlisted a total 24 numbers of species of key insect pests of mustard and rapeseed crop in India which cause severe damages in different stages of crop. According to Bakhetia and Sekhon [5], 38 numbers of insect species were associated with the mustard crop. According to Purwar *et al*. [6], more than 43 species of insect pests had been reported to infest rapeseed-mustard crop in India, out of which about a dozen of species are considered as major pest. Amongst all, the mustard aphid, *Lipaphis erysimi* (Kalt), the mustard saw fly, *Athalia lugens proxima* (Klug), the painted bug, *Bagrada hilaris* (Burmester) and the leaf miner, *Phytomyza horticola* (Goureau) are considered as major pests of mustard.

Heavy dependence on chemical insecticides for the control of insect pests of mustard leads to destruction of the beneficial fauna such as parasitoids and predators in mustard eco system. In this context, biological control approaches may be an important tools to maintain a sustainable production of mustard crop, which is very much necessary for management of sucking pests. Besides beneficial insects, entomopathogenic fungi are being a major component of bio intensive IPM approach that could provide an eco-friendly path of insect pests suppression. Several fungal species like *Beauveria bassiana* (Miranpuri & Khachatourians, 1995) [12], *Lecanicillium lecanii* (Harper & Huang, 1986 and Sukhova, 1987), *Metarhizium anisopliae* (Ekesi *et al*., 2000) and *Paecilomyces fumosoroseus* (Chen & Feng, 1999) have been reported pathogenic to all kinds mustard insect pests. In India, *L. lecanii* was found pathogenic to aphid, *L. erysimi* [7]. Most interestingly some important predaors like *Coccinella septempunctata, C. transversalis, Serangium parcesetosum* and *Harmonia dimidiata* were very predominant in cabbage and other crucifeous crop ecosystem of Assam [8], which may be destroyed by injudicious application of chemical pesticides.

Therefore, keeping in view of the importance of bio control of insect pests, the present investigation was carried out to evaluate the bio-efficacy of some entomopathogenic fungus against major insect pests of mustard.

Materials and Methods

The field experiment was conducted in the Instructional-cum-Research (ICR) Farm, Assam Agricultural University, Jorhat (26°45′ latitude and 94°12′ E longitude), Assam, India during *rabi* season of 2018-19. The experiment was laid out in field, adopting Randomized Block Design (RBD) with four replications. The net area for the experiment was 552.5 sq. m (32.5 m x 17 m). The net area was divided into four blocks representing each block as one replication. Each block was further divided into 7 equal plots measuring 14 sq. m (4 m x 3.5 m) each.

The population counts of the major insect pests of mustard in the field were recorded one day before spraying (pre-treatment count) and for observation of insect pests, 10 plants were selected at random in each plot and population were counted visually early in the morning *in situ*. Post treatment counts were recorded3, 7 and 10 days after spraying. Three round of sprays were carried out at fortnightly interval. Yield data were recorded from 1 m^2 area 5 random plots.

3. Results and Discussion

Mustard aphid, *Lipaphis erysimi* (Kalt.) (Hemiptera: Aphididae)

Amongst entomopathogenic fungus, *Lecanicillium lecanii* (NBAIR) was the most effective against *L. erysimi* (2.22 aphids/10 cm twig) after third sprayings followed by *L. lecanii* (AAU-J culture) (2.57 aphids/10 cm twigs), *Beauveria bassiana* (AAU-J culture) (2.77 aphids/10 cm twig), *Metarhizium anisopliae* (AAU-J culture) (3.35 aphids/10 cm twig) and Azadirachtin @ 2 ml/lit (5.45 aphids/10 cm twig), respectively (Table 1).

While comparing the per cent reduction of aphid with different treatments, Azadirachtin recorded the lowest reduction (65.42%) when the population number was 5.45 aphids/10 cm twig but comparatively superior to untreated control.

It was observed that amongst the entomopathogenic fungus, *L. lecanii* was recorded as the most effective against aphid during the present investigation. However, similar results were also recorded by Easwaramoorthy and Jayaraj [9]. They evaluated several insecticides and *L. lecanii* in field condition against aphid and reported that application of dimethoate 30 EC was the best for suppressing aphid. However, Harper and Huang [10] reported that *L. lecanii* isolated from soil had significantly reduced the populations of aphid. They also observed that pathogenicity *L. lecanii* found to be highest when humidity was high in the environment. In an experiment carried out by Borkakati *et al.,* [11], revealed that *B. bassiana* (NBAIR-Bb-5a) was very much effective against sucking pests of *Bhut Jalakia.*

The present findings were in agreement with those of Hayden *et al.* [12] who tested the virulence of the entomogenous fungi, *L. lecanii* and *B. bassiana* against aphid and reported that *L. lecanii* was the most virulent (LT_{50} = 2.4 days), whereas *B. bassiana* had an LT_{50} of 9.5 days. The results of present studies were found to be in confirmation of earlier results of Rana and Singh [7] who evaluated the feasibility of suppressing *L. erysimi* using *L. lecanii* and they reported that the conidial suspensions @ 10^6 spores per milliliter sprayed on mustard plants where the ETL of aphid was 13 to 15 aphids/plant and there was a significant reduction in aphid infestation at 10 days after spraying.

The highest aphid population was recorded in the plot treated with Azadirachtin @ 2 ml/lit (5.45 aphids/10 cm twig) when compared to other treatments and comparatively superior over untreated control. These results were also at par with the results of Prasad [13] who reported that the neem spray formulations were the most effective against *L. erysimi* on *B. campestris* for only 3 days after application and were found to be inferior to the level of control given by methyl-o-demeton.

Mustard sawfly, *Athalia lugens proxima* (Klug) (Hymenoptera: Tenthredinidae)

The data (Table 1) of sawfly population in different entomopathogenic fungus revealed that *L. lecanii* (NBAIR) was the superior treatment (0.29 sawfly/plant) compared to *L. lecanii* (AAU-J culture) (0.38 sawfly/plant) and *B. bassiana* (AAU-J culture) (0.48 sawfly/plant). The reduction of sawfly population in different treatments was in order of dimethoate 30 EC > *L. lecanii* (NBAIR) > *L. lecanii* (AAU-J culture) > *B. bassiana* (AAU-J culture) > *M. anisopliae* (AAU-J culture) > Azadirachtin @ 2 ml/lit.

From the present investigation, it was observed that the per cent reduction over control of Azadirachtin @ 2 ml/lit was 57.88% against mustard sawfly. Agrawal and Saroj (2003) observed the maximum larval mortality (47.5%) of *A. lugens proxima* in 2 per cent concentration followed by 30.0%, 22.5%, 15.0% and 6.25% mortality with the treatment of 1%, 0.5%, 0.25% and 0.125% concentration of neem oil in comparison to untreated control plot where the per cent mortality was nil. However, among the all concentrations, 2% neem oil was the most effective in causing larval mortality, pupal inhibition, and inhibition of adult emergence, larval antifeedant and larval repellent effect.

Patnaik *et al.* [14] observed that 3.0% neem oil caused larval mortality of *A. lugens proxima* Klug as compared to no mortality in the untreated check.

Flea beetle, *Phyllotreta Cruciferae* (Goeze) (Coleoptera: Chrysomelidae)

The data (Table 1) against flea beetle population after spraying indicated that, dimethoate 30 EC @ 2 ml/lit was recorded minimum number of flea beetle (0.02 flea beetle/plant) compared to all the treatments. However, amongst the entomopathogenic fungus, *L. lecanii* (NBAIR) with 0.09 flea beetle/plant was the best treatment followed by *L. lecanii* (AAU-J culture) with 0.12 flea beetle/plant. The reduction in flea beetle population in different treatments was in order of dimethoate 30 EC, *L. lecanii* (NBAIR), *L. lecanii* (AAU-J culture), Azadirachtin @ 2 ml/lit, *B. bassiana* (AAU-J culture) and *M. anisopliae* (AAU-J culture), respectively.

However, the results of the present investigation were in accordance with the findings of Saikia and Nath [15], who reported that application of neem extract @ 2 ml/lit was effective against mustard flea beetle.

Table 1: Efficacy of entomopathogenic fungus against different insect pests of *Brassica campestris* var. *toria*

Treatment	*L. erysimi*			*A. lugens proxima*			*P. cruciferae*		
	Pre treatment	Post treatment	Reduction over control (%)	Pre treatment	Post treatment	Reduction over control (%)	Pre treatment	Post treatment	Reduction over control (%)
B. bassiana (AAU-J culture#) @5 g/lit	25.02	2.77	82.39	5.72	0.48	67.11	5.60	0.20	76.92
M. anisopliae (AAU-J culture#) @5 g/lit	25.17	3.35	78.71	3.90	0.57	61.48	5.97	0.29	65.77
L. lecanii (AAU-J culture#) @5 g/lit	26.50	2.57	83.70	4.90	0.38	73.87	3.35	0.12	85.77
L. lecanii (NBAIR#) @5 g/lit	27.70	2.22	85.90	3.72	0.29	80.40	4.42	0.09	88.84
Azadirachtin 1500 ppm@2 ml/lit	22.75	5.45	65.42	4.90	0.62	57.88	5.55	0.18	79.23
Dimethoate 30 EC @2 ml/lit	26.87	0.39	97.48	4.50	0	100	4.62	0.02	97.30
Untreated control	22.15	15.77	-	3.07	1.48	-	3.16	0.86	-
S.Ed±	1.73	1.04	-	0.06	0.07	-	0.06	0.04	-
CD (P=0.05)	NS	2.18	-	NS	0.14	-	NS	0.08	-
CV (%)	3.21	6.25	-	1.93	14.03	-	1.74	10.87	-

NS= Non-significant; #1x10^8/spore/g

Efficacy of entomopathogenic fungi against natural enemies

It was revealed from the present investigation (Table 2) that maximum mortality of natural enemies *viz.* ladybird beetle i.e. *C. transversalis* and hymenopteran parasitoid i.e. *D. rapae* has recorded in *B. bassiana* treated plots. From an another experiment conducted by Borkakati *et al.*, [16], found that the highest numbers of Coccinellid predator was proportional to highest yield of cabbage, which is an important cruciferous vegetable. However, in an investigation carried out by Begam *et al.*, [17] observed that *Coccinella transversalis* and *Micraspis discolor* were the most dominant predator species observed throughout the cropping season of Bhut Jalakia and there was a positive correlation of thecae predators with pests.

In another set of experiment, Masarrat and Humayun [18] also reported that laboratory tests with six isolates of *B. bassiana* were highly pathogenic to the predatory coccinellid, *C. septempunctata*. These findings were also at par with the results of Manjula and Padmavathamma [19] who reported that the predator, *C. septumpunctata* was susceptible to *B. bassiana*. Similar observations were also recorded by Delate *et al.* [20] who considered *C. septumpunctata* to be somewhat susceptible to *B. bassiana* at 1x10^8 cfu/ml conidial concentration.

The yield was influenced by the differential efficacy of various treatments against insect pests. Among all the treatments, dimethoate 30 EC recorded highest yield (800 kg/ha) followed by *L. lecanii* (NBAIR) (690 kg/ha), *L. lecanii* (AAU-J culture) (685 kg/ha) and Azardiractin (670 kg/ha). The other entomopathogenic fungus *viz. B. bassiana* (AAU-J culture) (650 kg/ha) and *M. anisopliae* (AAU-J culture) (630 kg/ha) proved their superiority over untreated control (450 kg/ha/ha).

With respect to cost effectiveness (Table 3) of entomopathogenic fungus, *B. bassiana* (AAU-J culture) proved to be the most economical treatment as realized with high benefit cost ratio (2.25), followed by *M. anisopliae* (AAU-J culture) (2.15), *L. lecanii* (NBAIR) (2.04) and *L. lecanii* (AAU-J culture) (2.02). Chemical treatment i.e. dimethoate 30 EC registered the highest cost benefit ratio i.e. 2.76 and Azardiractin recorded 2.06 cost benefit ratio.

Table 2: Effect of entomopathogenic fungus against different natural enemies of insect pests of *Brassica campestris* var. *toria*

Treatment	*C. transversalis*			*D. rapae*		
	Pre treatment	Post treatment	Reduction over control (%)	Pre treatment	Post treatment	Reduction over control (%)
B. bassiana (AAU-J culture#) @5 g/lit	2.31	1.48	52.51	2.18	1.62	50.26
M. anisopliae (AAU-J culture#) @5 g/lit	3.10	1.64	47.60	3.03	2.01	38.38
L. lecanii (AAU-J culture#) @5 g/lit	2.89	1.71	45.14	3.02	1.92	40.94
L. lecanii (NBAIR#) @5 g/lit	2.61	1.55	50.27	2.78	1.87	42.68
Azadirachtin 1500 ppm@2 ml/lit	3.24	2.05	34.36	3.10	2.40	26.31
Dimethoate 30 EC @2 ml/lit	2.96	0.96	69.37	2.94	1.27	61.11
Untreated control	3.09	3.12	-	3.16	3.26	-
S.Ed±	0.29	0.30	-	0.37	0.27	-
CD (P=0.05)	NS	0.63	-	NS	0.57	-
CV (%)	6.88	2.68	-	9.60	2.35	-

NS= Non-significant
#1x10^8/spore/g

Table 3: Benefit cost ratio of different treatments used against major insect pests of *Brassica campestris* var. *toria*

Treatment	Yield (kg/ha)	Increase in yield over control (%)	Value of yield (Rs)	Cost of cultivation (Rs)	Net monetary return (Rs)	Benefit cost ratio
Beauveria bassiana (AAU-J culture) ($1x10^8$/spore/g)	650	44.44	27300	8400	18900	2.25
Metarhizium anisopliae (AAU-J culture) ($1x10^8$/spore/g)	630	40.00	26460	8400	18060	2.15
Lecanicillium lecanii (AAU-J culture) ($1x10^8$/spore/g)	685	52.22	28770	9525	19245	2.02
Lecanicillium lecanii (NBAIR) ($1x10^8$/spore/g)	690	53.33	28980	9525	19455	2.04
Azadirachtin 1500 ppm	670	48.89	28140	9204	18936	2.06
Dimethoate 30 EC @ 0.06%	800	77.78	33600	8940	24660	2.76
Untreated control	450	-	18900	8100	10800	1.33

4. Conclusion
From the present investigation it can be concluded that entomopathogenic fungi especially *L. lecanii* is most effective to control the insect pests of mustard. So, it can be recommended to bio control of mustard insect pests.

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