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Field evaluation of different entomopathogenic fungal formulations against sucking pests of okra

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Abstract: A field experiment was carried out to study the bioefficacy of different entomopathogenic fungal formulations *viz.*, crude, wettable powder and oil based formulation of *Beauveria bassiana*, *Metarhizium anisopliae* and *Verticillium lecanii* against sucking pests of okra during kharif 2007-08. Oil based formulation of *M. anisopliae* recorded minimum of 5.25 leafhopper/3 leaves followed by *B. bassiana* oil based (6.88) and V. lecanii oil based (7.75) after second spray. In aphid management, oil based formulation of *V. lecanii* was best and recorded 7.75 aphids/3 leaves followed by *B. bassiana* oil based recorded the 9.75 aphids/3 leaves after second spray. Oil based formulation of *V. lecanii* recorded the mean number of 2.70 whiteflies/3 leaves followed by oil based formulation of *B. bassiana* (3.15) after second spray. Similarly oil based formulations of *B. bassiana* recorded 2.58 thrips/3 leaves followed by *V.lecanii* oil based (3.00). The *M. anisopliae* oil based formulation recorded 9.75 mites/3 leaves followed by oil based formulations of B. bassiana (9.25) after second spray. However, all these formulations were next best to standard check. The yield of okra was significantly higher in oil based formulation of *M. anisopliae* (38.80 q/ha) and *V. lecanii* (38.50 q/ha) with monitory returns of Rs. 14720 and Rs. 14480/ha, respectively followed by *B. bassiana*. However, highest the benefit cost ratio of 18.40:1 and 16.68:1 were recorded in *V. lecanii* and *M. anisopliae* wettable powder formulation, respectively.

Key words : *Beauveria bassiana, Metarhizium anisopliae, Verticillium lecanii*, formulations, okra

Introduction

Okra (Bhendi) *Abelmoschus esculentus* (L.) Moench is one of the most important vegetables grown throughout the tropics and warmer parts of temperate zone. Though it is mainly used as a fresh vegetable, it is also consumed as canned, dehydrated or frozen forms. It is having potential exports accounting for 60 per cent of fresh vegetable (Sharman and Arora, 1993). One of the most important constraints in production of okra is insect pests. Many of pests occurring on cotton are found to ravage the okra crop. The sucking pest complex consisting of aphids, leaf hoppers, whiteflies, thrips and mites are major pests and cause 17.46 per cent yield loss in okra (Sarkar *et al.,* 1996). Failure to control them in the initial stages was reported to cause yield loss to the extent of 54.04 per cent (Chaudhary and Dadeech, 1989). The spider mite, T*etranychus cinnabarinus* (Boisduval) has assumed the status of major pest and caused 17.46 per cent yield loss in okra (Sarkar *et al*., 1996). To tackle the pest menace, a number of chemical insecticides are liberally sprayed on this vegetable crop which leads to several problems like toxic residues, elimination of natural enemies, environmental disharmony and development of resistance. Demand is ever increasing for organically produced agricultural commodities all round the globe and biological agents have vital role to contain the pest damage. During export there is also a risk of rejection of whole consignment due to presence of pesticide residues. To overcome these problems application of mycoinsecticides would be better option and thus forms integral part of IPM.

Material and methods

The experiment was laid out in a randomized block design with four replications in plots measuring the 2.5 x 2.5 m and with a spacing of 60 cm between rows and 30 cm between plants. Arka anamika okra variety was raised during late kharif by following all the recommended package of practices except the plant protection measures. To avoid the drift during spray tall sorghum was raised around the all treatment imposed plots. Nine formulations of the three fungi *viz, M. anisopliae, B. bassiana* and *V. lecanii* were tested along with the standard chemical check, oxydemeton methyl 25 EC and untreated check. High volume knapsack sprayer was used for spraying different formulations with a spray volume of 500 liter per hectare at 45 days after sowing. First spray was given at 35 days after sowing and subsequent sprays at an interval of 20 days. A day before spraying the pre count of all the sucking pests were made on 10 tagged plants from each replication of treatment forming a quadrate design which were tagged. The subsequent observations were made at 15 days after each spray.The observations of both pre and post count on top three, middle three and bottom three leaves of ten plants randomly selected from each replication for all the sucking pests of okra. The yield data was recorded in individual treatments of okra separately for assessing the efficacy of different treatments. The data was subjected for analysis of variance to draw the inference.

Results and discussion

There was no significant difference in the leaf hopper population among all the formulation of treatment a day before imposition of treatment with a population range of 5.96 to 6.36 leaf hoppers per 3 leaves indicating the uniformity in pest population. All the fungal pathogens irrespective of formulations were on par with each other and inferior to oxydemeton methyl 25 EC. At 15 days after second spray, there was gradual increase in leafhopper population in all the treatments (Table1). But all the treatments except *M. anisopliae* oil formulation failed to keep the pest population below economic threshold level (2 nymphs/leaf). The standard check oxydemeton methyl recorded least population of 5.00 leafhoppers/3 leaves followed by *M. anisopliae* oil formulation. Similar results were obtained by Anita (2007) and Girish Kumar (2000) who reported that although *M. anisopliae*, *V. lecanii* and *B. bassiana* were effective in reducing the leaf hopper population and they were inferior to chemical control (Oxydemeton methyl).

The chemical treatment and *V. lecanii* oil and wettable poweder formulation were significantly superior over rest of the treatments (2.08 and 2.58, aphids/3 leaves) followed by *M. anisopliae* oil, *B. bassiana* oil, *B. bassiana* wettable powder and *V. lecanii* crude formulation (Table1). During second spray of treatments there was no significant difference among various formulations indicating the uniformity in aphid population. At 15 days after spraying the oxydemeton methyl, *V. lecanii* oil formulation and *B. bassiana* oil formulation were on par with each other with population count ranged between 5.00 and 9.75 aphids/3 leaves. *V. lecanii* oil formulation recorded least population count of aphid followed by *B. bassiana* oil and *V. lecanii* wettable powder formulation. Whereas, chemical check recorded least population (5.00 aphids/3 leaves). The present findings are in agreement with Anita, (2007) who reported that among the botanicals and mycopathogens, neem oil and *V. lecanii* recorded 2.56 and 3.33 mean number of aphids/3 leaves and were next best treatments after oxydemeton methyl which recorded 3.30 mean number of aphids/3 leaves. Efficacy of mycopathogen against aphids is in accordance with Nirmala *et al*. (2006).

At 15 days after spraying, among fungal formulations, *V. lecanii* oil formulation recorded least whitefly population (2.00 whiteflies/3 leaves) which is superior over the standard check. (2.25 whiteflies/3 leaves). During second spray, the pre-treatment counts made a day before spraying indicated that, there was no significant difference among the treatments. However, population of whitefly ranged from 4.28 to 6.50 whiteflies/3 leaves. At 15 days after spraying, there was a gradual increase in whitefly population. Least population was recorded again in *V. lecanii* oil formulation (2.70 whiteflies/3 leaves) which was to be on par with oxydemeton methyl (1.93 whiteflies/3 leaves). While, the treatment *B. bassiana* crude, *M. anisopliae* crude and *V. lecanii* crude were least effective and failed to differ significantly from untreated control. (Table 1) The present findings are in agreement with Mallappanavar, (2000) according to whom the reduction of different stages of whiteflies was least at one day after treatments but increased gradually at 7DAS and became distinctly evident at 15 DAS and results indicated that *V.lecanii* @ 1.33 × 107 spores per ml and Vertilec 7.5 g per liter were most effective against the pests at all the days of interval of observations. The present findings are in agreement with Andrew *et al.* (2004), Anitha (2007), Quinden (1994), Meade and

Table 1. Efficacy of different formulation of *Beauveria bassiana, Metarhizium anisopliae* and *Verticillium lecanii* against leafhoppers, aphids and whiteflies in okra

Treatments	Dosage	Number of leafhoppers/ 3 leaves				Number of aphids/ 3 leaves				Number of whiteflies/ 3 leaves			
		I Spray		II Spray		I Spray		II Spray		I Spray		II Spray	
		1DBS	15DAS	1DBS	15DAS	1DBS	15DAS	1DBS	15DAS	1DBS	15DAS	1DBS	15DAS
Beauveria bassiana crude formulation	1x 10^8 cfu/ml	6.36 (2.62)a	4.02 (2.12)b	9.92 (3.22)a	9.35 (3.14)b	5.41 (2.43)a	4.25 (2.18) ab	17.33 (4.22)a	13.60 (3.75)a-c	3.81 (2.08)a	4.08 (2.14)b	5.38 (2.42)ab	4.30 (2.19)ab
Beauveria bassiana formulation	1x 10^8 cfu/ml	6.15 (2.58)a	3.69 (2.04)bc	9.40 (3.14)a	8.46 (2.99)bc	6.00 (2.55)a	3.72 (2.05)a-d	16.94 (4.17)a	11.00 (3.39)cd	3.72 (2.05)a	3.66 (2.04)bc	4.62 (2.26)b	4.00 (2.12)a-c
Beauveria bassiana Oil based formulation	1x 10^8 cfu/ml	5.98 (2.54)a	3.83 (2.08)b	8.83 (3.05)a	6.88 (2.72)b-d	5.67 (2.48)a	3.25 (1.94)b-d	19.19 (4.43)a	9.75 (3.20)de	3.72 (2.05)a	3.00 (1.87)b-d	5.22 (2.39)ab	3.15 (1.91)b-d
Metarhizium anisopliae crude formulation	1x 10^8 cfu/ml	5.97 (2.54)a	4.24 (2.17)b	9.55 (3.17)a	7.83 (2.89)bc	5.41 (2.43)a	4.26 (2.18)ab	17.21 (4.20)a	14.50 (3.87)ab	4.26 (2.18)a	3.96 (2.11)b	4.39 (2.21)b	4.03 (2.13)a-c
Metarhizium anisopliae WP formulation	1x 10^8 cfu/ml	6.11 (2.57)a	4.07 (2.13)b	8.80 (3.05)a	6.67 (2.68)cd	5.50 (2.45)a	3.95 (2.11)a-c	16.91 (4.17)	13.25 (3.71)a-c	3.95 (2.11)a	3.50 (2.00)bc	4.28 (2.18)b	3.83 (2.08)a-c
Metarhizium anisopliae Oil based formulation	1x 10^8 cfu/ml	6.05 (2.56)a	3.25 (1.93)bc	9.53 (3.16)a	5.25 (2.40)d	5.78 (2.50)a	2.83 (1.83)c-e	17.33 (4.22)a	11.50 (3.46)b-d	4.26 (2.18)a	3.33 (1.96)b-d	5.48 (2.44)ab	3.08 (1.89)b-d
Verticillium lecanii Crude formulatio	1x 10^8 cfu/ml	6.19 (2.59)a	3.08 (1.89)bc	9.13 (3.10)a	9.50 (3.16)b	5.98 (2.54)a	3.59 (2.02)a-d	16.87 (4.16)a	12.00 (3.54)b-d	3.59 (2.02)a	3.50 (2.00)bc	5.20 (2.38)b	4.10 (2.14)a-c
Verticillium lecanii WP formulation	1x 10^8 cfu/ml	6.22 (2.59)a	4.25 (2.17)b	9.55 (3.17)a	8.75 (3.04)bc	5.97 (2.55)a	2.66 (1.78)de	16.96 (4.17)a	10.00 (3.24)de	4.14 (2.15)a	3.32 (1.96)b-d	4.48 (2.23)b	3.00 (1.87)b-d
Verticillium lecanii Oil based formulation	1x 10^8 cfu/ml	6.06 (2.56)a	3.62 (2.03)bc	10.98 (3.38)a	7.75 (2.87)bc	6.01 (2.55)a	2.58 (1.76)de	17.34 (4.22)a	7.75 (2.87)e	4.34 (2.20)a	2.00 (1.58)d	5.25 (2.39)ab	2.70 (1.79)cd
Oxydemeton methyl 25EC (Standard check)	1.5 ml /l	6.15 (2.58)a	2.57 (1.75)c	11.13 (3.41)a	5.00 (2.35)d	5.91 (2.53)a	2.08 (1.61)e	16.75 (4.15)a	5.00f (2.35)	3.89 (2.09)a	2.25 (1.66)cd	4.43 (2.21)b	1.93 (1.56)d
Untreated control (Water spray)	—	5.96 (2.54)a	6.19 (2.58)a	10.00 (3.24)a	12.88 (3.66)a	6.03 (2.55)a	4.56 (2.25)a	16.80 (4.15)a	16.25 (4.09)a	4.56 (2.25)a	6.15 (2.58)a	6.50 (2.64)a	5.00 (2.35)a

DBS- Day before spray, DAS- Days after spray,

Figures in the parentheses are $\sqrt{x + 0.5}$ transformation, Figures in the same column with similar alphabets do not differ significantly at P=0.05 by DMRT

Table 2. Efficacy of different formulation of Beauveria bassiana, *Metarhizium anisopliae* and *Verticillium lecanii* against thrips and mites in okra

Treat ments	Dosage	Number of thrips / 3 leaves: I Spray 1DBS	I Spray 15DAS	II Spray 1DBS	II Spray 15DAS	Number of mites / 3 leaves: I Spray 1DBS	I Spray 15DAS	II Spray 1DBS	II Spray 15DAS	Fruit yield (q/ha)	Increase in yield over control	Monitory over control (Rs/ha)	B:C Ratio
Beauveria bassiana Crude formulation	1x 10^8 cfu/ml	3.00 (1.87)a	3.00 (1.87)ab	4.75 (2.29)a	3.50 (2.00)a-c	12.86 (3.65)ab	11.17 (3.42)b	21.67 (4.71)a	12.80 (3.65)b-d	27.50f	07.00	5680	6.68:1
Beauveria bassiana WP formulation	1x 10^8 cfu/ml	3.17 (1.91)a	2.50 (1.73)a-c	4.17 (2.16)a	2.75 (1.80)bc	14.55 (3.87)ab	9.25 (3.12)b-d	20.30 (4.54)a	10.75 (3.35)b-e	34.20d	13.80	11040	15.77:1
Beauveria anisopliae oil based formulation	1x 10^8 cfu/ml	3.17 1.91)a	2.00 (1.58)bc	4.58 (2.25)a	2.58 (1.76)cd	12.01 (3.53)b	8.75 (3.04)b-d	21.60 (4.69)a	9.25 (3.12)de	36.50c	16.10	12880	1.88:1
Metarhizium anisopliae Crude formulation	1x 10^8 cfu/ml	3.25 (1.93)a	3.25 (1.94)ab	4.25 (2.17)a	4.08 (2.14)ab	13.96 (3.80)ab	9.92 (3.23)bc	22.36 (4.55)a	13.00 (3.67)bc	28.60ef	08.20	6560	7.71:1
Metarhizium anisopliae WP formulation	1x 10^8 cfu/ml	3.08 (1.89)a	3.00 (1.87)ab	4.17 (2.16)a	3.16 (1.91)bc	14.30 (3.84)ab	8.25 (2.96)b-d	20.33 (4.54)a	11.00 (3.39)b-e	35.66cd	14.60	11680	16.68:1
Metarhizium anisopliae Oil based formulation	1x 10^8 cfu/ml	3.17 (1.91)a	2.75 (1.80)a-c	4.00 (2.12)a	2.83 (1.82)bc	13.49 (3.74)ab	7.25 (2.78)cd	21.22 (4.66)a	9.75 (3.20)c-e	38.80b	18.40	14720	13.57:1
Verticillium lecanii Crude formulation	1x 10^8 cfu/ml	3.25 (1.93)a	2.92 (1.85)ab	4.25 (2.17)a	3.83 (2.08)a-c	14.61 (3.88)ab	11.08 (3.40)b	20.91 (4.60)a	13.92 (3.80)b	29.50e	09.10	7280	8.56:1
Verticillium lecanii WP formulation	1x 10^8 cfu/ml	3.25 (1.93)a	2.50 (1.73)a-c	4.50 (2.23)a	3.25 (1.94)bc	15.09 (3.94)ab	10.25 (3.28)b	20.40 (4.57)a	11.75 (3.50)b-d	36.50c	16.10	12880	18.40:1
Verticillium lecanii Oil based formulation	1x 10^8 cfu/ml	3.17 (1.91)a	2.25 (1.66)bc	4.42 (2.21)a	3.00 (1.87)bc	15.60 (4.01)a	10.00 (3.24)bc	22.22 (4.66)a	11.00 (3.39)b-e	38.50b	18.10	14480	13.35:1
Oxydemeton methyl 25EC (Standard check)	1.5 ml /l	3.50 (2.00)a	1.50 (1.41)c	4.33 (2.19)a	1.58 (1.44)d	14.15 (3.82)ab	7.00 (2.74)d	21.93 (4.73)a	7.75 (2.87)e	45.50a	25.10	20080	20.80:1
Untreated control (Water spray)	—	3.25 (1.93)a	4.00 (2.12)a	4.58 (2.25)a	4.83 (2.31)a	14.60 (3.88)ab	21.78 (4.72)a	21.92 (4.72)a	17.75 (4.27)a	20.40g	-	-	-

DBS- Day before spray, DAS- Days after spray,

Figures in the parentheses are $\sqrt{x + 0.5}$ transformation Figures in the same column with similar alphabets do not differ significantly at P=0.05 by DMRT, Crude formulation (2.5 kg crude grain/ha for one spray) = Rs.850 /ha (cost of both spray including labour charge), Oil based formulation (500 g pure spore /ha for one spray +1.5 kg sunflower oil) = Rs.1084 /ha,

Wettable powder formulation (1.5 kg WP/ha for one spray) = Rs.700 /ha (cost of both spray including labour charge), Rs.75/100g pure Spore Oxydemeton methyl 25 EC (1.5 ml/l) = Rs. 965 (including labour charge), Rs.25/ kg talc powder, Rs. 200/kg of WP formulation, Rs.50/man day

Bruce (1991), Nier et al. (1993) and Mallappanavar (2000).

The data indicated no significant difference in thrips population (3.00 to 3.50 thrips/3 leaves) a day before imposing the treatments. The data on 15 days after spraying revealed that, *B. bassiana* oil and *V. lecanii* oil formulations recorded lowest thrips density of 2.00 and 2.25 thrips/3 leaves, respectively, which were on par with each other (Table2). However, the chemical treatment recorded least population of 1.50 thrips/3 leaves among all the treatments. The present findings are comparable with the results of Ramarethinam (2000) and Quinden (1994).

At 15 days after spray revealed that *M. anisopliae* oil formulation, wettable powder formulation and *B. bassiana* oil formulation recorded less mite population of 7.25, 8.25 and 8.75 mites/3 leaves, respectively, while chemical treatment recorded the mite population of 7.00 mites /3 leaves. During second spray, B. bassiana oil and M. anisopliae oil formulation recorded less mite count of 9.25 and 9.75 mites/3 leaves and significantly superior over the other treatments, while, there was no significant different between all other treatment, However, they differed significantly over untreated control (Table 2). The present findings are in agreement with the reports of Hanchinal (2000) and Ramarethinum *et al.* (2000).

Among the formulations, higher yield was obtained in *M. anisopliae* oil formulation (38.80 q/ha) followed by *V. lecanii* oil formulation (38.50 q/ha) and were at par with each other (Table2). These two formulations were of *B. bassiana* oil and *V. lecanii* wettable powder formulations with an identical yield of 36.50 q/ha and were statistically at par with each other. Among the treatments, the standard check which recorded highest yield of 45.50 q/ha was superior over all the fungal formulations. The least yield obtained in untreated control (20.40 q/ha). The incremental yield in different treatments varied from 7.10 to 25.10 q/ha. Among the formulations the highest incremental yield was recorded in *M. anisolpiae* and *V. lecanii* oil formulations (18.40 and 18.10 q/ha), respectively followed by *B. bassiana* oil and *V. lecanii* wettable powder formulations. Where as lowest incremental yield was recorded in *B. bassiana* crude (7.10 q/ha) followed by *M. anisopliae* crude (8.20 q/ha) and *V. lecanii* crude formulations (9.10 q/ha). However, the standard check recorded the 25.00 q/ha incremental yield of okra. Among different formulations the highest monitory returns was recorded in *M. anisoliae* oil and *V. lecanii* oil formulation with Rs. 14720 and 14480 per ha and it was followed by *B. bassiana* oil and *V. lecanii* wettable powder formulation with Rs. 12880 and 12880/ha. However, the highest monitory returns recorded in standard check with Rs. 20080/ha whereas least in case of *B. bassiana* crude formulation. *V. lecanii* oil and wettable powder formulations with highest benefit cost ratio (18.48:1) followed by *M. anisopliae* wettable powder formulation (16.68:1). These two formulations were followed by *B. bassiana* wettable powder formulation (15.77:1), *M. anisopliae* oil formulation (13.57:1) and *V. lecanii* (13.35:1). The highest benefit cost ratio was observed in standard check (20.8:1).

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