Studies on the potency of some biopesticides against whitefly in cotton and tomato

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ABSTRACT

Whitefly the tiny homopteran is now emerging as the most destructive pest in several crops. In cotton and tomato it is now being identified as the most destructive insect causing heavy loss of yield. Field experiment was set to evaluate some biopesticides against whitefly in cotton and tomato. Among the different biopesticides evaluated *Beauveria bassiana* (66.11% and 63.24% reduction of population over control in cotton and tomato, respectively) and *Verticillium lecanii* (64.33% and 61.27% reduction of population over control in cotton and tomato, respectively) was considered as the best against whitefly, while, *Metarhizium anisopliae*, neemazal and karanja oil were moderately effective against whitefly population. *Beauveria bassiana* recorded maximum yield both in case of cotton and tomato (334.33 kg/ha and 19.5 t/ha respectively).

Keywords: biopesticides, cotton, tomato, whitefly.

MS History: 03.04.2018 (Received)-17.05.2018 (Revised)-20.05.2018 (Accepted).

Citation: Abhijit Ghosal**.** 2018**.** Studies on the potency of some biopesticides against whitefly in cotton and tomato. *Journal of Biopesticides,* **11**(1):60–68.

INTRODUCTION

Cotton (*Gossypium hirsutum*), is Malvaceous shrub native to tropical and subtropical regions widely cultivated as fibre crop. This white gold plays a vital role in the economy of India. India continues to maintain the largest area under cotton and second largest producer of cotton next to china with 34% of world area and 21% of world production (Anonymous, 2013). As per the report of Union Ministry of Agriculture acreage under cotton had been increased 21 per cent (111.55 lakh hectare) during 2017-18 as compared to previous year, with 10-15% increased output (337.25 lakh bales of 170 kg each). On the other hand tomato (*Lycopersicon esculentum* Mill.), the Solanaceous vegetables is a good source of vitamins (A and C) and minerals. It is one of the most widely grown vegetable. In India, it is widely grown in winter and, to some extent, in summer season. During 2016-17 India has cultivated tomato in 809 thousand hectare of land with 19697 thousand metric tonnes production (Anonymous, 2017). In different parts of West Bengal tomato is cultivated as rabi as well as spring summer crop. Cotton and tomato are the two important widely cultivated crops throughout the globe. Among the numerous abiotic and biotic stresses that affect yield of cotton and tomato, insects are the major constraint in the production throughout the world. Both the crops are subjected to attack a by large number of borer and sucking insect pests starting from seedling to harvest. Among them whitefly is one of the major key pests and has now attained the status of major threatening insect throughout the globe. Whitefly (*Bemisia tabaci* Gennadius), the tiny white colored soft bodied plant sap-sucking insect placed in the family Aleyrodidae in the superfamily Aleyrodoidea, is broadly polyphagous, phloem feeder (Hendrix *et al.*, 1992) reported to attack an estimated 600 plant species 50% of them belong to five families: Fabaceae, Asteraceae, Malvaceae, Solanaceae and Euphorbiaceae (Mound and Halsey, 1978). Tomato and cotton are two of the preferred hosts of whitefly. To mitigate their damage farmers are habituated to use cocktail spray chemical insecticides, thus inflicting resurgence, resistance resulting impossible to control. Biopesticides are attaining the major thrust for managing the whitefly population in recent days. Therefore, for successful establishment of myco-insecticides or botanicals and to reduce insecticidal load in IPM program, the role of this selected biopesticides is very important. Entomopathogenic fungi and botanicals are ideal for IPM programs because they are relatively safe to use and have a narrower spectrum of activity than chemical insecticides. In this context it is essential to screen the potency of biopesticides against this notorious pest as an important component of integrated pest management (IPM).

MATERIALS AND METHODS

The present investigation was carried out in order to study whitefly management through biopesticides and therefore field experiments were conducted in C-Block Farm, B.C.K.V., Kalyani, Nadia, West Bengal, located at 22.580N latitude, 88.260E longitude and 11m above MSL. The experiments were conducted during rabi season, 2012-13 and 2013-14. *Verticillium lecani* (Mealikil) @ 5 g/lt, *Beauveria bassiana* (Racer) @ 5 g/lt, Karanja oil (Derisom) @ 2 mL/lt, *Metarhizium anisopliae* (Pacer) @ 5g/lt, Neemazal 10000 ppm (Neemazal) @ 3 mL/l were tested under field condition. To study the relative efficacy of test biopesticides the crops [Cotton: Var. Kaveri (Bollguard II) and Tomato: Var. Pathorkuchi (Local)] was raised in plots (12 sq m) under normal recommended package of practices at a spacing of 50 cm x 50 cm and left for natural infestation of whitefly. When the population of whitefly crosses conventional recommended ETL (economic threshold level) (150 adults/100leaf) (Ahmed *et al.*, 2002), two consecutive spray of biopesticides are imposed with pneumatic knapsack sprayer with hollow cone nozzle at recommended doses diluted in 500 litres/ha of water. Mean number of whitefly adults per three leaves (one from each upper, middle and lower leaf) of five randomly selected plants were observed before and one, seven and 15 days after each spray. To assay the effect of the test biopesticides population count on coccinelids and spiders were recorded on 1, 5 and 10 days after spraying periodically from the preselected plants.

RESULTS

Effect of biopesticides against whitefly (*B. tabaci*) in cotton:

During the field trial conducted in 2012-13 (Table 1),
there was no significant difference between the treatments before imposing any insecticides.

Table 1. Effect of biopesticides against whitefly (*Bemisia tabaci*) in cotton during 2012-2013

Treatment	Dose	Mean whitefly population/ 3 leaves								Overall mean	% reduction over control	Yield (kg/ha)
		1st spray				2nd spray						
		PT	1DAS	5DAS	10DAS	PT	1DAS	5DAS	10DAS			
T_1	5 g/ l	12.05	9.33	4.01	3.15	4.21	3.67	2.11	1.98	5.06	63.72	322.25
T_2	5 g/l	12.33	8.98	4.33	2.45	3.67	3.33	1.98	1.67	4.84	65.31	334.33
T_3	2 ml/l	11.88	6.33	5.78	7.05	8.10	5.65	4.33	4.00	6.64	52.43	302.67
T_4	5 g/l	12.67	10.15	5.45	5.05	5.55	5.25	3.33	2.67	6.27	55.12	311.98
T_5	3 ml/l	12.33	5.88	4.67	4.78	5.05	3.88	2.25	2.33	5.15	63.13	319.10
T_6	-	12.09	12.33	13.45	14.33	14.67	14.69	14.78	15.33	13.96	-	122.75
SEm ±	-	0.470	0.022	0.026	0.028	0.032	0.025	0.019	0.021	-	-	4.370
CD at 5%	-	NS	0.069	0.081	0.089	0.098	0.076	0.061	0.066	-	-	13.590

T_1= *Verticillium lecanii*, T_2= *Beauveria bassiana* 250-300 LE, T_3= Karanja oil, T_4= *Metarhizium anisopliae*, T_5= Neemazal, T_6= Control; DAS = days after spraying, PT = pre-treatment count, NS = Not significant

During 1 DAS, neemazal was considered as best treatments having the lowest population (5.88 whiteflies per three leaves) followed by karanja oil, the highest population was recorded by *Metarhizium* (10.15 whiteflies per three leaves). During 5 DAS *Verticillium* recorded the lowest population (4.01 whiteflies per three leaves) followed by *Beauveria*. At 10 DAS *Beauveria* recorded the lowest population. After second spray all the biopesticidal treatments documented an admirable result in checking the whitefly population below ETL. After 10 days of second spraying *Beauveria* recorded the lowest population (1.67 whiteflies per three leaves) followed by *Verticillium* (1.98). Regarding overall mean population again *Beauveria* recorded the least (4.84 whiteflies per three leaves) with maximum protection over control (65.31%) and recorded the highest yield of 334.33 kg/ha.

Table 2. Effect of biopesticides against whitefly (*Bemisia tabaci*) in cotton during 2013-14

Treatment	Dose	Mean whitefly population/ 3 leaves								Overall mean	% reduction over control	Yield (kg/ha)
		1st spray				2nd spray						
		PT	1DAS	5DAS	10DAS	PT	1DAS	5DAS	10DAS			
T_1	5 g/ l	10.45	8.25	4.33	3.67	4.01	2.33	1.67	1.33	4.51	64.93	319,45
T_2	5 g/l	11.24	8.33	3.78	2.89	3.33	2.03	1.33	1.09	4.25	66.90	333.78
T_3	2 ml/l	11.67	6.67	5.33	5.67	6.05	3.09	3.00	5.33	5.85	54.45	279.67
T_4	5 g/l	11.33	7.78	4.33	3.98	4.33	2.49	2.03	3.33	4.95	61.47	309.25
T_5	3 ml/l	10.67	5.67	4.45	4.33	5.78	2.88	2.33	3.67	4.97	61.29	310.45
T_6	-	11.33	11.67	12.33	12.77	12.89	13.33	13.78	14.67	12.85	-	119.68
SEm ±	-	0.250	0.032	0.028	0.030	0.042	0.025	0.022	0.027	-	-	4.110
CD at 5%	-	NS	0.088	0.089	0.093	0.127	0.077	0.066	0.085	-	-	13.010

T_1= *Verticillium lecanii*, T_2= *Beauveria bassiana* 250-300 LE, T_3= Karanja oil, T_4= *Metarhizium anisopliae*, T_5= Neemazal, T_6= Control; DAS = days after spraying, PT = pre-treatment count, NS = Not significant

Table 2 shows that all the treatments have a significant difference over control after the insecticide application. After one day of application, neemazal exerted a good effect on whitefly population and recorded the lowest whitefly population per three leaves (5.67) followed by karanja oil (6.67). The microbial insecticides were not so effective at 1 DAS, but their efficacy was increased at 5 DAS and onwards. During 5 DAS *Beauveria bassiana* recorded the lowest whiteflies per three leaves (3.78) followed by *Verticillium* and *Metarhizium*. Same trend was followed at 10 DAS. After 10 DAS the population was in the trend to increase with the reduction of the persistency of the biopesticides. *Beauveria* recorded the lowest population (1.09 whiteflies per three leaves) after 10 days of second spraying and the highest population was recorded in karanja oil (5.33 whiteflies per three leaves). In respect of overall mean population recorded after two sprays *Beauveria* again recorded the lowest population (4.25 whiteflies per three leaves) with the highest per cent reduction over control (66.90%) closely followed by *Verticillium* (4.51 whiteflies per three leaves and 64.93% reduction over control) and *Metarhizium* (4.95 whiteflies per three leaves and 61.47% reduction over control), whereas the highest population was recorded in control plot (12.85 whiteflies per three leaves). *Beauveria* recorded the highest yield (333.78 kg/ha), while in control in plot it was only 119.68 kg/ha.

The pooled results of both the years are presented in the table 3 and the results shows clearly that *Beauveria bassiana* is considered the best treatment which recoded lowest whitefly population (4.55 whiteflies per three leaves) the highest per cent reduction of whiteflies over control (66.11%) and

Table 3. Effect of biopesticides against whitefly (*Bemisia tabaci*) in cotton (Pooled)

Treatment	Dose	Mean whitefly population/ 3 leaves								Over all mean	% reduction over control	Yield (kg/ha)
		1st spray				2nd spray						
		PT	1DAS	5DAS	10DAS	PT	1DAS	5DAS	10DAS			
T_1	5 g/ l	11.25	8.79	4.17	3.41	4.11	3.00	1.89	1.66	4.79	64.33	322.25
T_2	5 g/l	11.79	8.66	4.06	2.67	3.50	2.68	1.66	1.38	4.55	66.11	334.33
T_3	2 ml/l	11.78	6.50	5.56	6.36	7.08	4.37	3.67	4.67	6.25	53.44	302.67
T_4	5 g/l	12.00	8.97	4.89	4.52	4.94	3.87	2.68	3.00	5.61	58.30	311.98
T_5	3 ml/l	11.50	5.78	4.56	4.56	5.42	3.38	2.29	3.00	5.06	62.21	319.10
T_6	-	11.71	12.00	12.89	13.55	13.78	14.01	14.28	15.00	13.41	-	122.75
SEm ±	-	0.360	0.027	0.024	0.029	0.036	0.024	0.020	0.024	-	-	4.240
CD at 5%	-	NS	0.079	0.085	0.091	0.111	0.074	0.064	0.074	-	-	13.301

T_1= *Verticillium lecanii*, T_2= *Beauveria bassiana* 250-300 LE, T_3= Karanja oil, T_4= *Metarhizium anisopliae*, T_5= Neemazal, T_6= Control; Values in the parentheses are √(x+0.5) transformed values, DAS = days after spraying, PT = pre-treatment count, NS = Not significant

maximum harvestable yield (334.33 kg/ha) followed by *Verticillium*, *Metarhizium*, neemazal and karanja oil. The control plot recorded only 122.75 kg yield/ha.

In respect of pooled data of two experimental years (Fig. 1,2),

Fig. 1. Effect of biopesticides on Coccinelid population in cotton

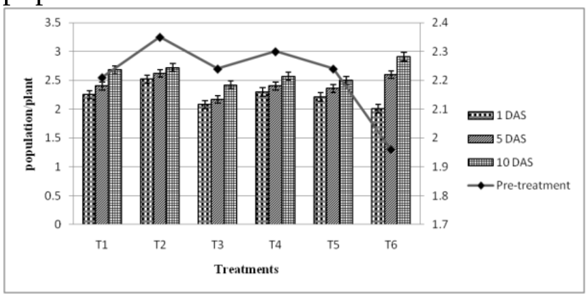
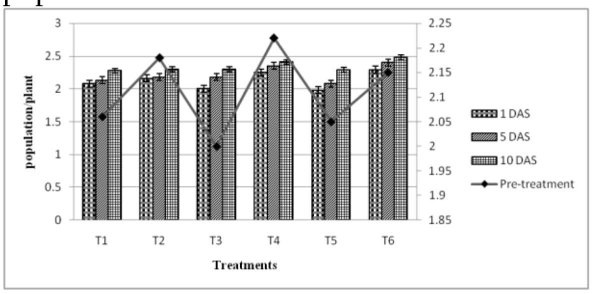


Fig. 2. Effect of biopesticides on spider population in cotton



it is unambiguous to say that the population of coccinelid and spider was increased as like as the population was increased in untreated plot, which reflects that all the selected biopesticides were very safe towards the coccinelid and spider. *Beauveria bassiana* recorded the highest population of coccinelid (2.52 per plant) in one day after spraying closely followed by *Metarhizium*. During 10 DAS it was recorded that control plot recorded the maximum population (2.91 per plant) which was at par with the other biopesticide treatments. *Beauveria bassiana* recorded the highest population of coccinelid (2.72 per plant) among the insecticidal treatments. Regarding the effect of biopesticides on spider population it is clear that there was a non-significant difference between the treatments on pre-treatment count as well as subsequent count taken in 1 DAS, 5 DAS and 10 DAS. *Metarhizium anisopliae* recorded the highest population of spider (2.41 per plant) after 10 DAS among the biopesticides used, closely followed by *Beauveria bassiana*, karanja oil, *Verticillium lecanii* and neemazal.

Effect of biopesticides against whitefly (B. tabaci) in tomato:

Efficacy of the said biopesticides was evaluated against whitefly (*B. tabaci*) in tomatoes during 2013-13 and duly presented in table 4 there was no significant difference between the treatments before imposing any insecticides. During 1 DAS, neemazal was considered as the best treatment which recorded the lowest population (4.17 per three leaves) followed by

Table 4. Effect of biopesticides against whitefly (*Bemisia tabaci*) in tomato during 2012-13

Treatment	Dose	Mean whitefly population/ 3 leaves								Overall mean	% reduction over control	Yield (t/ha)
		1st spray				2nd spray						
		PT	1DAS	5DAS	10DAS	PT	1DAS	5DAS	10DAS			
T_1	5 g/ l	8.25	6.75	3.25	2.77	3.09	2.18	1.69	1.72	3.71	62.30	19.33
T_2	5 g/l	8.05	6.67	3.09	2.66	3.11	2.13	1.33	1.46	3.56	63.83	19.75
T_3	2 ml/l	8.33	4.33	3.76	4.53	4.88	3.04	2.78	2.60	4.28	56.53	16.25
T_4	5 g/l	8.67	5.98	3.34	3.67	4.23	2.78	2.67	2.72	4.26	56.77	16.45
T_5	3 ml/l	8.33	4.17	3.37	4.33	4.67	2.36	2.45	2.88	4.07	58.67	17.18
T_6	-	8.39	8.40	9.01	9.33	10.05	10.10	11.45	12.06	9.85	-	10.67
SEm ±	-	0.390	0.021	0.017	0.015	0.017	0.015	0.014	0.011	-	-	1.140
CD at 5%	-	NS	0.066	0.054	0.045	0.059	0.038	0.028	0.037	-	-	3.430

T_1= *Verticillium lecanii*, T_2= *Beauveria bassiana* 250-300 LE, T_3= Karanja oil, T_4=*Metarrhizium anisopliae*, T_5= Neemazal, T_6= Control; DAS = days after spraying, PT = pre-treatment count, NS = Not significant

karanja oil (4.33 per three leaves) the highest population was recorded by *Verticillium lecanii* (6.75 whiteflies per three leaves). During 5 DAS, *Beauveria bassiana* recorded the lowest population (3.09 whiteflies per three leaves) followed by *Verticillium lecanii* (3.25 whiteflies per three leaves). On 10 DAS *Beauveria bassiana* again recorded the lowest population (2.66 whiteflies per three leaves). After second spray all the biopesticidal treatments recorded an outstanding result in checking the whitefly population below ETL. After 10 days of second spraying also *Beauveria bassiana* recorded the lowest population (1.46 whiteflies per three leaves) followed by *Verticillium lecanii* (1.72 whiteflies per three leaves). Regarding overall mean population again *Beauveria bassiana* recorded the least (3.56 per three leaves) with maximum protection over control (63.83%) and recorded the highest yield of 19.75 t/ha. Table 5

Table 5. Effect of biopesticides against whitefly (*Bemisia tabaci*) in tomato during 2013-14

Treatment	Dose	Mean whitefly population/ 3 leaves								Overall mean	% reduction over control	Yield (t/ha)
		1st spray				2nd spray						
		PT	1DAS	5DAS	10DAS	PT	1DAS	5DAS	10DAS			
T_1	5 g/ l	8.33	6.25	3.54	3.19	3.78	2.75	1.7	1.66	3.91	60.24	18.48
T_2	5 g/l	8.03	5.88	3.33	3.03)	3.67	2.68	1.67	1.09	3.67	62.65	19.25
T_3	2 ml/l	7.98	4.33	4.27	4.67	5.01	3.09	3.67	2.75	4.47	54.53	15.33
T_4	5 g/l	8.35	6.33	3.88	4.01	4.33	2.55	2.50	2.45	4.30	56.27	15.67
T_5	3 ml/l	8.33	4.25	3.89	3.98	4.39	2.33	2.43	2.40	4.00	59.32	16.15
T_6	5 g/ l	8.67	8.70	9.01	9.33	9.88	10.25	11.05	11.78	9.83	-	9.58
SEm ±	-	0.285	0.024	0.022	0.018	0.017	0.015	0.014	0.014	-	-	1.210
CD at 5%	-	NS	0.097	0.089	0.054	0.068	0.048	0.048	0.056	-	-	3.650

T_1= *Verticillium lecanii*, T_2= *Beauveria bassiana* 250-300 LE, T_3= Karanja oil, T_4=*Metarrhizium anisopliae*, T_5= Neemazal, T_6= Control

Values in the parentheses are $\sqrt{(x+0.5)}$ transformed values, DAS = days after spraying, PT = pre-treatment count, NS = Not significant

Conform that all the treatments have a significant difference over control after the insecticide application. After one day of application, neemazal exerts a good effect (may be due to antifeedant or deterrent effect) on whitefly population and recorded minimum whitefly population (4.25 whiteflies per three leaves) followed by karanja oil (4.33

whiteflies per three leaves). The microbial insecticides were not so effective during 1 DAS, but their efficacy increased at 5 DAS and onwards. *Beauveria bassiana* recorded the lowest population (3.33 whiteflies per three leaves) followed by *Verticillium lecanii* and *Metarhizium anisopliae* on five days after first spraying. Similar trend was followed at 10 DAS. After ten days of first spraying the population was in the trend to increase with the reduction of the persistency of the biopesticides. *Beauveria bassiana* recorded the lowest population (1.09 per three leaves) after 10 days of second spraying, whereas, the highest population was recorded in karanja oil (2.75 whiteflies per three leaves). A steady increase of population was recorded in untreated control plot (11.78 whiteflies per three leaves) on ten days after second spraying. In respect of overall mean whitefly population recorded after two sprays *Beauveria bassiana* again recorded the lowest population (3.67 whiteflies per three leaves) with the highest per cent reduction over control (62.65%) closely followed by *Verticillium lecanii* (3.91 number of whiteflies per three leaves and 60.24% reduction over control), whereas, the highest population was recorded in control plot (9.83 whiteflies per three leaves). *Beauveria bassiana* recorded the highest yield (19.25 t/ha), while in control in plot it was only 9.58 t/ha. The pooled data of two experimental are years illustrated in table-6

Table 6. Effect of biopesticides against whitefly (*Bemisia tabaci*) in tomato (Pooled)

Treatment	Dose	Mean whitefly population/ 3 leaves								Overall mean	% reduction over control	Yield (t/ha)
		1st spray				2nd spray						
		PT	1DAS	5DAS	10DAS	PT	1DAS	5DAS	10DAS			
T_1	5 g/ l	8.29	6.50	3.40	2.98	3.44	2.47	1.74)	1.69	3.81	61.27	18.91
T_2	5 g/l	8.04	6.28	3.21	2.85	3.39	2.41	1.50	1.28	3.62	63.24	19.50
T_3	2 ml/l	8.16	4.33	4.02	4.28	4.63	3.07	3.11	2.68	4.38	55.53	15.79
T_4	5 g/l	8.51	6.16	3.61	3.84	4.28	2.67	2.59	2.59	4.28	56.52	16.06
T_5	3 ml/l	8.33	4.21	3.63	3.72	4.02	2.35	2.38	2.64	4.04	59.00	16.67
T_6	-	8.53	8.55	9.01	9.33	9.97	10.18	11.25	11.92	9.84	-	10.13
SEm ±	-	0.332	0.023	0.020	0.017	0.017	0.015	0.014	0.013	-	-	1.140
CD at 5%	-	NS	0.082	0.072	0.050	0.064	0.043	0.038	0.047	-	-	3.482

T_1= *Verticillium lecanii*, T_2= *Beauveria bassiana* 250-300 LE, T_3= Karanja oil, T_4=*Metarrhizium anisopliae*, T_5= Neemazal, T_6= Control; DAS = days after spraying, PT = pre-treatment count, NS = Not significant

and it is unambiguous to say that *Beauveria bassiana* is considered as the best treatment, which recorded the lowest mean whitefly population after two sprays (3.62 whiteflies per three leaves) their highest per cent reduction over control (63.24%) and maximum yield (19.50 t/ha) followed by *Verticillium lecanii, Metarhizium anisopliae*, neemazal and karanja oil. The control plot recorded only 10.13 ton yield per ha. The pooled data of two experimental years has been depicted in fig. 3 and 4.

Fig. 3. Effect of biopesticides on coccinelids in tomato

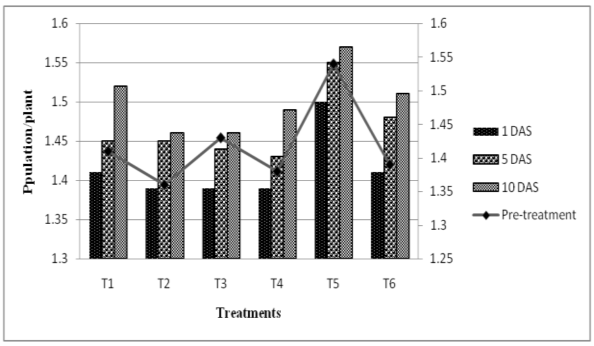
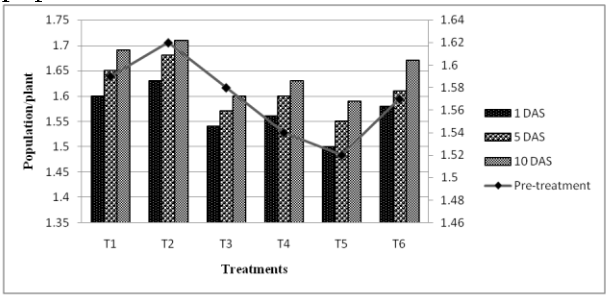


Fig. 4. Effect of biopesticides on spider population in tomato



It is explicit to say that the population of coccinelid and spider showed non significant effect in respect of untreated plot, which reflects that all the selected biopesticides had little impact on coccinelid and spider population in field level. Neemazal recorded the highest population of coccinelid (1.57 per plant) during ten days after spraying closely followed by *Verticillium*. *Beauveria bassiana* recorded the highest population of spider (1.71 per plant) after 10 DAS among the biopesticides used, closely followed by *Verticillium lecanii*, *Metarhizium anisopliae,* karanja oil and neemazal. As all the biopesticide treatments were found to be at par with control plot in all the post treatment counts, it clearly indicates that they were all found to be very safe to the predatory coccinelid beetle and spider complex.

DISCUSSION

Biopesticides are one of the effective tools for managing the insect pest. Organic agriculture greatly demands pest management through organic ways. That is why biopesticides are the only effective tool for insect pest management in organic agriculture as well as a component of IPM. In the present findings our objective was oriented to evaluate the efficacy of some biopesticides against whitefly in field condition. As per the result obtained, all the biopesticides treatment showed remarkable potency over whitefly and confirmed as the safest over the coccinelids and spiders. It was observed that *Beauveria bassiana* and *Verticillium lecanii* were considered as highly potent microbial insecticides against whitefly. Pathogenicity of *Beauveria bassiana* to whitefly species was also reported by Moraga *et al.*, (2006); as per their reports the mortality rates varied from 3 to 85%. Higher potency of *Beauveria bassiana* is in conformity with the findings of Larios *et al.,* (2000) they concluded that commercial formulation of *Beauveria bassiana* was as effective as endosulphan. Poprawski (1999) reported 65% control of *B. tabaci* on collards after 5 weekly applications of *B. bassiana,* which is in agreement with the findings of the present author. Strains of *Verticillium lecanii* (*Lecanicillium spp.*) possess the potentiality as microbial control agent of whitefly on cucumber and tomato reported by Koike *et al.* (2004) confirms our investigated findings. Nymphal stages of *B. tabaci* are highly susceptible to infection by *B. bassiana* (Vicentini *et al.*, 2001) and *V. lecanii* (Meade and Byrne, 1991). Young instars of *B. tabaci* tend to be more susceptible to fungal infections of *B. bassiana* than the 4th instar. Tests by Wraight *et al.* (2000) revealed that control levels of 86–98% were achieved with *P. fumosoroseus* and *B. bassiana* following 3–5 applications of low to high rates of conidia (1.25–5.0 x 10^{13}/ha). Higher efficacy of these myco-insecticides can be explained as both *B. bassiana* and *V. lecanii* can find sufficient moisture for germination and host penetration within the leaf or insect microclimate boundary layer, which confirmed that these fungi can show their potency even in dry climate and as whitefly population is favoured by the dry climatic condition they can be utilized successfully. This phenomenon has been demonstrated with respect to infection of whitefly nymphs by *Beauveria bassiana* by Wraight *et al.*, (2000). Successful application of *B. bassiana* needs favorable environmental conditions such as relatively high humidity and medium temperature (not exceeding 32°C) as documented by Faria and Wright, (2001); which can be utilized as the supporting document of our present studies as during the course of our investigation environmental factors like temperature and humidity were favorable for the successful conidia development for efficient infection. Unfortunately, the effects of temperature on efficacy of fungal biological control agents are difficult to characterize and remain poorly understood with respect to most pest-pathogen systems, and therefore no such reports regarding this were available. Side by side another microbial insecticide *Metarhizium anisopliae* can also be considered as highly potent against whiteflies, which can be correlated with the findings of Yacoub, (2003), who showed that nymphs and pupae of *B. tabaci* turned into black-greenish colour due to the fungal infection of *Metarhizium anisopliae*, 3 days after treatment. It was observed that efficacy of microbial insecticides was increased during 5 DAS and their persisteny continued up to 10 DAS depending on the existing weather.

Foliar application of neem based formulation neemazal and karanja oil provided batter check of whitefly during 1 DAS than the microbials antifeedant or repellency may be associated; with this result. As botanicals are very much photo-degradable their efficacy decreased after 5 DAS. Our experimental result is comparable with the findings of Kumar and Poehling, (2007); Wang *et al.*, (2008) and Adilakshmi *et al.*, (2008). Pavela and Herda, (2007) studied the repellent effects of pongam oil on settlement and oviposition of the common greenhouse whitefly *Trialeurodes vaporariorum* on chrysanthemum. These results are in agreement with our present outcome. It was observed that all the biopesticides treatments recorded as much as or higher population of coccinelids and spiders in both cotton and tomato during both the experimental years. Therefore, these biopesticides could be effective tools in IPM strategies of whitefly. Akmal *et al.* (2013) reported that the entomopathogenic fungus, *B. bassiana* showed little or no detrimental effects to *Coccinella septempunctata*. *Beauveria bassiana* and neem products had no adverse effect on predatory coccinelids (Vanlaldiki *et al.* 2013). Our findings are in the conformity of their findings.

REFERENCE

Adilakshmi, A., Korat, D. M. and Vaishnav, P. R. 2008. Bio-efficacy of some botanical insecticides against pests of okra. *Karnataka Journal of Agricultural Science*, 21(**2**): 290-292.

Ahmed, M. Mz., Elhassan, A. M. and Kannan, H. O. 2002. Use of combined economic threshold level to control insect pests on cotton. *Journal of Agriculture and Rural Development in the Tropics and Subtropics*, 103(**2**): 147-156.

Akmal, M., Freed, S., Malik, M. N. and Gul, H. T. 2013. Efficacy of *Beauveria bassiana* (Deuteromycotina: Hyphomycetes) against different aphid species under laboratory condition. *Pakistan journal of Zoology*, **45**: 71-78.

Anonymous 2013. Annual Report 2012-13. All India coordinated Cotton Improvement Project (Indian Council of Agricultural Research), Central Institute for Cotton Research, Coimbatore, **PP** 3.

Anonymous 2017. Horticulture statistics at a glance, Department of Agriculture, Cooperation and Farmers Welfare, Govt. of India, **PP** 16.

Faria, M. and Wraight, S. P. 2001. Biological control of *Bemisia tabaci* with fungi. *Crop Protection*, **20**: 767–778.

Koike, M., Higashio, T., Komori, A., Akiyama, K., Kishimoto, N., Masuda, E., Sasaki, M., Yoshida, S., Tani, M., Kuramoti, K., Sugimoto, M. and Nagao, H. 2004. Verticillium lecanii (Lecanicillium spp.) as epiphyte and its application to biological control of arthropod pests and diseases, *Bulletin*-OILB/SROP, 27(**8**): 41-44.

Kumar, P. and Poehling, H. M. 2007. Effects of azadirachtin, abamectin, and spinosad on sweetpotato whitefly (Homoptera: Aleyrodidae) on tomato plants under laboratory and greenhouse conditions in the humid tropics. *Journal of Economic Entomology*, **100**:411-420.

Larios, J. F., Santos, M. O. and Ramírez-Vazquez, N. R. 2000. Use of *Beauveria bassiana* for Silver leaf Whitefly (Bemisia argentifolii Bellows & Perring) Management in Muskmelon. *HortScience*, 35(**3**): 393.

Meade, D. L. and Byrne, D. N. 1991. The use of *Verticillium lecanii* against subimaginal instars of *Bemisia tabaci*. *Journal of Invertebrate Pathology*, **57**: 296–298.

Moraga, Q. E, Maranhao, E. A. A., Garcia, V. P. and Alvarez, S. C. 2006. Selection of *Beauveria bassiana* isolates for control of the whiteflies *Bemisia tabaci* and Trialeurodes vaporariorum on the basis of their virulence, thermal requirements, and toxicogenic activity. *Biological Control*, 36(**3**): 274-287.

Mound, L. A., and Halsey, S. H. 1978. Whiteflies of the world, a systematic catalogue of the Aleyrodidae (Homoptera) with host plant and natural enemy data. British Museum (Natural History), London, UK, **PP** 340.

Pavela, R. and Herda, G. 2007. Repellent effects of pongam oil on settlement and oviposition of the common greenhouse whitefly *Trialeurodes vaporariorum* on *chrysanthemum*. Insect Science, 14: 219–224.

Poprawski, T. J. 1999. Control of *Bemisia argentifolii* on collards using different formulations and rates of *Beauveria bassiana*. Arthropod Management Tests, **24**: 122–123.

Sabesh, M. 2007. List of insect and mite pests of cotton in India. (http://www.cicr.org.in/research_notes/insec_mite_pest.pdf)

Vanlaldiki, H., Sing, M. P. and Sarkar, P. K. 2013. Efficacy of eco-friendly insecticides on the management of diamond back moth (*Plutella xylostella* Linn.) on cabbage. The Bioscan, **8**: 1225-1230.

Vicentini, S., Faria, M. and Oliveira, M. R. V. 2001. Screening of *Beauveria bassiana* (Deuteromycotina: Hyphomycetes) isolates against nymphs of Bemisia tabaci biotype B (Hemiptera: Aleyrodidae) with description of a new bioassay method. *Neotropical Entomology*, **30**: 97–103.

Wang, S. Q., Guo, Y. L., Pang, S. T. and Shi, Z. H. 2008. Toxicities of different pesticides to B biotype *Bemisia tabaci*. *Acta Agriculturae Zhejiangensis*, **20**: 367-371.

Wraight, S. P., Carruthers, R. I., Jaronski, S. T., Bradley, C. A., Garza, C. J. and Galaini-Wraight, S. 2000. Evaluation of the entomopathogenic fungi *Beauveria bassiana* and *Paecilomyces fumosoroseus* for microbial control of the silverleaf whitefly, *Bemisia argentifolii*. *Biological Control*, **17**: 203–217.

Yacoub, A. B. 2003. Symptomatology of tobacco whitefly and red spidermite infection with the entomopathogenic fungus *Metarhizium anisopliae* (Metsch.) Sorokin. Agricultural Sciences, **30**: 3.

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