Management of sucking pests, by integration of organic sources of amendments and foliar application of entomopathogenic fungi on chilli

C. Chinniah*, A. Ravikumar, M. Kalyanasundaram and P. Parthiban

ABSTRACT

A field experiment was conducted to evaluate the efficacy of different organic amendments *viz*., farm yard manure (FYM), neem cake (NC) and *Pseudomonas fluorescens* in combination with certain entomopathogenic fungal formulations *viz*., *Hirsutella thompsonii* Fisher, *Beauveria bassiana* (Balsamo), and *Lecanicillium lecanii* (Zimm.) against sucking pests of chilli *viz.*, aphids, *Myzus persicae* (Sulzer), chilli thrips, *Scirtothrips dorsalis* Hood and muranai mite, *Polyphagotarsonemus latus* (Banks). Among fourteen treatments tested, seed treatment with *P. fluorescens* @10 g kg^{-1} of seed + foliar application of *B. bassiana* @ $1x10^8$ CFU ml^{-1}, neem cake @ 600 kg ha^{-1} + *B. bassiana* @ $1x10^8$ CFU ml^{-1} and farm yard manure @ 12.5 t ha^{-1} + *B. bassiana* @ $1x10^8$ CFU ml^{-1} were found promising against sucking pests of chilli, which are statistically on par. The next effective treatment was *P. fluorescens* @ 10 g kg^{-1} of seed + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} in reducing population of aphids and thrips on chilli, With regard to yellow mite of chilli, *P. fluorescens* @ 10g kg^{-1} of seed + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1} was found effective. Further, treatment combination of organic amendments with formulations of *B. bassiana* recorded highest yield of green chillies and cost benefit ratio (CBR).

Key words: Chilli, Entomopathogens, *Myzus persicae,* Organic amendments, *Polyphagotarsonemus latus, Scirtothrips dorsalis.*

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INTRODUCTION

Chilli, *Capsicum annum* L. is one of the most important widely cultivated crops grown for its value as fruits in India. India is rich in maximum diversity of chilli varieties with varied characters and it is a fascinating spice, as it has got two important commercial qualities. Some varieties are known for the characteristic red colour because of the presence of capsanthin pigment, others are known for the biting pungency imparted by the alkaloid capsaicin. Nutritionally, it is rich in vitamin A, C and E. India contributes about 36 % to the world production. Though it is cultivated all over India, its cultivation is mostly concentrated in Southern states *viz.*, Andhra Pradesh, Karnataka, Maharashtra and Tamil Nadu, occupying nearly 75 per cent of total area in India. Tamil Nadu stands fifth in terms of area and total production. It is cultivated in an area of 50,670 ha with an annual production of 23,060 tonnes of dry chillies (Anonymous, 2013).

Among several production constraints, arthropod pest are the main causes for low production. As many as 57 species of insect and mite fauna were recorded to damage chilli at various stages of crop growth (Reddy and Puttaswamy, 1984). Chilli leaf curl complex “murda” is one of the most destructive syndromes devasting chilli in India caused by thrips and mites (Puttarudriah, 1959). The yield loss caused by thrips and mites is estimated to be over 50 per cent in the event of serious infestation (Ahamed *et al*., 1987). During last two decades insecticidal control of chilli pests in general characterized by high pesticide usage, although the pesticide act as the first line of defense, the past experiences of unexpected resistance towards new chemicals and their adverse effects on the environment has posed problems of residues in the fruits, pest resurgence and destruction of natural enemies suggest the need to develop alternative management strategies. In order to mitigate these problems, interest on alternate methods of pest management in recent years indicated a great potential for harnessing organic amendments and biocontrol agents for the management of sucking pests of chilli. Very limited attempts were made to investigate the entomopathogens against chilli pests under Tamil Nadu conditions. Hence, the present investigation was undertaken to find out the effective combination of organic amendments *viz*., FYM, NC and *P. fluorescens* in combination with certain entomopathogenic fungi formulation as suitable component of IPM modules to sucking pests of chilli.

MATERIALS AND METHODS

The field experiments were carried out at Manchanaighampatty village of Aundipatty block, Theni district, Tamil Nadu during kharif 2014 in a randomized black design to assess the influence of organic sources of nutrients / amendments in combination with foliar application of entomopathogenic fungi on the incidence of sucking pests on chilli. Variety K 1 was transplanted adopting 60 cm x 45 cm spacing between rows and between plants, respectively with the plot size of 4 x 5 m which were replicated three times. The treatments were : T1- FYM @ 12.5 t ha^{-1} , T2- Neem cake @ 600 kg ha^{-1}, T3- *Pseudomonas flurescens* @ 10 g kg^{-1} of seed, T4- T1 + *Hirsutella thompsonii* (Foliar application $1x10^8$ CFU ml^{-1}), T5- T1 + *Beauveria bassiana* @ $1x10^8$ CFU ml^{-1}, T6- T1 + *Lecanicillium lecanii* @ $1x10^8$ CFU ml^{-1}, T7- T2 + *Hirsutella thompsonii* @ $1x10^8$ CFU ml^{-1},T8- T2 + *Beauveria bassiana* @ $1x10^8$ CFU ml^{-1}, T9- T2 + *Lecanicillium lecanii* @ $1x10^8$ CFU ml^{-1}, T10- T3 + *Hirsutella thompsonii* @ $1x10^8$ CFU ml^{-1}, T11- T3 + *Beauveria bassiana* @ $1x10^8$ CFU ml^{-1}, T12- T3 + *Lecanicillium lecanii* @ $1x10^8$ CFU ml^{-1}, T13- Profenophos 50 EC @ 2ml l^{-1} and T14- untreated control. Organic amendments were applied as basal application incorporated before planting, while *P. fluorescens* was applied as seed treatment at the time of sowing at prescribed quantity. All the agronomic practices were followed uniformly for all treatments. A total of two rounds of foliar application of entomopathogens were imposed based on the ETL starting from 30 days after transplanting. The spray fluid used was 500 L ha^{-1} and sprayed to run off point using high volume knapsack sprayer.

The population of aphids, thrips and mite were assessed from three leaves randomly selected and representing the top, middle and bottom portion from each plant on five randomly selected plants per replication. The pest population was on 1^{st}, 3^{rd}, 7^{th} and 14^{th} day after each spray apart from pretreatment count and expressed as number of aphids, thrips and mite / three leaves. Ten plants were selected at random from each replication in all the treatments and the severity of upward curling was scored visually by adapting 0-4 point scale and leaf curl index (LCI) was worked out as suggested by Desai *et al*. (2006). The yield of green chillies from each plot was weighed and recorded and computed as kg ha^{-1}. Data obtained from field experiment were subjected to ANOVA. Before analysis, data on population were subject to square root transformation. In order to assess the interaction between treatments, the data were subjected to factorial RBD analysis and the treatment means obtained were separated by LSD (Least Significant Difference).

RESULTS AND DISCUSSION

The findings emanated from the field investigations on the efficacy of different organic amendments *viz*., FYM, NC and *P. fluorescens* in combination with certain promising entomopathogenic fungal pathogens *viz*., *H. thompsonii*, *B. bassiana*, and *L. lecanii* against sucking pests of chilli are presented in table 1. The results revealed that, among the various treatment combinations evaluated, seed treatment with *P. fluorescens* @ 10 g kg^{-1} of seed + foliar application of *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1} recorded the least number of mean

Table 1. Effect of organic sources of nutrients and fungal pathogens against sucking pests of chilli

	Treatments	Mean pop. of aphid / 3 leaves	% reduction over control	*Mean pop. of thrips / 3 leaves	% reduction over control	*Mean pop. of mite / 3 leaves	% reduction over control	LCI / plant	% reduction over control
T_1	FYM @ 12.5 t/ha	13.61^{f}	38.78	14.42^{f}	45.58	16.87^{f}	40.33	2.33^{g}	40.71
T_2	Neem cake @ 600 kg/ha	13.09^{f}	41.12	14.20^{f}	46.42	16.12^{f}	42.98	2.28^{g}	41.98
T_3	*P. flurescens* (10 g/kg of seed)	12.83^{f}	42.29	13.98^{f}	47.25	16.05^{f}	43.23	2.24^{g}	43.00
T_4	T1 + *H. thompsonii* $1x10^8$ spores/ml	11.54^{e}	48.09	11.89^{e}	55.13	11.48^{cd}	59.39	2.09^{f}	46.82
T_5	T1 + *B. bassiana* $1x10^8$ spores/ml	7.74^{bc}	65.18	8.45^{bc}	68.11	9.87^{b}	65.09	1.60^{b}	59.29
T_6	T1 + *L. lecanii* $1x10^8$ spores/ml	8.65^{d}	61.09	9.73^{d}	63.28	12.80^{e}	54.72	1.95^{de}	50.38
T_7	T2 + *H. thompsonii* $1x10^8$ spores/ml	11.28^{e}	49.26	11.35^{e}	57.17	11.20^{c}	60.38	2.04^{ef}	48.09
T_8	T2 + *B. bassiana* $1x10^8$ spores/ml	7.26^{b}	67.34	8.05^{b}	69.62	9.66^{b}	65.83	1.56^{b}	60.31
T_9	T2 + *L. lecanii* $1x10^8$ spores/ml	8.48^{cd}	61.85	9.62^{c}	63.70	12.55^{e}	55.61	1.84^{cd}	53.18
T_{10}	T3 + *H. thompsonii* $1x10^8$ spores/ml	10.85^{e}	51.19	11.05^{e}	58.30	11.12^{c}	60.67	1.96^{de}	50.13
T_{11}	T3 + *B. bassiana* $1x10^8$ spores/ml	7.16^{b}	67.79	7.99^{b}	69.85	9.56^{b}	66.18	1.52^{b}	61.32
T_{12}	T3 + *L. lecanii* $1x10^8$ spores/ml	8.36^{cd}	62.39	9.26^{cd}	65.06	12.36^{de}	56.28	1.81^{c}	53.94
T_{13}	Profenophos 50 EC @ 2ml/lit	4.85^{a}	78.18	4.86^{a}	81.66	7.14^{a}	74.74	1.34^{a}	65.90
T_{14}	Untreated control	22.23^{g}	-	26.50^{g}	-	28.27^{g}	-	3.93^{h}	-
SEd		0.0706	-	0.0775	-	0.0848	-	0.1338	-
CD (0.05)		0.1451	-	0.1593	-	0.1743	-	0.2749	-

*Mean of three replications;

In a column, means followed by common letter(s) are not significantly different by LSD (p= 0.05) population of aphids, thrips and mites coupled with highest mean per cent reduction of 67.79, 69.85 and 66.18 respectively over untreated control (Table 1) followed by the application of NC @ 600 kg ha^{-1} + *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1} and FYM @ 12.5 t ha^{-1} + *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1} are the effective treatments which are statistically on par.

The next in the order of efficacy was *P. fluorescens* @ 10g kg^{-1} of seed + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} in reducing the population of aphids and thrips on chilli, registering population of 8.36 and 9.26 / 3 leaves with per cent reduction of 62.39 and 65.06 over control, which are statistically on par with NC @ 600 kg ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} and FYM @ 12.5 t ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1}) than by *P. fluorescens* @ 10g kg^{-1} of seed + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1}, NC @ 600 kg ha^{-1} + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1} and FYM @ 12.5 t ha^{-1} + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1}, respectively.

With regard to chilli yellow mite, *P. fluorescens* @ 10g kg^{-1} of seed + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1} was found effective with population of 11.12 / 3 leaves coupled with 60.67 per cent reduction over control, followed by NC @ 600 kg ha^{-1} + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1} and FYM @ 12.5 t ha^{-1} + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1} which is statistically on par with, ranking next to the application of organic amendments in combination with *B. bassiana*. The next in the order of efficacy are *P. fluorescens* @ 10g kg^{-1} of seed + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1}, NC @ 600 kg ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} and FYM @ 12.5 t ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1}.

The other treatments worth mentioning are *P. fluorescens* @ 10g kg^{-1} of seed with a mean population of aphids, thrips and mite coupled with mean per cent reduction of 42.29, 47.25 and 43.23 over untreated control, followed by NC @ 600 kg ha^{-1} and FYM @ 12.5 t ha^{-1}, all these treatments were statistically on par. Profenophos 50 EC @ 2ml/lit (standard check) was significantly superior than all other treatments evaluated which recorded the least mean population of aphids, thrips and mites, resulting / 3 leaves with the highest per cent reduction of 78.18, 81.66 and 74.74 respectively over control.

The data on leaf curl index revealed that (Table 1) among the organic amendments and entomopathogenic fungi combinations evaluated, The proportion of plants exhibiting leaf curl damage was low in *P. fluorescens* @ 10g kg^{-1} of seed + *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1}, recording 1.52 LCI / plant and the highest mean per cent reduction of 61.32 over untreated control (next to the standard check profenophos), which is statistically on par with other treatments. This was followed by *P. fluorescens* @ 10 g kg^{-1} of seed + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1}, NC @ 600 kg ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1}, FYM @ 12.5 t ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} and *P. fluorescens* @ 10g kg^{-1} of seed + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1} which were also on par in their efficacy. Other treatments namely NC @ 600 kg ha^{-1} + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1}, FYM @ 12.5 t ha^{-1} + *H. thompsonii* @ 1 x 10^{-8} CFU ml^{-1}, *P. fluorescens* @ 10g kg^{-1} of seed, NC @ 600 kg ha^{-1} and FYM @ 12.5 t ha^{-1} were next in the order and recorded 48.09, 46.82, 43.00, 41.98 and 40.71 per cent reduction respectively over untreated control.

The highest fruit yield of 9140 kg ha^{-1} was recorded with 57.18% increase over untreated control with a maximum cost benefit ratio of 1:1.78 in the plots treated with of *P. fluorescens* @ 10 g kg^{-1} of seed + *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1} (Table 2). Whereas application of NC @ 600 kg ha^{-1} + *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1} recorded 9025 kg ha^{-1} coupled with a percent increase of 55.20 over untreated control with the cost benefit ratio of 1:1.74, closely followed by the treatments *viz*., FYM @ 12.5 t ha^{-1} + *B. bassiana* @ 1 x 10^{-8} CFU ml^{-1} which recorded 9015 kg ha^{-1} coupled with percent increase of 55.09 over untreated control with the cost benefit ratio of 1:1.69 , *P. fluorescens* @ 10 g kg^{-1} of seed + *L. lecani* @ 1 x 10^{-8}

Table 2. Effect of organic sources of nutrients and fungal pathogens on yield of green chillies

Treatments		Yield Kg $plot^{-1*}$	Yield Kg ha^{-1}	% increase over control	Gross return Rs. ha^{-1}	CBR
T_1	FYM @ 12.5 t/ha	15.52	7760	33.45	116400.00	1:1.45
T_2	Neem cake @ 600 kg/ha	15.84	7920	36.20	118800.00	1:1.45
T_3	*P. flurescens* (10 g/kg of seed)	15.98	7990	37.40	119850.00	1:1.49
T_4	T1 + *H. thompsonii* $1x10^8$ spores/ml	17.09	8545	46.95	128175.00	1:1.51
T_5	T1 + *B. bassiana* $1x10^8$ spores/ml	18.03	9015	55.03	135225.00	1:1.69
T_6	T1 + *L. lecanii* $1x10^8$ spores/ml	17.56	8780	50.99	131700.00	1:1.56
T_7	T2 + *H. thompsonii* $1x10^8$ spores/ml	17.21	8605	47.98	129075.00	1:1.54
T_8	T2 + *B.bassiana* $1x10^8$ spores/ml	18.05	9025	55.20	135375.00	1:1.74
T_9	T2 + *L. lecanii* $1x10^8$ spores/ml	17.8	8900	53.05	133500.00	1:1.59
T_{10}	T3 + *H. thompsonii* $1x10^8$ spores/ml	17.34	8670	49.10	130050.00	1:1.55
T_{11}	T3 + *B. bassiana* $1x10^8$ spores/ml	18.28	9140	57.18	137100.00	1:1.78
T_{12}	T3 + *L. lecanii* $1x10^8$ spores/ml	17.87	8935	53.65	134025.00	1:1.62
T_{13}	Profenophos 50 EC @ 2ml/lit	19.02	9510	63.54	142650.00	1:2.01
T_{14}	Untreated control	11.63	5815	-	87225.00	1:0.98

CFU ml^{-1} recorded 8935 kg ha^{-1} coupled with percent increase of 53.65 over untreated control with the cost benefit ratio of 1:1.62, NC @ 600 kg ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} recorded 8900 kg ha^{-1} coupled with percent increase of 53.05 over untreated control with the cost benefit ratio of 1:1.59, FYM @ 12.5 t ha^{-1} + *L. lecani* @ 1 x 10^{-8} CFU ml^{-1} recorded 8780 kg ha^{-1} coupled with percent increase of 50.99 over untreated control with the cost benefit ratio of 1:1.56. The yield recorded in untreated control was only 5815 kg ha^{-1}. The standard check Profenophos 50 EC @ 2ml/lit recorded the highest fruit yield of 142650 kg ha^{-1} which accounts for 63.54 per cent increase of green chillies over untreated control with the highest cost benefit ratio of 1:2.01.

Among the three soil amendments evaluated *viz*., *P. fluorescens*, FYM and NC, all these three were found promising when applied in combination with *B. bassiana*. This may be attributed to the fact that application of organic amendments could have resulted in slow release of nutrients leading to a sequence of biochemical changes in plant, which could have probably made the host plant defensive against pest infestation. This finding are in agreement with the reports of Ramamoorthy *et al.* (2001) who opined that Plant growth promoting rhizobacteria (PGPR) belonging to *Pseudomonas* spp. bring about induced systemic resistance (ISR) through stimulating the physical and mechanical strength of the cell apart from changing the physiological and biochemical reaction of the host leading culminating in synthesis of defense chemicals against certain pathogens, insect and nematode pests under field conditions. Varma and Supare (1997) reported soil application of vermicompost (5t/ha) / farmyard manure

(5 t/ha) with full dose of NPK (150:50:50) recorded minimum population of aphids (2.92/leaf) and mites (3.81/leaf) and the highest yield in chilli. Sachan and Pal (1974) proved that soil application of neem cake @ 250 kg/ha minimized the incidence of white grub, *Holotrichia sp* in chillies. Varghese (2003) who reported that application of neem cake @ 500 and 1000 kg/ha and vermicompost @ 2500 kg/ha in combination with 50% RDF has significantly lowered thrips and mite and leaf curl index resulting in higher fruit yield. Giraddi and Smitha (2004) found that the organic amendments such as neem cake with 50% recommended dose of fertilizer resulted in lower thrips and mite induced leaf curl, fruit damage by *H. armigera* (8.7%) and high fruit yield (3.2 q/ha) in chilli.

The performance of *B. bassiana* @ 1×10^8 spores / ml is in accordance with reports of Sujay (2006) who found that application of *B. bassiana* @ 5×10^{13} spores ml^{-1} was very effective against *S. dorsalis* on chilli. Suresh *et al*. (2006) indicated that the application of *B. bassiana* 1×10^9 spores / ml twice at 20 and 30 DAP was found superior in reducing the thrips population in onion. The effect of *B. bassiana* against mite also is in agreement with the earlier findings of Pena *et al.* (1996) who reported that application of *B. bassiana* @ 1.6×10^6 conidia ml^{-1} resulted in higher infection and mortality of *P. latus*. Ihsan and Ibrahim (2007) reported that an application of WP formulation of *B. bassiana* @ 1×10^{10} conidia ml^{-1} was more effective against chilli mite.

Further, the effectiveness of organic amendments in combination with *B. bassiana* are in accordance with findings of Ambika and Chinniah (2007) who found that application of neem cake in combination with *B. bassiana* recorded the maximum reduction in mite population in chilli. Vinoth kumar *et al.* (2010) reported that application of *P. fluorescens* @ 10g/ kg of seed + two rounds of *B. bassiana* (1×10^8 spores / ml) as foliar application recorded the highest mean per cent reduction of mites (67.79 and 76.18) and eggs (54.57 and 72.08) after first and second spray on brinjal, respectively.

Publication of Senthilraja *et al.* (2010) also strongly vouches that application of mixture of *B. bassiana* and *P. fluorescens* strains significantly brought down the leaf miner incidences when applied as talc-based formulation through seed, soil and foliar application under glasshouse and field conditions.

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