Management of two spotted spider mite *Tetranychus urticae* Koch. a serious pest of brinjal, by integrating biorational methods of pest control

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ABSTRACT

Twenty three biorational treatments have been tested against *Tetranychus urticae*, an important pest of brinjal (MBH-11) under farmer field condition. Pest egg and life stages population were observed one, three, seven and 14 days after spraying. Results revealed that maximum pest population was reduced by T_{16} followed by T_{10} treatments. However, egg population was highly reduced by T_{16}, T_{19}, T_7 and T_4 treatments. Brinjal yield has been optimized by T_4 treatment followed by T_{13}. These two treatments have been recomended for the management of spider mite in brinjal.

Key words: Brinjal, spider mite, crop pest, biorational management.

INTRODUCTION

Brinjal is an important tropical vegetable; find an inseparable role in our day to day diet, very rich in vitamins and minerals besides its role as a cure for diabetics in ayurvedic medicine system. It is said to be originated from Africa and Asia; growing up to a height of 55 inches. It has got excellent medicinal properties for eg., the roots of the egg plant are used against internal hemorrhage and asthma; the leaves and bark against dysentery. This plant is also effective for the treatment of hypercholesterolemia. The fruit is suggested as a cure for diabetic in ayurvedic medicine system. The successful cultivation of egg plant is threatened by a number of pests and diseases. Among the arthropod pests of brinjal, the two spotted spider mite, *Tetranychus urticae* is the main threat next to shoot and fruit borer. The two spotted spider mite, *T.urticae* also assumes serious pest status, often causing 50 – 100 % yield loss, against which the synthetic acaricides are advocated, culminating in environmental pollution, pesticide resistance, pest resurgence, secondary pest outbreak, degradation of soil health, besides direct and indirect deleterious effect on human health eventually. Hence this is the need of the hour to find some alternative which should be cheaper, environmentally benign with satisfactory control of the target pests.

MATERIALS AND METHODS

Field experiments

A field trial was conducted at a farmer's holding at Kokkulam village, Madurai District, Tamil Nadu using the variety MBH-11, with the spacing 60 x 60 cm the soil type was clay loam, with a PH 8.0, well suited for vegetable cultivation in irrigated condition. This field experiment was conducted in RBD to evaluate the effect or influence of organic sources of nutrients/amendments in combination with foliar application of entomopathogenic fungi on the incidence of two spotted spider mite on brinjal, *Tetranychus urticae* with 23 treatments: T_1 - Farm Yard Manure @ 25 tonnes/ha, T_2 - *Pseudomonas fluorescens* @ 10g/ kg of seed, T_3 - Neem cake @ 200 kg/ ha, T_4 - T_1+ *Ocimum sanctum* (10% aqueous leaf extract) T_5 - T_1+ NSKE (5%) foliar spray, T_6 - T_1+ Neem oil (3%) foliar spray, T_7 - T_1+ *Beauveria bassiana* (foliar application @1x 10^8spores / ml), T_8 - T_1 + *Paecilomyces fumosoroseus*(foliar application @1x 10^8spores / ml), T_9 - T_1+ *Lecanicillium lecani* (foliar application @1x 10^8spores / ml), T_{10} - T_2+ *Ocimum sanctum* (10% aqueous leaf extract), T_{11} - T_2+ NSKE (5%), T_{12} - T_2+ Neem oil (3%) T_{13} - T_2+ *Beauveria bassiana* (foliar application @1x 10^8spores / ml), T_{14} - T_2+ *Paecilomyces fumosoroseus* (foliar application @1x 10^8spores / ml), T_{15} - T_2+ *Lecanicillium lecani* (foliar application @1x 10^8spores / ml), T_{16} - T_3+ *Ocimum sanctum* (10% aqueous leaf extract), T_{17} - T_3+ NSKE (5%), T_{18} - T_3+ Neem oil (3%), T_{19} - T_3+ *Beauveria bassiana* (foliar application @1x 10^8spores / ml), T_{20} - T_3+ *Paecilomyces fumosoroseus* (foliar application @1x 10^8spores / ml), T_{21} - T_3+ *Lecanicillium lecani* (foliar application @1x 10^8spores / ml), T_{22} - Dicofol @ 4ml /lit (standard check) and T_{23}- untreated control. Two rounds of foliar applications were given as and when the mite population crossed the threshold levels.

Preparation of leaf extracts

The medicinal herb *Ocimum sanctum* leaves were collected from the herbal garden maintained at AC & RI, Madurai. Five hundred grams of leaves were macerated with enough quantity of distilled water, and then transferred to a 500 ml beaker. After an hour, the extract was filtered, and the volume was made up to 500 ml. This stock solution was used to prepare further required test concentrations as prescribed in the protocol, by serial dilution. The 10 percent leaf extract was prepared by adding 10 ml of mother extract with 100 ml of distilled water and applied as foliar spray using high volume sprayer. Two rounds of foliar sprays were applied during the investigation.

Apart from pretreatment count, the post treatment counts were recorded on 1, 3,7 and 14 days after first and second spray as per protocol, population of mites from 10 randomly selected plants / plot @ 3 leaves / plant in $2cm^2$ area / leaf, egg count / leaf @ 3 leaves / plant, totally 10 plants / plot, fruit yield (kg/ha), natural enemy fauna, Soil micro flora (fungi, bacteria and actinomycets) and cost benefit ratio were recorded.

RESULTS

A field experiment was conducted to evaluate the efficacy of different organic amendments *viz.*, farm yard manure, neem cake, and *Pseudomonas fluorescens* in combination with foliar application of plant products *viz., Ocimum sanctum* (10% leaf extract), neem seed kernel extract (5%), neem oil (3%) and certain entomopathogenic fungal formulations *viz., Beauveria bassiana, Paecilomyces fumosoroseus, Lecanicillium lecanii*. The common acaricide dicofol was included as standard check in the treatment structure for comparison of efficacy. The pretreatment count of mite population ranged from 25.73 to 25.86 per $2cm^2$ area of leaf, and the eggs ranged between 41.33 to 45.42 per leaf. The post treatment counts were recorded on 1^{st}, 3^{rd}, 7^{th} and 14^{th} days after each spray (Tables 1 - 4).

The results revealed that among the various organic amendments evaluated in combination with two rounds of foliar application of entomopathogenic fungi at fortnightly interval in field condition, the basal application of *P. fluorescens* @ 10g/ kg of seed + two rounds of *B. bassiana* (1x 10^8spores / ml) as foliar application recorded the highest mean percent reduction of mites (67.79 and 76.18) and eggs (54.57 and 72.08) after first and second spray respectively. Followed by basal application of farm Yard Manure @ 25 tonnes/ha + *Ocimum sanctum* (10% aqueous leaf extract) recorded a mean percent reduction of mites (67.60 and 75.71) and eggs (54.47 and 72.32). However, neem cake @ 200 kg/ha + *B. bassiana* (1x 10^8spores / ml) resulted in the percent reduction of mites (67.47 and 75.38) and eggs (54.26 and 71.67) which are the best three treatments in the order of efficacy, closely followed by Neem cake @ 200 kg/ha + *O. sanctum* (10% aqueous leaf extract) with a percent reduction of mites (67.45 and 75.76) and eggs (54.23 and 71.87), Farm Yard Manure @ 25 tonnes/ha + *B. bassiana* (1x 10^8spores / ml) with a percent reduction of mites (67.62 and 75.29) and eggs (54.09 and 71.71), *Pseudomonas fluorescens* @ 10g/ kg of seed + *O. sanctum* (10% aqueous leaf extract) with a percent reduction of mites (67.39 and 74.49) and eggs (53.96 and 72.43) which recorded the maximum percent reduction of egg and mite population after first and second sprays respectively, and these treatments are statistically on par. Dicofol @ 4ml /lit (standard check) recorded the highest percent reduction of mites (73.09 and 81.41) and eggs (76.36 and 88.52) after first and second spray respectively. It was found to be superior than all other treatments. Hence as an alternative to the chemical pesticides, these naturally available cheaper botanicals and entomopathogenic fungal formulation which are ecofriendly can be harnessed in future for an effective management of two spotted spider mite in brinjal at a cheaper cost.

The highest fruit yield (16325 kg/ha) was recorded with 49.30 percent increase over untreated control with a maximum cost benefit ratio of 1:3.11 in the plots treated with *Pseudomonas fluorescens* @ 10g/ kg of seed + *Beauveria bassiana* (1x 10^8spores / ml) which is closely followed by Farm Yard Manure @ 25 tonnes/ha + *Ocimum sanctum* . Nevertheless farm yard manure @ 25 tonnes/ha + *B. bassiana* (1x 10^8spores / ml) treatment recorded 16006 kg/ ha with 48.29 percent increase over untreated control with the cost benefit ratio of 1:3.05 (Table 5). The standard check Dicofol @ 4ml /lit recorded the highest fruit yield of 16978 kg/ha which amounts to 51.25 per cent increase of brinjal fruits over untreated control recorded the highest cost benefit ratio of 1:3.23.

Among the organic amendments, basal application of farm yard manure/*P. fluorescens* and neem cake application in combination with fungal formulations was very effective. Among the botanical pesticides *O. sanctum* as foliar application is found to be superior in combination with any of the soil amendments tested. Among the fungal formulations tested as foliar spray *Beauveria bassiana* is very promising when combined with any of the soil amendments evaluated, against two spotted spider mite of brinjal. So the present field study explicitly pooves that either *O. sanctum* 10% leaf extract or *B. bassiana* @ (1x 10^8spores / ml) two rounds of application as foliar spray in combination with any one of these soil amendments viz., *P. fluorescens* @ 10g/ kg of seed, Farm yard manure @ 25 tonnes/ha or Neem cake @ 200 kg/ha can be recommended as a suitable alternative to the chemical acaricides like dicofol or wettable sulfur which are in vogue for more than two

Table 1. Evaluation of organic sources of nutrients and entomopathogenic fungi combination on the incidence of *T.urticae* on brinjal (mite count) - Field Trial I – spray – I (Season: October '08 - January '09)

T. N0	Treatments	* Pre treat-ment count	1DAS	3 DAS	7 DAS	14 DAS	Mean	% reduction over untreated control
T_1	Farm Yard Manure @ 25 tonnes/ha	25.73	25.36 (5.04)^d	17.89 (4.23)^d	11.62(3.41)^d	15.49(3.94)^d	17.59 (4.19)^d	52.75
T_2	*P. fluorescens* @ 10g/ kg of seed	26.85	25.21(5.02)^d	17.49(4.18)^d	11.33(3.37)^d	15.28(3.91)^d	17.33(4.16)^d	53.45
T_3	Neem cake @ 200 kg/ha	27.33	25.57(5.06)^d	17.84(4.22)^d	11.51(3.39)^d	15.86(3.98)^d	17.70(4.21)^d	52.45
T_4	T_1+ *O. sanctum* (10% aqueous leaf extract)	26.72	19.39(4.40)^b	13.12(3.62)^b	5.42(2.33)^b	10.29(3.21)^b	12.06 (3.47)^b	67.60
T_5	T_1+ NSKE (5%) foliar spray	25.35	25.32(5.03)^d	17.92(4.23)^d	11.86(3.44)^d	15.55(3.94)^d	17.66(4.20)^d	52.57
T_6	T_1+ Neem oil (3%) foliar spray	26.99	22.55(4.75)^c	16.87(4.11)^c	8.41(2.90)^c	13.2(3.63)^c	15.26(3.91)^c	59.01
T_7	T_1+ *B. bassiana* @1x 10^8spores / ml	25.71	19.39(4.40)^b	13.12(3.62)^b	5.42(2.33)^b	10.29(3.21)^b	12.06 (3.47)^b	67.62
T_8	T_1+ *P. fumosoroseus* @1x 10^8 spores / ml	26.44	22.50(4.74)^c	16.72(4.09)^c	8.32(2.88)^c	13.18(3.63)^c	15.18 (3.90)^c	59.23
T_9	T_1+ *Lecanicillium lecani* @1x 10^8spores / ml	27.84	25.46(5.05)^d	17.87(4.23)^d	11.42(3.38)^d	15.99(4.00)^d	17.69(4.21)^d	52.48
T_{10}	T_2+ *O. sanctum* (10% aqueous leaf extract)	27.80	19.22(4.38)^b	13.60(3.69)^b	5.22(2.28)^b	10.51(3.24)^b	12.14(3.48)^b	67.39
T_{11}	T_2+ NSKE (5%) foliar spray	26.32	25.31(5.03)^d	17.95(4.24)^d	11.73(3.42)^d	15.52(3.94)^d	17.63(4.20)^d	52.65
T_{12}	T_2+ Neem oil (3%) foliar spray	25.41	22.52(4.75)^c	16.8(4.10)^c	8.36(2.89)^c	13.25(3.64)^c	15.23(3.90)^c	59.09
T_{13}	T_2+ *B. bassiana* @1x 10^8spores / ml	26.02	19.00(4.36)^b	13.11(3.62)^b	5.02(2.24)^b	10.82(3.29)^b	11.99(3.46)^b	67.79
T_{14}	T_2+ *P. fumosoroseus* @1x10^8 spores / ml	26.00	23.54(4.85)^c	16.33(4.04)^c	8.41(2.90)^c	12.37(3.52)^c	15.16(3.89)^c	59.28
T_{15}	T_2+ *Lecanicillium lecani* @1x 10^8spores / ml	25.95	24.99(5.00)^d	17.21(4.15)^d	11.76(3.43)^d	15.35(3.92)^d	17.33(4.16)^d	53.45
T_{16}	T_3+ *O. sanctum* (10% aqueous leaf extract)	26.31	19.47(4.41)^b	13.15(3.63)^b	5.39(2.32)^b	10.37(3.22)^b	12.10(3.48)^b	67.45
T_{17}	T_3+ NSKE (5%) foliar spray	25.83	22.58(4.75)^c	16.76(4.09)^c	8.39(2.90)^c	13.22(3.64)^c	15.24(3.90)^c	59.07
T_{18}	T_3+ Neem oil (3%) foliar spray	27.11	22.76(4.77)^c	16.45(4.06)^c	8.11(2.85)^c	13.79(3.71)^c	15.28(3.91)^c	58.96
T_{19}	T_3+ *B. bassiana* @1x 10^8spores / ml	26.72	19.54(4.42)^b	12.99(3.60)^b	5.51(2.35)^b	10.4 (3.22)^b	12.11(3.48)^b	67.47
T_{20}	T_3+ *P. fumosoroseus* @1x 10^8 spores / ml	27.56	22.63(4.76)^c	16.84(4.10)^c	8.47(2.91)^c	13.27(3.64)^c	15.30(3.91)^c	58.90
T_{21}	T_3+ *L. lecani* @1x 10^8spores / ml	26.89	25.22(5.02)^d	16.34(4.04)^d	11.37(3.37)^d	15.66(3.96)^d	17.15(4.14)^d	53.93
T_{22}	Dicofol 18.5 EC @ 4ml /lit (standard check)	26.79	16.40(4.05)^a	11.51(3.39)^a	3.58(1.89)^a	8.58(2.93)^a	10.02 (3.17)^a	73.09
T_{23}	Untreated control	27.86	31.43(5.61)^e	35.88(5.99)^e	39.21(6.26)^e	42.41(6.51)^e	37.23(6.10)^e	-

DAS - days after spraying, Figures in parentheses are square root , transformed values, In a column, means followed by common letter(s) are not significantly different at P = 0.05% by DMRT, *NS – non significant

Table 2. Evaluation of organic sources of nutrients and entomopathogenic fungi combination on the incidence of *T.urticae* egg on brinjal - Field Trial I – spray – I (Season: October '08 - January '09)

T. N0	Treatments	* Pre treatment count	1DAS	3 DAS	7 DAS	14 DAS	Mean	% reduction over untreated control
T_1	Farm Yard Manure @ 25 tonnes/ha	41.33	42.54(6.52)^{d}	36.22(6.02)^{d}	31.44(5.61)^{d}	27.9(5.28)^{d}	34.53(5.88)^{d}	41.57
T_2	*Pseudomonas fluorescens* @ 10g/ kg of seed	44.99	42.66(6.53)^{d}	36.81(6.07)^{d}	31.29(5.59)^{d}	27.48(5.24)^{d}	34.56(5.86)^{d}	41.52
T_3	Neem cake @ 200 kg/ha	44.04	42.93(6.55)^{d}	36.11(6.01)^{d}	31.63(5.62)^{d}	27.66(5.26)^{d}	34.58(5.86)^{d}	41.49
T_4	T_1+ *Ocimum sanctum* aqueous leaf extract)	42.43	36.42(6.03)^{b}	30.52(5.52)^{b}	22.49(4.74)^{b}	18.21(4.27)^{b}	26.91(5.19)^{b}	54.47 (10%
T_5	T_1+ NSKE (5%) foliar spray	43.21	42.32(6.51)^{d}	36.35(6.03)^{d}	31.36(5.60)^{d}	27.88(5.28)^{d}	34.48(5.87)^{d}	41.66
T_6	T_1+ Neem oil (3%) foliar spray	43.09	40.41(6.36)^{c}	34.77(5.90)^{c}	27.43(5.24)^{c}	24.00(4.90)^{c}	31.65(5.63)^{c}	46.45
T_7	T_1+ *Beauveria bassiana* @1x 10^8spores / ml	43.22	36.55(6.05)^{b}	31.02(5.57)^{b}	22.26(4.72)^{b}	18.68(4.32)^{b}	27.13(5.21)^{b}	54.09
T_8	T_1+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	43.54	40.33(6.35)^{c}	34.16(5.84)^{c}	27.87(5.28)^{c}	23.8(4.88)^{c}	31.54(5.62)^{c}	46.63
T_9	T_1+ *Lecanicillium lecani* @1x 10^8spores / ml	42.31	42.41(6.51)^{d}	36.27(6.02)^{d}	31.39(5.60)^{d}	27.83(5.28)^{d}	34.47(5.87)^{d}	41.68
T_{10}	T_2+ *Ocimum sanctum* (10% aqueous leaf extract)	42.39	36.66(6.05)^{b}	30.27(5.50)^{b}	22.91(4.79)^{b}	18.99(4.36)^{b}	27.21(5.22)^{b}	53.96
T_{11}	T_2+ NSKE (5%) foliar spray	43.44	42.33(6.51)^{d}	36.99(6.08)^{d}	31.39(5.60)^{d}	27.3(5.22)^{d}	34.50(5.87)^{d}	41.62
T_{12}	T_2+ Neem oil (3%) foliar spray	43.26	40.38(6.35)^{c}	34.22(5.85)^{c}	27.75(5.27)^{c}	23.92(4.89)^{c}	31.57(5.62)^{c}	46.58
T_{13}	T_2+ *Beauveria bassiana* @1x 10^8spores / ml	42.74	36.52(6.04)^{b}	30.08(5.48)^{b}	22.47(4.74)^{b}	18.33(4.28)^{b}	26.85(5.18)^{b}	54.57
T_{14}	T_2+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	45.42	39.99(6.32)^{c}	34.96(5.91)^{c}	27.31(5.23)^{c}	23.41(4.84)^{c}	31.42(5.61)^{c}	46.84
T_{15}	T_2+ *Lecanicillium lecani* @1x 10^8spores / ml	43.20	42.11(6.49)^{d}	36.48(6.04)^{d}	31.25(5.59)^{d}	26.43(5.14)^{d}	34.07(5.84)^{d}	42.35
T_{16}	T_3+ *Ocimum sanctum* (10% aqueous leaf extract)	43.00	36.68(6.06)^{b}	30.48(5.52)^{b}	22.42(4.73)^{b}	18.6(4.31)^{b}	27.05(5.20)^{b}	54.23
T_{17}	T_3+ NSKE (5%) foliar spray	42.78	40.63(6.37)^{c}	34.25(5.85)^{c}	26.33(5.13)^{c}	23.05(4.80)^{c}	31.07(5.57)^{c}	47.43
T_{18}	T_3+ Neem oil (3%) foliar spray	43.99	40.18(6.34)^{c}	34.88(5.91)^{c}	26.49(5.15)^{c}	23.77(4.88)^{c}	31.33(5.60)^{c}	46.99
T_{19}	T_3+ *Beauveria bassiana* @1x 10^8spores / ml	44.80	36.81(6.07)^{b}	30.24(5.50)^{b}	22.3(4.72)^{b}	18.75(4.33)^{b}	27.03(5.20)^{b}	54.26
T_{20}	T_3+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	43.43	40.49(6.36)^{c}	34.38(5.86)^{c}	27.7(5.26)^{c}	23.76(4.87)^{c}	31.58 (5.62)^{c}	46.57
T_{21}	T_3+ *Lecanicillium lecani* @1x 10^8spores / ml	43.62	42.87(6.55)^{d}	36.45(6.04)^{d}	31.99(5.66)^{d}	27.83(5.28)^{d}	34.79(5.90)^{d}	41.13
T_{22}	Dicofol 18.5 EC @ 4ml /lit (standard check)	43.52	20.75(4.56)^{a}	12.93(3.60)^{a}	6.8(2.61)^{a}	15.38(3.92)^{a}	13.97(3.74)^{a}	76.36
T_{23}	Untreated control	45.08	47. 29(6.88)^{e}	51.76(7.19)^{e}	65.22(8.08)^{e}	72.11(8.49)^{e}	59.10(7.69)^{e}	-

DAS - days after spraying, Figures in parentheses are square root transformed values, In a column, means followed by common letter(s) are not significantly different at P = 0.05% by DMRT, *NS – non significant

Table 3. Evaluation of organic sources of nutrients and Entomopathogenic fungi combination on the incidence of *T.urticae* egg on brinjal - Field Trial I – spray - II (Season: October '08 - January '09)

T. N0	Treatments	* Pre treatment count	1DAS	3 DAS	7 DAS	14 DAS	Mean	% reduction over untreated control
T_1	Farm Yard Manure @ 25 tonnes/ha	14.26	11.19(3.35)^{d}	8.19(2.86)^{d}	5.72(2.39)^{d}	12.49(3.53)^{d}	9.40(3.07)^{d}	56.09
T_2	*Pseudomonas fluorescens* @ 10g/ kg of seed	14.54	11.54(3.40)^{d}	8.32(2.88)^{d}	5.61(2.37)^{d}	12.82(3.58)^{d}	9.57(3.06)^{d}	55.30
T_3	Neem cake @ 200 kg/ha	14.03	11.36(3.37)^{d}	8.21(2.87)^{d}	5.87(2.42)^{d}	12.90(3.59)^{d}	9.59(3.06)^{d}	55.20
T_4	T_1+ *Ocimum sanctum* (10% aqueous leaf extract)	13.56	8.56(2.93)^{b}	3.22(1.79)^{b}	2.89(1.70)^{b}	6.11(2.47)^{b}	5.20(2.28)^{b}	75.71
T_5	T_1+ NSKE (5%) foliar spray	14.43	11.12(3.33)^{d}	8.26(2.87)^{d}	5.98(2.45)^{d}	12.54(3.54)^{d}	9.48(3.08)^{d}	55.72
T_6	T_1+ Neem oil (3%) foliar spray	13.82	9.76(3.12)^{c}	5.43(2.33)^{c}	4.22(2.05)^{c}	9.49(3.08)^{c}	7.23(2.69)^{c}	66.23
T_7	T_1+ *Beauveria bassiana* @1x 10^8spores / ml	14.49	8.09(2.84)^{b}	3.98(1.99)^{b}	2.54(1.59)^{b}	6.54(2.56)^{b}	5.29(2.30)^{b}	75.29
T_8	T_1+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	14.22	9.42(3.07)^{c}	5.72(2.39)^{c}	4.00(2.00)^{c}	9.35(3.06)^{c}	7.12(2.67)^{c}	66.74
T_9	T_1+ *Lecanicillium lecani* @1x 10^8spores / ml	14.31	11.09(3.33)^{d}	8.20(2.86)^{d}	5.93 (2.44)^{d}	12.88(3.59)^{d}	9.53(3.09)^{d}	55.49
T_{10}	T_2+ *Ocimum sanctum* (10% aqueous leaf extract)	13.97	8.82(2.97)^{b}	3.77(1.94)^{b}	2.55(1.60)^{b}	6.71(2.59)^{b}	5.46(2.34)^{b}	74.49
T_{11}	T_2+ NSKE (5%) foliar spray	14.64	11.83(3.44)^{d}	8.38(2.89)^{d}	5.87(2.42)^{d}	12.9(3.59)^{d}	9.75(3.12)^{d}	54.46
T_{12}	T_2+ Neem oil (3%) foliar spray	14.47	9.51(3.08)^{c}	5.83(2.41)^{c}	4.12(2.03)^{c}	9.39(3.06)^{c}	7.21(2.69)^{c}	66.32
T_{13}	T_2+ *Beauveria bassiana* @1x 10^8spores / ml	14.54	8.22(2.87)^{b}	3.06(1.75)^{b}	2.49(1.58)^{b}	6.61(2.57)^{b}	5.10(2.26)^{b}	76.18
T_{14}	T_2+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	14.11	9.34(3.06)^{c}	5.31(2.30)^{c}	4.85(2.20)^{c}	9.27(3.04)^{c}	7.19(2.68)^{c}	66.42
T_{15}	T_2+ *Lecanicillium lecani* @1x 10^8spores / ml	15.00	11.25(3.35)^{d}	8.41(2.90)^{d}	5.36(2.32)^{d}	12.64(3.56)^{d}	9.42(3.07)^{d}	56.00
T_{16}	T_3+ *Ocimum sanctum* (10% aqueous leaf extract)	13.91	8.11(2.85)^{b}	3.94 (1.98)^{b}	2.42(1.56)^{b}	6.33(2.52)^{b}	5.19(2.28)^{b}	75.76
T_{17}	T_3+ NSKE (5%) foliar spray	14.66	9.49(3.08)^{c}	5.66(2.38)^{c}	4.09 (2.02)^{c}	9.51(3.08)^{c}	7.19 (2.68)^{c}	66.42
T_{18}	T_3+ Neem oil (3%) foliar spray	13.34	9.87(3.14)^{c}	5.82(2.41)^{c}	4.61(2.15)^{c}	9.33(3.05)^{c}	7.41(2.72)^{c}	65.39
T_{19}	T_3+ *Beauveria bassiana* @1x 10^8spores / ml	14.54	8.06(2.84)^{b}	3.89(1.97)^{b}	2.47(1.57)^{b}	6.64(2.58)^{b}	5.27 (2.29)^{b}	75.38
T_{20}	T_3+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	15.09	9.47(3.08)^{c}	5.73 (2.39)^{c}	4.04(2.01)^{c}	9.36(3.06)^{c}	7.15 (2.67)^{c}	66.60
T_{21}	T_3+ *Lecanicillium lecani* @1x 10^8spores / ml	13.14	11.42(3.38)^{d}	8.49(2.91)^{d}	5.22(2.28)^{d}	12.43(3.53)^{d}	9.39(3.06)^{d}	56.14
T_{22}	Dicofol 18.5 EC @ 4ml /lit (standard check)	14.55	6.83(2.61)^{a}	2.67(1.63)^{a}	0.99(0.99)^{a}	5.42(2.33)^{a}	3.98(1.99)^{a}	81.41
T_{23}	Untreated control	14.72	16.43(4.05)^{e}	19.52(4.42)^{e}	22.45(4.74)^{e}	27.23(5.22)^{e}	21.41(4.63)^{e}	-

DAS - days after spraying, Figures in parentheses are square root transformed values, In a column, means followed by common letter(s) are not significantly different at P = 0.05% by DMRT, *NS – non significant

Table 4. Evaluation of organic sources of nutrients and Entomopathogenic fungi combination on the incidence of *T.urticae* egg on brinjal - Field Trial I – spray – II (Season: October '08 - January '09)

T. N0	Treatments	* Pre treatment count	1DAS	3 DAS	7 DAS	14 DAS	Mean	% reduction over untreated control
T_1	Farm Yard Manure @ 25 tonnes/ha	32.00	26.22(5.12)^{d}	22.66(4.76)^{d}	17.98(4.24)^{d}	14.58 (3.82)^{d}	20.36 (4.51)^{d}	52.79
T_2	*Pseudomonas fluorescens* @ 10g/ kg of seed	31.65	26.34(5.13)^{d}	22.75(4.77)^{d}	17.61(4.20)^{d}	14.22(3.77)^{d}	20.23(4.50)^{d}	53.09
T_3	Neem cake @ 200 kg/ha	31.87	26.57(5.15)^{d}	22.11(4.70)^{d}	17.28(4.16)^{d}	14.73(3.84)^{d}	20.17(4.49)^{d}	53.23
T_4	T_1+ *Ocimum sanctum* (10% aqueous leaf extract)	32.34	17.32(4.16)^{b}	14.28(3.78)^{b}	9.75(3.12)^{b}	6.41(2.53)^{b}	11.94(3.46)^{b}	72.32
T_5	T_1+ NSKE (5%) foliar spray	31.83	26.19(5.12)^{d}	22.62 (4.76)^{d}	17.86 (4.23)^{d}	14.63(3.82)^{d}	20.33 (4.51)^{d}	52.86
T_6	T_1+ Neem oil (3%) foliar spray	32.11	22.64(4.76)^{c}	17.79(4.22)^{c}	12.66(3.56)^{c}	10.44(3.23)^{c}	15.88(3.99)^{c}	63.18
T_7	T_1+ *Beauveria bassiana* @1x 10^8spores / ml	31.62	17.95 (4.24)^{b}	14.39 (3.79)^{b}	9.62 (3.10)^{b}	6.82 (2.61)^{b}	12.20 (3.49)^{b}	71.71
T_8	T_1+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	32.66	22.52(4.75)^{c}	17.43 (4.17)^{c}	12.86 (3.59)^{c}	10.33(3.21)^{c}	15.79 (3.97)^{c}	63.39
T_9	T_1+ *Lecanicillium lecani* @1x 10^8spores / ml	33.91	26.25(5.12)^{d}	22.58 (4.75)^{d}	17.94 (4.24)^{d}	14.52(3.81)^{d}	20.32 (4.51)^{d}	52.89
T_{10}	T_2+ *Ocimum sanctum* (10% aqueous leaf extract)	32.80	17.21(4.15)^{b}	14.87(3.86)^{b}	9.36(3.06)^{b}	6.11(2.47)^{b}	11.89(3.45)^{b}	72.43
T_{11}	T_2+ NSKE (5%) foliar spray	33.07	26.33(5.13)^{d}	22.25(4.72)^{d}	17.33(4.16)^{d}	14.68(3.83)^{d}	20.15(4.49)^{d}	53.28
T_{12}	T_2+ Neem oil (3%) foliar spray	32.55	22.63 (4.76)^{c}	17.56 (4.19)^{c}	12.69 (3.56)^{c}	10.48 (3.24)^{c}	15.84 (3.98)^{c}	63.27
T_{13}	T_2+ *Beauveria bassiana* @1x 10^8spores / ml	32.72	17.55(4.19)^{b}	14.63(3.82)^{b}	9.71(3.12)^{b}	6.28(2.51)^{b}	12.04(3.47)^{b}	72.08
T_{14}	T_2+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	31.89	22.55(4.75)^{c}	17.72(4.21)^{c}	12.2(3.49)^{c}	10.28(3.21)^{c}	15.69(3.96)^{c}	63.62
T_{15}	T_2+ *Lecanicillium lecani* @1x 10^8spores / ml	31.36	26.91(5.19)^{d}	22.75(4.77)^{d}	17.28(4.16)^{d}	14.55(3.81)^{d}	20.37(4.51)^{d}	52.77
T_{16}	T_3+ *Ocimum sanctum* (10% aqueous leaf extract)	32.56	17.88 (4.23)^{b}	14.28 (3.78)^{b}	9.58 (3.10)^{b}	6.77 (2.60)^{b}	12.13 (3.48)^{b}	71.87
T_{17}	T_3+ NSKE (5%) foliar spray	32.37	22.47 (4.74)^{c}	17.48 (4.18)^{c}	12.98 (3.60)^{c}	10.52 (3.24)^{c}	15.86 (3.98)^{c}	63.23
T_{18}	T_3+ Neem oil (3%) foliar spray	31.98	22.81(4.78)^{c}	17.35(4.17)^{c}	12.45(3.53)^{c}	10.72(3.27)^{c}	15.83(3.98)^{c}	63.29
T_{19}	T_3+ *Beauveria bassiana* @1x 10^8spores / ml	33.75	17.83 (4.22)^{b}	14.45 (3.80)^{b}	9.71 (3.12)^{b}	6.9 (2.63)^{b}	12.22 (3.50)^{b}	71.67
T_{20}	T_3+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	32.69	22.55 (4.75)^{c}	17.72 (4.21)^{c}	12.65 (3.56)^{c}	10.61 (3.26)^{c}	15.88 (3.99)^{c}	63.18
T_{21}	T_3+ *Lecanicillium lecani* @1x 10^8spores / ml	33.46	26.22(5.12)^{d}	22.54(4.75)^{d}	17.39(4.17)^{d}	14.32(3.78)^{d}	20.12(4.49)^{d}	53.35
T_{22}	Dicofol 18.5 EC @ 4ml /lit (standard check)	32.67	8.59 (2.93)^{a}	4.32 (2.08)^{a}	1.49 (1.22)^{a}	5.39 (2.32)^{a}	4.95 (2.22)^{a}	88.52
T_{23}	Untreated control	31.33	32.54(5.70)^{e}	39.64(6.30)^{e}	47.11(6.86)^{e}	53.24(7.30)^{e}	43.13(6.57)^{e}	-

DAS - days after spraying, Figures in parentheses are square root transformed values, In a column, means followed by common letter(s) are not significantly different at P = 0.05% by DMRT, *NS – non significant

Table 5. Evaluation of organic sources of nutrients and entomopathogenic fungi combination on the incidence of *T.urticae* on brinjal yield (Kg/ha) and Cost Benefit Ratio (CBR)

T.N0	Treatments	Fruit yield(Kg/ha)	% increase over untreated control	CBR
T_1	Farm Yard Manure @ 25 tonnes/ha	9522	13.09	1:1.81
T_2	*Pseudomonas fluorescens* @ 10g/ kg of seed	9428	12.22	1:1.79
T_3	Neem cake @ 200 kg/ha	9871	16.15	1:1.97
T_4	T_1+ *Ocimum sanctum* (10% aqueous leaf extract)	16120	48.66	1:3.07
T_5	T_1+ NSKE (5%) foliar spray	9630	14.06	1:1.83
T_6	T_1+ Neem oil (3%) foliar spray	13280	37.68	1:2.53
T_7	T_1+ *Beauveria bassiana* @1x 10^8spores / ml	16006	48.29	1:3.05
T_8	T_1+ *Paecilomyces fumosoroseus*@1x 10^8spores / ml	13480	38.61	1:2.56
T_9	T_1+ *Lecanicillium lecani* @1x 10^8spores / ml	9548	13.32	1:1.82
T_{10}	T_2+ *Ocimum sanctum* (10% aqueous leaf extract)	15811	47.66	1:3.01
T_{11}	T_2+ NSKE (5%) foliar spray	10237	19.16	1:1.95
T_{12}	T_2+ Neem oil (3%) foliar spray	13172	37.17	1:2.51
T_{13}	T_2+ *Beauveria bassiana* @1x 10^8spores / ml	16325	49.30	1:3.11
T_{14}	T_2+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	13876	40.36	1:2.64
T_{15}	T_2+ *Lecanicillium lecani* @1x 10^8spores / ml	9429	12.23	1:1.79
T_{16}	T_3+ *Ocimum sanctum* (10% aqueous leaf extract)	15808	47.65	1:3.01
T_{17}	T_3+ NSKE (5%) foliar spray	13770	39.90	1:2.62
T_{18}	T_3+ Neem oil (3%) foliar spray	13174	37.18	1:2.51
T_{19}	T_3+ *Beauveria bassiana* @1x 10^8spores / ml	15802	47.63	1:3.01
T_{20}	T_3+ *Paecilomyces fumosoroseus* @1x 10^8spores / ml	13178	37.20	1:2.51
T_{21}	T_3+ *Lecanicillium lecani* @1x 10^8spores / ml	9735	14.99	1:1.85
T_{22}	Dicofol 18.5 EC @ 4ml /lit (standard check)	16978	51.25	1:3.23
T_{23}	Untreated control	8276	-	-

decades. These naturally available resources not only reduce the mite population but also reflects on increased fruit yield with highest cost benefit ratio.

DISCUSSION

Basal application of neem cake in combination with *B. bassiana* (1 X10^8 spores/ml) recorded the maximum per cent reduction of two spotted spider mite, *Tetranychus urticae* (Figure – 1) population on okra (Balaji *et al*., 2007). Higher infections of *B. bassiana* on red spider mite was recorded on beans (12.94%) in Karnataka, as reported by Basavaraj Kalmath *et al*. (2007). Foliar application of *B. bassiana* recorded the highest percent mycosis on coffee berry borer *H. hampei* (Irulandi, 2006), thus it is proved effective not only against sucking pests but also against coleopteran borers. Basal application of neem cake in combination with foliar application of *Ocimum sanctum* (20% aqueous extract) recorded the highest reduction of yellow mite and egg population on chilli (Ambika and Chinniah, 2007). Similarly Murugasen and Murugesh (2008) reported the insecticidial activity of the chosen plant products on the pest, spotted leaf beetle, *Henosepilachna vigintioocto punctata* in Brinjal.

These results are in agreement with the findings of Tamai *et al*. (1998) who tested 152 isolates of *B. bassiana*, *Metarhizium* spp. and *Paecilomyces lilacinus*, of which only *Beauveria bassiana* caused the highest mortality (35 to 95 per cent). Tamai *et al*. (1999) also tested the pathogenicity of *B.bassiana* isolates against *T.urticae* under laboratory conditions at a temperature of 25^{0}C and 70 per cent relative humidity and obtained a mortality of 50 per cent, within 6 days after application. Natural™ (Thermo Trilogy Corp.), a commercial product of *B. bassiana*, registered an excellent control of *T. urticae* on rose under glass house conditions (Wright and Kennedy, 1996). Selvasundaram *et al.* (2003) reported that *Paecilomyces fumosoroseus* was highly effective against red spider mite, *Oligonychus coffeae* on tea under laboratory conditions. Basal application of neem cake in combination with foliar application of *Ocimum sanctum* (20% aqueous extract) recorded the highest reduction in yellow mite and egg population on chilli (Ambika and Chinniah, 2007). Vinoth *et al*. (2009) have also confirmed that *Ocimum sanctum* was very effective against erinium mite of jasmine. All these works strongly vouch the findings of our investigations.

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