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# EFFECT OF BIO-RATIONALS AGAINST THE THRIPS, *SCIRTOTHRIPS DORSALIS* HOOD AND FRUIT BORER, *HELICOVERPA ARMIGERA* HUBNER INFESTING CHILLI

**RAVIKUMAR A.[1]*, CHINNIAH C.[1], MANISEGARAN S.[1], IRULANDI S.[2] AND PARTHIBAN P.[1]**

[1]Department of Agricultural Entomology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai - 625 104, Tamil Nadu, India.
[2]Krishi Vigyan Kendra, Pechiparai - 629 161, Tamil Nadu, India.
*Corresponding Author: Email-aravitnau@gmail.com

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**Abstract-** Field experiment was carried out to test the effectiveness of bio-rationals against thrips, *Scirtothrips dorsalis* Hood and *Helicoverpa armigera* Hubner on chilli with nine treatments including an untreated check. Thrips population was the lowest in spinosad 45 SC @ 0.4ml $l^{-1}$ (0.60 / leaf) which was on par with emamectin benzoate 5 SG @ 0.4g $l^{-1}$ (0.65 / leaf) and found to be superior to the standard check (dimethoate 30 EC @ 2ml $l^{-1}$). Similarly, spinosad 45 SC @ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ recorded the lowest larval population of *H. armigera* of 0.51 and 0.55 / plant. The next effective treatments were *Beauveria bassiana* @ 1 x $10^8$ spores $ml^{-1}$ and neem oil 3 % which recorded thrips population of 1.06 and 1.18 / leaf. With regard to fruit borer, *Bacillus thuringiensis var. kurstaki* @ 1 kg/ha (0.85 larvae / plant) ranked next to spinosad 45 SC and emamectin benzoate 5 SG. Similar trend was noticed with regard to leaf curl damage by thrips and per cent fruit damage by *H. armigera.* The highest yield of dry chilli fruits 1480 kg $ha^{-1}$ was registered in spinosad 45 SC @ 0.4ml $l^{-1}$, which was on par with emamectin benzoate 5 SG @ 0.4g $l^{-1}$ (1420 kg $ha^{-1}$) with respective additional income of Rs. 28,200 and Rs. 24,600. The highest cost benefit ratio (1:4.09) could be obtained in spinosad 45 SC @ 0.4ml $l^{-1}$ followed by 1:3.97 in case of emamectin 5 SG @ 0.4g $l^{-1}$.

**Keywords-** Bio-rationals, Chilli, *Helicoverpa armigera, Scirtothrips dorsalis*, Yield.

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## Introduction

Chilli (*Capsicum annum* L.) is an important commercial crop, grown as a vegetable and spice earning considerable foreign exchange for our country. India is the foremost producer of chillies in the world with a contribution of 25% to the world production. In India, chilli is grown in 7.75 lakh hectares with a production of 14.92 lakh tonnes [1]. Tamil Nadu stands fifth in terms of area (50,670 ha) with a production of 23, 060 tonnes of dry chillies. Among the constraints in chilli cultivation, the arthropod pests are of prime importance, which significantly reduce the production. The crop is affected with more than 293 species of insects and mite debilitates the crop in field as well as in storage space [2]. Of these, thrips, *Scirtothrips dorsalis* (Hood), mite, *Polyphagotarsonemus latus* (Banks) and fruit borer, *Helicoverpa armigera* (Hubner) are the major pests, responsible for causing considerable yield loss in Tamil Nadu [3]. To protect the crop farmers often prefer conventional pesticides of same or similar group repeatedly in large quantities without proper diagnosis. Several systemic pesticides have been evaluated against these pests, which have been recommended to control these pests. It is evidently quoted by [4] that wide spread and unscrupulous usage of synthetic insecticides has resulted in several ecological problems such as development of resistance in the insect, resurgence of secondary pests, demolition of natural enemies, changes in species dynamics, deposition of residues in soil and plant matrices, risk to mankind and animal health besides environmental pollution. This necessitated target specific insecticides, which will harmoniously fit in the integrated pest management programmes. Therefore, efforts were mainly directed to exploit eco-friendly insecticides. Among several options, bio-rational pesticides are environmentally sound and closely assemble or are one and the same to chemicals produced in nature. It is ensuing from a variety of biological sources including pathogens as well as chemical analogues of obviously occurring biochemical such as pheromones and insect growth regulators. Therefore, the present investigation is undertaken to evolve an effective bio-rationals which could be safer, feasible and effective for insect pest management.

## MaterialsandMethods

A field experiment was conducted in the farmer's holdings at Manchanaighampatty, Aundipatty block of Theni district of Tamil Nadu during November 2009 - April 2010 to test the effective bio-rationals against thrips and fruit borers of chilli. The experiment was tried in randomized block design with nine treatments replicated three times. Variety PKM-1 was transplanted adopting spacing of 60 cm x 45 cm between rows and among plants, respectively with the plot size of 4 x 5 m. The treatments details were as follows $T_1$ - Emamectin benzoate 5 SG @ 0.4g $l^{-1}$, $T_2$ - Spinosad 45 SC @ 0.4 ml $l^{-1}$, $T_3$ - Neem oil 3%, $T_4$- Castor soap oil 2%, $T_5$ - Panchakaviya 3%, $T_6$ - *Bacillus thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$, $T_7$ - *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$, $T_8$ - Dimethoate 30 EC @ 2 ml $l^{-1}$/ Chloriphyriphos 20 EC @ 2ml $l^{-1}$, $T_9$ - Untreated check. The regular agronomic operations were followed equally for all treatments. A total of six rounds of sprays were given based on the ETL starting from 30 days after transplanting.

The number of thrips was assessed from three leaves representing the top, middle and bottom region from each plant on five randomly selected plants per replication prior to spray and 1st, 3rd, 7th and 14th day after each spray and expressed as number of thrips/leaf. Ten plants were selected at random from each replication in all the treatments and 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.* [5]. For *H. armigera,* the larval population was assessed from five randomly selected plants per replication prior to spray at 1st, 3rd, 7th and 14th day after each spray and expressed as larvae per plant. The per cent fruit damage was assessed based on bore holes present on the fruits. The total number of fruits and infested fruits by larvae per plant on ten randomly selected plants per plot were estimated and the per cent fruit damage was calculated. The yield data of dry chillies from each plot was recorded and computed as kg/ha. Data are subjected to statistical analysis.

**Statistical analysis**

Data on field study were subjected to ANOVA. Before analysis, data on population and per cent damage were subject to square root and arcsine transformation. In order to know the interaction between treatments, data were subject to factorial RBD analysis and treatment means obtained were separated by LSD (Least Significant Difference)

**Results**

Results on the effect of bio-rationals on the population of thrips are given in [Table-1]. The population varied from 2.33 to 2.44 / leaf before imposing the treatments. After 1st spray, thrips population was low in plots which received biorationals pesticides *viz.,* spinosad 45 SC @ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ which recorded lower population of 0.82 and 0.86 / leaf which were on par with standard check dimethoate 30 EC @ 2ml $l^{-1}$ (0.84/ leaf). The next effective treatment in descending order of effectiveness were neem oil @ 3% and *B. bassiana* @ 1 x $10^8$ spores / ml, which recorded 1.13 and 1.14 / leaf respectively. But thrips population was high in the plots which received panchachaviya @ 3% (1.62 / leaf) and *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ (1.69/ leaf), when compared to untreated control (2.65 / leaf).

**Table-1** *Evaluation of certain bio-rationals against thrips, S. dorsalis and its damage on chilli*

| | Thrips (No/leaf)* | | | | | | Leaf Curl Index / plant | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Precount | I spray mean | II spray mean | III spray mean | Grand mean | Per cent reduction over control | Pre-count | I spray mean | II spray mean | III spray mean | Grand mean | Per cent reduction over control |
| T1 | 2.38 (1.70) | 0.86 (1.17)$^a$ | 0.72 (1.11)$^a$ | 0.37 (0.93)$^a$ | 0.65 (1.07)$^a$ | 79.17 | 0.81 | 0.88$^a$ | 0.95$^{ab}$ | 0.98$^a$ | 0.94$^a$ | 55.66 |
| T2 | 2.36 (1.69) | 0.82 (1.14)$^a$ | 0.67 (1.08)$^a$ | 0.33 (0.91)$^a$ | 0.60 (1.05)$^a$ | 81.77 | 0.82 | 0.86$^a$ | 0.93$^a$ | 0.97$^a$ | 0.92$^a$ | 56.60 |
| T3 | 2.33 (1.68) | 1.13 (1.28)$^b$ | 1.28 (1.33)$^d$ | 1.12 (1.27)$^d$ | 1.18 (1.30)$^d$ | 62.18 | 0.85 | 1.04$^b$ | 1.26$^c$ | 1.35$^c$ | 1.22$^c$ | 42.45 |
| T4 | 2.36 (1.69) | 1.26 (1.33)$^c$ | 1.49 (1.41)$^e$ | 1.49 (1.41)$^e$ | 1.41 (1.38)$^e$ | 54.81 | 0.86 | 1.18$^c$ | 1.38$^d$ | 1.50$^d$ | 1.35$^d$ | 36.32 |
| T5 | 2.33 (1.68) | 1.62 (1.46)$^d$ | 2.02 (1.59)$^f$ | 2.13 (1.62)$^f$ | 1.92 (1.56)$^f$ | 38.14 | 0.81 | 1.30$^d$ | 1.61$^e$ | 1.83$^e$ | 1.58$^e$ | 25.47 |
| T6 | 2.38 (1.70) | 1.69 (1.48)$^d$ | 2.10 (1.61)$^f$ | 2.16 (1.64)$^f$ | 1.99 (1.58)$^f$ | 36.86 | 0.80 | 1.33$^d$ | 1.66$^e$ | 1.88$^e$ | 1.62$^e$ | 23.58 |
| T7 | 2.44 (1.71) | 1.14 (1.28)$^b$ | 1.09 (1.26)$^c$ | 0.95 (1.20)$^c$ | 1.06 (1.25)$^c$ | 66.03 | 0.85 | 1.06$^b$ | 1.18$^c$ | 1.26$^c$ | 1.17$^c$ | 44.81 |
| T8 | 2.36 (1.69) | 0.84 (1.16)$^a$ | 0.82 (1.15)$^b$ | 0.64 (1.07)$^b$ | 0.77 (1.13)$^b$ | 75.32 | 0.82 | 0.92$^a$ | 1.06$^b$ | 1.13$^b$ | 1.04$^b$ | 50.94 |
| T9 | 2.42 (1.71) | 2.65 (1.17)$^e$ | 3.01 (1.87)$^g$ | 3.71 (2.05)$^g$ | 3.12 (1.90)$^g$ | - | 0.86 | 1.64$^e$ | 2.20$^f$ | 2.53$^f$ | 2.12$^f$ | - |
| SEd | NS | 0.0246 | 0.0240 | 0.0230 | 0.0257 | - | NS | 0.1234 | 0.1424 | 0.1550 | 0.1154 | - |
| CD | NS | 0.0522 | 0.0510 | 0.0487 | 0.0545 | - | NS | 0.2617 | 0.3019 | 0.3285 | 0.2447 | - |

T1-Emamectin benzoate 5G @ 0.4g /lit. T3 - Neem @ oil 3% T5- Panchakavya @ 3% T7- *Beauveria bassiana* @ 1X $10^8$ spores/ml T9 - Control
T2 - Spinosad 45 SC @ 0.4ml / lit. T4-Castor soap oil @ 2% T6 - *Bacillus thuringiensis* @ 1 Kg/ha T8-Dimethoate 30 EC @ 2ml / lit / Chloriphyriphos 20 EC @ 2ml/lit.
* Each value is the mean of three replications; NS: Non significant; Figures in parentheses are $\sqrt{X + 0.5}$ transformed values
Means in a column followed by same letter (s) are not significantly different by LSD (P= 0.05)

Second spray data revealed that, the thrips population was low in the plots treated with spinosad 45 SC @ 0.4ml $l^{-1}$and was on par with emamectin benzoate 5 SG @ 0.4g $l^{-1}$ (0.67 and 0.72 / leaf). But significantly differed from standard check dimethoate 30 EC @ 2ml $l^{-1}$ (0.82 / leaf). Next effective treatments among biorationals were *B. bassiana* @ 1 x $10^8$ spores / ml and neem oil @ 3% which registered 1.09 and 1.28 / leaf as against 3.01 / leaf in untreated check. Third spray data revealed the same trend as that of second spray. The best treatments among biorationals were *B. bassiana* @ 1 x $10^8$ spores / ml and neem oil 3% which recorded moderate thrips population (0.95 and 1.12 / leaf), respectively, whereas other treatments *viz.,* castor soap oil @ 2%, panchachaviya @ 3% and *B. thuringiensis* were inferior and recorded 1.49, 2.13 and 2.16 / leaf as against 3.71 / leaf in untreated control. Irrespective of number of sprays spinosad 45 SC @ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ were found superior to the standard check dimethoate 30 EC @ 2ml $l^{-1}$, which registered 81.77 and 79.17 % reduction over control. The next effective treatments were *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ and neem oil 3% which recorded 66.03 % and 62.82 % reduction over control [Table-1].

The data on leaf curl damage due to thrips are presented in [Table-1]. The pre treatment observations ranged from 0.80 to 0.86 LCI per plant. After 1st spray, the proportion of plants showing leaf curl damage was low in the plots treated with spinosad 45 SC @ 0.4ml $l^{-1}$ (0.86 LCI / plant) and was on par with emamectin 5 SG @ 0.4g $l^{-1}$ (0.88 LCI / plant) as well as standard check dimethoate 30 EC @ 2ml $l^{-1}$ (0.92 LCI / plant). This was followed by neem oil @ 3% (1.04 LCI / plant) and *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (1.06 LCI / plant) which were also on par in their efficacy. Other treatments namely castor soap oil @ 2%, panchachaviya @ 3% and *B. thuringiensis* were inferior and recorded 1.18, 1.30 and 1.33 LCI / plant when compared to untreated control (1.64 LCI / plant). After 2nd and 3rd spray, the leaf curl damage was low in plot treated with spinosad 45 SC @ 0.4ml $l^{-1}$ (0.93 and 0.97 LCI / plant) which was statistically on par with emamectin 5 SG @ 0.4g $l^{-1}$ (0.95 and 0.98 LCI / plant) and found superior to all the treatments followed by dimethoate 30 EC @ 2ml $l^{-1}$ (1.06 and 1.13 LCI / plant). However *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (1.18 and 1.26 LCI / plant) and neem oil @ 3% (1.26 and 1.35 LCI / plant) ranked next followed by castor soap oil @ 2% (1.38 and 1.50 LCI / plant), panchachaviya @ 3% (1.61 and 1.83 LCI / plant) and *B. thuringiensis* (1.66 and 1.88 LCI / plant). The untreated control recorded higher leaf curl index of 2.20 and 2.53 per plant. Regardless of sprays, spinosad and emmamectin benzoate were superior recording 56.60 and 55.66 per cent reduction over control [Table-1].

Results on the effect of biorationals against chilli fruit borer, *H. armigera* are furnished in [Table-2], indicated that, there was no significant difference in larval population ranged from 2.27 to 2.37 larvae/plant before imposing treatments. After first spray, among treatments significant reduction was noticed in the plots treated with spinosad 45 SC @ 0.4ml $l^{-1}$and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ which recorded the least average larval population of 0.87 and 0.92 / plant and was on par with each other followed by standard check chloriphyriphos 20 EC @ 2 ml $l^{-1}$ (1.02 larvae / plant). The next in the order of efficacy being *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ (1.20 larvae/plant) and *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (1.40 larvae/plant) which was on par and found superior to neem oil 3% (1.54 larvae/plant) and castor soap oil 2% (1.63 larvae / plant) as against untreated check (2.56 larvae / plant). After second spray, among the treatments, spinosad 45 SC@ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ maintained their superiority (0.46 and 0.50 larvae/plant) and significantly differed from standard check chloriphyriphos 20 EC @ 2ml $l^{-1}$ (0.69 larvae / plant) which was on par with *B. thuringiensis* var. *kurstaki* @ 1 kg $ha^{-1}$ (0.75 larvae / plant) followed by *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (0.93 larvae / plant), neem oil 3% (1.36 larvae / plant) as against untreated check (3.19 larvae / plant). Similarly, *H. armigera* larval population on chilli after third spray showed significant reduction in spinosad 45 SC @ 0.4ml $l^{-1}$, emamectin benzoate 5 SG @ 0.4g $l^{-1}$, *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ and *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (0.20 to 0.77 larvae/plant) compared to control (3.28 larvae/plant). Irrespective of sprays spinosad 45 SC @ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ were found highly effective against *H. armigera* which resulted in 83.06 and 81.73 per cent larval reduction over control. *B. thuringiensis var. kurstaki* @ 1 kg / ha ranked next to chloriphyriphos 20 EC @ 2 ml $l^{-1}$ by registering 71.76 per cent reduction of *H. armigera* larvae [Table-2].

**Table-2** *Evaluation of certain bio-rationals against fruit borer, H. armigera and its damage on chilli*

| | *H. armigera* (larvae/plant)*+ | | | | | | Fruit damage (%)* ++ | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Precount | I spray mean | II spray mean | III spray mean | Grand mean | Per cent reduction over control | Precount | I spray mean | II spray mean | III spray mean | Grand mean | Per cent reduction over control |
| T1 | 2.27 (1.66) | 0.92 (1.19)$^{a}$ | 0.50 (1.00)$^{a}$ | 0.23 (0.86)$^{a}$ | 0.55 (1.02)$^{a}$ | 81.73 | 30.40 (33.46) | 18.59 (25.54)$^{a}$ | 11.65 (19.96)$^{a}$ | 6.79 (15.10)$^{a}$ | 12.34 (20.57)$^{a}$ | 71.20 |
| T2 | 2.30 (1.67) | 0.87 (1.17)$^{a}$ | 0.46 (0.98)$^{a}$ | 0.20 (0.84)$^{a}$ | 0.51 (1.00)$^{a}$ | 83.06 | 30.57 (33.57) | 18.11 (25.19)$^{a}$ | 11.17 (19.52)$^{a}$ | 6.39 (14.64)$^{a}$ | 11.89 (20.17)$^{a}$ | 72.25 |
| T3 | 2.37 (1.69) | 1.54 (1.43)$^{e}$ | 1.36 (1.36)$^{d}$ | 1.38 (1.37)$^{d}$ | 1.43 (1.39)$^{d}$ | 52.49 | 30.53 (33.54) | 25.26 (30.17)$^{c}$ | 21.99 (27.97)$^{d}$ | 19.83 (26.44)$^{d}$ | 22.36 (28.22)$^{d}$ | 47.81 |
| T4 | 2.33 (1.68) | 1.63 (1.46)$^{e}$ | 1.55 (1.43)$^{e}$ | 1.68 (1.48)$^{e}$ | 1.62 (1.46)$^{e}$ | 46.18 | 30.77 (33.69) | 27.71 (32.40)$^{d}$ | 23.86 (29.24)$^{e}$ | 22.14 (28.07)$^{e}$ | 24.90 (29.94)$^{e}$ | 41.88 |
| T5 | 2.27 (1.66) | 1.78 (1.51)$^{f}$ | 1.82 (1.52)$^{f}$ | 1.99 (1.58)$^{f}$ | 1.86 (1.54)$^{f}$ | 38.21 | 31.02 (33.84) | 29.73 (33.04)$^{e}$ | 28.84 (32.48)$^{f}$ | 27.68 (31.74)$^{f}$ | 28.75 (32.42)$^{f}$ | 32.89 |
| T6 | 2.33 (1.68) | 1.20 (1.30)$^{c}$ | 0.75 (1.12)$^{b}$ | 0.60 (1.05)$^{b}$ | 0.85 (1.16)$^{b}$ | 71.76 | 30.68 (33.63) | 21.67 (27.74)$^{b}$ | 14.49 (22.37)$^{b}$ | 10.16 (18.59)$^{b}$ | 15.44 (23.14)$^{b}$ | 63.96 |
| T7 | 2.43 (1.71) | 1.40 (1.38)$^{d}$ | 0.93 (1.20)$^{c}$ | 0.77 (1.12)$^{c}$ | 1.03 (1.24)$^{c}$ | 65.78 | 31.15 (33.93) | 23.73 (29.15)$^{c}$ | 17.38 (24.64)$^{c}$ | 13.31 (21.40)$^{c}$ | 18.14 (25.21)$^{c}$ | 57.66 |
| T8 | 2.37 (1.69) | 1.02 (1.23)$^{b}$ | 0.69 (1.09)$^{b}$ | 0.63 (1.06)$^{b}$ | 0.78 (1.13)$^{b}$ | 74.09 | 30.71 (33.65) | 20.62 (27.01)$^{b}$ | 13.24 (21.34)$^{b}$ | 9.64 (18.90)$^{b}$ | 14.50 (22.38)$^{b}$ | 66.15 |
| T9 | 2.30 (1.67) | 2.56 (1.75)$^{g}$ | 3.19 (1.92)$^{g}$ | 3.28 (1.94)$^{g}$ | 3.01 (1.87)$^{g}$ | - | 30.43 (33.48) | 35.72 (36.70)$^{f}$ | 43.48 (41.26)$^{g}$ | 49.33 (44.61)$^{g}$ | 42.84 (40.89)$^{g}$ | - |
| SEd | NS | 0.0187 | 0.0238 | 0.0270 | 0.0212 | - | NS | 0.5903 | 0.5536 | 0.4900 | 0.8245 | - |
| CD | NS | 0.0396 | 0.0504 | 0.0572 | 0.0449 | - | NS | 1.2513 | 1.1735 | 1.0388 | 1.7478 | - |

T1 - Emamectin benzoate 5G @ 0.4g /lit. T3 - Neem @ oil 3% T5- Panchakavya @ 3% T7- *Beauveria bassiana* @ 1X $10^8$ spores/ml T9 - Control
T2 - Spinosad 45 SC @ 0.4ml / lit. T4 - Castor soap oil @ 2% T6 - *Bacillus thuringiensis* @ 1 Kg/ha T8- Dimethoate 30 EC @ 2ml / lit / Chloriphyriphos 20 EC @ 2ml/lit.
* Each value is the mean of three replications; NS: Non significant
+ Figures in parentheses are $\sqrt{X + 0.5}$ transformed values; ++ Figures in parentheses are arcsine transformed values
Means in a column followed by same letter (s) are not significantly different by LSD (P= 0.05)

The fruit damage due to *H. armigera* ranged from 30.40 to 31.15 per cent before imposing treatments. After 1st spray, fruit damage was low in spinosad 45 SC @ 0.4ml $l^{-1}$ (18.11 %) and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ (18.59 %) which were on par significantly deferred from chlorphyriphos 20 EC @ 2ml $l^{-1}$ ( 20.62 %) followed by *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ (21.67 %) and *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (23.73 %) which were on par, as against untreated control (35.72 %). Second spray data revealed that spinosad 45 SC @ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ excelled over other treatments by recording lowest fruit damage. Similarly, third spray indicated spinosad 45 SC @ 0.4ml $l^{-1}$ and emamectin benzoate 5 SG @ 0.4g $l^{-1}$ maintained their superiority, which recorded lower fruit damage of 6.39 % and 6.79 %, respectively followed by standard check chlorphyriphos 20 EC @ 2ml $l^{-1}$ (9.64 %) and *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ (10.16 %) which were on par. Further *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (13.31 %) ranked next and found superior to rest of treatments as against untreated control (49.33 %). The order of effectiveness are spinosad 45 SC @ 0.4 ml $l^{-1}$ > emamectin benzoate 5 SG @ 0.4g $l^{-1}$ > chlorpyriphos 20 EC @ 2.0 ml $l^{-1}$ > *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ > *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ > neem oil @ 3% > castor soap oil @ 2% > panchachaviya with a respective reduction of 72.25, 71.20, 66.15, 63.96, 57.66, 47.81, 41.88 and 32.89 per cent reduction over control [Table-2].

Data on dry chilli yield and cost benefit ratios worked out are presented in [Table-3]. Among biorationals, spinosad 45 SC @ 0.4ml $l^{-1}$ recorded the highest yield of 1480 kg/ha with an additional income Rs.28, 200/- and was significantly superior to all other treatments. This was followed by emamectin 5 SG @ 0.4g $l^{-1}$ (1420 kg/ha), *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$ (1175 kg/ha), *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ (1140 kg/ha), neem oil @ 3% (1120 kg/ha), castor soap oil @ 2% (1060 kg/ha) and panchachaviya (1040) with a respective additional income of 24,600/-, 9900/-, 7800/-, 6600/-, 3000/- and 1800/-. The standard check recorded an yield of 1160 kg / ha with additional income of 9000/- against the lowest yield (1010 kg/ha) in untreated control. Among bio-rationals, the highest cost benefit ratio (1:4.09) was obtained in spinosad 45 SC @ 0.4ml $l^{-1}$ followed by 1:3.97, 1:3.09, 1:3.00 and 1:2.51 in emamectin 5 SG @ 0.4g $l^{-1}$, *B. thuringiensis var. kurstaki* @ 1 kg $ha^{-1}$, *B. bassiana* @ 1 x $10^8$ spores $ml^{-1}$ and neem oil @ 3% respectively [Table-3].

**Table-3** *Evaluation of certain bio-rationals on natural enemies and dry chilli yield*

| Treatments | Yield* (Kg $ha^{-1}$) | Additional yield over control (Kg $ha^{-1}$) | Additional income over untreated check (Rs.) | Management cost (Rs.) | Cost benefit ratio |
|---|---|---|---|---|---|
| T1 Emamectin benzoate 5G @ 0.4g $l^{-1}$ | 1420$^{a}$ | 410 | 24600 | 6200 | 1:3.97 |
| T2 Spinosad 45 SC @ 0.4ml $l^{-1}$ | 1480$^{a}$ | 470 | 28200 | 6900 | 1:4.09 |
| T3 Neem @ oil 3% | 1120$^{c}$ | 110 | 6600 | 2625 | 1:2.51 |
| T4 Castor soap oil @ 2% | 1060$^{d}$ | 50 | 3000 | 2400 | 1:1.25 |
| T5 Panchakavya @ 3% | 1040$^{d}$ | 30 | 1800 | 1800 | 1:1.00 |
| T6 *B. t.var kurstaki* @ 1 Kg $ha^{-1}$ | 1175$^{b}$ | 165 | 9900 | 3200 | 1:3.09 |
| T7 *B. bassiana* @ 1X $10^8$ spores $ml^{-1}$ | 1140$^{bc}$ | 130 | 7800 | 2600 | 1:3.00 |
| T8 Dimethoate 30 EC @ 2ml $l^{-1}$ | 1160$^{b}$ | 150 | 9000 | 2700 | 1:3.33 |
| T9 Untreated Control | 1010$^{e}$ | - | - | - | - |

*Each value is the mean of three replications
Means in a column followed by same letter (s) are not significantly different by LSD (P= 0.05)

## Discussion and Conclusion

The findings on the consistent efficacy of biorationals *viz.,* spinosad 45 SC and emamectin benzoate 5 SG against *S. dorsalis* are in concurrence with the reports of several authors; Sparks *et al.* [6] who reported that spinosad was effective against Thysanopterans. Garzia and Buonocora [7] who found that Spinosad was effective against thrips, *Frankliniella occidentalis* on cucumber. Balikai and Patil [8] and Khalid Ahmed and Prasad [9] have reported that emamectin benzoate 5 SG, found to be effective against grape thrips and chilli thrips, respectively.

Similarly the superiority of spinosad 45 SC and emamectin benzoate against *H. armigera* was also reported by several authors *viz.,* Hansah *et al.* [10] on tomato; Suganyakanna [11] in tomato and Roopa and Ashok kumar [12] on capsicum. The performance of *B. bassiana* @ 1 x $10^8$ spores / ml ranked next. This finding is in confirmation with reports of Seal and Kumar [13] who found that application of *B. bassiana* @ 5x$10^{13}$ spores / ml was very effective against *S. dorsalis* on chilli.

Neem oil @ 3% ranked next to B*. bassiana.* The results on efficacy of neem oil 3% was in agreement with findings of Chandrasekaran and Veeravel [14] and Mallikarjuna Rao *et al*. [15] who reported that neem oil (3 and 5%) was effective against *S.dorsalis* in chilli. With regard to fruit borer, *B. thuringiensis var. kurstaki* @ 1 kg/ha ranked next to spinosad 45 SC and emamectin benzoate 5 SG. This result was in corroboration with findings of Rabindra *et al*., [16] on sunflower. Praveen *et al*. [17] and Balasubramanian *et al*. [18] reported that the *Btk* formulations were effective in checking *H. armigera* on tomato and chickpea, respectively.

The findings on the superiority of spinosad are in accordance with Roopa and Ashok kumar [12] who reported that application of Spinosad 45 SC @ 0.01% recorded the highest yield (30050 kg/ ha) in capsicum with benefit cost ratio (1:4.60), followed by emamectin benzoate 5 SG @ 0.4g / lit with an yield (27000 kg / ha) and benefit cost ratio (1:4.10)

**Conflict of Interest: None declared**

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