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Evaluation of Biopesticides and Biorationals against Thrips and Leafminer in *Rabi*/Summer Groundnut.

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Research Article

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ABSTRACT

Field experiment was conducted during R*abi*/Summer cropping season of 2012-13 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad with the objective of evaluating the efficacy of different biopesticides and biorationals against groundnut thrips and leaf miner. The treatments were *Lecanicillium lecanii, Beauveria bassiana, Metarrhizium anisopliae* @ 2, 4, 6 g/l, Buprofezin 25 EC @ 1ml/l and Spinosad 45 SC @ 1 ml/l. During the study efficacy of all three biopesticides were evaluated at different dosages. Results revealed that spinosad 45 EC @ 0.20 ml/l, *Lecanicillium lecanii* @ 6 g/l and *L. lecanii* @ 4 g/l found effective in reducing thrips population, whereas spinosad 45 EC @ 0.20 ml/l, buprofezin (25 EC @ 1.0 ml/l), *Beauveria bassiana* @ 6 g/l and *Metarrhizium anisopliae* @ 6 g/l found effective against leaf miner. Considering the cost of cultivation and the gross profit in different treatments, the benefit cost ratio (BCR) and net profit was calculated. Among the different treatments, spinosad and buprofezin recorded higher B:C ratio net profit and found superior over all other treatments in the trial. Among the biopesticides *L. lecanii* @ 6 g/l recorded higher B:C ratio and net profit as compare to other biopesticides treatments.

INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is a leading oilseed crop in India and an important oilseed crop of tropical and subtropical regions of the world. The seeds are rich source of edible oil (43-45%) and protein (25-28%) and also a valuable source of vitamins namely B, E and K. Groundnut cake, after the oil extraction is a high protein animal feed and haulm provides quality fodder. The cake is used as cattle and poultry feed and also serves as organic manure with high nitrogen content. The kernels are used in many Indian cuisines and also eaten raw, cooked or fried. In addition, its use in confectionary and other modes of consumption namely, roasted in shell and used as snacks in the restaurants and handpicked selected grade is exported. It is used as a peanut butter in preparation of sandwiches and peanut candy.

Groundnut is considered by farmers as the most remunerative crop with relatively low chance of crop failures despite an unpredictable monsoon. But the insect pests form the important constraints in its production. Red hairy caterpillars: *Amsacta albistriga* Walker*, A. moorei*, leaf miner: *Aproaerema modicella* Deventer, bihar hairy caterpillar: *Spilosoma obliqua* Walker*,* tobacco caterpillar: *Spodoptera* *litura* (Fabricius) Aphids: *Aphis craccivora* Koch, and leaf hopper: *Empoasca kerri* Pruthi*,* are important insect pests of groundnut crop in India.

In the recent years incidence of thrips on groundnut crop is increasing and known to cause yield loss to the tune of 14 to 40 per cent [1] and also responsible for spreading a viral disease called bud necrosis in groundnut. This pest can be present at any time of the year but are most numerous in the post-rainy season. Nymphs and adults suck sap from the surface of the leaflets initially, resulting in white patches on the upper and necrotic patches on the lower surface of the leaves. When infestation is severe, particularly during winter leaf distortion causes stunted plant growth thus contributing directly towards yield reduction and also more dangerously cause yield loss indirectly by transmitting peanut bud necrosis virus disease, which can cause widespread plant death. The leaf miner is considered as the most important insect pest of groundnut in South India and particularly under rainfed situations [2-4]. The pest initially appears as a leaf miner causing short blister like mines. Older larvae fold the leaflets and feed within. As a result, the leaflets turn brown, shrivel and dry up. Severely infested crop gives a burnt up appearance and yield losses can reach up to 76 per cent [5]. Objective of the study is to determine the effectiveness of the biopesticides and biorationals in order to develop an effective, environmentally safe and sustainable pest management practice for thrips and leaf miner in groundnut crop.

MATERIAL AND METHODS

Experiment was conducted at MARS, Dharwad to know the efficacy of biopesticides and 2 biorationals on thrips and leafminer during *rabi*/summer 2012 season in groundnut crop. Two sprays were taken at 15days interval and the groundnut variety used was Dh-216. The trial was laid out in randomized block design with twelve treatments and three replications. The observations were made on number of thrips per terminal bud and leafminer per plant. The observations were recorded from such of 10 plants in all the treatments and the average data was used in the table for expression. Yield and yield economics were worked out after the crop attained maturity. After harvest of groundnut crop, pods and fodder were kept separate from each treatment, dried properly and pod and fodder weight was recorded. Further, the plot wise yield was computed on hectare basis for statistical interpretations. The cost of cultivation was worked out as per the recommended package of practices. The economics of different treatments were worked out based on the pod and fodder yield and cost of protection. The cost, sale price of the pod and fodder of respective treatment was considered to calculate gross profit. Based on the cost of cultivation and the gross profit in different treatments, the CBR and net profit was calculated.

RESULTS AND DISCUSSION

Evaluation of biopesticides and biorationals against thrips

Thrips population one day before first spraying ranged from 9.27 to 10.37 per terminal bud and it was uniform across the treatments as indicated by insignificant difference between treatments. One day after spraying thrips population varied across the treatments. Significantly lowest thrips population was recorded in spinosad (1.20 thrips/terminal bud), which differed statistically from all the other treatments. The next best treatment was *Lecanicillium lecanii* @ 6 g/l (8.77 thrips/terminal bud), which was followed by *L. lecanii* @ 4 g/l (9.13 thrips/terminal bud), *Beauveria bassiana* @ 6 g/l (9.27 thrips/ terminal bud), *L. lecanii* @ 2 g/l (9.33 thrips/terminal bud), *Metarrhizium anisopliae* @ 4 g/l (9.33 thrips/terminal bud) *M. anisopliae* @ 6 g/l (9.33 thrips/terminal bud), *M. anisopliae* @ 2 g/l, (9.37 thrips/terminal bud) *B. bassiana* @ 4 g/l (9.37 thrips/terminal bud), *B. bassiana* @ 2 g/l (9.43 thrips/terminal bud) and buprofezin (10.03 thrips/terminal bud). The untreated check recorded highest thrips population of 10.23/terminal bud and at par with all the treatments excluding spinosad a day after spray. Three days after spray, once again spinosad recorded least thrips population of 0.63 per terminal bud. The *L. lecanii* @ 6 g/l (3.27 thrips/terminal bud) recorded lower and at par thrips population count with other two *L. lecanii* treatments and differed significantly with the remaining treatments after 3 days of spray. Buprofezin recorded moderate thrips population of 5.33 thrips/terminal bud and remained statistically different from all the other treatments. The *B. bassiana* @ 6 g/l (7.50 thrips/terminal bud) recorded comparatively higher population and at par with remaining *B. bassiana* and *M. anisopliae* treatments and differed significantly superior to untreated check. The untreated check recorded significantly highest thrips population of 11.13 thrips per terminal bud (Table 1). Five days after spray almost a similar treatment difference was observed as observed after 3 days of spray. The spinosad maintained its superiority even after 10 days of spray by recording least thrips population of 3.40 thrips/terminal bud and differed significantly from all the other treatments after ten days of spray. Buprofezin recorded 7.50 thrips per terminal bud and was being at par with all the doses of *L. lecanii* differed significantly with rest of the treatments. *B. bassiana* @ 6 g/l recorded 10.00 thrips/terminal bud and was on par with remaining doses of *B. bassiana* and *M. anisopliae*, differed significantly with untreated check (Table 1).

Thrips population after second spray ranged from 5.20 to 12.33 per terminal bud a day before spraying with statistical difference among the treatments due to effect of first spraying. One day after spraying, significantly lowest population of thrips was recorded in spinosad (0.53 thrips/terminal bud), which was statistically differed from all the other treatments. The next best treatment in the order of effectiveness was *L. lecanii* @ 6 g/l (6.77 thrips/terminal bud), was at par with buprofezin (7.73 thrips/terminal bud), *L. lecanii* @ 4 g/l (8.10 thrips/terminal bud), *L. lecanii* @ 2 g/l (8.33 thrips/terminal bud), *B. bassiana* @ 6 g/l (10.00 thrips/terminal bud), *B. bassiana* @ 4 g/l (10.03 thrips/terminal bud), *B. bassiana* @ 2 g/l (10.33 thrips/terminal bud) and *M. anisopliae* @ 6 g/l (10.00 thrips/terminal bud), differed significantly with the remaining treatments. The *M. anisopliae* @ 4 g/l (10.80 thrips/terminal bud) and *M. anisopliae* @ 2 g/l (11.37 thrips/terminal bud) recorded at par thrips population with untreated check (12.33 thrips/terminal bud) (Table 1). Three days after spraying the treatment efficacy trend was slight different. Spinosad maintained its superiority by recording lowest population of 0.30 thrips per terminal bud and remained statically different from all the other treatments. The *L. lecanii* @ 6 g/ l recorded lower thrips population of 3.07 per terminal bud, being at par with buprofezin (3.33 thrips/terminal bud), *L. lecanii* @ 4 g/l (3.87 thrips/terminal bud), and *L. lecanii* @ 2 g/l (3.93 thrips/terminal bud) differed significantly with the remaining treatments. All dosages of *B. bassiana* and *M. anisopliae* were at par with each other and was significantly different with untreated check (11.63 thrips/terminal bud). A similar trend of treatment difference was observed after five and 10 days of treatment imposition. Spinosad maintained its superiority even after 10 days of spray. Similarly buprofezin was the next best treatment, followed by *L. lecanii* @ 6 g/l (3.27 thrips/terminal bud), *L. lecanii* @ 4 g/l (4.73 thrips/terminal bud), *L. lecanii* @ 2 g/l 5.33 (thrips/terminal bud) and *M. anisopliae* @ 6 g/l (8.00 thrips/terminal bud). The remaining treatments such as *M. anisopliae* @ 4 g/l (8.67 thrips/terminal bud), *B. bassiana* @ 6 g/l (8.33 thrips/terminal bud), *B. bassiana* @ 4 g/l (9.00 thrips/terminal bud), *B. bassiana* @ 2 g/ l (9.13 thrips/terminal bud) and *M. anisopliae* @ 2 g/l (9.37 thrips/terminal bud) supported comparatively higher thrips population (Table 1).

Among the treatments spinosad was very effective in checking thrips incidence and which was demonstrated during both the spray by recording significantly lower thrips population after both the spray treatments and also by registering higher yield. buprofezin was the next best treatment to reduce the thrips population and to record significantly higher yield. *Lecanicillium lecanii* @ 6 g/l recorded comparatively lower thrips population and higher pod yield was at par with *L. lecanii* @ 4 g/l. The next best treatment was *L. lecanii* @ 2 and 4 g/l was at par with *Metarrhizium anisopliae* @ 6 g/l in checking thrips population. The remaining dosages of microbial pesticides did not exert any eye catching reduction of thrips population and also registered comparatively lower yield.

Van der Schaaf *et al.* [6] reported that *V. lecanii* successfully controlled western flower thrips (*Frankliniella occidentalis*) on chrysanthemum is in agreement with the result of present study. Similarly Sacco *et al.* [7] studied the efficacy of spinosad and *Beauveria bassiana*, against rose thrips, *F. occidentalis* under glasshouse conditions and reported that spinosad (12 g/100 liters) gave the best results, with a population reduction between 91 and 74 per cent. The said efficacy of spinosad is contradictory with the present study. However, the effectiveness of *Beauveria* in their study may be due to the prevailing microclimate in glass house condition, crop ecosystem and weather existed made the difference with present findings under open field condition during summer season. Anand *et al.* [8] found *L. lecanii* reduced the pomegranate thrips (*Scirtothrips dorsalis* Hood, *Rhipiphorothrips cruentatus* and *Anaphothrips oligochaetus* population to 50 per cent at 7 days after treatment. Dakshina and Vivek Kumar [9] evaluated the efficacy of spinosad and *B. bassiana* against chilli thrips *Scirtothrips dorsalis* in bell pepper, *Capsicum annuum L.* spinosad significantly suppressed both adults and larvae through 15 days after treatment and *B. bassiana* significantly suppressed only the larvae at 5 days after treatment. The reported efficacy of *Beauveria* may be due to different ecological condition of study. Jagdish and Purnima [10] reported that *M. anisopliae* is known to cause only 8.46 and 13.07 per cent mortality of thrips after three days and five days of spraying in rose is in total agreement with the present study where *M. anisopliae* performance against groundnut thrips was comparatively poor in all dosages tested under the trial. The reported effectiveness of the spinosad against thrips, *Frankliniella* spp Roy [11] is in line with the present study.

The leaf miner larval population one day before imposing treatments (first spray) revealed that all the treatments including untreated check recorded uniform larval load with a mean population of 1.67 to 1.93 larvae per plant which was statistically insignificant. One day after the spraying significant difference was observed between the treatments with respect to larval population and lowest pest incidence was observed in spinosad (0.40 larva/plant), differed significantly from remaining treatments and buprofezin recorded moderate population of 1.40 larvae per plant. *B. bassiana* @ 6 g/l recorded 1.50 larvae per plant was statistically at par with all other doses of *B. bassiana, M. anisopliae*, and *L lecanii* after a day of spray. After three days of spray spinosad maintained its superiority by recording significantly lowest larval population (0.23 larva/plant) and was statistically different from remaining treatments and it was followed by *B. bassiana* @ 6 g/l (0.90 larva/plant) was at par with buprofezin (1.00 larva/plant) and *M. anisopliae* @ 6 g/l (1.10 larvae/plant), *B. bassiana* @ 4 g/l (1.10 larvae/plant), *B. bassiana* @ 2 g/l (1.27 larvae/plant). *M. anisopliae* @ 4 g/l (1.30 larvae/plant), *M. anisopliae* @ 2 g/l (1.33 larvae/plant) *L. lecanii* @ 6 g/l (1.37 larvae/plant), *L. lecanii* @ 4 g/l (1.50 larvae/plant) *L. lecanii* @ 2g/l (1.63 larvae/plant) were on par with each other and untreated check which recorded 2.03 larvae per plant (Table 2). Larval population, after five days of spraying followed almost a similar trend as observed after 3 days of spray. Lowest larval population of 0.16 larva per plant was observed in spinosad differed significantly with the remaining treatments. The next best treatment was *B. bassiana* @ 6 g/l (0.77 larva/plant), was at par with *B. bassiana* @ 4 g/l, buprofezin (0.80 larva/plant), *M. anisopliae* @ 6 g/l (0.83 larva/plant), *M. anisopliae* @ 4 g/l (0.87 larva/plant), *B. bassiana* @ 2 g/l (0.90 larva/plant) and statistically differ from remaining treatments. These were followed by *L. lecanii* @ 6 g/l (1.13 larvae/plant) which was at par with *L. lecanii* @ 4 g/l (1.33 larvae/plant) and *L. lecanii* @ 2 g/l (1.50 larvae/plant) whereas untreated check recorded highest larval population of 2.20 larvae per plant which was statistically different from all the other treatments (Table 2).

Observations recorded at ten days after spraying revealed that lowest population was recorded again in the spinoasd (0.50 larvae/plant) which was statistically different from remaining treatments and it was followed by *B. bassiana* @ 6 g/l (0.90 larva/plant), *B. bassiana* @ 4 g/l and *M. anisopliae* @ 6 g/l (1.10 larvae/plant), *B. bassiana* @ 2 g/l (1.20 larvae/plant) they were statistically at par with each other. Remaining treatments recorded larval population as *M. anisopliae* @ 4 g/l, buprofezin (1.23 larvae/plant), *M. anisopliae* @ 2 g/l (1.33 larvae/plant), *L. lecanii* @ 6 g/l (1.37 larvae/plant), *L. lecanii* @ 4 g/l (1.47 larvae/plant) which were on par with each other and *L. lecanii* @ 2 g/l recorded larval population of 1.60 larvae per plant and it differed from all other treatments and maximum pest population was observed in untreated check (2.53 larvae/plant) (Table 2).

The mean larval population one day before second spray ranged from 1.20 to 2.67 larvae per plant across the treatment plots. One day after spraying lowest larval population was recorded in spinosad and was significantly superior to all the other treatments by recording least larval population of 0.23 larvae per plant. Buprofezin was next best treatment to record 1.33 larvae per plant which was on par with remaining treatments and differed significantly with untreated check, which recorded maximum larval population of 2.63 larvae per plant (Table 2). The spinosad remained effective even after 10 days of treatment imposition and differed significantly with all the other treatments. All the remaining treatments supported at par and comparatively higher population of leaf miner after 3, 5 and 10 days of spray. The untreated check recorded highest population and remained statistically different from all the other treatments from 1, 3, 5 and 10 days after spray (Table 2). Results of this investigation revealed that among the different treatments spinosad was most effective in reducing the larval population of leafminer, while buprofezin was the next effective treatment which was at par with *B. bassiana* and *M. anisopliae* in all the three doses tested in the trial. Whereas, *L. lecanii* was failed to establish its effectiveness against leafminer on groundnut crop. The results of present study was in line with Sahayaraj and Namachivayam [12] who reported the effectiveness of *B. bassiana* on groundnut leafminer in reducing the larval population on 7th and 14th day after spray when compare to *V. lecanii.* Ranga Rao and Reddy [13] reported dead groundnut leafminer (GLM; *Aproaerema modicella*) larvae due to infection of *M. anisopliae* in the field at Patancheru, India, during 1996 groundnut cropping season support the present findings of effectiveness of *M. anisopliae* against leafminer on groundnut crop. The spinosad and buprofezin are effective against groundnut leafminer [14] support the present findings.

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Table 1: Evaluation of biopesticides and biorationals against thrips in *rabi*/summer groundnut

Treatments	Number of thrips/terminal bud Ist spray					Number of thrips/terminal bud IInd spray				
	1DBS	1DAS	3DAS	5DAS	10DAS	1DBS	1DAS	3DAS	5DAS	10DAS
Lecanicillium lecanii @ 2 g/l	9.53 (3.16)^{a}	9.33 (3.13)^{b}	4.33 (2.19)^{c}	6.50 (2.64)^{bc}	7.50 (2.82)^{b}	8.47 (2.99)^{b}	8.33 (2.97)$^{b-d}$	3.93 (2.10)^{b}	5.33 (2.41)^{c}	6.77 (2.69)^{cd}
Lecanicillium lecanii @ 4 g/l	9.53 (3.16)^{a}	9.13 (3.10)^{b}	3.80 (2.07)^{bc}	5.33 (2.41)^{b}	6.83 (2.70)^{b}	8.33 (2.97)^{b}	8.10 (2.93)^{bc}	3.87 (2.09)^{b}	4.73 (2.28)^{bc}	6.03 (2.55)^{c}
Lecanicillium lecanii @ 6 g/ l	9.27 (3.12)^{a}	8.77 (3.04)^{b}	3.27 (1.94)^{bc}	5.17 (2.38)^{b}	6.43 (2.63)^{b}	8.00 (2.91)^{b}	6.77 (2.69)^{b}	3.07 (1.88)^{b}	3.27 (1.94)^{b}	5.53 (2.45)^{bc}
Beauveria bassiana @ 2 g/l	9.67 (3.18)^{a}	9.43 (3.15)^{b}	8.00 (2.91)^{e}	9.50 (3.16)^{d}	10.63 (3.33)^{cd}	10.50 (3.31)^{c}	10.33 (3.29)^{de}	8.67 (3.02)^{c}	9.13 (3.10)^{d}	9.53 (3.16)^{e}
Beauveria bassiana @ 4 g/l	9.47 (3.15)^{a}	9.37 (3.14)^{b}	7.80 (2.88)^{e}	9.33 (3.13)^{d}	10.13 (3.25)^{cd}	10.30 (3.28)^{c}	10.03 (3.25)$^{c-e}$	8.37 (2.97)^{c}	9.00 (3.08)^{d}	9.37 (3.14)^{e}
Beauveria bassiana @ 6 g/l	9.53 (3.16)^{a}	9.27 (3.12)^{b}	7.50 (2.82)^{e}	9.00 (3.08)^{d}	10.00 (3.23)^{c}	10.13 (3.26)^{c}	10.00 (3.24)$^{c-e}$	7.50 (2.82)^{c}	8.33 (2.97)^{d}	9.13 (3.10)^{e}
Metarrhizium anisopliae @ 2 g/l	9.50 (3.16)^{a}	9.37 (3.14)^{b}	8.50 (3.00)^{e}	10.00 (3.24)^{de}	11.63 (3.48)^{cd}	11.60 (3.48)^{cd}	11.37 (3.44)^{e}	9.00 (3.08)^{c}	9.37 (3.14)^{d}	10.00 (3.23)^{e}
Metarrhizium anisopliae @ 4 g/l	9.53 (3.16)^{a}	9.33 (3.13)^{b}	8.20 (2.94)^{e}	9.60 (3.17)^{d}	11.00 (3.38)^{cd}	11.13 (3.41)^{cd}	10.80 (3.36)^{e}	7.90 (2.88)^{c}	8.67 (3.02)^{d}	9.50 (3.16)^{e}
Metarrhizium anisopliae @ 6 g/l	9.70 (3.19)^{a}	9.3 (3.13)^{b}	8.00 (2.91)^{e}	9.23 (3.11)^{d}	10.33 (3.28)^{cd}	10.37 (3.30)^{c}	10.00 (3.24)$^{c-e}$	7.80 (2.88)^{c}	8.00 (2.91)^{d}	8.47 (2.98)^{de}
Buprofezin 25EC @ 1.0 ml/l	10.37 (3.29)^{a}	10.03 (3.24)^{b}	5.33 (2.41)^{d}	7.00 (2.73)^{c}	7.50 (2.82)^{b}	7.83 (2.88)^{b}	7.73 (2.86)^{b}	3.33 (1.95)^{b}	4.60 (2.25)^{bc}	4.47 (2.22)^{b}
Spinosad 45SC @ 0.2 ml/l	9.83 (3.21)^{a}	1.20 (1.30)^{a}	0.63 (1.06)^{a}	0.70 (1.09)^{a}	3.40 (1.97)^{a}	5.20 (2.38)^{a}	0.53 (1.01)^{a}	0.30 (0.89)^{a}	0.63 (1.06)^{a}	2.93 (1.85)^{a}
Control	9.77 (3.20)^{a}	10.23 (3.27)^{b}	11.13 (3.41)^{f}	11.63 (3.48)^{e}	12.27 (3.57)^{d}	12.33 (3.58)^{d}	12.00 (3.53)^{e}	11.63 (3.48)^{d}	10.37 (3.29)^{d}	10.33 (3.29)^{e}
SEm±	NS	0.09	0.06	0.10	0.09	0.07	0.11	0.12	0.11	0.10
CD at 5%	NS	0.27	0.18	0.29	0.27	0.21	0.31	0.36	0.33	0.30

NS – Non-significant , DBS – Day before spraying, DAS – Days after spraying ,Figures in parenthesis are square root transformed values Means followed by same letter in the column do not differ significantly by DMRT (P=0.05)

Table 2: Evaluation of biopesticides and biorationals against leafminer in *rabi*/summer groundnut

Treatments	Number of larvae/plant Ist spray					Number of larvae/plant IInd spray				
	1DBS	1DAS	3DAS	5DAS	10DAS	1DBS	1DAS	3DAS	5DAS	10DAS
Lecanicillium lecanii @ 2 g/l	1.83 (1.52)^{a}	1.80 (1.51)^{bc}	1.63 (1.45)^{de}	1.50 (1.41)^{d}	1.60 (1.44)^{c}	1.87 (1.53)^{b}	1.73 (1.49)^{b}	1.53 (1.42)^{d}	1.40 (1.37)^{d}	1.70 (1.48)^{d}
Lecanicillium lecanii @ 4 g/l	1.90 (1.54)^{a}	1.87 (1.53)^{bc}	1.50 (1.41)^{cd}	1.33 (1.35)^{cd}	1.47 (1.40)^{c}	1.83 (1.52)^{b}	1.70 (1.40)^{b}	1.51 (1.41)^{cd}	1.27 (1.33)^{cd}	1.57 (1.43)^{cd}
Lecanicillium lecanii @ 6 g/ l	1.80 (1.51)^{a}	1.67 (1.47)^{bc}	1.37 (1.36)$^{b-d}$	1.13 (1.27)^{bcd}	1.37 (1.36)^{bc}	1.80 (1.51)^{b}	1.60 (1.40)^{b}	1.43 (1.38)^{cd}	1.13 (1.27)$^{b-d}$	1.47 (1.40)$^{b-d}$
Beauveria bassiana @ 2 g/l	1.70 (1.48)^{a}	1.63 (1.63)^{bc}	1.27 (1.33)$^{b-d}$	0.90 (1.18)^{bc}	1.20 (1.30)^{bc}	1.77 (1.50)^{b}	1.70 (1.48)^{b}	1.07 (1.25)$^{b-d}$	0.87 (1.17)^{bc}	1.23 (1.31)$^{b-d}$
Beauveria bassiana @ 4 g/l	1.70 (1.48)^{a}	1.57 (1.43)^{bc}	1.10 (1.26)$^{b-d}$	0.80 (1.14)^{b}	1.10 (1.26)^{bc}	1.70 (1.48)^{b}	1.57 (1.43)^{b}	0.90 (1.18)^{b}	0.73 (1.10)^{b}	1.20 (1.30)$^{b-d}$
Beauveria bassiana @ 6 g/l	1.90 (1.54)^{a}	1.50 (1.41)^{bc}	0.90 (1.18)^{b}	0.77 (1.12)^{b}	0.90 (1.18)^{b}	1.47 (1.40)^{ab}	1.33 (1.35)^{b}	0.83 (1.15)^{b}	0.70 (1.09)^{b}	1.13 (1.27)^{bc}
Metarrhizium anisopliae @ 2 g/l	1.70 (1.48)^{a}	1.77 (1.50)^{bc}	1.33 (1.35)^{bcd}	1.10 (1.26)$^{b-d}$	1.33 (1.35)^{bc}	1.90 (1.54)^{b}	1.63 (1.45)^{b}	1.40 (1.33)$^{b-d}$	0.97 (1.21)$^{b-d}$	1.40 (1.37)$^{b-d}$
Metarrhizium anisopliae @ 4 g/l	1.80 (1.51)^{a}	1.67 (1.47)^{bc}	1.30 (1.34)^{bcd}	0.87 (1.17)^{bc}	1.23 (1.31)^{bc}	1.77 (1.50)^{b}	1.40 (1.37)^{b}	1.23 (1.31)$^{b-d}$	0.90 (1.18)^{bc}	1.33 (1.35)$^{b-d}$
Metarrhizium anisopliae @ 6 g/l	1.70 (1.48)^{a}	1.63 (1.46)^{bc}	1.10 (1.26)^{bcd}	0.83 (1.15)^{b}	1.10 (1.26)^{bc}	1.67 (1.47)^{b}	1.37 (1.36)^{b}	1.13 (1.27)$^{b-d}$	0.73 (1.10)^{b}	0.97 (1.21)^{b}
Buprofezin 25EC @ 1.0 ml/l	1.67 (1.47)^{a}	1.40 (1.37)^{b}	1.00 (1.22)^{bc}	0.80 (1.14)^{b}	1.23 (1.31)^{bc}	1.47 (1.40)^{ab}	1.33 (1.35)^{b}	1.00 (1.22)^{bc}	0.83 (1.15)^{bc}	1.30 (1.34)$^{b-d}$
Spinosad 45SC @ 0.2 ml/l	1.70 (1.48)^{a}	0.40 (0.94)^{a}	0.23 (0.85)^{a}	0.16 (0.81)^{a}	0.50 (1.00)^{a}	1.10 (1.26)^{a}	0.23 (0.85)^{a}	0.16 (0.81)^{a}	0.10 (0.77)^{a}	0.46 (0.98)^{a}
Control	1.93 (1.55)^{a}	1.97 (1.57)^{c}	2.03 (1.59)^{e}	2.20 (1.64)^{e}	2.53 (1.74)^{d}	2.67 (1.77)^{c}	2.63 (1.76)^{c}	2.83 (1.82)^{e}	2.90 (1.84)^{e}	3.13 (1.90)^{e}
SEm±	**NS**	**0.06**	**0.05**	**0.04**	**0.04**	**0.04**	**0.06**	**0.05**	**0.05**	**0.05**
CD at 5%	**NS**	**0.17**	**0.15**	**0.13**	**0.12**	**0.13**	**0.16**	**0.15**	**0.15**	**0.15**

NS – Non-significant ,DBS – Day before spraying, DAS – Days after spraying ,Figures in parenthesis are square root transformed values Means followed by same letter in the column do not differ significantly by DMRT (P=0.05)

Table 3: Effect of biopesticides and biorationals on the pod and haulm yield of groundnut during *rabi*/summer season

Sl. No.	Treatments	Pod yield q/ha	Haulm yield t/ha	Gross income from pod yield (Rs 3500/q	Gross income from haulm yield (Rs 200/t	Total gross income	Total cost of cultivation/ha	Net profit Rs	BCR
1	*Lecanicillium lecanii* @ 2 g/l	23.75	5.77	83125	1154	84279	45175	39104	1.86
2	*Lecanicillium lecanii* @ 4 g/l	24.86	5.93	87010	1186	88196	45350	42846	1.94
3	*Lecanicillium lecanii* @ 6 g/ l	25.23	5.97	87710	1194	88904	45525	43379	1.95
4	*Beauveria bassiana* @ 2 g/l	22.66	5.65	79310	1130	80440	45175	35265	1.78
5	*Beauveria bassiana* @ 4 g/l	22.83	5.71	79905	1142	81047	45350	35697	1.78
6	*Beauveria bassiana* @ 6 g/l	23.60	5.81	82600	1162	83762	45525	38237	1.83
7	*Metarrhizium anisopliae* @ 2 g/l	23.43	5.83	82005	1166	83171	45175	37996	1.84
8	*Metarrhizium anisopliae* @ 4 g/l	24.33	5.87	85155	1174	86329	45350	40979	1.90
9	*Metarrhizium anisopliae* @ 6 g/l	24.50	5.90	85750	1180	86930	45525	41405	1.91
10	Buprofezin 25SC @ 1.0 ml/l	28.70	6.03	100450	1206	101656	45750	55906	2.22
11	Spinosad 45SC @ 0.2 ml/l	31.29	6.50	109515	1300	110815	46400	64415	2.38
12	Control	21.26	5.56	74410	1112	75522	45000	30522	1.67
	SEm	**1.21**	**0.24**	-	-	-	-	-	-
	CDat 5%	**3.56**	**NS**	-	-	-	-	-	-

NS-Non significant

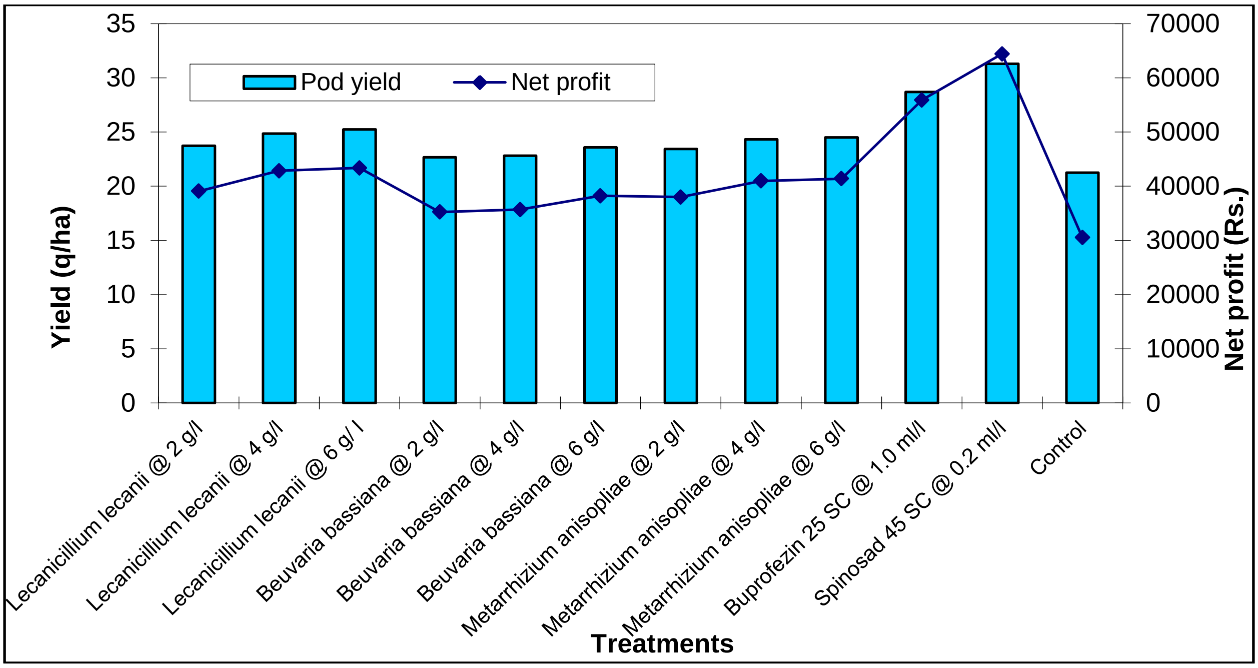

Figure 1: Economics of different biopesticides and biorationals for the effective management of thrips and leafminer in groundnut

The groundnut pod and haulm yield per treatment plot was recorded and computed on hectare basis. The cost economics was calculated based on the input cost and prevailing rate of groundnut pod and haulm at harvest. Pod yield was ranged from 21.26 to 31.29 q/ha across the treatments. Significantly highest pod yield of 31.29 q/ha was recorded in spinosad treatment and it was at par with buprofezin (28.70 q/ha), significantly superior over all the other treatments. This was followed by *L. lecanii* @ 6 g/ l (25.23 q/ha), *L. leccanii* @ 4 g/l (24.86 q/ha), *M. anisopliae* @ 6 g/l (24.50 q/ha), *M. anisopliae* @ 4 g/l (24.33 q/ha), *L. lecanii* @ 2 g/l (23.75q/ha), *B. bassiana* @ 6 g/l (23.60 q/ha), *M. anisopliae* @ 2 g/l (23.43 q/ha), *B. bassiana* @ 4 g/l (22.83 q/ha), and *B. bassiana* @ 2 g/l (22.66 q/ha)which were on par with each other. Whereas lowest pod yield of 21.26 q/ha was recorded in untreated check (Table 3). Similarly numerically highest haulm yield was recorded by spinosad (6.50 t/ha) which was followed by buprofezin (6.03 t/ha), *L. lecanii* @ 6 g/l (5.97 t/ha), *L. lecanii* @ 4 g/l (5.93 t/ha), *M. anisopliae* @ 6 g/l (5.90 t/ha), *M. anisopliae* @ 4 g/l (5.87 t/ha), *M. anisopliae* @ 2 g/l (5.83 t/ha), *B. bassiana* @ 6 g/l (5.81 t/ha), *L. lecanii* @ 2 g/l (5.77 t/ha), *B. bassiana* @ 4 g/l (5.7 t/ha), and *B. bassiana* @ 2 g/l (5.65 t/ha). Considering the cost benefit ratio (CBR) spinosad registered the highest gross return of Rs. 110815 per hectare and CB ratio of 2.38 (Table 3). This was followed by buprofezin which recorded Rs. 101656 per hectare ha of gross returns with CB ratio of 2.22. *L. lecanii* @ 6 g/l (1.95), *L. lecanii* @ 4 g/l (1.94), *M. anisopliae* @ 4 g/l (1.90) *M. anisopliae* @ 6 g/l (1.91), *L. lecanii* @ 2 g/l (1.86), *M. anisopliae* @ 2 g/l (1.84) and *B. bassiana* @ 6 g/l (1.83) while *B. bassiana* @ 2 g/l and *B. bassiana* @ 4 g/l recorded lower CB ratio of 1.78 and untreated check recorded lowest CB ratio of 1.67 (Table 3).

Among the different treatments, spinosad stood superior to all the other treatments in the trial by recording higher pod and haulm yield, net profit and B:C ratio. Among the microbial pesticides used *L. lecanii* @ 6 g/l registered at par yield with buprofezin by exerting equally effective control of thrips. Further, the same treatment has recorded appreciable pod and haulm yield, net profit and B:C ratio (Figure 1). Praveen [14] reported higher net return and CB ratio for spinosad and buprofezin against the leafminer in groundnut. These findings are in line with present findings. However, there was no earlier reported findings on the cost economics of *L. lecanii* against thrips or any other insect pest.

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