Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(3): 288-292

Received: 11-03-2017
Accepted: 12-04-2017

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Evaluation of biorational pesticides against Leaf hopper, *Empoasca kerri* in groundnut ecosystem at different spraying intervals

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Abstract
The present study was undertaken with application of bio-rational like Agniasthra, Brahmasatra, Punchapatta, plant extracts, bio-pesticides, botanicals and indigenous technologies to overcome population of leafhopper, *Empoasca kerri* in groundnut ecosystem at Main Agricultural Research Station, University of Agricultural Sciences, Raichur during 2010-11 by using RBD design. Leaf hoppers population per two sweeps of hand ranged from 1.87 to 10.00 in Profenophos 50 EC and untreated control respectively. The standard chemical check profenophos 50 EC was found to be most effective and superior over all the treatments evaluated. Among different biorationals evaluated, the Neem Seed Kernal Extract (NSKE) at 5 per cent was found to be more effective in reducing the leaf hoppers population by recording less numbers of leaf hoppers (4.67/two sweep net) during 7th day after spraying.

Keywords: Biorationals, leafhopper, organics, biopesticides

1. Introduction
In India, groundnut is the principal oilseed crop and is grown in 11 states on an area of 5.98 million hectare with a production of 4.98 million tonnes of pod per annum and with an average productivity of 860 kg per ha [1]. The principal groundnut growing states of the country include Gujarat, Andhra Pradesh, Tamil Nadu, Karnataka and Maharashtra accounting more than 80 per cent of the total acreage and production. In Karnataka, it is grown on an area of 0.86 million hectare with a production of 0.60 million tonnes [2].
Despite its high production potential (4000 kg ha^{-1}), the actual yields on farmers field are quite low (1000 kg ha^{-1}), largely because of insect pests and diseases. More than 350 species of insects damage this crop in different parts of the world [3]of which the major insect pests are sucking pests like leafhoppers are serious threat to the crop especially in recent years which cause loss in pod yield up to 40.5 per cent and haulm yield up to 20.16 per cent [4]. Regular and indiscriminate use of broad spectrum insecticides has caused turbulence in the environment consequently it has led to many undesirable problems like buildup of insecticides resistance in insects, upset in balance of life in nature due to weakening of biotic pressure, pest resurgence, secondary pest out break etc., besides pollution problems. The unilateral approach of controlling these pests by synthetic insecticides has necessitated developing cost effective, eco-friendly and safe pest control strategies without using any chemical toxicants which suits well in the organic farming. In this direction, scientific evaluation of bio-pesticides, botanicals and bio-rational including indigenous technologies are considered as very much essential to combat insect pests which are noxious to groundnut. With these issues the present study was undertaken with application of bio-rational, bio-pesticides, botanicals and indigenous technologies to overcome population of leafhopper in groundnut ecosystem.

2. Materials and Methods
2.1 Procedure for preparation of different organic pesticides
2.2 Agniasthra
Neem leaves 10 kg, Tobacco leaf powder 3 kg, Garlic 3 kg; Green chilli (crushed) 4 kg all these ingredients were soaked in 20 liters of cow urine for 10 days. The contents were agitated thrice a day for 10 days, and the mixture was filtered and the supernatant was used for spraying. After 30 days, the mixture was filtered with muslin cloth and the resultant supernatant was used for spray.

2.3 *Vitex negundo* (5%)
Fresh leaves of *V. negundo* were collected and brought to the laboratory, washed thoroughly 3-4 times with tap water and chopped into small pieces with a knife. 50 g of the chopped leaves were soaked overnight in enough water, squeezed through muslin cloth and residue was smashed in mortar and pestle, again extracted and filtered through muslin cloth and volume was made up to one litre and used for spraying.

2.4 Sweet flag rhizome extracts (2%):
Sweet flag rhizome was procured from market and was made in to bits and then grinds in to fine powder with the help of grinder. This fine powder and water were mixed in equal volume (1:1) in required quantity. Then the mixture was kept overnight to soak to obtain the extract. In the morning, soaked material was squeezed by using muslin cloth and obtained extract was considered as pure concentrated extract. To obtain 2 per cent concentration of sweet flag extract, 2 ml of pure extract was mixed with 98 per cent of water and 0.5 g soap was added to get 2 per cent sweet flag extract.

2.5 Panchapatta (5%)
V. negundo, Nilgiri, besharmi, Neem and custard apple leaves were crushed and kept in plastic barrel and water was put at three inch above all these ingredients in the barrel. The mixture was stirred twice a day and same procedure was continued for 30 days and after 30 days the material was filtered through muslin cloth and stored in well aerated place and used for spraying by adding 4 gm of jaggery and 1 g of Asafoetida powder before 3 hours of application.

2.6 Garlic Chilli Kerosene Extract (GCKE)
Fifty grams each of dried garlic and green chilli were crushed using mortar and pestle separately and soaked in 25 ml of kerosene and kept overnight. Next day contents were mixed and the volume was made up to 100 ml to get 50 per cent GCKE, later 10 ml solution was added in a litre of water to get 5 per cent concentration.

2.7 Neem Seed Kernel Extract (NSKE 5%)
Fifty grams of powdered seeds of neem was soaked overnight in one
litre of water, squeezed through muslin cloth and the extract collected was used for spraying.

2.8 Statistical analysis
The observation on leaf hoppers population (Two sweeps /plot) was recorded at 3,7,10 and 15 days after spraying from each plot and the collected data was subjected to the Statistically Analysis by using software Statistic 8.1.ANOVA (Statistic, version 8.1 Tallahassee, USA).Significantly different means (P Tallahassee, USA). Significantly different means ($P<0.05$) were separated using Duncan Multiple Range Test (DMRT) at5% probability

3. Result and Discussion
3.1 Leaf hoppers population during 1st spray
A day before spray leafhoppers population ranged from 10. 00 to 12.67 per two sweep and was statistically non-significant indicating their uniform distribution in experimental plots. On third day after first spray profenophos treatment recorded a minimum leafhopper population (4.00/ two sweep) and proved to be the most effective in reducing the leafhoppers and differed significantly from rest of the treatments. Among biorationals, NSKE emerged as the effective organic to suppress the leafhoppers followed by commercial neem, Brahmasthra, Agniasthra, *V. negundo* and panchapatta which recorded 7.33, 7.67, 8.00, 8.00 and 8.33 leaf hoppers per two sweep. The other biorationals recorded higher leafhopper population and were found to be at par with the untreated check which recorded 12.67 leaf hoppers per two sweep net count.

During 7th day after spraying again profenophos was found statistically superior over all other treatments by recording significantly very low leaf hoppers population (3.00 leafhoppers/ two sweep) followed by NSKE and commercial neem which recorded 4.67 and 5.00 leaf hoppers per two sweep and were at par with treatments namely Agniasthra, Brahmasthra, *V. negundo* and panchapatta. Among the biorationals GCKE, both Bts, entomopathogenic fungi and sweet flag recorded higher leafhopper population and were found to be at par with untreated control (11.00 / two sweep).

The leafhoppers population on 10th day after spraying ranged from 1.87 (profenophos) to 10.00 (untred control) per two sweep net count. Among the biorationals NSKE, commercial neem, V.negundo, respectively recorded 3.67, 4.00, and 4.00, leafhoppers per sweep net and proved to be effective in reducing the leaf hoppers population. Other biorationals were moderately effective except Bt products which were similar to untreated control in recording the leaf hoppers. After 15 days of spraying the treatment with profenophos recorded the least leaf hoppers 1.67 /two sweeps net and was statistically superior to all the biorationals. While NSKE and commercial neem and V.negundo were promising among biorationals and recorded 4.67,5.00 and 6.33 leafhoppers per two sweep net count, while other biorationals were moderately effective except Bts, entomopathogenic fungi, GCKE and sweet flag which were at par with untreated control in reducing the leaf hoppers population (Table 1).

3.2 Leaf hoppers population during 2nd spray
The leaf hoppers population was very least (1.33 /two sweep) in profenophos treated plot during third day after spraying and the treatment was found to be statistically superior over all other treatments. Among biorationals NSKE was proved to be more effective by recording less leaf hoppers (3.33 / two sweep net) and was found to be at par with remaining other biorationals except *M. anisopliae*, commercial Bt, sweet flag, GCKE and N. releyi which recorded significantly higher population (5.00, 5.33, 5.67, 6.33 and 6.67 leaf hoppers/ two sweep net count respectively) and were proved to be least effective in bringing down the leaf hoppers. However, the untreated control recorded significantly the highest population among all treatments (9.00 /two sweep net).

On seventh day after spraying again the standard check profenophos excelled over rest of the treatments and was found statistically superior by recording very negligible leaf hoppers population (0.67 /two sweep). The next best biorationals was NSKE (2.00/ two sweep) which was statistically at par with commercial neem, V.negundo, Agniasthra and Brahmasthra respectively recorded 2.43, 2.67, 3.33 and 3.67 leaf hoppers per two sweeps which proved to be effective in minimizing the leaf hoppers, whereas remaining other treatments were found at par with untreated check (5.67 /two sweep) and were proved to be least effective. On 10th day after spraying among different biorationals evaluated NSKE, commercial neem and V.negundo were proved to be most effective by recording significantly lower population (1.67, 1.67 and 3.00 leaf hoppers/ two sweeps respectively). However, remaining biorationals were moderate in their

efficacy, while, GCKE, *M. anisopliae*, sweet flag and commercial Bt were least effective by recording 4.00, 4.33, 4.53 and 5.00 leaf hoppers per two sweep respectively and found at par with untreated control (6.00 leafhoppers/two sweep). On 15 days after spraying there was no leaf hopper incidence in profenophos indicating its statistical superiority over all other treatments and was followed by NSKE and commercial neem (1.33 /two sweep) which were found at par with *V. negundo*, Agniasthra and panchapatta and proved to be more effective. Whereas other biorationals viz. Brahmasthra, *M. anisopliae* and DOR Bt were moderate in effectiveness except commercial Bt, sweet flag and N. releyi which were found statistically at par with untreated check and were proved to be less effective (Table 2).

3.3 Leaf hoppers population during 3rd spray

During third day after spraying very negligible leafhoppers population (0.67/ two sweep) was noticed in profenophos treated plot indicating its statistical superiority over rest of the treatments. Among different biorationals evaluated, the NSKE proved to be most effective by recording lower leaf hopper population (2.33/ two sweep) and was found at par with commercial neem, *V. negundo*, panchapatta and agniasthra which recorded significantly lower population, 2.67, 2.67, 4.00 and 4.33 leafhoppers /two sweep respectively. However, remaining other biorationals were found statistically at par with untreated control (7.33 /two sweep net) were proved to be ineffective in reducing the leaf hopper population. On 7th day after spray there was no leafhopper population in profenophos treatment. Among biorationals commercial neem was found to be best treatment by recording least population (1.33 /two sweep) and was found at par with NSKE and V.negundo. However, the agniasthra, panchapatta and Brahmasthra were found to be moderately effective, whereas remaining other treatments though recorded significantly higher population and were found to be superior over untreated control. Similar trend in efficacy of biorationals was observed after 10 day of spraying (Table 3). Fifteen days after spraying profenophos maintained its superiority in controlling the leaf hoppers. Among the biorationals, commercial neem, NSKE, V.negundo, Agniasthra and panchapatta were found to be statistically at par with each other and were effective in controlling the leaf hoppers. While other biorationals though recorded higher population but were statistically superior to untreated control which recorded 6.67 leaf hoppers/ two sweeps (Table 3).

The leaf hoppers population ranged from 1.87 (profenophos 50 EC) to 10.00 (untreated) (Table of 1st spray) leaf hoppers per two sweeps of hand and the standard chemical check profenophos 50 EC was found to be most effective and superior over all the treatments evaluated. Among different biorationals evaluated, the NSKE at 5 per cent was found to be more effective in reducing the leaf hoppers population by recording less numbers of leaf hoppers (4.67/two sweep net) (Table 12) during 7th day after spraying.

The effectiveness of NSKE (5%) during present study is in line with report of [7] who has reported significant reduction of leaf hoppers with NSKE (5%). The effectiveness of NSKE (5%) of the present investigation is also supported by different authors, [5, 6, 7]. The commercial neem oil was the next best bio-rational in bringing down the leaf hoppers population (5.00 leaf hoppers/two sweep net) (Table 1) during 7th day after spraying and was proved to be effective in controlling the leaf hoppers. Further, the findings of [6] also are in agreement with the result of present investigation wherein neem oil at 3 per cent was most effective while commercial neem formulation (Rakshak) at 3125 ml per hectare was less effective which may be due to change in formulation. Other biorationals like Agniasthra, Brahmasthra, *V. negundo* and panchapatta were proved to be moderate in their effectiveness against leaf hoppers during present investigation. The above biorationals are new in the present study and no literature is available to further discuss on this aspect. However, the biorationals namely, both Bt products,both entomopathogenic fungi, GCKE and sweet flag were found to be less effective during present study in controlling the leaf hoppers recorded leaf hoppers ranging from 5 to 7 per two sweeps of a net and were found to be better than the untreated (9.00 leaf hoppers/two sweeps).(Table 2). However, [8] reported the oil based formulation of M. anisopliae as effective and recorded less leaf hopper population which is in agreement with present investigation.

3.4 Yield and cost economics

The highest pod and haulm yield were recorded in profenophos 50 EC treated plot (1783 and 4495 kg/ha respectively) and was found to be significantly superior over all other biorationals. Among biorationals, commercial neem, NSKE and Agniasthra were found to be effective in bringing down the pest population and resulting in higher pod and haulm yields (1532, 1523 and 1474; 3933, 3903 and 3655 kg/ha respectively). The effectiveness of Agniasthra and NSKE of present study is in line with [9] reported that NSKE 5per cent and Agniasthra were found effective by recording higher seed yield of soybean (22.27 and 21.02 q/ha respectively). Whereas lowest pod and haulm yield was recorded in N. rileyi, GCKE and sweet flag and were proved to be least effective in controlling the insect pests on groundnut but were proved to be superior over untreated control which recorded 1908 and 3023 kg pod and haulm yield per hectare respectively. The treatment profenophos 50 EC recorded the highest gross return (Rs.75815/ha), net return (Rs.74085/ha) and incremental benefit of Rs.25742/ha indicating the highest monitory benefit per hectare. Among biorationals, commercial neem recorded maximum gross return of Rs.65213 /ha followed by NSKE (Rs.64823/ha). However, net return was maximum with NSKE (Rs.64289/ha) as compared to commercial neem owing to higher plant protection cost of the latter. Therefore the incremental benefit was also higher in NSKE (Rs.15946/ha). Since these biorationals are new to the present study there is no available information to discuss on the present findings.

Table1: Efficacy of different organics against leaf hoppers in groundnut ecosystem during 1st spray (30 day after sowing)

Treatments		Pre count	Number of leaf hoppers per two sweep			
			3 DAS	7 DAS	10 DAS	15 DAS
T_1	Commercial Bt (Lipel) @ 1 g	10.33	9.67 (3.25)^{bcde}	8.67 (3.09)^{cd}	7.67 (2.92)^{de}	10.33 (3.36)^{ghi}
T_2	DOR Bt @ 1 g	11.33	9.33 (3.21)^{bcde}	8.67 (3.10)^{cd}	7.40 (2.90)^{de}	10.00 (3.31)^{fghi}
T_3	Agniasthra @ 3%	11.67	8.00 (2.99)^{bcd}	6.00 (2.63)^{bc}	4.67 (2.38)^{bc}	6.67 (2.76)^{cd}
T_4	Brahmasthra @ 5%	10.00	7.67 (2.93)^{bcd}	6.00 (2.63)^{bc}	5.67 (2.58)^{bcd}	7.00 (2.82)^{de}
T_5	NSKE @ 5%	10.70	7.00 (2.81)^{b}	4.67 (2.37)^{b}	3.67 (2.16)^{b}	4.67 (2.38)^{b}
T_6	GCKE @ 5%	12.67	10.00 (3.30)^{bcde}	9.00 (3.15)^{cd}	6.33 (2.70)^{cd}	8.67 (3.11)^{efgh}
T_7	*V.negundo* @ 5%	10.70	8.00 (3.00)^{bcd}	6.67 (2.75)^{bc}	4.00 (2.23)^{b}	6.33 (2.70)^{bcd}
T_8	Panchapatta @ 5%	12.67	8.33 (3.05)^{bcd}	7.00 (2.82)^{bc}	4.67 (2.37)^{bc}	7.00 (2.82)^{de}
T_9	Sweet flag @ 2%	10.20	10.33 (3.35)^{cde}	8.00 (2.99)^{cd}	6.33 (2.70)^{cd}	8.33 (3.05)^{efg}
T_{10}	Commercial neem oil @ 3 ml	10.67	7.33 (2.89)^{bc}	5.00 (2.44)^{b}	4.00 (2.23)^{b}	5.00 (2.44)^{bc}
T_{11}	*M.anisipoliae* @ 1 X 10^8 cfu	10.33	11.00 (3.45)^{de}	8.33 (3.05)^{cd}	6.67 (2.75)^{cd}	7.67 (2.94)^{def}
T_{12}	*N. rileyi* @ 1 X 10^8 cfu	12.00	10.67 (3.40)^{cde}	8.30 (3.00)^{cd}	7.00 (2.82)^{d}	10.67 (3.41)^{hi}
T_{13}	Profenophos 50 EC	11.00	4.00 (2.24)^{a}	3.00 (1.99)^{a}	1.87 (1.69)^{a}	1.67 (1.63)^{a}
T_{14}	Untreated control	10.67	12.67 (3.69)^{e}	11.00 (3.45)^{d}	10.00 (3.31)^{e}	12.33 (3.65)^{i}
	S.EM±	0.26	0.18	0.18	0.14	0.12
	C.D (P=0.05)	NS	0.52	0.52	0.42	0.34

DAS – Days after spraying.
* Figures in the parentheses are √x+1 transformed values. # Similar letters in the columns do not differ significantly by the DMRT (0.05)

Table 2: Efficacy of different organics against leaf hoppers in groundnut ecosystem during 2nd spray (45 day after sowing)

Treatments		Number of leaf hoppers per two sweeps			
		3 DAS	7 DAS	10 DAS	15 DAS
T_1	Commercial Bt (Lipel) @ 1 g	5.33 (2.50)^{cdef}	4.33 (2.31)^{def}	5.00 (2.43)^{de}	4.33 (2.30)^{def}
T_2	DOR Bt @ 1 g	4.67 (2.37)^{bcde}	4.33 (2.29)^{cdef}	3.67 (2.16)^{cd}	3.00 (1.99)^{cd}
T_3	Agniasthra @ 3%	4.33 (2.31)^{bcd}	3.33 (2.08)^{bcd}	3.00 (1.99)^{bc}	2.43 (186)^{bc}
T_4	Brahmasthra @ 5%	4.67 (2.38)^{bcde}	3.67 (2.15)^{bcdef}	3.33 (2.08)^{cd}	2.67 (1.91)^{c}
T_5	NSKE @ 5%	3.33 (2.08)^{b}	2.00 (1.73)^{b}	1.67 (1.63)^{b}	1.33 (1.52)^{b}
T_6	GCKE @ 5%	6.33 (2.70)^{ef}	4.67 (2.37)^{ef}	4.00 (2.23)^{cde}	3.33 (2.08)^{cde}
T_7	*V.negundo* @ 5%	3.67 (2.15)^{bc}	2.67 (1.91)^{bcd}	3.00 (2.00)^{bc}	2.33 (1.82)^{bc}
T_8	Panchapatta @ 5%	4.33 (2.29)^{bcd}	3.78 (2.26)^{cdef}	3.33 (2.07)^{cd}	2.43 (186)^{bc}
T_9	Sweet flag @ 2%	5.67 (2.58)^{def}	5.00 (2.43)^{ef}	4.53 (2.39)^{cde}	4.33 (2.30)^{def}
T_{10}	Commercial neem oil @ 3 ml	3.67 (2.15)^{bc}	2.43 (1.86)^{bc}	1.67 (1.63)^{b}	1.33 (1.52)^{b}
T_{11}	*M.anisipoliae* @ 1 X 10^8 cfu	5.00 (2.44)^{bcdef}	3.87 (2.26)^{cdef}	4.33 (2.29)^{cde}	2.67 (1.91)^{c}
T_{12}	*N. rileyi* @ 1 X 10^8 cfu	6.67 (2.76)^{f}	5.00 (2.44)^{ef}	3.67 (2.15)^{cd}	4.56 (2.38)^{ef}
T_{13}	Profenophos 50 EC	1.33 (1.52)^{a}	0.67 (1.28)^{a}	0.33 (1.14)^{a}	0.00 (1.00)^{a}
T_{14}	Untreated control	9.00 (3.16)^{g}	5.67 (2.57)^{f}	6.00 (2.63)^{e}	5.33 (2.50)^{f}
	S.Em±	0.13	0.15	0.15	0.13
	C.D (P=0.05)	0.37	0.44	0.42	0.38

DAS – Days after spraying.
* Figures in the parentheses are √x+1 transformed values. # Similar letters in the columns do not differ significantly by the DMRT (0.05)

Table 3: Efficacy of different organics against leaf hoppers in groundnut ecosystem during 3rd spray (60 day after sowing)

Treatments		Number of leaf hoppers per two sweeps			
		3 DAS	7 DAS	10 DAS	15 DAS
T_1	Commercial Bt (Lipel) @ 1 g	6.00 (2.64)^{def}	5.33 (2.51)^{fg}	4.33 (2.31)^{cdef}	3.33 (2.08)^{e}
T_2	DOR Bt @ 1 g	5.33 (2.49)^{def}	4.67 (2.37)^{efg}	4.00 (2.23)^{cdef}	2.33 (1.80)^{bcde}
T_3	Agniasthra @ 3%	4.33 (2.31)^{cde}	3.00 (2.00)^{cd}	2.33 (1.82)^{bc}	1.67 (1.63)^{bcd}
T_4	Brahmasthra @ 5%	5.33 (2.50)^{def}	4.00 (2.23)^{def}	3.33 (2.06)^{cde}	2.00 (1.72)^{bcde}
T_5	NSKE @ 5%	2.33 (1.82)^{b}	2.00 (1.73)^{bc}	1.67 (1.63)^{b}	1.47 (1.57)^{bc}
T_6	GCKE @ 5%	6.33 (2.70)^{ef}	5.33 (2.50)^{efg}	5.33 (2.51)^{f}	3.67 (2.15)^{e}
T_7	*V. negundo* @ 5%	2.67 (1.91)^{bc}	2.00 (1.72)^{bc}	1.67 (1.63)^{b}	1.47 (1.57)^{bc}
T_8	Panchapatta @ 5%	4.00 (2.23)^{bcd}	3.67 (2.16)^{de}	2.67 (1.91)^{bcd}	1.67 (1.63)^{bcd}
T_9	Sweet flag @ 2%	5.33 (2.50)^{def}	5.67 (2.57)^{fg}	5.33 (2.51)^{f}	3.33 (2.08)^{e}
T_{10}	Commercial neem oil @ 3 ml	2.67 (1.91)^{bc}	1.33 (1.52)^{b}	1.33 (1.52)^{b}	1.33 (1.52)^{b}
T_{11}	*M. anisopliae* @ 1 X 10^8 cfu	5.33 (2.50)^{def}	5.67 (2.58)^{fg}	4.33 (2.29)^{def}	3.33 (2.07)^{de}
T_{12}	N. rileyi @ 1 X 10^8 cfu	6.63 (2.78)^{f}	6.33 (2.70)^{g}	5.00 (2.44)^{ef}	3.00 (1.99)^{cde}
T_{13}	Profenophos 50 EC	0.67 (1.28)^{a}	0.00 (1.00)^{a}	0.00 (1.00)^{a}	0.00 (1.00)^{a}
T_{14}	Untreated control	7.33 (2.88)^{f}	8.67 (3.11)^{h}	9.00 (3.16)^{g}	6.67 (2.77)^{f}
	S.Em±	0.15	0.12	0.14	0.15
	C.D (P=0.05)	0.43	0.35	0.41	0.44

DAS – Days after spraying.
* Figures in the parentheses are √x+1 transformed values. # Similar letters in the columns do not differ significantly by the DMRT (0.05).

4. Conclusion

The preliminary field study revealed that the leaf hoppers population was very least (1.33 /two sweep) in profenophos treated plot during third day after spraying and the treatment was found to be statistically superior over all other treatments. Among biorationals, NSKE emerged as the effective organic to suppress the leafhoppers followed by commercial neem, Brahmasthra, Agniasthra, *V. negundo* and panchapatta which recorded 7.33, 7.67, 8.00, 8.00 and 8.33 leaf hoppers per two sweep. The other biorationals recorded higher leafhopper population and were found to be at par with the untreated check which recorded 12.67 leaf hoppers per two sweep net count. Other biorationals like Agniasthra, Brahmasthra, *V. negundo* and panchapatta were proved to be moderate in their effectiveness against leaf hoppers during present investigation.

5. Acknowledgement

Author is very much grateful to Dr. Abdhul H Khadar, Phd, scholar Department of Entomology, Main Agricultural Research Station, Raichur, for their kind help, valuable suggestions, profound source of inspiration and constant ambitious encouragement.

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