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Kanimozhi E
PG Scholar, Department of Plant Protection, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

C Gailce Leo Justin
Professor and Head, Department of Plant Protection, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

S Sheeba Joyce Roseleen
Assistant Professor, Department of Plant Protection, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

T Ramesh
Assistant Professor, Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

Corresponding Author:
Kanimozhi E
PG Scholar, Department of Plant Protection, Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India

Evaluation of insecticides and biorationals for the management of Leafhopper, *Amrasca biguttula biguttula* (Ishida) (Hemiptera: Cicadellidae) in Okra

Kanimozhi E, C Gailce Leo Justin, S Sheeba Joyce Roseleen and T Ramesh

Abstract
Field trials were conducted at Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli District, Tamil Nadu, India to evaluate insecticides and biorationals for the management of leafhopper, *Amrasca biguttula biguttula* (Ishida) in okra during *Kharif*, 2019 and *Rabi*, 2019. The results revealed that the highest reduction of leafhopper population in *Kharif*, 2019 and *Rabi*, 2019 was recorded in dinotefuran 20 SG @ 0.30g/l (91.34 and 90.57%) followed by buprofezin 25 SC @ 2ml/l (88.36 and 87.02%). Among the biorationals, ginger + garlic + green chilli extract 5 per cent was effective with 77.91 and 76.31 per cent reduction over untreated control, respectively in *Kharif*, 2019 and *Rabi*, 2019 followed by NSKE 5 per cent and *Lecanicillium lecani* @ 10ml/l. Based on the moderate to high efficacy levels and low toxicity to environment and human beings, Dinotefuran 20 SG @ 0.30g/l, Buprofezin 25 SC @ 2ml/l and Ginger + Garlic + Green Chilli extract 5 per cent would be used as a potent component in IPM module for okra leafhopper, *A. biguttula biguttula* with limited use of insecticides.

Keywords: Okra, leafhopper, *A. biguttula biguttula*, insecticides, biorationals

Introduction
Okra, *Abelmoschus esculentus* L. the "Queen of vegetables" is one of the important vegetable crop under the family Malvaceae grown for its green tender fruits. It is rich in calcium, ascorbic acid and iodine which help to control goiter as well as rich in protein and minerals and is cultivated in tropical, subtropical and warm temperate regions around the globe (Singh *et al*., 2014) [12]. India ranks second in terms of vegetable production in the world with the production of about 162897 thousand MT while it occupies the first position in okra production which is about 67 per cent of the total world's production. In India okra occupies an area of 530.8 thousand ha with the production and productivity of 6350.3 thousand MT and 12 MT/ha, respectively (Bhatt and Karnatak, 2018) [3]. It is frequently attacked by several insect pests right from germination to till harvest. Among them, the sucking pest leafhopper, *Amrasca biguttula biguttula* (Ishida) is serious pest as heavy infestation of the pest leads to both nymphs and adults desap the plant tissues which results in curling and crinkling of leaves, stunted growth, hopper burn symptom and ultimate death of plants (David and Ramamurthy, 2016) [4]. Krishnaiah (1980) [9] reported about 40 to 56 per cent losses in yield of okra due to leafhopper infestation. In vegetable crops like okra, there is always small time lag between pesticide application and harvesting, farmers are unaware about use of pesticides at fruiting stage and non adoption of safe waiting period leads to accumulation of pesticide residues. The residues of non-approved pesticides were detected in 1180 vegetable sample and okra was found to have higher level of pesticide residue above Maximum Residual Limit (MRL) among those vegetables as reported by Monitoring of Pesticide Residues at National Level (MPRNL), (Anon., 2015) [1]. Considering the limitations of using insecticides alone and pesticide residue accumulation, the present study was conducted to find out the efficacy of new insecticides and biorationals to reduce the hazardous effects of the insecticides in the management of leafhopper and emphasizing the importance of biorationals as a component of IPM were carried out.

Materials and Methods

Field trials were conducted at the experimental farm of Anbil Dharmalingam Agricultural College and Research Institute, Tiruchirappalli, Tamil Nadu, India to evaluate insecticides and biorationals against okra leafhopper, *A. biguttula biguttula* during *Kharif*, 2019 and *Rabi*, 2019. The experiment was laid out in a Randomized Complete Block Design with ten treatments replicated thrice in both the seasons. Okra seed of Shakti hybrid was used for the study sown at a spacing 45×30 cm. The standard agronomic practices recommended by Tamil Nadu Agricultural University were adopted except the plant protection practices. The treatments were imposed when the leafhopper population crossed ETL. The observations on the incidence of the leafhopper were recorded before treatment and on 1, 3, 7 and 14 days. The nymphs and adults of leafhopper were recorded on three leaves one each from top, middle and bottom portion in each of the ten randomly selected plants from each replication.

The reduction of leafhopper population in respective treatments over control was computed by using following formula (Susheelkumar *et al*., 2020) [14],

$$\text{Reduction over control (\%)} = \frac{\text{Pest population in control} - \text{Pest population in treatment}}{\text{Pest population in control}} \times 100$$

Statistical analysis

The data was statistically analyzed after square root transformation using AGRES programme. The treatment mean values were compared by Latin Square Design (LSD).

Results and Discussion

Field efficacy of insecticides and biorationals against *A. biguttula biguttula* in okra

a. *Kharif*, 2019

The pretreatment count ranged from 1.34 to 1.52 leafhopper/ 3 leaves. The Leafhopper population assessed at 1, 3, 7 and 14 DAT indicated significant differences among the treatments and all the treatments were superior to untreated control (Table 1). The minimum 0.74 leafhopper / 3 leaves leafhopper population after imposition of treatment was recorded in dinotefuran 20 SG @ 0.30g/l followed by buprofezin 25 SC @ 2ml/l (1.03 leafhopper / 3 leaves), clothianidin 50 WG @ 0.10g/l (1.19 leafhopper / 3 leaves), imidacloprid 17.8 SL @ 0.20ml/l (1.39 leafhopper / 3 leaves), spinosad 45 SC @ 0.32ml/l (1.64 leafhopper / 3 leaves), ginger + garlic + green chilli extract 5% (1.99 leafhopper / 3 leaves), NSKE 5% (2.22 leafhopper / 3 leaves), *Lecanicillium lecani* @ 10ml/l (2.44 leafhopper / 3 leaves) and *Chrysoperla zastrowi sillemi* @ 100000/ha (2.91 leafhopper / 3 leaves). The maximum yield was recorded in the effective treatment dinotefuran 20 SG (5.12 t/ha) followed by buprofezin 25 SC (4.86 t/ha) in *Kharif*, 2019.

b. *Rabi*, 2019

In *Rabi* (2019), the pretreatment population ranges from 1.29 to 1.42 leafhopper/ 3 leaves. Significant differences among different treatments were noted on 1, 3, 7 and 14 DAT and all the treatments could effectively laid down the population of leafhopper compared to control (Table 2). The leafhopper population was minimum in dinotefuran 20 SG @ 0.30g/l (0.77 leafhopper / 3 leaves) followed by buprofezin 25 SC @ 2ml/l (1.10 leafhopper / 3 leaves), clothianidin 50 WG @ 0.10g/l (1.20 leafhopper / 3 leaves), imidacloprid 17.8 SL @ 0.20ml/l (1.44 leafhopper / 3 leaves), spinosad 45 SC @ 0.32ml/l (1.71 leafhopper / 3 leaves), ginger + garlic + green chilli extract 5% (2.02 leafhopper / 3 leaves), NSKE 5% (2.27 leafhopper / 3 leaves), *L. lecani* @ 10ml/l (2.49 leafhopper / 3 leaves). The leafhopper population was maximum in *C. zastrowi sillemi* @ 100000/ha (2.95 leafhopper / 3 leaves) treatment. The maximum yield was recorded in dinotefuran 20 SG (5.04 t/ha) followed by buprofezin 25 SC (4.79 t/ha) in *Rabi*, 2019.

The results of the present field trials revealed that among the treatments, dinotefuran 20 SG @ 0.30g/l followed by buprofezin 25 SC @ 2ml/l was found to be the most effective treatment with 91.34 and 88.36 per cent reduction of leafhopper population respectively in *Kharif*, 2019 (Fig.1) and 90.57 and 86.43 per cent reduction respectively in *Rabi*, 2019 (Fig.2).

Dinotefuran is a new insecticide belonging to neonicotinoids act as an agonist of nicotinic acetylcholine receptor and labeled as "Reduced – Risk" by the EPA, generally safer to humans and the environment (Anon., 2011 and Mahesh, 2017) [10]. The mechanism of buprofezin (IGR) restricts the synthesis of new cuticle, thereby preventing leafhopper from moulting successfully to next stage and finally leads to mortality. The buprofezin had comparatively slower action against leafhopper while peak mortality was recorded at 3 DAT and that was consistent up to 7 DAT when compared to synthetic insecticides.

Similarly, results were projected by Dipak *et al*., (2013) [5] who reported that most effective for controlling the jassid, *A. biguttula biguttula* population was dinotefuran 20% SG @ 40 g/ha followed by clothianidin 50 WG @ 40 g/ha in cotton. The results are in agreement with Halappa and Patil (2014) [6] *i.e*., dinotefuran 20 SG @ 0.25g/l, fipronil 5 SC @ 1 ml/l, diafenthiuron 50 WP @ 0.75 g/l and buprofezin 25 EC 1ml/l were most effective against leafhopper with 79.57, 76.59, 76.23 and 73.69 per cent reduction compared to untreated check respectively in cotton. Further, Sreenivas *et al*., (2015) [13] also proved that dinotefuran 20% SG @ 30 g a.i./ha performed significantly superior by recording lowest population of jassid, thrips, aphids and whiteflies as compared to imidacloprid 17.8 SL and thiamethoxam 25 WG in cotton. Mahesh (2017) [10] reported that dinotefuran 20% SG @ 30 g a.i. per ha is most effective for the management of leafhopper, *A. biguttula biguttula*, aphids, *A. gossypii*, thrips, *T. tabaci* and whiteflies, *B. tabaci* with higher fruit yield of 93.01 q per ha in okra. The buprofezin had a significant effect on the mortality of *A. biguttula biguttula* with low residue accumulation and good alternative for a selective insect pest control. Similarly, Halder *et al*., (2018) [7] reported that buprofezin 25% SC @ 1.6ml/l was the most effective with 80.16 per cent reduction in controlling *A. biguttula biguttula* in cotton.

The biorationals were less effective when compared to the insecticides as evidenced by increased leafhopper incidence in terms of more leafhopper population. Among the biorationals, ginger + garlic + green chilli extract 5% was effective with 77.91 and 76.31 per cent reduction over untreated control respectively in *Kharif*, 2019 and *Rabi*, 2019 followed by NSKE 5% and *L. lecani* @ 10ml/l in okra ecosystem. Similarly, the effectiveness of ginger + garlic + green chilli extract 5% against *A. biguttula biguttula* as revealed in the present study was in close agreement with Anon., (2006) [2]. Kamil and Bina (2018) [8] reported that NSKE with 54.92 per cent reduction in jassid population followed by garlic extract at fruiting stage in brinjal. Manivannan *et al*., (2018)[11] reported that *L. lecani* @ 1× 10^{8} spores/ml showed the highest mortality of 85 per cent against *A. biguttula biguttula* in *in vitro* condition.

Table 1: Field efficacy of insecticides and biorationals against *A. biguttula biguttula* in okra (*Kharif*, 2019)

Treatments	Dose	Leafhopper (no./ 3leaves/ plant)*												Yield (t/ha)
		Pre-treatment observation	First Treatment Application					Second Treatment Application					Pooled mean	
			1 DAT	3 DAT	7 DAT	14 DAT	Mean	1 DAT	3 DAT	7 DAT	14 DAT	Mean		
T_{1}- Dinotefuran 20 SG	0.30 g/l	1.36 (1.36)	0.46 (0.98)^{a}	0.32 (0.90)^{a}	0.98 (1.22)^{a}	1.83 (1.53)^{a}	0.90	0.31 (0.90)^{a}	0.24 (0.86)^{a}	0.43 (0.96)^{a}	1.36 (1.36)^{a}	0.59	0.74	5.12 (2.37)^{a}
T_{2}- Clothianidin 50 WG	0.10 g/l	1.34 (1.36)	0.76 (1.12)^{b}	0.63 (1.06)^{c}	1.38 (1.37)^{c}	2.72 (1.79)^{c}	1.37	0.63 (1.06)^{b}	0.56 (1.03)^{c}	0.82 (1.15)^{c}	1.98 (1.57)^{c}	1.00	1.19	4.65 (2.27)^{c}
T_{3}- Spinosad 45 SC	0.32 ml/l	1.47 (1.40)	0.96 (1.21)^{e}	0.84 (1.16)^{e}	1.83 (1.53)^{e}	3.66 (2.04)^{e}	1.82	1.14 (1.28)^{e}	0.93 (1.19)^{e}	1.26 (1.33)^{e}	2.48 (1.72)^{e}	1.45	1.64	4.24 (2.18)^{e}
T_{4}- Buprofezin 25 SC	2 ml/l	1.39 (1.37)	0.82 (1.15)^{c}	0.51 (1.00)^{b}	1.17 (1.29)^{b}	2.14 (1.64)^{b}	1.16	0.84 (1.16)^{c}	0.42 (0.96)^{b}	0.65 (1.07)^{b}	1.67 (1.47)^{b}	0.90	1.03	4.86 (2.32)^{b}
T_{5}- Imidacloprid 17.8 SL	0.20 ml/l	1.43 (1.38)	0.88 (1.17)^{d}	0.79 (1.14)^{d}	1.65 (1.56)^{d}	2.94 (1.85)^{d}	1.57	0.96 (1.21)^{d}	0.76 (1.12)^{d}	0.97 (1.21)^{d}	2.15 (1.63)^{d}	1.21	1.39	4.47 (2.23)^{d}
T_{6}- Neem Seed Kernel Extract	5%	1.45 (1.40)	1.08 (1.26)^{g}	0.98 (1.21)^{g}	2.49 (1.73)^{g}	4.95 (2.33)^{g}	2.38	1.73 (1.49)^{g}	1.27 (1.33)^{g}	2.08 (1.61)^{g}	3.15 (1.91)^{g}	2.06	2.22	3.78 (2.07)^{g}
T_{7}- Ginger + Garlic + Green Chilli extract	5%	1.37 (1.37)	1.02 (1.23)^{f}	0.90 (1.18)^{f}	2.28 (1.67)^{f}	4.36 (2.20)^{f}	2.14	1.35 (1.36)^{f}	1.13 (1.27)^{f}	1.94 (1.56)^{f}	2.94 (1.85)^{f}	1.84	1.99	4.02 (2.13)^{f}
T_{8}-*Lecanicillium lecani*	10 ml/l	1.48 (1.40)	1.16 (1.29)^{h}	1.02 (1.23)^{h}	2.87 (1.83)^{h}	5.25 (2.40)^{h}	2.58	1.98 (1.57)^{h}	1.54 (1.43)^{h}	2.27 (1.66)^{h}	3.42 (1.98)^{h}	2.30	2.44	3.43 (1.98)^{h}
T_{9}- *Chrysoperla zastrowi sillemi*	100000/ha	1.44 (1.39)	1.27 (1.33)^{i}	1.12 (1.27)^{i}	3.34 (1.96)^{i}	6.45 (2.64)^{i}	3.05	2.37 (1.69)^{i}	1.97 (1.57)^{i}	2.86 (1.83)^{i}	3.86 (2.09)^{i}	2.77	2.91	3.12 (1.90)^{i}
T_{10}- Untreated control	-	1.52 (1.42)	1.48 (1.41)^{j}	4.28 (2.19)^{j}	7.47 (2.82)^{j}	13.36 (3.72)^{j}	6.65	12.37 (3.59)^{j}	14.24 (3.84)^{j}	16.52 (4.12)^{j}	18.24 (4.33)^{j}	15.34	11.00	2.14 (1.63)^{j}
SEd		-	0.01	0.01	0.02	0.02	-	0.01	0.01	0.01	0.02	-	-	0.02
CD (p=0.05)		NS	0.02	0.01	0.04	0.04	-	0.03	0.03	0.02	0.03	-	-	0.04

*Mean of three replications; DAT- Days after Treatment; Figures in parentheses are square root transformed values;
Values in the column followed by common letters are not different statistically, (p=0.05) by LSD; NS – Non significant

Table 2: Field efficacy of insecticides and biorationals against *A. biguttula biguttula* in okra (*Rabi*, 2019)

Treatments	Dose	Leafhopper (no./ 3leaves/ plant)*												Yield (t/ha)
		Pre-treatment observation	First Treatment Application					Second Treatment Application					Pooled mean	
			1 DAT	3 DAT	7 DAT	14 DAT	Mean	1 DAT	3 DAT	7 DAT	14 DAT	Mean		
T_{1}- Dinotefuran 20 SG	0.30 g/l	1.40 (1.38)	0.48 (0.99)^{a}	0.36 (0.93)^{a}	0.99 (1.22)^{a}	1.76 (1.50)^{a}	0.90	0.38 (0.94)^{a}	0.26 (0.87)^{a}	0.47 (0.99)^{a}	1.42 (1.38)^{a}	0.63	0.77	5.04 (2.35)^{a}
T_{2}- Clothianidin 50 WG	0.10 g/l	1.37 (1.37)	0.80 (1.14)^{b}	0.68 (1.09)^{c}	1.36 (1.36)^{c}	2.58 (1.75)^{c}	1.36	0.66 (1.08)^{b}	0.58 (1.04)^{c}	0.92 (1.19)^{c}	2.04 (1.59)^{c}	1.05	1.20	4.53 (2.24)^{c}
T_{3}- Spinosad 45 SC	0.32 ml/l	1.34 (1.35)	1.02 (1.23)^{e}	0.89 (1.17)^{e}	1.88 (1.54)^{e}	3.54 (1.92)^{e}	1.83	1.21 (1.31)^{e}	1.09 (1.26)^{e}	1.46 (1.40)^{e}	2.62 (1.77)^{e}	1.60	1.71	4.00 (2.12)^{e}
T_{4}- Buprofezin 25 SC	2 ml/l	1.36 (1.36)	0.90 (1.18)^{c}	0.56 (1.03)^{b}	1.14 (1.28)^{b}	2.10 (1.61)^{b}	1.18	0.98 (1.22)^{c}	0.46 (0.98)^{b}	0.75 (1.12)^{b}	1.87 (1.54)^{b}	1.02	1.10	4.79 (2.30)^{b}
T_{5}- Imidacloprid 17.8 SL	0.20 ml/l	1.41 (1.38)	0.97 (1.21)^{d}	0.82 (1.15)^{d}	1.59 (1.44)^{d}	2.79 (1.81)^{d}	1.54	1.07 (1.25)^{d}	0.84 (1.16)^{d}	1.08 (1.26)^{d}	2.38 (1.70)^{d}	1.34	1.44	4.25 (2.18)^{d}
T_{6}- Neem Seed Kernel Extract	5%	1.29 (1.34)	1.13 (1.28)^{g}	1.02 (1.23)^{g}	2.51 (1.73)^{g}	4.83 (2.31)^{g}	2.37	1.78 (1.51)^{g}	1.32 (1.35)^{g}	2.14 (1.62)^{g}	3.41 (1.98)^{g}	2.16	2.27	3.46 (1.99)^{g}
T_{7}- Ginger + Garlic + Green Chilli extract	5%	1.33 (1.35)	1.08 (1.26)^{f}	0.95 (1.20)^{f}	2.26 (1.66)^{f}	4.18 (2.16)^{f}	2.12	1.47 (1.40)^{f}	1.18 (1.30)^{f}	1.98 (1.57)^{f}	3.04 (1.88)^{f}	1.92	2.02	3.78 (2.07)^{f}
T_{8}-*Lecanicillium lecani*	10 ml/l	1.30 (1.34)	1.18 (1.30)^{h}	1.09 (1.26)^{h}	2.85 (1.83)^{h}	5.06 (2.36)^{h}	2.55	2.09 (1.61)^{h}	1.65 (1.48)^{h}	2.36 (1.69)^{h}	3.63 (2.03)^{h}	2.43	2.49	3.17 (1.92)^{h}
T_{9}- *Chrysoperla zastrowi sillemi*	100000/ha	1.39 (1.37)	1.28 (1.33)^{i}	1.14 (1.28)^{i}	3.41 (1.98)^{i}	6.07 (2.56)^{i}	2.98	2.75 (1.80)^{i}	2.06 (1.60)^{i}	2.94 (1.85)^{i}	3.92 (2.10)^{i}	2.92	2.95	2.98 (1.87)^{i}
T_{10}- Untreated control	-	1.42 (1.38)	1.40 (1.38)^{j}	3.97 (2.11)^{j}	7.38 (2.81)^{j}	11.95 (3.53)^{j}	6.18	11.68 (3.49)^{j}	13.84 (3.79)^{j}	15.69 (4.02)^{j}	17.35 (4.22)^{j}	14.64	10.41	2.00 (1.58)^{j}
SEd		-	0.01	0.01	0.02	0.02	-	0.01	0.01	0.01	0.02	-	-	0.02
CD (p=0.05)		NS	0.01	0.02	0.04	0.05	-	0.02	0.02	0.03	0.05	-	-	0.04

*Mean of three replications; DAT- Days after Treatment; Figures in parentheses are square root transformed values;
Values in the column followed by common letter(s) are not different statistically, (p=0.05) by LSD; NS – Non significant.

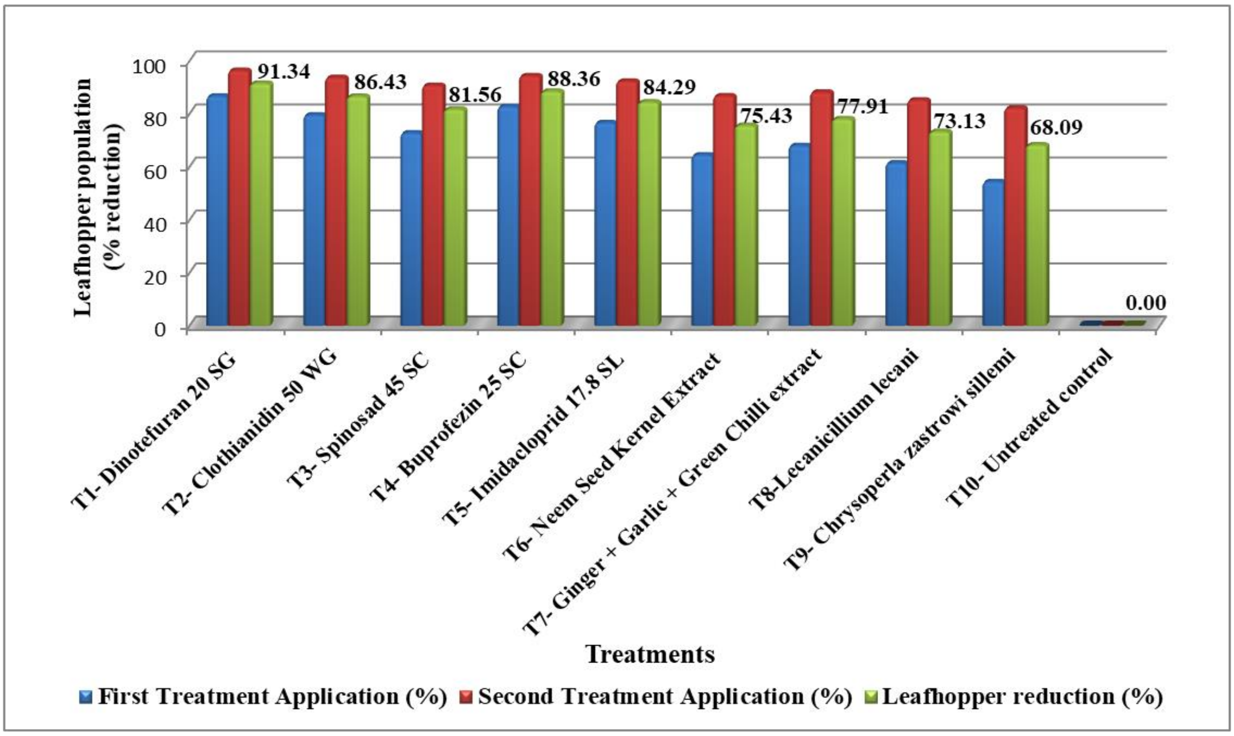

Fig 1: Field efficacy of insecticides and biorationals against *A. biguttula biguttula* in okra (*Kharif*, 2019)

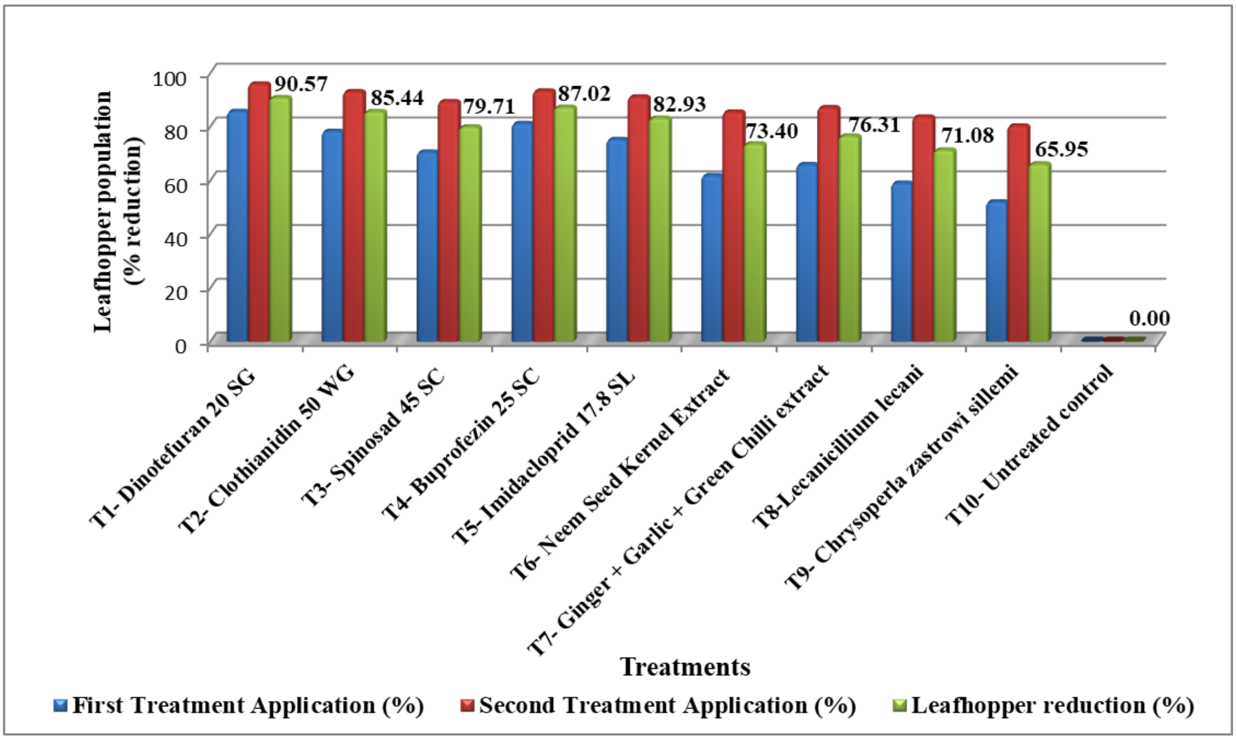

Fig 2: Field efficacy of insecticides and biorationals against *A. biguttula biguttula* in okra (*Rabi*, 2019)

Conclusion

The present study concludes that dinotefuran 20 SG @ 0.30g/l was found to be superior with lowest leafhopper population and maximum yield of okra followed by buprofezin 25 SC @ 2ml/l. Among the biorationals, ginger + garlic + green chilli extract 5% was effective for the management of *A. biguttula biguttula* in okra. Among the effective treatments, dinotefuran 20 SG was a "Reduced risk" labeled insecticide by EPA and buprofezin 25 SC and ginger + garlic + green chilli extract were most suited for use in IPM programme due to their moderate to high efficacy levels, as well as low residue accumulation, effective pest resistance management strategy and safety to natural enemies, human beings and environment. Therefore, dinotefuran 20 SG @ 0.30g/l followed by the buprofezin 25 SC @ 2ml/l and ginger + garlic + green chilli extract 5% would be the potent component in IPM module for okra leafhopper, *A. biguttula biguttula*.

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