**Evaluation of the efficacy of botanicals against leafhopper, *Amrasca biguttula biguttula* (Ishida) infesting okra**

**Abstract**

A field experiment was conducted to determine bio-efficacy of botanicals against, leafhopper, *Amrasca biguttula biguttula* (Ishida) infesting okra at Centre for Vegetable Research, Chimanbhai Patel wCollege of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The result revealed that the treatment of azadirachtin @ 0.006 per cent was found most effective and recorded the lowest leafhopper population (1.81/leaf). However, the next best treatments, tobacco decoction @ 2 per cent (2.26/leaf) and neem seed kernel extract @ 5 per cent (2.49/leaf) were at par with each other.

**Keywords:** Okra, leafhopper, azadirachtin, tobacco decoction, leaf extract and NSKE

**Introduction**

“Okra (*Abelmoschus esculentus* L.) is the only vegetable crop of significance in the Malvaceae family and it is very popular in the tropical areas of including Asia and South America. Its centre of origin is Ethiopia and Sudan, in the North- Eastern African countries” (Eagri, 2023). Okra has many uses and is considered an economically important vegetable crop because its fresh leaves, buds, flowers, pods, stems and seeds all have value. “The composition of okra pods per 100 g edible portion is water 88.6 g, energy 144.00 kJ (36 kcal), protein 2.10 g, carbohydrate 8.20 g, fat 0.20 g, fibre 1.70 g, calcium 84.00 mg, potassium 90.00 mg, iron 1.20 mg, β-carotene 185.00 μg, riboflavin 0.08mg, thiamine 0.04 mg, niacin 0.60 mg and ascorbic acid 47.00 mg.” (Swamy *et al*., 2023). Okra seed oil is also a rich source of linoleic acid, a polyunsaturated fatty acid essential for human consumption (Gemede *et al*. 2014). “The oil content of the seed is quite high at about 40%” (Tripathi *et al*., 2011). “Its mature fruit and stems contain crude fibre, which is used in the paper industry” (Kumar *et al*. 2013). It is also a good source of iodine which is useful in the treatment of simple goiter. The sucking insect pests i.e., aphids, leafhoppers, whiteflies, thrips and mites attacking okra caused 17.46 per cent yield loss and failure to control them at the initial stages which caused 54.04 per cent yield loss (Chaudhary and Daderch, 1989; Anitha and Nandihali, 2008a). The okra crop attacked with eleven insect pest species have been recorded in Gujarat and among these, leafhopper is the destructive pest of okra when it occurs in the early seedling stage (Dabhi and Koshiya, 2014). Among the major insect pests infesting okra are leafhopper, shoot and fruit borer, fruit borer, leaf roller, whitefly, aphid, mealy bug, dusky cotton bug, red cotton bug and blister beetle (Kumar *et al*. 2002). Okra crop was attacked by some new insect pest species *i.e*., beet armyworm (*Spodoptera exigua* Hubner) at the early stage of the crop in middle Gujarat (Pathan *et al.*, 2018). Pathan *et al*. (2016a) recorded coccinellids, *Scymnus* *sp*. predating on red spider mite (*Tetranychus urticae*) infesting okra. Seed beetle, *Spermophagus* sp. recorded in okra under storage conditions (Pathan *et al*., 2016b) that cause significant loss. Okra is the most suitable host for the survival and feeding of the leafhopper. Furthermore, “leafhopper attack caused a reduction of 49.8% and 45.1% in plant height and numbers of leaves, respectively” (Hmdanay *et al.,* 2017). The incidence of leafhopper commenced in the first week of March (10th SMW) and continued up to the removal of crop in the 4th week of May (21st SMW) during summer 2023 (Patel *et al*, 2024a; Patel *et al*, 2024b). When it is concerned from health point of view as well as for the export purpose to the other country, it is also important to reduce the level of residues of insecticide in okra fruits (Pathan *et al*., 2017a and Pathan *et al*., 2017b). Therefore, it is important to develop alternative eco-friendly techniques such as the use of bio pesticides that can prevent other environmental hazards.

**Material and Methods**

The experiment was conducted during the summer of 2023 at the Centre for Vegetable Research, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. Okra variety GAO 5 was raised at a spacing of 45 × 30 cm. All agronomical practices were followed to raise the okra crop. The experiment was laid out in a Randomized Block Design (RBD) with three replications. Seven botanicals, *viz*., azadirachtin 0.006 per cent, tobacco (*Nicotiana tabacum)* decoction 2 per cent, neem seed kernel extract (NSKE) 5 per cent, *Pongamia* oil 1 per cent, nafatiya (*Ipomea* sp.) leaf extract 10 per cent, custard apple (*Annona reticulata*) leaf extract 10 per cent and *Lantana* leaf extract 10 per cent, were evaluated for their efficacy against leafhopper.

The first spray was applied on the appearance of leafhopper and the subsequent two sprays were applied at 10 days interval. Treatment-wise application of botanicals was made by using a high-volume knapsack sprayer, fitted with a hollow cone nozzle, with the required concentration as per treatment details. To record observations on leafhopper population, ten plants were randomly selected from each net plot area. From each selected plant, one leaf each from the top, middle and lower canopy was observed and the number of leafhoppers was counted before spray as well as 3, 7 and 9 days after each spray. Picking wise yield was recorded and converted into kg per ha. The data obtained were analyzed by following standard statistical technique (Steel and Torrie, 1980). Increase in yield over control, avoidable losses, and economics were worked out.

**Results and Discussion**

**First spray**

 The data on periodical observation of leafhopper population are presented in Table 1. Before the first spray, the differences among the treatments for leafhopper population were non-significant, indicating that there was a uniform distribution of leafhopper population.

Data on pooled over period indicated that the treatment of azadirachtin @ 0.006 per cent and tobacco decoction @ 2 per cent to be most effective and recorded the lowest leafhopper population (3.70 and 4.12 /leaf) respectively and it was at par with neem seed kernel extract @ 5 per cent (4.47/leaf) thus, all these treatments were found most effective than the rest of treatment. It was followed by *Pongamia* oil @ 1 per cent (5.31/leaf), Nafatiya leaf extract @ 10 per cent (5.40/leaf) and custard apple leaf extract @ 10 per cent (5.60/leaf), which were next nearly similar in order of their effectiveness. While treatment of leaf extract @ 10 per cent (6.84/leaf) was found least effective in the reduction of leafhopper population, yet better than control (10.86/ leaf).

**Second spray**

The data of the pooled over periods presented in Table 2 showed that there was a significant difference among various botanical treatments. The treatment of azadirachtin @ 0.006 per cent was found most effective and recorded the lowest leafhopper population (1.75/leaf) and it was at par with tobacco decoction @ 2 per cent (2.22/leaf). It was followed by neem seed kernel extract @ 5 per cent (2.49/leaf). However, the next best treatments were *Pongamia* oil @ 1 per cent (3.11 /leaf) and it was at par with nafatiya leaf extract @ 10 per cent (3.42/leaf). It was followed by custard apple leaf extract @ 10 per cent (3.95/leaf). However, treatment of *Lantana* leaf extract @10 per cent (5.16/leaf) was found least effective in the reduction of leafhopper population; it was found to be superior to control (12.32/leaf).

**Third spray**

 The data from pooled over periods presented in Table 3 showed that there was a significant difference among various botanical treatments. The treatment of azadirachtin @ 0.006 per cent was found most effective and recorded the lowest leafhopper population (0.52/leaf). However, the next best treatment was the tobacco decoction @ 2 per cent (0.92/leaf) and neem seed kernel extract @ 5 per cent (1.04/leaf) were at par with each other. Pongamia oil @ 1 per cent (1.90/leaf) and nafatiya leaf extract @ 10 per cent (2.16/leaf) were at par with each other and found moderately effective to manage the leafhopper. Further, it was followed by custard apple leaf extract @ 10 per cent (2.74/leaf). However, treatment of lantana leaf extract @10 per cent (4.21/leaf) was found least effective in the reduction of leafhopper population, yet it’s superior to control (13.12/leaf).

**Pooled over spray**

 The data on pooled over sprays presented in Table 4 revealed that the treatment of azadirachtin @ 0.006 per cent was found most effective and recorded the lowest leafhopper population (1.81/leaf). However, the next best treatments, tobacco decoction @ 2 per cent (2.26/leaf) and neem seed kernel extract @ 5 per cent (2.49/leaf), were at par with each other. While pongamia oil @ 1 per cent (3.34/leaf) and nafatiya leaf extract @ 10 per cent (3.58/leaf) were at par with each other. However, custard apple leaf extract @ 10 per cent (4.04/leaf) was found least effective in the reduction of leafhoppers. Further, it was followed by lantana leaf extract @ 10 per cent recorded the highest leafhopper population (5.36/leaf), but yet better than the control, which recorded 12.10 leafhoppers per leaf.

 In the past, Naik *et al*. (2012) found that the spray of NSKE @ 5% resulted in significantly higher levels of reduction recorded (3.53 and 4.00 leafhoppers/3 leaves) at 10 DAS of first and second spray, respectively. Solangi *et al*. (2013) reported that neem powder (65.46%) and tobacco leaves (63.16%) were more effective in reducing the population of leafhoppers. Mahmood *et al*. (2014) revealed that tobacco *Nicotiana tabacum* extract reduced the population of leafhopper up to 0.04 (99.57%), followed by neem powder *Azadirachta indica* 0.14 (98.18%). Iqbal *et al.* (2015) observed that the neem leaf extract 5% followed by garlic leaf extract 5% significantly reduced the leafhopper population (6.31 and 6.86) of leafhopper per plant, respectively. Deepika *et al*. (2018) found that the maximum reduction of jassid was found in the NSKE 5% treated plots during the first and second spray (2.77 and 2.31 leafhopper /3leaves), respectively, followed by garlic crude extract 5% (3.50 and 2.68 leafhopper/3 leaves). Devra and Kumar (2022) found that spray of azadirachtin 5000 ppm @ 1.5 ml/ l resulted in significantly higher levels of reduction recorded (44.56%), followed by neem oil @ 10 ml/l (40.34%), respectively, effective against leafhopper. Kekan *et al.* (2022) revealed that *Azadirachtin* 1 EC @ 0.003 per cent was the best treatment, which recorded the minimum population (3.07 leaf hopper/3 leaves) and was at par with treatment *Lecanicillium lecanii* @ 5 gm per lit, which recorded 3.48 leafhopper per 3 leaves.

**Impact of botanicals on the fruit yield of okra**

The data on okra fruit yield recorded in various botanical treatments as well as in control plots are presented in Table 3. The fruit yield of okra was significantly affected by different treatments. Azadirachtin 0.006 per cent recorded the significantly highest fruit yield of okra (14421 kg/ha) and it was at par with tobacco decoction 2 per cent (13077 kg/ha) and neem seed kernel extract 5 per cent (12659 kg/ha). The maximum increase in yield over control (39.90%) was observed in plots treated with azadirachtin 0.006 per cent, followed by tobacco decoction 2 per cent (33.72%) and neem seed kernel extract 5 per cent (31.53%). The highest avoidable loss was found in the control plot (39.90%), whereas avoidable loss was nil for azadirachtin 0.06 per cent.

In the past, Zobayer & Hasan (2013) reported that neem leaf extract % 4.5 @ 7 ml/l had a higher okra fruit yield. Iqbal *et al.* (2015) also observed that the maximum fruit yield of okra was obtained in the neem leaf extract 5 per cent treated plot. Devra and Kumar (2022) reported that yield was also significantly higher in azadirachtin 5000 ppm @ 1.5 ml/ l treated plots. Thus, present findings conformity with earlier findings.

The Protection Cost Benefit Ratio (PCBR) for the different treatments was worked out based on yield and documented in Table 4. Data indicated that the highest (₹ 115080/ha) realization was obtained from treatment of: azadirachtin @ 0.006 per cent followed by tobacco decoction @ 2 per cent (₹ 88200/ha), neem seed kernel extract @ 5 per cent (₹ 79840/ha), pongamia oil @ 1 per cent (₹ 61220/ha) and nafatiya leaf extract @ 10 per cent (₹ 50780/ha). The lowest (₹ 36660/ha) net realization was calculated with treatment of lantana leaf extract @ 10 per cent, followed by custard apple leaf extract @ 10 per cent (₹ 40440/ha).to Concerning, the highest protection cost benefit ratio was obtained when the crop was treated with tobacco decoction @ 2 per cent (1:30.15) followed by neem seed kernel extract @ 5 per cent (1:19.36) and azadirachtin @ 0.006 per cent (1:18.49). The lowest protection cost-benefit ratio was recorded in the treatment of lantana leaf extract @ 10 per cent (1:11.37). Thus, based on the cost of protection and yield obtained after application of various treatments, the treatment of tobacco decoction @ 2 per cent found most economic for the management of leafhopper in okra.

**Table 1: Bio-efficacy of botanicals against leaf hopper in okra**

|  |  |
| --- | --- |
|  | **No of leaf hopper/leaf** |
| **Tr. No.** | **Treatments** | **Conc.****(%)** | **Before spray** | **First spray** | **Second spray** | **Third spray** |
|  **3 DAS** |  **7 DAS** | **9 DAS** | **3 3 DAS** |  **7 DAS** | **9 DAS** |  **3 DAS** |  **7 DAS** | **9 DAS** |
| T1 | Azadirachtin 1500 ppm | 0.006 | 2.48a(5.66) | 2.10a(3.93) | 2.00a(3.50) | 2.05a(3.68) | 1.62a(2.13) | 1.40a(1.45) | 1.50a(1.75) | 1.07a(0.65) | 0.96a(0.43) |

|  |
| --- |
| 1.00a |
| (0.50) |

 |
| T2 | Custard apple leafextract | 10 | 2.58a(6.16) | 2.54bc(5.93) | 2.44bc(5.45) | 2.46bc(5.55) | 2.25cd(4.56) | 1.99c(3.46) | 2.10ed(3.91) | 1.89c(3.07) | 1.73c(2.50) |

|  |
| --- |
| 1.80c |
| (2.73) |

 |
| T3 | Lantana leaf extract | 10 | 2.80a(7.33) | 2.77c(7.20) | 2.66c(6.60) | 2.70c(6.76) | 2.51d(5.82) | 2.38d(5.17) | 2.27e(4.66) | 2.23d(4.46) | 2.12d(4.00) |

|  |
| --- |
| 2.18d |
| (4.25) |

 |
| T4 | Nafatiya leaf extract | 10 | 2.58a(6.17) | 2.50bc(5.73) | 2.40bc(5.25) | 2.42abc(5.36) | 2.17cd(4.22) | 1.80bc(2.72) | 2.00cde(3.49) | 1.70c(2.39) | 1.58c(2.00) |

|  |
| --- |
| 1.62c |
| (2.12) |

 |
| T5 | Neem seed kernel extract | 5 | 2.54a(5.97) | 2.29ab(4.73) | 2.19ab(4.29) | 2.24ab(4.53) | 1.90abc(3.09) | 1.60ab(2.07) | 1.70abc(2.39) | 1.36ab(1.34) | 1.17b(0.87) |

|  |
| --- |
| 1.21b |
| (0.96) |

 |
| T6 | Tobacco decoction | 2 | 2.53a(5.89) | 2.21ab(4.38) | 2.09ab(3.88) | 2.15ab(4.12) | 2.15ab(4.12) | 2.15ab(4.12) | 2.15ab(4.12) | 1.24a(1.03) | 1.15b(0.82) |

|  |
| --- |
| 1.20b |
| (0.94) |

 |
| T7 | Pongamia oil | 1 | 2.57a(6.08) | 2.48bc(5.65) | 2.36abc(5.08) | 2.40abc(5.26) | 2.11bc(3.96) | 1.76bc(2.58) | 1.85bcd(2.93) | 1.61bc(2.08) | 1.52c(1.80) |

|  |
| --- |
| 1.56c |
| (1.92) |

 |
| T8 | Untreated control | - | 2.78a(7.26) | 3.29d(10.32) | 3.35d(10.69) | 3.50d(11.74) | 3.56e(12.20) | 3.58e(12.30) | 3.60f(12.48) | 3.66e(12.87) | 3.70e(13.16) | 3.75e(13.53) |
|  S. Em.± | T | 0.15 | 0.11 | 0.15 | 0.12 | 0.11 | 0.09 | 0.10 | 0.10 | 0.08 | 0.09 |
| P | - | - | - | - | - | - | - | - | - | - |
| T×P | - | - | - | - | - | - | - | - | - | - |
| C. D. at 5% |  T | NS | 0.32 | 0.45 | 0.35 | 0.35 | 0.27 | 0.29 | 0.29 | 0.24 | 0.27 |
| P | - | - | - | - | - | - | - | - | - | - |
| T×P | - | - | - | - | - | - | - | - | - | - |
| C. V. (%) | 9.90 | 7.27 | 10.45 | 8.04 | 8.89 | 7.76 | 8.06 | 9.11 | 7.96 | 8.55 |

DAS: Days After Spray,

Figures in parentheses are retransformed values of √(X+0.5) transformation

Treatment means with the letter(s) in common are not significant by DNMRT at 5 per cent level of significance

**Table 2: Bio-efficacy of botanicals against leafhopper in okra (Pooled over periods and sprays)**

|  |  |  |  |
| --- | --- | --- | --- |
| **Tr. No.** | **Treatments** | **Conc****(%)** | **No of leaf hopper/leaf** |
| **First spray****(pooled)** | **Second spray****(pooled)** | **Third spray****(pooled)** | **Pooled over periods****over sprays** |
| T1 | Azadirachtin 1500 ppm | 0.006 | 2.05a(3.70) | 1.50a(1.75) | 1.01a(0.52) | 1.52a(1.81) |
| T2 | Custard apple leaf extract | 10 | 2.47c(5.60) | 2.11d(3.95) | 1.80d(2.74) | 2.13d(4.04) |
| T3 | Lantana leaf extract | 10 | 2.71d(6.84) | 2.38e(5.16) | 2.17e(4.21) | 2.42e(5.36) |
| T4 | Nafatiya leaf extract | 10 | 2.43c(5.40) | 1.98cd(3.42) | 1.63c(2.16) | 2.02c(3.58) |
| T5 | Neem seed kernel extract | 5 | 2.23ab(4.47) | 1.73b(2.49) | 1.24b(1.04) | 1.73b(2.49) |
| T6 | Tobacco decoction | 2 | 2.15a(4.12) | 1.65ab(2.22) | 1.19b(0.92) | 1.66b(2.26) |
| T7 | Pongamia oil | 1 | 2.41bc(5.31) | 1.90c(3.11) | 1.55c(1.90) | 1.96c(3.34) |
| T8 | Untreated control | - | 3.37e(10.86) | 3.58f(12.32) | 3.69f(13.12) | 3.55f(12.10) |
| S. Em.± | T | 0.06 | 0.05 | 0.05 | 0.03 |
| P | 0.04 | 0.04 | 0.03 | 0.02 |
| S | - | - | - | 0.02 |
| T×P | 0.12 | 0.10 | 0.08 | 0.06 |
| T×S | - | - | - | 0.06 |
| P×S | - | - | - | 0.40 |
| T×P×S | - | - | - | 0.10 |
| C. D. at 5% | T | 0.18 | 0.16 | 0.13 | 0.10 |
| P | - | - | - | 0.06 |
| S | - | - | - | 0.06 |
| T×P | NS | NS | NS | NS |
| T×S | - | - | - | 0.17 |
| P×S | - | - | - | NS |
| T×P×S | - | - | - | NS |
| C. V. (%) | 8.66 | 8.30 | 8.58 | 8.85 |

DAS: Days After Spray,

Figures in parentheses are retransformed values of √(X+0.5) transformation

Treatment means with the letter(s) in common are not significant by DNMRT at 5% level ofsignificance

**Table 3: Impact of botanicals on fruit yield of okra**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Tr.****No.** | **Treatments** | **Conc.****(%)** | **Yield** **(kg/ha)** |  **Increase in yield over control (%)** | **Avoidable loss (%)** |
| T1 | Azadirachtin 1500ppm | 0.006 | 14421a | 39.90 | - |
| T2 | Custard apple leaf extract | 10 | 10689d | 18.91 | 25.87 |
| T3 | Lantana leaf extract | 10 | 10500d | 17.45 | 27.18 |
| T4 | Nafatiya leaf extract | 10 | 11206cd | 22.65 | 22.29 |
| T5 | Neem seed kernel extract | 5 | 12659abc | 31.53 | 12.21 |
| T6 | Tobacco decoction | 2 | 13077ab | 33.72 | 9.32 |
| T7 | Pongamia oil | 1 | 11728bcd | 26.09 | 18.67 |
| T8 | Untreated control | - | 8667e | **-** | 39.90 |
| S.Em.± | 563.53 | - | - |
| C.D.at5% | 1709.30 | - | - |
| C.V.% | 8.40 | - | - |

Treatment means with the letter(s) in common are not significant by DNMRT at 5 % level of significance

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Tr.****No.** | **Treatments** | **Quantity of botanicals required for three sprays****(Kg orL/ha)** | **Cost of botanicals(₹/ha)** | **Cost of labour (₹/ha)** | **Total cost (₹/ha)** | **Yield (kg/ ha)** | **Gross realization (₹/ha)** | **Net****Realization****Over control (₹/ha)** | **Net profit (₹/ha)****(9-6)** | **PCBR****(9/6)** |
| **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** |
| T1 | Azadirachtin1500ppm | 6 | 3600 | 2625 | 6225 | 14421 | 288420 | 115080 | 108855 | 1:18.49 |
| T2 | Custard apple leaf extract | 150 | 600 | 2625 | 3225 | 10689 | 213780 | 40440 | 37215 | 1:12.54 |
| T3 | Lantana leaf extract | 150 | 600 | 2625 | 3225 | 10500 | 210000 | 36660 | 33435 | 1:11.37 |
| T4 | Nafatiya leaf extract | 150 | 600 | 2625 | 3225 | 11206 | 224120 | 50780 | 47555 | 1:15.75 |
| T5 | Neem seed kernel extract | 75 | 1500 | 2625 | 4125 | 12659 | 253180 | 79840 | 75715 | 1:19.36 |
| T6 | Tobacco decoction | 30 | 300 | 2625 | 2925 | 13077 | 261540 | 88200 | 85275 | 1:30.15 |
| T7 | Pongamia oil | 15 | 1500 | 2625 | 4125 | 11728 | 234560 | 61220 | 57095 | 1:14.84 |
| T8 | Untreatedcontrol | - | - | - | - | 8667 | 173340 | - | - | - |

# Table 4: Economics of botanicals evaluated against leafhopper in okra

# 1.Price of okra fruit: ₹20/kg, Water required for 1ha=500 L

2. Cost of labour charge for spray: ₹375/day labour (Required 2 labour for1 ha and one labour required for extract preparation)

3. Neem seed- ₹20/kg, custard apple leaf-₹4/kg, Nafatiya leaf-₹4/kg, Azadirachtin 1500ppm -₹600/liter, Lantana leaf -₹4/kg,

Tobacco dust -₹10/kg, Pongamia oil-₹100/liter

**Conclusion**

 The study was concluded that the spray application of botanicals, *viz*., azadirachtin 0.006 per cent and tobacco decoction 2 per cent was found to be the most effective for the management of leafhopper, *A. biguttula biguttula,* infesting okra in the summer season.

**Disclaimer (Artificial intelligence)**

**Option 1:**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, manuscript.

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