Influence of different bio-pesticides and mulching in management of Okra Jassids *Amrasca biguttula biguttula* (Hemiptera: Cicadellidae) in Chitwan district of Nepal

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**Abstract:** The use of synthetic pesticides in vegetables is burgeoning these days. A field experiment was conducted in the Horticulture Farm of Agriculture and Forestry University, Chitwan, Nepal from March to June 2019 to evaluate the effect of bio-pesticides, mulching materials, and synthetic pesticides in the management of okra jassid (*Amrasca biguttula biguttula*). The experiment was laid out in split plot design with three replications. The treatment consisted of three insecticides (Chloropyriphos 50% + Cypermethrin 5% EC (3 ml/liter), Neem oil 1% EC (2 ml/liter) and *Trichoderma* (2 gm/liter) and four mulching materials (silver plastic, black plastic, wheat straw, and bare soil). The best performance was recorded in the synthetics treated plots with the lowest jassid population (14.11/5 leaves) followed by *Trichoderma* spp. (16.37/5 leaves) and Neem oil (17.96/5 leaves). Similarly, the synthetic was found statistically superior in the reduction of jassid population (~45–62%). However, the synthetics and *Trichoderma* spp. treated plots had a statistically similar yield, 20.11 t/ha, and 18.68 t/ha, respectively. Silver plastic was found efficient for jassid (14.01/5 leaves) management, higher fruit yield (25.36 t/ha), pod length (27.37 cm), and pod diameter (7.05 cm). The interaction of silver plastic mulch and the synthetics provided the highest yield (27.74 t/ha) which was...
statistically similar to the combination of *Trichoderma* and silver plastic mulch (27.27 t/ha). Results from this experiment suggest that the application of *Trichoderma* spp. in combination with silver plastic mulch could be recommended for maximum and healthy okra production and effectively substitutes the use of synthetics.

**Subjects:** Agriculture & Environmental Sciences; Botany; Entomology

**Key words:** bio-pesticides; Okra; silver plastic mulch; straw mulch; Trichoderma

1. Introduction

Okra (*Abelmoschus esculentus*) is one of the known and utilized species of the family Malvaceae. The fruit contains essential vitamins (vitamin C) and minerals like calcium, magnesium, potassium, and iron (Ijuyah & Usman, 2013). The crop is widely grown from tropics to sub-tropics and warmer parts of temperate zones for its tender pods that can be consumed as boiled vegetable, fried, or added to salads and soups (Kumar & Kumar, 2017). Okra is one of the most popular vegetable crops of Nepal and grown widely in the Terai region. The total production of okra across the country was 122,101.6 metric tons on 10,781.4 hectares and yielded 11.3 t/ha (MoAD, 2017). The productivity of okra, in Nepal, is seriously affected by many pests like whitefly (*Bemisia tabaci*), red spider mite (*Tetranychus telarius*), leaf roller (*Sylepta derogata*), fruit borer (*Helicoverpa armigera*), and fruit and shoot borer (*Earias vitellii*), and jassid (*Amrasca biguttula biguttula*) is prominent among them (Lok et al., 2011; A. Sharma et al., 2018). They cause damage by sucking plant sap and have the potential to transmit various viral diseases. The insects may cause 35–40% of crop yield losses and can damage up to 60–70% in optimal conditions (Acharya et al., 2002). Loss due to these insects is usually minimized by using various types of synthetic pesticides. Pesticide usage in Nepal is low when compared to other south Asian countries. However, commercial vegetable farmers apply an exceptionally higher dose of pesticides—396 gm a.i./ha (PDD, 2015; D. R. Sharma et al., 2013). Pesticide use in vegetables and fruits cultivation in Nepal is increasing at 10–20% per year (Diwaker et al., 2008). Apart from the high cost of synthetic pesticides and health hazards to both farmers and consumers, they undoubtedly destroy natural enemies (Gilden et al., 2010). Thus, sourcing substitutes for synthetic pesticides is a must for sustainable pest management. Bio-pesticides are much safer and better approach for insect pest management compared to synthetics (Copping & Menn, 2000). Botanical pesticides like Neem oil has been reported as an eco-friendly option for managing jassid (Akramuzzaman et al., 2018; Hafeez-ur-Rehman et al., 2015). Neem pesticides possess antifeedant, repellant, and toxic properties against insect pests (Senthil-Nathan et al., 2009). Mohanty et al. (1988) reported the correlation of repellent and antifeedant properties of neem with pest reduction. The major component of neem oil is azadirachtin which at physiological level blocks the synthesis and release of molting hormones (ecdysteroids) from the prothoracic gland leading to incomplete ecdysis in immature insects and sterility in adult female (Gossé et al., 2005). Likewise, the spore of entomopathogenic fungus germinates on insects’ integument thereby excreting the enzymes like chitinase, protease, lipase, etc., which degrades the insects’ cuticle aiding penetration of fungal body into haemocoel and leading to death (Mora et al., 2018). *Trichoderma* spp. has been described as a biological control agent for stag beetle in date palm (Alahmadi et al., 2012). Moreover, Kaoud et al. (2013) reported up to 100% mortality of lesser grain borer (*Rhizoperth adominica*) adults by *Trichoderma album* at high concentrations. Similarly, Ganassi et al. (2001), Coppola et al. (2017), and Hussain et al. (2018) reported the effectiveness of *Trichoderma* spp. in the management of sucking pests.

The natural enemies keep pest populations below the economic threshold level; straw mulching enhances the number of natural enemies (Mochiah et al., 2012). Silver plastic mulch reflects the incoming light in the blue (400–500 nm) and the near-ultraviolet (395 nm) regions of the spectrum which repel insects before they visit the plants (Csizinszky et al., 1999). Similarly, (Ojako et al., 2019) found black plastic more effective for reducing insect pests in okra. Besides controlling insect
pests, mulching minimizes weed infestation, conserves soil moisture, reduces fertilizer leaching, prevents temperature fluctuation, and ultimately enhances the growth and yield of the crop (Bhardwaj, 2013; Jha et al., 2018).

This study evaluated the influence of bio-pesticides and mulching materials with synthetic pesticides in the management of okra jassid (Amrasca biguttula biguttula).

2. Materials and methods

2.1. Location of the experimental site

An experiment was conducted to determine the impact of different mulching materials (silver plastic, black plastic, wheat straw and different insecticides (Cypermethrin + Chloropyriphos, Neem oil, and Trichoderma) on the management of okra jassid (Amrasca biguttula biguttula) in Agriculture and Forestry University, Rampur, Chitwan, Nepal from March 5 to June 13, 2019. Okra variety (Abelmoschus esculentus var. US 7109) was grown during summer season under recommended practices of okra production (Jha et al., 2018). The experiment was carried out to find out the effect of different types of mulching materials (silver plastic, black plastic, wheat straw, and bare soil) and different commercially available insecticides (Chloropyriphos 50% + Cypermethrin 5% EC 3 ml/liter, Neem oil 1% EC 2 ml/liter and Trichoderma 2 gm/liter) on okra jassid population. Treatments were replicated three times in split plot design to examine the effect of both factors (different mulching and insecticides) and their interaction. The size of individual plot was 2.25 × 1.5 m², distance between subplot and main plot was 50 cm and 1 meter, respectively. The crop was planted with normal spacing of 30 × 45 cm (Jha et al., 2018).

Commercial insecticide Sannata 505 (Chloropyriphos 50% EC + Cypermethrin 5% EC) at 3 ml/litre, neem oil (azadirachtin 1% EC) at 2 ml/litre and Trichoderma spp. 10⁹ CFU (Colony forming units) at 2 gm/litre were sprayed three times at an interval of 12 days; the first spray was made at the initiation of infestation. The amount of insecticide required per liter of water was calculated using the formula:

\[
\text{Insecticides per liter} = \frac{\text{Concentration required}}{\text{Percent.ai}} \times 100
\]

Five randomly selected plants, considering border effects, were selected and tagged with red thread for the convenience of data collection. The jassid population was recorded 3, 7, and 11 days after each spraying by counting jassid on each leaf of five apical leaves from five previously selected plants from each plot. The percent reduction of a pest population was calculated by the formula similar to that used by Alam et al. (2010).

\[
\text{Percent of reduction} = \frac{(Pr - Po) \times 100}{Pr}
\]

Where, \(Pr\) = Pre count plant (jassid population 24 hours before the application of treatment) and \(Po\) = Post count plant (jassid population 24 hours after the application of treatment).

Data on yield of okra (pod length, pod diameter and yield) was taken from the predetermined five plants in the plot. Pod yield was converted into ton per hectare (ton/ha). The data of jassid count were transformed by square root transformation (Forsythe & Gyrisco, 1961). Also, the percent reduction in jassid population was transformed using arcsine square root transformation (Neupane, 2000). The data collected were entered in MS-Excel and then analyzed using RStudio Version 3.6.3.
3. Results

3.1. Efficacy of different insecticides against jassid population
The percentage reduction in the jassid population after 72 hours of insecticide application is shown in Table 1. After completion of the first spray (Date I), the treatment differed significantly (p < 0.05) in reducing the jassid population. The highest reduction in the jassid population was seen in Chloropyriphos + Cypermethrin (45%), statistically superior to neem oil (22.21%) and Trichoderma (21.11%). A similar result was obtained in the second (Date II) and the third spray (Date III) in which Chloropyriphos + Cypermethrin reduced the jassid population to 30% and 62% respectively. However, after 2nd spray, percentage reduction by synthetic insecticide was statistically similar to Trichoderma spp. Reduction in jassid population obtained from neem oil and Trichoderma spp. at third spray (38.61 and 38.14% respectively) were statistically at par with each other (Table 1).

The number of jassids observed in different treatments is presented in Table 2. Insecticides did not have significant effect on jassid numbers after the first spray. However, after the third day of second spray, Chloropyriphos + Cypermethrin treated plots recorded a statistically lower jassid population (15.73/5 leaves). A similar result was observed after the third spray except the day before third spray where jassid population were statistically similar on both Chloropyriphos + Cypermethrin treated plots and Trichoderma treated plots. After all three consecutive sprayings, Chloropyriphos + Cypermethrin treatment (14.11/5 leaves) was the most effective with lowest mean jassid population followed by Trichoderma (16.37/5 leaves) and Neem oil (17.97/5 leaves).

3.2. Effect of different mulches against jassid population
The efficacy of different mulching materials on the jassid population is presented in Table 3. Significantly different jassid population was recorded among the mulching materials used. All mulching materials used resulted significantly lower population than control (without mulch). The silver plastic mulch had consistently the lowest jassid population throughout the trial, whereas the plants grown over the bare plots recorded the highest number of jassids. Wheat straw mulch and black plastic mulch significantly performed better than the bare soil throughout the experiment. The overall mean jassid population revealed that the silver plastic mulch was the most effective mulching material with the lowest jassid population (14.01/5 leaves) followed by wheat straw mulch (15.78/5 leaves), black plastic mulch (18.13/5 leaves) and control (22.13/5 leaves) respectively.

| Insecticides       | Dosage | Date I   | Date II  | Date II |
|--------------------|--------|----------|----------|---------|
| Chloropyriphos 50% + Cypermethrin 5% EC | 3 ml/litre | 45.06±(0.722) | 30.04±(0.576) | 61.92±(0.870) |
| Neem oil (1% EC)   | 2 ml/litre | 22.21±(0.489) | 13.35±(0.373) | 38.61±(0.662) |
| Trichoderma        | 2 gm/litre | 21.11±(0.475) | 18.58±(0.444) | 38.14±(0.65)  |
| SEM                | -      | 0.08     | 0.084    | 0.084   |
| LSD                | -      | 0.182*   | 0.149*   | 0.208*  |
| CV (%)             | -      | 28.6     | 28.4     | 21.3    |

NS = non-significant, *, ** and *** represent significant at 5%, 1% and 0.1% level of significance respectively. Treatment means followed by the common letter within column are not significantly different among each other based on DMRT at 0.05 level of probability. Figure in parenthesis represents arcsine square root transformation in percent reduction of jassid population. SEM = standard error of mean, LSD = least significant difference and CV = coefficient of variance.
| Insecticides                  | First spray          | Second spray         | Third spray         |
|------------------------------|----------------------|----------------------|---------------------|
|                              | BS       | 3DAS    | 7DAS    | BS       | 3DAS    | 7DAS    | BS       | 3DAS    |
| Chlorpyriphos 50% +          |          |         |         |          |         |         |          |         |
| Cypermethrin 5% EC           | 10.80(3.28)| 5.96(2.44)| 14.67(3.83)| 22.91(4.78)| 15.73(3.96)| 24.84(4.98)| 22.19(4.71)| 8.88(2.96)|
| Neem oil (1% EC)             | 10.03(3.16)| 7.78(2.79)| 15.80(3.97)| 26.68(5.16)| 22.96(4.79)| 27.58(5.25)| 24.59(4.95)| 15.13(3.88)|
| Trichoderma                  | 8.40(2.89)| 6.61(2.57)| 15.05(3.87)| 25.77(5.07)| 20.79(4.56)| 24.73(4.97)| 23.13(4.80)| 14.17(3.76)|
| SEM                          | 0.114    | 0.101   | 0.042   | 0.114    | 0.245    | 0.091    | 0.072    | 0.288    |
| LSD                          | NS       | NS      | NS      | NS       | 0.465*   | NS       | 0.202*   | 0.52*    |
| CV (%)                       | 15.9     | 10.3    | 15      | 8.7      | 9.3      | 7.4      | 3.7      | 13       |

BS = Before spray, DAS = Days after spray. SEM = standard error of mean, LSD = least significant difference and CV = coefficient of variance. NS = non-significant, *, ** and *** represent significant at 5%, 1% and 0.1% level of significance respectively. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of probability.
Table 3. Efficacy of different mulching materials against jassid population

| Mulch          | First spray | Second spray | Third spray |
|---------------|-------------|--------------|-------------|
|               | BS  | 3DAS | 7DAS | BS  | 3DAS | 7DAS | BS  | 3DAS |
| Silver plastic |   6.52 | 3.89 | 11.38 | 20.88 | 15.25 | 23.83 | 21.21 | 8.27 |
| Black plastic  |   8.13 | 7.28 | 14.35 | 25.94 | 21.05 | 27.16 | 24.20 | 13.93 |
| Wheat straw    | 10.84 | 5.90 | 14.88 | 23.25 | 18.38 | 21.52 | 21.07 | 12.46 |
| Control        | 14.91 | 10.90 | 20.74 | 30.81 | 24.77 | 30.75 | 26.92 | 16.21 |
| SEM            | 0.281 | 0.277 | 0.244 | 0.209 | 0.227 | 0.197 | 0.142 | 0.288 |
| LSD            | 0.286*** | 0.264*** | 0.286*** | 0.383*** | 0.41*** | 0.292*** | 0.357*** | 0.244*** |
| CV (%)         | 9.30 | 10.3 | 7.4 | 7.7 | 9.3 | 5.8 | 7.5 | 9.7 |

NS = non-significant, *, **, and *** represent significant at 5%, 1% and 0.1% level of significance respectively. Treatment means followed by common letter(s) within column are not significantly different among each other based on DMRT at 0.05 level of significance. Figure in parenthesis represents square root transformation of jassid population. BS = before spray, DAS = Days after spray. SEM = Standard error of mean, LSD = least significant difference and CV = coefficient of variance.

The effect of interaction of the mulching and insecticides on jassid population was not significant; however, the lower jassid population was observed in interaction of silver plastic mulch and synthetic insecticides (Figure 12).

3.3. Efficacy of different insecticides, mulching materials and their interaction on the yield of okra

Insecticides exhibited a significant effect on fruit yield (Table 4). The highest production (20.11 t/ha) was obtained from synthetic insecticide treatment followed by Trichoderma (18.68 t/ha) and neem oil (17.74 t/ha). Likewise, mulching materials had a statistically significant result in the yield of okra (Table 4). All the subplot (mulches) treatment was statistically superior over the control plot. The silver plastic mulch recorded significantly higher yield (25.36 t/ha) followed by black plastic mulch (20.53 t/ha), wheat straw mulch (17.00 t/ha), and control (12.49 t/ha) respectively.

Figure 1. Effect of interaction of insecticides and mulches on mean jassid population (SEM = 0.119).
Also, the interaction between the insecticides and the mulching materials showed a significant difference for the yield. The mean yield of okra (27.74 ton/ha) was higher in plots with a combination of Chloropyriphos + Cypermethrin with silver plastic mulch, and the result was statistically at par with the yield obtained from interaction of Trichoderma with silver plastic mulch (27.27 ton/ha). However, the interaction between Trichoderma and bare soil gave the lowest yield (11.76 ton/ha), presented in Table 5.

3.4. Effect of different insecticides, mulches, and their interaction on fruit size of okra

Analysis of variance indicated that the influence of different insecticides did not have a significant effect on pod diameter and pod length (Table 6). However, the mulching materials exhibited a significant effect in both pod diameter and pod length (Table 6). The average Pod length of 27.37 cm and 25.22 cm was obtained from silver plastic mulch and black plastic mulch treatments, respectively. These pod lengths observed were statistically at par with each other but superiorly significant to organic mulch and control, whereby the pod lengths of 20.88 cm and 19.88 cm, respectively, were observed. Also, organic mulch and control treatment were statistically at par

| Mulch material         | Yield(t/ha) | Insecticides                        | Yield(t/ha) |
|------------------------|-------------|------------------------------------|-------------|
| Silver plastic mulching| 25.36<sup>a</sup> | Chloropyriphos 50% + Cypermethrin 5% EC | 20.11<sup>a</sup> |
| Black plastic mulching | 20.53<sup>b</sup> | Neem oil                           | 17.74<sup>b</sup> |
| Organic mulching       | 17.00<sup>c</sup> | Trichoderma                        | 18.68<sup>ab</sup> |
| Control                | 12.49<sup>c</sup> | SEM                                | 1.04<sup>c</sup> |
| SEM                    | 2.72<sup>SE</sup> | LSD                                | 1.47**<sup>c</sup> |
| LSD                    | 1.66<sup>c</sup> | CV (%)                             | 7<sup>c</sup> |
| CV (%)                 | 8.90<sup>c</sup> |                                    |             |

NS = non-significant, *, ** and *** represents significant at 5%,1% and 0.1% level of significance respectively. Treatments mean followed by common letter(s) within a column are not significantly different among each other based on DMRT at 0.05 level of probability. SEM = standard error of mean, LSD = least significance difference and CV = coefficients of variance.
with each other regarding pod length. A similar result was obtained for the pod diameter. The pod diameter of 7.053 cm and 6.833 cm observed on silver plastic mulch and black plastic mulch, respectively; but, the result was statistically similar. Further, this result was statistically superior to that obtained in organic mulch and control (4.94 cm and 4.82 cm, respectively). However, the interaction of the insecticides and the mulching materials did not exhibit significant differences in both pod length and pod diameter.

Table 5. Interaction of insecticides and mulching in yield of okra

| Insecticides× Mulching       | Chloropyriphos 50% +Cypermethrin 5% EC | Neem oil (1%EC) | Trichoderma (10⁹ CFU) |
|------------------------------|----------------------------------------|-----------------|-----------------------|
| Silver plastic              | 27.74a                                 | 21.07b          | 27.27ⁿ              |
| Black plastic               | 20.49bc                                | 20.45bc         | 20.64bc              |
| Wheat straw                 | 18.45bc                                | 17.50 cd        | 15.06ⁿ              |
| Control                     | 13.76ᵃ†                                | 11.95 ᵇᵗ        | 11.76 ᵇᵗ            |
| SEM                         | 1.51                                   |                 |                      |
| LSD                         | 2.88*                                  |                 |                      |
| CV (%)                      | 8.9                                    |                 |                      |

NS = non-significant, *, **, and *** represents significant at 5%,1%, and 0.1% level of significance respectively. Treatments mean followed by common letter(s) within a column are not significantly different among each other based on DMRT at 0.05 level of significance. SEM = standard error of mean, LSD = least significant difference and CV = coefficient of variance.

Table 6. Effect of insecticides and mulching in fruit size of okra

| Insecticides                | Pod length | Pod diameter |
|-----------------------------|------------|--------------|
| Chloropyriphos 50% +Cypermethrin 5% EC | 24.41      | 6.09         |
| Neem                         | 23.23      | 5.98         |
| Trichoderma                 | 22.38      | 5.66         |
| SEM                         | 0.59       | 0.12         |
| LSD                         | NS         | NS           |
| CV (%)                      | 12         | 12.6         |

Mulching

| Silver plastic              | 27.37ᵃ      | 7.05ᵃ        |
| Black plastic               | 25.22ᵃ      | 6.83ᵃ        |
| Wheat straw                 | 20.88ᵇ      | 4.94ᵇ        |
| Control                     | 19.88ᵇ      | 4.82ᵇ        |
| SEM                         | 1.77        | 0.59         |
| LSD                         | 2.42***     | 0.56***      |
| CV (%)                      | 10.5        | 9.7          |
| SEM                         | 0.97        | 0.32         |
| LSD                         | NS          | NS           |
| CV (%)                      | 14          | 9.7          |

NS = non-significant, *, ** and *** represents significant at 5%,1% and 0.1% level of significance, respectively. Treatments mean followed by common letter(s) within a column are not significantly different among each other based on DMRT at 0.05 level of significance. SEM = Standard error of mean, LSD = least significant difference and CV = coefficient of variance.
4. Discussion

Synthetic insecticide treatment (Chloropyriphos 50% + Cypermethrin 5% EC) was found to be more effective on controlling jassids than bio-pesticides like Neem oil and Trichoderma. Janghel (2015) reported a similar result regarding the effectiveness of a synthetic pesticide (Acetamiprid) over Neem-based pesticides and entomopathogenic fungi on controlling jassids. Likewise, the effectiveness of synthetic pesticides over bio-pesticides in controlling sucking pests of okra was reported by Sarkar et al. (2016) and Asif et al. (2018). Though the use of Trichoderma spp. and neem oil was less effective than synthetics (Chloropyriphos 50% + Cypermethrin 5% EC), they were likely to suppress the jassid population after each spray, as shown in table no. 1. The efficacy of various Trichoderma spp. on pest management was explained by Alahmadi et al. (2012), Kaoud et al. (2013), and Rodriguez-González et al. (2018). Similarly, Ganassi et al. (2001), Coppola et al. (2017), and Hussain et al. (2018) reported the effectiveness of Trichoderma spp. in the management of sucking pests. In our experiment, there was no effective reduction in the jassid population after 3 days of each spray (Table 1), suggesting an increase in spray frequency to control the jassid population. As the use of Trichoderma and Neem oil has no health hazard, it is advisable to use them by increasing their frequency of application for better jassid management. Fewer jassids were counted on a silver plastic mulched plots compared to other mulches and bare soil. Csizinszky et al. (1997) reported a lower number of whiteflies in UV reflective mulch (silver plastic) compared to standard black plastic and is currently being suggested as an alternative to conventional pesticides (Summers et al., 2004). Black plastic mulch and wheat straw mulch has also been shown effective in reducing the incidence of jassid. Forias-Larios and Orozco-Santos (1997) found that watermelon grown over black plastic had a lower incidence of aphid than grown over bare soil. Similarly, Summers et al. (2004) observed lower whitefly and aphid infestation in zucchini in wheat straw mulched plot compared to bare soil. That fewer jassids in silver plastic mulched plot in our experiment might be due to the reflection of incident light in blue (400–500 nm) and near ultraviolet (395 nm) region of spectrum (Csizinszky et al., 1995) which repels the insects before they visit the plants (Csizinszky et al., 1999) whereas bare plot might not have such reflecting properties causing more jassid incidence. Further, the insects repelled by mulches might land on the bare plot with standing green crops, increases the jassid population.

In our experiment; Chloropyriphos + Cypermethrin gave significantly higher yield than other insecticides. Gosh and Chakraborty (2015) reported a similar result; where they observed higher yield in imidachloropid-treated plots compared to Beauveria bassiana and other biopesticide treated plots. Likewise, Shivankar et al. (2008) observed a higher yield in a synthetic pesticide-treated plot compared to a neem oil-treated plot similar to our result. The production of marketable fruit, in the experiment, reflected the degree of jassid suppression. The highest yield was obtained from Chloropyriphos + Cypermethrin treated plots. The same treatment had a lower incidence of the jassid. Similar was the result for Trichoderma, and neem oil-treated plots (Table 4).

Fruit yield from mulched plots was significantly higher than those produced on bare soil. This result agrees with the findings of Jha et al. (2018). Among the mulched plots silver plastic mulch exhibited significantly higher yield. This may be consequence of lower jassid infestation, better hydrothermal condition, and weeds control. Reflective mulch like silver-colored mulch reflects higher quanta of photosynthetically active radiation than other mulches (Csizinszky et al., 1995). Similar to our result, Aniekwe (2015) found that black plastic mulch produced a significantly higher yield of okra coupled with better weed suppression than that of okra grown over wheat straw mulch and bare plots. Okra grown over plastic mulch had higher pod size; corroborating a similar result by Parte et al. (2020). In our experiment, the combination of Chloropyriphos + Cypermethrin and the silver plastic mulch produced the highest yield. This yield was statistically at par with the yield obtained from Trichoderma and silver plastic mulch. As synthetic pesticide has several health hazards, a combination of Trichoderma and silver plastic mulch can be considered as a better choice.
5. Conclusion

Our study showed that the combination of Chloropyriphos and Cypermethrin is an effective pesticide for control of jassid, while neem oil and Trichoderma have also shown promising results. Trichoderma, though not equally effective as the synthetic insecticide for jassid control, is in par with the synthetic insecticide for the yield. Besides, chemical pesticides pose several threats to human health and agro-ecology. Similarly, silver plastic mulch was found superior in the management of jassids and boosting yield. Further, the interaction of Trichoderma and silver plastic mulch had statistically superior results in the production of okra.

Based on the results of this experiment, it would be reasonable to suggest that okra growing farmers apply Trichoderma and use silver plastic mulch, substituting synthetic pesticides, for maximum production without compromising the human health and ecosystem.

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