Journal of Entomology and Zoology Studies 2020; 8(2): 404-409

Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(2): 404-409

Received: 07-01-2020
Accepted: 09-02-2020

**Johnny Ernest Norman**
Crop Protection Department, School of Agriculture and Food Sciences, Njala University, Njala, Sierra Leone

**Dan David Quee**
Njala Agricultural Research Centre, Sierra Leone Agricultural Research Institute, Njala, Sierra Leone

**Alusaine Edward Samura**
Njala Agricultural Research Centre, Sierra Leone Agricultural Research Institute, Njala, Sierra Leone

**Sahr N Fomba**
Crop Protection Department, School of Agriculture and Food Sciences, Njala University, Njala, Sierra Leone

**Corresponding Author:**
**Dan David Quee**
Njala Agricultural Research Centre, Sierra Leone Agricultural Research Institute, Njala, Sierra Leone

# Influence of mulch materials on flea beetles (*Podagrica uniforma* L.), weeds, growth and yield of okra (*Abelmoschus esculentus* L. Moench) in Njala, Southern Sierra Leone

**Johnny Ernest Norman, Dan David Quee, Alusaine Edward Samura and Sahr N Fomba**

**Abstract**
A field trial was carried out at the Department of Crop Protection, School of Agriculture and Food Sciences, Njala University, to evaluate mulch materials for the control of *Podagrica uniforma* L., weeds, growth and yield of *Abelmoschus esculentus* L. The experiment was arranged in a randomized complete block design, with three replications. Treatments included two varieties of okra Clemson spineless (Improved) and Comi (Local) and four mulch materials (*Carica papaya*, *Imperata cylindrica*, *Azadirachta indica* and *Gmelina arborea* leaves) and control. Growth and yield characteristics were higher in Comi variety, significantly recorded the lowest population of *Podagrica uniforma* L. and number of damaged leaves. The findings revealed that *Azadirachta indica* (4.87 plant$^{-1}$) leaves mulch however proved to be the most effective in the control of *Podagrica uniforma* L. whereas *imperata cylindrica* controls weeds. Significant and positive correlation existed between pod yield and width, and also between plant height and stem girth.

**Keywords:** *Podagrica uniforma* L., weed, *Abelmoschus esculentus* L., mulch materials, growth, yield

## Introduction
Okra (*Abelmoschus esculentus* L.) is one of the prominent vegetable crops of the family Malvaceae, it originated from tropical America and was first cultivated in Egypt in 12$^{th}$ century [18]. The most significant production countries in West Africa are Ghana, Burkina Faso and Nigeria [4].
Okra is a multipurpose crop due to its various uses of the fresh leaves, buds, flowers, pods, stems and seeds [20]. Its fruit contains water (86%), calorie (4550 Kcal/kg), proteins (2.2%), carbohydrates (10%), fats (0.2%) and vitamins A, B, C, minerals, iron and iodine [10]. The tender leaves of okra contain calcium and iron, okra mucilage is used for glace paper production and confectionary [6, 2]. The fibre also absorbs water and ensures bulk in stool thereby preventing and improving constipation problem [14]. In Sierra Leone okra is a delicious fruits, boiled, fried or cooked and can be consumed alone or in combination with other food [5].
Despite the enormous potentials of okra fruits production, farmers' low production and crop yield per hectare in Sierra Leone has been significantly compounded by the infestation of various insect pests, such as flea beetles (*Podagrica uniforma* L..); cotton stainer (*Dysdercus superstitious*); white fly (*Bemisia tabaci*); and green stink bug (*Nezera viridula*) [25]. The damage caused by *Podagrica uniforma* L.; comprises characteristic perforation of leaves, the irregular holes reducing photosynthetic surface area of the leaf and transmitting a large number of viral diseases indirectly [11, 12, 9].
Considering the above mentioned facts, locally available and economically sustainable crop production strategies such as mulching can lower the germination and development of weed seeds through allelopathic effects [8, 16], useful for the control of insects, reduce disease incidence and severity [1]. Moreover, mulching conserve soil moisture required for plant vigour and to promote plant tolerance to insect attack, reduce infiltration rate, reduce fertilizer leaching, prevent from extremes of temperature, reduce weed growth and ultimately increase yield of crop [15, 7]. Plant mulches can be an effective way to provide shelter for predatory insects and to control weeds [15, 23, 28]. Mulching exerts decisive effects on earliness, yield and quality of the crop [7].

Mulched plants grew taller and had more branches and a greater number and weight of fruits [17]. Several workers have reported that most of the mulches, whether organic or synthetic, are helpful in controlling weed population [3, 7]. Therefore, the present study was initiated to fill up the gaps for elucidating information on the development of sound, stable, eco-friendly and viable management practices to manage insect pest infestation and weeds in okra.

## Materials and methods

### Experimental site

The research was conducted during one main cropping season (June) 2018 at the experimental site of the Department of Crop Protection, School of Agriculture and Food Sciences, Njala University, Njala Campus, Kori Chiefdom, Moyamba District, Southern Sierra Leone (N $08^0$.06, W $12^0$.06 and altitude: 63m). The climatic condition experienced in the research area was alternating rainy season (May-October) and a dry season (November-April). Cumulative temperature was $29^0$ C; rainfall 2,526 mm and relative humidity 95%. The soil was loamy, with low soil organic carbon, total nitrogen and available phosphorus.

### Experimental design and treatments

The experiment was 2 x 5 factorial arranged in a Randomized Complete Block Design (RCBD) with three replications. Treatments involved two varieties of okra, Clemson spineless (Improved) and Comi (Local) in combination with four mulching materials (*Carica papaya*, *Imperata cylindrica*, *Azadirachta indica* and *Gmelina arborea* leaves) and control (no mulch). The experimental area was 25 m x 8 m (200 $m^2$ or 0.02 ha) with 1 m x 0.5 m space apart, marked out into plot sizes of 2 $m^2$ containing 40 plants $plot^{-1}$.

### Crop management

The experimental field was brushed, wreckage removed, ploughed to the depth of about 5-10cm, levelled using west India hoes and shovels. Seeds of the okra varieties were acquired from the Crop Science Department, Njala University, Njala Campus and were sown in June 2018. Prior to sowing, organic manure (poultry) was applied at the rate of 200kg $ha^{-1}$ two weeks before planting. The mulching materials *Carica papaya*, *Imperata cylindrical*, *Azadirachta indica* and *Gmelina arborea* were slice to 25cm length using a machete. These mulching materials were spread evenly on the soil surface at a rate of 6.3 kg $plot^{-1}$ three weeks after planting. Two seeds were sown per hill at 60cm x 40cm planting distance and later thinned to one two weeks after planting to give an optimum plant density of 50,000-60,000 plants $ha^{-1}$. The improved cultivar (Clemson spineless) was harvested within 2-3 months after sowing while the local cultivar was harvested above 3 months.

## Observations

### Growth attributes

Plants height (cm) was measured from the base of the stem to the last emerged leaf. Stem diameter (cm) was taken 10cm above ground level from the base of the okra plant. Leaf area was measured using a leaf area meter and number of leaves $plant^{-1}$ was determined by counting and scores computed. Number of insects and damaged leaves were determined by dividing total number of insects or damaged leaves by five. Species wise weed count was taken from the sampling strip using 0.25 $m^2$ quadrat. The quadrat was placed at random inside the sampling strip and observations were taken from two places in each plot at 30 and 60 Days after seedling (DAS) count was expressed in number $m^{-2}$.

### Yield attributes

Weight of the total number of pods was recorded using a digital balance and fresh pod weight $plant^{-1}$ was determined by dividing the total weight of the pods by five. Fresh pod yield (t $ha^{-1}$) was calculated using the following formula:

$$\text{Fresh pod yield (t ha}^{-1}) = \frac{\text{Weight of fresh pods from net plot (kg) x 10,000 m}^2 \text{ x 1 t}}{\text{4 m}^2 \text{ x 1 ha x 1000 kg}}$$

Pod length was measured from the neck of the pod to the bottom using a measuring scale (Model Swordfish, China).

### Statistical Analysis

Data were subjected to analysis of variance using Proc GLM statement in Statistical Analysis System (SAS) 9.4 version. Mean separation was done using the Student Newman-Keuls (SNK) test at 5% level of probability.

## Results and Discussion

### Insect population

Table 1 indicates the impact of various mulch materials and okra varieties on the population of flea beetles (*Podagrica uniforma* L.). The result revealed that Comi (local variety) was significantly ($p$<0.0027) affected by *Podagrica uniforma* L. (16.22 $plant^{-1}$) than Clemson spineless (8.80 $plant^{-1}$). This may be attributed to the physiology and taste of Comi which attracted more *Podagrica uniforma* L.to feed on this variety. This finding is similar to Memon *et al*. (2013) [19], who showed that infestation varied significantly ($p$<0.05) in different varieties. Furthermore, the study showed that Comi and Clemson spineless had no significant ($p$<0.05) difference with respect to damaged leaves caused by *Podagrica uniforma* L.

However, the increased population of *Podagrica uniforma* L. (22.27) and greater damage on okra leaves (5.06 $plant^{-1}$) was significantly ($p$<0.05) recorded in the control treatment and relatively reduced in the mulched treated plots. *Azadirachta indica* (4.87 $plant^{-1}$) significantly ($p$<0.05) recorded the lowest *Podagrica uniforma* L. population followed by *Imperata cylindrica* leaf mulch (7.10 $plant^{-1}$), thus indicating that it was more efficacious than the other mulch materials. Similarly the number of damaged leaves was decreased in plots mulched with *Azadirachta indica* (0.99 $plant^{-1}$) and *Imperata cylindrica* (1.34 $plant^{-1}$) leaves. The result is consistent with the findings of many other researchers testing the potential of mulching with plant leaves to control pests of crops [22, 21].

**Table 1:** Effect of variety and mulch materials on the population of *Podagrica uniforma* L. and damaged on okra leaves.

| Treatment | Insect population ($Plant^{-1}$) | Damaged leaves ($Plant^{-1}$) |
|---|---|---|
| **Variety** | | |
| Comi | $16.22^a$ | $2.91^a$ |
| Clemson spineless | $8.80^b$ | $1.79^a$ |
| Pr >F | 0.0027 | 0.0725 |
| **Mulch materials** | | |
| *Carica papaya* | $13.01^{bc}$ | $1.77^b$ |
| *Azadirachta indica* | $4.87^c$ | $0.99^b$ |
| *Imperata cylindrica* | $7.10^{bc}$ | $1.34^b$ |
| *Gmelina arborea* | $15.27^{ab}$ | $2.59^b$ |
| Control | $22.27^a$ | $5.06^a$ |
| Pr >F | 0.0005 | 0.0024 |
| Pr >F: Mulch*variety | 0.7702 | 0.8634 |

Means within columns with no common letter (s) are significantly different according to Student Newman-Keuls (SNK) multiple range test at 5% probability ($p$<0.05).

**Weed density**

The trial site consisted of 6,135.83 different weed species, comprising of 1,998.57 grasses (32.57%), broadleaved 3,863.7 (62.97%) and sedges 273.56 (4.46%) respectively. Among various weed species identified and classified, broadleaved weeds were the most dominant species among the weed flora of okra in this study. These results are similar to the previous work of Singh *et al*. (2007) [27] who reported varying weed flora of crops.

Analysis of variance showed that Clemson spineless (Improved) variety had significantly ($p<0.05$) lower density of grasses ($23.99m^{-2}$), broadleaves ($67.41m^{-2}$) and sedges ($3.67m^{-2}$) compared with Comi variety (Table 2), which was attributed to shading occasioned by the lesser quantity and quality of light reaching the soil surface, hence negatively influenced weed growth. This result agrees with Silva *et al*. (2012) [26], who reported that high vegetative biomass of early branching crop is a good potential for physical obstruction of light and weed seedling emergence. The un-mulched plots (Control) had significantly ($p<0.05$) higher density of grasses, broadleaved and sedge weeds which also showed dominance over other mulch treatments. However, control treatment allowed weeds to supersede the crop which resulted to higher weed population over other plots treated with mulch materials. This observation is in agreement with the report of Akintoye *et al*. (2011) [5] that competition between weeds and crop starts right from germination of the crop up to harvest affecting both growth and yield parameters adversely. Plots treated with *Imperata cylindrica* leaf mulch significantly ($p<0.05$) recorded the lowest number of grasses and broadleaved weed density, whereas *Azadirachta indica* leaf mulch obtained the lowest number of sedge weeds. This could be ascribed to either the thickness of mulch layer that inhibited weed seed germination and establishment of weeds or the potential of allelopathic compounds found in these weed species Silva *et al*. (2012) [26], also reported earlier that the use of live mulch in okra to control weeds appeared to be useful and considered more effective against weeds. The analysis of variance for weed density showed that the interaction between variety and mulch materials are significant ($p<0.05$) under grass and sedge weed species.

**Table 2:** Effect of variety and mulch materials on grasses, broadleaved and sedge weeds.

| Treatment | Grasses ($m^{-2}$) | Broadleaves ($m^{-2}$) | Sedges ($m^{-2}$) |
|---|---|---|---|
| **Variety** | | | |
| Comi | $109.24^{a}$ | $190.17^{a}$ | $14.56^{a}$ |
| Clemson spineless | $23.99^{b}$ | $67.41^{b}$ | $3.67^{b}$ |
| Pr > F | <.0001 | <.0001 | <.0001 |
| **Mulch materials** | | | |
| *Carica papaya* | $37.78^{c}$ | $110.93^{ab}$ | $6.41^{b}$ |
| *Azadirachta indica* | $61.83^{b}$ | $148.77^{a}$ | $4.25^{b}$ |
| *Imperata cylindrica* | $31.41^{c}$ | $67.68^{b}$ | $12.71^{a}$ |
| *Gmelina arborea* | $45.66^{bc}$ | $131.78^{ab}$ | $7.78^{b}$ |
| Control | $156.40^{a}$ | $184.78^{a}$ | $14.41^{a}$ |
| Pr > F | <.0001 | 0.0087 | <.0001 |
| Pr > F: Mulch*variety | <.0001 | 0.5813 | 0.0109 |

Means within columns with no common letter (s) are significantly different according to Student Newman-Keuls (SNK) multiple range test at 5% probability ($p<0.05$).

**Growth characteristics of okra**

Both variety and mulch materials had significant ($p<0.05$) effect on plant height, stem diameter, number of leaves and leaf area at the various sampling periods (Table 3). Plant height of Comi (Local) variety was significantly ($p<0.05$) higher (33.25cm) than Clemson spineless (Improved) variety (23.30cm). Stem diameter, number of leaves and leaf area of okra showed similar pattern like plant height in the order of Comi > Clemson spineless. The *Carica papaya* leaf mulch treatment recorded significantly ($p<0.05$) the highest plant height (51.26cm) followed by *Azadirachta indica* leaf mulch (37.98cm) than all other mulch materials. The control treated plots had significantly ($p<0.05$) lower plant height (8.82cm) than treatments. This result is corroborated with the findings of Roy *et al*. (2010) [24].

Analysis of variance revealed that stem diameter showed varietal differences, with Comi variety recording significantly ($p<0.05$) higher (1.04cm) stem diameter than Clemson spineless (0.68). The untreated plots (Control) recorded significantly ($p<0.05$) lower (0.29cm) stem diameter, while *Carica papaya* leaf mulch treatment was greatest throughout the sampling periods and had significantly ($p<0.05$) higher (1.47cm) stem diameter followed by *Azadirachta indica* leaf mulch (1.17cm). Additionally, stem diameter of *Imperata cylindrica* and *Gmelina arborea* leaf mulches were not statistically different, but *Imperata cylindrica* leaf mulch recorded broader (0.78cm) stem diameter than *Gmelina arborea* (0.60cm) leaf mulch.

Number of okra leaves $Plant^{-1}$ were significantly ($p<0.05$) affected by both variety and mulch materials. The result showed that plots planted with Comi variety had significantly higher (13.45 $plant^{-1}$) number of leaves than Clemson spineless (10.35 $plant^{-1}$). At the various sampling occasions, plots treated with *Carica papaya* leaf mulch significantly recorded the greatest (19.33 $plant^{-1}$) number of leaves than all other mulch treatments, whereas lower number of leaves were observed in the control plots (5.27 $plant^{-1}$).

The results in Table 3 indicates that Comi (25.33cm) variety had significantly ($p<0.05$) broader leaf area, whereas narrower leaf area was noted in the Clemson spineless (19.15cm) variety. In the case of mulching, *Carica papaya* leaf mulch recorded significantly ($p<0.05$) broader leaf area (33.49cm) than all other treatments. Narrower leaf area was significantly ($p<0.05$) observed in the control plots, while *Azadirachta indica* (27.15cm) and *Imperata cylindrica* (22.32cm) leaf mulches as indicated by Student Newman-Keuls multiple range test was not statistically significant at 5% level of probability. The interaction between variety and mulch materials did not also show significant ($p<0.05$) effect among plant growth and development characteristics of okra.

**Table 3:** Effect of variety and mulch materials on growth characteristics of okra

| Treatment | Plant height (cm) | Stem girth (cm) | Leaf number (Plant$^{-1}$) | Leaf area (cm) |
|---|---|---|---|---|
| **Variety** | | | | |
| Comi | 33.25$^{a}$ | 1.04$^{a}$ | 13.45$^{a}$ | 25.33$^{a}$ |
| Clemson spineless | 23.30$^{b}$ | 0.68$^{b}$ | 10.35$^{b}$ | 19.15$^{b}$ |
| Pr > F | 0.0003 | 0.0003 | 0.0285 | 0.0004 |
| **Mulch materials** | | | | |
| *Carica papaya* | 51.26$^{a}$ | 1.47$^{a}$ | 19.33$^{a}$ | 33.49$^{a}$ |
| *Azadirachta indica* | 37.98$^{b}$ | 1.17$^{b}$ | 15.11$^{ab}$ | 27.15$^{b}$ |
| *Imperata cylindrica* | 26.08$^{c}$ | 0.78$^{c}$ | 11.29$^{bc}$ | 22.32$^{b}$ |
| *Gmelina arborea* | 17.22$^{d}$ | 0.60$^{c}$ | 8.51$^{cd}$ | 17.04$^{c}$ |
| Control | 8.82$^{e}$ | 0.29$^{d}$ | 5.27$^{d}$ | 11.19$^{d}$ |
| Pr >F | <.0001 | <.0001 | <.0001 | <.0001 |
| Pr >F: Mulch*variety | 0.2070 | 0.8370 | 0.9937 | 0.9712 |

Means within columns with no common letter (s) are significantly different according to Student Newman-Keuls (SNK) multiple range test at 5% probability ($p$<0.05).

**Yield attributes**

Yield characteristics results in Table 4 shows that variety and mulch materials had significant ($p$<0.05) effect on the yield and length of okra pods. The local variety (Comi) produced significantly ($p$<0.05) the highest pod yield (2.35 t ha$^{-1}$) with 47.23% yield increase over Clemson spineless. Similarly, pod length and weight of okra showed that the Comi variety produced longer pod length (6.71cm) with 39.79% pod length and pod weight (220.49g plant$^{-1}$) with 67.28% increase over Clemson spineless. For mulching effects, the control treatment had significantly ($p$<0.05) the lowest pod yield (0.85 t ha$^{-1}$), pod length (3.03cm) and pod weight (92.10 g plant$^{-1}$), which could be attributed to greater number of insect attack, weeds and damaged leaves in the control plots. *Azadirachta indica* leaf mulch significantly ($p$<0.05) produced higher pod yield (2.79t ha$^{-1}$), pod length (7.01cm) and pod weight (233.18 g plant$^{-1}$) than the other mulch materials. The higher yield and yield components of Comi variety could be ascribed that the variety efficiently converts photosynthetic materials into yield. Thus increase in yield was attributed to the maximum number of pods, hence similar finding has also been found by Islam *et al*. (2007) [13].

**Table 4:** Effect of variety and mulch materials on yield attributes of okra

| Treatment | Pod yield (t ha$^{-1}$) | Pod length (cm) | Pod weight (g plant$^{-1}$) |
|---|---|---|---|
| **Variety** | | | |
| Comi | 2.35$^{a}$ | 6.71$^{a}$ | 220.49$^{a}$ |
| Clemson spineless | 1.24$^{b}$ | 4.04$^{b}$ | 72.13$^{b}$ |
| Pr > F | <.0001 | <.0001 | <.0001 |
| **Mulch materials** | | | |
| *Carica papaya* | 1.72$^{b}$ | 5.27$^{b}$ | 118.60$^{b}$ |
| *Azadirachta indica* | 2.79$^{a}$ | 7.01$^{a}$ | 233.18$^{a}$ |
| *Imperata cylindrica* | 2.22$^{ab}$ | 6.65$^{a}$ | 182.63$^{a}$ |
| *Gmelina arborea* | 1.41$^{bc}$ | 4.91$^{b}$ | 105.03$^{b}$ |
| Control | 0.85$^{c}$ | 3.03$^{c}$ | 92.10$^{b}$ |
| Pr > F | <.0001 | <.0001 | 0.0006 |
| Pr > F: Mulch*variety | 0.1677 | 0.1838 | 0.0208 |

Means within columns with no common letter (s) are significantly different according to Student Newman-Keuls (SNK) multiple range test at 5% probability ($p$<0.05).

**Correlation analyses**

Correlation coefficients was worked out to study the relationship of pod yield with plant height, stem girth, leaf number, leaf area, insect number, leaf damaged, pod length, pod width, petiole length and internode length are summarized in Table 5. The results of correlation coefficients indicated that pod yield of okra was moderately and positively correlated with pod width (r = 0.59) and depletion by leaf area (r = 0.37022) and plant height (r = 0.35425) at 5% level of significance. In addition, leaf area was moderately and positively correlated with plant height (r = 0.65102) and stem girth (r = 0.61302), and internode length was significantly ($p$<0.05) and positively correlated with petiole length (r = 0.71247)

**Table 5:** Correlation coefficients showing relationship between okra pod yield (kg/ha) and independent variables

| Independent variables | Yield | Plant height | Stem girth | Leaf number | Leaf area | Insect number | Leaf damaged | Pod length | Pod width | Petiole length | Internode length |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yield | 1.00000 | | | | | | | | | | |
| Plant height | 0.35425** | 1.00000 | | | | | | | | | |
| Stem girth | 0.06043 | 0.59634** | 1.00000 | | | | | | | | |
| Leaf number | 0.26565 | 0.41860** | 0.49096** | 1.00000 | | | | | | | |
| Leaf area | 0.37022** | 0.65102** | 0.61302** | 0.49952** | 1.00000 | | | | | | |
| Insect number | 0.06480 | 0.14563 | 0.17844 | 0.07972 | 0.18203 | 1.00000 | | | | | |
| Leaf damaged | 0.11522 | 0.04733 | -0.16390 | -0.19750 | 0.06877 | 0.20604 | 1.00000 | | | | |
| Pod width | 0.59129** | 0.16677 | 0.01060 | 0.27978 | 0.13634 | -0.13425 | -0.11398 | 1.00000 | | | |
| Pod length | 0.00778 | 0.33307 | 0.25193 | 0.19377 | 0.04974 | 0.28468 | 0.03894 | 0.16449 | 1.00000 | | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Petiole length | 0.13075 | 0.10614 | 0.06344 | 0.31829 | 0.04318 | -0.17235 | -0.15924 | 0.46596** | 0.24025 | 1.00000 | |
| Internode length | -0.06066 | -0.02665 | 0.09774 | 0.18011 | -0.11789 | -0.23117 | -0.13118 | 0.44966** | 0.02968 | 0.71247** | 1.00000 |

**Key:** **Significant at ($P<0.05$)

## Conclusion

The findings of this study revealed that all the mulch materials exhibited some level of insecticidal and herbicidal properties, but *Azadirachta indica* and *Imperata cylindrica* leaves however proved to be the most effective in the control of *Podagrica uniforma* L. *Imperata cylindrica* leaf mulch significantly ($p<0.05$) decreased the density of grass and broadleaved weeds, whereas lower sedge weed density was recorded in plots treated with *Azadirachta indica* leaf mulch. Okra growth characteristics were greatest in plots mulched with *Carica papaya* leaves. *Azadirachta indica* leaf mulch significantly produced higher pod yield (2.79 t ha$^{-1}$), pod length (7.01cm) and pod weight (233.18 g plant$^{-1}$) than the other three plants species evaluated. Comi (Local) variety was superior in growth and yielded greater than Clemson spineless (Improved) variety. Therefore, this study is significant for the management of *Podagrica uniforma* L. and weeds without the use of synthetic pesticides which causes environmental pollution, cost involved, skills and equipment required for application. The study revealed that pod yield correlated positively with pod width, leaf area positively correlated with plant height and stem girth, and internode length positively correlated with petiole length.

It is therefore recommended to use *Azadirachta indica* as mulching material or bio-insecticides in integrated pest management of okra in Sierra Leone. Further studies should be done to evaluate *Azadirachta indica*, *Carica papaya*, *Imperata cylindrica* and *Gmelina arborea* in controlling other insect pests of okra.

## References


1. Abbasi NA, Zafar L, Khan HA, Qureshi AA. Effects of naphthalene, acetic acid and calcium chloride application on nutrient uptake, growth, yield and post-harvest performance of tomato fruit. Pakistan Journal of Botany. 2013; 45(5):1581-1587.
2. Adetuyi FO, Osagie AU, Adekunle AT. Nutrient, antinutrient, mineral and zinc bioavailability of okra *Abelmoschus esculentus* (L) Moench Variety. American Journal of Food and Nutrition. 2011; 1:49-54.
3. Aggarwal, Sonia, Korla BN, Raina JN. Effects of mulches on soil hydrothermal regimes, weed incidence, yield and quality of ginger. Journal of the Indian Society of Soil Science. 2003; 51:65-67.
4. Ahmed BI, Abdlhameed A, Yusuf SR, Aliyu M. Comparative study of the defoliators activities of *Podagrica sjostedti* and *Podagrica uniforma* (Coleoptera: Chrysomelidae) on two intercropped okra varieties in Bauchi State, Nigeria. Savannah Journal of Agriculture 2006; 1(1):12-14.
5. Akintoye HA, Adebayo AG, Aina OO. Growth and yield response of okra intercropped with live mulch. Agricultural Research 2011; 5:146-153.
6. Akinyele BO, Temikotan T. Effect of variation in soil texture on the vegetative and pod characteristics of okra (*Abelmoschus esculentus* (L.) Moench). International Journal of Agricultural Research. 2007; 2:165-169.
7. Bhardwaj Rl. Effect of mulching on crop production under rainfed condition- a review. Agricultural Review. 2013; 34 (3):188-197.
8. DenHollander NG, Bastiaans L, Kropff MJ. Clover as a cover crop for weed suppression in an intercropping design. I. Characteristics of several clovers species. European Journal of Agronomy. 2007; 26:92-103.
9. Echezona BL, Offordile JI. Responses of flea beetles (*Podagrica spp*.) and okra plants (*Abelmoschus esculentus* L. Moench) to differently coloured polyethylene shades. International Journal of Pest Management. 2011; 57(2):161-168.
10. Edet GE, Etim NA. Economic analysis of okra production: A case of Ivo Local Government Area of Ebonyi State, Nigeria. Nigerian Journal of Agriculture, Food and Environment. 2010; 6 (1&2):99-103.
11. Ek-Amnuay P. Plant diseases and insect pests of economic crops. Amarin Printing and Publishing Public Co. Ltd, Bangkok, Thailand, 2007, 379.
12. Fasunwon BT, Banjo AD. Seasonal population fluctuations of *Podagrica* Species on okra plant (*Abelmoschus esculentus*). Research Journal Agriculture and Biological. Sciences. 2010; 6:283-288.
13. Islam MJ, Hossain AKMM, Khanam F, Majumder UK, Rahman MM, Rahman MS. Effect of mulching and fertilization on growth and yield of garlic at Dinajpur in Bangladesh. Asian Journal of Plant Sciences. 2007; 6(1):98-101.
14. Izuogu NB, Oyedunmade EEA, Olabiyi TI, Oluwatayo II, Abolusoro SA. Control of Nematode pests of Okra (*Abelmoschus esculentus* L. Moench) using two plant materials and carbofuran. Nigerian Journal of Horticultural Science. 2011; 16:33-40.
15. Johnson JM, Hough-Goldstein JA Vangessel MJ. Effects of straw mulch on pest insects, predators, and weeds in watermelons and potatoes. Environ. Entomol. 2004; 33:1632-1643.
16. Kruidhof HM, Bastiaans L, Kropff MJ. Ecological weed management by cover cropping: Effects on weed growth in autumn and weed establishment in spring. Weed Research. 2008; 48:492-502.
17. Kundu DK, Singh R, Chowdury RS. Effect of rice straw mulch and irrigation on nutrient availability in soil and tuber yield of sweet potato (*Ipomoea batatas* L.) in Coastal Orissa. In: Naskar SK, Nedunchezhiyan M, Rajasekhara RK, Sivakumar PS, Ray RC, Misra RS *et al*. (eds.), Root and tuber crops: in nutrition, food security and sustainable environment. Regional centre of CTCRI, ICAR, Bhubaneswar, 2006, 117-122.
18. Maurya RP, Bailey JA, Chandler JS. Impact of Plant Spacing and Picking Interval on the Growth, Fruit Quality and Yield of Okra (*Abelmoschus esculentus* L. Moench). American Journal of Agriculture and Forestry. 2013; 1 (4), 48-54.
19. Memon AJ, Abro GH, Syed TS. Varietal resistance of okra against *Earias* spp. Journal of Entomology. 2004; 1:1-5.
20. Mihretu Y, Wayessa G, Adugna D. Multivariate Analysis among Okra (*Abelmoschus esculentus* L.) Moench) Collection in South Western Ethiopia. Journal of Plant Sciences. 2014; 9:43-50.
21. Pavela R, Sajfrtova M, Sovova H, Karban J, Barnet M. The effects of extracts obtained by supercritical fluid

extraction and traditional extraction techniques on larvae *Leptinotarsa decemlineata* Say. Journal of Essential Oil Research. 2009; 21:367-373.
22. Pavela R. Possibilities of botanical insecticide exploitation in plant protection. Pest Technology. 2007; 1:47-52.
23. Reeleder RD, Capell BB, Roy RC, Grohs R, Zilkey B. Suppressive effect of bark mulch on weeds and fungal diseases in ginseng (*Panax quinquefolius* L.). Allelopathy. Journal. 2004; 13:211-232.
24. Roy S, Arunachalam K, Dutta BK, Arunachalam A. Effect of organic amendments of soil on growth and productivity of three common crops viz. *Zea mays*, *Phaseolus vulgaris* and *Abelmoschus esculentus*. Applied Soil Ecology. 2010; 45(2):78-84.
25. Senjobi BA, Ande OT, Senjobi CT, Adepiti AO, Adigun MO. Performance of *Abelmoschus esculentus* (L.) Moench under various applications of pesticides and fertilizers in an Oxic Paleustalf. International Journal of Plant and Soil Sciences. 2013; 2(1):24-40.
26. Silva DV, Santos JB, Carvalho FP, Ferreira EA, França AC, Fernandes JSC *et al*. Seletividade de herbicidas pós-emergentes na cultura da mandioca. Planta Daninha. 2012; 30:835-841.
27. Singh R, Sharma RR, Goyal RK. Interacting effects of planting time and mulching on “Chandelier” strawberry. (*Fragaria* x *ananassa* Dutch.). Scientific Horticulture. 2007; 111:344-351.
28. Teasdale JR, Abdul-Baki AA, Mill DJ, Thorpe KW. Enhanced pest management with cover crop mulches. Acta Horticulture (ISHA). 2004; 638:135-140.