

Full Length Research Paper

Growth and yield response of okra (*Ablemochus esculentus*) to varying rates of different sources of organic soil amendments at Njala, Moyamba District, Southern Sierra Leone

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Synthetic fertilizers and pesticides in vegetable production have negatively impacted the soils, water quality, food security and health of farmers and consumers. Hence, sustainable, economically feasible, environmentally friendly soil fertility, pests and disease management options are needed to improve vegetable production. This study evaluated the growth and yield of okra due to varying rates of different sources of organic soil amendments to promote its productivity and tolerance in Sierra Leone. A randomized complete block design (RCBD) with three (3) replicates and ten (10) treatments was used. The treatments included; *Gliricidia sepium*, chicken manure and cow dung applied as sole treatments and in combination with papaya leaf and neem leaf as biopesticides. Data was collected on the growth, yield and percentage leaf damage of okra. Analysis of Variance (ANOVA) showed significant differences in treatment means. The application of poultry manure in combination with papaya leaf gave the most satisfactory performance in all parameters compared to chicken manure, *G. sepium*, and cow dung in sole application, and their combined applications with paw-paw leaf and neem leaf. Incidence of pest (*Podagrica* spp) was minimal with the application of poultry manure in combination with papaya leaf, resulting in less severity leaf damage on okra.

Key words: Okra, Organic, Biopesticides, Pest, Productivity, Tolerance.

INTRODUCTION

Poor fertility status of soils combined with pest and disease problems are the major constraints facing okra productivity and other vegetables in Sierra Leone. Okra (*Abelmoschus esculentus* L.) belongs to the Malvaceae family and is one of the most popular fruit vegetables cultivated in Africa (Schippers, 2000). The West and

Central Africa region accounts for more than 75% of okra produced in Africa but the average productivity in the region is very low (2.5 t/ha) compared to East Africa (6.2 t/ha) and North Africa (8.8 t/ha) (FAOSTAT, 2006). Nigeria is the largest producer (1,039,000 t) followed by Cote d'Ivoire and Ghana (FAOSTAT, 2008).

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Okra cultivation requires nutrients such as nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), sodium (Na) and Sulphur (S) for fertility maintenance and crop production. Lack of sufficient amounts of these nutrients results in poor performance and low yields of okra (Chauhan, 1972; Shukla and Naik, 1993). As a result, there is increase in the use of synthetic fertilizers and pesticides by vegetable growers and agriculturist with the aim of promoting the growth of the plant and to protect the growing plants from pests.

The increase in the use of synthetic fertilizers and pesticides has brought along substantial negative impacts to farmers and their surrounding environment. Cases of acute pesticide poisoning (APP) account for significant morbidity and mortality worldwide, especially in developing countries (Kishi and Ladou, 2001; Jeyaratnam, 1990). Studies in developed countries have demonstrated the annual incidence rates of APP in agricultural workers to be as much as 18.2 per 100 000 full time workers (Calvert et al., 2004) and 7.4 per million among schoolchildren (Alarcon et al., 2005). The irrational use of synthetic pesticides by farmers without following instructions and regularity of their use is increasing pest resistance to these pesticides. Indiscriminate use of synthetic fertilizers and pesticides may result in toxicity which affects farmers, and the ecosystems may also become unbalanced. The application of synthetic chemicals of different types in the environment will result to accumulation of their residues in soil and water bodies that adversely affect the entire ecosystem.

However, the nutritional quality of okra can be influenced by the application of organic fertilizers amendments. Organic amendments help to improve the physical condition of soil and provide adequate amount of nutrients for the soil productivity (Qhureshi, 2007). However, organic manure rely on soil organisms to break down organic matter in the soil, as a result, nutrients are released more slowly. This slow-release method reduces the risk of nutrient leaching (Renee, 2018). On the contrary, inorganic fertilizers release nutrients quickly, but most of them leach out easily. Most of the inorganic fertilizers used in conventional agriculture mainly contain NPK and the long-term application of inorganic fertilizers could lead to serious soil acidification, nutritional imbalance, and deterioration of the rhizosphere micro-ecological environment, which further increased the activity of heavy metal ions in soil (Lin et al., 2019). Application of excess inorganic fertilizer leads to higher pest and disease attacks and also destroys the soil microorganisms. Hence, sustainable farming gears towards making the best use of natural resources without damaging the environment and indigenous agricultural knowledge is a vital part of the process of making agriculture sustainable (Ramprasad et al., 2009). This has encouraged scientists towards making use of organic materials (both organic manures as well as organic

wastes) for improving the physical properties of soils that allow profitable crop production (Somani and Totawat, 1996). The use of organic amendments applied to soil not only enhances its nutrient status but also reduces the incidence of soil pests (Adilakshmi et al., 2010).

The use of organic manures as a means of maintaining and increasing soil fertility has been advocated by many researchers (Alasiri and Ogunkeye, 1999). And some of these organic manures have also been found to control pathogens (Muhammed et al., 2001). Organic fertilizers when used efficiently, ensure sustainable soil productivity by immobilizing nutrients that are susceptible to leaching. Nutrients contained in organic fertilizers are released more slowly and are stored for a longer time in the soil, thus ensuring longer residual effects, improving root development and higher crop yields (Sharma and Mittra, 1991; Abou-Magel et al., 2006).

Various pest management methods have been used to protect crops from pests, increase crop yields, and improve food security. Smallholder farmers in Africa rely heavily on the use of synthetic pesticides to control pests in vegetables (Phophi et al., 2020). Other pest control methods are needed, such as plant materials (biopesticides) and their extracts, as well as cultural methods to increase crop yields. The use of biological control to manage problem pests is an environmentally friendly method that will not pose any danger to farmers and consumers (Lundström et al., 2017). Plant materials and their extracts have been used for more than 150 years, and most small farmers in Africa have been effectively using various plant materials to control problematic pests (El-Wakeil, 2013). These plant materials contain different chemicals or compounds and modes of action, and have different characteristics, such as insect repellants, insecticides, anti-food, growth inhibitors, oviposition inhibitors, ovocidal and the growth of a variety of pests (Beltagy and Omar, 2016). Various plant materials and other natural products, such as pepper, tobacco, neem, moringa, lantana, aloe, cow manure and urine, ash, etc. are used for pest management (Mugisha-Kamatenesi et al., 2008). The knowledge and use of plant materials to protect plants from pests has existed for decades (Isman, 2000). However, farmers in Sierra Leone still do not consider it an alternative to synthetic pesticides due to many factors, including the lack of field research (Belmain et al., 2013). Researchers and scientists should conduct more field studies to stimulate local knowledge of small farmers about plant materials for pest management; this is one of the few studies whose main objective is to evaluate the growth and yield of okra to varying rates of different sources of organic soil amendments for okra production in Southern Sierra Leone. The organic fertilizer sources; chicken manure, *Gliricidia sepium*, and cow manure were treated as separate treatments and combined with papaya leaves and neem leaves as biological pesticides for this experiment.

Table 1. The different treatment and their rates of applications.

No.	Treatment	kg/ha	kg/Plot	kg/hill	Ton/ha
1	Chicken manure	5000	4.5	0.225	5
2	<i>Gliricidia sepium</i>	5000	4.5	0.225	5
3	Cow dung	5000	4.5	0.225	5
4	Control	-	-	-	-
5	Chicken manure + pawpaw leaf	5000	4.5	0.225	5
6	Chicken manure + neem leaf	5000	4.5	0.225	5
7	Cow dung + neem leaf	5000	4.5	0.225	5
8	Cow dung + pawpaw leaf	5000	4.5	0.225	5
9	<i>Gliricidia sepium</i> + neem leaf	5000	4.5	0.225	5
10	<i>Gliricidia sepium</i> + pawpaw leaf	5000	4.5	0.225	5

MATERIALS AND METHODS

Location and climate of study area

The study area was located at the School of Agriculture (SOA) experimental site, Njala University, kori chiefdom, Moyamba District, Southern Sierra Leone during the 2019 raining season. Moyamba district is located on Latitude: 8.162051° and Longitude: -12.435192° with an Elevation of 61 m above sea level.

The mean annual rainfall of the study area totals around 2800 mm. The maximum mean annual rainfall occurs between the month of July and September with a maximum of 20-25 days per month falls. The study area experiences a dry period starting from end of November to end of March. However, the study area also experiences an intermittent rainfall pattern from end of October with intervals of about 3-5 days between one rainfall and another. The temperature ranges from 24.6 to 32°C. However, temperatures vary in diurnal and seasonal patterns with maximum in March and April and minimum in July and August because of high rain within the month of July and August. The relative humidity was 95-100% from July to September and it dropped to as low as 20% in December/January during the harmattan period.

Description of experimental site and site preparation

The experimental site selected was flat and had been cropped with cowpea and maize respectively in previous years. The dominant soils in Njala belong to the Ultisols and Oxisols series. The soil of the experimental sites was gravelly, the gravel content varies with the depth of the soil, it decreases gradually with depth and is replaced at a depth of about 2.4 m or more with red plinthite mottles in a pale to white matrix. The textures are generally clay with gravel in the surface soil. The colour of the topsoil ranges from dark to greyish brown. The soil drains well and is never waterlogged. Njala soil has a very low nutritional status for plants.

The study area was measured to an area of 38 m × 11 m and had previously been cropped for two to three years. The area selected was first brushed and cleared, later ploughed by native Indian hoe to obtain a depth of about 5-10 cm and harrowed a week later. The total land area selected for this study was 418 m² with

three replications, each replication consisting of 10 small plots. Each plot had a total area of 3 m × 3 m (9 m²) and 0.5 m between each plots and 1.0 m between replications to serve as a footpath.

Experimental design, okra variety, and description of treatment

The experimental design used was randomized complete block design (RCBD). An improved Clemson spineless okra variety was used to carry out this experiment. It produces dark green edible pods suitable for use in culinary dishes that include soups and stews. Unlike other okra varieties, the leaves and stems of the "Clemson Spineless" plant are spine-free, allowing gardeners to touch it without any resulting irritation. This herbaceous warm-season vegetable reaches heights of 4 to 5 ft.

The organic fertilizers used were applied as sole treatment and each of these three organic fertilizers was applied in combination with each of the bio-pesticides (papaya leaf and Neem leaf). There were ten (10) treatments in this experiment (Table 1). The biopesticides leaves were chopped and weighed separately. The treatments were allocated to plots using a raffling method.

The different treatments rates were measured with a beam balance scale and applied to every plant hill accordingly.

Planting methods

The seeds were directly sown to the field two weeks after the application of the treatments at the spacing of 80 cm between rows and 60 cm between plants and 2 seeds per hole maintaining the depth of 2 cm. Planting population per plot was 40 stands and the overall population was 55,500 stands/hectare.

Data collection

In each plot, five plants were randomly selected and tagged for data collection. The parameters for data collection were as follows; plant height, stem girth, leaf number, leaf length, leaf breadth, leaf area, untagged pod weight, tagged pod weight, tagged pod number, pod length, pod girth. The sampling observation period for growth data

collections were 3, 6, and 9 weeks after planting (WAP).

The plant height was measured from the base to the terminal bud of the plant and the values were recorded. Leaf length and leaf breadth were measured with a centimeter ruler. Numbers of leaves on tagged plants were counted physically and the values were recorded. Stem girths were measured from 5 cm above the ground level using a manual vernier caliper. Leaf area was measured by multiplying the length of the leaf by the breadth. Percentage leaf damaged was obtained by dividing the number of leaves damaged by insect pest by the total number of leaves per plant and the values obtained were multiplied by 100. Tagged pod number was physically counted and values recorded. Fruit pod girth was obtained using a calliper. Pod length was measured from the base of the pod to the tip using a ruler in centimetres. Tagged pod weight and untagged pod weight was got using an electronic scale. Harvesting was done manually at the early hours of the day and in the evening using a sharp knife after the crop has reached physiological maturity.

Data analysis

The data collected was subjected to ANOVA statistical analysis procedures using GenSTAT software and means were separated using least significant difference (LSD) at (5%) probability. The severity of the pest damage was visually assessed at 9 WAP using a modified 0 to 5 scale (Kirsh, 1986).

RESULTS

Mean leaf number, plant height and stem girth as affected by treatments

Leaf number

Results of the mean leaf number of the okra variety are presented in Figure 1. However, the differences in mean number of leaf with respect to the different sources of organic soil enhancement was significantly different ($P < 0.05$) at 3 and 9 weeks after planting (WAP) but was not significantly different at 6 WAP.

As the plants grew from 3, 6 to 9 WAP, the highest mean leaf numbers (7.27, 17.47 and 8.47) were recorded respectively at the different observation periods for the plot enhanced with the application of chicken manure in combination with papaya leaf. This was statistically at par with the mean leaf numbers (6.13, 10.73 and 8.27) obtained in the plot with application of chicken manure in combination with neem leaf at the different observation periods. The lowest mean numbers of leaves (3.80, 4.00 and 4.47) across the observation periods were obtained in the plot with no soil amendment (control). With respect to sole organic soil enhancement, chicken manure continued to maintain the trend of growth and recorded the highest mean values (5.00, 7.67 and 5.87) amongst other treatments.

Plant height (cm)

Results of the mean plant height measurement of the

okra variety tested are presented in Figure 1. There was variation in the mean plant height as the plant grew per observation period. The differences in mean plant height with respect to the different sources of organic soil enhancement was however not significantly different ($P < 0.05$) at 3 WAP but was significantly different at 6 and 9 WAP. From 3, 6 to 9 WAP of growth, the tallest mean plant height (11.04, 48.75 and 69.87 cm), were respectively recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf; statistically, these means were at par with the means (10.93, 46.33 and 68.86 cm) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. The shortest mean plant heights (6.99, 21.74 and 40.95 cm) were obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure continue to maintain the highest mean plant height values (8.09, 31.09 and 47.96) at the different observation periods compared to other treatment.

Stem girth (cm)

Results of the mean stem girth measurement of the okra variety tested are presented in Figure 1. There was a small range of variation in the mean stem girth as the plant grows per week. The statistical analysis showed that significant differences ($P < 0.05$) existed in the mean stem girth with respect to the different sources of organic soil enhancement. At the different observation periods (3, 6 and 9 WAP), the largest mean stem girths (0.41, 1.31 and 1.41 cm) were recorded for the plot enhanced with the application of chicken manure in combination with paw-paw leaf. Statistically, this means were at par with the means (0.38, 1.25 and 1.35 cm) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. The smallest mean stem girths (0.15, 0.62 and 0.80 cm) were obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure also maintained the highest mean stem girth values (0.21, 0.75 and 0.93 cm) in all respects.

Mean leaf length, leaf breadth and leaf area as affected by treatment

Leaf length (cm)

Results of the mean leaf length measurement of the okra variety tested are presented in Figure 2. Statistical analysis showed that no significant differences ($P < 0.05$) existed at 3 and 6 WAP but was significantly different at 9 WAP.

However, at 3, 6 and 9 WAP, the longest mean leaf lengths (7.82, 22.13 and 16.53 cm) were recorded for the plot enhanced with the application of chicken manure in

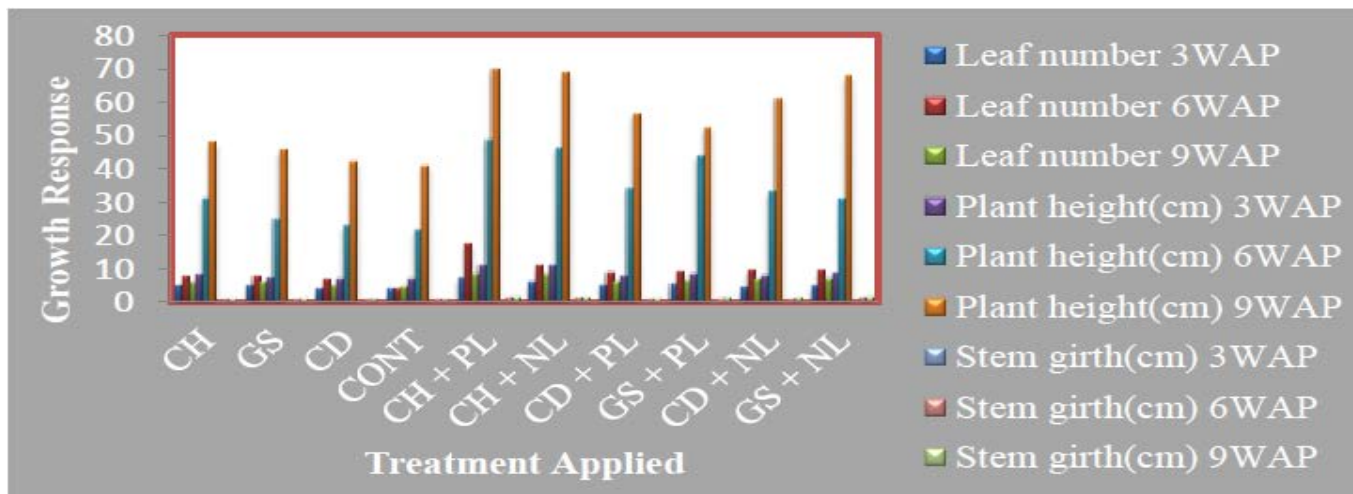


Figure 1. Effect of varying rates of different sources of organic soil amendments on the Mean Leaf number, Plant height, and Stem girth as the plant grows from across the three sampling periods of observations. Chicken manure (CH), *Gliricidia sepium* (GS), Cow Dung (CD), Control (CONT), Paw-paw leaf (PL), Neem Leaf (NL).

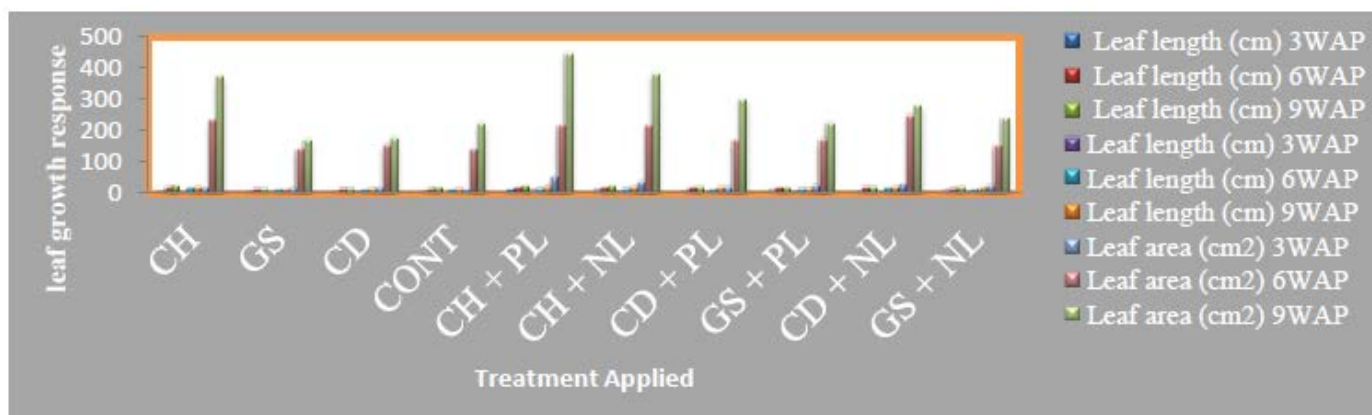


Figure 2. Effect of varying rates of different sources of organic soil amendments on the Mean leaf length, leaf breadth and Leaf area as the plant grows across the three sampling periods of observations. Chicken manure (CH), *Gliricidia sepium* (GS), Cow Dung (CD), Control (CONT), Paw-paw leaf (PL), Neem Leaf (NL).

combination with papaya leaf. Statistically, these means were at par with the means (6.56, 20.55 and 15.51 cm) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. The shortest mean leaf lengths (3.51, 11.58 and 12.65 cm) were obtained in the plot with no soil (0 g application) enhancement (control) throughout the different observation periods. With respect to sole organic soil enhancement, chicken manure continued to maintain the highest mean values (4.23, 14.83 and 13.95) amongst other treatments as the plant grows from 3 to 9 WAP.

Leaf breadth (cm)

Results of the mean leaf breadth measurement of the

okra variety tested are presented in Figure 2. There were however no significant differences in the mean leaf breadth ($p < 0.05$) at 3 WAP but significant differences were found at 6 and 9 WAP. At 3, 6 and 9 WAP, the widest mean leaf breadths (5.94, 19.75 and 14.69 cm) were recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf. Statistically, these means were at par with the means (4.90, 18.12 and 14.02 cm) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf while the narrowest mean leaf breadth (2.88, 9.65 and 10.94 cm) was obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure continues to maintain the highest mean values (3.33, 13.27 and 11.92 cm) amongst others.

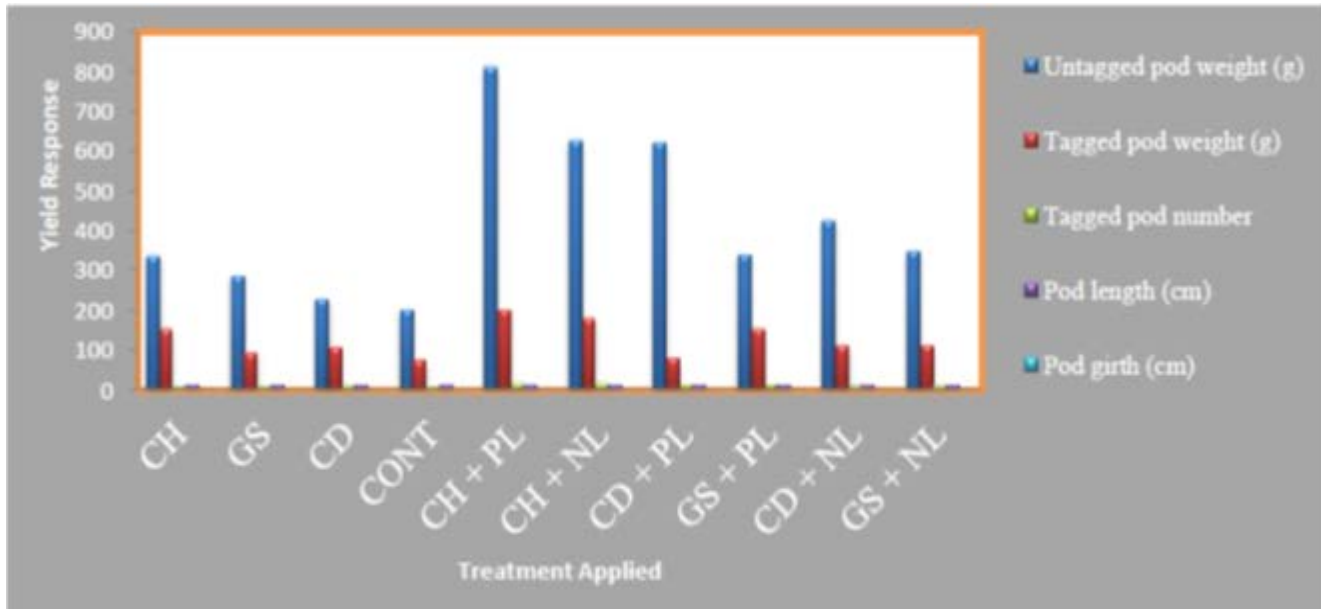


Figure 3. Effect of varying rates of different sources of organic soil amendments on the mean untagged pod weight, tagged pod weight, tagged pod number, pod length and pod girth at harvest. Chicken manure (CH), *Gliricidia sepium* (GS), Cow Dung (CD), Control (CONT), Paw-paw leaf (PL), Neem Leaf (NL)

Leaf area (cm²)

Results of the mean leaf area (cm²) measurement of the okra variety tested are presented in Figure 2. There were significant differences ($P < 0.05$) in mean leaf area with respect to the different sources of organic soil enhancement at 3 and 9 WAP but difference was not significant at 3 WAP.

The widest mean leaf areas (49.95, 247.98 and 447.20 cm²) were recorded respectively at 3, 6 and 9 WAP for the plot enhanced with the application of chicken manure in combination with papaya leaf. Statistically, these means were at par with the means (35.97, 381.28 and 231.98 cm²) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. The narrowest mean leaf areas (11.40, 137.53 and 166.44 cm²) were obtained in the plot with no soil (0 g application) enhancement (control). Looking at the sole organic soil enhancement, chicken manure continues to maintain the highest mean values (15.63, 209.86 and 177.45 cm²) amongst others.

Mean untagged pod weight, tagged pod weight, tagged pod number pod length and pod girth as affected by treatment at harvest

Untagged pod weight (g)

Results of the mean untagged pod weight of the okra variety tested are presented in Figure 3. The difference in

mean pod weight with respect to the different sources of organic soil enhancement was not significantly different ($P < 0.002$).

The highest mean untagged pod weight (808.75 g) was recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf. Statistically, this mean was at par with the mean (626.67 g) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. The smallest mean untagged pod weight (200.57 g) was obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure continues to maintain the highest mean values (336.09 g) amongst others.

Tagged pod weight (g)

Results of the mean tagged pod weight of the okra variety tested are presented in Figure 3. The difference in mean tagged pod weight with respect to the different sources of organic soil enhancement was not significantly different ($P < 0.034$). The highest mean tagged pod weight (197.98 g) was recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf. Statistically, this mean was at par with the mean (179.29 g) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. The smallest mean untagged pod weight (73.25 g) was obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole

Table 2. Showing Mean incidence and severity of *Podagrica spp.* as affected by treatment on okra

Treatment	Incidence %	Severity
Chicken manure	53.1	2.4
<i>Gliricidia sepium</i>	58.1	2.6
Cow Dung	64.8	3.3
Control	96.4	4.7
Chicken manure + Paw-paw Leaf	13.1	0.9
Chicken Manure + Neem Leaf	33.1	1.5
Cow Dung + Paw-paw leaf	43.1	2.2
<i>Gliricidia sepium</i> + Paw-paw leaf	39.8	2.1
Cow Dung + Neem Leaf	51.4	2.5
<i>Gliricidia sepium</i> + Neem Leaf	38.4	2.8
F pr.	<.001	0.007
CV%	29.9	35
LSD	25.5	1.5

organic soil enhancement, chicken manure continues to maintain the highest mean values (152.17 g) amongst others.

Tagged pod number

Results of the mean tagged pod number of the okra variety tested are presented in Figure 3. However, the differences in mean number of pod with respect to the different sources of organic soil enhancement was significantly different ($P < 0.037$). The highest mean tagged pod number (14.89) was recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf, which was statistically at par with the application of chicken manure in combination with neem leaf (14.42). The lowest mean number of tagged pod (5.39) was obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure continues to maintain the highest mean values (6.06) amongst others.

Pod length (cm)

Results of the mean pod length of the okra variety tested are presented in Figure 3. However, the differences in mean pod length with respect to the different sources of organic soil enhancement was significantly different ($P < 0.05$).

The highest mean pod length (12.66 cm) was recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf which was statistically at par with the application of chicken manure in combination with neem leaf (12.48 cm). The lowest mean pod length (11.39 cm) was obtained in the plot with

no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure continues to maintain the highest mean values (12.01 cm) amongst others.

Pod girth (cm)

Results of the mean pod girth of the okra variety tested are presented in Figure 3. However, the differences in mean pod girth with respect to the different sources of organic soil enhancement was significantly different ($P < 0.05$). The highest mean pod girth (2.11 cm) was recorded for the plot enhanced with the application of chicken manure in combination with papaya leaf which was statistically at par with the application of chicken manure in combination with neem leaf (2.04 cm). The lowest mean pod girth (1.88 cm) was obtained in the plot with no soil (0 g application) enhancement (control). With respect to sole organic soil enhancement, chicken manure continues to maintain the highest mean values (1.97 cm) amongst others.

Results of the incidence and severity of pest in okra variety tested are presented in Table 2. The ANOVA analysis at 5% probability level using Genstat software however showed significant differences among the treatments. Still, the plot with the lowest mean incidence (13.1%) was recorded for the plot enhanced with the application of chicken manure in combination with paw-paw leaf. This was statically in line with the incidence mean (33.1) obtained in the plot enhanced with the application of chicken manure in combination with neem leaf. This was followed by the application of *G. sepium* in combination with neem leaf (38.4), and *G. sepium* in combination with papaya leaf (39.8). The highest percentage mean (96.4%) of pest incidence in this experiment was recorded in the plot with no soil

amendment (control).

The minimum mean severity (0.9) of damaged by insect pest of okra was registered in the plot enhanced with the application of chicken manure in combination with paw-paw leaf, and was at par with the plot enhanced with the application of chicken manure in combination with neem leaf (1.5). These were followed by cow dung + paw-paw leaf, *G. sepium* + Paw-paw leaf, Cow dung + Neem leaf, *G. sepium* + Neem leaf with severity mean values of (2.2, 2.1, 2.5 and 2.8) respectively. The maximum severity of damaged by insect pest of okra was registered in the plot with no soil (0 g application) enhancement (control). This plot has the plants with only fewer leaves intact, most leaves were eaten, but stems were green; it registered a mean severity of (4.7), one that was significantly different ($P > 0.05$) from the mean severity (0.9) of pest in the plot enhanced with the application of chicken manure in combination with paw-paw leaf.

DISCUSSION

A wide range of goals set by organic crop producers mainly is increasing the productivity of crops through the use of organic soil fertility enhancement and organic pest's control methods. In achieving this goal, the efficacy of two different pesticides from plant origin - neem leaf and pawpaw leaf in combination with selected known organic fertilizers – chicken manure, cow dung and *G. sepium* green manure to increase okra productivity were evaluated during the 2019 cropping season. With this focus, growth parameters of okra are highly significant in determining the effect of these combinations. Hence, the study was conducted focusing on the performance of the Clemson spineless okra variety with respect to growth and yield characteristics response. The results presented in Figures 1 to 3 indicate that organic soil enhancements are capable of significantly ($P < 0.05$) promoting productivity and tolerance of okra. Significant differences were observed in the mean values of the treated plots compared to the control plot.

The highest mean leaf number was significantly recorded for the chicken manure treatment in combination with papaya leaf and it was statistically similar with the application of chicken manure in combination with neem leaf. These differences might be related to the release of balanced nutrient contained in the poultry manure. This result is similar to the findings of Nweke et al. (2013) and Adesina et al. (2014) who reported increase in pepper leaves number due to increase in levels of poultry manure application. Also, there must have been disturbance in the eating activities of insect pests, which must have resulted in the high number of leaves. The papaya leaves contain the enzymes papain, saponins, flavonoids, and tannins these have a role as vegetable pesticides. The enzymes also work as stomach poisons

that enter through the mouthpiece of insects. Thereafter, the liquid enters through the insect's esophagus and then enters the digestive tract which will cause disruption of eating activities (Setiawan and Oka, 2015).

At the initial period of growth (3 WAP), there was no significant difference in plant height, but with the advance in time from 6 to 9 WAP, the application of chicken manure in combination with papaya leaf was significantly different compared to the control treatment in promoting plant height. Chicken manure in combination with neem leaf was observed to be significant. The later response of the okra can be attributed to the application of organic manures which may improve soil properties resulting in better supply of macro and micro nutrients for better growth of okra and maintaining soil fertility. This agrees with the study of John et al. (2004) who reported that PM contains essential nutrients which are associated with high photosynthetic activities that promote root and vegetable growth. This study shows that fertilization with PM could possibly sustain okra production under green agriculture in the tropics. Also, papaya leaf in mixture with the chicken manure might have helped to suppress the activities of the crop pest due to its systemic nature of assimilation into a plant compared to the other treatments. Papaya leaf, which is applied as a basal, has several advantages over the foliar insecticides. This is in agreement with studies by Karnataka (2008) who showed that the application of organic amendments significantly lowered aphid population.

The plots treated with the different chicken-based combination of bio-pesticides were significantly different in promoting the growth of the stem girth as compared to the untreated plot. However, the means obtained from the plot treated with chicken manure combined with paw-paw leaf and the plot treated with chicken manure combined with neem leaf was not significantly different. The smallest mean stem girth was obtained in the plot with no soil (0 g application) enhancement (control). The variations in stem girth may be attributed to a timely and better absorption of available nutrients which might have resulted in an increased photosynthetic ability of the crop, impacting greater cell division and expansion which have resulted in the production of larger stem. The results stressed the importance of organic manure during the vegetative growth of crop plants (Tindall, 1992). It might also be a combining effect of suppressing the insect pest by the organic manure applied. Prakash et al. (2002) also showed lower percentages of fruit borer infestation in okra when treated with organic fertilizer.

The features of the leaf measured were the leaf length, breadth and area. However, mean leaf length and breadth were not significantly different at 3 and 9 WAP. But this is not the case for the leaf area, which was significantly different at all sampling period of observation. The increased supply of nitrogen might have significantly promoted the growth of the plant or may probably be that the papaya latex containing cysteine protease must have

Table 3. Mean incidence and severity of *Podagrica* spp. as affected by treatment on okra.

Treatment	Incidence %	Severity
Chicken manure	53.1	2.4
<i>Gliricidia sepium</i>	58.1	2.6
Cow Dung	64.8	3.3
Control	96.4	4.7
Chicken manure + Paw-paw Leaf	13.1	0.9
Chicken Manure + Neem Leaf	33.1	1.5
Cow Dung + Paw-paw leaf	43.1	2.2
<i>Gliricidia sepium</i> + Paw-paw leaf	39.8	2.1
Cow Dung + Neem Leaf	51.4	2.5
<i>Gliricidia sepium</i> + Neem Leaf	38.4	2.8
F pr.	<.001	0.007
CV%	29.9	35
LSD	25.5	1.5

Incidence and severity score (severity scale: 0-5).

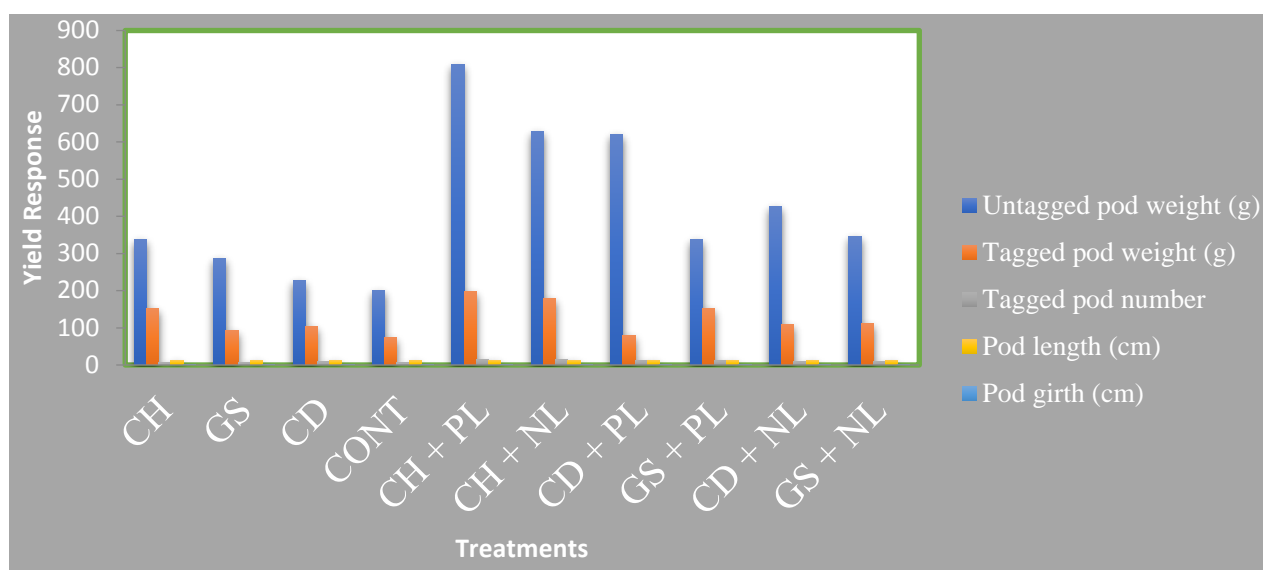


Figure 4. Effect of varying rates of different sources of organic soil amendments on the mean untagged pod weight, tagged pod weight, tagged pod number, pod length and pod girth at harvest. Chicken manure (CH), *Gliricidia sepium* (GS), Cow Dung (CD), Control (CONT), Paw-paw leaf (PL), Neem Leaf (NL)

been sufficiently absorbed by the okra plant root which have inhibited the insects from eating the leaves or even kill the pests. Papaya sap also produces compounds such as alkaloids, terpenoids, flavonoids and nonprotein amino acids that are very toxic to plant-eating insects (Konno et al. 2004).

The mean pod number, tagged pod weight and untagged pod weight all follow the same trend, and means were highest in the plot enhanced with the application of chicken manure in combination with papaya leaf. Statistically, the means for these traits were respectively at par with the mean obtained in the plot

enhanced with the application of chicken manure in combination with neem leaf. The smallest mean pod number, tagged and untagged pod weight was obtained in the plot with no soil (0 g application) enhancement (control). The highest mean pod number, tagged pod weight and untagged pod weight observed gives a clear indication that this treatment was able to suppress the activities of the pest. This result confirms the findings of the proponents of organic farming who are of the view that the likelihood of pest outbreaks is reduced with organic farming practices including the establishment and maintenance of healthy soil (Merrill, 1983). This study

revealed that poultry manure in combination with papaya leaf have the ability to suppress pest activities in okra production. This agrees with the findings of Karnataka (2008) who reported that the application of organic amendments significantly lowered aphid population. Surekha and Rao (2001) also concluded that organic amendment was effective in bringing down population of aphids in okra. Prakash et al. (2002) also reported lower percentages of fruit borer infestation in okra when treated with organic fertilizer.

Yield characteristics

Comparatively, the highest mean pod length and pod girth was recorded for the plot enhanced with the application of chicken manure in combination with paw-paw leaf. This was at par with the application of chicken manure in combination with neem leaf. The lowest mean pod length and pod girth was obtained in the plot with no soil (0 g application) enhancement (control). The same trend was maintained when chicken manure was applied as a sole fertilizer. Sharma (2004) observed that organic manure improves pod size, fruit weight and fruit yield when manure is correctly applied at the required amount. The expressed improvement in the yield of the okra could be connected to the efficacy of the poultry manure in combination with papaya leaf to improve the soil organic matter status and chemical composition of the soil as well as suppressing the insect population. Surekha and Rao (2001) also showed that organic amendment was effective in bringing down population of aphids in okra.

Effect of the treatment on pest

From this analysis, chicken manure in combination with paw-paw leaf recorded less number of *Podagrica* spp. The okra must have absorbed and assimilated to a maximum rate of the bioactive compound in papaya leaf which has acted as deterrents to the activities of the pest. This may be attributed to the fact that pawpaw leaf has been reported to possess insecticidal and repellent properties (Jewel, 2008). This finding is also in line with the results of Smith (1989) who reported that allelochemical compounds acting as deterrent are frequently alkaloids, flavonoids, terpenes, lactones and phenols, which are found to be present in papaya leaf. Palaniappan and Annadurai (1999) and Farlex (2004) reported that pest repellent plants may serve as an alternative method in controlling pests in organic agriculture and thus avoid the use of synthetic pesticides.

Conclusion

This study was conducted to evaluate the growth and yield of okra to different sources of organic soil

enhancement to promote the productivity of the okra and its tolerance to the common pest in the study area. From all the different organic sources, 5 ton/ha chicken manure in combination with 5 ton/ha papaya leaf had the best performance with the highest synergistic effects in promoting okra growth and controlling *Podagrica* spp. pest which have resulted in the overwhelming performance of the crop. The overwhelming performance of the poultry manure in combination with papaya leaf cannot also be devoid of the fact that organic manure has suppressive effect on insect, high rate of nutrient mineralization and increased nutrient level in soil. These qualities must have led to disturbance of insect pest that could have affected the growth and development of the plants.

Recommendation

As a recommendation, there is need for further investigation on the assimilation of these botanicals compound into the crops to determine the level of uptake by the plants.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Abou-Magel EI, El-Bassiony MA, Fawzy ZF (2006). Effect of organic manure with or without chemical fertilizer on growth, yield and quality of some varieties of Broccoli plants. *Journal of Applied Sciences Research* 2(10):791-798
- Adesina JM, Sanni KO, Afolabi LA, Eleduma AF (2014). Effect of variable rate of poultry manure on the growth and yield of pepper (*Capsicum annum*) in south western Nigeria. *Academia Arena* 6(1):9-13.
- Adilakshmi A, Korat DM, Vaishnav PR (2010). Effect of organic manures and inorganic fertilizers on insect pests infesting okra. *Karnataka Journal of Agricultural Sciences* 21(2):287-289.
- Alarcon WA, Calvert GM, Blondell JM, Mehler LN, Sievert J, Propeck M, Tibbetts DS, Becker A, Lackovic M, Soileau SB, Das R (2005). Acute illnesses associated with pesticide exposure at schools. *Jama* 294(4):455-465.
- Alasiri KO, Ogunkeyede SA (1999). Effect of different levels of poultry manure on seed yield of okra. *Soil Science* 25:102. Proceedings of the 25th Annual Conference of the Soil science Society of Nigeria, 21st -25th November, Benin, Nigeria, 1999.
- Belmain SR, Haggart J, Holt J, Stevenson PC (2013). *Managing Legume Pests in Sub-Saharan Africa: Challenges and Prospects for Improving Food Security and Nutrition through Agro-Ecological Intensification*; Natural Resources Institute: London, UK pp. 1-34.
- Beltagy BI, Omar GA (2016). Alteration in some biological and biochemical parameters in *Tribolium castaneum* (Coleoptera: Tenebrionidae) due to garlic oil effect. *Journal of Advances in Biology* 9:1704-1714.
- Calvert GM, Plate DK, Das R, Rosales R, Shafey O, Thomsen C, Male D, Beckman J, Arvizu E, Lackovic M (2004). Acute occupational pesticide-related illness in the US, 1998–1999: surveillance findings from the SENSOR-pesticides program. *American Journal of Industrial Medicine* 45(1):14-23.

- Chauhan DVS (1972). Vegetable Production in India (3rd edition). Ram Prasad and Sons, Agra.
- EI-Wakeil NE (2013). Retracted article: botanical pesticides and their mode of action. *Gesunde Pflanzen* 65(4):125-149.
- FAOSTAT (2006). Food and Agricultural Organization of the United Nations. On-line and Multilingual Database. <http://faostat.fao.org/foostat>
- FAOSTAT (2008). Food and Agricultural Organization of the United Nations. On-line and Multilingual Database. <http://faostat.fao.org/foostat>
- Farlex (2004). Integrated Pest Management. <http://encyclopedia.thefreedictionary.com> (Accessed November 11, 2004)
- Renee M (2018). Inorganic Fertilizer vs. Organic Fertilizer. <https://homeguides.sfgate.com/inorganic-fertilizer-vs-organic-fertilizer-39528.html>
- Isman MB (2000). Plant essential oils for pest and disease management. *Crop Protection* 19(8-10):603-608.
- Jewel KB (2008). How to Grow Crops without Endosulfan. Field Guide to Non-Chemical Pest Management P 52.
- Jeyaratnam J (1990). Acute pesticide poisoning: a major global health problem. *World Health Statistics Quarterly* 43:139-144.
- John LW, Jamer DB, Samuel LT, Warner LW (2004). Soil fertility and fertilizers: An introduction to nutrient management. Person Education, Delhi pp. 106-153. (Parson Edu. India, 2004).
- Karnataka (2008). Effect of organic manures and inorganic fertilizers on insect pests infesting okra. *Journal of Agricultural Science* 21(2):287-289.
- Kirsh K (1986). Studies of the efficiency of neem extracts in controlling major insect pests in cabbage and tomato. Proceedings of the Third International Neem Conference. GTZ GmbH, Escbborn, Germany.
- Kishi M, Ladou J (2001). International pesticide use. *International Journal of Occupational and Environmental Health* 7:259-265.
- Konno K, Hirayama C, Nakamura M, Tateishi K, Tamura Y, Hattori M, Kohno K (2004). Papain protects papaya trees from herbivorous insects: role of cysteine proteases in latex. *The Plant Journal* 37(3):370-378.
- Lin W, Lin M, Zhou H, Wu H, Li Z, Lin W (2019). The effects of chemical and organic fertilizer usage on rhizosphere soil in tea orchards. *PLoS one* 14(5):e0217018.
- Lundström NL, Zhang H, Brännström Å (2017). Pareto-efficient biological pest control enable high efficacy at small costs. *Ecological Modelling* 364:89-97.
- Merrill MC (1983). Eco-agriculture: a review of its history and philosophy. *Biological Agriculture and Horticulture* 1(3):181-210.
- Mugisha-Kamatanesi M, Deng AL, Ogendero JO, Omolo EO, Mihale MJ, Otim M, Buyungo JP, Bett PK (2008). Indigenous knowledge of field insect pests and their management around Lake Victoria basin in Uganda. *African Journal of Environmental Science and Technology* 2(10):342-348.
- Muhammed NA, Amusa HA, Subeni AA, Magaji D (2001). The effects of soil amendment with saw dust and rice husks on the incidence of seedling blight caused by *Fusarium solani* and *Rhizoctonia solani* and the growth of *Parkia biglobosa*. *Moor Journal of Agricultural Research* 2:40-46.
- Nweke IA, Ijearu SI, Igili DN (2013). Effect of different sources of animal manure on the growth and yield of okra (*Abelmoschus esculentus* L. Moench) in Ustoxic Dystropept at Enugu South Eastern, Nigeria. *Journal of Scientific and Technology Research. International journal of Scientific and Technology Research* 2(3):33-38.
- Palaniappan SP, Annadurai K (1999). Organic Farming: Theory and Practice. Scientific Publishers, Jodhpur.
- Phophi MM, Mafongoya P, Lottering S (2020). Perceptions of climate change and drivers of insect pest outbreaks in vegetable crops in Limpopo province of South Africa. *Climate* 8:27.
- Prakash YS, Bhadoria PB, Amitava R (2002). Relative efficiency of organic manures in improving resistance and pest tolerance of okra. *Annals of Agricultural Sciences* 23(1):525-531.
- Qhureshi Z (2007). Breeding Investigation in Bendi (*Abelmoschus esculentus* (L.) Moench). Master Thesis, University of Agriculture Sciences, GKVK, Bangalore.
- Ramprasad V, Srikanthamurthy HS, Ningappa S, Nagaraju B, Ningaraju S, Doddappa VA, Shivanna M, Obanna N, Pandu AC, Rama S, Sundhya M (2009). A Handbook on Sustainable Agricultural Practices. First edition, Green Foundation, Bangalore.
- Schippers RR (2000). African Indigenous Vegetables: An Overview of the Cultivated Species. Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation, Chathan, United Kingdom 214 p.
- Setiawan H, Oka AA (2015). The influence of dosage variations of papaya leaves (*Carica papaya* L.) on the mortality of aphid craccivora on long bean plants (*Vigna Sinensis* L.) as a Learning Resource for Biology. *Jurnal Bioedukasi* 6(1):54-62. <https://doi.org/10.24127/bioedukasi.v6i1.158>
- Sharma AR, Mittra BN (1991). Effect of different rates of application of organic and nitrogen fertilizers in a rice-based cropping system. *The Journal of Agricultural Science* 117(3):313-318
- Sharma DH (2004). Fundamental of soil science. 7th edition UK Longman
- Shukla V, Naik LB (1993). AgroTechnique for Malvaceae vegetables, In: *Advances in Horticulture* P 5.
- Smith CM (1989). Plant Resistance to insects: A fundamental approach, John ijl and Sons, New York P 676.
- Somani LL, Totawat KL (1996). Soil Conditioners and Amendments. Agrotech Pub. Academy, Udaipur 1st Edition pp. 28-160.
- Surekha J, Rao PA (2001). Management of aphids on bendi with organic sources of NPK and certain insecticides. *Andhra Agricultural Journal* 48(1):56-60.
- Tindall HD (1992). Vegetables in the Tropics. Macmillan Press Ltd, London P 533.