Okra Varietal Response under Soil Amended with Different Rates of Gliricidia Sepium Green Manure

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Abstract: ***The wide spread use of low yielding varieties, unimproved traditional methods of production couple with other constrains such as pest and disease infestation, improper agronomic practices and the general poor condition of soil in Sierra Leone are major causes for the low yield of crops experienced in Sierra Leone. Okra yields have been observed to decline in recent years due to over use of land for its production. It is believed that the organic matter content of the soil will be low and the general level of essential nutrients also low in an exhausted soil. These need to be replaced in order to realise high crop yields. This experimental work therefore intends to evaluate the response of two Okra Varieties under soils amended with different levels of Gliricidia sepium green manure. A randomized complete block design (RCBD) with three (3) replications and eight (8) treatments were used in this experiment. The treatment included Gliricidia sepium source of organic manure applied as sole organic fertilizer treatment. Data were collected on the follows parameters: Plants height, Stem girth, Leaf number, leaf area, untagged pod weight, Tagged pod weight, Tagged pod number, Pod length, and pod girth. The data were subjected to ANOVA using Genstat software and means were separated using least significant difference (LSD) at 5% probability. The result indicates that lady's finger variety responded well to Gliricidia green manure at the rate of 15ton/ha than the stubby variety which makes the Gliricidia green manure the most suitable for the production of improved varieties. It may therefore be recommended that Gliricidia green manure at the rate of 15ton/ha most be adopted by okra growers for the production of improved okra varieties for high yield in the Njala environment. Meanwhile, future further research is required to confirm the results as reported.***

Keywords: Gliricidiasepium, green manure, varietal

1. Introduction

Okra (*Ablemochusesculentus*) vegetable is one of the large tropical and subtropical corps grown in most Africa countries. Its cultivation and production has been widely practiced because of its great effect on the economic development of many countries in Africa and other regions in the world. It can be found in almost every market in Africa (Opong-sekyere, 2011). It serves as a source of income to farmers as well as a cheap source of protein, vitamins (A and B) and minerals (Ca, P, Fe and I) to many households (Adebisi et al; 2007). In Sierra Leone, okra is grown across different agro ecological zones because it serves as a source of income to farmers, especially women who are highly engaged in the cultivation and production of vegetables throughout the country. Okra vegetable plays "drawing quality" role that aids easy consumption of bulky staple foods such as gari, Fofo and Rice. It is a nutritious vegetable containing 86.1% water, 2.2% protein 0.2% fat, 9.7% carbohydrate, 1.0% fibre and 0.8% ash (SaifullahanaRabbani, 2009); hence, it plays a vital role in human diet (Uguru,1996). Okra production in Sierra Leone is often associated with low yield. The low yield experienced has been attributed to poor soil fertility and deficiency in important mineral nutrients and farmers do not use inorganic fertilizers because, fertilizer has become a scare commodity and even when available, it is beyond the reach of the resource-poor farmers due to its high cost. Organic matter plays a critical role in soil ecosystem because it provides substrates for decomposing microbes (that in turn supply mineral nutrients to plants), improves soil structure and water holdingcapacity (Abiven et al., 2009), increases natural suppressiveness against soil-borne pathogens (Bonanomi et al., 2010), and reduces heavy metal toxicity (Park et al., 2011). In this scenario, a recovery of depleted soil organic matter and its maintenance to an adequate level is a critical task. It has been shown that application of organic amendments is a reliable and effective tool to ameliorate soil structure and both chemical (Scotti et al., 2013) and biological fertility of soils (Ros et al., 2003), as well as to suppress soil-borne pathogens (Zaccardelli et al., 2013a). Different varieties and hybrids grown have different soil and climatic requirements for their optimum production. Sierra Leone being a country with varied soils and agro-climatic conditions, a single variety may not be suitable for all the agro-ecologies and climatic conditions. Hence, new varieties need to be introduced and evaluated for specific regions. Among the agro-techniques, nutrition is one of the main factors which govern the growth and yield of okra. There is a possibility of varied response of different varieties. There is need therefore, to study the response of okra varieties as influenced by different levels of Gliricidia sepium green manure that are readily available to farmers in Sierra Leone.

Gliricidia enhances soil organic matter when the green foliage and dry leaf litter are incorporated. Being a nitrogen fixer, the biomass of Gliricidia is a rich source of nitrogen. Theessential nutrient compositions are 2.9%N 0.5% P_2O_5 and 2.8% K_2o. Nitrogen, Phosphorus and Potassium are essential nutrients required for vigorous growth due to their immediate availability to the plant root and hence resulting to high yields (Mohamed et al 2012).

2. Materials and Methods

The experiment was conducted within a 5-6 ha agricultural field that has been mechanically tilled and cropped with tropical arable crops (okra, maize, cowpea, tomato, potato and groundnut) continuously for over ten years. The experiment was done in the upland area at the Njala University, School of Agriculture. The field experiment was conducted in the 2019 farming season from September 2019 to December 2019 at the School of Agriculture experimental site. Njala is located at an elevation of 54m above sea level on 08° and 06° latitude and 12° and 06° longitude.

The mean annual rainfall total was 2800mm. The heaviest rainfall occurs between July and September when the maximum of 20-25 days per month falls. The dry season started from end of November to end of March (2014/2015). However, there was an intermittent rainfall pattern from end of October with intervals of about 3-5 days between one rainfall and another.The temperature was generally high ranging from between 24.6 - 32.0c. 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 this month. Sunshine was abundant. But it varied with the amount of cloudiness. The average sunshine hours were between 12-13 hours per day during the dry season and only about 8-9 hours per day during the rainy season.The relative humidity was high 95-100 percent from July to September and it dropped to as low as 20% in December /January during the hamattan period.

The nature of the land is flat with slightly gentle slope. Secondary bush is the predominant vegetation at the experimental site; this is as a result of various human activities. The soil belongs to the Njala soil series (orthotic paleumult). It contains some amount of pebbles on the surface.The experiment was conducted in a randomized complete block design (RCBD) and replicated three times. The land was brushed, cleared and ploughed to get a fine tilth using appropriate tools. The experimental site was divided into three replications with eight plots in each replication. Each plot measured 3m × 3m and the whole experimental site measured 27.5m × 11m. Gliricidia pruning green manure was used as the organic source of manure to carry out this experiment. There were ten (8) treatments in this experiment. The treatment included; Variety-1 with 0 ton/ha Gliricidia sepium green Manure , Variety-2 with 0 ton/ha Gliricidia sepium green Manure, Variety 1 +5.0 ton/ha Gliricidia sepium green Manure, Variety 1 + 10.0 ton/ha Gliricidia sepium green Manure, Variety 1 + 15.0ton/ha Gliricidia sepium green Manure, Variety 2 + 5.0 ton/ha Gliricidia sepium green Manure, Variety 2 + 10.0 ton/ha Gliricidia sepium green Manure, Variety 2 + 15.0 ton/ha Gliricidia sepium green Manure.Two Okra Varieties were used in this experiment:- Lady's Finger and Stubby Okra (Local). Seeds were planted on the 4/09/2019 at a spacing of 80cm x 60cm with two to three seeds per hole which were later thinned to two seedlings per stand two weeks after germination. Each plot consisted of 4 rows and 2 plants per stand giving a total of 40 plants /plot.

The plots were prepared in the form of raised beds on which the treatments were applied two week before planting for the organic fertilizer sources to decompose.These are the activities that were carried out on the experiment before and during data collection. These include: Application of Gliricidia Sepium green manure two weeks before planting. This was done in order to ensure proper decomposition of the organic manure sources. Planting was done and the time taken for germination ranged between 3-7days. Regular weeding was carried out on the field in order to prevent infestation of pest and diseases to ensure maximum growth of crops. It was carried out manually and as frequent as the weeds emerged

Five plants were randomly tagged per plot for data collection. The parameters for data collection were as follows: Plants height, Stem girth, Leaf number, Leaf length, Leaf breadth, leaf area, untagged pod weight, Tagged pod weight, Tagged pod number, Pod length, and pod girth. The sampling observation periods for growth data collections were 3, 6 and 9 weeks after planting (WAP).Plant height was measured by taking the height of a tagged plant from the base of the stem to the top of the plant. It was measured with a ruler in (cm).Number of leaves was done by counting the leaves with my hands on a tagged plant in the plot. stem girth was measuredon the plant from 5cm above the ground level. It was done by using a manual Viner caliper.Number of fresh pod per tagged plant, this involves the physical counting of all the fruits that emerged on the tagged plants.Fruit pod diameter was measured with Viner caliper. Fresh pod length, this is to know how long the fruit is and was measured with a ruler in (cm).Fresh pod weight per bed: This involves the weighing together of all the okra fruits harvested on a bed in a fresh form. It was weighed with an electronic scale.The data were subjected to ANOVA using of Genstat software and means were separated using least significant difference (LSD) at (5% probability)

3. Results

3.1 Effect treatment on the mean plant height of two okra varieties at 3, 6 and 9weeks after planting (WAP)

Analysis of variance revealed significant differences ($P<0.05$) in mean plant height with respect to different levels of Gliricidia soil amendments from 3WAP – 9WAP. (Figure 1)

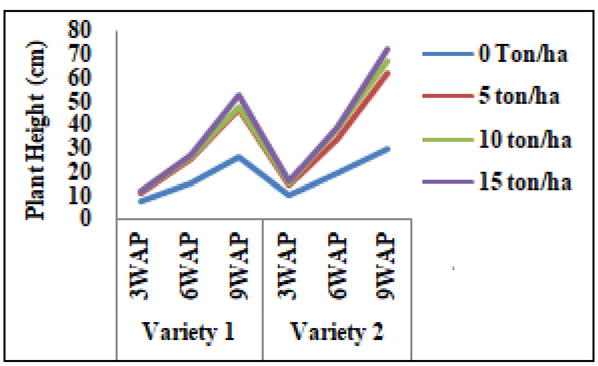

Figure 1: Mean plant height at 3wap, 6wap and 9wap

At 3WAP, 6WAP and 9WAP, the mean plant height had significantly ($p < 0.05$) lowest mean values in plots with 0ton/ha Gliricidia sepium green manure, planted with variety-1 (7.4cm), (15.0cm), (26.5cm) and variety-2 (10.0cm), (19.3cm), (29.5cm) respectively when compared to the plot treated with Gliricidia sepium green manure. However, as the plants grows from 3WAP, 6 WAP and 9WAP, plots treated with 15ton/ha for both variety-1 (12.2cm), (27.8cm), (47.9cm) and variety-2 (16.5cm), (39.5cm)and (72.6cm) had significantly ($p < 0.05$)the highest mean plant heights. These were consistently followed by plots treated with 10ton/ha Gliricidia sepium green manure for variety-1 (15.4cm), (26.7), (53.1) and variety-2 (11.6cm), (38.2cm), (67.7cm). Varietal response to the different levels of Gliricidia sepium green manure was significantly different (<0.05) in mean plant height. Variety-2 (34.92cm) significantly recorded the longest mean plant height than variety-1 (25.95cm).

3.2 Effect Treatment on the Mean Leaf Number of Two Okra Varieties 3, 6 and 9 Weeks After Planting (WAP)

Analysis of variance revealed significant differences (P<0.05) in mean leaf number with different levels of Gliricidia soil amendment from 3WAP – 9WAP. (Figure 2)

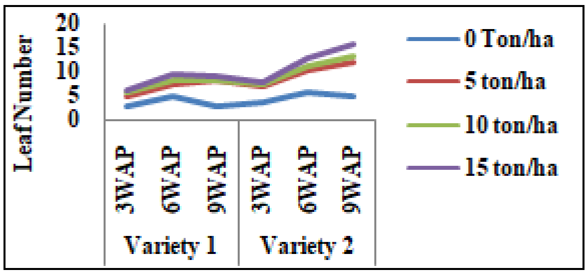

Figure 2: Mean leaf number at 3wap, 6wap and 9wap

The highest number of leaves for variety-1(5.00), (7.50), (8.40), and variety-2 (7.00), (10.30), (12.0) at all the three observation periods were recorded for the plot with application of 15ton/ha Gliricidia sepium green manure and the lowest mean number of leaves for variety-1 (3.10), (4.90), (3.30) and variety-2 (4.00), (5.90), (5.00) registered for the application of 0ton/ha of Gliricidia sepium green manure. Varietal response to the different levels of Gliricidia sepium green manure was significant different (<0.05) in mean leaf number. Variety-2 (9.425) significantly recorded the highest mean leaf number than Variety-1(6.692). The two okra cultivars varied significantly among themselves with respect to number of leaves per plant. These results are in full conformity with Gondane and Bahatia (1995); Martin and Rhodes (1983) who found significant varietal differences for the number of leaves per plant in okra.

3.3 Effect of treatment on the mean leaf area of two okra varieties at 3, 6 and 9 weeks after planting (WAP)

Analysis of variance revealed significant differences (P<0.05) in mean leaf area with respect to different levels of Gliricidia soil amendment as the plant grows from 3WAP – 9WAP. (Figure 3)

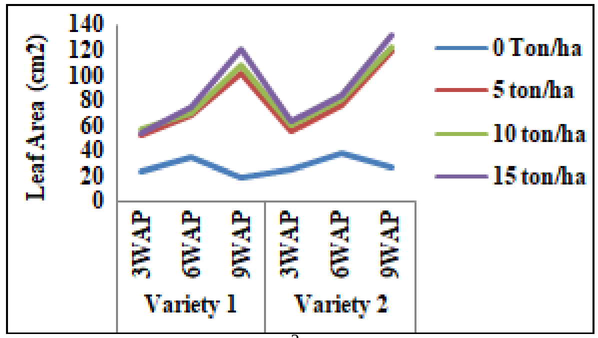

Figure 3: Mean leaf area (cm^2) at 3WAP, 6WAP and 9WAP

At 3WAP, 6WAP and 9WAP, the mean leaf area had significantly ($p < 0.05$) the lowest mean values in plots with 0ton/ha Gliricidia sepium green manure, planted with variety-1 (24.8cm^2), (35.0cm^2), (19.7 cm^2) and variety-2 (26.4cm^2), (38.1cm^2), (27.1cm^2) respectively when compared to the Gliricidia sepium green manure treated plot. However, as the plant grows from 3WAP, 6 WAP and 9WAP, plots treated with 15ton/ha for both variety-1 (54.2 cm), (74.8cm), (121.1 cm) and variety 2 (64.3cm), (85.5cm), (132.9 cm) had significantly ($p < 0.05$) the highest mean leaf area. These were consistently followed by plots treated with 10ton/ha Gliricidia sepium green manure plot with variety-1 (57.1cm), (70.3), (108.7) and variety-2 (59.7cm), (81.6cm), (123.1 cm). Variety-2 (74.39cm^2) significantly recorded the largest mean leaf area than Variety-1(65.88cm^2).

3.4 Effect treatment on the mean stem girth of two okra varieties at 3, 6 and 9 weeks after planting (WAP)

Analysis of variance revealed significant differences (P<0.05) in mean stem girth with respect to different levels of Gliricidia soil amendment as the plant grows from 3WAP – 9WAP. (Figure 4)

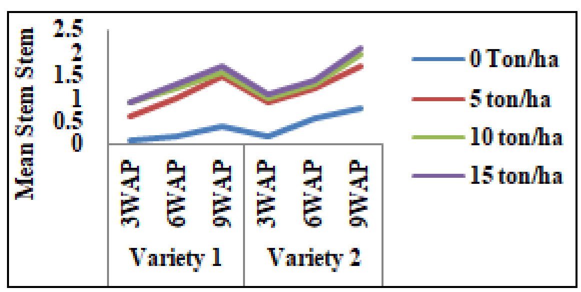

Figure 4: Mean stem girth (cm) at 3wap, 6wap and 9WAP

The results indicated that the different levels of soil amendments had highly significant ($P < 0.05$) effect on stem girth at 3WAP, 6WAP and 9WAP, the larggest mean stem girth for Variety-2 (1.0cm), (1.3 cm), (1.7 cm) and variety-1 (0.9 cm), (1.2 cm), (1.6 cm) were recorded from the application of 15ton/ha Gliricidia sepium green manure, which was significantly ($p < 0.05$) larger than those of the control plots. This was followed by the means of variety-1 (0.9 cm),

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(1.3 cm), (1.7 cm) and variety 2 (1.1 cm), (1.4 cm), from the application of 10ton/ha of Gliricidia soil amendment. While the smallest mean stem girths for variety-1 (0.1 cm), (0.2 cm), (0.4 cm) and variety-2 (0.2 cm), (0.6 cm), (0.8 cm) at the different observation periods came from the application of 0ton/ha of Gliricidia sepium green manure, Variety-2 (1.192cm) significantly recorded the largest mean stem girth than Variety-1(0.950cm).

3.5 Effect of Treatment on the Mean No. of Pods, Pod Weight, Pod Length, and Pod Diameter of Two Okra Varieties at Harvest

Analysis of variance revealed significant differences (P<0.05) in mean number of pods, pod weight, pod length, and pod diameter with respect to different levels of Gliricidia soil amendments at harvest (Figure5)

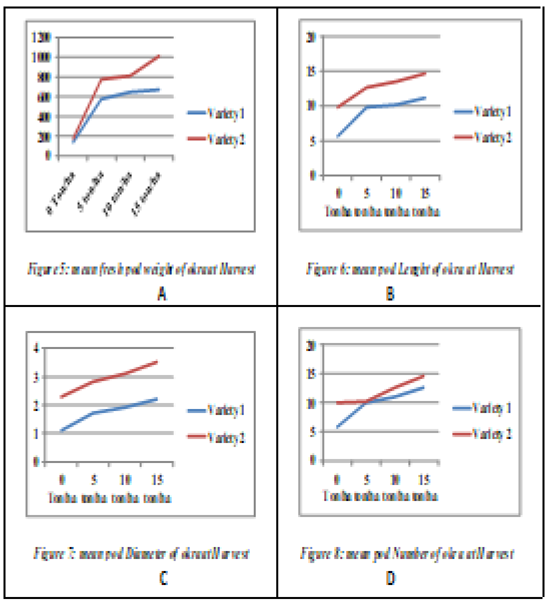

Figure 5: Showing mean pod weight (A), pod length (B), pod diameter (C) and pod number of (D) with respect to different levels of Gliricidia soil amendments at harvest

3.5.1 *Pod weight* (g)

Regarding pod weight (Figure 5A),the application of 15ton/ha Gliricidia sepium green manure produced the heaviest podweight for both variety-1 (667g) and variety-2 (1017g) compared to the other treatments. These were closely followed by plots treated with 10ton/ha Gliricidia sepium green manure for variety-1 (650g) and variety-2 (810g). Whilst the least pod weight was recorded for plot with 0ton/ha Gliricidia sepium green manure for variet-1 (145g) and variety-2 (177g).

3.5.2 *Pod length* (cm)

Analysis of variance revealed significant differences (P<0.05) in mean pod Length (Figure 5B) with respect to soil amendment at 3WAP, 6WAP and 9WAP. The longest mean pod Length was recorded for variety-2 (14.7cm) and variety-1 (11.1cm) when the plot was treated with 15ton/ha Gliricidia sepium green manure.This was followed by variety-1(10.2cm) and variety-2 (13.5cm) when the plot was treated with 10ton/ha Gliricidia sepium green manure, whereas the least Pod Length was recorded for variety-1 (5.7cm) and variety-2 (9.9cm) in the control plot with 0ton/ha Gliricidia sepium green manure. 15ton/ha recorded more length and diameter of the pod and Variety-2 significantly recorded the longest mean pod length than Variety-1.

3.5.3 Pod diameter (cm)

Analysis of variance revealed significant differences (P<0.05) in mean pod diameter with respect to soil amendment at 3WAP, 6WAP and 9WAP (Figure5C). For soil amendment, the widest mean Fruit diameter was recorded for variety-2 (3.5cm) and variety-1 (2.2cm) whenthe plotswere treated with 15ton/ha Gliricidia sepium green manure. This was followed by variety-2 (3.1cm) and variety-1(1.9cm) for plots treated with 10ton/ha Gliricidia sepium green manure, whereas the least mean pod diameter was recorded for variety-1 (1.1cm) and variety-2 (2.3cm) in the control plots with 0ton/ha Gliricidia sepium green manure.

3.5.4 Number of pods

Result of number of pods is presented in Figure5D**.**Plots treated with 15ton/ha had the highest significant (p < 0.05) mean number of fruits for both variety-1 (12.7) and variety 2 (14.7). The control treatments with 0ton/ha Gliricidia sepium green manure for variety-1(5.7) and variety-2 (9.9) had the lowest mean number of pod. It is also worth noting that the entire Gliricidia treated plots hadhigher number of pod as compared to the control. Variety-2 significantly recorded the highest mean pod number than Variety-1.

4. Discussion

Vegetative Parameters

The Growth characteristics of two Okra Varieties under soils amended with different rates of Gliricidia sepium green manure showed significant differences Plant height, leaf number, leaf area and stem girth, The significantly higher mean plant height obtained in the plots treated with 15ton/ha Gliricidia sepium green manure for both variety-1 and variety-2 may be as a result of increased N uptake by the plant which is directly related to the greater availability of soil N, possibly resulting from the decomposition of the incorporated G. sepium biomass. Gliricidia sepium has several characteristics that make it particularly suitable for use as a green manure. It is high in several major nutrients. The rate of nitrogen release is also critical. Mwiinga et al. (1994) have shown that G. sepium leaves decompose in soil more rapidly, and have a higher N content, than other commonly-used .hedgerow species. In the present study, among the varieties, significant variations were observed in mean plant height indicating that genetic potential of any variety is unique to its own genetic components. Khan et al. (2002) and Rahman et al. (2012) also reported significant differences for plant height among the five okra varieties evaluated in Pakistan. The number of leaves increased significantly due to application of 15ton/ha. Proper nourishments of the crops are also expressed by the number of leaves produced by the plants. The significant increase of leaf number in the plots with 15ton/ha Gliricidia sepium green manure over controlled plot could imply that the 15ton/ha plots constituted higher mineral nutrients from decomposed Gliricidia sepium green manure, this has benefited the plant. Similar superiority for fertilizer levels has also been reported by Balle Gowda (2000). Number of leaves per plant is considered a crucial component for yield in okra because of its usefulness as the facility for photosynthesis. Greater use of Gliricidia as a green manure has been made outside the native range with reports as early as the 1930s in Sri Lanka (Joachim and Kandiah 1934) on its benefits. Gliricidia has been found to be an excellent organic fertilizer (Liyanage 1987). The two okra cultivars varied significantly among themselves with respect to number of leaves per plant. These results are in full conformity with Gondane and Bahatia (1995); Martin and Rhodes (1983) who found significant varietal differences for the number of leaves per plant in okra. It is most evident that the higher leaf area was due to the activities of photosynthesis and also the ready source of photosynthate. In this regard, it is important that plants should possess more number of functional leaves. In the present study, leaf area per plant differed significantly due to nutritional levels, resulting from the high fertilizer level incorporated in to the soil. This profited the variety to express leaf area within statistical significance. Similar results were also reported by BalleGowda (2000). The Green manure incorporation into the soil most have increase the soil organic matter and nitrogen, improvement of soil physical characteristics, aeration and drainage; and reduction in soil temperature, and conservation of moisture. (Kang et aI., 1990). The cultivars did not show any significant differences with respect to leaf area. This is contrary to the findings of Okonmah (2011) who had reported a significant effect of leaf area at 6, 8 and 10 weeks after planting on the three cultivars of okra evaluated in Asaba, Nigeria. Different nutritional levels affected the stem girth of the plants at all growing stages of the crop. The plot with 15ton/ha Gliricidia sepium green gave the best performance with regards to okra stem girth; the reason being a better nitrogen release than the other treatments. This could also be attributed to better nutrient uptake and development of the plants. Gliricidia sepium has several characteristics that make it particularly suitable for use as a green manure. It is high in several major nutrients: 3.0-4.5% nitrogen, 0.2-0.3% phosphorus, 1.6-3.6% potassium, 1.4% calcium and 0.4- 0.6% magnesium. (Glover, 1989). Among the varieties, there were no significant differences, however, variety-2 recorded largest stem girth at all stages of crop growth compared to varieties-1. Apart from inherent genetic character, this variety thrived well in the given set of conditions. The presence of wide genetic variability provides an indication of a better scope for genetic improvement. Similar results were reported by other workers (Akortkar et al., 2010; Ade-Oluwa and Kehinde, 2011. The lack of significant differences in mean stem girth with respect to the two cultivars in this study is contrary to the findings of Simon et al., 2013) who also investigated genetic variability in okra and found significant cultivar effect in all the studied traits.

Yield Parameter

Similarly yield characters such as pod weight, pod length; pod diameter and pod number indicated significant differences. This result may be due to adequate supply of nutrients from decomposed G. sepium leaf needed for proper pod development in okra. This result is in line with the findings of Sharma (2004) who observed that organic manure improves pod weight and pod yield when manure is correctly applied at the required amount. However Variety-2 significantly recorded the heaviest mean pod weight than Variety-1 which agrees with Khan et al. (2002) and Rahman et al. (2012) who recorded significant effect of cultivar on single pod weight. Variety-2 significantly recorded the longest mean pod length than Variety-1. This was mainly due to efficient conversion of photosynthates and its effective translocation to the sink. The results corroborates with findings of BalleGowda (2000). The behavior and fruit characteristic may be due to inherent genetic ability and also response to the added fertilizer and soil conditions. Significant cultivar effect was observed in the pod length. The result obtained in this study on length of pod between varieties supports the findings of Mishra et al. (1996) and Shridhar (1995). Analysis of variance revealed significant differences ($P<0.05$) in mean pod diameter with respect to soil amendment. This result is in line with the findings of Sharma (2004) who observed that organic manure improves pod size when manure is correctly applied at the required amount. Significant cultivar effect was also observed with respect to pod diameter. This report finding contradicts the findings of Khan et al. (2002) who observed a non-significant cultivar effect on fruit size in their study but was supported by Dash and Mishra (1995). The increase in mean pod number in the Plots treated with 15ton/ha may be ascribed to the release of sufficient macro and micro nutrients during G. sepium leaf mulch decomposition. Gliricidia sepium has several characteristics that make it particularly suitable for use as a green manure. It is high in several major nutrients: 3.0-4.5% nitrogen, 0.2-0.3% phosphorus, 1.6-3.6% potassium, 1.4% calcium and 0.4- 0.6% magnesium. (Glover, 1989). The rate of nitrogen release is also critical. Mwiinga et al. (1994) have shown that G. sepium leaves decompose in soil more rapidly, and have a higher N content, than other commonly-used hedgerow specie. Number of pods per plant showed significant effect among the okra cultivars. This result corroborates the earlier reports of several authors (Choudhary et al., 2006; Rahman et al., 2012) who also had significant effect in number of pods per plant in different okra cultivars.

5. Conclusion

Based on the findings of this research, the following conclusive remarks have been stated to serve as a guide to farmers in order to promote the cultivation of okra. When practiced by farmers, it will increase their income through the sale of the produce which will influence food security problems in Sierra Leone. Variety two responded well to Gliricidia green manure at the rate of 15ton/ha than variety-1 which makes the Gliricidia green manures the most suitable for the production of improved varieties.Gliricidia green manure application at the rate of 15ton/ha needs to be encouraged for both sustainable soil fertility maintenance and optimum plant growth for resource poor farmers in Sierra Leone. Variationsin response among the okra varieties follow this trend: variety-2 > variety-1. And for the levels of the Gliricidia green manures, the trend was: "15ton/ha> 10ton/ha> 5ton/ha> 0ton/ha.It can also be recommended that this trial be repeated in the first growing season to confirm this result.

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