Effect of Charcoal and NPK Fertilizer on the Yield of Two Peppers (*Capsicum annuum* L.) Varieties: Jalapeno and Local

James Flomo Gaydaybu¹, Lamin K. M. Fatty²*, Francis Gbelee³, Philips G. S. Ndaloma⁴ and J. Gayflor B. Argba⁵

¹Cuttington University, Bong County, Liberia.
²School of Agriculture and Environmental Sciences, University of the Gambia, Brikama Campus, Gambia.
³Bong County Technical College, BRAC, Gbarnga Office, Gbarnga City, Liberia.
⁴Bong County Technical College, Gbarnga City, Liberia.
⁵Solidaritare, Lofa County, Liberia.

Authors’ contributions

This work was carried out in collaboration among all authors. Author JFG designed the experiment, lay trials, collected data and drafted the first manuscript. Author LKMF carried out the data analysis and presentation of results. Author FG prepared the seedlings, transplanting and was part of laying trials. Author PGSN managed the literature review and part of data analysis. Author JGBA managed the fertilizer application and the crop after transplanting. All authors read and approved the final manuscript.

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ABSTRACT

This research was conducted to analyze the effects of charcoal + NPK (charcoal combines with NPK) fertilizer on the yield of two pepper (*Capsicum annuum* L.) varieties: Jalapeno and Local. This research considered four treatment levels: control = no treatment, charcoal = 450 g plot⁻¹.
NPK = 112.5 g plot-1 and charcoal + NPK combination. The experimental plot size was 1.5 square meter. Treatments were replicated 8 times. Data collected on yield parameters were: Number of pods, pod weight, pod length and pod diameter. Data collections were done for three consecutive months. Data analyzed indicated that Local pepper performed better than Jalapeno for all treatments. The charcoal + NPK treated plots performed best than other treatments. For the Local pepper number of pods, charcoal + NPK applied plots had a mean of 16.79 million pods ha-1, NPK applied plots had a mean of 12.69 million pods ha-1, charcoal applied plots also had a mean of 7.20 million pods ha-1 while the control plots had a mean of 6.76 million pods ha-1 as an average means of pods harvested for the 3 months. For the Jalapeno pod weight, charcoal + NPK had a mean of 1.85 ton ha-1, NPK had 1.58 ton ha-1 as a mean, charcoal also had a mean of 1.05 ton ha-1 while the Control plots had 0.85 ton ha-1 as a mean for total pod weight.

Keywords: Charcoal; NPK fertilizer; growth; yield and pepper.

1. INTRODUCTION

Pepper, which scientific name Capsicum annuum belonging to the family of Nightshade, is spicy and pungent vegetable. The spicy and pungent horticultural crop history can be traced far back from 7500BC from the west particularly Southern America, where it was eaten as food. The crop was introduced into Europe by an explorer Christopher Columbus upon his return from America and later spread to Asia and Africa. Before this crop was brought to Europe, black pepper was used by Europeans as currency or medium of exchange. After the introduction of pepper into European societies, it rapidly spread to replace the black pepper [1]. Soil fertility management varies between different farm types and farming practices. Plantation farms and continuous farming deplete soil faster. Crop rotation and shifting cultivation help restored nutrients for plant uptake. The restoration of soil fertility is recognized as the key entry point for increasing agricultural productivity in smallholder farms [2]. Agronomists are engaging in newer technologies to enhance crop productions under different seasons. Soil solarization is one of the techniques used by covering the soil with clear polythene sheets during hot season to trap the solar energy by heating the soil [3,4] experimental the soil solarization technique and consented that this technique significantly control soil-borne diseases with a resultant increase in plant growth, yield and the quality of the crop. With the growing population, scientists need to research newer methods of crop productions to meet the economic demands of the people. Some of these problems of poor crop productions are targeted toward fertilizer application rate and method, types of fertilizer that meet the population purchasing demand, pesticides availability and many others. The provision of inorganic fertilizers cannot be reached everywhere due to the cost associated and inaccessibility of farms caused by bad roads. These are some major factors causing poor crop production and most farmers are not accepting to treat crops with both organic and inorganic fertilizers for better yield. Sood et al. [5] studied the effects of different mineral fertilizer with amendments on different forms of potassium. The report concluded that continuous application of chemical fertilizers and amendments improved all the potassium fractions in soil. The combined used of balanced dose of chemical fertilizer with Farm Yard Manure (FYM) or lime sustained higher yields of maize.

1.1 Objectives of the Study

The broad objective:

- To determine which of the two pepper varieties can do better with the application of charcoal + NPK fertilizer in Suakoko loamy soil.

The specific objective:

- To determine the effects of charcoal + NPK on the yield of peppers
- To determine the effect of charcoal on yield of peppers
- To determine the effects of NPK 15:15:15 on the yield of peppers

1.2 Hypotheses

1.2.1 Null hypothesis

The application of NPK fertilizer + charcoal dose not influenced the yield of the two pepper varieties (Jalapeno from USA and Local from Suakoko, Bong County, Liberia) on Sinyea sandy loam soil.
1.2.2 Alternative hypothesis

The application of NPK fertilizer + charcoal significantly influences the yield of pepper varieties on Sinyea sandy loam soil.

2. METHODOLOGY

2.1 The Study Setting and Duration

This research was conducted at the College of Agriculture and Sustainable Development, CASD, research farm, Cuttington University. The University campus is located in central region of Liberia approximately 184 kilometres from Monrovia, capital of Liberia and 11 kilometres from Gbarnga, Bong County. The research was conducted from March 22, 2014; to October 10, 2014. Sowning of seeds on nursery was done on March 22, 2014. Fertilizer and Charcoal were applied on April 26, 2014 while seedlings transplanting was on April 30, 2014. Harvesting dates were August, September and October for date 1, 2 and 3 respectively. Weeding was done monthly to reduce competition in nutrient intake with peppers.

2.2 Research Population

The total experimental plots were 32, with a plot size of 1.5 m x 1.5 m. The plant population was 288 plants planted in the field with a spacing of 60 cm x 60 cm. Each plot contains 9 plants, 3 x 3 in row and column. The total of 16 plots was assigned local pepper variety while 16 plots were also assigned the foreign pepper variety, Jalapeno. The following treatments were observed: control plots were 8, charcoal plots were 8, fertilizer (NPK 15:15:15) plots were 8 while charcoal with fertilizer plots were 8. The application rates were 450 g/plot or 2 tons/ha and 112.5 g/plot or 150 kg/ha of charcoal and NPK 15:15:15 fertilizer respectively.

2.3 Sampling Techniques

A total of 3 (three) plants was randomly selected from each plot summing up to 96 plants considered for data collection. The Complete Randomize Block Design Method, CRBDM, was carried out in assigning plots with pepper varieties and fertilities level. The fertilities levels were four (4), replicated two (2) times in four (4) blocks.

2.4 Varieties and Fertility Levels

Varieties

- V1 = Local pepper (from Suakoko, Liberia)
- V2 = Jalapeno pepper (from North Carolina, USA)

Level of fertilities

- C1 = Control (No Charcoal)
- C2 = Charcoal (2 tons/ha)
- F1 = Control (No Fertilizer)
- F2 = Fertilizer (150 g/ha)

2.5 Methods of Data Collection

Among the 9 plants in every plot, 3 plants were randomly selected for data collection. The plants selected for data collection were marked in every plot as plat 1 to plant 3 for continuation of data collection. This was to remember plants selected for accurate data collection. Data were collected on plant yield. The yield parameters measured were a number of pods, pod weigh, pod length and pod diameter.

3. RESULTS AND DISCUSSION

3.1 Data Presentation and Analysis

Fig. 1 showed the pepper pods of two pepper varieties as affected by NPK fertilizer and Charcoal. For the Jalapeno pepper, the charcoal + NPK fertilizer combination showed more number of pods of 2.1 million pods per hectare, the NPK fertilizer and Control plots showed 1.6 million pods per hectare while the Charcoal applied plots showed 1.0 million pods per hectare. The Local pepper data showed that charcoal + NPK fertilizer plots had many pods as recorded as 31.5 million pods per hectare, the NPK fertilizer applied plots had 23.8 million pods per hectare, and the charcoal applied plots had 13.4 million pods per hectare while the Control plots had 12.0 million pods per hectare. The application of combine charcoal + NPK gives the best result for pepper pod for the varieties of pepper. But more differences were observed in the Local pepper than Jalapeno results as the Local pepper had more pods than its counterpart the Jalapeno which is shown in Fig. 1.

Fig. 2 gave the pepper yields of two pepper varieties as affected by NPK fertilizer and
Fig. 1. Pepper pods of two pepper varieties as affected by NPK fertilizer and charcoal

Charcoal. For the Jalapeno variety, charcoal + NPK fertilizer plots had produced better with 2.93 tons of pepper per hectare, and the NPK fertilizer applied plots had 2.33 tons per hectare. The charcoal applied plots had 1.5 tons per hectare while the control plots had 1.0 ton per hectare. The Local pepper data revealed that charcoal + NPK fertilizer performed best with 0.78 ton per hectare and the NPK fertilizer also had produced 0.8 ton per hectare. The Control plots performed better than the Charcoal applied plots with 0.7 ton per hectare and 0.6 ton per hectare respectively. The charcoal + NPK had performed better than the charcoal plots for the two pepper
### Table 1. Effects of charcoal on two pepper varieties pods

| Pepper variety | Harvest – (Million/ha) | Harvest - 2 (million/ha) | Harvest – 3 (Million/ha) | Total pods (million/ha) |
|----------------|------------------------|--------------------------|--------------------------|-------------------------|
|                | Charcoal               | Control                  | Charcoal                 | Control                 |
| Jalapeno       | 0.91                   | 0.64                     | 0.31                     | 0.60                    | 0.36                   | 0.35                   | 1.58                   | 1.59                   |
| Local          | 3.39                   | 4.34                     | 8.0                      | 6.36                    | 11.0                   | 7.19                   | 22.39                  | 17.89                  |

### Table 2. Effects of charcoal on yields of two pepper varieties

| Pepper variety | Harvest – 1(ton/ha) | Harvest - 2 (ton/ha) | Harvest – 3 (ton/ha) | Total pods (ton/ha) |
|----------------|---------------------|----------------------|----------------------|---------------------|
|                | Charcoal            | Control              | Charcoal             | Control             |
| Jalapeno       | 1.14                | 0.95                 | 0.60                 | 0.29                | 0.48                 | 0.41                 | 2.21                   | 1.66                   |
| Local          | 0.25                | 0.26                 | 0.19                 | 0.23                | 0.24                 | 0.26                 | 0.69                   | 0.76                   |

### Table 3. Effects of NPK on pepper pods of two varieties

| Pepper variety | Harvest – (Million/ha) | Harvest - (million/ha) | Harvest – (Million/ha) | Total pods (million/ha) |
|----------------|------------------------|------------------------|------------------------|-------------------------|
|                | Control                | NPK                    | Control                | NPK                     |
| Jalapeno       | 0.50                   | 1.05                   | 0.54                   | 0.38                    | 0.26                   | 0.45                   | 1.30                   | 1.84                   |
| Local          | 2.61                   | 5.11                   | 4.95                   | 9.41                    | 5.09                   | 13.10                  | 12.66                  | 27.04                  |
Table 4. Effects of NPK on pepper yields of two varieties

| Pepper variety | Harvest – 1(ton/ha) | Harvest -2(ton/ha) | Harvest – 3(ton/ha) | Total pods(ton/ha) |
|----------------|----------------------|---------------------|----------------------|-------------------|
|                | Control   | NPK      | Control   | NPK      | Control   | NPK      | Control   | NPK      |
| Jalapeno       | 0.58      | 1.51     | 0.29      | 0.61     | 0.38      | 0.51     | 1.25      | 2.63     |
| Local          | 0.21      | 0.21     | 0.18      | 0.24     | 0.23      | 0.28     | 0.65      | 0.80     |

varieties. But the charcoal applications have some levels of improvements and can influence results as evidence shown in Fig. 2.

Table 1 showed the effects of charcoal on pepper pods of the two pepper varieties on three dates. The Jalapeno pepper that had no treatment referred to as control had 1.59 million pods per hectare while the charcoal applied plots had 1.58 million pods per hectare. The Local pepper variety with the charcoal had 22.39 million pods per hectare while the control plots had 17.89 million pods per hectare. This analysis showed that charcoal application was influential than the control. There was a great gap between charcoal and control treated plots for the local pepper. For the Jalapeno, the difference in pods number was not much which means both treatments had no much influence on yield as given in Table 1. A study conducted in Ghana by [6] revealed that maize planted on charcoal site soils (CSS) had increased in yield by 91% over an adjacent field soils(AFS) with 44%.

Table 2 showed the effects of charcoal on the yields of two pepper varieties on three dates. The varieties were Jalapeno and Local pepper form Suakoko, Bong County, Liberia. The three harvested date’s data are sum up in the total pods row with subheading charcoal and control. The Jalapeno pepper treated with charcoal had 2.21 tons of pepper per hectare while the Local pepper treated with charcoal had 0.69 ton per hectare. The Jalapeno that was control (without treatment) had 1.66 ton per hectare while the Local pepper that was control had 0.76 ton per hectare. The pod weight analysis showed that Jalapeno treated with charcoal was heavier than the control plots pods. The reverse was seen for the Local pepper harvested that the control plots pepper pods weight was heavier than the charcoal applied plots pepper weight as shown in Table 2.

Table 3 revealed clearly the effects analysis of NPK fertilizer on pepper pods of two varieties collected on three harvesting dates and summed up in the total pods row. The Jalapeno pepper treated with NPK fertilizer performed poorer with 1.84 million pods per hectare while the Local pepper performed better with 27.04 million pods per hectare. For the control plots, Local pepper performed better with 12.66 million pods per hectare while the Jalapeno pepper had 1.30 million pods per hectare. The NPK performed better than a control for the two varieties. But the Local pepper had responded better than the Jalapeno for the two treatments. The number of pods produced by the Local pepper was far above the Jalapeno pepper indicated in Table 3.

Table 4 showed the effects of NPK fertilizer on the pepper yields of two varieties harvested on the three dates. The three date’s data were sum to give the total pods yield. The Jalapeno performed better than the charcoal pepper. The NPK fertilizer plots had 2.63 tons pods per hectare while the control plots had 1.25 tons per hectare. The Local pepper treated with NPK fertilizer had 0.80 ton per hectare of pods while the control had 0.65 ton per hectare of pods. The weight of pods produced by the application of NPK compared to control plots shown in Table 4 confirmed that Jalapeno was heavier than the Local pepper. The NPK had greater influence on pod weight from this research analysis. A research conducted by [7] consented that an increased doses of NPK (50:100:150 NPK kg/ha) resulted in an increased in total yield (tonnes) per hectare of the three onion varieties.

Table 5 showed the effects of NPK fertilizer and charcoal on pepper yields on three dates. The three months harvested data were analyzed and total to the value given in the total pods row. Control plots had the least pepper yields of 6.76 million pods per hectare while the charcoal applied plots had 7.20 million pods per hectare. The best-performed plot was the charcoal combined with NPK fertilizer with 16.79 million pods per hectare while the NPK applied plots
Table 4. Effects of NPK and charcoal on pepper yields

| Treatment | Harvest – 1 (Million/ha) | Harvest – 2 (million/ha) | Harvest – 3 (Million/ha) | Total pods (million/ha) |
|-----------|--------------------------|--------------------------|--------------------------|------------------------|
| Control   | 1.38                     | 3.01                     | 2.38                     | 6.76                   |
| Charcoal  | 1.74                     | 2.48                     | 2.98                     | 7.20                   |

Table 6. Effects of NPK and charcoal on pepper pods

| Treatment | Harvest – 1(ton/ha) | Harvest -2(ton/ha) | Harvest – 3(ton/ha) | Total pods(ton/ha) |
|-----------|---------------------|--------------------|---------------------|--------------------|
| Control   | 0.39                | 0.14               | 0.30                | 0.85               |
| Charcoal  | 0.40                | 0.33               | 0.30                | 1.05               |

Table 7. ANOVA result in pod weight (first harvest)

| Source of variations | DF | Sums of square | Means square | F-value | Pr – value |
|----------------------|----|----------------|--------------|---------|------------|
| Model                | 7  | 1.304          | 0.18643      | 6.26    | 0.0003     |
| Error                | 24 | 0.715          | 0.02979      |         |            |
| Total                | 31 | 2.02           |              |         |            |
| Variety              | 1  | 0.45           | 0.45         | 15.15   | 0.0007     |
| Charcoal             | 1  | 0.15           | 0.15         | 5.08    | 0.0337     |
| NPK                  | 1  | 0.28           | 0.28         | 9.44    | 0.0052     |
| V*C                  | 1  | 0.25           | 0.25         | 8.22    | 0.0085     |
| V*N                  | 1  | 0.13           | 0.13         | 4.2     | 0.0516     |
| C*N                  | 1  | 0.02           | 0.02         | 0.67    | 0.4207     |
| V*C*N                | 1  | 0.03           | 0.03         | 1.05    | 0.316      |

Note: p≤ 0.05 means the result is significance
had 12.69 million pods per hectare. The four treatments were analyzed here in Table 5 comparing the number of pods. The charcoal + NPK had the best result followed by the NPK fertilizer per the number of pods produced. The charcoal performed better than the control plots. This is an indication that charcoal has an influence on plant yield than control. This result consented with a research conducted by [8] which revealed that 100% NPK + FYM (farm yard manure) treatment in all locations of the research area indicated a beneficial effect on sustaining higher crop productivity than 100% N and NP.

In Table 6, the data collected were analyzed focusing on the effects of NPK fertilizer and charcoal on pepper pods for the three harvested dates. The sum provided in the total pods row was the results from the three dates of harvests and data collection. From displacement, charcoal and NPK fertilizer applied plots performed best with 1.85 tons of pod per hectare while the NPK applied plots had produced 1.58 tons of pods per hectare. The control plots produced the least with 0.85 ton per hectare and the charcoal treatment plots had 1.05 ton per hectare. The determinations of weight on the application of the four treatments were done and the results indicated in Table 6 showed that charcoal + NPK had the heaviest pod weight than the NPK applied plots, charcoal applied plots and the control plots.

Table 7 showed the ANOVA results on pod weight for the first date of harvest. The results showed that there were 32 plots which are indicated by 31 under the Degree of Freedom coded as DF. The p-values represented the probability values which showed the level of significance of the results. For the Model, the result indicated highly significance difference of 0.0003. The following values indicated highly significance difference at 0.0007, 0.0337, 0.0052, 0.0085 and 0.0516 for Variety, Charcoal, NPK, Variety versus Charcoal and Variety versus NPK respectively. The Analysis of Variance (ANOVA) result for the pod weight indicated that there was a significance difference in the treatment between variety, Charcoal, NPK, variety versus charcoal and variety versus NPK. And there were no significance difference in charcoal versus NPK and Variety versus charcoal versus NPK.

4. CONCLUSION AND RECOMMENDATIONS

4.1 Conclusions

When NPK was added to charcoal, Local variety significantly grew taller and produced highest Pepper yield of 31.5 ton/ha. Similar trend was observed in all yield parameters except for pod weight which the Jalapeno produced the heavier pod weight than the Local pepper. When NPK or charcoal applied alone growth and yields were lesser than charcoal and NPK combined. When NPK added with charcoal, Local variety significantly grew taller and produced highest Pepper yield of 31.5 ton/ha. When NPK or charcoal applied alone growth and yields were lesser than charcoal + NPK combined. It was observed that Local variety did well in growth and yield than the Jalapeno variety. Local pepper produced a higher number of pods than the Jalapeno. The researcher found out that the data analyzed, Local did well in terms of yield on Suakoko soil. It is concluded that charcoal works very well when blended with inorganic fertilizers for better yield of crops.

4.2 Recommendations

It is an exciting pleasure to recommend this research for further investigation. Extension program should be designed to convey this result to the farmers so that they can increase the yield of their various crops. Government and private sectors should retain ownership by financing or empowering local farmers in executing this mandate.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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