Analysis of the Effect of Organic and Inorganic Fertilizer on Growth Performance and Yield of Maize

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Abstract: A pot randomized design experiment was conducted to analyze the effects of organic and inorganic fertilizer on growth performance and yield of maize. Fifteen (15) kg air dried topsoil was collected from the initially laid out 3m x 2m randomized block design of three replications and six treatments into 20kg sized horticultural pots leaving about 5cm to the brim. Good quality maize (Sudan1 TZEEY) seeds with 75 days lifespan was used and irrigated. The treatments used for the growth performance and yield of the maize include; Poultry dropping/manure (A), SSP (B), NKP 20:10:10 (C), combination of poultry droppings and SSP (D), combination of NPK 20:10:10 and SSP (F), and the control (no addition of SSP, NPK or Poultry droppings) (E). At 8th weeks after planting, the leaf area were 621.65 cm^2, 531.18 cm^2, 531.22 cm^2, 492.42 cm^2, 422.13 cm^2, and 436.73 cm^2 respectively for the treatments which contained NPK + SSP, NPK, SSP + Manure, Manure, SSP and the control. The highest plant height at 10th weeks after planting was 201.07 cm under the treatment of SSP + Manure followed by NPK + SSP (191.10 cm), NPK (189.73 cm), control (188.63 cm), manure (177.40 cm) and the SSP being the least with 169.20 cm; whereas the leave area decreased compare to that of 8th week after planting. The shelling percentage and harvest index were fairly constant throughout the 10 weeks experimental periods. Combination of organic and mineral fertilizers resulted in high maize grain yields and improved soil chemical properties.
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1. Introduction

Maize (*Zea mays*) belongs to the family Graminae of the tribe Maydae (Obi and Ebo, 1995). It is an important cereal crop which ranks the third after wheat and rice in the world (Onasanya *et al*., 2009). In Nigeria, maize is an important food, fodder and industrial crop grown both commercially and at subsistence level (Eleweanya *et al*., 2005). Maize is used for the production of indigenous and commercial food products that are relished for their unique and distinctive flavours. It is eaten fresh or milled into flour and serves as a valuable ingredient for baby food, cookies, biscuits, ice cream, pancake mixes, livestock feed and a variety of traditional beverages (Okoruwa, 1998). It is an important source of carbohydrate and if eaten in the immature state, provides useful quantities of vitamin C (Bundy *et al.,* 2001). Maize cultivation is increasing every year, in spite of its economic importance and the increase in land areas under maize production, yield is still low. Some of the major causes of low maize yield are declining soil fertility and insufficient use of fertilizers resulting in severe nutrient depletion of soils (Onasanya *et al*., 2009). Studies indicate the depletion is a result of a combination of high rates of erosion, leaching, removal of crop residues, continuous cultivation of the land without adequate fertilisation or fallowing (Sanchez and Jama, 2002). Increasing the nutrient status of the soil may be achieved by boosting the soil nutrient content either with the use of inorganic fertilizers such as NPK or through the use of organic materials such as poultry manure.

Fertilizer is any organic (manure) or inorganic material (chemical fertilizer) of natural or synthetic origin (other than liming materials) that is added to soil to supply one or more plant nutrients essential to the growth of plants. Fertilizers are major factors in maintaining soil fertility, but using too much of them, especially when dealing with poor management practices such as burning crop residues combined to greatly reduce the amount of soil organic matter. This can have profound effects on the physical, chemical and biological soil features and may increase soil erosion in these soils (Zhao *et al.,* 1998).

Nitrogen and phosphorus are the main limiting nutrients in food crop production. Maize requires adequate supply of nutrients particularly nitrogen, phosphorus and potassium for good growth and high yield and these elements are depleted in the soil. One of the ways of addressing the impact of deficiency in the soil is through the use of inorganic fertilizers, but use of these inputs among smallholder farmers is currently very low, and is not expected to increase significantly in Nigeria; probably as a result of inadequate production of substantial quantities of +its fertilizer requirements from natural resources. The two fertilizer manufacturing plants Federal superphosphate Fertilizer Company (FSFC) and National Fertilizer

Company of Nigeria (NAFCON) were shut down in 1999 and later privatized without adequate management. Therefore, inorganic fertilizers are rather imported into Nigeria, and are expensive and may be largely unaffordable and not available to the resource-poor farmers in Nigeria.

Moreover, continuous use of mineral fertilizer as the main source of nutrients can have detrimental effects on soil properties and can also lead to rapid decline in crop yields because of acidification and soil compaction (Lungu and Dynoodt, 2008). Although organic fertilizers usually contain a lower concentration of nutrients, but they break down slowly into complex organic structures (humus) which build the soil's structure, moisture and nutrient-retaining capacities. Organic manure such as poultry droppings is readily available as a cheap source of nitrogen for sustainable crop production. The aim of this study was to analyze the effect of organic and inorganic fertilizer on growth performance and yield of maize grown inside plastic contains.

2.0 MATERIALS AND METHODS

2.1 Practical site

This research work was carried out at the farm section of the Department of Biology, School of Sciences, Federal Capital Territory College of Education, Zuba-Gwagwalada, Abuja, Nigeria.

2.1.1 Preparation of practical site

A pot randomized block design experiment was conducted at the farm section of the Department of Biology, School of Sciences, Federal Capital Territory College of Education, Zuba-Gwagwalada. Fifteen (15) kg air dried topsoil was collected from the initially laid out 3m x 2m randomized block design of three replications and six treatments into 20kg sized horticultural pots leaving about 5cm to the brim to conveniently permit watering. Each pot was perforated at the bottom to control drainage and aeration, then labeled according to the initial field layout. The soil samples that involve poultry droppings as treatment were mixed thoroughly with 10.0g of poultry manure. All the treatment pots were watered before planting.

2.2 Collection of maize seeds and sowing

Good quality maize (Sudan1 TZEEY) seeds with 75 days lifespan were collected from Agricultural Development Programme (ADP) Abuja, Gwagwalada. Four seeds were planted in the center of the soil at a depth of 1 cm, and then covered with little soil and irrigated. Thinning was done to two maize plant per pot two weeks after planting.

2.4 Crop management and treatments

The treatments used for the growth performance and yield of maize include; Poultry dropping/manure (A), SSP (B), NKP 20:10:10 (C), combination of poultry droppings and SSP (D), combination of NPK 20:10:10 and SSP (F), and the control (no addition of SSP, NPK or Poultry droppings) (E). The quantities of fertilizers applied were equivalent amount required by 1 ha of land (standard measurement) against 15kg soil used in the experiment as calculated below:

The standard rate of NPK 20-10-10 on a hectare of land cultivated with maize is approximately 120kgha^{-1} and for SSP, is approximately 60kgha^{-1}.

Where 1ha = 100m x 100m =10,000m^2.

Therefore, 120kg of NPK 20-10-10 = 10,000m^2 and 60kg of SSP = 10,000m^2

Normal spacing for maize planting is 75cm x 30cm

100m = 100 x 100 = 10,000cm

Number of ridges=$\frac{10,000\text{cm}}{75\text{cm}}$=133.3 (Inter-row spacing)

Number of stands per ridge = $\frac{10,000\text{cm}}{30\text{cm}}$ = 333.3 (Intra-row spacing)

Total number of stands = Inter-row stands x intra-row stands

133.3 x 333.3=44,428.89 maize stands per hectare.

Where, 1kg = 1000g

Quantity of fertilizer per stand = $\frac{\text{Fertilizer amount}}{\text{Total number of stands}}$

For NPK 20-10-10: $\frac{120,000\text{g}}{44,428.89}$ = 2.7g per maize plant stand

For SSP = $\frac{60,000\text{g}}{44,428.89}$ = 1.35g per maize plant stand

2.4.1 Nitrogen phosphorus and potassium (NPK) 20-10-10 fertilizer

2.7g of the inorganic fertilizer, NPK:20-10-10 was applied by ring placement 14 days after sowing the maize and the straight fertilizer top dressed at 5½ weeks later as it is the custom of the local farmers (Gao *et al*., 2007).

3.4.2 Single super phosphate (SSP) Fertilizer

About 1.3g of the chemical fertilizer, SSP was applied by ring placement 14 days after sowing the maize and the straight fertilizer top dressed at 5½ weeks later.

3.4.3 Poultry manure

Poultry manure (about 11% moisture content) was collected from layer birds in deep litter system from University of Abuja Agricultural farm pen at Gwagwalada, Abuja-FCT. 10.0g manure, semi-decomposed, was mixed thoroughly with soil samples that required it as treatment and watered 6 days before sowing maize, the test crop (Lalljee and Costa, 1995).

3.4.4 Poultry manure plus NPK 20-10-10

At first, 10.0g of poultry manure (about 11% moisture content), semi-decomposed, was mixed thoroughly with the soil and watered 6 days before sowing, followed by 2.7g of NPK 20-10-10 fertilizer which was applied by ring placement 14 days after sowing the maize. Their combination were applied by straight fertilizer top dressed at 5½ weeks later.

3.4.5 Poultry manure plus SSP Fertilizer

At first, 2.7g of poultry manure (about 11% moisture content), semi-decomposed, was mixed thoroughly with the soil and watered 6 days before sowing maize, the test crop, followed by 1.35g of SSP fertilizer which was applied by ring placement 14 days after sowing the maize and the straight fertilizer top dressed of their combination was applied 5½ weeks later.

3.4.6 Control

The control experiment was allowed to grow without addition of any of the manure, inorganic fertilizer or the combinations.

2.5 Determination of Growth performance of Maize

The growth performance and yield of maize was determined using the physical parameters such as; Plant height, number of leaves, leaf length, leaf width, stem girth at 2 weeks interval from the 2nd to the 12th week and leaf area index was computed. These parameters were measured in the following ways: Plant height: A carpenter's tape was used for measuring the height from the ground level to the top-most leaf. The mean from the three plants (Replication) was then determined. Number of leaves: Visual counting of leaves was made and the number was recorded for each plant. The mean values were then calculated for treatmeat. Stem girth: The stem girth of the maize plants was measured with a thread and the actual measurements were determined on a carpenter's tape in centimeter for each pot and the values were averaged. Leaf area: The leaf area was determined by the non destructive length x width method using the relation: Leaf area = 0.75 (length x width), where 0.75 is a constant.

Leaf area (cm^2) = Length of leaf x Breadth at the widest portion x 0.75 (1) Biomass was taken by oven-drying the harvested plant material (stems and leaves) at a temperature of 70 °C for 3 days. The parameters measured were the average Plant Height at Tarseling (PH), Leaf Area (LA), Harvest Index (HI), Shelling Percentage (SP) and Grain Weight (WG).

Average plant height (cm) was the average height of three plants from ground level to tarsel tip.

$$\text{Shelling percentage (\%)} = \frac{\text{Grain weight}}{\text{Cob weight}} \text{x}100\% \quad (1)$$

$$\text{Harvest index} = \frac{\text{Grain weight}}{\text{Total above ground biomass}} \quad (2)$$

Leaf area (cm^2) = Length of leaf x Breadth at the widest portion x 0.75 (3)

Grain weight (g) was the average grain yield of ten randomly chosen maize cobs using the table of random numbers.

2.6 Statistical Analysis

Data on all parameters were analysed on the computer using standard statistical packages for means, standard deviations and Growth performance and yield data were analyzed using one-way analysis of variance (ANOVA). Means of significant difference were further separated using the Least Significant Difference (LSD).

3. Results

3.1 Growth Parameters of 4-weeks old maize planted under different treatments

At 4th week after planting, the plant height and leaf area increase simultaneously. The maximal plant height was recorded for the treatment which contained Single Super Phosphate (SSP) + Manure, followed by manure, then that of Nitrogen, Phosphate and Potassium (NPK) + SSP; whereas the control being the least as shown in Figure 1.

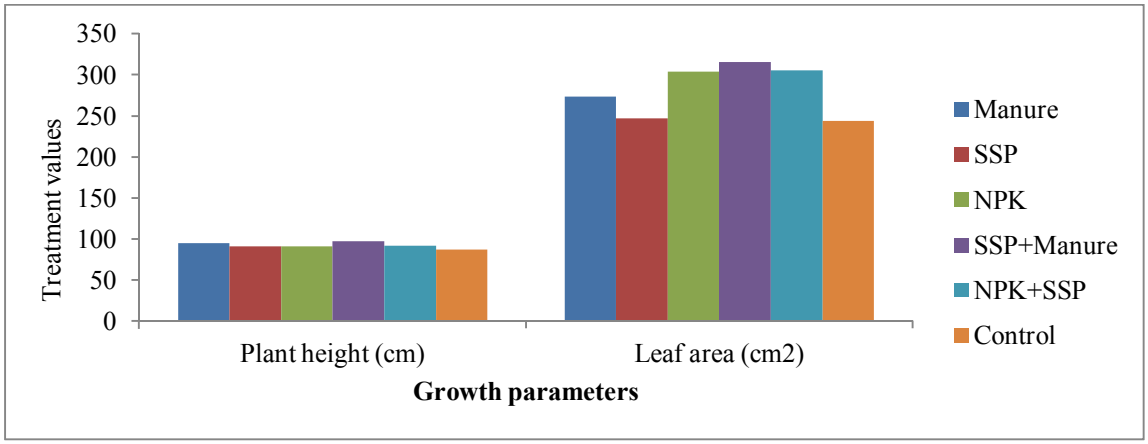

Figure 1: Growth Parameters of 4-weeks old maize planted under different treatments

3.2 Growth Parameters of 6-week old maize plants under different treatments

The highest plant height at 6th weeks after planting was 155.77 cm and 155.73 cm under the treatment of SSP + Manure and NPK respectively, followed by manure (150 cm), NPK + SSP (147.53 cm), SSP (132.83) and the least height was recorded for the control (126.17 cm) as shown in Figure 2.

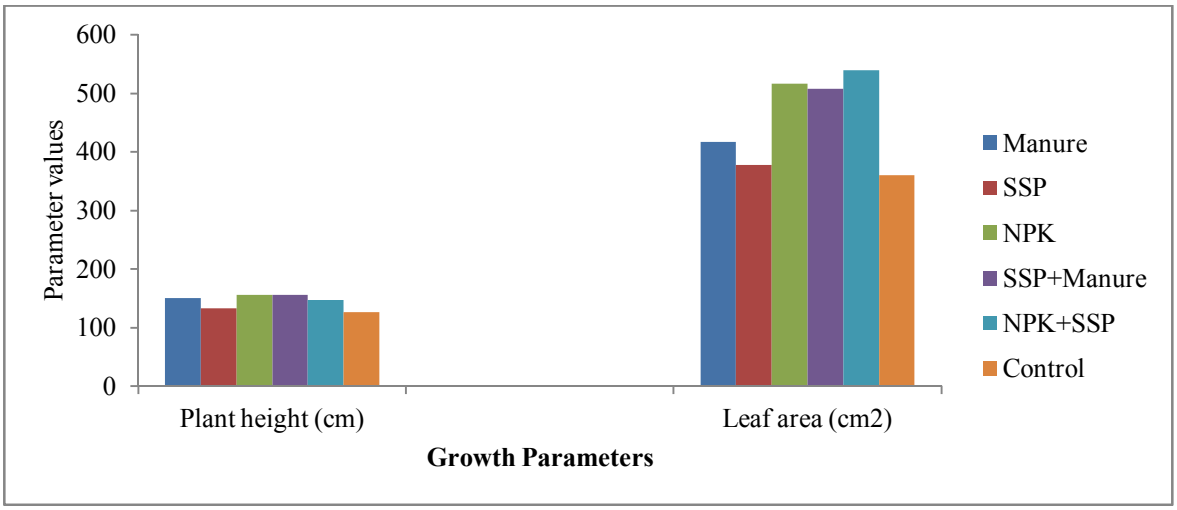

Figure 2: Growth parameters of 6-weeks old maize planted under different treatments

3.3 Growth parameters of 8-week old maize plants under different treatments

At 8th weeks after planting, the leaf area were 621.65 cm^2, 531.18 cm^2, 531.22 cm^2, 492.42 cm^2, 422.13 cm^2, and 436.73 cm^2 respectively for the treatments which contained NPK + SSP, NPK, SSP + Manure, Manure, SSP and the control as shown in the Figure 3 below.

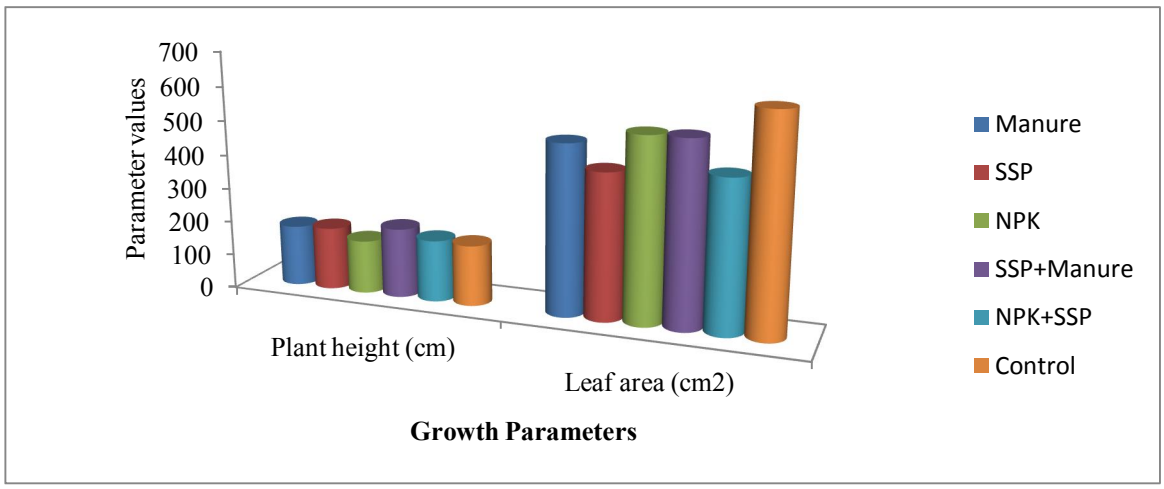

Figure 3: Growth Parameters of 8-week old maize plants under different treatments

3.4 Growth Parameters of 10-week old maize plants under different treatments

The highest plant height at 10th weeks after planting was 201.07 cm under the treatment of SSP + Manure followed by NPK + SSP (191.10 cm), NPK (189.73 cm), control (188.63 cm), manure (177.40 cm) and the SSP being the least with 169.20 cm; whereas the leave area decreased compare to that of 8th week after planting as shown in Figure 4. The shelling percentage and harvest index were fairly constant throughout the 10 weeks experimental periods.

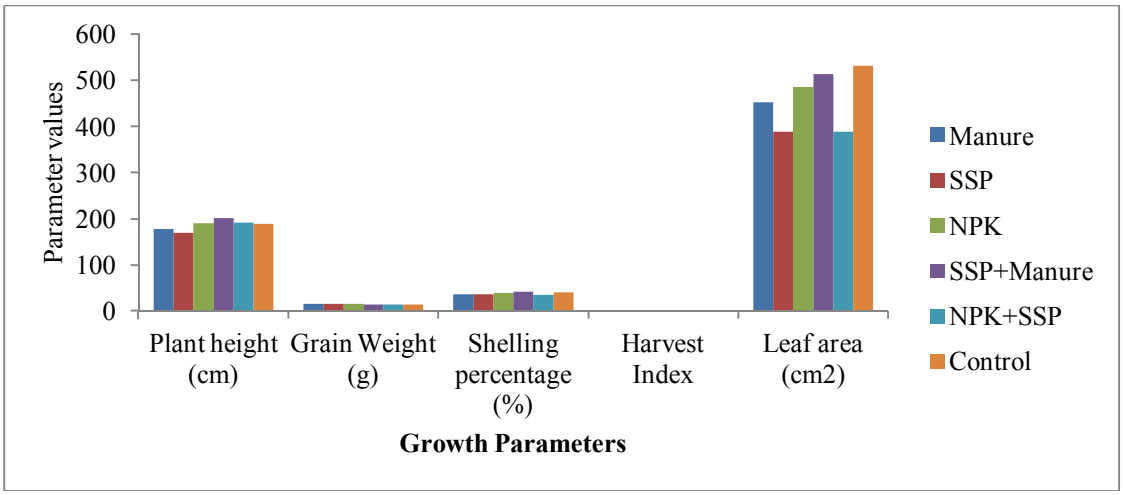

Figure 4: Growth Parameters of 10-week old maize plants under different treatments

4. Discussion

This study shows that using various treatments, plant height increases from 4th weeks to the 8th weeks after planting and remain slightly different at the 10th weeks. The leaf areas decreased at 10th week after planting compare to that of 8th week and this could be due to ageing, declined in the available nutrients or as a result of yield performance since the plant need more energy to tassel and to produce cobs. At 4th week after planting the maximal leaf area was recorded for the treatment which contained Single Super Phosphate (SSP) + Manure, followed by Nitrogen, Phosphate and Potassium (NPK) + SSP, NPK, Manure and SSP being the least with the following values 315.35 cm^2, 305.55 cm^2, 303.68 cm^2, 273.76 cm^2, 246.61 cm^2, and 243.92 cm^2 respectively, these agree with Gao *et al.* (2007). The highest plant height at 4th weeks after planting was 97.37 cm using the treatment of SSP + Manure, followed by manure (94.47 cm), NPK + SSP (92.00 cm), SSP and NPK were measured 91.00 cm and 91.03 cm respectively and the least height was recorded for the control (86.90 cm).

At 6th week after planting, the leaf area were 540.19 cm^2, 516.69 cm^2, 507.93 cm^2, 417.11 cm^2, 377.53 cm^2, and 361.02 cm^2, respectively for the treatments of NPK + SSP, NPK, SSP + Manure, Manure and SSP. The highest plant height at 6th week after planting was 155.77 cm and 155.73 cm under the treatment of SSP + Manure and NPK respectively, followed by manure (150 cm), NPK + SSP (147.53 cm), SSP (132.83) and the least height was recorded for the control (126.17 cm) as shown in Table 2 and Figure 2. Only the grain weight value for NPK was slightly differing and higher (13.33 g), the grain weight value for manure, SSP and SSP + manure include 12.00 g, 12.33 g and 12.67 g respectively, while the least values were recorded for NPK + SSP and the control as 11.67g as shown in Table 4 and Figure 4.

At 8th week after planting, the leaf area were 621.65 cm^2, 531.18 cm^2, 531.22 cm^2, 492.42 cm^2, 422.13 cm^2, and 436.73 cm^2 respectively for the treatments which contained NPK + SSP, NPK, SSP + Manure, Manure, SSP and the control. The highest plant height at 8th weeks after planting was 202.43 cm under the treatment of SSP + Manure followed by SSP (182.30 cm), NPK + SSP (179.43 cm), manure (177.40 cm) and the control (176.20 cm) was higher than the NPK (155.20 cm).

At 10th weeks after planting, the leaf area were 531.22 cm^2, 485.63 cm^2, 514.14 cm^2, 452.62 cm^2, 389.28 cm^2, and 388.58 cm^2 respectively for the treatments which contained NPK + SSP, NPK, SSP + Manure, Manure, SSP and the control. The highest plant height at 8th weeks after planting was 201.07 cm under the treatment of SSP + Manure followed by NPK + SSP (191.10 cm), NPK (189.73 cm), control (188.63 cm), manure (177.40 cm) and the SSP being the least with 169.20 cm.

The harvest index for NPK (0.40) was higher than the other treatments, SSP + manure was next in quality of the harvest index (0.38), followed by SSP (0.33), NPK + SSP and manure have 0.32 each, while the least harvest index for the 10th week after planting was 0.28 in the control (Table 4 and Figure 4), These also agree with Okalebo *et al.* (2003). The shelling percentages at 10th week after planting for all the treatments include SSP (35.88 %), SSP + manure (42.40 %), NPK (38.75 %), that of the manure was 36.00 %, SSP (35.88 %), NPK + SSP (40.22 %) and the control 34.50 % . The grain weight for both SSP and manure have 15.33 g each, SSP + manure and NPK + SSP also have 14.67 g each while NPK and the control have 16.00 g and 14.00 g respectively. Okalebo *et al.* (2003) have reported a higher yield of

maize from a combined use of NPK fertilizer and poultry manure than from sole applications. Some researchers have earlier reported that maize yields from a mixture of organic and inorganic fertilizer applications were significantly higher than yields from sole organic fertilizer application. These observations, though values were low, indicate that the Plant height, grain weight, shelling percentage, harvest index and leaf area were significantly influenced by the application of poultry manure and mineral fertilizers as shown in Table 1, 2, 3, 4 and Figure 1, 2, 3, 4 these agree with Fan and Yang, (2009). This study shows that under the various treatments used, plant height increases from 4th weeks to the 8th weeks after planting and remain slightly different at the 10th weeks. The leaf areas decreased at 10th week after planting compare to that of 8th week and this could be due to ageing, declined in the available nutrients or as a result of yield performance since the plant need more energy to tassel and to produce cobs.

Conclusion

The results presented herein show that the application of organic and inorganic fertilizers improved the general soil fertility parameters with N, Ca, Mg and K increasing in all treatments. Organics and/or mineral fertilizers amended soil that is, manure and/or NPK as well as SSP produce better maize yields to those obtained where no treatments were used that is, the control. However, the organic materials may not be available in large amounts that are required for sole application but indication shows that it is a good such of fertilizer. Farmers are therefore encouraged to adopt the combination of organic and mineral fertilizers if available as they resulted in high maize grain yields and improved soil chemical properties.

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