THE EFFECTS OF PALM KERNEL CAKE, CHICKEN MANURE, GLIRICIDIA sepium AS COMPARED TO INORGANIC MANURE (NPK-15:15:15 & UREA) ON GROWTH, YIELD AND YIELD COMPONENTS OF IRRIGATED MAIZE (ZeamaysL.)

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Abstract

A field experiment was conducted at the School of Agriculture, Njala University in an Inland Valley Swamp to investigate the effects of Palm Kernel Cake, Chicken manure and Gliricidia sepium fertilization at equal rates of 10t/ha on the growth and yield of maize. The variety of maize used in the experiment was the most widely adopted improved DMR-ESR yellow maize. The maize was planted with treatments as thus: No fertilization (control), recommended rate of NPK-15:15:15 & Urea, 10t/ha PKC, Chicken manure and Gliricidia sepium. The trial was laid out in a randomized complete block design with three replications. The plot size was $12m^2$ and planting distance was 75cm by 50cm. Traits evaluated were subjected to analysis of variance using Genstat.The results of the study indicate that fertilization of maize with PKC and Chicken manure significantly increased the yield of maize in the lowland soils of Njala. NO significant difference was observed between these organic minerals and the recommended rates of NPK.

Keywords: Palm kernel cake, Chicken manure, Gliricidia, irrigated maize

1. INTRODUCTION

One of the members of the cereal family that has added great value to man and animals is maize. Maize (*Zea mays* L.) is a member of the grass family, *Poaceae*. It grows up to 1-3m height producing a single upright stem with about ten to fourteen leaves inserted alternatively. It is believed that the crop was originated in Mexico and introduced to West Africa in the early 1500s by the Portuguese traders (Dowswell*et al*., 1996). It was brought to Ethiopia in the 1600s to 1700s (Haffanaghel, 1961). Currently, maize is widely grown in most parts of the world over a wide range of environmental conditions ranging between 50° latitude North and South of the equator.It ranks third following wheat and rice in world production (FAO, 2002), while in Sierra Leone it ranks second to rice. Africa produces about 60% of the total world production of the crop, most of which is used for human consumption (FAO, 2003). Widely grown in the humid tropics and sub-Saharan Africa, the crop serves for food and livelihood for millions of people today. (Enujeke, 2013). It is consumed roasted, baked, fried, boiled or fermented in Nigeria (Agbato, 2003). In developed countries, maize is source of such industrial products as corn oil, syrup, corn flour, sugar, brewers' grit and alcohol (Dutt, 2005). As an energy supplement in livestock feed, maize is cherished by various species of animals, including poultry, cattle, pigs, goats, sheep and rabbits (DIPA, 2006).

In Sierra Leone, statistical survey indicates that the area under cultivation is approximately 16,060ha with an average yield of 0.8t/ha FAO, (2003). Most of its cultivation in Sierra Leone is by traditional methods in mixed cropping systems in the upland with cassava, rice, groundnut and several vegetables. However, due to increase in demand for maize in Sierra Leone, most farmers have resorted to the commercial production of maize as a sole crop. Three crops of maize can be grown in Sierra Leone. The first (late May or early June and second planting (early September) are done on the upland soils. Third planting is done in the Inland Valley Swamp (IVS) during the dry season to ensure uninterrupted supply of maize. Maize is rich in starch or carbohydrate (71%) and low in protein. It contains 11.6% water, 9.4% protein and 4.2% fat (FAO, 2003). It is a good sources of energy for both humans and animals and it is high yielding and easy to process. Many varieties have been discovered worldwide. Some improved recommended varieties grown for consumption in both upland and Inland Valley Swamp ecologies in Sierra Leone include DMR-ESR Yellow, TZSR-Yellow and Western Yellow. These have high yielding potential. Maize is relatively a short duration crop and capable of utilizing inputs more efficiently and is potentially capable of producing large quantity of food grains per unit area. Maize yield is influenced by soil fertility conditions of which nitrogen and phosphorus are the most important nutrients in maize nutrition. Lack of soil nutrients is reflected in the plant characteristics of maize more than in most other crops and it is often said "maize speaks" implying that maize cannot produce maximum yields unless sufficient nutrients are available (DeloriteAhlgren., 1967. Organic fertilizers including chicken manure, Palm Kernel Cake, and green manure of Gliricidia sepium may be used for the crop production as a substitute of the chemical fertilizers because the importance of the organic manures cannot be overlooked. Worldwide, there is growing interest in the use of organic manures due to depletion in the soil fertility. Economic premiums for certified organic grains have been driving many transition decisions related to the organic farming (Delate and Camberdella, 2004). Continuous use of fertilizers creates potential polluting effect in the environment (Oad*et al*, 2004).The addition of organic sources could increase maize yield through improving soil fertility and higher fertilizer use efficiency (Gangwar*et al.,* 2006). Higher and sustained yield could be obtained with judicious and balanced fertilization combined with organic manures for ecological balance, low cost cultivation, clean environment and nutritious food without affecting human health (Bhatti*et al.,*2008). Farm manure is the decomposition of dung and urine of farm animals along with litter and left over material from roughages or fodder fed of cattle. On an average it contains 0.5% N, 0.2% P and 0.5% K (Rasool*et al.,* 2007).Manures and fertilizers are the life wire of improved technology contributing about 50 to 60% increase in productivity of food grains in many parts of the world, irrespective of soil and agro-ecological zone (DIPA, 2006). Reijnties*et al,* (1992) and Adepetu (1997) remarked that the downward trend in food production should prompt farmers to amend the soil with different materials in order to enhance growth and yield of crops. Several organic materials such as cattle dung, poultry dropping, pig dung and refuse compost have been recommended to subsistence farmers in West Africa as soil amendments for increasing crop yield. Sobulo and Babalola (1992) reported that poultry dropping and cattle dung increased root growth of maize and the crop extracted soil water more efficiently for increased grain yield. Stefan (2003) indicated that fresh poultry dropping contain 70% water, 1.4% N, 1.1% P2O5 and 0.5% K2O while dried poultry manure contains 13% water, 3.6% N, 3.5% P2O5 and0.5% K2O while dried poultry manure contains 13% water, 3.6% N, 3.5% P2O5 and 1.6% K2O. Among the different sources of organic manure which have been used in crop production, poultry manure was found to be the most concentrated in terms of nutrient content (Lombin*et al,* 1992). Kostchi*et al,* (1989) observed that application of poultry manure improved the availability of some minerals in the soil, and especially the transfer of nutrients from rangeland to the crop plant. Izunobi (2002) reported that poultry manure, especially those produced in deep litter or battery cage house are the richest known farmyard manure supplying greater amounts of absorbable plant nutrient. Amujoyegbe*et al,* (2007) reported that poultry manure increased the leaf area total chlorophyll content and grain yield of maize and sorghum. According to Brady and Weil (1999), poultry manure mineralizes faster than other animal manure such as cattle or pig dung; hence it releases its nutrients for plant uptake and utilization rapidly. Sharply and Smith (1991) reported that poultry manure contains basic nutrients required for enhancing growth and yield of crops. Application of poultry manure increases carbon content, water holding capacity, aggregation of soil, and decreases bulk density (Egerszegi, 1990).

Trees in agroforestry offer diverse advantages like biological nitrogen fixation, nutrient recycling from deeper soil layers and minimization of leaching and soil erosion (Nyadzi et al., 2003). A number of studies revealed the benefits of Gliricidia sepium for soil fertility (Ikerra et al., 1999;

Chiwara et al., 2003; Makumba et al., 2005; Akinnifesi et al., 2009). Its green manure can contribute N (and other recycled nutrients) by 20-65 kg/ha in smallholder farming systems (Zingore et al., 2003; Baggie et al., 2004; De Costa et al., 2005).Repeated green manure applications can provide more long-term (Sileshi&Mafongoya, 2006; Kimaro et al., 2007; Makumba et al., 2007) or more short-term (Sangakkara et al., 2004; Reddy et al., 2008; Silva et al., 2008) benefits. However, there are not always positive effects (Pandey&Rai, 2007; Marin et al., 2007). Farmers were encouraged to use green manure as part of their agricultural practices and to integrate nutrient management by synchronizing the application of mineral fertilizers and organic constituents. The hypothesis was that Gliricidia green manure can increase the production potential of the model crop maize, irrespective of the terrain. It is a leguminous tree which sheds off its leaves before flower initiation during the month of January. These leaves could be used for manuringpurpose.In the case of Palm Kernel Cake (PKC),when the oil has been extracted from the kernel (seed) the residue known as “palm kernel cake” (PKC) is rich in carbohydrate (48%) and protein (19%) and is used as cattle feed (Onwueme and Sinha, 1991).Keeping in view the importance of organic manure, a field experiment was conducted with the objective of finding out the effect of organic fertilizers such as *Gliricidia sepium*, Chicken manure,and Palm kernel cake and inorganic fertilizers i.e. (NPK: 15:15:15 and Urea) applied at equal rate of 10 tons/ha of organic manure and recommended rates of inorganic fertilization on the growth and yield attributes of maize under lowland agro climatic conditions of Njala, Moyamba district.

2. MATERIALS AND METHODS

Location and climate of study area

The experiment was conducted in the dry season in 2017 in the inland Valley swamp (IVS) at the school of agriculture, Njala, in the Moyamba District, Southern Sierra Leone. Njala is located at an elevation of 50m above sea level on 8^0 06N latitude and 12^0 06W longitude. Njala experiences a distinct dry and wet season. The rainy season which is monomodal lasts from April to November while the dry season extends from December to March. Mean monthly maximum temperature ranges from 21^0 C to 23^0 C for the greater part of the day and night especially during the rainy season

Description of Experimental Site

The predominant vegetation of Njala is secondary bush. The soil at the experimental site belongs to Njala series (OrthoxicPalehumult). Textures are usually gravely clay in the sub soil. The soils are low in soil moisture, have a very low nutrient status and are slightly acidic with pH ranging from 5.5-6.0. The experiment was conducted in an Inland Valley Swamp (IVS) close to the School of Agriculture, Njala University.

Land Preparation

The experimental site was manually cleared with cutlasses and left to lie for a week before the site was ploughed. Garden hoes were used to plough and harrow the site. The experimental layout was done and sectioned into blocks and plots. Pocket holes were dug on flat land in each of the plots as determined by the plant population per plot. The holes were filled with various manure as prescribed by the experiment. Watering was done on alternate days to enhance fast decomposition of manure for two (2) weeks before planting.

Description of Crop Variety

An improved variety known as DMR-ESR-Yellow was planted. This variety was introduced in Sierra Leone from IITA, Nigeria. It is particularly resistant to downy mildew and early streak disease. It takes about 50-70 days to silk. It has a sweet taste and matures in about 80-85 days. Tassel type is primary and yield potential is in the range of 1.5-2.1 tons per hectare.

Experimental design, layout and randomization

The experiments was laid out in a randomized complete block design (RCBD) and lasted for three months with each treatment replicated thrice. Each replicate consisted of five (5) treatments. Total land area measured 242 m^2 (22 m by 11m) with 15 plots in all and each plot size measured 4m by 3m (12 m^2) with 0.5 m alley ways between plots and 1m between replicates

Treatments

All treatments were applied as basal during the cropping period. The Palm kernel cake and Chicken manure were applied to the soil in powdery form and Gliricidia sepium as green manure by incorporating it into the soil. The applied treatments were well watered and thoroughly mixed seven days before planting of maize. The treatment comprised the followings:

I. control (no treatment)
II. NPK 15:15:15 and Urea
III. 10 tons (10,000 kg/ha) of Palm Kernel Cake
IV. 10 tons (10,000 kg/ha) of Chicken manure
V. 10 tons (10,000 kg/ha) of *GliricidiaSepium*

Table 2: NPK, Urea and Organic Manure Application rates 0n Maize in the lowland.

TREATMENT NUMBER	TREATMENTS	RATE KG/HA	AMOUNT/PLOT 12M^2 (KG)	AMOUNT/STAND (G)
T 3	Palm Kernel Cake	10 tons (10,000)	12	375
T 2	NPK 15:15:15 & Urea	200(15:15:15)& 130 Urea	0.24 & 0.16 Respectively	7.6&5.0 Respectively

T 4	Chicken manure	10 tons (10,000)	12	375
T 5	Gliricidia sepium	10 tons (10,000)	12	375
T 1	Control	-	-	-

Planting and cultural practices

The seeds of maize (*Zea mays* L.) were sown in an already prepared experimental field manually at 3 cm depth. Maize was sown at a spacing of 75 x 50 cm between and within rows respectively resulting in 32 stands per plot with a planting population of 53,333 plants/ha. Weed control was done manually by hand pulling and hoeing. Weeding was done three times throughout the cropping period. The first, second and third weeding were carried out at the 2nd, 6th and 9th weeks after planting. Weeds were not allowed to thrive before weeding was carried out in the experimental plots. Weeds uprooted were packed out of the experimental plots, so as not to interfere with the results of the experiment. The plants were watered once every day and mostly in the evening hours. Watering continued until the ears attained physiological maturity. Harvesting of course was done when the ears were physiologically matured at 75 days.

3. Data collection

In each plot, five plants were tagged for the collection of data on the above ground parts. The following characteristics were measured:

1. Percentage germination-Number of seeds that germinated after sowing per plot divided by the total number of seeds planted multiplied by 100.
2. Number of leaves- The leaves produced by each tagged plant were counted and the number got was recorded.
3. Plant height (cm^2) - Plant height was measured from the base of the plant to the tip. The values were recorded in centimeters (cm).
4. Leaf area (cm2) –Length and breadth of one middle leaf of each tagged plant was measured to determine the leaf area.
5. Ear height – Average ear height was recorded from the base of the plant to the uppermost height of the ear bearing node.
6. Number of ears per 5 tagged plants was counted per plot.
7. Total number of ears per plot was also counted and the values were recorded.
8. Fresh weight of cobs per 5 tagged plants per plot
9. Total fresh weight of cobs per plot.
10. Dry weight of cobs/5 tagged plants/plot
11. Dry weight of cobs produced per plot
12. Grain weight/5 tagged plant/plot
13. 1000 grain weight/plot

14. Total grain weight harvested/plot.
15. Total fresh weight of biomass produced/plot.

3.1Data analysiss

The data collected were subjected to analysis of variance using GenStatrevised version. Standard Error of Difference (SED) was used to separate means.

4. RESULTS

4.1 Germination Percentage

Differences I germination observed among treatments were not significant except for plants in plots treated with PKC (80%) which obtained the lowest germination % significantly different from other treatments. Control and Gliricidiasepium scored the same germination % (91.7%) and being the highest. The lowest germination % in PKC as observed can be attributed to the heat that could have been generated during the decomposition process (Table3).

4.2 Plant Height

Plant height increased from two weeks after planting (WAP) to two months WAP. However, application of 10 t/ha chicken manure at equal rate of both palm kernel cake PKC and Gliricidiasepium, had the tallest plants (124.5 cm) followed by PKC 100.cm). The recommended NPK fertilizer application had (97.3 cm) which also showed significant effect. The control crop had significantly the shortest plant with 66.8 cm (Table 3).

4.3 Leaf Number

Leaf number increased from germination to two months after planting (MAP). Control with no treatment produced the leas number of leaves (8.67), highly significantly lower than all other treatments. However, in comparison of treatments means, application of Gliricidiasepium at 10 t/ha of the same rate of that of PKC and chicken manure, produced more leaves than the control plots but significantly lower leaves in plots of NPK-15:15:15, PKC and chicken manure (Table3).

Table: 3- Effects of Various Treatments on Growth and Yield Component of Maize

TREATMENT	GERMINATION (%)	PLANT HEIGHT (Cm)	LEAF NUMBER
C. manure	90.0	124.5	10.67
Control	91.7	66.8	8.67
G. *sepium*	91.7	68.1	9.00
NPK- 15:15:15	86.7	97.3	10.33
PKC	80.0	100.8	11.00
Mean	88.0	91.8	9.93

SED	4.08	11.17	0.516
C. V %	5.7	14.9	6.4

4.4 Leaf Area

Leaf area varied with treatments at various stages of growth of plants. The largest leaf area ($664 cm^2$) was observed in the 10 t/ha application of chicken manure which showed most significant difference from 10 t/ha treatments of both PKC and NPK 15:15:15 fertilizer. The control ($381\ cm^2$)had the least leaf area which was significantly smaller than the other treatments. However, significant difference was observed among 10 t/ha application of Gliricidiasepium and those of PKC, chicken manure and NPK 15:15:15 of the same application rate of 10 t/ha (Fig. 2).

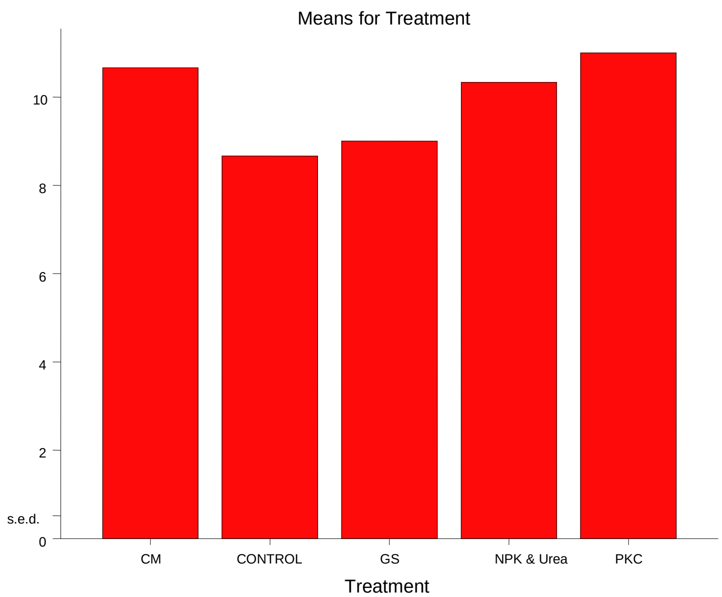

Figure 2: Leaf Area (Cm^2)

4.5 Stem Girth

Palm kernel cake ($7.70\ cm^3$) produced the largest stem girth, followed by chicken manure ($7.17\ cm^3$) and NPK 15:15:15 ($7.03\ cm^3$) respectively with no significant difference. The control (5.37 cm3) produce the smallest size stem girth which was highly significantly different from PKC, chicken manure and NKP treatments. No significant difference was observed among the stem girth of the plant in the control plot and that of the plot treated with Gliricidiasepium (Figure 3).

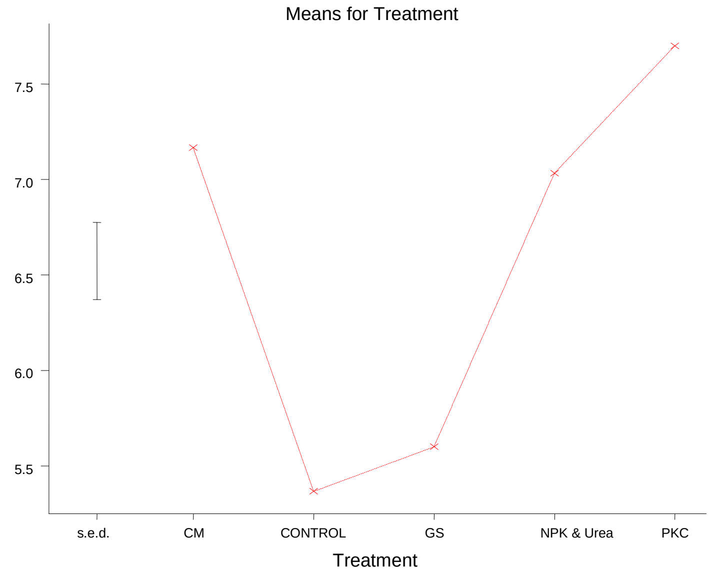

Figure 3: Stem Girth

4.6 Fresh Biomass Weight

No significant difference was observed in terms of total weight of biomass (kg) among PKC and chicken manure treatments, except for the control (4.30 kg) which had significantly the lowest weight followed by Gliricidiasepium plot (4.90 kg). The highest weight (12.83 kg) total biomass was attained by the 10 t/ha application of PKC.

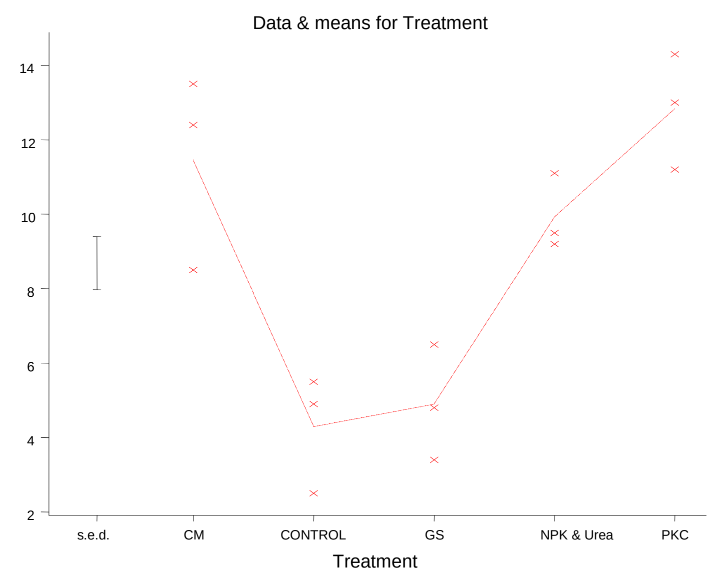

Figure 4. Fresh Biomass Weight

4.7 Ear Height

No significant difference was observed among PKC, Chicken Manure and NPK 15:15:15 treatments. The lowest ear height was observed in the control plot which had (58.2cm) after (72.9cm) application of Gliricidiasepium. Palm kernel cake (88.8cm) treatment attained the highest height (Table 4).

4.8 Ear Number

Palm kernel cake (PKC) plot produced the highest number of Ear (11.67) which was not significantly different from plots treated with chicken manure and NPK-15:15:15. The control plot had the least number of Ears (7.00), significantly lower than other treatments followed by Gliricidiasepium (8.67) (Table 4)

4.9 Fresh Ear Weight

Significant difference was not observed in terms of fresh weight of Ear per 5 plants among treatments except for the control plot (1.233kg). The largest weight was attained by plot with PKC treatment (2.633kg) (Table 4)

4.10 Total Number of Ear

Maximum Ear of equal number was recorded from plots treated with PKC and recommended rate of NPK -15:15:15. Control plot recorded the least number of Ear significantly lower than other treatments. No significant difference was observed among applications of PKC, Chicken manure and Gliricidiasepium (Table 4)

4.11 Total Fresh Ear Weight

Total fresh Ear weight per plot did not show significant difference among plots with treatments of PKC (7.23kg), NPK-15:15:15 (6.77kg) and chicken manure (6.23kg). Significant difference in fresh Ear weight was observed in the control plot which produced the least weight (3.07kg) followed by plot with Gliricidiasepium (4.37kg) (Table 4).

4.12 Fresh Cob Weight

The highest weight was attained by plot treated with PKC (1.667kg) followed by recommended rate of NPK-15:15:15 (1.533kg) and Chicken manure (1.467kg) with no significant difference. The control (0.900kg) plot had significantly the lowest height than other treatments followed by Gliricidiasepium (1.100kg) (Table 4)

4.13 Total Weight of Fresh Cob

No significant differences were observed among treatments with the exception of the control plot which had significantly lower fresh cob weight(1.80kg) compared to the Gliricidiasepium which had (2.73kg) per plot. Total fresh cob weight per plot was highest for plot with PKC and Chicken manure treatments (4. 07kg) with no significant difference from NPK-15:15:15 application (Table 4)

Table: 4 – Effect of Various Treatments on the Yield of on Irrigated Maize

TREATMENT	EAR HEIGHT (cm)	NO OF EAR	F. EAR WT (kg)	TOTAL NO. OF EAR	TOTAL F.EAR WEIGHT kg)	F. COB WT. (kg)	TOTAL WT.OF FRESH COB (kg)
C. manure	87.5	10.0	2.067	29.7	6.32	1.467	4.07
Control	58.2	7.00	1.233	20.0	3.07	0.900	1.80
G. *sepium*	72.9	8.67	1.600	25.0	4.37	1.100	2.73
NPK-15:15:15	81.9	9.67	2.267	30.0	6.77	1.533	4.03
PKC	88.1	11.67	2.633	30.0	9.23	1.667	4.07
Mean	77.9	9.40	1.960	26.9	5.58	1.333	3.34
SED	7.56	1.211	0.2319	3.35	0.733	0.2338	0.938
C V %	11.9	15.8	14.5	15	16.2	21.5	34.4

4.14 Dry Cob Weight

No significant difference was observed in cob weight per 5 plants among Chicken manure (1.267kg), NPK-15:15:15 (1.00kg) and PKC (0.900kg). The control plot had significantly the lowest (0.500kg) dry cob weight per 5 plants compared to the plot of Gliricidiasepium (0.633kg). However the highest dry cob weight was exhibited by Chicken manure (1.23kg) followed by NPK (0.9kg) and PKC (0.83kg) (Fig 5).

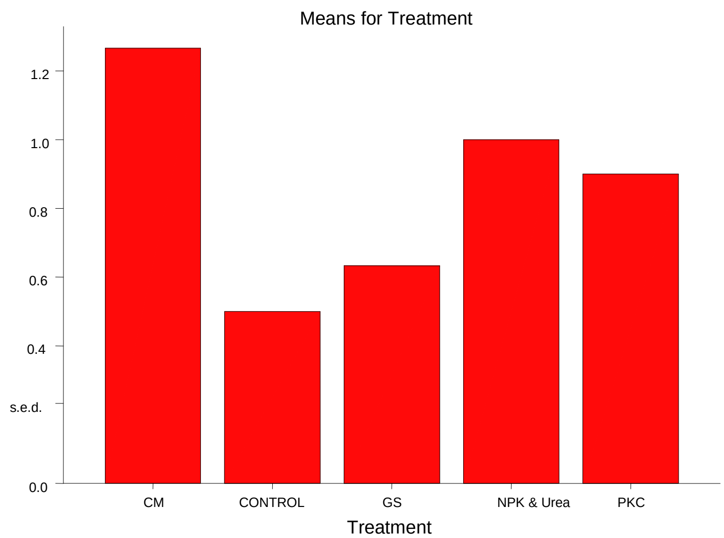

Figure 5: Dry cob weight

4.15 Total Weight of Dry Cob

Total weight of dry cob did not produce any significant difference among treatments. Though no significance difference occurred among treatments, control plot had the least weight of dry cob per plot. Chicken manure (2.73kg) attained the highest dry cob weight per plot followed by NPK-15:15:15 (2.60kg), PKC (2.38kg) and Gliricidiasepium (1.73kg) respectively. (Fig.6).

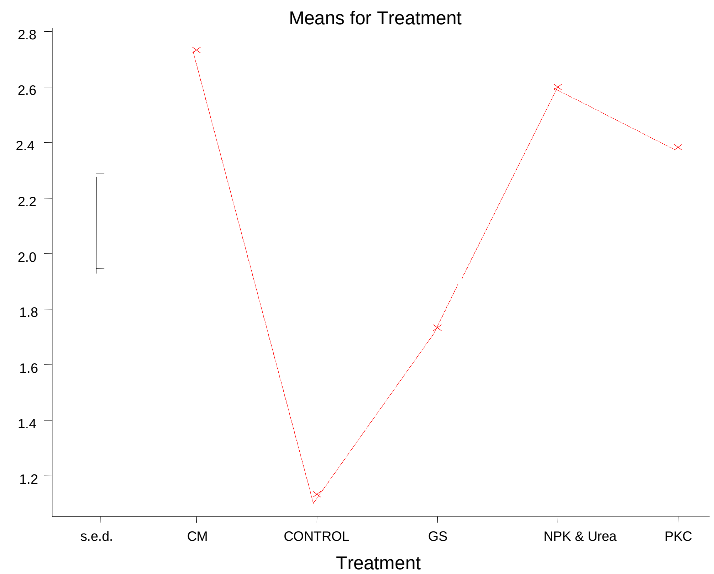

Figure 6: Total weight of dry cob (Kg)

4.16 Grain weight

NPK-15:15:15 exhibited the largest weight (0.600kg) with no significant difference among Chicken manure (0.567kg) and PKC (0.500kg) treatments. Control (0.167kg) had the lowest grain weight per 5 plants significantly different from other treatments followed by Gliricidiasepium (1.333kg) (Fig 7).

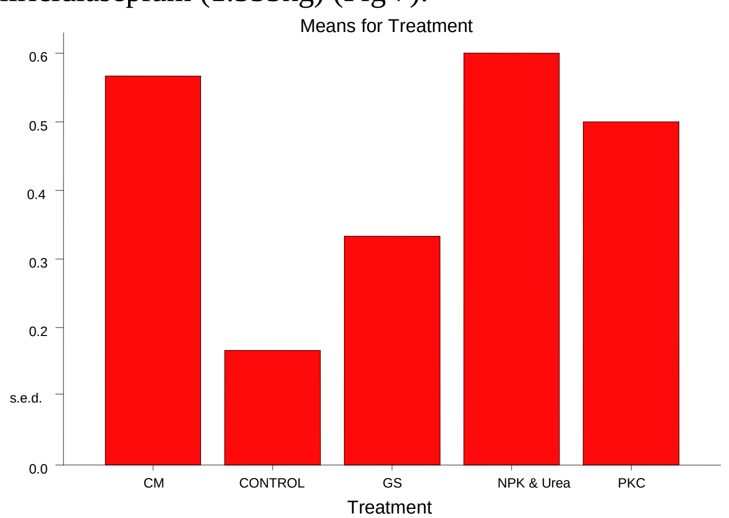

Figure 7: Grain weight (Kg)

4.17 1000 Grain Weight

Treatments of Chicken manure (178.9gm), NPK-15:15:15 (178.6gm) and PKC (160.7gm) exhibited no significant difference except for the control (134.3gm) which had the lowest grain weight significantly lower than other treatments followed by Gliricidiasepium (156.6gm). Chicken manure produced the largest weight in terms of 1000 grain weight per plot (Fig. 8).

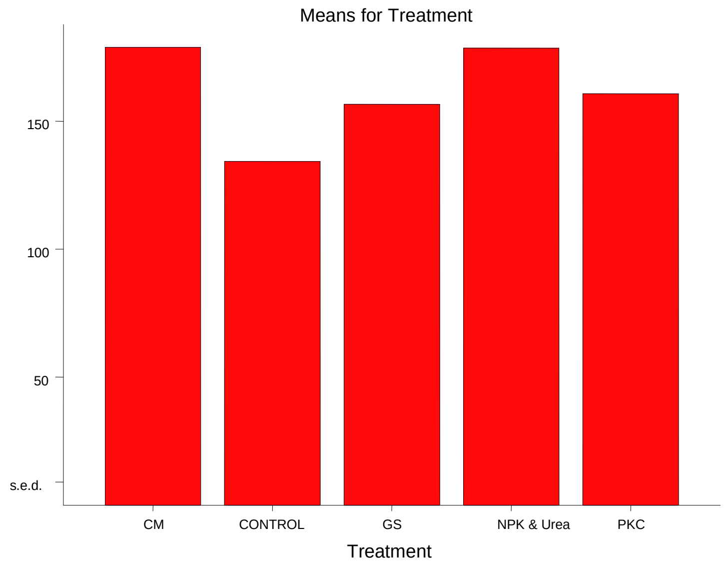

Figure 8: 1000 grain weight of maize

4.18 Total Grain Weight

NPK-15:15:15 and Chicken manure had the same grain weight (1.87kg) per plot with no significant difference from PKC (1.57kg) treatment. Control (0.50kg) had the least grain weight per plot significantly lower than Gliricidiasepium (1.10kg) (Fig. 9).

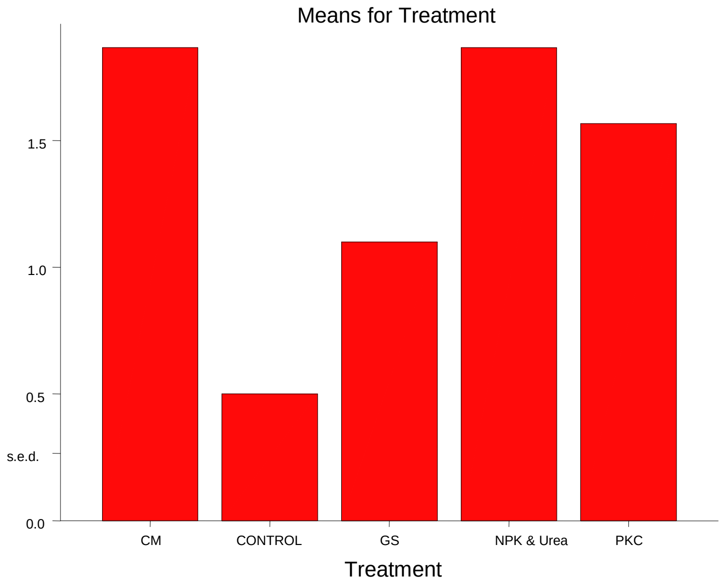

Figure 9: Total grain Weight

5. DISCUSSION, CONCLUSION AND RECOMMENDATION

DISCUSSION

The importance of the organic manures cannot be overlooked because it can serve as substitute to chemical fertilizers for crop production. Worldwide, there is growing interest in the use of organic manures due to depletion in the soil fertility.

Fertilizer use, being one of the factors influencing production, holds the key to increased maize production in Sierra Leone, especially in areas where soils of low nutrient status are found. The need for improved soil fertility is imperative for these farmers. It is, however, true that Sierra Leonean farmers, like most farmers in Africa, have always recognized the need for improving the fertility status of their soils. As a measure to improving on the low nutrient status soils, organic materials including chicken manure, palm kernel cake and *gliricidiasepium*, which are within the reach of the resource-poor farmers, were used in this experiment to determine their effects on the growth, yield and yield components of maize as compared to the recommended inorganic fertilization.

It can be noted from the results that germination percentage (%) of the crop in general was not affected by chemical fertilizer (NPK-15:15:15 & Urea) and organic manures. More than 90% of the germination was noted in control plots. However, seed germination percentage in plot treated with PKC was the lowest. This could be as a result of high heat generation during decomposition. The results suggested that factors like soil moisture and environment required for seed germination were similar throughout the field and thus, the crops response was similar in all the treatments. These results were quite in line with Loecke*et al.* (2004) and Theodora *et al.* (2003) who concluded that plant emergence was not affected by manure treatments.

This study revealed that Chicken manure, Palm Kernel Cake (PKC) and *Gliricidia sepium* had significant effect on the growth, development and yield of maize. The application of10t/ha of Chicken manure and Palm Kernel Cake significantly produced better growth parameters, yield and yield components of maize than the control during growth period and at harvest. Plant height was found to be significantly influenced by organic manure. Chicken manure produced significantly the tallest plants at 10 t/ha followed by PKC and *Gliricidia sepium* respectively than the control at all the sampling dates. An increase in plant height might be due to the adequate availability of nutrients required for plant growth and development. This supports the integrated use of chemical and organic nutrient sources for an improvement in excellent vegetative growth of plant. These results are in agreement with those of Shah *et al.* (2009) and Achieng*et al.* (2010) who reported that application of mineral N alone or with organic N significantly increased the height of maize plants. The increase in plant height with chicken manure treatment was mainly due to more availability of nutrients by chicken manure throughout the growing season. These results are in accordance with the findings of Mitchell and Tu (2005) and Warren et al, (2006).

Maximum number of green leaves was recorded in plots where PKC was applied, while minimum number of green leaves was recorded from control treatment. An increase in number of green leaves might be due to the chlorophyll content of leaves, which improved significantly with the availability of essential nutrients at all growth stages of maize. The results are in agreement with the findings of Namakha*et al.* (2008) and Mahmood*et al.* (2001) who also found that it might be due to optimum and regular supply of nitrogen to plants from soil during growth period with more assimilation rate and its integral part of protein (the building blocks of plant.)

Total leaf area per plant of maize was significantly influenced by organic manure. The application of 10t /ha PKC and chicken manure produced significantly larger leaf area than the control at all the sampling dates. Application of 10t/ha Chicken manure produced the largest total leaf area during growth period. In a similar vein, Silva et al. (2003) reported that poultry litter leads to increase in leaf number and size, which results in more longer photosynthetic apparatus by increasing total leaf area of maize plant. Ibeawuchi et al. (2007) reported the leaf area of a maize plant gradually increased with increase in poultry manure and the application of 10t/ha poultry manure gave the widest leaf area than the plots treated with various amounts of NPK.

The maximum stem girth was recorded from plants grown with PKC followed by Chicken manure treatment, while minimum stem girth was recorded in plot with no treatment. Increase in stem girth is a reflection of retention of appreciable amount of assimilates in the stem for leaf production. This might be due to the better nutrient uptake and development of the plants due to the combined application of mineral fertilizer and organic manures. It was also due to the increase in nitrogen content of soil, which was responsible for overall enhancement of growth, increase in metabolic activities, assimilation rate and cell division within the plant (Cyrus *et al.*, 2010; Lawogbomo and Lawogbomo, 2009).

Maximum number (30.0) of cobs per plant was noted in both plots of PKC and NPK-15:15:15 treatments. Organic manures and inorganic fertilizer resulted in more number of cobs per plant, possibly due to least N losses and availability of nutrients throughout the growing season of the crop. Control plots resulted in less number of cobs (20.0). The increase in number of cobs might be attributed to the availability of more nitrogen and other nutrients from both inorganic and organic source required for plant development at least up to cob formation. These results suggested that adequate supply of nutrients from both organic and inorganic fertilizers throughout vegetative growth was necessary for proper cob development in maize. These results are in line with Chapagain (2010) and Zhang *et al.* (1998) who reported that application of organic manure and mineral fertilizer to maize crop could be as effective as commercial N fertilizer for yield response.

Dry kernel yield of maize was significantly influenced by chicken manure and Palm Kernel Cake. Application of 10t/ha chicken manure produced the highest maize kernel yield. In a similar report, Smaling*et al.* (2002) recorded a significant increase in the number of kernel per ear of maize with the application of poultry manure. They attributed this significant increase in yield to the favorable beneficial effect of poultry manure on leaves and its number, leaf size, dry matter production, length and number of ears per plant, kernel weight which all have direct bearing on yields of cereals. PKC and Chicken manure had significant influence on the weight of fresh husked cob in this study. Application of 10t/ha PKC produced significantly higher fresh cob yield than Chicken manure, and NPK-(15:15:15).

Grain yield is a function of interaction among various yield components that were affected differentially by the growing conditions and crop management practices. The maximum 1000-grain weight (178.9 g) was recorded in plots with Chicken manure followed by NPK-15:15:15 plot (128.6) while minimum 1000-grain weight (134.3g) was recorded in control plot whereno treatment was applied. The grain yield usually depends upon various factors such as status of soil fertility, water availability, crop management, agronomic practices, environmental factors and plant genetic characteristics. The results of this study show that treatments that received N from organic and mineral sources producedmaximum 1000-grain weight. Yield improvement under these treatments might be due to enhanced use of N, water and other associated soil improving benefits of organic sources, which made plants more efficient in photosynthetic activity. Decrease in 1000-grain weight in control treatment might be due to low availability of nitrogen and other nutrients (Khan *et al.*, 2009). These results are in agreement with the findings of Achieng*et al.* (2010) and Shah *et al.* (2009) who were of the view that increase in 1000-grain weight was mainly due to the balanced supply of nitrogen with P and K and maximum N use efficiency from both inorganic and organic sources during the grain filling, development and growth stages.

5.2 CONCLUSION ANDRECOMMENDATIONS

The results of this study showed the advantages of using PKC, Chicken manure and *Gliricidia sepium*for the production of maize in terms of growth, yield and nutrient composition. The trend of events in plant growth and yield observed in this research implies that organic manure use could compete favorably with inorganic fertilizer. Plant growth and yield monitored in this research work showed that Palm Kernel Cake (PKC), Chicken manure and *Gliricidia sepium*, applied at 10 t/ha enhanced the nutrient composition and yield of maize. This suggest that the above materials are good sources of sustainable and efficient organic amendment which could be recommended to small holder maize farmers for improving soil properties, optimum growth and yield of maize in the study area. The nutrient composition of maize as influenced by organic minerals used in this research is also capable of meeting the nutritional requirement of the people. Therefore, the use of Palm Kernel Cake, Chicken manure and *Gliricidia sepium* as sources of nutrient for Maize growth has further lend credence to the possibility of organic materials increasing the yield and nutritional content of maize. The results have shown that there is potential for increase in the average yields of maize in Sierra Leone from 0.8t/ha to over 2t/ha through the use of PKC and Chicken manure.From the result of the study, the following conclusion can be made:

1. The application of Chicken manure and Palm Kernel Cake tended to increase the nitrogen content of the leaves and hence the chlorophyll content resulting in increased grain yield
2. That the application of Chicken manure or Palm Kernel Cake at 10t/ha can be used in place of the recommended NPK: 15:15:15 without any significant reduction in grain yield.
3. Nitrogen fertilization is very important for increased maize yield in Sierra Leone.
4. The yield of maize was very low without organic or inorganic nitrogen fertilization.
5. The study indicates that PKC and Chicken manure are valuable fertilizer sources whose use need to be encouraged.

5.2.1 Recommendations

Based on the findings of the study, and due to an increasing cost of chemical fertilizers, it is recommended that Sierra Leonean farmers adopt the use of Palm Kernel Cake and/or Chicken manure as a mean of soil improvement technology and as a source of nitrogen which is one of the major nutrient required for maize production.

For efficient and economic use of PKC and Chicken manure, a rate of 10t/ha and above is recommended for maize production as it will yield the same as the recommended rate of NPK-15:15:15.

It is also recommended that the trial be repeated in a rain-fed situation on upland soils across various agro ecological zones to ascertain the findings of this study.

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