COMPARING OF GROWTH AND YIELD RESPONSES OF LOCAL MAIZE AND OBA SUPER 6® HYBRID UNDER ORGANIC AND INORGANIC SOIL AMENDMENTS

Chinedu Felix Amuji, Emmanuela Ogochukwu Ukwueze and Solomon Oluwaseyi Adewuyi*
Department of Crop Science, Faculty of Agriculture, University of Nigeria Nsukka
Corresponding author contact: solomon.adewuyi@unn.edu.ng

ABSTRACT

Maize (*Zea mays*) is one of the major staple annual crops grown and consumed in Nigeria. Due to increasing human population and continual degradation of agricultural land for this crop to continue to grow and yield optimal, it now requires addition of nutrient elements. Fertilizers addition have been proven to be important input to get higher maize productivity, however there is a need to compare their various recommended quantities impacts on yield of the crop. A field study was carried out to confirm the effectiveness of organic manure and inorganic fertilizers alternatives to maize production. The objective this study was to compare the influence of organic and inorganic fertilizers on local maize and oba super 6® hybrid under open field rain-fed natural conditions at Nsukka. Four treatments (local maize and organic manure, local maize and inorganic fertilizer, oba super 6® and organic manure, and oba super 6® and inorganic manure). The manure rates used were the conventional recommended quantities of poultry manure and NPK fertilizers. The treatments were arranged in randomised complete block design with four replications. Both growth and yield parameters such are plant height, number of leaves, leaf area, 100 seed weights, and weight of fresh and dry cobs etc. were collected from the fourth weeks after planting till maturity, then statistically analysed. Results of the experiment after analysis showed that oba super 6® with organic (poultry) manure had the best yield when compared with the other treatment combinations studied in this work, and are thus recommended.

Keywords: maize, soil, nutrients, plant growth, grain yield.

INTRODUCTION

Maize botanically known as *Zea mays L.* (also known as corn), is among the top three most abundant cereals in the world. It belongs to the family *poeceae*, order, *Poeles* and tribe *Mavdeae* is a tall monoecious plant commonly cultivated in tropical areas and grown at a summer crop in temperate areas; being a sun loving crop and also (Ajakaye et al, 2019) grown in every continent except Antarctica. Maize is the leading cereal crop in terms of worldwide production, and it is used for the production of an array of human foods, animal feeds, biofuels, and other industrial uses (Erenstein et al., 2022). Maize is stable food as well as an industrial crop for flour mills, breweries, breakfast cereals, and baby food in Nigeria. The demand for maize is always higher than what is being produced in the country (Abdulraheem et al, 2018). In terms of human foods, maize is usually channeled into three major milling industries: dry and wet, which generate raw materials that are further transformed into breakfast cereals, snacks (popcorn, extruded- and lime-cooked), yeast and chemically leavened bakery items, tortillas, corn syrups, beer, and distilled spirits.

In 2019, the total global maize production stood at about 1148 million tons. The USA is by far the largest producer of maize, accounting for 40% of world production in 2010, followed by China at 20%. In Africa and Latin America, maize is a major staple, with more than 90% of the maize in Africa used for food and an average per capital consumption of about 50 kg (Abidemi, 2023). According to FAO (2021), it is primarily utilized in the United States, which is the world's top producer, consumer, and exporter. On a global scale, maize production has expanded from 205 million tons to 1145 million tons since 1961 (FAO, 2021). In 2016, the global maize production record was about 1 billion tons. Africa produced about 73 million tons; out of this amount, Nigeria produced about 11 million tons and South Africa, produced about 7 million tons (FAOSTAT, 2016).

Maize has various varieties but the two being considered here is the Oba super 6 hybrid and the local maize. Oba super 6 hybrid maize is a high-yielding hybrid maize seed noted for profitable maize plantation (Ibikunle *et al.*, 2009). Compared to other maize varieties, it has wider adaptability and tolerance to low moisture stress. It has low soil nitrogen efficiency. It also has ears aspect and is drought tolerant. The photoperiod is neutral, the plant height is between 180 - 195 cm and ear height is around 85 - 95cm (Nigeria Seed Portal Initiative, 2024). Local maize generally refers to maize varieties that are indigenous or traditionally grown in a specific region. These varieties are often adapted to local climatic conditions, soil types, and agricultural practices. They may not be as high-yielding as modern hybrids but are valued for their resilience and adaptation to local environmental conditions. Local maize can also have unique traits such as specific flavors, colors, or resistance to certain pests and diseases that are characteristic of the region where it is grown.

Organic soil amendment is the composition of organic moieties derived from biomass and/or living beings. It generally includes compost, wood chips, biochar, animal manure, straw, husk, geotextile, and sewage manure. It's the addition of organic fertilizer to modify the soil for good; organic fertilizer is a fertilizer derived from organic sources, including organic compost, cattle manures, poultry droppings, and domestic sewage. These substances are extremely rich in organic matter and macro- and micro elements that increase the fertility of soils by ameliorating micro-climatic conditions and may also provide substrates for microbial growth (Abdel-Fattah, 2020).

Soil quality can be restored through proper management practices that enhance SOM content and improve microbial biodiversity and soil properties, thereby improving its productivity (Shakoor et al., 2020; Haider et al., 2021). Inorganic soil amendments involves the addition of inorganic fertilizers. Inorganic fertilizers are synthetic, chemical, artificial material added to the soil to supply one or more required nutrients for plants. Inorganic fertilizer are one of the essential input in maize production. They play a vital role in the enhancement and improvement of soil fertility and increasing of crop yields (Abdulraheem et al, 2018).

Soil amendment is a necessary condition for good crop yield in Nigeria due to inherent low fertility status of the soils especially the soils in the south eastern part of the country. The land nutrient is limited and the demand for higher production is increasing. The stability of production depends on replenishing the nutrients removed from the soil by crops, maintaining desirable physical condition of the soil, preventing an increase in soil acidity and toxicity, minimizing erosion and low crop yield and growth (Abdulraheem et al., 2018). The aim of this study is to compare the yield and growth responses of two varieties of maize; Nsukka local maize and Oba super 6 hybrid under organic and inorganic soil amendments.

MATERIALS AND METHOD

Experimental Site: The experiment was conducted under rain-fed conditions at the Teaching and Research Farm of the Department of Crop Science, University of Nigeria, Nsukka, in Enugu state, Nigeria. Nsukka is characterized by lowland humid tropical conditions with bimodal annual rainfall distribution ranging from 1155 mm to 1955 mm, with a mean annual temperature of 29°C to 31°C and a relative humidity between 69% and 79% (Uguru et al., 2011).

The materials used for the experiment

The materials used for the experiment included: well-cured poultry manure (organic manure) and NPK fertilizer (inorganic manure), Oba Super 6 hybrid seeds, Local maize seeds sourced from a seed vendor at Ogige Market, Nsukka. Measurement instruments such as measuring tape and weighing balance and, other necessary tools including a knapsack sprayer and marking tape

Source of experimental materials: Oba Super 6 hybrid maize seeds were sourced from the Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka. Local maize seeds were obtained from Ogige Market, Nsukka. Poultry manure was sourced from the Animal Science Farm in the Faculty of Agriculture.

Land Preparation: A land area of 18m x 8m was carefully mapped out using a measuring tape and pegged at the edges. The site was cleared, and the land was plowed to a fine tilth. The seeds were planted at a depth of approximately 2-3 cm. Plant spacing was maintained at 75 cm x 25 cm (inter and intra-row, respectively). The beds were partitioned into four blocks, with each block containing four treatments.

Experimental Design: The experiment was laid out in a Randomized Complete Block Design (RCBD) of four treatment combination. The land area was 144m with each plot 4×1.5m, we had a total of four treatments with four replications. Each plot on a block had a 0.6m space from the next plot and 2m space between blocks. Each plot had 8 plants on each row and had a total of four rows making a total of 32 plants per plot. The experiment consisted of four treatments and was replicated four times. The treatments were T1= PM + Oba Super 6, T2=NPK + Oba super 6, T3= PM +LM and T4= NPK+LM. Where PM =Poultry Manure, LM= Local Maize, N= Nitrogen, P = Phosphorus, K = Potassium. The NPK Used was in the ratio of 15:15:15.

Data Collection: The maize seeds were planted at a spacing of 75×25cm. Data were collected at two-week intervals for a period of 10 weeks. The parameters recorded included: days to tasseling, days to silking, plant height at 4, 6, 8, and 10 weeks after planting, number of leaves per plant at 4, 6, 8, and 10 weeks after planting, leaf length at 4, 6, 8, and 10 weeks after planting, stem girth at 8 and10 weeks after planting, ear height at 10weeks.

Yield Parameters: At harvest, data were collected on: **c**ob circumference and cob length, number of rows per cob, number of seeds per cob and 100-seed weight, fresh cob weight with husk, dry cob weight with husk and dry cob weight without husk.

Data Analysis: The collected data were subjected to Analysis of Variance (ANOVA) following standard procedures for split-plot experiments using GENSTAT Release 12.0 DE Discovery Editions. Treatment means were compared using Fisher's Least Significant Difference (F-LSD) at a 5% probability level. Which-won-where graph was plot using GGE biplot

RESULTS

Table 1 shows effect of the treatment on the parameter measured at the 4th week after planting, from the result it was observed that PM + oba super 6 significantly ($p<0.05$) higher value for leaf area. It was closely followed by NPK + oba super 6 while NPK + local maize gave the least mean value. Based on number of leaves, the plot with PM + oba super 6 recorded significantly ($p<0.05$) higher mean value while the plot with Npk + local maize gave the least mean value. However, the plot with PM + oba super 6 recorded significantly ($p<0.05$) higher mean value for plant height, whereas the plot with NPK + local maize recorded the least mean value. Table 2 shows the effect of treatment on the parameter measured at the 6th week after planting, based on the result, it was observed that the plot with PM + oba super 6 recorded significantly ($p<0.05$) higher mean value for leaf area, followed by NPK + oba super 6 which while the plot with NPK + local maize shows the least mean value. With respect to the plant height, the plot with PM + oba super 6 maize plants recorded significantly ($p<0.05$) higher mean value while the plot with NPK + local maize gave the least mean value.

Table 1: Effect of the treatment on the growth parameter measured at the 4th week after planting

TREATMENTS	LA (cm^2)	NL	PH (cm)
PM + oba super 6	368.5	9.5	41.22
Npk + oba super 6	392.7	9.81	46.94
Pm + local maiza	307.8	7.19	25.54
Npk + local maize	309.7	7.00	27.41
LSD (0.05)	**19.47**	**0.597**	**1.914**

Where LA = leaf area (cm), NL = number of leaves, PH = plant height (cm), LSD (0.05) = least significant difference at 5% probability level, PM = poultry manure.

Table 2: Effect of the treatment on the growth parameter measured at the 6th week after planting

TREATMENTS	LA (cm^2)	NL	PH (cm)
PM + oba super 6	486.2	12.69	45.83
Npk + oba super 6	523.1	12.75	47.06
Pm + local maiza	391.4	10.94	35.64
Npk + local maize	409.4	10.94	37.51
LSD (0.05)	**19.32**	**0.596**	**0.995**

Where LA = leaf area (cm), NL = number of leaves, PH = plant height (cm), LSD (0.05) = least significant difference at 5% probability level, PM = poultry manure.

The results of the treatment effect on the parameter measured at the 8th week after planting, shows that the leaf area recorded significantly ($p<0.05$) higher mean value for the plot with PM + oba super 6 maize varieties (Table 3). It was closely followed with the plot with NPK + oba super 6, while the plot with NPK + local maize gave the least value. Similarly, the result recorded for plant height shows that PM + oba super 6 recorded significantly ($p<0.05$) higher mean value also the plot with NPK + local maize gave the least mean value. The stem girth studied shows that the plot with PM + oba super 6 recorded significantly ($p<0.05$) highest mean value while the plot with Npk + local maize recorded the least mean value. Table 4 shows the effects of the treatment on the parameter measured at the 10th week after planting, from the result, it was observed that the plant ear length recorded significantly ($p<0.05$) highest mean value on the plot with PM + oba super 6 maize while the plot with NPK + local maize recorded the least mean value. Furthermore, the plot with NPK + local maize recorded the least mean value for number of leaves, as well as the least mean values for the plant height and stem girth, respectively.

Table 3: Effect of the treatment on the growth parameter measured at the 8th week after planting

TREATMENT	LA (cm^2)	NL	PH (cm)	SG (cm)
PM + oba super 6	577.7	15.31	54.7	6.54
Npk + oba super 6	539.4	14.00	49.49	5.95
Pm + local maiza	429.3	13.66	45.92	5.53
Npk + local maize	368.6	13.44	43.37	5.50
LSD (0.05)	**12.64**	**0.5516**	**1.149**	**0.2617**

Where LA = leaf area (cm), NL = number of leaves, PH = plant height (cm), SG = stem girth (cm), LSD (0.05) = least significant difference at 5% probability level, PM = poultry manure
.

Table 4: Effect of the treatment on the growth parameters measured at the 10th week after planting

TREATMENTS	EL (cm)	LA (cm^2)	NL	PH (cm)	SG (cm)
PM + oba super 6	67.19	1252.6	15.55	109	6.94
Npk + oba super 6	64.71	1219.2	15.38	117	6.79
Pm + local maize	55.77	744	14.55	96.3	5.87
Npk + local maize	53.84	743.7	14.44	100.4	5.01
LSD (0.05)	**0.946**	**58.15**	**0.546**	**6.099**	**0.203**

Where LA = leaf area (cm), NL = number of leaves, PH = plant height (cm), SG = stem girth (cm), EL = ear length (cm), LSD (0.05) = least significant difference at 5% probability level, PM = poultry manure.

The effect of the treatment on the emergence data observed on the plant silking (Table 5). From the result, it observed that days to first silking recorded significantly ($p<0.05$) higher mean value on the plot with PM + oba super 6 and Npk + oba super 6 while the plot with local maize varieties combinations gave the least mean values. However, days to 100% silking shows that the treatments did not have any significant effect on the maize varieties. The effects of Npk and poultry manure on the yield components of the Maize are shown on Figures 1 to 4. From the result, it was observed showed consistently that PM+ oba super 6 recorded significantly ($p<0.05$) highest mean values in all traits respectively while plot with NPK + local maize recorded the least mean values. The result also revealed that plot with PM + oba super 6 recorded significantly ($p<0.05$) best yield on fresh and dry cob weights as well as 1000 seeds weight and number of seeds per cob while recording of the least mean values were on the plots with Npk + local maize variety.

The correlation matrix (Figure 5) revealed strong positive correlations among yield-determining traits ($r > 0.90$, $p < 0.001$). Plant height showed near-perfect positive correlation with days to first silking ($r = +0.98$, $p < 0.001$) and positive correlations with fresh cob weight ($r = +0.71$, $p < 0.01$), dry cob weight ($r = +0.58$, $p < 0.05$), and hundred seed weight ($r = +0.86$, $p < 0.001$). Fresh cob weight correlated strongly positively with dry cob weight ($r = +0.98$), seeds per cob ($r = +0.97$), hundred seed weight ($r = +0.96$), ear length ($r = +0.98$), and leaf area ($r = +0.95$) (all $p < 0.001$). Dry cob weight similarly correlated with seeds per cob ($r = +0.99$), hundred seed weight ($r = +0.88$), and ear length ($r = +0.91$) ($p < 0.001$). Among vegetative traits, stem girth correlated positively with leaf area ($r = +0.91$), number of leaves ($r = +0.87$), and hundred seed weight ($r = +0.92$) ($p < 0.001$). Leaf area showed near-perfect positive correlation with hundred seed weight ($r = +0.99$) and ear length ($r = +0.96$) ($p < 0.001$). Days to first silking also correlated positively with fresh cob weight ($r = +0.78$) and hundred seed weight ($r = +0.92$) ($p < 0.001$).

Figure 6 "which-won-where" Genotype-Trait (GT) biplot provides a visual summary of the interaction between your maize genotypes and soil amendments, explaining 94.8% of the total variation. The sector containing Pm + Oba Super 6 is the most productive, as it aligns with the majority of high-impact yield traits: Dry Cob Weight, Number of Seeds per Cob, Fresh Cob Weight, and 100-Seed Weight. This indicates that this treatment is superior for all grain yield components. This indicates a strong positive association between organic amendment with the hybrid variety and the expression of key yield components.

Table 5: Effect of the treatment on the emergence data observed on the plant silking

TREATMENTS	D1stS	D100%S
PM+oba super 6	9.50	13.25
Npk + oba super 6	11.50	13.90
Pm + local maize	5.75	13.50
Npk + local maize	6.00	12.25
LSD (0.05)	**2.899**	**NS**

Where D1stS = days to first silking, D50%S = days to 50%silking, D100%S = days to 100% silking, PM = poultry manure, LSD (0.05) = least significant difference at 5% probability level

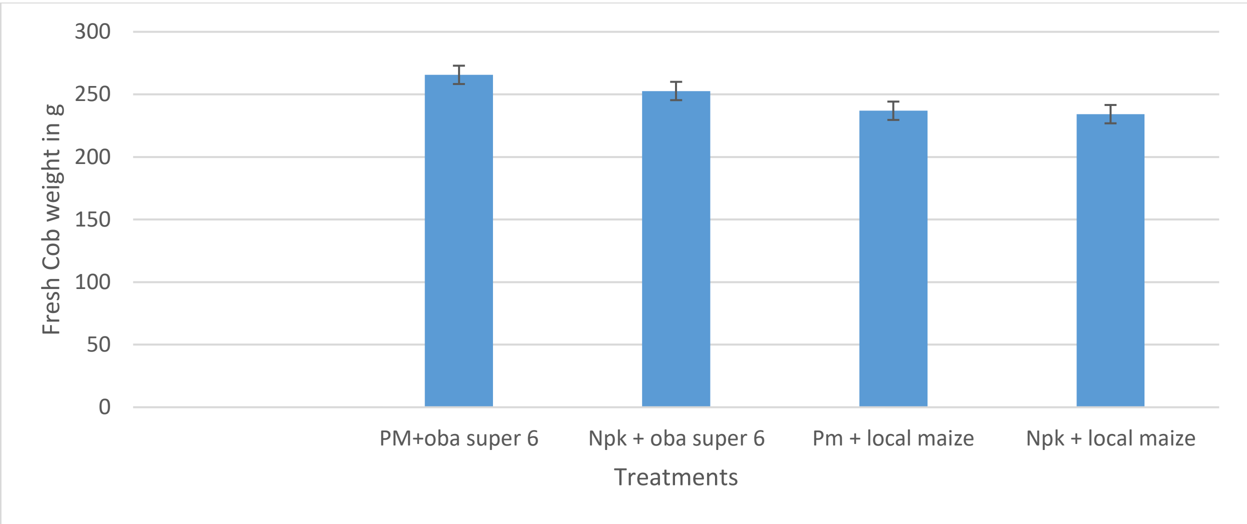

Figure 1: Effect of the treatments on the fresh cob weight of the Maize.

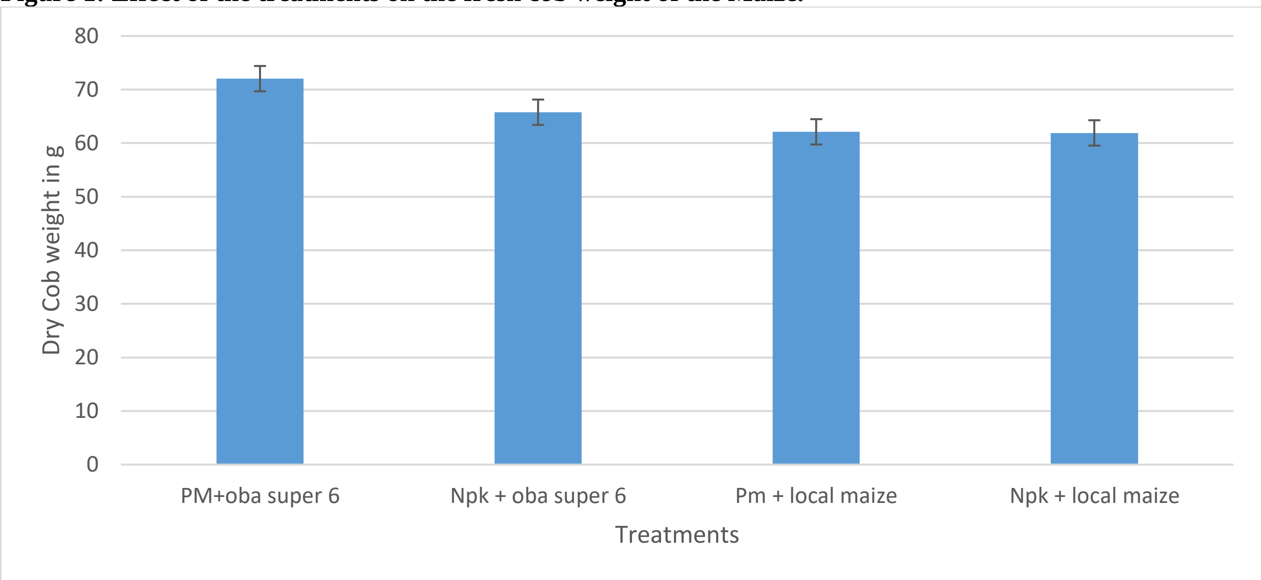

Figure 2: Effect of the treatments on the dry cob weight of the Maize.

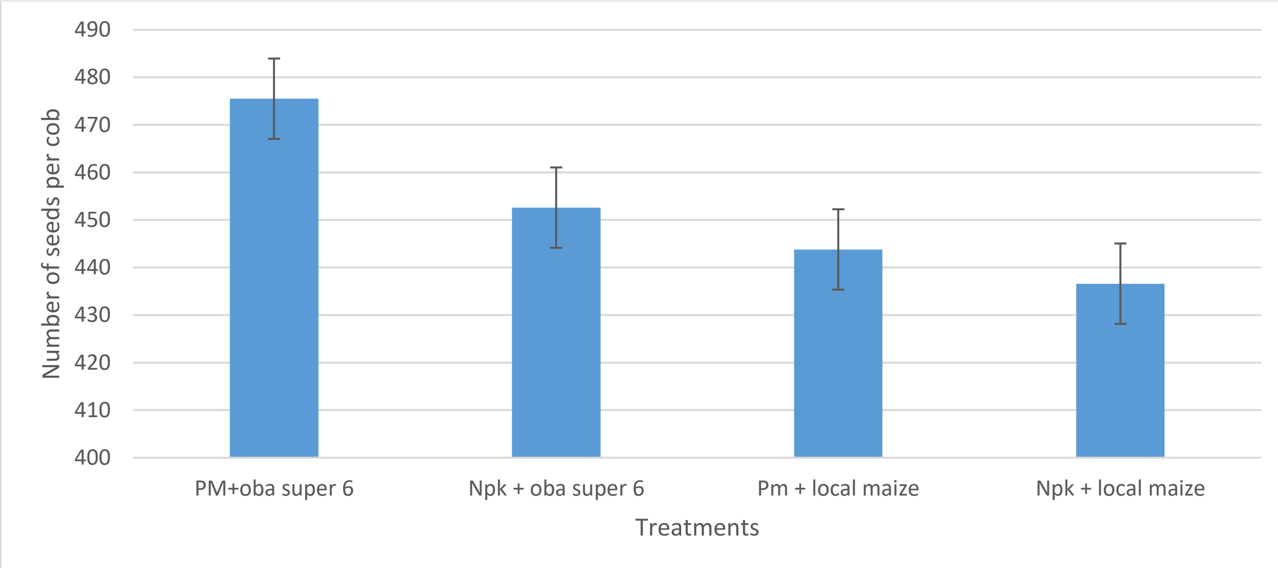

Figure 3: Effect of the treatments on number of seeds produced by the Maize.

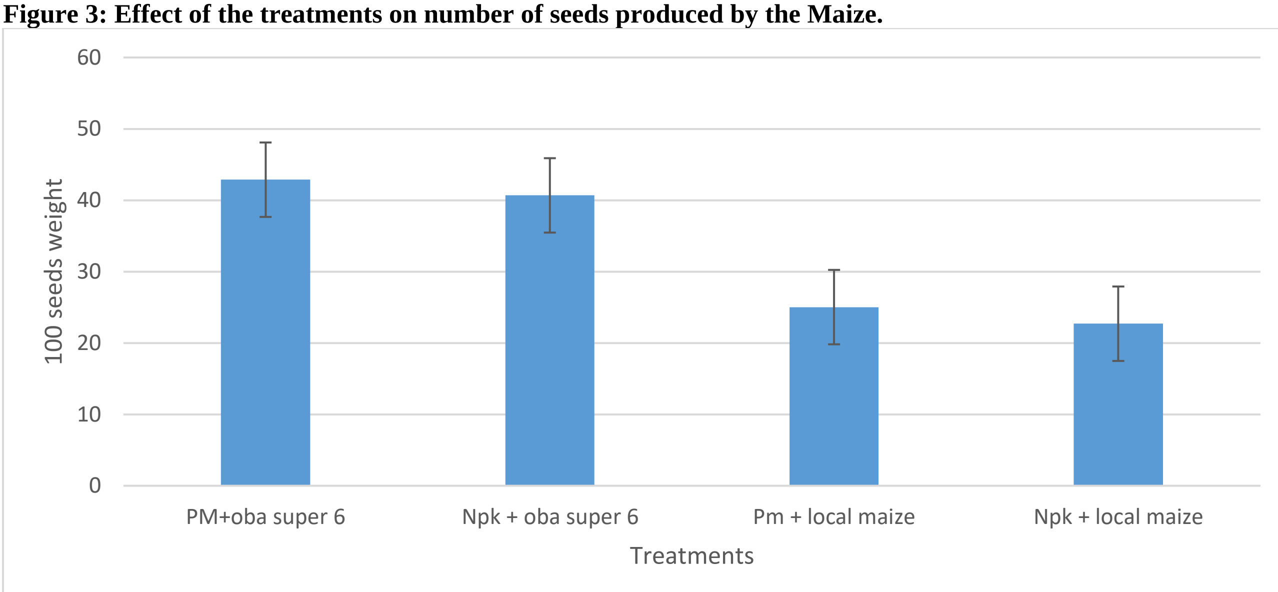

Figure 4: Effect of the treatments on 100 seeds weight of the Maize.

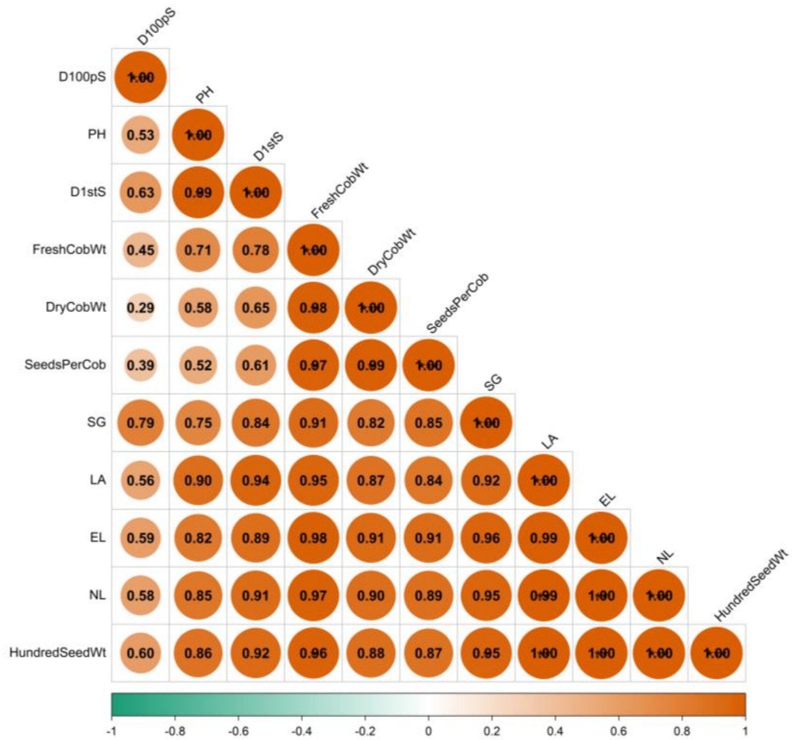

Figure 5: Pearson Correlation Analysis of Growth and Yield Trait of the Maize. Days to 100% silking (D100pS), plant height (PH), days to first silking (D1stS), fresh cob weight (FreshCobWt), dry cob weight (DryCobWt), seeds per cob (SeedsPerCob), stem girth (SG), leaf area (LA), ear length (EL), number of leaves (NL), and hundred seed weight (HundredSeedWt).

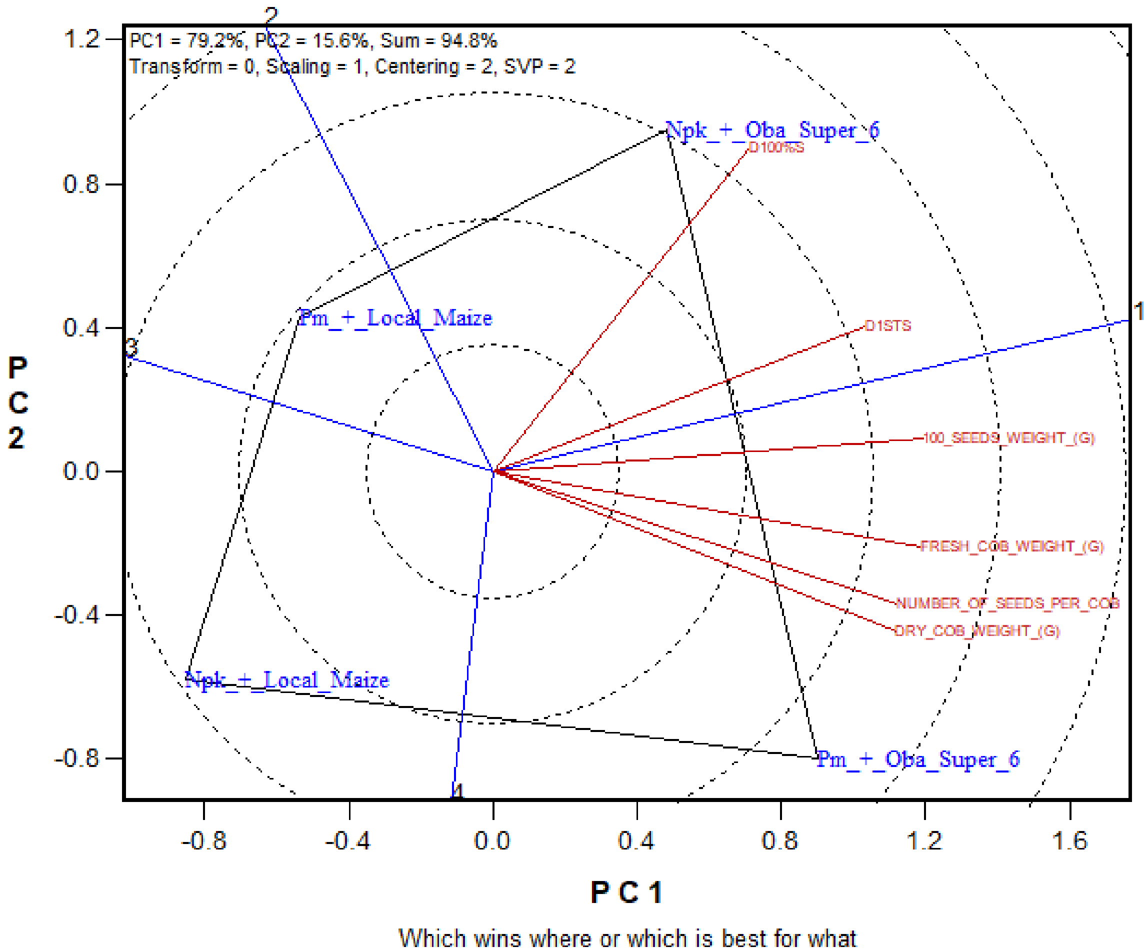

Figure 6: Which-Won-Where Biplot of Maize Performance under Organic and Inorganic Soil Amendments

DISCUSSION

The study demonstrates compelling evidence regarding the comparative performance of maize varieties under different soil amendment regimes. The superior performance of PM combined with Oba Super 6 hybrid maize across multiple growth parameters aligns with findings from previous studies that highlight the enhanced nutrient use efficiency of hybrid varieties (Jyothsna et al., 2021). This combination consistently produced the highest values for leaf area, number of leaves, and plant height throughout the growing period from the 4th to 10th week after planting. The rapid vegetative growth observed under PM treatment likely results from possible more nutrient elements when compared to NPK inorganic fertilizer, which are crucial for cellular division, chlorophyll formation, and overall plant development (Nisa, 2021) and (Ugo, 2023). This observation suggests that organic amendments can effectively support hybrid maize growth this corresponds with the findings of Eden et al. (2017)'s demonstration that the enhanced stem girth under poultry manure treatment may be attributed to the slow-release nature of organic nutrients and the improvement in soil physical properties.

The reproductive development patterns revealed through silking data did not provide any valuable insights into the influence of different soil amendments on maize phenology. The absence of significant difference across treatments suggests that this developmental stage is more strongly influenced by genetic and environmental factors than nutrient sources. The yield components analysis revealed a complex interaction between variety selection and nutrient source. The PM + Oba Super 6 treatment demonstrated superior performance in most yield parameters. This finding aligns with research by Nisa (2021) regarding the importance of potassium in enhancing maize yield. However, the notably higher fresh cob weight observed in the PM + Oba Super 6 treatment suggests that organic amendments might contribute unique benefits to grain filling and moisture retention, possibly through improved soil physical properties and water-holding capacity.

The correlation analysis revealed strong positive relationships among growth, phenological, and yield traits, indicating an integrated system of maize productivity under both organic and inorganic amendments. The near-perfect correlation between leaf area and hundred seed weight (r = 0.99) highlights the importance of source–sink balance, where photosynthetic capacity directly influences grain filling and yield (Liu et al., 2022; Bonelli et al., 2016). Similarly, the strong intercorrelations among yield traits (r > 0.90) suggest that cob weight, seed number, and seed weight are governed by closely related processes of biomass accumulation and partitioning (Bonelli et al., 2016). The high association between plant height and days to first silking (r = 0.98) indicates that extended vegetative growth enhances assimilate accumulation before reproduction, thereby influencing yield formation. Stem girth also showed strong positive relationships with yield traits, reflecting its role in structural support and assimilate translocation. Overall, the consistency of these relationships across treatments suggests that fundamental physiological processes governing maize yield remain stable regardless of nutrient source, while the superior performance of PM + Oba Super 6 reflects optimal coordination of growth, phenology, and sink strength. The "which-won-where" genotype-trait (GT) biplot (explaining 94.8% of total variation) confirms the distinct performance of maize genotypes under varying soil amendments. The positioning of PM + Oba Super 6 in the sector containing Dry Cob Weight, Number of Seeds per Cob, and Fresh Cob Weight validates its superior productivity, likely driven by the enhanced nutrient use efficiency of the hybrid and the slow-release properties of poultry manure. This supports the assertion that hybrid varieties possess a greater genetic potential for biomass and grain filling when provided with optimal organic nutrients (Jyothsna et al., 2021).

The study's findings have significant implications for integrated nutrient management strategies. The strong performance of both organic and inorganic amendments with hybrid varieties supports the potential for organo-mineral approaches, as discussed by Baradhan et al. (2022) regarding integrated nutrient management practices. The results suggest that while NPK fertilizer might provide optimal short-term results, organic amendments like poultry manure can offer competitive yields while potentially contributing to long-term soil health.

CONCLUSION

The study provides comprehensive evidence regarding the comparative performance of different soil amendments and maize varieties on crop growth, development, and yield. The research findings demonstrate that the combination of poultry droppings as source of organic manure with Oba Super 6 hybrid maize consistently exhibited higher performance across multiple growth parameters throughout the growing period. The treatment showed remarkable results in vegetative growth, with significantly higher leaf area development together with higher plant height and improved leaf numbers, indicating optimal vegetative development under this treatment management.

The comparative analysis between varieties clearly demonstrated the genetic superiority of Oba Super 6 hybrid over local maize varieties, regardless of the soil amendment applied. This consistent performance differential highlights the enhanced nutrient use efficiency and genetic potential of hybrid varieties in modern agricultural systems. The local maize varieties consistently showed lower performance in both vegetative growth parameters and yield components, emphasizing the importance of variety selection in maize production systems.

REFERENCES

Abdulraheem, M.I., Charles, E.F., Moshood, A.Y. and Omogoye, A.M. (2018). Comparative performance of different varieties of maize under organic, inorganic and combined (Organic and Inorganic) fertilization. Agricultural Studies International Technology and Science Publications 2 (2): 20-29. DOI: 10.31058/j.as2018 22008

Abidemi, O. T. (2023). Nutritional Benefits of cereals and pseudo- cereals. Sustainable Food Science - A Comprehensive Approach. Elsevier. 176-183. https://doi.org/10.1016/B978-0-12-823960-5.00022-6

Baradhan, G., Saranya, M., Kumar, S., Immanuel, R. and Sudhagar G. (2022). Effect of integration of chemical fertilizers with organic manures on growth, yield and nutrient uptake in hybrid maize (*Zea mays* L.). Crop Research 57: 325-329. DOI: 10.31830/2454-1761.2022.CR-834

Bonelli, L. E., Monzon, J. P., Cerrudo, A., Rizzalli, R. H., & Andrade, F. H. (2016). Maize grain yield components and source–sink relationship as affected by the delay in sowing date. Field Crops Research 198: 215–225. https://doi.org/10.1016/j.fcr.2016.09.003

Borrás, L., & Gambín, B. L. (2010). Trait dissection of maize kernel weight: Towards integrating hierarchical scales using a plant growth approach. Field Crops Research 118 (1): 1–12. https://doi.org/10.1016/j.fcr.2010.04.010

Eden, M., Gerke, H. H. and Houot, S. (2017). Organic waste recycling in agriculture and related effects on soil water retention and plant available water: A review. Agronomy for Sustainable Development 37 (11): 1-21. DOI: 10.1007/s13593-017-0419-9

Erenstein, O., Jaleta, M., Sonder, K., Mottaleb, K. and Prasanna, B.M. (2022). Global maize production, consumption and trade: trends and R&D implications. Food security 14 (5): 1295-1319.

Haider, F. U., Liqun, C., Coulter, J. A., Cheema, S. A., Wu, J., Zhang, R., Wenjun, M., and Farooq, M. (2021). Cadmium toxicity in plants: Impacts and remediation strategies. Ecotoxicology Environmental Safety 211 (15): 111887. DOI:10.1016/j.ecoenv.2020.111887

Ibikunle, O. A., Omijidi, M. O., and Menkir, A. (2009). Evaluation and identification of maize Hybrids adapted to the southern and northern guinea savannas of Nigeria. African Crop Science Conference Proceedings 9: 9-15.

Jyothsna K., Padmaja, J., Sreelatha, D., Kumar, M. R., and Madhavi, A. (2021). Study on nutrient management of hybrid maize (*Zea mays* L) through decision support tools. Journal of Pharmacognosy and Phytochemistry 10 (2): 760-764

Liu, G., Yang, Y., Guo, X., Liu, W., Xie, R., Ming, B., Xue, J., Wang, K., Li, S., & Hou, P. (2022). Coordinating maize source–sink relationship to achieve yield potential of 22.5 Mg ha^{-1}. Field Crops Research 283: 108544. https://doi.org/10.1016/j.fcr.2022.108544

Nisa, Z. U. (2021). Comparison of different potassium application methods for maize (Zea mays L.) growth under salt-affected soils. Journal of Pure and Applied Algebra 6 (1): 44-53. https://www.cabidigitallibrary.org/doi/pdf/10.5555/20210390621

Shakoor, A., Ashraf, F., Shakoor, S., Mustafa, A., Rehman, A., and Altaf, M. M. (2020). Biogeochemical Transformation of Greenhouse Gas Emissions from Terrestrial to Atmospheric Environment and Potential Feedback to Climate Forcing. Environmental Science and Pollution Research 27(31): 38513–38536. DOI: 10.1007/s11356-020-10151-1

Ugo, D., (2022). Governance of the soil amendment to enhance suppression to soil-borne plant Pathogens from a long term perspective. Applied Soil Ecology 182: 104721. https://doi.org/10.1016/j.apsoil.2022.104721

Uguru, M. I., Baiyeri,K. P., and Aba S. C. (2011). Indicators of climate change in the derived Savannah niche of Nsukka, South-Eastern Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension 10 (1): 17-26. DOI: 10.4314/as.v10i1.68718

Zhang, W., Xiong, Y., Li, Y., Qiu, Y. and Huang, G. (2022). Effects of organic amendment incorporation on maize (*Zea mays* L.) growth, yield and water-fertilizer productivity under arid conditions. Agricultural Water Management 269: 107663. https://doi.org/10.1016/j.agwat.2022.107663