Technoscience Journal for Community Development in Africa 3 (2024) 1-7
ISSN 2659-0573

Research Article

Effects of combined application of inorganic fertilizer and poultry manure on growth and yield of sweet maize (*Zea mays linn. var. saccharata*) in Southern Guinea Savannah, Nigeria

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Abstract: A field trial was carried out in 2014 cropping season at the nursery unit of the Kwara State Agricultural Development Project, Ilorin, in the Southern Guinea Savanna agro ecological zone of Nigeria. The aim of the study was to investigate the growth and yield responses of sweet maize to combined application of organic poultry manure and inorganic fertilizer. The treatments were: NPK 120 kgN/ha, Poultry manure (Pm) alone at 10 t/ha, 7.5 t/ha Pm + 90 kgN/ha, 5.0 t/ha Pm + 60 kgN/ha and 2.5 t/ha Pm + 25 kgN/ha. The control was without soil amendment. The treatments were arranged in a randomized complete block design and replicated three times. Among the treated plots, 5.0 t/ha Pm + 60 kgN/ha and 2.5 t/ha Pm + 25 kgN/ha were significantly lower in the grain weight and grain yield. The highest number of grains per cob (553.40) and thickest cob (14.18cm) were obtained at the treated plot where, 7.5t/ha Pm was combined with 90kgN/ha. There was no significant difference in the grain yield between application of NPK at 120 kgN/ha and 7.5 t/ha Pm mixed with 90 kgN/ha. The study showed that combinations of poultry manure and inorganic fertilizer enhanced the growth and yield of sweet maize. Mixing inorganic fertilizer at 90kgN/ha and 7.5 t/ha, is recommended for adoption in sweet maize in the southern guinea savanna of Nigeria.

Keywords: Application Rate, Grain Yield, Inorganic Fertilizer, Poultry Manure, Sweet Maize

1. INTRODUCTION

Sweet maize (Zea maysL. varsaccharata Strut) is an important cultivated crop in the United States of America, East Asia, and some European countries. It is the second largest field grown vegetables crop in Ontario, with respect to farm- gate value (Badu-Apraku and Fakorede, 2006). More recently, sweet maize consumption has become a popular delicacy among the elites in African countries. In Nigeria, the crop is mainly cultivated in the eastern part as a cash crop. Unlike other maize cultivars, sweet maize is delicious with high sugar content at milk dough stage. The kernel is also wrinkled and translucent when dry. The crop is consumed at the milk dough stage when fresh as vegetables, along with other mixture delicacies, either boiled or roasted. At maturity, the chemical composition consists of 5-6% sugar, 10-11% starch, 3%water soluble polysaccharide, 70% water and moderate quantity of proteins, vitamins A and K (FAO, 2020). In addition to human consumption, it is also an excellent raw material for the production of starch oil, gluten flour and alcohol. According to Dewanto *et al.* (2002), the antioxidant activity of sweet maize is not reduced even after canning. Among cultural practices, fertilizer application is critical for improved crop growth, and it yields particularly in the Guinea Savanna ecological zone of Nigeria. The soil in this zone like other Sub-Saharan Africa, is low in organic matter and was reported not to support intensive cultivation due to rapid decline soil fertility under intensive

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cultivation (Shiyam & Binang, 2013). According to Quansah (2010) and Meyer *et al.* (2011)cultivated soils are characterized by insufficient plant nutrients for high and sustained optimum productivity due to soil degradation, soil acidification, soil organic matter reduction and decreased aggregate stability of soil.

Nitrogen, Phosphorous and Potassium (NPK) are critical macro nutrients essential for plant growth and development. Phosphorus was reported as an essential nutrient required for increasing maize yield in South West Nigeria (Onasanya *et al.,* 2009). Studies carried out in the tropics have shown significant increase in plant height, number of branches per plant, leaf area index, total dry matter and grain yield per unit area, due to nitrogen and phosphorous application (Okpara *et al.,* 2007). According to Nilesh (2009), the growth and yield of sweet corn increased linearly with the application of NPK. In the study, the grain yield was maximized at NPK 210: 105: 105 kg/ha. Similarly, Arun et al. (2007) reported that the growth and yield components of sweet corn increased with the increased application of the NPK.

Although inorganic fertilizer increases crop growth and yield, indiscriminate application without adequate knowledge of the crop requirement and nutrient status of the soil could be detrimental to the plant health and the environment (Savci, 2012; Adediran *et al.,* 2004). Excess application of inorganic fertilizer was reported to cause nutrients loss from soils through fixation, leaching and gas emission, and can lead to diminish fertilizer efficiency (Alimi *et al.,* 2007; Chen, 2008; Savci, 2012). Nitrogen, when applied above the crop requirement could incabbage, spinach and rapeseed, reduce plant growth and yield (Zhaohui & Shengxiu, 2007).

In recognition of the detrimental effects of inorganic fertilizer in addition to its rising costs and availability, the use of organic fertilizer as alternative soil amendment strategy was advocated (Shehu *et al.,* 2010). Similarly, John *et.al.* (2004) and Ayeni (2011) advocated the combined use of low level inorganic fertilizer with organic manure to supply adequate plant nutrients for sustainable crop production with a view of reducing environmental impact from nutrient use. Recently, Oluwatosin (2016) noted an increased used of inorganic fertilizer compared to organic fertilizer in Ondo State, Nigeria and called for awareness, promotion and readily availability of organic fertilizers.

Organic manures provide necessary macro and micro nutrients in available form with consequent improvement in physical and chemical properties of the soil (Abou El-Magd *et al.,* 2010). As an excellent organic manure, poultry manure supplies the macro and micro nutrient during mineralization, increases the organic matter contents and also improves the texture, nutrient retention, aeration, moisture holding capacity and water infiltration in the soil (Akinrinde *et al.,* 2006: Dekissa, 2008). According to Garge and Bahla (2008), poultry manure supplies phosphorous more readily to plant than other organic sources.

Sweet maize, like other maize cultivars, required adequate soil nutrient for optimum growth and yield. Ferenc *et al.* (2009) reported a positive response of grain yield in sweet maize with increasing application of nitrogen, phosphorous and potassium. Similarly, Uwah *et al.*(2011) in the rain forest zone of Nigeria reported that the highest rate of inorganic NPK 15:15:15 at 400 kg/ha mixed with 10 t/ha Pm maximized leaf area index, number of grains per cob and harvest index and grain yield of sweet maize. Although several studies have been carried out on the combined application of organic and inorganic fertilizers on various crops, information on sweet maize is scanty, particularly in the Southern Guinea Savanna agro-ecological zone of Nigeria. This study was therefore designed to evaluate the growth and yield responses of sweet maize to integrated application of organic and inorganic fertilizers.

2. MATERIALS AND METHODS

The experiment was carried out at the nursery unit of Kwara Agricultural Development, Project, Ilorin, in the 2014 cropping season. The treatments consisted of poultry manure alone at 10t/ha, Pm 7.5t/ha+90kgN/ha, Pm 5.0t/ha+60kgN/ha, Pm 2.5+30kgN/ha, and NPK 120kgN/ha, and the control without fertilizer. The Pm used for the trial was collected from layers unit at the Kwara State University Teaching and Research Farm, Malete. The treatments were arranged in a randomized complete block design and replicated three times. Soil sample of the experimental site at 0-15cm depth, was collected to determine the physico-chemical properties. Nutrient composition of poultry manure was also determined in the laboratory.

The land was ploughed and harrowed twice. Each plot size measured 4.0m × 4.0m with, 0.5m between plots and 1.0m between blocks. Four seeds were planted at intra and inter row spacing of 0.75m and 0.50m respectively, and were thinned to two plants per stand at two weeks after planting. Air dried poultry manure was applied two weeks before planting while the NPK was applied at three and six weeks after planting. Atraxine (80WP) mixed with pendimethalin [N- (1-ethylpropyl) – 3, 4 dimethyl -2, 6 dinitrobenzene amine] were applied at the rate of 1.5kg/ha and 2.0litre/ha, as specified by the manufacturer immediately after planting using the knapsack sprayer.

Data were collected on days to 50% flowering, plant height at eight weeks after planting (WAP), stem girth, number of cobs per plant, cob length and circumference, number of grains per cob, weight of 1000 grains and grain yield per hectare. Data collected were subjected to analysis of variance using statistical analysis system (SAS) package and treatment means were compared using Duncan Multiple Range Test. This was carried out where the results were significant at 5% level of probability.

3. RESULTS AND DISCUSSIONS

The soil of the experimental site was clay-loam, slightly acidic with pH 5.68, total nitrogen 0.98 %, available phosphorous 6.98 mg/kg, exchangeable potassium 0.94 mg/kg and organic carbon 1.25% (Table 1).The effects of combined application of poultry manure and inorganic fertilizer on days to 50% tasseling, stem girth and plant height of sweet maize (Table 2) shows that all the treatments had similar days to 50% tasseling, except the control that tassels lately at about sixty days after planting.

Although, the control without soil amendment took longer days (45.98) to flower compared to other treatments, it was not statistically different. The height of maize and the stem girth at the control treatment were inferior to other treatments. The tallest maize (2.74 m), was recorded where 120 kgN/ha was applied. This value was not different from the treatment where soil amendments were applied (Table 2).

The effect of combined application of inorganic manure and poultry manure on number of cobs produced per plant, as well as the circumference and length of the cobs at the control treatments, were significantly lower compared to other treatments (Table 3). Application of 2.5t/ha Pm mixed 25 kgN/ha and 5.0 t/Pm mixed with 60 kgN/ha, produced similar number of cobs and cob length. The control without soil amendment significantly had lower number of grains and grain weight, compared to other treatments. Application of Pm alone at 10 t/ha and inorganic application of NPK at 120 kgN/ha, had similar number of grains per cob and grain weight. The treated plot where 2.5 t/hPm was mixed with 25 kgN/ha, significantly had lower number of grains and grain weight compared to other treated plots.

The combined application of poultry manure and inorganic fertilizer on grain yield shows that the least grain yield (425.23 kg/ha) was recorded at the control treatment without soil amendment. In addition, the grain yield (2,111.09 kg/ha) was obtained with the application of Pm alone at 10 t/ha was at par with the treatment, where 7.5 t/ha Pm was combined with 90 kgN/ha (Figure 1).

Table 1: Physico-chemical Properties of the Experimental Field (0-15cm) and Nutrient Composition of the Poultry Manure

Soil Composition		Poultry Manure
Physico-chemical properties		
Sand (%)	58.18	
Silt (%)	17.35	
Clay (%)	30.01	
Textural class	Clay-loam	
Chemical properties		
pH(H_2O)	5.68	4.63
Organic Carbon	1.25	7.00
Available Pmgkg^{-1}	6.98	4.32
Total N	0.98	3.18
Exchangeable bases		
Ca(mgkg^{-1})	2.72	0.23
Na(mgkg^{-1})	0.85	0.25
Mg(mgkg^{-1})	2.15	0.64
Mn(mgkg^{-1})	0.92	25.08
Zn(mgkg^{-1})	2.78	23.94
Cu(mgkg^{-1})	0.33	2.13
Fe(mgkg^{-1})	3.08	4.72
K (mgkg^{-1})	0.94	1.08

Table 2: Effects of Combined Inorganic Fertilizer and Poultry Manure Application on Days to 50% FloweringPlant Height and Stem Girth and of Sweet Maize

Treatments	Days to 50% Flowering	Plant Height (m)	Stem Girth (cm)
Pm @ 10 tons/ha	45.5a	2.63a	2.52ab
NPK@120kgN/ha	42.0a	2.74a	2.64a
7.5tPm + 90kgN/ha	43.0a	2.52a	2.46ab
5.0tPm +60kgN/ha	42.50a	2.46a	2.32ab
2.5tPm +25kgN/ha	43.00a	2.42a	2.16bc
Control	45.98a	1.05b	1.85c
SEM	NS	0.17	0.18

Values with the same letter(s) in the same column are not statistically different at 5% level of probability by Duncan's Multiple Range Test.

Table 3: Effects of Combined Inorganic Fertilizer and Poultry Manure Application on Number of Cobs/Plant, Cob Circumference and Cob Length

Treatments	Number of Cobs/Plant	Cob Circumference (cm)	Cob Length (cm)	Number of Grains/Cob
Pm @ 10 tons/ha	2.50a	13.78ab	13.98ab	488.97b
NPK@120 kgN/ha	2.63a	13.63ab	14.63a	495.41b
7.5tPm + 90 kgN/ha	2.46a	14.18a	13.18b	553.40a
5.0tPm +60 kgN/ha	2.32a	13.38bc	13.38b	407.58c
2.5tPm +25 kgN/ha	2.10a	12.85c	12.85b	495.01b
Control	1.52b	8.52d	7.61c	201.62d
SEM	0.14	0.22	0.18	5.53

Values with the same letter(s) in the same column are not statistically different at 5% level of probability by Duncan's Multiple Range Test.

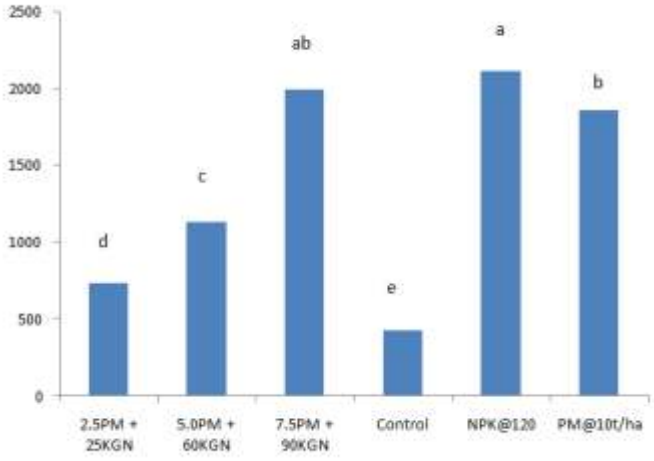

Figure1. Effect of Combined Inorganic Fertilizer and Poultry Manure Application on Grain Yield of Sweet Maize.

The moderate to low nutrient status of the experimental site is a reflection of savanna soils. The low nutrients status at the experimental site agreed with the reported work of Shiyan and Binang (2013) on tropical soils justifying for fertilizer inputs to study crop response to fertilizer dosage. This inherent low nutrient could be due to plant nutrient uptake as a result of continuous farming or over-cultivation leading to desertification of the forest ecology as earlier reported by Quansah (2010) and Meyer *et. al.* (2011). The ECA (2001), reported that the zone is characterized by continuous cultivation which lead to rapid decline of soil nutrients and unstable microbial population.

The improved growth and yield as observed in this study with the applications of integrated poultry manure and inorganic NPK is consistent with earlier reported work of Haruna, (2011) on sesame growth and yield. Mahmood *et al*. (2017), as well as Ayeni and Adetunji (2010) reported that combination of organic manure with inorganic fertilizers significantly ($p < 0.05$) increased maize yield than individual use of organic or inorganic fertilizer. In another study, Garge and Bahla (2008) observed that poultry manure readily supplies phosphorous to plants than other organic sources. Combinations of poultry manure and inorganic NPK fertilizer as observed in this study was found to enhance crop growth and development compared to the untreated plots, where fertilizer was not added.

The excellent macro and micro nutrients present in the poultry manure was complemented with the nutrient supplied from inorganic NPK. Comparable yield achieved with the reduced rate of poultry manure in combination with inorganic NPK as observed in the study, was similar to the findings of Makinde *et al*. (2001) and Uwal *et al.* (2011) on maize and sweet maize in the south western andeastern part of Nigeria.

The observed poor growth and yield of the un-treated plot could be attributed to low nutrient status of the experimental field. According to Zhao *et al*. (2003), nitrogen deficiency decreased leaf area index resulting in shorter plants with less dry matter accumulation. Combinations of 7.5 tons/ha Pm and 90kgN/ha produced higher maize yield than the sole application of 10.0 t/ha Pm as well as 120kgN/ha. This indicates that integration of the two types of fertilizer provides a better source of nutrients for improved growth and yield of sweet corn in the savanna agro ecological zone of Nigeria. Vasanthi and Kumaraswanty (2000) reported that Pm plus one-half of the recommended inorganic fertilizer

rate, out-yielded full rate of NPK alone in green folder corn. Boateng *et al*. (2006) recommended the combine application of Pm and NPK because of the complementary and synergistic effects of the fertilizers on maize growth and yield.

4. CONCLUSION

The study showed that combinations of poultry manure and inorganic fertilizer enhanced growth and yield of sweet maize. Combination of inorganic fertilizer at 90 kgN/ha and poultry manureat 7.5 t/ha achieved a desirable yield of 1,992.07 kg/ha in sweet maize. This will reduce the high tonnage of PM required as well as the inorganic fertilizer recommended in the study area.

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