GROWTH AND YIELD EVALUATION OF SOME WHEAT (*Triticum aestivum* L.) CULTIVARS ON POULTRY MANURE-ENRICHED COASTAL PLAIN SOILS

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Abstract

Wheat is a food crop of global significance, but it is not yet a component of the Nigerian cropping system due to ecological and environmental limitations, especially in Southeastern Nigeria. Polybag experiment was conducted to evaluate four spring wheat cultivars (*Imam*, *SC. Sahai*, *Norman* and *WZ 272 2015*) based on growth and yield attributes on soils derived from coastal plain sands. The four cultivars were arranged in a completely randomized design and replicated nine times to give a total of 36 experimental units. Plant height, number of tillers, number of functional tillers, number of days to heading and yield components were investigated. The cultivars, *WZ 273 2015* and *Norman* were superior ($p \leq 0.05$) in plant height, number of tillers and number of functional tillers relative to *Imam* and *SC. Sahai*. *SC. Sahai* cultivar had significantly lesser (46.11) number of days to heading. Although there were no significant differences in grain yield among the cultivars, there was a considerable variation in their yield components. The number of spikelets per main spike and per plant varied significantly ($p \leq 0.05$) in the order *SC. Sahai* (18.30; 23.68,) > *Imam* (17.08; 21.71) > *WZ 273 2015* (14.25; 20.89). The plant dry weight was highest ($p \leq 0.05$) in *Norman* (4.49 g; 0.24 t/ha) than the other cultivars. Overall, *Norman*, *Imam* and *SC. Sahai* significantly had the highest values based on yield components, but *Imam* was highest ($p > 0.05$) in yield (0.42 tons/ha) while the least was recorded in *Norman* (0.23 tons/ha) under the humid tropical soil condition.

Keywords: *Triticum aestivum* L., spring wheat, soil chemical properties, yield components, acid sands

Introduction

Wheat is one of the most widely cultivated crops in the world. It is the second highest contributor to the Nigeria's food import bill with pressure on the country's foreign reserve (CBN, 2021). Based on FAO (2024), global wheat production was estimated at 792.9 to 798 million tonnes, representing a 0.5 % to 1 % year-on-year increase. For 2025, a further, albeit marginal, increase, ranging from 796 to 800.1 million tonnes, with improved prospects in the European Union was recorded (FAO, 2025). Low wheat productivity has been attributed to environmental incompatibility which confirms that wheat requires cold climates during the growing season to thrive especially at critical developmental stage between tillering and grain filling (Mahmood *et al.,* 2021). The United States Department of Agriculture data shows that Nigeria has annual demand of between 4.5 and 5.0 million tonnes of wheat but produces only about 60,000 Metric Tonnes (USDA, 2024). This implies that 90 % of wheat locally consumed is imported. This has increased dependence on importation of wheat from other countries. This is in line with the report of the CBN (2024), where it was reported that the current demand for wheat in Nigeria is between 5-6 million Metric Tonnes (MT). Out of this value, Nigeria locally produces 1 % only (63,000 MT) (CBN, 2024). To meet the local demand, Nigeria imports above 5 million metric tonnes (MT) which cost up to $2 billion. Consequently, wheat ranks second highest contributor to Nigeria's food import bill. The Central Bank of Nigeria, CBN, has decided to intervene in the wheat value chain by financing increased domestic wheat production through the Anchor Borrowers Programme (ABP). More Nigerian households currently recourse to wheat derivative foods to meet their dietary needs more than ever before owing to low cost and convenient staple of baked foods from wheat products (Falola *et al.,* 2017). Key food staples such as semolina, bread, noodles, and pasta among others are produced from wheat flour and are the bulk of meals in most urban and rural households across the country.

Soil acidity is a major yield-limiting factor for wheat production in soils of South-Eastern Nigeria (Bamiro *et al.,* 2020). High levels of nitrogen fertilizer applied to increase crop yields, and the associated removal of lime-like elements contribute to soil acidity (Gill and Walia, 2023). The cause of soil acidity could be the type of parent materials from which the soils are formed, leaching of base forming cations, and continuous use of acid forming fertilizers (Danbazau *et al.,* 2021). At pH below 5, aluminium is soluble in water and becomes the dominant ion in the soil solution. Excessive aluminium injures the root apex and inhibits root elongation (Scott *et al.,* 2001). Poor root growth leads to reduced water and nutrient uptake, and consequently reduced growth and crop yield.

The performance of different cultivars of wheat under different management and environmental conditions is of interest to the agronomist. Over the years, several wheat cultivars have been developed and released in Nigeria (Miko, 2012). These cultivars vary in their response to management and environmental conditions (Mahmood *et al.,* 2021). Significant differences in grain yield among wheat cultivars were reported in various wheat growing areas of Nigeria; Bauchi (Jibrin and Fagam, 2012), Borno (Bibinu *et al.,* 2016), Kano (Grzebisz and Potarzycki, 2022) and Sokoto (Sokoto and Singh, 2013). Similarly, variation in yield and yield components of wheat cultivars have also been reported in Nigeria and other parts of the globe under organic inputs (Abbas and Fadul, 2013), inorganic (Farrokh and Farrokh, 2014) inputs and their combinations (Zahoor, 2014). With the human population expected to reach approximately 8.2 to 8.3 billion globally by 2025-2026, coupled with continuous deterioration and losses of agricultural lands, there is urgent need for heightened food production (FAO, 2026). Increasing food production of the country in the next 20 years due to much population growth is a big challenge in Nigeria. It is more difficult because land areas devoted to agriculture will decline (FAO, 2022 a,b). To grow more food from marginal lands, the quality of seed planted is critical. More so, crop cultivars play an important role in the quantity and quality yield of wheat produced. This is because different cultivars respond differently based on their genotypic characteristics (Miko, 2012), input requirement (Gill and Walia, 2023), growth processes (Grzebisz and Potarzycki, 2022) and the prevailing environment during growing season (Mahmood *et al.,* 2021). There is a paucity of information on growth responses of some wheat varieties in the humid tropics. Hence, this study was undertaken to assess the growth, yield components and yield of some wheat cultivars under a humid tropical soil, the coastal plain sands.

Materials and methods

Experimental Site

The experiment was conducted at the University of Calabar, Calabar-Nigeria. The mean annual temperature ranges between 27°C and 28°C while the relative humidity is 70-80 % (Simon, 2010). The rainy season starts from March to late October following the dry season from November to late February. Calabar soils are mainly acid sands, classified as *Typic Paleudult* in the *Ultisol* order of the USDA soil taxonomy (Akpanidiok and Ukwang, 2012).

Collection and preparation of research materials

i) Wheat cultivars used in the study

The experimental wheat cultivars *Imam, SC.Sahai, Norman and WZ 272 2015* were obtained from Lake Chad Research Institute (LCRI), Maiduguri, Borno State, Nigeria. The cultivars are well adapted to irrigated conditions, heat tolerance and high yielding, following good crop management conditions.

ii) Soil sample collection and preparation for planting

Bulk soil was sampled from 8 points to the plough layer (0-30 cm) using a spade. About 200 g of soil was weighed and used for routine physicochemical analysis using standard laboratory procedures as outlined in Udo *et al.* (2009) and Otie *et al.* (2025).

The remaining soil samples were air-dried and sieved with a 4 mm sieve and weighed (12.0 kg) to fill the 36 poly bags, each with volume = 0.07 m^3 and perforated at the base to drain excess water. Cured poultry manure (PM), sourced from Cross River State Agricultural Development Project (CRADP), Calabar, was shade-dried, crushed and analysed for nutrient contents as described in Udo *et al.* (2009). The PM contained (%) 2.38 N, 0.56 P, 2.10 K, 4.80 Ca and 2.74 Mg was basally and thoroughly incorporated into the soil at 10 tons/ha recommended rate for wheat production in Nigeria (Uwa *et al.,* 2014).

Experimental design, treatments and treatment allocation

The experiment comprised of four wheat varieties (*Imam, SC. Sahai, Norman and WZ 272 2015*) laid out in a completely randomized design (CRD). Each treatment was replicated nine times to give a total of thirty-six (36) experimental units.

Agronomic Practices

Pre-sowing irrigation (2-litre of water per polybag) was done prior to sowing of the wheat crop because it is necessary to maintain optimum moisture level to ensure good germination and emergence during the dry season (Salim and Raza, 2020).

Planting and maintenance of experimental units

This research was conducted at the peak of dry season (December, 2024) at the University of Calabar experimental farm. The polybags were arranged according to the treatment combinations and spaced out at 25.0 cm within and between the rows to reduce competition and optimize light use (Saini and Tiwana, 2023). The cured PM was applied basally at 60 g per polybag following the recommended rate (10 tons/ha), five (5) days before seeding. Fifteen seeds of wheat were sown 2 cm deep in 3 rows (five seeds per row) per pot at 10 cm apart and later thinned to nine vigorous seedling (3 seeds per row) 14 days after sowing (DAS). Irrigation was carried out twice daily at 500 mL per pot. The polybags were weeded manually as the need arose. Insect pest attacks were also monitored. Harvesting was done at physiological maturity and dried for one week under an open field until properly dried and manually threshed.

Plant data collection

i. Plant height: The height measurement for wheat plant was taken once at 8 weeks after sowing (WAS). It was measured from the soil base to the leaf apex.
ii. Flag leaf area: The flag leaf area was calculated at 6 WAS, using the formula:
Flag leaf area = length x breadth x 0.75 (Quarrie and Jones, 1979).
iii. Tiller count: The tiller (additional shoots from main stem) count per plant was obtained from each plant at 4 WAS.
iv. Functional tillers: The functional tillers are the specific ones that survive, develop fully and produce a grain-bearing head

(ear) at maturity. They were counted per plant at 8 WAS.

v. Number of days to heading: The number of days from sowing to when the plants started heading was recorded through visual observation at 6 WAS.

vi. Length of spike: The length of spike was measured using a tape-rule and counted per plant at 10 WAS.

vii. Number of spikes per main stem: The number of spikes per main stem was counted per plant at 10 WAS.

viii. Number of spikelets per main spike: The number of spikelets per main spike was measured at 10 WAS.

ix. Number of spikelets per main stem: The number of spikelets per main stem was measured at 10 WAS.

x. Weight of spike + grain: The weight of spikes + grain was recorded at harvest by weighing with a sensitive weighing balance (Ashton Meyers, Marsh Wall, London E14 9HD, United Kingdom).

xi. Plant dry weight: The Plant dry weight was measured after harvest after oven drying in the laboratory at 75 $^{\circ}$C for 72 hours.

xii. Number of seeds per plant: The number of seeds per plant was measured after harvest. The plants were threshed, and the seeds were counted manually. The grain weight from the individual polybags was measured using a sensitive weighing balance (Ashton Meyers, Marsh Wall, London E14 9HD, United Kingdom).

xiii. Grain yield estimates in tons/ha.

Laboratory analysis

Particle size distribution was determined by Bouyocous hydrometer method as described in Udo *et al.* (2009). The soil textural classes were determined from percent sand, silt and clay using USDA textural triangle as described in Akpanidiok and Ukwang (2012).

The soil pH was determined with a pH meter in a 1:2.5 soil: water suspension using a glass-electrode. Total N was determined by micro-Kjeldahl method (Black, 1965) as modified by Jackson (1989). Available phosphorus was extracted with acidic fluoride using the Bray P1 method (Bray and Kurtz, 1945); phosphorus in the extract was determined calorimetrically by the molybdenum blue method of Murphy and Riley (1962). Exchangeable bases (K, Ca, Mg and Na) were extracted with IN NH_4OAc using 1:10 soil solution ratio. Potassium and sodium in the filtrate were determined by flame photometer, while calcium and magnesium were determined with an atomic absorption spectrophotometer (Model 6405 UV/visible spectrophotometer, Jenway, UK). The effective cation exchange capacity was determined by summation of exchangeable bases and exchangeable acidity (Juo, 1981). Exchangeable acidity was determined by successive leaching of the soil with neutral un-buffered IN KCl using a 1:10 soil liquid ratio. The amount of acidity (H and Al) in the leachate was estimated by titration with 0.05 NaOH to a permanent pink end point using phenolphthalein indicator (Maclean, 1982). The sum of the exchangeable bases and exchangeable acidity was taken as the effective cation exchange capacity (ECEC). Organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (1934). The organic carbon result was multiplied by van Bemmelen factor of 1.724 (Page *et al.*, 1982) to estimate the soil organic matter content.

Statistical analysis

Data collected were subjected to analysis of variance and treatment were compared using the least significant difference at the 5 % level of probability.

Results and discussion

Chemical properties of experimental soil before sowing

The chemical properties of the experimental soil before poultry manure addition (Table 1) showed that the soil was strongly acid (pH = 5.4), a condition attributed to high rainfall exceeding 3500 mm per annum in the study location. The soil organic matter (SOM) content was within a moderate value of 1.04 %, it may be able to sustain intensive production only with careful fertilization and crop management practices (Adekayode, 2010). Total nitrogen content was also low (0.09 %). This low N level may not sustain crop production, being below the 4.5 g/kg established for productive soils (Dong *et al.*, 2012). Available P (4.50 mg/kg) was low and could be attributed to high phosphorus retention capacity of aluminum and iron oxides and low total phosphorus contents characterized by acidic nature of the soil (Hanyabu *et al.*, 2020). The exchangeable cation values (cmol/kg) were 3.36, 1.60, 0.08 and 0.10 for Ca, Mg, Na and K, respectively. The values (cmol/kg) of exchangeable acidity were 2.52 for Al^{3+} and 0.76 for H^+. The soil effective cation exchange capacity was also low (< 10 cmol/kg) with the value of 8.42 cmol/kg. However, the base saturation (61.0 %) was within the sufficiency limit of 60.0 – 80.0 % (Landon, 1991).

Table 1: Soil nutrient analysis before addition of poultry manure

Soil nutrient	Value
pH (H_20)	5.4
Organic matter (%)	1.04
Total nitrogen (%)	0.09
Available P (mg/kg)	4.50
Exchangeable Bases (cmol/kg):	
Calcium (Ca)	3.36
Magnesium (mg)	1.60
Sodium (Na)	0.08
Potassium (k)	0.10
Exchangeable acidity (cmol/kg):	
Aluminum (Al^{3+})	2.52
Hydrogen (H^+)	0.76
ECEC (cmol/kg)	8.42
Base saturation (%)	61.0

Growth attributes

The plant height, number of tillers, number of functional tillers, flag leaf area and days to heading of the four spring wheat cultivars are shown in Table 2. Growth attributes varied significantly (p≤0.05) across the wheat cultivars. Cultivar *WZ 273 2015* showed superior performance in plant height resulting in taller plants (52.89 cm) than other cultivars with *Imam* being the shortest (42.78 cm) at 8 weeks after sowing (WAS). These variations in growth may be attributed to their unique genetic potential and growth characteristics (Nehe *et al.*, 2018) such as high vegetative and adaptation tendencies. *Norman* had the highest (p≤0.05) number of tillers at 4 WAS, followed by *cultivar WZ 273 2015*. Whereas *Imam* and *SC. Sahai* did not differ significantly in their number of tillers, and were statistically at par. The dissimilar in the number of tillers may likely be due to the unique genetic potential of *Norman* and *WZ 273 2015*, soil characteristics, and prevalent weather conditions. This is in line with the report of Peng *et al.* (2021) that wheat performance could be attributed to its genetic capabilities with appropriate environmental conditions for increased productivity. On the contrary, the number of functional tillers were highest (p≤0.05) in *WZ 273 2015* (2.83) at 8 WAS relative to other cultivars, possibly due to its superiority in agro-morphological performance and unique genetic potential and traits that may have influenced better functional tillering emergence and overall growth. According to Huang *et al.* (2020), functional tillering and number of total tillers initiated in wheat cultivars are basically regulated by many genetic, physiological and environmental factors. Previous studies on wheat have reported that genetic variation and its component traits can result in diverse responses in growth among different wheat cultivars (Gaju *et al.*, 2011; Nehe *et al.*, 2018). When wheat spikes partially emerge from their enclosing sheath is referred to heading (Hossain *et al.*, 2013). The time taken for heading depends on the growth conditions as well as the genetic makeup of the wheat cultivar (Hossain *et al.*, 2009). *SC. Sahai* headed (p≤0.05) earlier (46.11) compared to all other cultivars.

Table 2: Growth attributes of four spring wheat cultivars

Wheat Variety (V)	No. of tillers at 4 WAS	Leaf area of Flag leaf (cm^2) at 6 WAS	Number of days to 50 % heading at 6 WAS	Plant height (cm) at 8 WAS	No. of functional tillers at 8 WAS
Imam	4.37	4.20	62.11	42.78	1.10
SC. Sahai	4.03	4.07	46.11	43.70	1.13
Norman	4.69	4.47	61.67	46.62	1.20
WZ 273 2015	4.44	4.60	63.67	52.89	2.83
F-LSD (0.05)	0.58	NS	2.60	2.27	0.16

WAS = weeks after sowing; NS = not significant

Yield components

Table 3 shows results on the length of spikes, number of spikes/plants, number of spikelets/main spike, number of spikelets/plant and weight of spike+grain of four spring wheat cultivars. There were no significant (p>0.05) differences in length of spikes and number of spikes/plant. However, significant (p<0.05) differences in the number of spikelets/main spike and spikelets/plant were observed at 10 WAS with *SC. Sahai* having the highest values of 18.30 and 23.68, respectively relative to other cultivars. Spike length is a genotypic trait that is significantly affected by environmental factors (Ozkan, 2022). Mahpara *et al.* (2017) reported that increase in wheat spike length could contribute to an increase in grain yield. The results obtained for the number of spikelets are in line with previous studies. For instance, Gungor and Dumlupinar (2019) and Gungor *et al.* (2022) noted that the number of spikelets per main spike and plant could vary between 17.67 to 25.20 pieces/spike, 16.20 to 20.70 pieces/spike, 15.20 to 18.67 pieces/spike, and 16.4 to 20.30 pieces/spike, respectively. Spike weight+grain is a trait directly related to the photosynthetic capacity of plants and varies depending on genotype, climate, and cultivation techniques applied (Singh and Sharma, 2019). Among the wheat cultivars, *WZ 273 2015* showed a higher spike weight+grain value.

Table 3: Yield attributes of four spring wheat cultivars

Wheat Variety (V)	Length of spikes (cm) at 10 WAS	No. of spikes/plant at 10 WAS	No. of spikelet/main spike at 10 WAS	No. of spikelets/plant at 10 WAS	Weight of spike + grain (g/plant) at harvest
Imam	6.27	1.10	17.08	21.71	4.25
SC. Sahai	6.03	1.13	18.30	23.68	4.29
Norman	5.83	1.28	16.70	21.57	4.30
WZ 273 2015	5.84	1.31	14.25	20.89	4.34
F-LSD (0.05)	NS	NS	0.83	0.42	NS

WAS= weeks after sowing; NS= not significant

Plant dry weight, number of seeds/plant and grain weight

The plant's dry weight, number of seeds/plant and grain weight of four spring wheat cultivars are presented in Table 4. Dry matter accumulation of wheat cultivars varied significantly. This could be attributed to their genetic differences and influence in distributing photo-assimilates across their leaves, resulting in different plant growth patterns and yield (Aydoğan and Soylu, 2017). Among the wheat cultivars, *Norman* had the highest ($p \leq 0.05$) dry weight after harvest probably due to its superior tillering capacity as compared with the other cultivars (Table 2). Factors such as plant height, number of tillers, spike size, and hormones are likely responsible for the variations observed in biomass capacity among wheat cultivars (Yang *et al.*, 2023).

Table 4: Plant dry weight, number of seeds/plant and grain weight of four spring wheat cultivars

Wheat Variety	Plant dry weight (g/plant) after harvest	No. of seeds/plant	Grain weight (g/plant)	Grain yield (tons/ha)
Imam	2.45	5.22	0.42	0.42
SC. Sahai	2.76	4.44	0.41	0.41
Norman	4.49	3.11	0.23	0.23
WZ 273 2015	2.11	5.89	0.37	0.37
F-LSD (0.05)	0.26	NS	NS	NS

NS= not significant

Conclusion

The present study evaluated the performance of four wheat cultivars (*Imam, SC. Sahai, Norman and WZ 273 2015*) grown on poultry manure enriched coastal plain sands. *Norman* and *WZ 273 2015* cultivars showed good performance in plant height, number of tillers and functional tillers. For number of days to heading, numbers of spikelets/main spike and dry matter yield, *Norman, Imam* and *SC. Sahai* cultivars were superior relative to *WZ 273 2015*. The yield, though not significant, was highest in *Imam* (0.42 tons/ha), while the least was in *Norman* (0.23 tons/ha). Their inherent traits strongly indicate that they have the potential to be efficient candidates with good adaptability in soil and environmental conditions that could enable farmers to ensure sustainable agricultural practices for better yield. However, a long-term field studies are needed to validate the findings of this study prior to recommending any cultivar for cultivation in South-Eastern Nigeria.

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