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INFLUENCE OF POULTRY MANURE AND NPK RATES ON GROWTH INDICES AND YIELD OF SWEET CORN (*Zea mays* saccharrata L.) IN SAVANNA AGRO-ECOLOGICAL ZONES OF NIGERIA

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Abstract

Field experiment was conducted to study the response of sweet corn to rates of poultry manure and NPK (20:10:10) fertilizer during 2021 rainy season at the research farm of the Institute for Agricultural Research, Samaru and the National Horticultural Research Sub-station, Bagauda, both located in the Northern Guinea and Sudan Savanna agro-ecological zones of Nigeria. The treatments consisted of three rates of poultry manure (0, 4 and 8 t ha^{-1}) and three rates of NPK (20:10:10) fertilizer (0:0:0, 60:30:30, and 120:60:60 kg ha^{-1}). The treatments were laid out in a randomized complete block design and replicated three times. The result showed that increase in poultry manure rates from 0 to 8 t ha^{-1} significantly increased growth indices such as leaf area index, crop growth rate, relative growth rate and net assimilation rate of sweet corn at both locations. Application of Poultry manure (at either 4 or 8 t ha^{-1}) significantly influenced yield characters of sweet corn such as number of cobs per plant, cob diameter and dry yield per hectare. Other parameters (100 seed weight and fresh yield) were significantly influenced up to the highest poultry manure rate of 8 t ha^{-1} at both locations. Growth index and yield characters of sweet corn: leaf area index, number of cobs per plant, cob diameter, 100 grain weight and fresh yield per hectare increased with increasing rate of NPK fertilizer up to the highest rate of 120:60:60 kg ha^{-1}.

Keywords: NPK, Poultry manure and Sweet corn

Introduction

Sweet corn (*Zea mays* ssp. s*accharata*) is a vegetable crop grown for human consumption throughout the world. The crop is primarily grown for its immature green ear, as food for man (Sani *et al*., 2011). It is utilized raw, boiled or roasted and can also be added to salad, among other food ingredients (Jibrin and Sarkin-Fulani, 2011, Akintoye and Olaniyan, 2012). Its unique characteristic lies in its capacity to produce and preserve large amount of sugar content within the kernel, setting it apart from other varieties of maize (Jibrin and Sarkin-Fulani, 2011). Considerable proof indicates a rising prominence of sweet corn production in Nigeria, particularly in urban areas and regions with export capabilities (Sani *et al*., 2011).

Sweet corn, a popular crop, holds great potential for contributing to food security and income generation. However, soil fertility depletion remains a major challenge in Nigeria, especially the Savannah Agroecological Zones largely on account of bush burning, intensive cropping without nutrient replenishment, removal of crop residues for fuel, fodder etc. and intense rainfall resulting in leaching and erosion of topsoil are important factors that affect crop productivity (Jones *et al*., 2013) and (Kidane, 2015). The crop is mostly grown through the use of inorganic fertilizer in Nigeria, and the use of manures is not preferred by small scale farmers, despite its role in maintaining soil quality, increasing soil organic matter, as well as improving soil physical and chemical properties through the decomposition of its substances and the enhancement of soil nutrients, plant growth regulators, and biodiversity (Mader *et al*., 2002; Kakar *et al*., 2019). Therefore, this study investigated the response of growth and yield indices of sweet corn to rates of poultry manure and NPK with a view to determine the poultry manure rates required for optimum growth and yield of sweet corn as well as the NPK (20:10:10) fertilizer rates required for optimum growth and yield of sweet corn.

Materials and Methods

The experiment was conducted simultaneously at two locations during the 2021 rainy season; one at the Horticultural Garden of the Institute for Agricultural Research, Samaru (latitude $11^0$11'N, longitude $07^0$38'E, 686m above sea level) in the Northern Guinea Savannah and the other one at the National Horticultural Research Sub-station; Bagauda (latitude $11^0$39'N, longitude $08^0$02'E), 500m above sea level in the Sudan savannah ecological zone of Nigeria. Prior to each trial, composite samples of poultry manure as well as the soil of the experimental sites were analyzed for their physical and chemical properties using standard laboratory procedure at the Analytical laboratory, Department of Agronomy, Ahmadu Bello University Zaria. The treatments consisted of three rates of poultry manure (0, 4 and 8 t ha^{-1}) and three rates of NPK (20-10-10) at 0-0-0, 60-30-30 and 120-60-60 kg ha^{-1}. The treatments were factorially combined in a 3x3 with a total of 9 treatments which were laid out in a Randomized Completely Block Design with three replications.

The gross plot consisted of 8 ridges, 0.75m apart, 6m wide and 4m long (24 m^2); the net plot consisted of 4 innermost ridges (12 m^2) while the 4 side rows (12 m^2) formed the discard for destructive sampling. Sweet corn 'Sugar king F1' variety used for the trial was a tropical hybrid sweet corn with strong plant vigor and root system. It is tolerant to lodging and matures between 71-73 days after sowing. It produces large ears with good shelf life and a very sweet taste. Ears are yellow and between 20 to 21cm in length. It has a brix content of 13%. Chemical weed control using glyphosate at the rate of 1.44 kg a.i ha^{-1} using a 16-litre manual knapsack sprayer was carried out two weeks prior to land preparation. The land was manually cleared, mechanically harrowed and ridged. The land was then demarcated into 27 plots each measuring 4 m x 6 m. The gross plot consisted of 8 rows (4 m x 6 m = 24 m^2), 4 inner rows constituted the net plot (4 m x 3 m = 12 m^2), 0.75 m and 1.5 m for alley ways, between plots and replicates respectively. Basal application of poultry manure was done as per treatment. The seeds were treated with Apron star (Thiamethoxam + Difenoconazole) 1.2 kg a.i ha^{-1} before sowing at the rate of 1 sachet (10 g) to 3 Kilograms of seed. This was to ensure that the seeds were protected from seed and soil borne pathogens. Seeds were sown at inter-row spacings of 0.75 m and intra-row spacing of 0.50 m at the rate of two seeds per hole and were later thinned to a plant per stand two weeks after sowing. NPK compound fertilizer (20:10:10) was applied as per treatments in two equal split doses; first half at 2WAS while the other half was side-dressed at 6WAS. Harvesting was done at milk / dough stage, while the bract of ears were green and firm. Data collected were subjected to analysis of variance (ANOVA) as described by Steel and Torrie (1987) and treatment means were compared using Duncan Multiple Range Test (DMRT) (Duncan, 1955) at 5% probability level. The magnitude and type of relationship between characters was assessed through simple correlation analysis (Dewey and Lu, 1959).

Results

Leaf Area Index

Considering the two locations, significant differences in leaf area index due to varying manure rates were not observed at Samaru site in all sampling dates, however, significant influence of different manure rates were observed at 4, 6 and 8WAS at Bagauda (Table 3). At Bagauda 4WAS, significant improvement in leaf area index was recorded with each and progressive increase in poultry manure rate. At both 6 and 8WAS, applied 4 t ha^{-1} of poultry manure resulted in significantly higher LAI of sweet corn than the untreated control. Further increasing the rate to 8t/ha at same sampling periods, no significant differences were observed when compared with applied 4 t ha^{-1} of poultry manure. Application of varying rates of NPK fertilizer had no significant effect on leaf area index at both locations except at 4WAS at Samaru, when increase in fertilizer rate from 0:0:0 to 60:30:30 kg ha^{-1} resulted in leaf area index that were at statistical parity with that given no fertilizer treatment. Further increment in fertilizer rate to 120:60:60 kg ha^{-1} recorded significant increase in leaf area index value compared with that of the untreated control. The interaction of poultry manure and fertilizer (P*F) was not significant for this character at all sampling dates and at both locations.

Crop Growth Rate

Application of 4 or 8 t ha^{-1} of poultry manure consistently resulted in higher crop growth rate of sweet corn between 4 to 6 and 6 to 8WAS at Samaru and between 4 to 6WAS at Bagauda compared to the control (Table 1). Comparing 0 and 4 t ha^{-1} of poultry manure with respect to crop growth rate of sweet corn between 6 to 8WAS showed no significant difference at Bagauda. However, increasing the poultry manure rate to 8 t ha^{-1} at same location and sampling period resulted in significantly higher crop growth rate of sweet corn over lower poultry manure rates evaluated. Application of NPK fertilizer had significant effect on crop growth rate at all sampling period except between 8 -10WAS at both locations. At Samaru between 4 – 6WAS, application of 60:30:30 kg ha^{-1} of NPK recorded significantly higher crop growth rate of sweet corn above the untreated control. Further increase in NPK rate to 120:60:60 kg ha^{-1} significantly enhanced crop growth rate of sweet corn over lower NPK fertilizer rates evaluated. At Bagauda, application of 120:60:60 kg ha^{-1} of NPK fertilizer resulted in statistically similar crop growth rate of sweet corn with that given 60:30:30 kg ha^{-1}, but significantly higher compared to the untreated control. The 1st order interaction of poultry manure and fertilizer (P*F) was not significant for CGR at all sampling dates and at both locations.

Relative Growth Rate

Relative growth rate of sweet corn significantly increased with increase in poultry manure rates from 0 to 4 t ha^{-1} between 6 – 8 and 8 – 10WAS at Samaru and between 6 – 8WAS at Bagauda (Table 1). Further increase in poultry manure rate to 8 t ha^{-1} at same sampling periods and locations recorded no significant increase in relative growth rate of sweet corn.

Significant response of sweet corn relative growth rate to NPK fertilizer was only recorded between 8 – 10WAS at Samaru, when application of 60:30:30 kg ha^{-1} NPK significantly enhanced relative growth rate of sweet corn. Evaluating the highest NPK rate (120:60:60 kg ha^{-1}) at same sampling period and location resulted in no significant difference with applied 60:30:30 kg ha^{-1} NPK on relative growth rate of sweet corn.

The interaction of poultry manure and fertilizer (P*F) was not significant for RGR at all sampling dates and at both locations

Net Assimilation Rate

Effect of poultry manure on net assimilation rate of sweet corn was only significant between 6 – 8WAS at both locations, when application of 8 t ha^{-1} of poultry manure produced statistically similar assimilates with applied 4 t ha^{-1}, but significantly higher (assimilate production) compared to the controls (Table 2).

Data analysis result revealed that significant response of net assimilation rate of sweet corn was only notable between 4-6 and 6-8WAS at Samaru, when NPK control and applied 60:30:30 kg ha^{-1} of NPK resulted in statistically similar net assimilation rate of sweet corn. When a higher NPK rate of 120:60:60 kg ha^{-1} was applied at same sampling period and location, more assimilates were significantly produced than the lower NPK rates evaluated.
The 1^{st} order interaction of poultry manure and fertilizer (P*F) was not significant for this character at all sampling dates and at both locations.

Number of Cobs per Plant, Length (Cm) and Diameter (Cm) of Sweet Corn
Treatment with either 4 or 8 t ha^{-1} of poultry manure produced statistically similar number of cobs and cob diameter of sweet corn while the control produced significantly least number of cobs and cob diameter of sweet corn (Table 4). At Bagauda, there was significant response on number of cobs and cob diameter of sweet corn when 4t ha^{-1} of poultry manure was applied compared with poultry manure control. Further increase in poultry manure rate from 4 to 8 t ha^{-1} was significantly beneficial only to number of cobs. Looking at the effect of NPK on number of cobs and cob diameter (cm) of sweet corn at both locations indicates significant difference only on cob diameter at Samaru, as well as number of cobs at both locations. At both locations, each increase in NPK rate significantly and progressively increases number of cobs of sweet corn. At Samaru, plots treated with either 0:0:0 or 60:30:30 kg ha^{-1} of NPK fertilizer produced cobs with statistically similar diameter. Highest mean cob diameter of sweet corn was recorded when NPK fertilizer rate was raised to 120:60:60 kg ha^{-1} which was significantly higher compared to the control.

100 Grains Weight
100 grains weight showed no significant response to rates of poultry manure at Samaru. However, there was significant response to poultry manure rates at Bagauda, where each increase in poultry manure rate significantly and progressively increases 100 grains test weight of sweet corn (Table 4). The varying rates of NPK fertilizer evaluated on 100 grains weight at both locations were not significant except at Bagauda, where each increase in NPK fertilizer rate significantly enhances 100 grains test weight of sweet corn. The interactions between poultry manure and NPK fertilizer on 100 grains weight was highly significant at Bagauda, and is presented in table 5, where increase in poultry manure rate from 0 to 4 t ha^{-1} at applied 0:0:0 and 120:60:60 kg ha^{-1} of NPK significantly increased 100 grains weight of sweet corn. Further increase in poultry manure rate at same NPK rate had no significance on 100 grains weight of sweet corn. At applied 60:30:30 kg ha^{-1} of NPK, heavier grain yield was only observed with application of 8 t ha^{-1} of poultry manure as against plots without applied poultry manure. Looking at the poultry manure rate, application of NPK from 0:0:0 to 120:60:60 kg ha^{-1} led to heavier 100 grains weight.

Fresh Yield per Hectare (T)
Increase in application of poultry manure from 0 to 4 t ha^{-1} significantly enhanced Fresh yield per hectare of sweet corn at both locations (Table 4). Highest fresh yield per hectare of sweet corn was recorded with the application of the highest poultry manure rate of 8 t ha^{-1} at both locations which was significantly higher than lower rates evaluated. Considering the effect of varying rates of NPK fertilizer on fresh yield per hectare of sweet corn, significant and progressive increase in yield per hectare was notable with each increase in NPK fertilizer rate at

Both locations. Applied 120:60:60 kg ha^{-1} NPK produced the highest fresh yield per hectare at both locations.

Table 1: Effect of Poultry Manure and NPK on Crop Growth Rate and Relative Growth Rate of Sweet Corn during 2021 Rainy Season at Samaru and Bagauda

Crop Growth Rate and Relative Growth Rate

	Crop growth rate (g/cm^2/wk)						Relative growth rate (g/g/wk)					
	Samaru			Bagauda			Samaru			Bagauda		
Treatment	4-6WAS	6-8WAS	8-10WAS	4-6WAS	6-8WAS	8-10WAS	4-6WAS	6-8WAS	8-10WAS	4-6WAS	6-8WAS	8-10WAS
Poultry manure (P) (tha^{-1})												
0	9.88^{b}	19.83^{b}	9.71	7.71^{b}	27.73^{b}	7.33	0.93	0.38^{b}	0.10^{b}	1.10	0.52^{b}	0.11
4	12.76^{ab}	33.59^{a}	10.69	16.92^{a}	29.60^{b}	10.43	0.76	0.55^{a}	0.17^{a}	1.15	0.86^{a}	0.11
8	16.02^{a}	34.57^{a}	11.67	14.67^{a}	46.25^{a}	10.64	0.90	0.45^{ab}	0.12^{ab}	1.21	0.77^{ab}	0.08
SE+	1.175	4.484	1.466	2.042	4.708	1.791	0.122	0.055	0.017	0.122	0.110	0.017
NPK (20-10-10) (F) (Kgha^{-1})												
0:0:0	8.37^{c}	17.63^{b}	9.04	9.27^{b}	24.69^{b}	8.23	0.85	0.43	0.09^{b}	1.08	0.66	0.08
60:30:30	12.42^{b}	29.74^{ab}	12.24	14.16^{ab}	34.86^{ab}	7.84	0.80	0.44	0.14^{a}	1.17	0.73	0.10
120:60:60	17.87^{a}	40.62^{a}	10.79	15.87^{a}	44.03^{a}	12.33	0.94	0.51	0.16^{a}	1.21	0.77	0.12
SE+	1.175	4.484	1.466	2.042	4.708	1.791	0.122	0.055	0.017	0.122	0.110	0.017
Interaction												
P*F	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

SE+: Standard Error; a, b: Means with the same superscript in the same column are not different statistically at *P=0.05* level of probability using DMRT.

Table 2: Effect of Poultry Manure and NPK on Net Assimilation Rate of Sweet Corn during 2021 Rainy Season at Samaru and Bagauda

	Net assimilation rate ($gg^{-1}wk^{-1}$)					
	SAMARU			BAGAUDA		
Treatment	4-6WAS	6-8WAS	8-10WAS	4-6WAS	6-8WAS	8-10WAS
Poultry manure (P) (t ha^{-1})						
0	48.98	43.62^{b}	20.15	45.90	57.95^{b}	22.54
4	63.64	72.87^{a}	15.16	48.62	81.80^{ab}	26.93
8	67.44	72.34^{a}	21.42	38.26	95.83^{a}	21.57
SE±	7.503	9.679	2.772	9.234	11.831	4.917
NPK (20-10-10) (F) (Kg ha^{-1})						
0:0:0	42.33^{b}	40.20^{b}	15.93	36.36	67.96	23.70
60:30:30	50.16^{b}	60.40^{b}	21.67	49.49	73.66	18.66
120:60:60	87.57^{a}	88.24^{a}	19.13	46.92	93.96	28.68
SE±	7.503	9.679	2.772	9.234	11.831	4.917
Interaction						
P*F	NS	NS	NS	NS	NS	NS

SE+: Standard Error; a, b: Means with the same superscript in the same column are not different statistically at *P=0.05* level of probability using DMRT.

Table 3: Effect of Poultry Manure and NPK on Leaf Area Index of Sweet Corn during 2021 Rainy Season at Samaru and Bagauda

	Leaf Area Index							
	Samaru				Bagauda			
Treatment	4WAS	6WAS	8WAS	10WAS	4WAS	6WAS	8WAS	10WAS
Poultry manure (P) (t ha^{-1})								
0	0.38	0.93	1.48	1.57	0.34^{c}	0.91^{b}	1.00^{b}	1.09
4	0.45	1.03	1.67	1.65	0.66^{b}	1.42^{a}	1.25^{a}	1.28
8	0.44	1.02	1.57	1.53	0.97^{a}	1.51^{a}	1.26^{a}	1.36
SE±	0.052	0.068	0.109	0.096	0.102	0.134	0.070	0.145
NPK (20-10-10) (F) (Kg ha^{-1})								
0:0:0	0.35b	0.91	1.54	1.57	0.57	1.07	1.07	1.15
60:30:30	0.39ab	1.09	1.63	1.53	0.64	1.36	1.21	1.21
120:60:60	0.53a	0.98	1.55	1.65	0.78	1.41	1.23	1.37
SE±	0.052	0.068	0.109	0.096	01.02	0.134	0.070	0.145
Interaction								
P*F	NS	NS	NS		NS	NS	NS	

SE+: Standard Error; a,b,c: Means with the same superscript in the same column are not different statistically at *P=0.05* level of probability using DMRT.

Table 4: Effect of Poultry Manure and NPK Fertilizer on Number of Cobs, Length, Diameter and Fresh Yield per Hectare of Sweet Corn at Samaru and Bagauda during 2021 Rainy Season

	Samaru				Bagauda			
Treatment	No of cobs/plant	Cob diameter (cm)	S100W (g)	Fresh Yield per hectare (t)	No of cobs/plant	Cob diameter (cm)	S100W (g)	Fresh Yield per hectare (t)
Poultry manure (P) (t ha^{-1})								
0	2.2^{b}	5.7^{b}	12.4	18.0^{c}	2.3^{c}	5.3^{b}	12.4^{c}	13.5^{c}
4	3.0^{a}	6.1^{a}	12.9	28.7^{b}	3.1^{b}	5.7^{a}	13.7^{b}	20.5^{b}
8	3.6^{a}	6.0^{a}	12.6	35.8^{a}	3.7^{a}	5.9^{a}	14.2^{a}	28.1^{a}
SE$\pm$	0.30	0.10	0.43	0.95	0.20	0.10	0.15	0.93
NPK (20-10-10) (F) (Kg ha^{-1})								
0:0:0	2.1c	5.8^{b}	12.0	15.5^{c}	1.9^{c}	5.5	11.9^{c}	12.2^{c}
60:30:30	3.0^{b}	5.9^{ab}	12.7	29.4^{b}	3.2^{b}	5.7	13.5^{b}	21.8^{b}
120:60:60	3.7^{a}	6.1^{a}	13.2	37.6^{a}	4.0^{a}	5.7	14.9^{a}	28.1^{a}
SE$\pm$	0.30	0.10	0.43	0.95	0.20	0.10	0.15	0.93
Interaction								
PXF	NS	NS	NS	NS	NS	NS	**	NS

SE+: Standard Error; a,b,c,d,e,f: Means with the same superscript in the same column are not different statistically at *P=0.05* level of probability using DMRT.

Table 5: Interaction of poultry manure and NPK fertilizer on 100 grains weight of sweet corn during 2021 rainy season at Bagauda

	Poultry manure (t/ ha)		
Treatment	0	4	8
NPK (20-10-10) (F) (kg ha^{-1})			
0:0:0	10.1^{e}	12.5^{d}	13.2^{cd}
60:30:30	12.9^{cd}	13.6^{bc}	14.1^{b}
120:60:60	14.1^{b}	14.9^{a}	15.6^{a}
SE$\pm$		0.25	

SE+: Standar Error; a,b,c,d,e: Means with the same superscript in the same column are not different statistically at *P=0.05* level of probability using DMRT.

Discussion

Increase in poultry manure rates from 0 to 8 t ha^{-1} significantly increase growth indices such as leaf area index, crop growth rate, relative growth rate and net assimilation rate of sweet corn at both locations. This increase in growth indices could be attributed to the higher essential nutrients in poultry manure which increases nutrients and synthesis of photo assimilates thereby leading to crop growth and development through chemical (nutrients), biological (biological activities and microorganisms) and physical (aeration, water holding capacity and improved soil structure). This is consistent with the report of Enujeke (2013) who indicated that higher rates (30 t ha^{-1}) of poultry manure increased growth parameters of maize. Makinde *et al*. (2011) and Garg and Bahla (2008) reported that poultry manure is a good organic resource that contains high amounts of macronutrients (N, P, and K) and other essential nutrients. Yield attributes such as number of cobs per plant, cob diameter, 100 grains weight and fresh yield significantly responded to applied poultry manure from 0 to 8 t ha^{-1} at both locations since inherent nutrient and organic matter is relatively low in these soils, the soil tend to benefit from use of poultry manure which has the three prong effect of chemical, biological and physical activities. For each increase in application of poultry manure rate from 0 to 4 and 4 to 8 t ha^{-1} led to increase in yield parameter at both locations. This could be due to adequate supply and availability of nutrients (N, P, K, Ca and Mg) which obviously stimulated rapid crop growth and development in plots nourished with poultry manure. This observation is in consistence with the findings of Udom and Bello (2009) who reported that the application of poultry litter significantly increased grain yield of maize and attributed the increase to the supply of nutrients especially Nitrogen and phosphorus by the poultry litter which promoted better crop performance. This is also in harmony with the findings of Boateng *et al*. (2006) who reported that the application of poultry manure at a rate of 4 t ha^{-1} helps to improve maize yields significantly. Shiyam *et al.,* (2017) also reported increase in number of cobs per plant and grain yield of popcorn to increased poultry manure rate.

Sweet corn leaf area index, number of cobs per plant, cob diameter and fresh yield per hectare were significantly increased with increase in NPK fertilizer, with applied 120:60:60 kg ha^{-1} recording the highest fresh yield at both locations. This could be ascribed to the role of NPK fertilizer in supplying essential nutrients (N, P, K) required for physiological activities such as root development, dry matter production transformation of sugars to starch in grain-filling process and crop maturity. This is in line with the findings of Sani *et al*., (2011), who reported that yield components of sweet corn such as 1000-grain weight and fresh cob yield responded significantly to NPK fertilization up to the highest rate of 120:60:60 kg ha^{-1}. Similarly, Lawal (2000) also reported that maize yield responded to fertilizer application up to 600kg ha^{-1} (120:60:60 kg ha^{-1}).

Conclusion

From the study, it can be concluded that growth indices and yield components of sweet corn increased with increase in poultry manure and inorganic fertilizer rates up to 8 t ha^{-1} and 120:60:60 kg ha^{-1}, respectively.

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Appendix I

Physical and Chemical Properties of Soils at the Experimental sites during the 2021 Rainy Season

Soil Composition	Depth of Soil (0 – 30cm)	
Particle size distribution (g kg^{-1})	**Samaru**	**Bagauda**
Sand	480	560
Silt	380	340
Clay	140	100
Textural class	Loam	Sandy Loam
Chemical composition		
pH in H_2O (1:2.5)	5.64	6.70
pH in 0.01M $CaCl_2$ (1:2.5)	4.85	5.25
Organic Carbon (g kg^{-1})	12.60	14.25
Total Nitrogen (g kg^{-1})	1.50	1.65
Available Phosphorus (mg kg^{-1})	8.65	10.45
Exchangeable cations (cmol kg^{-1})		
Calcium (Ca^{2+})	2.65	3.16
Magnesium (Mg^{2+})	0.46	0.59
Potassium (K^{+})	0.15	0.18
Sodium (Na^{+})	0.21	0.24
Aluminum and Hydrogen (Al^{3++} H^{+})	0.21	0.16
Cation Exchange Capacity (C.E.C)	3.68	4.33

Analyzed at the Department of Agronomy, Ahmadu Bello University Zaria.

Appendix II

Chemical Properties of poultry manure used

Poultry manure nutrient composition.	
Total Nitrogen (g kg^{-1})	19.61
Available Phosphorus (mg kg^{-1})	13.65
Exchangeable cations (cmol kg^{-1})	
Calcium (Ca^{2+})	4.35
Magnesium (Mg^{2+})	2.69
Potassium (K^{+})	11.05

Analyzed at the Department of Agronomy, Ahmadu Bello University Zaria.

Appendix III

Meteorological data showing mean of Rainfall amount, Temperatures, Relative humidity and Solar Radiation during 2021 rainy at Samaru

Month	Rainfall (mm)	Temperature (ºC)		Relative humidity (%)	Solar Radiation (Sunshine hours)
		Min.	Max.		
June	170.90	30.50	23.00	74.17	N/A
July	238.40	28.16	22.58	79.26	N/A
August	341.60	29.10	22.45	82.32	N/A
September	195.60	30.00	22.57	74.73	N/A
October	48.80	32.84	22.19	63.35	N/A
November	0.00	34.00	18.40	26.57	N/A

Key: NA = Not Available

Source: IAR Meteorological Unit, Ahmadu Bello University, Zaria, Nigeria (2021)

Appendix IV

Meteorological data showing mean of Rainfall amount, Temperatures, Relative humidity and Solar Radiation during 2021 rainy at Bagauda

Month	Rainfall (mm)	Temperature (ºC)		Relative humidity (%)	Solar Radiation (Sunshine hours)
		Min.	Max.		
June	85.00	29.2	37.9	56.00	N/A
July	162.00	26.8	34.4	62.00	N/A
August	446.00	24.5	31.3	89.00	N/A
September	124.80	22.8	32.5	85.00	N/A
October	22.30	25.3	33.9	46.00	N/A
November	0.00	23.4	31.2	38.00	N/A

Key: NA = Not Available
Source: Meteorological Unit, National Horticultural Research Sub-station, Bagauda (2021)