

GROWTH AND YIELD OF ROSELLE (*Hibiscus sabdariffa* L.) AS INFLUENCED BY POULTRY MANURE AND NPK FERTILIZER RATES AT SAMARU

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ABSTRACT: The experiment to determine effect of poultry manure and NPK fertilizer on the growth and yield of Roselle (*Hibiscus sabdariffa* L.) in the 2021 and 2022 rainy seasons at the research farm of Institute for Agricultural Research (IAR) Samaru (11° 11'N, 7° 38'E, 686m above sea level) in the Northern Guinea Savanna ecological zone of Nigeria. The treatments consisted four rates of poultry manure 0, 2, 4, and 6 t/ha (tonnes per hectare) equivalent to 0:0:0, 38:27:20, 77:55:41, 115:82:61 N:P₂O₅:K₂O kg/ha (kilograms per hectare) during the 2021 season, with 0:0:0, 42:30:25, 83:60:51, 125:90:76 N:P₂O₅:K₂O kg/ha during 2022 season. And also NPK 20-10-10 fertilizer rates 0, 300, 600, and 900 kg/ha equivalent to 0:0:0, 60:30:30, 120:60:60 and 180:90:90 N:P₂O₅:K₂O kg/ha. The treatments were laid in a Randomized Complete Block Design (RCBD) and replicated thrice. The results showed the application of up to 4 t/ha of poultry manure significantly increased LAI (Leaf Area Index) at 10 WAS (Weeks After Sowing), days to 50% flowering, number of fruits per plant, and calyx yield/ha (per hectare). It was also observed that application of NPK 20-10-10 at the rate of 300 kg/ha (60:30:30 N:P₂O₅:K₂O kg/ha) significantly increased LAI at 10 WAS, days to 50% flowering, number of fruits per plant, calyx weight/plant (per plant), and total calyx yield/ha. The regression of combined yield for the two years showed that the maximum NPK 20-10-10 alone at the rate of 493.5 kg/ha (98.7:49.35:49.35 N:P₂O₅:K₂O kg/ha) resulted in the maximum calyx yield of 679 kg/ha.

Keywords: Roselle, Hibiscus, Poultry manure, NPK fertilizer, Samaru

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is one of the plants belonging to the Malvaceae family (El-Dissoky *et al.*, 2020). It is cultivated as an annual shrub in tropical and subtropical regions (Evan *et al.*, 2021; Gashua *et al.*, 2022). It is cultivated for its stem, fiber, edible calyxes (calyces), leaves, and seeds (Haruna *et al.*, 2011). It is known by many names such as 'Florida Roselle' or 'Florida cranberry' in Florida, United States of America, and 'Sobo' 'Zobo' or 'Zoborodo' in Nigeria (Akanbi *et al.*, 2009).

Fertilizing can change rates of plant growth, maturity time, size of parts, and phytochemical content (Bekeko, 2014). Anyinkeng and Mih (2011) reported poultry manure application of up to 20 t/ha (tonnes per hectare) significantly increased growth, biomass, and economic yield of Roselle. Contrary, Haruna *et al.*, (2011) and Mera *et al.*, (2009) recommended the application of 2.5 t/ha of poultry manure to significantly increase yield roselle. It is worth noting that the application of 90:45:45 N:P₂O₅:K₂O kg/ha (kilograms per hectare) which is equivalent to 450 kg/ha NPK 20-10-10 was reported by Musa *et al.*, (2024) to be the best for capsule, yield, and seed of Roselle. Notwithstanding, Sa'id *et al.*, (2015) reported the application of 150 kg/ha of NPK 20-10-10 as the best for obtaining highest calyx yield of roselle. Applications of both organic and mineral fertilizer have been reported to improve the performance of various crops (Isah *et al.*, 2023; Luka and Arunah, 2021; Luka *et al.*, 2023; Yahaya *et al.*, 2023).

MATERIALS AND METHODS

The experiment was conducted during the 2021 and 2022 rainy seasons at the Institute for Agricultural Research (IAR) Samaru Research Farm (11° 11'N, 7° 38'E, 686 m above sea level) in the northern Guinea Savanna ecological zone of Nigeria. Annual rainfall ranges from 800 – 1054.8 and lasts from April/May to September/October. Mean maximum and minimum temperatures during the rainy season range from 29-38°C and 18-24°C, respectively. The soil of the area is described as well-drained often leached ferruginous tropical soil (Aliyu and Adekpe, 2022). The treatments consisted of four poultry manure rates and four rates of NPK (20:10:10) fertilizer. The rates of 0:0:0, 60:30:30, 120:60:60 and 180:90:90 kg N:P₂O₅:K₂O ha⁻¹ were the NPK rates, and 0, 300, 600, and 900 kg/ha as the equivalent. While the poultry manure rates of 0, 2, 4 and 6 t/ha were equivalent to 0:0:0, 38:27:20, 77:55:41, and 115:82:61 kg N:P₂O₅:K₂O ha⁻¹ during the 2021 season, and 0:0:0, 42:30:25, 83:60:51, and 125:90:76 kg N:P:K ha⁻¹ during the 2022 season. The treatments were combined in all possible factorial combinations and laid out in a Randomized Complete Block Design (RCBD) replicated three times. The test crop variety was SAMARU-1882 which is a variety obtained from I.A.R Artemisia Research Unit, Samaru. It is of medium height with dark red stems, petioles, and high-quality calyces. It matures in 4-5 months. (Maunde, 2011).

The land was harrowed and ridged at 75 cm apart and then marked into plots. The seeds were sown on 10th July, 2021 and 23rd July, 2022 during the 2021 and 2022 rainy seasons respectively. Three seeds were sown per hole and the seedlings were thinned to one plant per stand at 30cm intra-row spacing. Poultry manure was incorporated into the crest of the ridges according to treatments two weeks before planting. Inorganic fertilizer (NPK 20:10:10) was applied by side dressing in two equal split doses; at 2 WAS (Weeks After Sowing), and 6 WAS. The method of application for the inorganic fertilizer was side dressing. Cypermethrin at the rate of 1.5kg a.i/ha was applied to control insect pests.

The data collected (leaf area index, crop growth rate, relative growth rate, net assimilation rate, days to 50% flowering, number of fruits per plant, calyx weight/plant (per plant), and calyx yield/ha) were subjected to analysis of variance as described by. The treatment means were compared using Duncan's Multiple Range Test. Combined analyses was carried out on the treatment means of calyx yield/ha to further compare the means. The calyx yield/ha result was subjected to regression analyses.

RESULTS AND DISCUSSION

RESULTS

The effect of poultry manure and NPK 20-10-10 fertilizer on LAI (Leaf Area Index) at 10 WAS, CGR (Crop Growth Rate) at 10 WAS, RGR (Relative Growth Rate) at 10 WAS, and NAR (Net Assimilation Rate) at 10 WAS of roselle during the 2021 and 2022 rainy seasons is presented in table 1. LAI at 10 WAS during both seasons showed that the increase in poultry manure resulted in a significant increase up to 4 t/ha, and a further increase in poultry manure did not result in any significant difference. CGR at 10 WAS during the 2021 season showed there was no significant difference in poultry manure rates applied from 0 to 4 t/ha while a further increase to 6 t/ha resulted in a significantly lower CGR. During the 2022 season, there was a significant increase in CGR at 10 WAS with an increase in poultry manure up to 6 t/ha. RGR during the 2021 season and NAR during both seasons at 10 WAS showed the application of 0 t/ha of poultry manure to be the highest and significantly higher than other rates applied. At 10 WAS during the 2022 season, all poultry manure rates applied were statistically the same.

The application of NPK 20-10-10 fertilizer during both years resulted in a significant increase in LAI during both seasons, CGR, and RGR during the 2022 season at 10 WAS up to application rate of 300 kg/ha, which was significantly higher than other rates when statistically compared. NPK 20-10-10 fertilizer application rate of 0 kg/ha resulted in the highest CGR and RGR at 10WAS during the 2021 season, and NAR during both seasons which was statistically higher than other rates applied.

Interaction between poultry manure and NPK 20-10-10 at 10 WAS in the 2021 season on NAR is presented in table 2. Where the poultry manure rates were compared at the same NPK 20-10-10 level, it was observed that when 0kg NPK 20-10-10 was applied, each increase in poultry manure rate reduced NAR, with the highest at 0 t/ha.

Table 1: Effect of poultry manure and NPK fertilizer on LAI at 10 WAS, CGR at 10 WAS, RGR at 10 WAS and NAR at 10 WAS of roselle during the 2021 and 2022 rainy seasons

Treatment	LAI 10WAS		CGR 10WAS (g cm ⁻² wk ⁻¹)		RGR 10WAS (g g ⁻¹ wk ⁻¹)		NAR 10WAS (g cm ⁻² wk ⁻¹)	
	2021	2022	2021	2022	2021	2022	2021	2022
Poultry manure (t ha ⁻¹)								
0	3.86c	1.31c	3.72a	1.55c	0.32a	0.14	0.01a	0.01a
2	4.27b	1.51b	3.68a	1.68bc	0.30b	0.14	0.01b	0.01b
4	4.46ab	1.62ab	3.63a	1.73b	0.28b	0.15	0.01b	0.01bc
6	4.63a	1.73a	3.41b	1.88a	0.25c	0.15	0.01c	0.01c
SE±	0.090	0.041	0.063	0.050	0.006	0.004	0.001	0.001
NPK 20-10-10 (kg ha ⁻¹)								
0	3.20d	0.89d	4.13a	1.40c	0.40a	0.14b	0.01a	0.01a
300	5.47a	2.19a	2.76d	1.94a	0.17d	0.15a	0.01d	0.01d
600	4.53b	1.75b	3.64c	1.80b	0.25c	0.15ab	0.01c	0.01c
900	4.02c	1.34c	3.90b	1.71b	0.32b	0.15ab	0.01b	0.01b
SE±	0.090	0.041	0.063	0.050	0.006	0.004	0.001	0.001
Interaction								
F×PM	NS	NS	NS	NS	NS	NS	**	NS

Means followed by same letter(s) in the same treatment column are not different statistically at $P \leq 0.05$ level of probability using DMRT. WAS = Weeks after sowing. ** = Significant interaction

Table 2: Interaction of poultry manure and NPK 20-10-10 fertilizer on NAR (g cm⁻² wk⁻¹) of Roselle at 10 WAS for the 2021 rainy season at Samaru

NPK 20-10-10 (kg ha ⁻¹)	Poultry manure (t ha ⁻¹)			
	0	2	4	6
0	0.0012a	0.0008b	0.0008c	0.0007bc
300	0.0004c	0.0003c	0.0003c	0.0003c
600	0.0005bc	0.0005bc	0.0005bc	0.0004c
900	0.0006bc	0.0006bc	0.0006bc	0.0006bc
	SE± 0.00002			

Means followed by same letter(s) in the same treatment column and row are not different statistically at $P \leq 0.01$ level of probability using DMRT

Table 3: Effect of poultry manure and NPK 20-10-10 fertilizer on days to 50% flowering and number of fruits per plant of roselle during the 2021 and 2022 rainy seasons

Treatment	Days to 50% flowering		Number of fruits per plant	
	2021	2022	2021	2022
Poultry manure (t ha ⁻¹)				
0	91.7c	92.4b	12.4c	11.7c
2	91.8cb	93.2ab	13.7b	12.4b
4	92.0b	93.6ab	14.4a	13.1a
6	92.4a	93.9a	15.0a	13.5a
SE±	0.09	0.41	0.21	0.16
NPK 20-10-10 (kg ha ⁻¹)				
0	90.9d	91.3c	10.2d	9.7d
300	93.2a	95.0a	17.9a	15.6a
600	92.3b	93.8b	14.9b	13.9b
900	91.5c	93.0b	12.6c	11.5c
SE±	0.092	0.41	0.21	0.16
Interaction				
F×PM	NS	NS	NS	NS

Means followed by same letter(s) in the same treatment column are not different statistically at $P \leq 0.05$ level of probability using DMRT. WAS = Weeks after sowing. ** = Significant interaction

The effect of poultry manure and NPK 20-10-10 fertilizer on days to 50% flowering and the number of fruits per plant of roselle is presented in table 3. With the increase in poultry manure rates, there is a significant increase in days to 50% flowering up to 6 t/ha during the 2021 season and a significant increase of up to 2 t/ha during the 2022 season. It was then observed that there was a significant increase in the number of fruits during both seasons with the increase in poultry manure rates applied up to application of 4 t/ha. NPK 20-10-10 fertilizer application rate of 300kg/ha resulted in the highest significant days to 50% flowering and the number of fruits per plant.

The results of calyx weight per plant and calyx yield per hectare are presented in Table 4. An increase in poultry manure rate from 0 to 6 tonnes per hectare resulted to significant increase in calyx weight/plant in both seasons and calyx yield/ha during the 2022 season, while calyx yield/ha during the 2021 season and the combined years shows a significant increase up to application of 4 t/ha. Notably, an increase in NPK 20-10-10 application rate to 300 kg/ha resulted in the significantly highest calyx weight/plant during both seasons and the significantly highest calyx yield/ha during both years and the two years combined.

Table 4: Effect of poultry manure and NPK 20-10-10 fertilizer on calyx weight/plant and total calyx yield/ha of roselle during the 2021 and 2022 rainy seasons

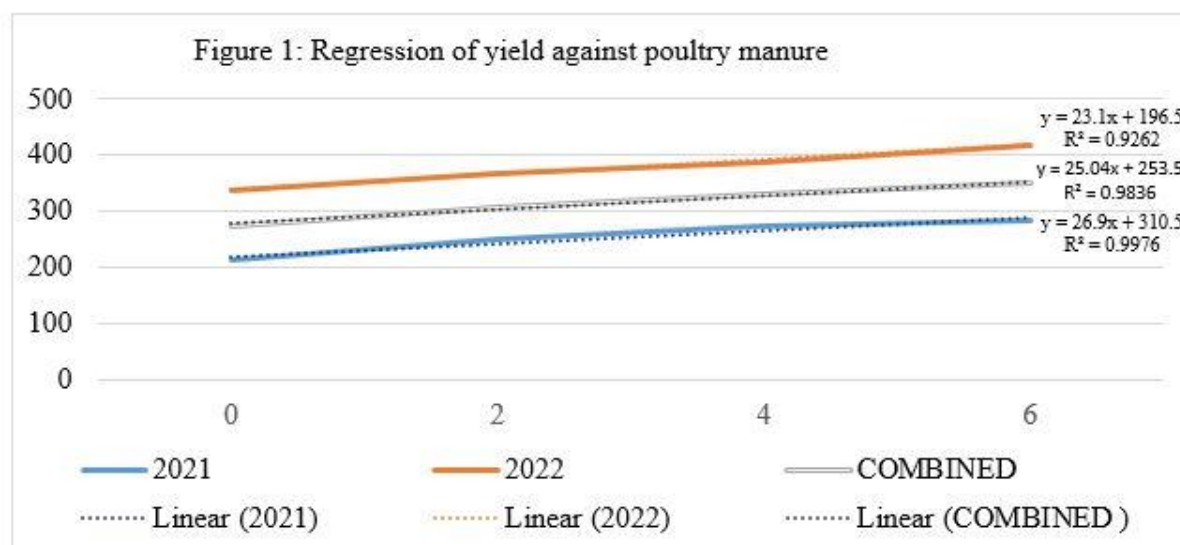
Treatment	Calyx/per plant (g)		Calyx yield/ha (kg)		
	2021	2022	2021	2022	Combined
Poultry manure (t ha⁻¹)					
0	6.2c	10.0c	212.4c	336.7c	274.6c
2	7.3b	10.9b	250.8b	366.2bc	308.5b
4	7.8b	11.3b	272.1a	389.0b	330.6ab
6	8.4a	12.2a	282.3a	419.1a	350.7a
SE _±	0.18	0.21	6.04	10.33	8.19
NPK 20-10-10 (kg ha⁻¹)					
0	4.1d	7.0d	143.4d	205.4d	174.4d
300	11.5a	14.5a	386.6a	514.6a	450.6a
600	8.1b	12.6b	282.5b	445.5b	364b
900	6.0c	10.3c	205.0c	345.5c	275.3c
SE _±	0.18	0.21	6.04	10.33	8.19
Interaction					
F×PM	NS	NS	NS	NS	NS

Means followed by same letter(s) in the same treatment column are not different statistically at $P \leq 0.05$ level of probability using DMRT

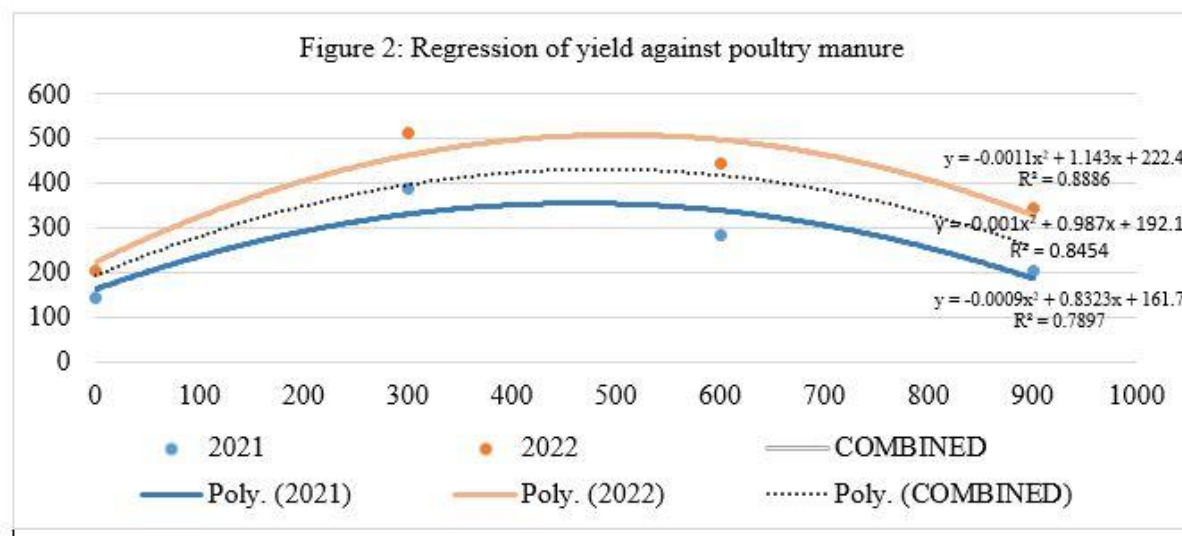
WAS = Weeks after sowing

** = Significant interaction

The result of the dried calyx yield regressed against poultry manure application rates is presented in Figure 1. It indicated a linear response for the 2021, 2022 wet season, and the two years combined.



The result of the dried calyx yield regressed against poultry manure application rates is presented in Figure 2. The result indicated a quadratic response for the 2021, 2022 wet season, and the two years combined.



DISCUSSION

Effect of Poultry Manure

It is noteworthy that an increase in the application of poultry manure consistently led to a significant improvement in growth and yield parameters throughout the experiment. Notably, poultry manure rates of 4 tonnes and 6 t/ha exhibited similar effects during the 2021 season, resulting in a significant increase in leaf area index, and the number of fruits per plant. In contrast, during the 2022 season, increase in these rates significantly boosted total calyx yield/ha. These results align with the findings of Hinjari *et al.*, (2021) and Luka *et al.*, (2021) which emphasized the substantial positive impact of poultry manure on Musk melon and Onion. It could be noted that the poultry manure application of 6 t/ha led to a substantial increase in calyx weight/plant in both the 2021 and 2022 seasons, as well as total calyx yield/ha in the 2022 season. Also, regression of poultry manure against yield showed a linear response which means the optimum was not achieved in this research. This is consistent with the findings of Anyinkeng and Mih in 2011 that reported application of up to 20 tonnes to significantly increased growth, biomass, and economic yield of Roselle. The improvement in the crop's performance with addition of poultry manure could be adduced to the capacity of the manure to enhance soil fertility and organic matter content. In addition, poultry manure improves soil properties such as aeration, water retention capacity, etc., which in turn supports robust growth and consequently higher yield.

Effect of NPK 20-10-10 Fertilizer

Generally, this research showed that 300kg/ha of NPK 20-10-10 fertilizer improved growth and yield parameters such as leaf area index, days to 50% flowering, number of fruits per plant, calyx/per plant, and calyx yield/ha. This is in line with Musa *et al.*, 2024 that reported 60kg nitrogen/ha significantly increased total dry matter yield and height.

The positive and significant response of the crop to NPK 20-10-10 could be attributed to the ability of the fertilizer to increase crop growth, improve photosynthetic efficiency and subsequently higher assimilate production which was ultimately translated into higher yield. Application of 150kg NPK 20-10-10 as recommended by Sa'id *et al.*, (2015) also falls within the range of 0-300 kg/ha of this experiment.

Regression Analysis of Roselle Yield

Regression analysis of poultry manure against the yield for the 2021 season, 2022 season, and both years combined showed a linear response. It indicates that an increase in poultry manure rate from 0-6 tonnes per hectare of poultry manure directly increases the yield of roselle calyx.

Regression analysis was carried out on NPK 20-10-10 against calyx yield of roselle for the 2021 season, 2022 season, and both years combined showed a quadratic response. An increase in NPK 20-10-10 rates increased calyx yield, reaching a maximum of 493.5 kg/ha with a maximum calyx yield of 679.18 kg/ha, and the yield started to decline with an increase in NPK 20-10-10 thereafter.

CONCLUSION

Regression analysis of poultry manure against calyx yield showed a linear increase of yield from application of 0 to 6 t/ha. While the regression of combined yield showed that the maximum rate of NPK 20-10-10 at the rate of 493.5kg/ha (98.70:49.35:49.35 N:P₂O₅:K₂O kg/ha) resulted in a maximum calyx yield of 679.18 kg/ha. Hence, it was concluded that a poultry manure rate of up to 6 t/ha was not optimum for roselle production. While NPK 20-10-10 fertilizer rate of 493.5 kg/ha gave the maximum yield attained in the study.

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REFERENCES

- Akanbi, W.B., Olaniyan, A.B., Togun, O.A., Ilupeju, A.E.O., and Olaniran, O.A., Akanbi, W.B. (2009). The Effect of organic and inorganic fertilizer on growth, calyx yield and quality of Roselle (*Hibiscus sabdariffa* L.). *American-Eurasian Journal of Sustainable Agriculture*, 3(4): 652-657.
- Aliyu, L. and Adekpe, D.I. (2022). Effect of stand density and intra-row spacing on the growth and yield of Roselle (*Hibiscus sabdariffa* L.) at Samaru. Terminal report on sub-project EIII/2/3 submitted to the Artemisia Research Programme, I.A.R., A.B.U., March 2022. pp.10.
- Anyinkeng, N. and Mih, A. M. (2011). Soil nutrient supplementation on growth and biomass production of Roselle under tropical conditions. *Agriculture and Biology Journal of North America*. 2011.2.4.603.609.
- Bekeko, Z. (2014). Effect of enriched farmyard manure and inorganic fertilizers on grain yield and harvest index of hybrid maize (bh-140) at Chiro, eastern Ethiopia. *African Journal of Agriculture Research*, 9(7):663-669.
- El-Dissoky, R.A., Attia, A.M., and Awad, A.M. (2020). Managing Roselle Plant (*Hibiscus sabdariffa* L.) Requirements of fertilizers and irrigation grown under Upper Egypt conditions. *Journal of Soil Sciences and Agricultural Engineering, Mansoura Univ.*, Vol 11 (12):693 - 700, 2020.
- Evan, A.H., Ali, S.A., Hussam, F.N., and Dalai, T.A. (2021). *IOP Conference Series: Earth Environmental Science*. 735(2021)012052.
- Gashua, A.G., Alhassan, I., Bello, T.T., Gwio-kura, K.K., and Peter, S. (2022). Influence of organic manure, variety and intra row spacing on dry calyx yield and nutrients uptake of Roselle in Yobe State, Nigeria. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*. 15(4):1:28-33.
- Haruna, I.M., Ibrahim, H.Y., and Rahman, S.A. (2011). The yield and profitability of roselle (*Hibiscus sabdariffa* L.) at varying Poultry manure and nitrogen fertilizer rates in the Southern Guinea Savanna of Nigeria. *Journal of Agricultural Technology*. 7(3):605-609.
- Hinjari, A.D., Oteri, F.E., Ibrahim, U., and Sani, I. (2021). Fruit quality of Musk Melon as influenced by poultry manure and intra-row spacing. In Orisajo *et al.* (eds). Proceedings of the 39th Annual Conference of HORTSON. CRIN, Ibadan, Nigeria 14th – 18th Nov 2021. Pg 1070 – 1073.
- Isah, A.S., Yakubu, A.A., Maiyaki, M.M., and Mahmud, A.Y. (2023). Optimizing Tomato (*Solanum lycopersicum*, L.) growth, yield, and soil quality with inorganic and farm yard manure in Sudan Savannah of Nigeria. *Journal of Agriculture and Environment* 19(2):105-112.
- Luka, G.L. and Arunah, U.L. (2021). Growth and yield response of cucumber to organic manures in Samaru, Northern Guinea Savanna of Nigeria. *Journal of Agriculture and Environment*. 17(1):125-131.
- Luka, G.L., Ibrahim, U., and Robo, M (2023). Performace of Amaranthus (*Amaranthus cruentus*) as influenced by NPK fertilizer and organic liquid fertilizer at Samaru, Northern Guinea Savanna of Nigeria. *FUDMA Journal of Science*. 7(4):175-181.
- Luka, G.L., Kundimi, B. and Ibrahim, U. (2021). Productivity of Onion (*Allium cepa* L.) as influenced by poultry manure application and intra-row spacing at Samaru. In Orisojo, S.B. *et al.* (eds). Proceedings of the 39th Annual Conference of HORTSON. CRIN, Ibadan, Nigeria 14th-18th Nov. 2021. pp. 1074-1076.
- Maunde, S.M. (2011). Growth and Yield of Roselle (*Hibiscus sabdariffa* L.) as influenced by Nitrogen, Phosphorus and Farmyard manure. Ph.D. Dissertation, Department of Agronomy, A.B.U Zaria.

- Mera, U. M., Singh, B. R., Magaji, M. D., Singh, A., Musa, M., and Kilgori, M. J. S. (2009). Response of Roselle (*Hibiscus sabdariffa* L.) to Farmyard Manure and Nitrogen-fertilizer in the semi-arid savanna of Nigeria. *Nigerian Journal of Basic and Applied Science* (2009), 17(2):246-251.
- Musa, L., Ahmed, A., Pop, G., (2024). Influence of NPK fertilizer on yield of Roselle (*Hibiscus sabdariffa* L.) in the savanna ecology of Nigeria. *Research Journal of Agricultural Science*. 56 (3), 2024.
- Sa'id, A., Rabo, B.S., Mustapha, A.B., Simon, S.Y., and Hamma, I.L. (2015). Influence of NPK fertilizer on the performance of roselle (*Hibiscus Sabdariffa* (L.) in Samaru, Zaria. *Nigerian Journal of Agriculture, Food and Environment*. 11(3):61-64.
- Yahaya, R.A., Aliyu, L., Odion, E.C., and Babaji, B.A. (2023). Effects of sheep manure, plant manure, plant population and nitrogen levels on growth and fresh fruit yield of chilli pepper (*Capsicum frutescens* L.) at Samaru, Zaria, Nigeria. *Journal of Agriculture and Environment*. 19(2):113-123.