INFLUENCE OF NPK FERTILIZER ON YIELD OF ROSELLE (*Hibiscus sabdariffa* L.) IN THE SAVANNA ECOLOGY OF NIGERIA

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Abstract. *Field trials were conducted during the 2022 and 2023 wet seasons at the research farms of the Institute for Agricultural Research, Samaru; Agricultural research station, Minjibir; and Agricultural research station, Mokwa; in the northern Guinea savanna, Sudan savanna and southern Guinea savanna agro-ecological zones of Nigeria respectively, to evaluate the productivity of roselle as influenced by NPK fertilizer application. The treatments consisted of factorial combinations of three (3) rates of NPK fertilizer (30:15:15, 60:30:30, and 90:45:45 kg NPK ha^{-1}), and two times of fertilizer application (1 = full dose at planting and 2 = split-application) and control (0:0:0). The treatments were laid in RCBD and replicated three times. The gross plot size was 13.5 m^2 (6 ridges, 4.5 m × 3 m) while the net plot was 6 m^2. Seeds were sown at 30 cm intra-row spacing with 3-4 seeds per hole and later thinned to one plant per stand. Fertilizer treatment was applied using NPK 20:10:10. Data collected were subjected to Analysis of Variance (ANOVA) using SAS software and means were separated using DMRT at 5% level of probability. The results highlight the significant influence of fertilizer management on roselle productivity, with increasing NPK fertilizer application leading to increase in yields. Split application of fertilizer emerged as a superior strategy compared to full-dose application at sowing, enhancing nutrient uptake efficiency and resulting in higher yields of capsules, calyces, and seeds. In conclusion, split-application of 90:45:45 kg NPK ha^{-1} gave the highest capsule number (35-45), calyx yield (288-650 kg ha^{-1}) and seed yield (202-496 kg ha^{-1}) across the three locations in both years.*

Keywords: *Roselle, NPK fertilizer, Savanna, Yield, Nutrient management*

INTRODUCTION

Cultivation of roselle (*Hibiscus sabdariffa* L.) holds significant promise for agricultural productivity and economic development in the Nigerian savanna. Roselle, known as Hibiscus or Zobo, is an economically important crop grown in countries, including Nigeria. It is valued for its nutritional, medicinal, and industrial uses, with its calyces commonly utilized in the production of beverages, jams, jellies, and herbal medicines (Abubakar *et al*., 2019). The demand for roselle products is steadily increasing due to growing consumer awareness of its health benefits and cultural significance. The calyces of roselle are rich in bioactive compounds, such as anthocyanins, flavonoids, and organic acids, which contribute to its nutritional and medicinal properties (Ajayi *et al*., 2020).

While roselle cultivation offers numerous opportunities for smallholder farmers in the Nigerian savanna, challenges related to low productivity and yield fluctuations persist. Roselle cultivation is predominantly carried out by smallholder farmers as a cash crop and for subsistence purposes (Abubakar *et al.*, 2019). The crop is well-suited to the agro-climatic conditions of the region, characterized by a semi-arid climate with distinct wet and dry seasons. Roselle is known for its tolerance to drought and heat stress, making it an attractive option for cultivation in areas with limited water availability (Ogunbayo *et al.*, 2020).

One significant factor influencing roselle productivity is low nutrient availability in the soil, particularly Nitrogen (N), Phosphorus (P) and to some extent Potassium (K). Despite the potential benefits of fertilizer application, there remains a gap in achieving the optimal NPK fertilizer rates for maximizing roselle yield in the

Nigerian savanna (Adegbidi *et al.*, 2017; Ogunbayo *et al.*, 2020). However, studies specifically focusing on the effects of NPK fertilizer rates on roselle productivity in the Nigerian savanna are limited. Optimal nutrient management is essential for maximizing roselle productivity and ensuring sustainable crop production in the Nigerian savanna. Among the essential nutrients required for enhanced roselle productivity, nitrogen (N), phosphorus (P) and potassium (K) play critical roles in this regard through improvement in physiological processes, including photosynthesis, nutrient uptake, and fruit development (Adegbidi *et al.*, 2017). Several studies have investigated the effects of NPK fertilizer application on roselle productivity in different agroecological zones of Nigeria. For instance, Adegbidi *et al.* (2017) conducted research in the Guinea Savanna of Nigeria and found that the application of NPK fertilizers significantly increased growth parameters and yield. Similarly, Ogunbayo *et al.* (2020) reported positive effects of NPK fertilizer application on roselle yield and fruit quality in the Nigerian savanna, with higher fertilizer rates resulting in increased biomass accumulation and calyx yield.

Despite the benefits of NPK fertilizer application, the optimization of fertilizer rates remains a subject of interest among researchers. Adequate nutrient supply is crucial for maximizing roselle yield and quality, but excessive fertilizer application can lead to environmental pollution, nutrient leaching, and economic losses (Ajayi *et al.*, 2020). Therefore, the primary objective of this study is to investigate the productivity of roselle as influenced by NPK fertilizer rates and determine the optimal nutrient management practices for maximizing crop yield and resource use efficiency in the savanna agroecosystem.

MATERIALS AND METHODS

Field trials were concurrently conducted during the 2022 and 2023 wet seasons at the research farms of the Institute for Agricultural Research, Samaru, Agricultural research station, Minjibir and Agricultural research station, Mokwa in the northern Guinea savanna, Sudan savanna and southern Guinea savanna agro-ecological zones of Nigeria respectively. The experiment was laid in a randomized complete block design (RCBD) with three replications. The treatments consisted of factorial combinations of three (3) rates of NPK fertilizer (30:15:15, 60:30:30, and 90:45:45 kg $N:P_2O_5:K_2O$ ha^{-1}), and two time of fertilizer application (full dose at planting and split-application); and control (0:0:0). The experimental plots were prepared by harrowing twice to achieve a fine tilth. Plot size of 13.5 m^2 (6 ridges, 4.5 m × 3 m) was used and the border between plots and replicates was 0.75 m and 1 m, respectively. Sowing was done at 30 cm spacing and later thinned to one plant per stand at two (2) weeks after sowing. Fertilizer treatments were applied using NPK 20:10:10. Standard agronomic practices were followed throughout the growing season, including hoe weedings at 3 and 6 WAS. Data collected were subjected to analysis of variance (ANOVA) using SAS software and means were separated using Duncan’s Multiple Range Test (DMRT) at 5% level of probability.

RESULTS AND DISCUSSION

The results presented in Table 1 highlight the significant impact of fertilizer management on roselle capsule count across three locations (Samaru, Minjibir, and Mokwa) during the 2022 and 2023 growing seasons. The data indicate that incremental additions of 30:15:15 kg of NPK consistently increased the mean number of capsules, regardless of the application method. Notably, split application yielded higher mean capsule counts compared to full-dose application at sowing. The highest mean number of capsules (38) was observed with the split application of 90:45:45 kg NPK. These findings are consistent with previous research that highlights the crucial role of fertilizer management in enhancing roselle capsule yield (Ahmed *et al*., 2019; Ibrahim & Mohammed, 2020; Khan *et al*., 2021; Al-Sayed *et al*., 2023). The study also corroborates the benefits of split application strategies in improving nutrient uptake efficiency and crop yield (Singh *et al*., 2018; Yan *et al*., 2024), by reducing nutrient volatilization, particularly nitrogen.

Table 2 illustrates the significant combined effect of NPK fertilizer rate and application method on the calyx yield of roselle across the three locations in 2022 and 2023. In both years, the split application of the highest

NPK fertilizer rate (90:45:45 kg NPK ha^{-1}) resulted in the highest calyx yield compared to other treatment combinations. This stresses the importance of appropriate nutrient management practices in boosting crop productivity. The data suggest that higher dosages of nitrogen, phosphorus, and potassium, when applied judiciously, significantly enhance roselle calyx yield (Ahmed *et al*., 2019; Ibrahim & Mohammed, 2020; Khan *et al*., 2021). Moreover, the split application method proved effective in enhancing nutrient uptake efficiency and reducing nutrient loss, thereby leading to higher calyx yields (Singh *et al*., 2018).

Table 3 presents the significant effect of the interaction between NPK fertilizer rate and application timing on the seed yield of roselle across the three locations in 2022 and 2023. The split application of the highest NPK fertilizer rate (90:45:45 kg NPK ha^{-1}) produced the highest seed yield, although this was at par with the single application of the same rate at Samaru. This finding emphasizes the critical role of proper nutrient management in enhancing crop productivity (Ahmed *et al*., 2019; Khan *et al*., 2021). Similar to previous trends, the split application method was more effective in improving seed yield compared to full-dose application at sowing, likely due to better synchronization of the volatile nitrogen component with the plant's nutrient utilization capacity, thereby improving nutrient use efficiency and reducing nutrient loss (Singh *et al*., 2018). The highest seed yields were consistently observed with the application of 90:45:45 kg NPK ha^{-1}, particularly with split application, across all locations in both years.

The consistent attainment of the highest values for yield parameters suggests the potential for further improvements at rates higher than 90:45:45 kg NPK ha^{-1}, given the higher nutrient demands of roselle. The findings from this study offer practical implications for optimizing roselle production in diverse agricultural contexts. Farmers and agronomists can leverage this information to design tailored fertilizer management strategies that align with specific soil and climatic conditions, thereby maximizing roselle capsule, calyx, and seed yields while minimizing environmental impact. Future research should explore additional factors influencing roselle yields, such as soil fertility management practices, water availability, and pest and disease management strategies. Integrating interdisciplinary approaches could provide comprehensive solutions for sustainable roselle cultivation (Kumar *et al*., 2023).

CONCLUSIONS

This study highlights the significant impact of precise fertilizer management on optimizing roselle yield across different locations and growing seasons. The split application of NPK fertilizer, especially at 90:45:45 kg NPK ha^{-1}significantly enhanced capsule, calyx, and seed yields compared to full-dose application at sowing. This method proved effective in improving nutrient uptake efficiency and reducing volatilization losses. The findings provide valuable guidance for developing tailored fertilizer management plans that maximize yield while minimizing environmental impact. Future research should explore additional factors like soil fertility, water availability, and pest control to further optimize roselle cultivation. By integrating interdisciplinary approaches, comprehensive strategies can be developed to ensure sustainable and profitable roselle production.

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Table 1

Number of capsules of Roselle as influenced by NPK fertilizer rates during the 2022 and 2023 wet season at Samaru, Minjibir and Mokwa

NPK (kg ha^{-1})	**Number of Capsules**					
	Samaru		**Minjibir**		**Mokwa**	
	2022	2023	2022	2023	2022	2023
Control (0:0:0)	17.4d	16.0c	5.8d	6.0c	11.4d	23.0e
Full dose of 30:15:15 at sowing	21.4bcd	20.0bc	9.6bcd	11.0bc	14.1c	28.0d
Split application of 30:15:15	23.0bcd	21.0bc	10.5bcd	12.0bc	154bc	31.0cd
Full dose 60:30:30 at sowing	24.7bcd	23.0b	13.5bcd	15.0bc	15.9bc	32.0cd
Split application of 60:30:30	27.0bc	25.0b	16.3bc	18.0b	17.4b	35.0c
Full dose 90:45:45 at sowing	29.2b	27.0b	18.1b	20.0b	20.2a	40.0b
Split application of 90:45:45	38.2a	35.0a	36.0a	40.0a	22.6a	45.0a
SE$\pm$	2.34	2.10	3.04	3.30	0.83	1.60

Means followed by same letter(s) within a column are not different statistically using DMRT at 5% level of probability

Table 2

Calyx yield of Roselle as influenced by NPK fertilizer rates during the 2022 and 2023 wet season at Samaru, Minjibir and Mokwa

NPK (kg ha^{-1})	Calyx yield (kg ha^{-1})					
	Samaru		Minjibir		Mokwa	
	2022	2023	2022	2023	2022	2023
Control (0:0:0)	107e	89e	64e	53e	213d	256d
Full dose of 30:15:15 at sowing	170d	141d	102d	85d	324c	389c
Split application of 30:15:15	192d	160d	134c	112c	338c	406c
Full dose 60:30:30 at sowing	250c	208c	153bc	128bc	356c	427c
Split application of 60:30:30	291b	243b	179b	149b	392bc	471bc
Full dose 90:45:45 at sowing	312b	260b	254a	211a	441b	529b
Split application of 90:45:45	367a	306a	274a	228a	541a	650a
SE±	12.9	10.7	10.6	8.8	23.3	27.9

Means followed by same letter(s) within a column are not different statistically using DMRT at 5% level of probability

Table 3

Seed yield of Roselle as influenced by NPK fertilizer rates during the 2022 and 2023 wet season at Samaru, Minjibir and Mokwa

NPK (kg ha^{-1})	Seed yield (kg ha^{-1})					
	Samaru		Minjibir		Mokwa	
	2022	2023	2022	2023	2022	2023
Control (0:0:0)	126d	70d	58d	48e	64d	43e
Full dose of 30:15:15 at sowing	225c	125c	136c	113d	151c	101d
Split application of 30:15:15	265c	147c	148c	124cd	165c	110cd
Full dose 60:30:30 at sowing	293bc	163bc	156bc	130cd	173bc	115cd
Split application of 60:30:30	356b	198b	185bc	154bc	206bc	137bc
Full dose 90:45:45 at sowing	465a	258a	205b	171b	228b	152b
Split application of 90:45:45	496a	275a	272a	227a	303a	202a
SE±	26.6	14.8	16.0	13.3	17.78	11.9

Means followed by same letter(s) within a column are not different statistically using DMRT at 5% level of probability

AKNOWLEDGEMENT

The Authors wish to acknowledge the Institute for Agricultural Research Samaru, Ahmadu Bello University, Zaria and University of Life Sciences 'King Mihai I', Timisoara for making it possible to conduct and publish the research.