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EFFECT OF NUTRIENT MANAGEMENT ON GROWTH, YIELD AND NUTRIENT UPTAKE IN SORGHUM

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Abstract

A two-year field study was conducted at Agronomy Research Field, BARI, Gazipur, during *rabi* season of 2023-2024 and 2024-2025 to evaluate the effect of nutrient management on the growth, yield and nutrient uptake of sorghum. The experiment was conducted in Randomized Complete Block Design (RCBD) with 3 replications consisting five treatments viz., T_1: 150-75-62.5-33.75-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_2: 120-60-50-27-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_3: 90-45-37.5-20.25-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_4: 60-30-25-13.5-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_5: Control (Native fertility).The unit plot size was 3.6m × 3.6m. BARI Sorghum-1 seeds were sown on 29 November 2023 and 1 December 2024, respectively. Plant spacing was maintained at 60 cm × 10 cm. One third of N and other fertilizer were applied as basal at final land preparation. The rest N was applied at 25 and 50 DAS in equal splits. Data for growth analysis were taken at 35 days after sowing (DAS), 55 DAS, 75 DAS, 95 DAS and 115 DAS in the year of 2023-2024. Chlorophyll content was measured using a SPAD meter (Model SPAD-502, Minolta crop, Ramsey, NJ). The yield component data was taken from randomly selected 10 plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. The collected data were analyzed statistically and means were adjudged by LSD test at 5% level of significance using Statistics 10. The highest SPAD value was observed at 60 DAS which declined gradually reaching the lowest at 90 DAS in all treatments. The highest SPAD values were observed in T_1 treatment (28.1 at 35 DAS to 45.8 at 115 DAS) in the growing season. The results indicated that higher nutrient level showed higher SPAD values. The total dry matter (TDM) accumulation was slower up to 55 DAS then increased rapidly up to 95 DAS and afterwards increased slowly up to harvest. TDM accumulation was higher (1316 g m^{-2}) at harvest in higher dose of fertilizer (T_1) applied. T_1 treatment (150-75-62.5-33.75-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B) produced the highest yield (4.5 t ha^{-1} in 2023–2024 and 3.9 t ha^{-1} in 2024–2025). The 1000-grain weight was also found higher in T_1 (39.5 g in 2023–2024). Nutrient uptake (N-P-K-S-Zn-B) showed a positive correlation with sorghum grain yield. Nutrient concentrations and uptake were influenced by Nutrient levels.

Introduction

In Bangladesh and India, sorghum is commonly known as "jowar". It is grown as a "safe" crop in the global agricultural ecosystem and is used as a staple food and fodder crop (Kale *et al.*, 2023). Sorghum is important food and fodder crop in rabi and kharif season in Bangladesh. Among the different inputs, nutrients play vital role in crop productivity. The inadequate management of nitrogen, phosphorus and potassium is considered a major limiting factor for sorghum grain yield. Generally, farmers of Bangladesh are not using judicious levels of nutrients to the crop, hence not realizing potential yield of crop (Mondal, 2011). The balanced nutrient management, helps to restore and sustain fertility and crop productivity. Effective nutrient management is pivotal for maximizing sorghum yield, quality, and sustainability. By understanding sorghum's nutrient requirements, soil fertility, and implementing appropriate management practices, farmers can enhance productivity while minimizing environmental impact. Continued research and adoption of innovative nutrient management strategies are essential for the sustainable cultivation of sorghum in diverse agricultural landscapes. There is no fertilizer recommendation for sorghum production in Bangladesh. Hence, the experiment was conducted to find out the optimum fertilizer for higher yield of sorghum.

Materials and Methods

Field experiment was conducted at the Agronomy Research Field of BARI, Gazipur during rabi season of 2023-2024 and 2024-2025. The soil of the research area belongs to the Chihata series under AEZ-28. Soils of the experimental plots were collected and analyzed. The physical and chemical properties of initial soil of the experimental plot has been presented in Table1.The soil was clay loam with pH 5.69, OM 1.25% (very low), total N 0.107% (low), exchangeable K 0.092 meq 100g $soil^{-1}$ (low), available P 22.15 g ml^{-1} (optimum), available S 25.63 g g^{-1} (optimum), available Zn 0.513 g g^{-1} (low) and available B 0.235 g g^{-1} (low). The experiment was consisted of five treatments viz., T_1: 150-75-62.5-33.75-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_2: 120-60-50-27-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_3: 90-45-37.5-20.25-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_4: 60-30-25-13.5-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_5: Control (Native fertility). The experiment was laid out in a RCBD with three replications. The unit plot size was 3.6m × 3.6m. BARI $Sorghum^{-1}$ seeds were sown on 29 November 2023 and 01 December 2024, respectively maintaining 60 cm line spacing and 10 cm plant to plant distance. One third N and all other fertilizer were applied as basal during final land preparation and rest N was applied at 25 and 50 DAS in two equal amounts.

Data for growth analysis and chlorophyll were taken in the year 2023-2024 only. In 2024-2025 growing season, growth data was not recorded due to technical problem. Growth analysis data were recorded at 35 DAS, 55 DAS, 75 DAS, 95 DAS and 115 DAS. Chlorophyll content was measured using a SPAD meter (Model SPAD-502, Minolta crop, Ramsey, NJ). The yield component data was taken from 10 randomly selected plants prior to harvest from each plot. At harvest, the yield data was recorded plot wise. Dry matter of crop was recorded at harvesting time. The collected data were analyzed statistically and means were adjudged by LSD test at 5% level of significance using Statistics 10.

Table 1. Initial soil analytical data of the experimental site at Agronomy research field, Gazipur

pH	OC (%)	Total N (%)	Exchangeable K (meq $100g^{-1}$ soil)	Available P (g g^{-1} soil)	Available S (g g^{-1} soil)	Available Zn (g g^{-1} soil)	Available B (g g^{-1} soil)
5.69	1.25	0.107	0.092	22.15	25.63	0.513	0.235
	VL	L	L	O	O	L	L
Critical levels		0.12	0.12	7.0	10.00	0.60	0.20

VL= Very low, L= Low, O= Optimum

Results and Discussion

SPAD value was influenced by fertilizer level (Fig. 1). The leaf greenness which indicated the leaf chlorophyll content was measured by SPAD meter. The highest SPAD value was observed at 60 DAS which declined progressively reaching the lowest at 90 DAS in all treatments. The highest SPAD values were observed in T_1 treatment (from 28.1 at 35 DAS to 45.8 at 115 DAS) all through the growing season. The results indicated that higher nutrient level showed higher values of SPAD. Higher nutrient dose enhanced greenness of leaves. Similar results were reported by Guo *et al.*, 2025 (28.2 to 45.6 SPAD reading) during different stages of sorghum plant.

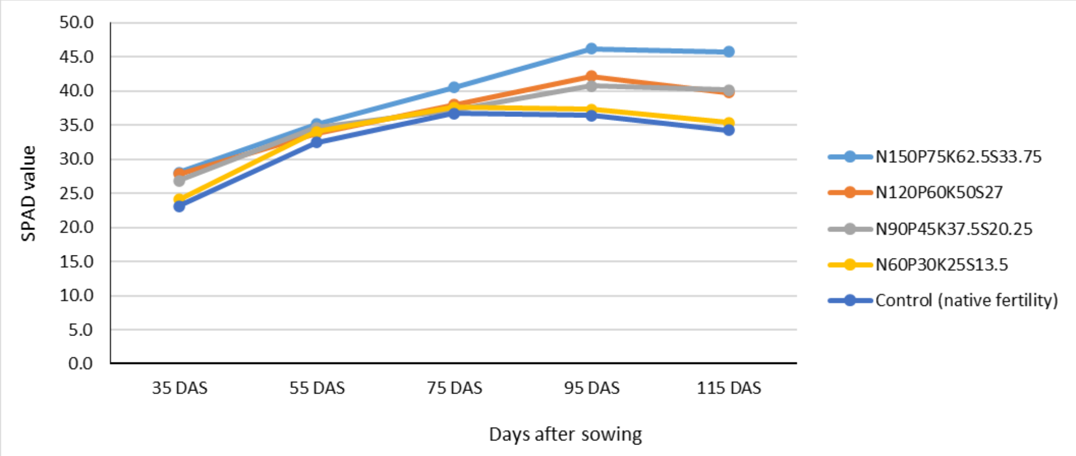

Fig. 1. SPAD value of sorghum at different days after sowing (DAS) as influenced by different nutrient management (2023-2024)

Total dry matter (TDM) accumulation was influenced (Fig. 2) by different treatments. The TDM accumulation rate was slower up to 55 DAS then increased rapidly up to 95 DAS and then increased slowly up to harvest. TDM accumulation was less with native fertility and higher in higher dose of fertilizer (T_1) applied (1316 g m^{-2}) at harvest.

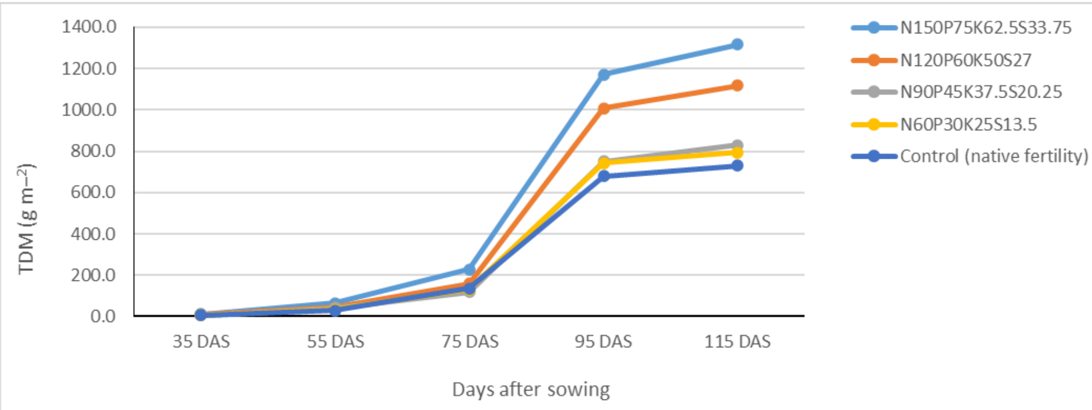

Fig. 2. Total dry matter (TDM) accumulation of sorghum at different days after sowing (DAS) as influenced by nutrient management (2023-2024)

Yield components and yield of sorghum were affected (Table 2) by different nutrient management practices except plant height. Grain yield was significantly influenced by nutrient levels. Among the treatments, T_1 consistently showed superior performance, producing the tallest plants (137 cm), highest plant population (16.4 plants m^{-2} in 2023–2024), and the highest yields (4.5 t ha^{-1} in 2023–2024 and 3.9 t ha^{-1} in 2024-2025). T_2 also performed well, although its yield was slightly lower than T_1 which was statistically similar. But T_3, T_4 and especially T_5 showed a gradual decline across all parameters, with T_5 recording the lowest values in plant height, grain weight, and yield in both years. This result indicates the requirement of balanced fertilizer use for sorghum. A general decline in grain weight and yield was observed across all treatments in 2024–2025, possibly due to environmental factors.

Table 2. Yield components and yield of sorghum as affected by different treatments

Treatments	Plant population (no. m^{-2})		Plant height (cm)		1000-grain weight (g)		Yield (t ha^{-1})	
	2023-2024	2024-2025	2023-2024	2024-2025	2023-2024	2024-2025	2023-2024	2024-2025
T_1	16.4	13.3	137	137	39.5	36.2	4.50	3.94
T_2	12.8	13.3	138	138	39.2	34.7	4.10	3.70
T_3	12.1	13.2	129	133	36.2	34.2	3.50	3.49
T_4	11.6	12.8	128	134	35.3	30.1	3.00	2.80
T_5	11.9	12.5	127	129	32.9	29.4	2.50	2.20
LSD $_{(0.05)}$	1.6	0.4	11.3	7.1	4.3	8.1	0.4	0.6
CV (%)	6.7	1.6	4.6	2.8	6.2	13.1	5.7	10.2

T_1: 150-75-62.5-33.75-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_2: 120-60-50-27-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_3: 90-45-37.5-20.25-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_4: 60-30-25-13.5-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_5: Control (Native fertility)

1000-grain weight showed a clear nutrient response, with the highest values in T_1 and T_2 in both years. It declined sharply in lower nutrient levels, particularly in T_5. Sorghum's response to nutrient management varied significantly across years, with 2023-2024 outperforming 2024-2025 in yields.

Table 3. Dry matter of sorghum as affected by different treatments at harvest

Treatments	2023-2024		2024-2025	
	Grain (t ha^{-1})	Straw (t ha^{-1})	Grain (t ha^{-1})	Straw (t ha^{-1})
T_1	3.96	2.77	3.47	2.51
T_2	3.61	2.68	3.26	2.40
T_3	3.08	2.29	3.07	3.39
T_4	2.64	1.97	2.46	1.98
T_5	2.20	1.68	1.94	1.69

Dry matter of sorghum as affected by different treatments at harvest has been showed in Table 3. Both grain and straw dry matter were produced higher by T_1 treatment in both years. As a result Nutrient uptake by grain (Table 4 and Table 5) and straw (Table 6 and Table 7) was affected by the grain and straw dry matter content.

Table 4. Nutrient uptake in sorghum grain as affected by different treatments in 2023-2024

Treatments	N uptake	K uptake	P uptake	S uptake
T_1	89.50	40.79	12.67	12.28
T_2	66.03	38.61	12.27	11.18
T_3	55.13	33.57	10.78	9.86
T_4	46.46	29.30	9.77	8.45
T_5	35.86	25.30	8.36	7.48

Table 5. Nutrient uptake in sorghum grain as affected by different treatments in 2024-2025

Treatments	N uptake	K uptake	P uptake	S uptake
T_1	76.77	34.99	10.87	10.53
T_2	59.58	34.84	11.07	10.09
T_3	55.45	33.76	10.84	9.91
T_4	43.37	27.35	9.12	7.88
T_5	31.56	22.26	7.36	6.58

Table 6. Nutrient uptake in sorghum straw as affected by different treatments in 2023-2024

Treatments	N uptake	K uptake	P uptake	S uptake
T_1	43.20	27.98	8.59	4.43
T_2	33.84	27.07	8.31	4.29
T_3	28.28	23.36	7.33	3.89
T_4	23.92	20.09	6.30	3.55
T_5	18.89	17.30	5.54	3.19

Table 7. Nutrient uptake in sorghum straw as affected by different treatments in 2024-2025

Treatments	N uptake	K uptake	P uptake	S uptake
T_1	39.14	25.35	7.78	4.02
T_2	30.30	24.24	7.44	3.84
T_3	41.87	34.58	10.85	5.76
T_4	24.05	20.20	6.34	3.56
T_5	19.01	17.41	5.58	3.21

Cost and return analysis of sorghum is showed in Table 8. In both years. T_1 generated the highest gross returns, with Tk. 202500 in 2024 and Tk. 177300 in 2025.

Table 8. Cost and return analysis of sorghum cultivation as influenced by different treatments

Treatments	Gross return (Tk.ha^{-1}) 2024	Gross return (Tk.ha^{-1}) 2025	Total Cost (Tk.ha^{-1}) 2024	Total Cost (Tk.ha^{-1}) 2025	Gross margin (Tk.ha^{-1}) 2024	Gross margin (Tk.ha^{-1}) 2025	BCR 2024	BCR 2025
T_1	202500	177300	84500	85000	118000	92300	2.40	2.09
T_2	184500	166500	80000	80500	104500	86000	2.31	2.07
T_3	157500	157050	75500	76000	82000	81050	2.09	2.07
T_4	135000	126000	71000	71500	64000	54500	1.90	1.76
T_5	112500	99000	62000	62500	50500	36500	1.81	1.58

Sorghum price Tk. 45 kg^{-1} T_1: 150-75-62.5-33.75-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_2: 120-60-50-27-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_3: 90-45-37.5-20.25-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_4: 60-30-25-13.5-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B; T_5: Control (Native fertility)

It also had the highest gross margins—Tk. 118000 in 2024 and Tk. 92300 in 2025 followed by T_2, offering slightly lower gross returns and gross margins, but with reduced costs, resulting in a competitive BCR (2.40 in 2024 and 2.09 in 2025). Notably, all treatments showed a decline in gross returns and gross margins from 2024 to 2025, possibly due to reduced yields.

Conclusion

Balanced and adequate nutrient application significantly enhanced sorghum growth, yield, and seed quality. The treatment T_1 (150-75-62.5-33.75-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B) consistently outperformed others, followed by T_2 (120-60-50-27-2.8-1.4 kg ha^{-1} of N-P-K-S-Zn-B), suggesting that higher nutrient inputs result in superior crop performance. Nutrient management, therefore, is the key for maximizing sorghum productivity, particularly in nutrient-deficient soils.

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