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Growth and nutrient uptake of multicut fodder sorghum (*Sorghum bicolor* (L.) Moench) as influenced by nutrient levels and foliar nutrition

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Abstract
An experiment was performed to evaluate the effect of nutrient levels and foliar nutrition on growth and nutrient uptake of multicut fodder sorghum (*Sorghum bicolor* (L.) Moench). The experiment was undertaken at the Instructional Farm attached to the College of Agriculture, Vellayani, Kerala, from 31 January - 01 July 2025. The field experiment laid out in randomized complete block design with 10 treatments and three replications. The study consisted of (3x3) +1 treatments with two factors and a control. The first factor was source of nutrients (S), which included (s_1: 1% DAP; s_2: 1% KNO_3; s_3: 1% 19:19:19), second factor was levels of nutrients (N), which included (n_1: 50 per cent RDN; n_2: 75 per cent RDN; n_3: 100 per cent RDN) and a control (KAU POP 2024). The results revealed that basal application of FYM at 5 t $ha^{-1,}$ along with soil application of 75% RDN supplemented with foliar spray of 1% DAP at 20 DAS, 40 DAS, and 20 days after the first and second cut, recorded the highest growth and nutrient uptake, such as length of internodes, nitrogen uptake, and phosphorus uptake. Higher stem girth was also recorded by the same treatment, which was on a par with soil application of 75% RDN supplemented with foliar spray of 1% KNO_3 at 20 DAS, 40 DAS, and 20 days after the first and second cut. The study concluded that basal application of FYM 5 t ha^{-1} along with soil application of 75% RDN supplemented with foliar spray of 1% DAP at 20 DAS, 40 DAS, and 20 days after the first and second cut improved growth characters and nutrient uptake.

Keywords: Multicut fodder sorghum, foliar nutrition, Di Ammonium phosphate, potassium nitrate, Recommended dose of nutrients (RDN)

1. Introduction

India sustains about 20% of global livestock and 17.5% of the human population, both expanding annually at 0.66% and 1.6% respectively, thereby intensifying the competition for limited land resources for food and fodder production. Only 4% of the total cultivable land in the country is utilized for cultivated fodder. At the national level, there was an overall deficit of 11.24% in green fodder availability and 23.4% in dry fodder availability. Expanding the land area for fodder cultivation over food and commercial crop cultivation is a challenge. Under these circumstances, the cultivation of livestock feed source from coarse grains plays an important role (Dhamodharan *et al.* 2024) [1]. Among coarse grains, multicut fodder sorghum (*Sorghum bicolor* L. Moench) has emerged as one of the promising fodder crops in tropical and subtropical regions

because of its ability to produce large quantities of biomass with strong tillering ability, good nutritive value, adaptability, drought tolerance, and quick regrowth ability after each harvest (Chaudhary *et al.* 2018) [2].

Even though sorghum is naturally hardy, unbalanced fertilization often limits both its yield and its feed value. Conventional soil-based fertilization is limited by nutrient losses through leaching, fixation, or volatilization, particularly for nitrogen, phosphorus, and potassium, resulting in lower nutrient-use efficiency (Ladha *et al*. 2005) [3]. In multicut systems, successive harvests exhaust nutrient reserves and necessitate rapid nutrient replenishment to sustain regrowth. Under such circumstances, foliar nutrient supplementation serves as an efficient complement to soil fertilization, providing nutrients directly to photosynthetically active tissues and allowing immediate absorption and translocation within the plant canopy, which enables faster nutrient uptake and allows for correcting nutrient deficiencies more quickly than with soil applications (Reena *et al*. 2018) [4].

2. Materials and Methods

The experiment was conducted at the Instructional Farm, College of Agriculture, Vellayani, Kerala, India, during January - July 2025. The soil was sandy clay loam with strongly acid, normal EC, high in phosphorus, medium in organic carbon and nitrogen and low in potassium. The experimental field was geographically located at 8°42 latitude and 76°98 longitude, at an altitude of 29 m above mean sea level. The total rainfall recorded during the cropping period was 138.1 mm, and the mean evaporation noted was 3.48 mm per day. The mean maximum temperature ranged from 33.5 ^{O}C to 29.8 ^{O}C, and RH ranged from 95.9 per cent and 86.4 per cent.

The variety used for the study was multicut fodder sorghum hybrid CSH 24-MF, which was released from GB Pant University of Agriculture and Technology, Pantnagar. It is a tall, 120-150 days duration fodder crop variety with very low HCN content, high protein content, high dry matter digestibility, and resistance to foliar diseases as reported by ICAR-IIMR [5].

The field experiment laid out in randomized complete block design with 10 treatments as (3 X 3) +1, replicated thrice. The treatment comprised two factors: source of nutrients (S) and nutrient levels (N), and one control (C). The treatment combinations included three levels of source of nutrients (s_1: 1% DAP; s_2: 1% KNO_3; s_3: 1% 19:19:19) and levels of nutrients (n_1: 50 per cent RDN; n_2: 75 per cent RDN; n_3: 100 per cent RDN). The control treatment was the Package of Practices Recommendation of Kerala Agricultural University (KAU POP 2024).

The spacing adopted was 30 cm × 15 cm. The fertilizer recommendation followed was 60:40:20 kg NPK ha^{-1} as per KAU POP 2024. Nitrogen was applied in three splits as basal, 25% at 20 DAS and 25% at 40 DAS. Entire phosphorus and potassium were given as basal.1 per cent each of DAP, KNO_3, and 19:19:19 were given through foliar application at 20 DAS, 40 DAS and 20 Days after the first and second cut. All other agronomic practices were followed uniformly in all the treatments as per the Package of Practices Recommendations of Kerala Agricultural University, India (KAU POP 2024). The first harvest was taken at 63 DAS, and subsequent harvests were done at an interval of 45 days. A total of 3 harvests were taken during the cropping period and their means were computed. Nutrient uptake was calculated by multiplying the nutrient content with the dry fodder yield. The data were statistically analyzed using Analysis of Variance (ANOVA), which is appropriate for a randomized complete block design (Panse and Sukhatme, 1985) [6].

3. Results and Discussion

Growth attributes

The data on stem girth revealed that foliar nutrition had significant influence (Table 1). The foliar spray of 1% DAP showed wider stem girth compared to the foliar spray of 1% KNO_3 and 1% 19:19:19. These outcomes are in line with Yerawar (2022) [7]. Plants treated with 75% RDN recorded the highest stem girth (3.34 cm) compared to 100% RDN and 50% RDN. The highest stem girth at 75% RDN can be attributed to the balanced availability of nutrients, which increased the crop's ability to absorb nitrogen and might have improved the process of cell division, expansion, and differentiation, ultimately resulting in the highest growth. Among treatment combinations, s_1n_2 and s_2n_2 were found to be on par. Compared to the control, treatment combinations showed a significant influence. The increased stem girth might be due to enhanced nutrient availability and uptake. This is similar to the findings of Lagad *et al.* (2022) [8].

The number of internodes and the number of leaves per plant were not significantly influenced by either the source of nutrients or nutrient levels as in table 1.

Table 1: Effect of foliar nutrition and nutrient levels on growth attributes.

Treatments	Stem girth (cm)	Number of leaves per plant	Number of internodes	Length of internodes (cm)
Source of nutrients (S) - 3				
s_1: 1% DAP	3.30 ± 0.24^a	5.83 ± 0.44	4.24 ± 0.45	10.91 ± 1.23^a
s_2: 1% KNO_3	3.11 ± 0.34^b	5.70 ± 0.48	4.09 ± 0.39	9.64 ± 1.14^b
s_3: 1% 19:19:19	2.97 ± 0.10^c	5.82 ± 0.29	4.17 ± 0.30	9.88 ± 0.55^b
S.Em (±)	0.03	0.13	0.11	0.12
CD (0.05)	0.09	NS	NS	0.36
Nutrient levels (N) - 3				
n_1: 50% RDN	3.01 ± 0.13^b	5.81 ± 0.37	4.31 ± 0.35^a	9.66 ± 0.38^c
n_2: 75% RDN	3.34 ± 0.27^a	5.84 ± 0.44	4.30 ± 0.32^a	11.03 ± 1.03^a
n_3: 100% RDN	3.02 ± 0.27^b	5.70 ± 0.42	3.89 ± 0.32^b	9.74 ± 1.27^b
S.Em (±)	0.03	0.13	0.11	0.12
CD (0.05)	0.09	NS	0.33	0.36
S x N interaction				
s_1n_1	3.03 ± 0.12^{cd}	5.63 ± 0.58	4.17 ± 0.60	9.60 ± 0.30^{de}
s_1n_2	3.53 ± 0.12^a	6.10 ± 0.17	4.56 ± 0.10	12.3 ± 0^a
s_1n_3	3.33 ± 0.06^b	5.77 ± 0.50	4.00 ± 0.44	10.83 ± 0.71^b
s_2n_1	3.10 ± 0.10^c	5.90 ± 0.17	4.39 ± 0.10	10.07 ± 0.15^{cd}
s_2n_2	3.50 ± 0^a	5.77 ± 0.68	4.28 ± 0.25	10.67 ± 0.21^{bc}
s_2n_3	2.73 ± 0.06^e	5.43 ± 0.51	3.61 ± 0.10	8.20 ± 0.36^f
s_3n_1	2.90 ± 0.10^d	5.90 ± 0.35	4.39 ± 0.26	9.30 ± 0.10^e
s_3n_2	3 ± 0.10^{cd}	5.67 ± 0.35	4.05 ± 0.39	10.13 ± 0.59^{cd}
s_3n_3	3 ± 0.10^{cd}	5.90 ± 0.17	4.06 ± 0.20	10.20 ± 0.35^{cd}
S.Em (±)	0.05	0.23	0.19	0.21
CD (0.05)	0.15	NS	NS	0.62
Control	3.3	6.10	4.33	11.13
Treatment vs Control	S	NS	NS	S

The data on the length of internode revealed that the source of nutrients had a significant effect on the levels of nutrients, as shown in table 1. Plants treated with 1% DAP recorded the longest internode of 10.91 cm, followed by 1% 19:19:19, while the lowest was observed in 1% KNO_3 (9.64 cm). The increase in internode length may be attributed to the rapid absorption of nitrogen and phosphorus through leaf tissues, which might have stimulated cell elongation and division in the internodal meristem and enhanced gibberellin-mediated hormonal activity that promoted internode elongation (Kebrom, 2017) [9]. Among nutrient levels, 75% RDN recorded the highest internode length of 11.03 cm, followed by 100% RDN (9.74 cm). Higher internode length at 75% RDN could be due to optimum nutrient supply ensuring balanced nutrient uptake and utilization, resulting in improved vegetative growth and internode elongation (Sri *et al.* 2023) [10]. Considering the treatment combinations, s_1n_2 recorded the highest internode length of 12.3 cm, followed by s_1n_3 (10.83 cm). The superior performance of s_1n_2 could be due to the synergistic effect of soil and foliar nutrient supply, which ensured continuous nutrient availability during the critical stages of growth. The integrated nutrient approach enhanced nutrient-use efficiency and maintained the hormonal balance required for cell expansion and internode growth (Kushwaha *et al.* 2018) [11]. Compared to control, treatment s_1n_2 showed a significant increase in internode length. The present findings are in accordance with the results of Kebrom (2017) [9] and Sri *et al.* (2023) [10].

Nutrient uptake

Nutrient uptake is essential for providing the necessary elements that support growth, development, and crop productivity by enabling physiological and biochemical functions. Data on nutrient uptake disclosed that the source of nutrients and nutrient levels had significant effect, as shown in table 2. The highest N uptake and higher P uptake were recorded in the foliar spray of 1% DAP. Among nutrient levels, soil application of 75% RDN showed the highest N and P uptake. The treatment combination s_1n_2 recorded the highest N and P uptake, followed by s_2n_2. The treatment combinations exhibited significant differences in comparison with the control. This might be due to adequate root-zone nutrient availability and faster absorption of nitrogen and phosphorus through foliar spray of DAP, which enhanced physiological and biochemical processes. Comparable results of N and P uptake were reported in Kumar *et al.* (2010) [12].

The data on K uptake showed that among sources of nutrients, foliar spray of 1% KNO_3 recorded higher K uptake, which was on a par with foliar spray of 1% DAP. Among nutrient levels, the highest K uptake was recorded in 75% RDN, followed by 100% RDN. Comparison with the control revealed significant difference in treatment combinations, as shown in Figure 1. The increase in K uptake might be due to direct absorption of potassium ions through leaves that bypasses soil limitations; similarly, enzyme activation, osmoregulation, and photosynthetic efficiency drive greater nutrient assimilation and growth. These findings confirm with Blevins *et al.* (1974) [13] and Shahane *et al.* (2018) [14].

Table 2: Effect of foliar nutrition and nutrient levels on nutrient uptake.

Treatments	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Source of nutrients (S) - 3			
s_1: 1% DAP	39.64 ± 10.77^a	9.49 ± 4.31^a	28.82 ± 4.32^{ab}
s_2: 1% KNO_3	32.33 ± 7.96^b	7.86 ± 1.71^{ab}	33.44 ± 9.86^a
s_3: 1% 19:19:19	28.81 ± 5.16^c	6.69 ± 2.18^b	25.25 ± 6.96^b
S.Em (±)	1.15	0.62	1.62
CD (0.05)	3.45	1.87	4.87
Nutrient levels (N) - 3			
n_1: 50% RDN	26.33 ± 4.36^c	6.00 ± 1.55^b	22.50 ± 3.89^c
n_2: 75% RDN	41.05 ± 8.94^a	10.25 ± 3.73^a	35.35 ± 7.84^a
n_3: 100% RDN	33.39 ± 7.33^b	7.80 ± 2.04^b	29.65 ± 5.68^b
S.Em (±)	1.15	0.62	1.62
CD (0.05)	3.45	1.87	4.87
S x N interaction			
s_1n_1	26.53 ± 1.26^{cd}	5.76 ± 1.71^b	24.22 ± 1.87
s_1n_2	50.83 ± 2.06^a	14.92 ± 1.26^a	31.79 ± 4.56
s_1n_3	41.55 ± 2.59^b	7.79 ± 0.59^b	30.45 ± 1.25
s_2n_1	28.35 ± 3.40^{cd}	6.40 ± 0.45^b	23.79 ± 1.94
s_2n_2	41.86 ± 1.53^b	8.59 ± 1.68^b	44.16 ± 4.08
s_2n_3	26.78 ± 5.80^{cd}	8.60 ± 1.96^b	32.42 ± 7.28
s_3n_1	24.11 ± 7.02^d	5.85 ± 2.49^b	19.55 ± 5.8
s_3n_2	30.47 ± 0.81^c	7.23 ± 0.80^b	30.11 ± 5.63
s_3n_3	31.84 ± 2.37^c	7.00 ± 3.25^b	26.08 ± 6.56
S.Em (±)	1.99	1.08	3.98
CD (0.05)	5.97	3.24	NS
Control	41.58	11.31	38.14
Treatment vs Control	S	S	S

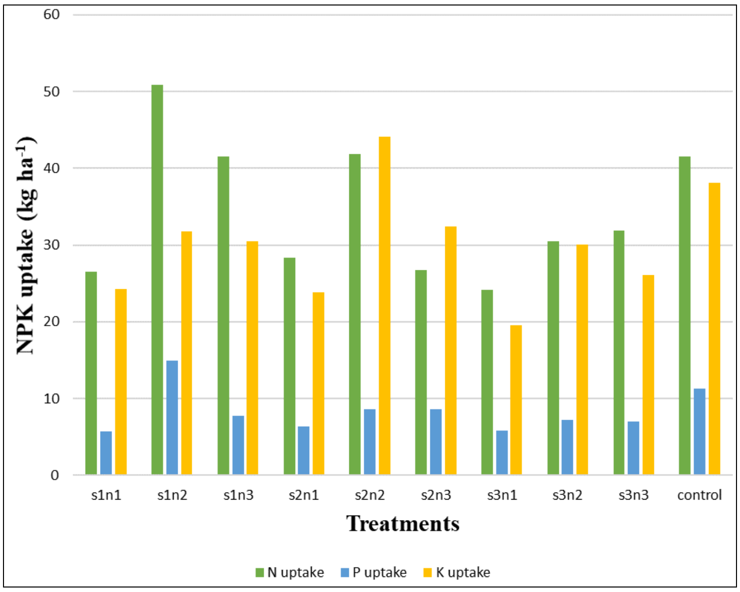

Fig 1: Effect of foliar nutrition and nutrient levels on NPK uptake of multicut fodder sorghum, kg ha^{-1}

4. Conclusion
Based on the study, it can be concluded that basal application of farm yard manure at the rate of 5 t ha^{-1}, in combination with soil application of 75% RDN supplemented with foliar spray of 1% DAP at 20 DAS, 40 DAS, and 20 days after the first and second cut, resulted in improved growth attributes and nutrient uptake.

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