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Response of fodder sorghum yield and nutrient uptake under: Artificial soil fertility gradients

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Abstract
Sorghum the primary feed crop farmed intensively in India. By using inductive methods, a field experiment was carried out to investigate how fodder sorghum (*var.* CO 30) production and nutrient uptake responded to an artificial soil fertility gradient field. (Fertility gradient concept). In 2021, a field trial was carried out in the "Tapioca and Castor Research Station" in Yethapur, Salem district, Tamil Nadu, India ($11^0$35' N, 78^0 29' E). The research area was separated into three parallel strips, with strip I ($N_0P_0K_0$), strip II ($N_1P_1K_1$), and strip III ($N_2P_2K_2$), receiving three graded amounts of fertilizer N, P_2O_5, and K_2O in the forms of urea, SSP, and MOP, respectively. The N1 level was calculated based on the general recommendation of fodder sorghum, and the P1 and K1 values were established based on the soil's fixing capacity to fix P (100 kg/ha) and K (80 kg/ha) respectively. Sorghum var. CO 30 was cultivated as a gradient crop, and fodder production were estimated. Samples of plants were collected during the time of harvest, and the concentrations of nitrogen (N), phosphorus (P), and potassium (K) were assessed. Additionally, an estimation was made about the uptake of nitrogen, phosphorus, and potassium. The results indicated that the utilization of varying quantities of major nutrient fertilizers (NPK) had a significant influence on the fertility of the soil, the intake of NPK, as well as the production of sorghum fooder.

Keywords: Fodder sorghum, artificial gradient, fodder yield and uptake

Introduction
Fertilizers are essential, essential elements of current agriculture that boost plant growth and output. Fertilizers are thought to be a crucial to the development of fodder crops because they play a role to make the soil become more fertile, which encourages growth. (Tariq *et al*., 2007) [30]. The AICRP-STCR Correlation studies implemented a novel field experimental approach known as the inductive methodology. This approach involved creating a microcosm of a field experiment by manipulating soil fertility levels using graded doses of fertilizer, as outlined by Ramamoorthy *et al*. (1967) [21]. The aforementioned statement establishes the fundamental basis for the implementation of “Soil Test Crop Response” (STCR) research. These studies aim to make fertiliser prescription equations and adjustment sheets that facilitate the accurate recommendation of fertilisers by utilizing soil testing methods. The ultimate goal is to attain targeted crop yields, as outlined by Singh and Biswas (2010).

As a significant grain and fodder crop, sorghum plays a significant role among the cereals in India. The plant's robust ability to withstand many stressors has led to its widespread cultivation as a significant fodder source, often preferred over maize during the kharif season. According to Sumeriya and Singh (2014) [29], this particular crop is considered an exceptional choice for fodder production due to its noteworthy characteristics. These include its ability to tiller rapidly and abundantly, its high dry matter content, its leafiness, its high palatable qualities, as well as its robustness and versatility. In India, forage sorghum is cultivated on roughly 2.5 million acres. Following rice, wheat, and maize, this crop holds the fourth position in terms of significance among cereal crops in India. According to Dwivedi *et al.* (2001) [12], sorghum has a comprehensive capacity to extract nutrients from the soil, which can be attributed to its exhaustive nature. Additionally, the bigger biomass output of sorghum contributes to an enhanced major nutrients uptake. The objective of this study was to determine the impact of artificial fertility gradient tactics on fodder sorghum production, nutrient uptake by sorghum and soil fertility.

Materials and Methods

The study employed a approach referred to as the "Inductive cum Targeted yield model" as described by Ramamoorthy *et al*. (1967) [21], which delivers an empirical foundation for achieving optimal fertilization by effectively balancing the nutrients from both external sources and those naturally present in the soil. The intentional manipulation of soil fertility levels was undertaken to generate a comprehensive dataset that encompasses a diverse range of fertilizer doses for each controllable element, while accounting for varying levels of an uncontrolled variable, namely soil fertility. This approach was implemented to account for the inherent variability in soil fertility that would not typically be expected to occur uniformly at a single location. Hence, to mitigate the diversity in the soil population under investigation, the selected management practices, and the prevailing climate circumstances, an experimental study was conducted in the field. The objective was to produce changes in fertility within the same field by implementing a gradient crop. Based on the preceding information, the current study was carried out to investigate the properties of an simulated soil fertility gradient technique on sorghum fodder production, sorghum plant nutrient uptake, and soil fertility. A field investigation was carried out in the year 2020, utilizing the sorghum crop (variety CO 30) which act as nutrient exhaustive crop to make the applied fertilizer in soil to undergo nutrient transformation. The research was carried out in TCRS Yethapur and the study location had an elevation of 282 meters above MSL and was situated at coordinates 11°35' N latitude and 78°29' E longitude. The study area was divided into three comparable sections, namely strip I- N0P0K0, strip II - $N_1P_1K_1$, and strip III - $N_2P_2K_2$. Each strip was subjected to three different amounts of fertilizer application, specifically major nutrient (NPK), in the form of urea, single superphosphate (SSP), and muriate of potash (MOP), respectively. The determination of the standard dosage of P_2O_5 and K_2O fertilizer was based on the soil's capacity to retain and utilize phosphorus and potassium. Similarly, the standard dosage of nitrogen (N) was determined based on the recommended guidelines for sorghum cultivation (Table 1). The generally recommended application rate of nitrogen fertilizer for fodder sorghum is 90 kg per hectare. In experimental treatments II and III, a baseline application of 50% N and 100% P and K was applied. The remaining 50% nitrogen (N) was applied 30 DAS.

Pre and post soil sample were collected from the each strips and collected samples were subsequently subjected to air drying, sieving through a 2 mm sieve, and analysis for the soil available nitrogen, available phosphorus (Olsen *et al*., 1954) [19], and available potassium (Hanway and Heidal, 1952) [15]. At the time of harvest, plant samples were collected from each strip and the samples were subsequently processed and analyzed for their respective levels of total Nitrogen, Phosphorus (Piper, 1966), and Potassium (Piper, 1966). Furthermore, the N, P, and K uptake by fodder sorghum were determined by multiply the nutrient content percentage in plant *viz* total dry matter. On the 60th day, the gradient crop was collected for the purpose of fodder, and a systematic assessment of the yield of green fodder was conducted on a strip-by-strip basis.

Table 1: Fertiliser doses applied to the gradient crop of fodder sorghum

Levels of Nutrients	Strip			Fertiliser doses (kg ha^{-1})		
	I	II	II	I	II	II
N	N_0	N_1#	N_2	0	90	180
P_2O_5	P_0	P_1##	P_2	0	229	458
K_2O	K_0	K_1##	K_2	0	97	194

N_1: As per blanket recommendation; ## P_1 and K_1: As per P and K fixing capacities of the experimental field

Results and Discussions

Soil properties

The soil used in the experiment had a texture classified as red sandy clay loam. It was found to be non-calcareous, with a CEC of 22.7 cmol (p^+) kg^{-1}. Additionally, the soil was determined to be non-saline, with an EC of 0.32 dS m^{-1}, and had a pH value of 7.52, indicating neutrality. The initial experimental soil contained 0.61 g kg^{-1} of OC, low status of available nitrogen (210 kg ha^{-1}), medium status of available P (16.3 kg ha^{-1}), and 245 kg ha^{-1} of soil available potassium, respectively. The levels of cationic micronutrients *viz*., iron (Fe), copper (Cu), zinc (Zn), and manganese (Mn) in the experimental soil were found to be within the sufficient ranges as determined by the DTPA extraction method.

Pre-sowing soil available nutrients

Before sowing the fodder sorghum (exhaustive crop), soil sample were taken to analysis the soil available NPK status. The mean values for corresponding strips were 202, 205, and 202 kg ha^{-1} for $KMnO_4$-N, respectively, which exhibiting a range of 202 to 205 kg ha^{-1} (Table 2). The Olsen-P levels exhibited a range of 14.4 to 15.2 kg ha^{-1}, corresponding strips average values of 14.6, 14.4, and 15.2 kg ha^{-1}, respectively. The mean values for strips I, II, and III were 232, 230, and 228 kg ha^{-1} for NH_4OAc-K.

Table 2: The impact of applying varying levels of nitrogen (N), phosphorus (P_2O_5), and potassium (K_2O) on the fertility of soil in a gradient experiment

Strip	Fertiliser doses (kg ha^{-1})			Pre-sowing soil test values			Post-harvest soil test values		
	N	P_2O_5	K_2O	$KMnO_4$-N	Olsen-P	NH_4OAc-K	$KMnO_4$-N	Olsen-P	NH_4OAc-K
				(kg ha^{-1})			(kg ha^{-1})		
I	0	0	0	202	14.6	232	176	10.6	214
II	90	229	97	205	14.4	230	203	17.8	239
III	180	458	194	202	15.2	228	220	24.3	253
SEd							3.7	0.5	4.6
CD (P= 0.05)							10.4	1.4	12.8

Green fodder yield

Experimental result revealed that application of higher dose of major fertilizer NPK significantly increased the sorghum fodder yield (Table 3). There were a significant relation between the major nutrient applied and the green fodder yield. In strip I, where no application of fertilizers (N0P0K0), the sorghum fodder crop yielded 15.21 t ha^{-1}. The increase in fodder production in strip II, which exhibited a 51.4% higher yield compared to strip I, was accomplished by implementing a 90 kg ha^{-1} nitrogen application rate, adhering to the standard recommendation. Additionally, phosphorus and potassium fertilizers were applied as per the soil fixing capacity of respective. The crop yield in strip III, where the amount of major nuitrient applied as twice as much as in strip II, amounted to 28.60 t ha^{-1}. This represents an increase of 88.1% and 24.1% compared to the yields in strips I and II, respectively. The potential reason for this outcome could be attributed to the utilization of proportionally adjusted quantities of fertilizer, which enhanced the absorption of nutrients and promoted growth indicators such as plant height. Consequently, these factors collectively contributed to higher yield of fodder sorghum. Udayakumar *et al.* (2017) [34] result revealed that the implementation of varying levels of fertilizers on a gradient sorghum crop led to enhanced growth and fodder yield in strip III in comparison to strip I. According to the findings of Marsalis *et al.* (2010) [16], it was demonstrated that positive impact on the production of sorghum fodder by application of nitrogen fertilizer. The present study's findings exhibit a high degree of similarity with the research conducted by Singh (2014) [33], Chotiya (2005) [9] and Singh (2007) [24] in the context of sorghum. The observed increase in green fodder output can be attributed to the enhanced nutrient availability in the soil resulting from the use of fertilizers, as well as the micro-organism involved in nutrient transformation. Rashid and Iqbal (2012) [22] reported comparable findings for fodder sorghum, whereas Alias *et al.* (2003) [2] saw similar outcomes in their study on fodder maize. According to the findings of Meena *et al.* (2012) [17], it was also determined that the improvement of sorghum fodder can be achieved by elevating the nitrogen application rate from 40 to 120 kg ha^{-1}.

Table 3: The impact of the application of varying quantities of NPK on the sorghum fodder production and nutrient uptake

Strip	Fertiliser doses (kg ha^{-1})			Green fodder yield (t ha^{-1})	Nutrient uptake (kg ha^{-1})		
	N	P_2O_5	K_2O		N	P	K
I	0	0	0	15.21	38.1	9.9	37.2
II	90	229	97	23.05	55.3	14.4	54.2
III	180	458	194	28.60	71.5	18.8	70.0
SEd				0.6	1.3	0.19	0.7
CD (P= 0.05)				1.7	3.5	0.5	2.1

Nutrient uptake

Data presented in the Table 3 exposes that there is gradual increase in uptake of nitrogen by plant in strip III compared to strip I with mean values of 38.1, 55.3, and 71.53 kg ha^{-1}, respectively. N uptake increased by 29.3 percent in strips III compared to strips I, 87.7 percent increase over Strip I, respectively, and in strip II there was 45.1 percent higher uptake comparing Strip I. The mean phosphorus uptake was were 9.9, 14.4, and 18.8 kg/ha respectively in corresponding strips showing significantly the available phosphorus status due to graded dose of fertilizer application. The potassium uptake in each strip were 37.2, 54.2 and 70.0 kg ha^{-1}. The percent increase in uptake of P and K in strip III over strip II and strip I were 30.6 and 89.9, 29.2 and 81.2, respectively. Similarly the percent increase in the uptake of P and K in strip II over strip I was 45.5 and 45.7, respectively. This could be as a result of the yield and uptake having a linear relationship. The present study demonstrates the utilization of varying concentrations of major nutrient (NPK) fertilizers, which resulted in a substantial increase in nutrient uptake by fodder sorghum, as compared to the control group. In a study conducted by Reddy and Bhanumurthy (2010), it was revealed that the nitrogen uptake by fodder maize was higher in the higher fertilizer treated plot and the similar result were reported by Siam *et al.* (2008) [23]. Similar research result was reported by Bhoya *et al.* (2013) in fodder sorghum, Singh *et al.* (2015) [25] in rice crop. Higher levels of phosphorus treatment, which would have resulted in more root multiplication of the crop, were the cause of the considerable increase in P uptake (Verma *et al.*, 2015) [35]. These outcomes closely match those in sorghum reported by Singh (2014) [33] and Sonune *et al.* (2010) [26].

Post - harvest soil available nutrients

The soil samples were collected from sorghum field after harvest and the soil nutrient status were estimated to understand the influence of fertilizer application in graded dose for development of artificial fertility gradient. Table 2 present the available status of nutrient in soil with range and mean data. The soil available status of available N in strips I, II and III were were 176, 203 and 220 kg ha^{-1} respectively. Available status of Phosphorus in strips I, II and III were 10.6, 17.8, 24.3 kg ha^{-1} respectively. Available potassium status in in strip I were 214 kg ha^{-1}, strip II (239 kg ha^{-1}) and in strip III (253 kg ha^{-1}). Result data reveals that there was soil available N, P and K status were increased significantly in strip III comparing Strip II and Strip I indicating the creation of artificial fertility gradient due to application of graded level of fertilizer. The post-harvest soil test data were statistically analyzed, and the results revealed that the soil nutrient status varied significantly between three strips.

Conclusion

In summary, the experimental outcome of the aforementioned study reveals that varying levels of application of major nutrient fertilizers (NPK) to the experimental field resulted in the establishment of an artificial gradient in soil fertility. The fodder crop grow in the above mentioned gradient field significantly influenced the sorghum growth, fodder production, nutrient uptake and the soil nutrient status.

References

1. Agarwal SB, Shukla VK, Sisodia HPS, Ranji Tomar, Arti Shrivastava. Effect of inoculation and nitrogen levels on growth, yield and quality of fodder sorghum [*Sorghum bicolor* (L.) Moench] varieties, Forage Res. 2005;31:106-108.
2. Alias A, Usman M, Ullah E, Waraich EA. Effects of different Phosphorus levels on the growth and yield of two cultivars of maize (*Zea mays* L.). Int. J Agric. and Biol. 2003;5(4):632-634.
3. Amandeep S. Forage quality of sorghum (Sorghum bicolor) as influenced by irrigation, N levels and harvesting stage, Indian J Sci. Res. 2012;3(2):67-72. and

consequences for the metabolism of cyanogenic glucosides. In A Esen, ed, b-Glucosidases. Biochem. Mol. Biol., ACS Symp. Ser.,
4. Amer AI, Kewan KZ. Effect of NP fertilization levels on sorghum (*Sorghum bicolor* L.) yield and fodder quality for animals. Alex. J Agric. Res. 2014;59(1):51-59.
5. Ayub M, Nadeem MA, Tanveer A, Husnain A. Effect of different levels of nitrogen and harvesting times on growth, yield and quality of sorghum fodder. Asian J Plant Sci. 2002;1(4):304-7.
6. Ayub M, Tanveer A, Muhmud K, Ali A, Azam M. Effect of nitrogen and phosphorus on the fodder yield and quality of two sorghum (*Sorghum bicolor* L.) cultivars. Pak. J Bio. Sci. 1999;2(1):247-50.
7. Bhatt S, Kumarm N, Dharma Reddy VK, Malve S. Extended Summaries, Vol 2. 3rd International Agronomy Congress, Nov. 26-30, held at New Delhi; c2012. p. 496-497.
8. Bhilare RL, Aher VB, Hiray AG, Gethe RM. J Maharashtra Agric. Uni. 2002;27:339-340.
9. Chotiya A. M.Sc. thesis, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. 2005.
10. Coumaravel K, Santhi R, Maragatham S. Soil test crop response correlation studies under integrated plant nutrition system for hybrid maize on an Alfisol. Madras Agric. J 2013;100(7-9):660-664.
11. Dhinesh V, Santhi R. Effect of initial soil fertility and integrated plant nutrition system (IPNS) on yield and NPK uptake by Brinjal on an Alfisol. Indian J Agric. Res. 2016;50(2):131-134.
12. Dwivedi BS, Arvind K, Shukla VK Singh, Yadav RL. Results of PDCO based trials from the state of Uttar Pradesh. In. Development of Farmers' Resource Based Integrated Plant Nutrient Supply System. Experience of an FAO-ICAR-IFFCO Collaborative Project and AICRP on STCR (A. Subba Rao and S. Srivastava, Eds.); c2001. p. 50-75. IISS, Bhopal, India.
13. Gowda CLL. Objectives of the expert meeting on alternative uses of sorghum and pearl millet in Asia. In. Alternative uses of sorghum and pearl millet in Asia. Proc. Expert Meeting, ICRISAT, Patancheru, Andhra Pradesh, India, 1-4. CFC Technical Paper No. 34 PO Box No. 74656, 1070 BR Amsterdam, The Netherlands. Common Funds for Commodities and Patancheru, A.P., India; c2004. p. 10.
14. Gupta K, Rana DS, Sheoran RS. Forage Res. 2008;34:156-159.
15. Hanway JJ, Heidal H. Soil analysis methods as used in Iowa State College, Agri. Bull. 1952;57:1–13.
16. Marsalis MA, Angadi SV, Contreras-Govea FE. Dry matter yield and nutritive value of corn, forage sorghum, and BMR forage sorghum at different plant populations and nitrogen rates. Field Crops Res. 2010;116:52-57.
17. Meena AM, Pushpendra Singh, Pushpa Kanwar. Effect of nitrogen levels on yield and quality of [*Sorghum bicolor* (L.) Moench] sorghum genotypes. Forage Res. 2012;37(4):238-240.
18. Moghimi N, Emam Y. Growth and yield responses of two forage sorghum cultivars to different nitrogen fertilizer rates. Iran Agrl. Res. 2015;34(1):39-45.
19. Olsen SR, Cole CV, Watanabe FS. Estimation of Available Phosphorous in Soils by Extraction with Sodium Bicarbonate. Circular US Dept. of Agriculture, 1400 Independence Ave. S.W., Washington DC; c1954. p. 939.
20. Praveena KS, Santhi R, Maragatham S, Natesan R, Ravikumar V, Pradip Dey. Soil test based fertilizer prescriptions through inductive cum targeted model for transgenic cotton on Inceptisol. J Agric. Veteri. Sci. 2013;6(5):36-44.
21. Ramamoorthy B, Narasimham RL, Dinesh RS. Fertilizer application for specific yield target of sonara-64 wheat. Indian Farming. 1967;17:43–45.
22. Rashid, Iqbal M. Response of sorghum (*Sorghum bicolor* L.) fodder to phosphorus fertilizer on torripsamment soil. The J. Animal Plant Sci. 2011;21(2):220-225.
23. Siam SH, Abd-El- Kader GM, El-Alia IH. Yield and yield components of maize as affected by different sources and application rates of nitrogen fertilizer. Res. J Agric. Bio. Sci. 2008;4(5):399-412.
24. Singh H. M. Sc. thesis, Department of Agronomy, Rajasthan College of Agriculture, MPUAT, Udaipur. 2007.
25. Singh YV, Shiva AM, Dey P. Soil test crop response based gradient experiment on rice (*Oryza sativa* L.) to NPK fertilizers in the alluvial soil of the Indo-Gangetic plains. Crop Res. 2015;50(1-3):9-11.
26. Sonune BA, Rewatkar SS, Prerana Gadge, Gabhane VV. Ann. Plant Phys. 2010;24:33-37.
27. Srinivasan S, Angayarkanni A. STCR gradient experiment with rice (*Oryza sativa*) to NPK fertilizers. Plant Archieves. 2008;8:631-32.
28. Subbaiah BV, Asija GL. A rapid procedure for determination of available nitrogen in soil. Curr. Sci. 1956;25:259–260.
29. Sumeriya HK, Singh P. Productivity of sorghum (*Sorghum bicolor*) genotypes as influenced by different fertility levels and their residual effect on succeeding wheat. Ann. Bio. 2014;30:266-275.
30. Tariq JMT, Arif M, Akbar H, Ali S. Response of wheat to source, type and time of N application. Sarhad J Agric. 2007;23(4):871-879.
31. Tiwana US, Puri KP. Effect of nitrogen levels on the fodder yield and quality of pearl millet varieties under rainfed conditions. Forage Res. 2005;31:142-143.
32. Radha Madhav M, Ravikumar A, Venkateswaralu B. Effect of different sources of nitrogen on growth, yield and nutrient uptake of rice. Andhra Agri. J. 1996;43(2-4):119-122.
33. Singh YV. STCR based gradient experiment with sorghum (*Sorghum biocolar* L.) to NPK fertilizers in the alluvial soil. Indian J Crop Ecol. 2014;2(2):83-86.
34. Udayakumar S, Santhi R. Impact of Artificial Soil Fertility Gradient Strategy on Soil Fertility, Nutrient Uptake and Fodder Yield of Sorghum. Int. J Curr. Microbiol. App. Sci. 2017;6(3):938-944. https://doi.org/10.20546/ijcmas.2017.603.111.
35. Verma Maneesh, Singh YV, Ajay Babu, Sudhanshu Verma, Meena R, Sahi SK. Soil test crop response based gradient experiment on rice (*Oryza sativa* L.) to fertilisers in the alluvial soil. Indian J Agri. Allied Sci. 2014;1(4):51-53.