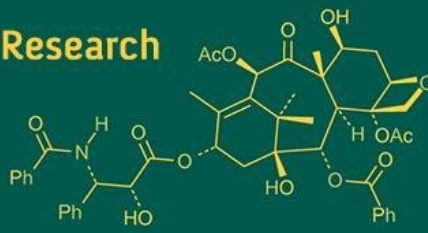


International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating (2026): 5.29
IJABR 2026; SP-10(4): 536-539
www.biochemjournal.com
Received: 08-01-2026
Accepted: 10-02-2026

Anitha G
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Visveswaran S
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Rani B
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Rajasree G
Department of Agronomy, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Pratheesh P Gopinath
Department of Agricultural Statistics,
College of Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Kiran Karthik Raj
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Raji Swaroop
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Safeer MM
Instructional Farm, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Rohith AK
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Esakkimuthu M
ICAR-KVK, Kerala Agricultural
University, Thiruvananthapuram,
Wayanad, Kerala, India

Corresponding Author:
Anitha G
Department of Soil Science &
Agricultural Chemistry, College of
Agriculture, Vellayani, Kerala
Agricultural University,
Thiruvananthapuram, Kerala, India

Development of fertility gradients and STCR based nutrient management for fodder maize in the southern laterite soils of Kerala

Anitha G, Visveswaran S, Rani B, Rajasree G, Pratheesh P Gopinath, Kiran Karthik Raj, Raji Swaroop, Safeer MM, Rohith AK and Esakkimuthu M

DOI: <https://www.doi.org/10.33545/26174693.2026.v10.i4Sg.8151>

Abstract

Fodder maize is a vital forage crop in India, particularly in Kerala where livestock-based farming systems rely heavily on green fodder. However, the productivity of fodder maize in southern lateritic soils is constrained by factors such as soil acidity, low nutrient availability, poor organic matter content, and imbalanced fertilizer use. In this context, a field experiment was conducted during 2023-2024 at the Instructional Farm, Department of Soil Science and Agricultural Chemistry, Vellayani, to develop fertility gradients and evaluate Soil Test Crop Response (STCR) based nutrient management for fodder maize. The experimental field was divided into three fertility strips representing low (N₀P₀K₀), medium (N₁P₁K₁) and high (N₂P₂K₂) fertility levels by applying graded doses of fertilizers. The results indicated a clear establishment of fertility gradients, as evidenced by the progressive increase in available soil nutrients across strips. Available nitrogen, phosphorus and potassium increased significantly from 176.38, 21.17, and 106.25 kg ha⁻¹ in the low fertility strip to 523.85, 63.51 and 286.14 kg ha⁻¹, respectively, in the high fertility strip. Growth parameters such as plant height, number of leaves, leaf area and leaf area index showed a consistent increase with higher fertility levels, indicating improved vegetative growth. Similarly, green fodder yield increased from 32.27 to 39.52 t ha⁻¹, accompanied by a corresponding increase in total nutrient uptake. Nitrogen, phosphorus and potassium uptake were significantly higher in the high fertility strip due to enhanced nutrient availability and biomass production. The study confirms that the fertility gradient approach effectively creates variability in soil nutrient status which is essential for developing STCR-based fertilizer prescription equations.

Keywords: Fodder maize, fertility gradient, fertilizer prescription equations, soil test crop response and nutrient management

1. Introduction

Fodder maize is an important forage crop in India, especially in regions like Kerala where livestock-based farming systems depend heavily on green fodder availability. However, the productivity of maize in the southern lateritic soils of Kerala is often limited due to inherent soil constraints such as acidity, low nutrient reserves, poor organic matter and imbalanced fertilizer use. These soils are highly weathered and leached, resulting in the loss of bases and silica and leading to low fertility status. Moreover, lateritic soils are characterized by high acidity and deficiencies of essential nutrients like nitrogen, phosphorus and potassium due to intense leaching processes. Soil acidity is also recognized as a major constraint to crop production in regions of laterite soils, affecting nutrient availability and crop performance (Sreelakshmi and Aparna, 2022) [12]. Therefore, efficient nutrient management becomes a key challenge for sustaining crop yield and maintaining soil health in these soils.

In this context, the Soil Test Crop Response (STCR) approach has emerged as a scientific and practical method for fertilizer recommendation. Unlike conventional blanket recommendations, STCR aims to prescribe fertilizers based on soil test values and targeted yield goals, thereby improving nutrient use efficiency and ensuring balanced fertilization. It integrates the contributions of soil, fertilizers and organic sources to achieve specific yield targets in a sustainable manner (Murthy *et al.*, 2024) [8]. A crucial step in developing STCR equations is the creation of fertility gradients in the experimental field. This involves establishing different fertility strips (low, medium and high nutrient status) to study crop

response across a wide range of soil nutrient levels. However, this approach helps in accurately quantifying nutrient requirements, fertilizer efficiency and soil nutrient contributions which are essential for deriving reliable fertilizer prescription equations.

Studies conducted under the All India Coordinated Research Project (AICRP) on STCR demonstrated that targeted yield-based nutrient management not only enhances crop productivity but also improves soil fertility status and sustainability over time (Dwivedi *et al.*, 2024) [2]. In lateritic soils of Kerala, similar approaches showed promising results in optimizing fertilizer use and achieving desired crop yields under varying soil conditions (Karthu *et al.*, 2025) [4]. Therefore, developing fertility gradients and applying STCR-based nutrient management for fodder maize is a vital step toward achieving higher productivity, efficient fertilizer use and long-term soil health sustainability in the humid tropical ecosystem of southern Kerala.

2. Materials and Methods

2.1 Experimental details

The methodology adopted in this study aimed to generate a wide range of soil fertility levels within a single field, thereby enabling the accurate assessment of the relationship between crop yield and soil fertility without the influence of other yield-affecting factors by Ramamoorthy *et al.* (1967) [9]. Artificial fertility gradients will be created in the field as a preparatory experiment by growing soil-exhausting crops, fodder maize. The field was divided into three different fertility plots or strips of 45 m x 15 m size by applying varying doses of fertilizer and followed as per KAU (2016). Soil samples were collected from each strip (both from 0-15 cm and 0-30 cm depths). These soil samples are used to study the status of major available nutrients in the experimental area before the conduct of the fertility gradient experiment. The secondary and micronutrient status of the soil will be adjusted based on the soil test values of pH and respective nutrients.

2.2 Experimental site

A field experiment was carried out on fodder maize to establishment of fertility gradients in the soil during the year 2023-2024. The study was conducted in D block of Instructional farm at the Department of Soil Science and Agricultural Chemistry, Vellayani, located in Agro-Ecological Unit (AEU) 8. The experimental site lies at 8°25'45.69" N latitude and 076°59'23.67" E longitude and at an altitude of 29 m above mean sea level.

2.3 Experimental design

The selected field was divided into three strips and size of each being 45 m x 15 m. The first strip (SI) receiving no fertilizer, second (SII) and third (III) full and two times the recommended dose of N, P and K for fodder maize, respectively. In fertility gradient experiment 3 strips (plots) such as strip I (Low), strip II (Medium) and strip III (High) was created and each strip (plot) will be divided into 9 sub plots (3 strips + 9 sub plots) resulting in 27 sub plots. Treatments comprise various selected combinations of nitrogen, phosphorus, potassium and FYM to be randomized in each plot phosphorous and potassium rates were calibrated to the critical value based on its fixation capacity followed by Waugh and Fitts (1966) [15]. This un-replicated experiment will be laid out as per the following plan and design.

Table 1: Fertilizer doses for fertility gradient experiment (FGE)

Plot	Symbol	Nutrient dose (kg ha ⁻¹)		
Strip I	NoP ₀ K ₀	0	0	0
Strip II	N ₁ [*] P ₁ ^{**} K ₁ ^{**}	120	60	40
Strip III	N ₂ P ₂ K ₂	240	120	80

* : As per Blanket recommendation

** : As per P and K fixing capacities of the soil.

3. Results and Discussion

The experimental field soil was classified as sandy clay loam in texture, with a pH of 4.98, electrical conductivity of 0.14 dS m⁻¹ and soil organic carbon content of 0.62 percent. The initial soil test values indicated that available nitrogen, phosphorus and potassium were 188.16 kg ha⁻¹, 43.81 kg ha⁻¹, and 126.12 kg ha⁻¹, respectively.

3.1 Soil fertility status after the creation of fertility gradient experiment

The data presented in the table 2 clearly demonstrated that the effect of graded nutrient application on post-harvest soil fertility status after fodder maize cultivation. A well-defined fertility gradient was established across the experimental strips, as evidenced by the progressive increase in available nitrogen (N), phosphorus (P) and potassium (K) from strip I (NoP₀K₀) to strip III (N₂P₂K₂). The available nitrogen content increased substantially from 176.38 kg ha⁻¹ in the control to 309.11 kg ha⁻¹ in N₁P₁K₁ and further to 523.85 kg ha⁻¹ in N₂P₂K₂. This increase can be attributed to the direct addition of nitrogen fertilizers and the residual accumulation of unused nitrogen in the soil. Similar findings were reported by Ramamoorthy *et al.* (1967a) [9] who emphasized that fertility gradient experiments result in differential nutrient buildup which is essential for studying crop response. Available phosphorus also showed a consistent increase from 21.17 to 63.51 kg ha⁻¹ across the fertility strips. Despite the high phosphorus fixation capacity of lateritic soils, the increasing trend indicates that higher fertilizer application can overcome fixation to some extent and contribute to residual phosphorus availability. This observation is in agreement with the findings of Waugh and Fitts (1966a) [15] who highlighted the importance of calibrating phosphorus application based on soil fixation characteristics.

Table 2: Effect of graded levels of nutrients on soil fertility status after the harvest of fodder maize

Strip	Symbol	Available nutrients (kg ha ⁻¹)		
		Nitrogen	Phosphorous	Potassium
I	NoP ₀ K ₀	176.38	21.17	106.25
II	N ₁ P ₁ K ₁	309.11	48.23	153.79
III	N ₂ P ₂ K ₂	523.85	63.51	286.14

A similar trend was observed for available potassium which increased markedly from 106.25 to 286.14 kg ha⁻¹ with increasing fertility levels. The higher potassium content in treated plots may be due to both fertilizer addition and reduced depletion compared to the control. These results corroborate the findings of Subba Rao and Srivastava (2001) [14] who reported significant increase of soil potassium under higher fertilizer regimes in STCR studies. However, the progressive increase in soil nutrient status across fertility strips confirms the successful establishment of a fertility gradient in the experimental field. Such variation is crucial for developing reliable Soil Test Crop Response (STCR)

based fertilizer prescription equations, as it enables the quantification of nutrient contributions from soil and fertilizers. The results are in line with the principles outlined by Ramamoorthy and velayutham (1971) ^[10] who stated that creating wide variability in soil fertility within a single field is fundamental for deriving accurate fertilizer recommendations based on targeted yield approaches.

3.2 Growth attributes at the harvest stage of fodder maize

Growth parameters, including plant height, number of leaves, leaf area by Elshahookie and Cheyed (2014) ^[3] and leaf area index were recorded at harvest stage using standard measurement procedures were calculated as per the formula by Radford (1967) ^[9].

A consistent and progressive increase in all growth attributes was observed with increasing fertility levels from strip I to strip III. Plant height increased from 257.17 cm in strip I to 273.49 cm in strip II and further to 288.61 cm in strip III (table 3). This enhancement in plant height can be attributed to improved nutrient availability, particularly nitrogen which plays a crucial role in cell division, elongation and vegetative growth. The increased nitrogen supply under higher fertility levels likely promoted vigorous plant development. Similarly, the number of leaves per plant showed steady increase from 10.3 in strip I to 12.7 and 15.1 in strips II and III, respectively. This indicates better vegetative growth under higher nutrient availability, as nutrients especially nitrogen and phosphorus are essential for leaf initiation and development.

Table 3: Effect of graded dose of nutrients on growth parameters in soil fertility gradient experiment

Strip	Plant height (cm)	Number of leaves	Leaf area (cm ²)	Leaf area index
I	257.17	10.3	3482.76	3.56
II	273.49	12.7	4215.53	3.90
III	288.61	15.1	4468.33	4.14

Leaf area also exhibited a marked increase, ranging from 3482.76 cm² in strip I to 4215.53 cm² in strip II and 4468.33 cm² in strip III. The corresponding increase in leaf area index (LAI) from 3.56 to 4.14 further confirms the improvement in canopy development with increasing fertility levels. Enhanced leaf area and LAI contribute to greater photosynthetic efficiency, ultimately leading to higher biomass production. The overall improvement in growth parameters with increasing fertility levels clearly demonstrates the successful establishment of fertility gradients in the experimental field. The results indicate that higher nutrient availability positively influences vegetative growth, which is a prerequisite for higher fodder yield in maize.

These findings were observed by Ramamoorthy and velayutham (2011) ^[11] who emphasized that fertility gradient experiments create distinct variations in soil nutrient status, thereby influencing crop growth and yield. Similar results were reported by Subba Rao and Srivastava (2001) ^[14], who observed significant improvements in growth parameters of crops with increasing fertilizer application under STCR-based studies. Furthermore, Bray (1954) who is highlighted that adequate nutrient supply enhances leaf area development and photosynthetic activity, leading to improved crop growth.

3.3 Yield and nutrient uptake by fodder maize

The exhaustive crop fodder maize was cultivated in accordance with recommended agronomic practices. The crop was harvested at 60 days after sowing (DAS) and observations made on growth parameters, green fodder yield and nutrient uptake were systematically recorded. Subsequently, composite soil samples were collected from each experimental strip after harvest and subjected to analysis for various physico-chemical properties.

Table 4: Effect of graded levels of nutrients on green fodder yield and total nutrient uptake by fodder maize in soil fertility gradient experiment

Strip	Green fodder yield (t ha ⁻¹)	Total nutrient uptake (kg ha ⁻¹)		
		N	P	K
I	32.27	41.65	8.26	37.05
II	35.13	47.23	11.41	44.11
III	39.52	56.79	15.93	56.27

The data presented in Table 4 clearly illustrated that the influence of graded levels of nutrient application on green fodder yield and total nutrient uptake by fodder maize under a soil fertility gradient experiment. A consistent and significant increase in both yield and nutrient uptake was observed with increasing fertility levels from strip I to strip III. The green fodder yield increased progressively from 32.27 t ha⁻¹ in strip I to 35.13 t ha⁻¹ in strip II and further to 39.52 t ha⁻¹ in strip III. This increase in yield can be attributed to improved nutrient availability, which enhanced vegetative growth, photosynthetic activity, and biomass accumulation. The higher fertility levels ensured an adequate and balanced supply of essential nutrients, thereby promoting better crop performance.

A similar increasing trend was observed in total nutrient uptake. Nitrogen uptake increased from 41.65 kg ha⁻¹ in strip I to 47.23 kg ha⁻¹ in strip II and 56.79 kg ha⁻¹ in strip III. Phosphorus uptake also showed a marked increase from 8.26 to 15.93 kg ha⁻¹, while potassium uptake increased from 37.05 to 56.27 kg ha⁻¹ across the fertility strips. The enhanced uptake of nutrients at higher fertility levels can be attributed to both increased nutrient availability in the soil and greater biomass production, leading to higher nutrient demand and absorption by the crop. The positive relationship between nutrient application, yield, and nutrient uptake clearly indicates that fodder maize responds significantly to improved soil fertility conditions. The results also confirm that nutrient uptake is directly proportional to yield, as higher biomass production leads to greater removal of nutrients from the soil. Similar trends were reported by Subba Rao and Srivastava (1998) ^[13] where increased fertilizer application resulted in higher crop yield and nutrient uptake. Furthermore, Mengel and Kirkby (2012) ^[7] emphasized that adequate nutrient supply enhances nutrient absorption and biomass production, leading to improved crop productivity.

4. Conclusion

The development of fertility gradients and Soil Test Crop Response (STCR) based nutrient management for fodder maize in the southern lateritic soils of Kerala clearly demonstrated the effectiveness of the approach in improving soil fertility and crop performance. The creation of distinct fertility strips through graded nutrient application successfully established a wide variation in soil nutrient

status, which is a prerequisite for developing reliable STCR-based fertilizer prescription equations. The results validate that the STCR approach can effectively quantify the contributions of soil and applied nutrients, thereby enabling precise and site-specific fertilizer recommendations. This approach holds great potential for sustainable fodder maize production in the humid tropical conditions of Kerala and can be extended to similar agro-ecological regions for improving nutrient use efficiency and achieving targeted yield goals.

5. References

1. Bray RH. A nutrient mobility concept of soil-plant relationships. *Soil Sci.* 1954;78(1):9-22.
2. Dwivedi S, Srivastava A, Gangwar SP, Dey P, Dey P, Bhatt MK, *et al.* Soil-test-crop-response based nutrient scheduling can improve soybean-wheat productivity and system sustainability. *BMC Plant Biol.* 2024;24(1):1203.
3. Elsayookie MM, Cheyed SH. Estimating sorghum leaf area by measuring one leaf length. *Iraqi J Agric Sci.* 2014;45(1):1-5.
4. Karthu PV, Visveswaran S, Rani B. Nutrient management for targeted yield for the groundnut crop in lateritic soils. *J Sci Res Rep.* 2025;31(5):327-335.
5. Kerala Agricultural University (KAU). Package of practices recommendations: crops. 15th ed. Thrissur: KAU; 2016.
6. Kumar D, Singh M, Kumar Meena R, Kumar S, Meena BL, Yadav MR, *et al.* Productivity and profitability improvement of fodder maize under combined application of panchagavya with organic and inorganic nutrient sources. *J Plant Nutr.* 2023;46(14):3519-3534.
7. Mengel K, Kirkby EA. Principles of plant nutrition. Dordrecht: Springer; 2012.
8. Murthy RK, Nagaraju B, Govinda K, Uday Kumar SN, Basavaraja PK, Saqeebulla HM, *et al.* Soil test crop response nutrient prescription equations for improving soil health and yield sustainability—A long-term study under Alfisols of southern India. *Front Plant Sci.* 2024;15:1439523.
9. Ramamoorthy B, Narasimham RK, Dinesh RS. Fertilizer application for specific yield targets on Sonora 64 (wheat). *Indian Farming.* 1967;17:43-45.
10. Ramamoorthy B, Velayutham M. Soil test crop response correlation work in India. *World Soil Res Rep.* 1971;41:96-105. Rome: FAO.
11. Ramamoorthy B, Velayutham M. The law of optimum and soil test-based fertilizer use for targeted yield of crops and soil fertility management. *Madras Agric J.* 2011;98(10-12):295-307.
12. Sreelakshmi MM, Aparna B. Soil acidity and its distribution in laterite soils of northern Kerala: a descriptive analysis. *Int J Environ Clim Change.* 2022;12(12):1158-1166.
13. Subba Rao A, Srivastava S. Annual report of the All India Coordinated Research Project for investigations on soil test crop response correlation. Bhopal: IISS; 1998. p. 1-87.
14. Subba Rao A, Srivastava S. Progress report of the All India Coordinated Research Project for investigations on soil test crop response correlation. Bhopal: IISS; 2001. p. 1-200.
15. Waugh DL, Fitts JW. Soil test interpretation studies: laboratory and potted plant. *Tech Bull. North Carolina State Agric Exp Stn.* 1966; No. 3.