Original Research Article

Nutrient management for targeted yield for the groundnut crop in lateritic soils

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ABSTRACT

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| A study was conducted in the southern lateritic soils of Kerala to test and verify the STCR-based targeted yield equation for groundnut, which was developed under the AICRP on STCR. The experiment was conducted at a latitude of 8o 25’ 46’’ N and 76o 59’ 21’’ E longitude, at 36.16 m above mean sea level in 2023. The crop variety used in the experiment was CO-7. The study followed a randomised block design (RBD) involving four replications and six treatments. The treatments included- T1–where nutrient management was carried out under organic management practices, T2-Kerala Agricultural University Package of Practices Recommendations: crops (KAU, 2016) based soil test recommendations, T3, T4, T5 and T6 were based on STCR–driven fertilizer prescription for yield targets of 2.6, 3, 3.4 and 3.8 tonnes respectively. The fertilizer applied for a yield target of 3.8 tonnes, i.e., T6 recorded a significantly higher plant height, number of branches per plant and dry matter production. Yield parameters such as the number of pods per plant, test weight, pod length, and pod girth were highest in treatment T5. The treatments T3 and T4 attained their respective yield targets. However, even though treatment T5 recorded the highest yield, a superior B: C ratio of 2.65 compared to other treatments, it failed in attaining the expected targeted yield. Further supplementation of fertilizers as in treatment T6 led to a reduction in yield and the same was also unsuccessful in fulfilling the yield target. Therefore, the STCR–based targeted yield equation can be used up to a target of 3 tonnes, and since a higher yield of 3.31 tonnes in treatment T5, a yield target of 3.4 tonnes can also be utilized. |

*Keywords: [groundnut, Targeted yield, prescription-based, soil test, crop response to fertilizer]*

1. INTRODUCTION

Oilseed crops are a vital component of world agriculture. They include various crop species predominantly cultivated to produce edible oil. About 40 oilseeds belong to multiple families and genera and are consumable [1] (Lennerts, 1983). Among them, groundnut is one of India's most significant oilseed crops. According to [2] (DOD, 2024), in India, groundnut was cultivated in an area of 47.02 lakh ha with a production of 101.801 lakh tonnes and an average yield of 2163 kg ha-1 in 2023-24. Groundnut, also called peanut or monkey nut, is a significant protein-rich legume crop grown mainly under rainfed conditions in India. Groundnut seeds are rich in oil (45%), protein (26-28%), fibre (5%) and carbohydrate (20%) [3] (Fageria *et al*., 1997). Apart from oil production, it is also used in various oleochemical industries. With agriculture becoming more intensive, extensive fertilizer application and rising crop demands, it has become important to ensure optimal productivity levels. However, the management and maintenance of soil fertility is a major concern in attaining increased production. Reduced organic matter content, poor soil fertility and imbalanced fertilizer utilization without organic amendments had resulted in the limited productivity of groundnut [4] (Akbari, 2011). Therefore, balanced nutrition is significant for enhancing the productivity of the crop. Soil testing enables speedy assessment of nutrient contents and aids in interpreting the results of tests conducted, along with formulation of fertilizer recommendations based on crop responses and economic attributes [5] (Dwivedi *et al*., 2015). The soil test-based fertilizer prescription concept is a promising and profitable technique for obtaining good crop yield. This method ensures the supply of nutrients to the crop in the required and proper quantity. The target yield approach is gaining more attention with the shift in agricultural trends. [6] (Troug,1960) and [7] (Ramamoorthy *et al*., 1967) introduced the targeted yield approach which focuses on balance between applied and soil nutrients available in the soil. The All India Coordinated Research (AICRP) on Soil Test Crop Response (STCR), initiated by ICAR in 1967-68, evolved STCR-based crop fertilizer recommendations. A notable benefit of this method is that yield targets can be altered based on the availability of resources. Various field experiments have been conducted based on STCR on different crops. In most cases, better responses and B: C ratios were obtained compared to the conventional method. In the light of this context, a field study was carried out to test and verify the STCR-based targeted yield equation for ground nuts in southern laterites of Kerala.

2. material and methods

A field study was conducted on the groundnut crop to evaluate the STCR-based targeted yield equation developed by AIRCP for STCR at Vellanikkara. The location of the experiment was at the Department of Soil Science and Agricultural Chemistry, Vellayani, AEU 8, situated at a geographical site of 8o25 46’’ N latitude and 76o59’21’’ E longitude, with an elevation of 36.16 m above mean sea level. This region has soils with low activity, laterite clays, and is devoid of gravel and plinthite. Agroecological unit 8 covers an area of 38,727 ha, which accounts for 1.02% of the total area of Kerala. The cropping period experienced tropical sub-humid weather with mean atmospheric temperature ranging from 23.60 to 31.93 °c and relative humidity between 79.23 and 89.19%. 370.7 mm of rainfall was recorded during the crop growing period. The soil in the study area had a sandy clay loam texture with sand (57.76 %), silt (16%) and clay (26.24%) and initial soil available N, P and K were 253.38, 9.25 and 138.88 kg ha-1, respectively. The organic carbon level in the soil was 0.66%. The experiment was carried out following randomized block design method involving six treatments and four replications. Treatment T1 followed organic management practices which received FYM (2 t ha-1), Vermicompost (2.5 t ha-1), Neem cake (250 kg ha-1), Bone meal (350 kg ha-1), Panchagavyya (3%) and Cow urine (10%) spray both at 45 and 60 DAS [8] (Ravisankar et al., 2017), while treatment T2 was according to Kerala Agricultural University Package of Practices Recommendations: crops, (KAU, 2016) and based on soil test values, where the recommendation for the crop is 10: 75: 75 kg ha-1 (N: P2O5: K2O) [9] (KAU, 2016). Treatments T3, T4, T5 and T6 were based on STCR-based targeted yield recommendations for targets 2.6, 3.4 and 3.8 tonnes, respectively. All the treatments received FYM at the rate of 2 t ha-1. Treatments T3, T4, T5 and T6 were selected to evaluate the equation against the average yield of 1444 kg ha-1. The test values of the initial soil samples were used to determine the fertilizer doses required for achieving the respective yield targets. Proper management practices like amendment for soil pH amelioration were followed as per [9] (KAU, 2016), weeding, irrigation and need based plant protection were followed for the crop.

STCR-based fertilizer prescription equation for targeted yield in groundnut [10] (KAU, 2014).

FN = 108.44T – 0.616SN – 1.561ON

FP2O5 = 38.01T – 1.577SP – 1.87OP

FK2O = 71.43T – 0.305SK – 1.853OK

T = Targeted yield

FN = Nitrogen supply from fertilizer

SN = Nitrogen supply from soil

ON = Nitrogen supply from an organic source

FP2O5 = Phosphorus supply from fertilizer

SP = Phosphorus supply from soil

OP = Phosphorus supply from organic source

FK2O = Potassium supply from fertilizer

SK = Potassium supply from soil

OK = Potassium supply from organic sources

**Table 1: Quantification of nutrients applied through various resources**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | N (kg ha-1) | P (kg ha-1) | K (kg ha-1) |
| T1 \*(Organically managed) | 72.78 | 23.15 | 21.44 |
| T2 (KAU-POP based on soil test values) | 34.50 | 43.46 | 65.77 |
| T3 (STCR recommendation for a yield target of 2.6 tonnes) | 111.71 | 36.27 | 123.07 |
| T4 (STCR recommendation for a yield target of 3 tonnes) | 154.98 | 42.21 | 139.01 |
| T5 (STCR recommendation for a yield target of 3.4 tonnes) | 199.36 | 48.41 | 162.33 |
| T6 (STCR recommendation for a yield target of 3.8 tonnes) | 241.73 | 54.11 | 186.87 |

\* T1-(includes FYM, vermicompost, neem cake, bone meal, panchagavyya spray and cow urine spray)-Organically managed treatment (Ravisankar *et al*., 2017).

**2.1 DATA COLLECTION**

Biometric observations of each treatment plot were made from 25 plants and used as representative samples. The representative samples were analyzed for nutrient uptake, yield and quality parameters. The plant samples collected, which included the shoot, root and pods, were oven dried at a temperature of 80° C to a constant weight. The plant samples were then powdered, and analysis was performed using standard methods. Single acid digestion using sulphuric acid was followed for estimation of N. Diacid digestion was performed for the estimation of other nutrients using nitric acid and perchloric acid in the ratio 9:4. The nutrient contents in the shoot, root and pods were analyzed using their respective standard methods. The soil samples collected from the experimental plot were air dried, ground and sieved using a sieve of 2mm diameter and stored in a closed, air-tight container. N, P and K contents were analyzed following the standard analyzing procedures.

**2.2** **STATISTICAL ANALYSIS**

The field experiment data were statistically analyzed using the software Grapes, developed by [11] (Gopinath *et al*., 2021). The variance analysis, ANOVA and the F test were used to assess the significance.

3. results and discussion

**3.1 AVAILABLE N**

The post-harvest available nitrogen in the soil ranged between 296.98 and 382.58 kg ha-1 as given in Table 2. A significant variation was observed among all the treatments. Compared to the initial levels of soil available N, a general enhancement in nutrient status was observed across all the treatments after the crop harvest. The surge might be likely due to the integrated supply of organic and inorganic fertilizers, resulting in higher organic carbon content, which would have aided in attaining balanced nutrition, higher adsorption of ionic forms of nitrogen on the surface of soil clay minerals and a higher rate of mineralization of organic forms of nitrogen. The highest value for available N was recorded in treatment T6 and the least in treatment T1. Comparable results were observed by [12] (Tiwari et al., 2024).

**Table 2. Effect of treatments on available N, P and K in soil after the crop harvest**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | Available N (kg ha-1) | Available P (kg ha-1) | Available K (kg ha-1) |
| T1 | 269.69f | 18.66f | 148.40d |
| T2 | 291.64e | 22.39e | 126.00e |
| T3 | 310.46d | 30.14d | 151.20d |
| T4 | 332.41c | 26.45d | 179.20c |
| T5 | 357.50b | 35.92b | 201.60b |
| T6 | 382.58a | 42.22a | 224.00a |
| SE(m) | 4.721 | 0.184 | 4.61 |
| CD | 14.23 | 0.555 | 13.897 |
| CV | 2.914 | 1.256 | 5.369 |

**3.2 AVAILABLE P**

After the crop harvest, the highest P levels in the soil were recorded in treatment T6 (42.22 kg ha-1) and the lowest value was registered in treatment T1 (18.66 kg ha-1), which is almost double the initial value as depicted in table 2. Significant differences were observed between all the treatments. The increase in the P levels observed might be due to the combined application of organic and inorganic nutrients and this would have helped in the mineralization of P. [13] (Arsalan et al., 2024) and [12] (Tiwari *et al*., 2024) reported a similar trend. In addition to serving as a readily available source of nutrients to the crop, the application of FYM might have aided in solubilizing the immobile phosphorous which is otherwise insoluble, through the release of different organic acids produced by its decomposition [14] (Thakur *et al*., 2011).

**3.3 AVAILABLE K**

The available K status in the soil samples of different treatments ranged between 126 and 224 kg ha-1 as shown in Table 2. The post-harvest soils showed an enhancement in the K levels compared to the initial K. The supply of FYM along with inorganic nutrient supplements might have increased the availability of K in the soil. In the organically managed treatment T1, where SOP (K2SO4) was the major source of K, a higher amount of organic clay complexes formed, likely due to the supply of FYM, vermicompost, bonemeal, and neem cake, which might have played a role in retaining K.

**3.4 YIELD ATTRIBUTES**

Findings from the data revealed a significant effect of various treatments on the yield attributes viz., number of pods per plant, number of seeds per pod, test weight (100 kernel weight) and yield plot-1 (t ha-1) which are provided in Table 3. The total number of pods per plant ranged from 10.72 to 16.97. Treatment T5 recorded the highest number of pods per plant, which was on par with treatment T6. This could be due to the improved nutrient concentration in the soil, which would have ultimately aided in better absorption of nutrients by the plant. [15] (Veeramani and Subramaniyan, 2012) also too noted comparable results, where an application of 175% RDF resulted in the highest number of pods per plant, followed by 200% RDF. A similar pattern for peak value for test weight was reflected in treatment T5 (38.60 g). In both cases, the lowest value was observed in treatment T1. This might be due to increased NPK levels supplied to the crops. In the case of test weight, [16] (Kundu *et* *al*., 2023) reported a similar trend in groundnut, where enhanced NPK led to an increase in test weight. The number of seeds per pod recorded no significant variation among all the treatments.

**Table 3. Effect of treatments on Yield and Yield parameters and B: C ratio**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Treatments | No: of pods plant‑1 | No: of seeds per pod | Test weight (g) | Yield (t ha-1) | B: C ratio |
| T1 | 10.72d | 1.95 | 36.65e | 1.78f | 1.24d |
| T2 | 11.01d | 1.98 | 37.01d | 1.91e | 1.95c |
| T3 | 13.50c | 1.97 | 37.26d | 2.58d | 2.42b |
| T4 | 14.71b | 1.99 | 37.76c | 2.96c | 2.57a |
| T5 | 16.97a | 2.00 | 38.60a | 3.31a | 2.65a |
| T6 | 15.12a | 2.00 | 38.16b | 3.20b | 2.38b |
| SE(m) | 0.386 | 0.015 | 0.087 | 0.030 | 0.026 |
| CD | 1.163 | NS | 0.263 | 0.092 | 0.078 |
| CV | 5.645 | 1.470 | 0.465 | 2.315 | 2.334 |

Pod yield per plot was recorded as the highest in treatment T5 despite failing to achieve the anticipated yield target of 3.4 t ha-1. Treatment T6 also failed in attaining its anticipated targeted yield of 3.8 t ha-1. However, treatments T3 and T4 effectively met their respective yield targets of 2.6 and 3 t ha-1. The drop in yield observed after treatment T5 might result from the principle embedded in the law of diminishing returns, as observed to be followed by the available soil nutrients. This could also be ascribed to a significant re-distribution of photosynthates to the vegetative parts when the available nutrient ratios of soil and ratios of total nutrient uptake reach an optimum level, resulting in higher growth rates and values of yield parameters. [17] Lamina (2009) also observed a similar trend.

**3.5 NPK UPTAKE**

The total N, P, and K uptake was highest in treatment T6, while treatment T1 registered the least as indicated in table 4. The highest uptake by the crop was for nitrogen, followed by potassium and phosphorus. However, the number of pods per plant, test weight and B: C ratio were highest in treatment T5. Although the nutrient availability in the soil was greater in treatment T6, the plants were inefficient in absorbing the nutrients, potentially due to multiple factors such as nutrient imbalance because of the ratio of N/P, N/K and P/K of both available soil nutrients and total nutrient uptake values or their saturation in the soil plant system. When these values exceeded a critical value, it may result in toxicity within the plant, resulting in reduced growth and yield, which again depends on the degree of deviation of such ratio. In general, enhanced dry matter production and improved nutrient content might have increased nutrient uptake. A similar trend can be seen in the findings of [18] Satpute *et* *al*. (2020) and [19] (Dekhane *et* *al*., 2011).

It can be seen from Fig. 1, Table 2, and Table 3 that maximum yield was obtained when the available soil nutrient ratios, viz., N/P, N/K and P/K, are 9.95, 1.78 and 0.18, respectively, for T5. These values may be considered the optimum ratio because they have also resulted in the highest number of pods per plant, test weight and B: C ratio were highest in treatment T5, and all the ratios below and above have resulted only in a lower yield. Similarly, from Fig. 2 and Table 6, it can be inferred that the optimum ratios of nutrient uptake N/P, N/K and P/K for maximum yield are 8.47, 4.34 and 1.95, respectively. Within this range of nutrient management levels, a significant negative correlation exists between yield and ratio of available nutrients, viz., N/P and N/K, indicating that a variation from the optimum will result in a yield reduction as depicted in Table 5. Similarly, the correlation between the yield and the ratio of nutrient uptake, viz., N/P and N/K, is also significantly negative. Results should be clearly described in a concise manner.

**Table 4. Effect of treatments on total nutrient uptake**

|  |  |  |  |
| --- | --- | --- | --- |
| Treatments | N (kg ha-1) | P (kg ha-1) | K (kg ha-1) |
| T1 | 152.78f | 16.02e | 67.66f |
| T2 | 180.73e | 18.50d | 81.48e |
| T3 | 232.99d | 25.29c | 112.87d |
| T4 | 273.02c | 29.63b | 138.00c |
| T5 | 327.49b | 38.68a | 167.97b |
| T6 | 342.15a | 39.74a | 179.82a |
| SE(m) | 3.059 | 0.657 | 2.402 |
| CD | 9.22 | 1.979 | 7.242 |
| CV | 2.431 | 4.693 | 3.855 |

**Fig.1: Effect of treatments on post-harvest soil nutrient ratios**

**Fig.2: Effect of nutrient uptake ratios on yield (t ha-1)**

**Table 5: Correlation between post-harvest soil nutrient ratios and yield**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | N/P | N/K | P/K | Yield (t ha-1) |
| N/P | 1 |  |  |  |
| N/K | 0.354 | 1 |  |  |
| P/K | -0.773\*\*\* | 0.31 | 1 |  |
| Yield (t ha-1) | -0.812\*\*\* | -0.552\*\* | 0.416\* | 1 |

**\*\*\*** Correlation is significant at the 0.001 level; \*\* Correlation is significant at the 0.01 level

\*Correlation is significant at the 0.05 level

**Table 6: Correlation between total nutrient uptake ratios and yield**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | N/P | N/K | P/K | Yield (t ha-1) |
| N/P | 1 |  |  |  |
| N/K | 0.664\*\*\* | 1 |  |  |
| P/K | -0.079 | 0.693\*\*\* | 1 |  |
| Yield (t ha-1) | -0.774\*\*\* | -0.769\*\*\* | -0.288 | 1 |

**\*\*\*** Correlation is significant at the 0.001 level; \*\* Correlation is significant at the 0.01 level

\*Correlation is significant at the 0.05 level

4. Conclusion

The soil test crop response-based targeted yield equation formulated for groundnut can be adopted up to a yield target of 3.31 tonnes, particularly when resource availability and management are efficient and optimal. Among the treatments, an enhanced economic return was obtained in treatment T5, producing a yield of 3.31 tonnes and a superior B: C ratio of 2.65 with suggested nutrient application as per treatment T5. Increasing nutrient application, surpassing treatment T5, could lead to a decline in crop yield. Therefore, STCR-based targeted equations can be adopted for efficient and optimum fertilizer utilization and contribute towards obtaining improved yields and returns.

References

1. Lennerts, L. 1983. Oelschrote, oelkuchen, pflanzliche Oele und Fette, Herkunft, Gewinning, Verwendung, Bonn: Alfred Strothe, Hannover.
2. DOD [Directorate of Oilseed Development]. 2024. Oilseed production statistics for 2023-2024. Available at https://oilseeds.dac.gov.in.
3. Fageria, N.K., Baligar, V.C. and Jones, C. 1997. Growth and mineral nutrition of field crops (2nd Ed.). Marcel Dekker, Inc, New York 1001 k, Pp: 494.
4. Akbari, K.N., Kanzaria, K.K., Vora, V.D., Sutaria, G.S. and Padmani D.R. 2011. Nutrient management practices for sustaining groundnut yield and soil productivity on sandy loam soils. Journal of the Indian Society of Soil Science, 59(3), 308-311.
5. Dwivedi, B.S., Tiwari, R.K., Pandey, A.K., Tiwari, B.K. and Thakur, R.K. 2015. Economically viable STCR-based nutrient management on soybean (*Glycine* *max*). Economic Affairs, 60(2), 225-228
6. Troug, E., 1960. Fifty years of soil testing, transactions of 7th International Congress of Soil Science, Madison, Wisconsin, USA, 3: 46-53.
7. Ramamoorthy, B., Narasimham, R.L. and Dinesh, R.S. 1967. Fertiliser application for specific yield targets on Sonora 64 (wheat). Indian Farming, 17(5), 43-45.
8. Ravisankar, N., Panwar, A.S., Prasad, K., Kumar, V. and Bhaskar, S., 2017. Organic farming crop production guide. Network Project on Organic Farming, ICAR-Indian Institute of Farming Systems Research, Modipuram, Meerut-250, 110, 586p.
9. KAU [Kerala Agricultural University]. 2016. Package of Practices Recommendations: crops (15th Ed.). Kerala Agricultural University, Thrissur. 393p.
10. KAU [Kerala Agricultural University]. 2014. Annual Progress Report All India Co-ordinated Research Project (AICRP) on Soil Test Crop Response (STCR), 50p.
11. Gopinath, P. 2021. grapesAgri1: Collection of Shiny Apps for Data Analysis in Agriculture. J. Open-Source Software, 6(63), 3437. Doi: https://doi.org/10.21105/joss.03437.
12. Tiwari, R., Dwivedi, B.S., Sharma, Y.M., Thakur, R., Sharma, A. and Nagwanshi, A. 2024. Soil properties and soybean yield as influenced by long term fertilizer and organic manure application in a Vertisol under Soybean-Wheat Cropping Sequence. Legume Research, 47(7), 1158-1164.
13. Arsalan, M., Latif, A., Khan, M., Syed, S., Ullah, R., Ahmad, I., Bilal, M., Mahmood, M.T., Ehsan, M., Latif, R. and Ghaffar, A. 2024. Integrated Effect of Organic Amendments and Chemical Fertilizers on yield of Groundnut and Soil Health Under Rainfed Condition. Journal of Applied Research in Plant Sciences, 5(1), 99-104.
14. Thakur, Risikesh, Sawarkar, S.D., Vaishya, U.K. and Singh, Muneshwar. 2011. Impact of continuous use of inorganic fertilizers and organic manure on soil properties and productivity under soybean-wheat intensive cropping of a vertisol. Journal of the Indian Society of Soil Science, 59(1), 74-81.
15. Veeramani, P. and Subrahmaniyan, K. 2012. Physical and economic optimum of response model for NPK application in irrigated groundnut (*Arachis* *hypogaea* L.). Madras Agricultural Journal, 99 (7-9), 526-529.
16. Kundu, R., Poddar, R., Sen, A., Sarkar, A. and Ghosh, D. 2023. Effect of varietal selection and nutrient management on productivity, soil fertility and economics of summer groundnut (*Arachis hypogaea*). The Indian Journal of Agricultural Sciences, 68(4), 392-397.
17. Lamina, V.K., 2009. Soil Test based fertilizer requirements for oriental pickling melon (*Cucumis melo* var. conomon) Ph.D. Thesis, Kerala Agricultural University, Thrissur, 132p
18. Satpute, A.V., Patil, J.B., Shende, S.M. and Gedam, V.B. 2020. Effect of inorganic and bio-fertilizers on nutrient (NPK) content, nutrient (NPK) uptake and available nutrient (NPK) at harvest of summer groundnut (*Arachis hypogaea* L.). International Journal of Chemical Studies, 8(6), 1612-1616.
19. Dekhane, S.S., Khafi, H.R., Raj, A.D. and Parmar, R.M. 2011. Effect of bio fertilizer and fertility levels on yield, protein content and nutrient uptake of cowpea [*Vigna unguiculata* (L.) Walp.]. Legume Research, 34(1), 51-54.