

Original Research Article

Development of Fertilizer Prescription Equations and Recommendations in Meghalaya

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Abstract

Three soil test crop response (STCR) experiments were conducted with maize, soybean and rice during 2004–2006 at the Soil Science Division of the ICAR Research Complex for NEH Region, Umiam, Meghalaya. Four fertility-gradient strips were developed for each crop during the first year. Grain and straw samples were collected at harvest and analysed for nitrogen (N), phosphorus (P) and potassium (K) concentrations, and total nutrient uptake was calculated. Soil samples were also analysed for available N, P and K. The resulting soil-test and crop-response information was used to develop fertilizer adjustment equations for targeted yields of rice, maize and soybean. Follow-up trials were conducted in a selected village field using fertilizer doses calculated from the target-yield equations and soil-test values. The developed equations provide a quantitative basis for adjusting fertilizer application according to soil fertility status and desired yield targets. The approach can support balanced and efficient fertilizer use and improve the precision of fertilizer recommendations under the soil and crop conditions of Meghalaya.

Keywords: soil test crop response, STCR, fertilizer prescription, target yield, soil fertility, rice, maize, soybean, Meghalaya

Introduction

Fertilizer management is a major determinant of crop productivity and long-term soil fertility. Conventional blanket fertilizer recommendations may not adequately account for variation in soil fertility, crop requirements and local growing conditions. Soil test crop response (STCR) correlations establish quantitative relationships between soil-test nutrient status, fertilizer application and crop response under field conditions. Such relationships provide a scientific basis for developing calibration charts and recommending balanced fertilizer doses for specified yield targets.

A well-calibrated STCR approach enables fertilizer nutrients to be applied in appropriate amounts according to the nutrient-supplying capacity of the soil and the yield target of the crop. This can improve fertilizer-use efficiency, reduce unnecessary fertilizer application and support sustainable crop production. Rice, maize and soybean are important crops in Meghalaya, where productivity can be improved through balanced and soil-test-based nutrient management. The present study was undertaken to develop fertilizer adjustment equations and ready reckoners for rice, maize and soybean using STCR experiments conducted at Umiam, Meghalaya. The objective was to relate soil-test N, P and K status to fertilizer requirements for predetermined yield targets and thereby provide a practical basis for site-specific fertilizer recommendations.

Materials and Methods

STCR experiments and fertility gradients

Three STCR experiments were conducted on maize, soybean and rice during 2004–2006 at the experimental block of the Soil Science Division, ICAR Research Complex for NEH Region, Umiam, Meghalaya. Four fertility-gradient strips were developed for each crop during the first year. The experimental soil was analysed for basic soil properties and exhaustive crops were grown to create fertility gradients. After harvest, the strips were subdivided into smaller plots and the soil of each plot was analysed for available N, P and K.

Crop sampling and nutrient uptake

During the second year, maize, soybean and rice were grown in the respective STCR plots. Fertilizer treatments were imposed across the fertility gradients according to the treatment combinations. Grain and straw yields were recorded at harvest. Grain and straw samples were collected and processed for estimation of N, P and K concentrations. Total uptake of N, P and K (kg ha^{-1}) was calculated from the nutrient

concentrations and crop yield data.

Follow-up trial and fertilizer prescription

A village field was selected for a follow-up trial. Soil samples from the selected field were analysed for available N, P and K during the third year. Fertilizer doses were calculated using the target-yield approach and the fertilizer adjustment equations developed for the respective crops. The resulting recommendations were used for the follow-up trial.

Development of ready reckoners

The accuracy of fertilizer recommendations depends on the representativeness of the soil sample used for calibration and recommendation. Soil properties can vary spatially because of soil-forming processes, erosion, nutrient accumulation or loss, and management practices such as tillage, fertilization, crop selection and irrigation. Therefore, appropriate soil sampling is essential for reliable fertilizer recommendations. Based on soil-test nutrient status, soils were grouped into low, medium and high fertility categories, and ready reckoners were prepared for specified crop-yield targets.

Fertilizer Adjustment Equations

The fertilizer adjustment equations developed for rice, maize and soybean are presented below. In these equations, F_N , $F_{P_2O_5}$ and F_{K_2O} denote fertilizer N, P_2O_5 and K_2O , respectively; S_N , S_P and S_K denote soil-test N, P and K in elemental form; and T denotes the predetermined crop-yield target (q ha^{-1}).

Table 1. Fertilizer adjustment equations for rice, maize and soybean

Crop	Fertilizer adjustment equations
Rice	$F_N = 2.82 \times T - 0.13 \times S_N$ $F_{P_2O_5} = 1.88 \times T - 0.08 \times S_P$ $F_{K_2O} = 1.69 \times T - 0.07 \times S_K$
Maize	$F_N = 1.99 \times T - 0.11 \times S_N$ $F_{P_2O_5} = 1.49 \times T - 0.11 \times S_P$ $F_{K_2O} = 0.83 \times T - 0.06 \times S_K$
Soybean	$F_N = 1.81 \times T - 0.06 \times S_N$ $F_{P_2O_5} = 5.42 \times T - 4.33 \times S_P$ $F_{K_2O} = 4.51 \times T - 0.21 \times S_K$

Results

Development of fertilizer prescription equations

The STCR experiments conducted on rice, maize and soybean generated quantitative relationships between soil-test nutrient status, fertilizer application and crop yield target. The fertilizer prescription equations

Table 2. Ready reckoner for fertilizer application to rice based on soil N, P and K fertility status

Target yield (q ha ⁻¹)	Low NPK soil			Medium NPK soil			High NPK soil		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
10	15.2	18	9.9	None	17.2	2.9	None	16.8	None
20	43.4	36.8	26.8	23.9	36	19.8	None	35.6	12.8
30	71.6	55.6	43.7	52.1	54.8	36.7	19.6	54.4	29.7
40	99.8	74.4	60.6	80.3	73.6	53.6	47.8	73.2	46.6
50	128	93.2	77.5	108.5	92.4	70.5	76	92	63.5

Table 3. Ready reckoner for fertilizer application to maize based on soil N, P and K fertility status

Target yield (q ha ⁻¹)	Low NPK soil			Medium NPK soil			High NPK soil		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
10	8.9	13.8	2.3	None	12.7	None	None	12.15	None
20	28.8	28.7	10.6	12.3	27.6	4.6	None	27.05	None
30	48.7	43.6	18.9	32.2	42.5	12.9	4.7	41.95	6.9
40	68.6	58.5	27.2	52.1	57.4	21.2	24.6	56.85	15.2
50	88.5	73.4	35.5	72.0	72.3	29.5	44.5	71.75	23.5

developed for the three crops showed that fertilizer requirements were influenced by both the desired yield target and the available nutrient status of the soil. For rice, the fertilizer requirements were estimated as $F_N = 2.82T - 0.13S_N$, $F_{P_2O_5} = 1.88T - 0.08S_P$, and $F_{K_2O} = 1.69T - 0.07S_K$. Similarly, equations developed for maize were $F_N = 1.99T - 0.11S_N$, $F_{P_2O_5} = 1.49T - 0.11S_P$, and $F_{K_2O} = 0.83T - 0.06S_K$. For soybean, the corresponding equations were $F_N = 1.81T - 0.06S_N$, $F_{P_2O_5} = 5.42T - 4.33S_P$, and $F_{K_2O} = 4.51T - 0.21S_K$. These equations demonstrate that fertilizer requirements can be adjusted according to soil nutrient-supplying capacity and the targeted yield. The equations are presented in the manuscript source.

Fertilizer requirement for rice, maize and soybean

The ready reckoners developed from the fertilizer prescription equations indicated substantial differences in fertilizer requirements among low-, medium- and high-fertility soils. For a given yield target, fertilizer requirements generally declined with increasing soil-test nutrient availability. For rice, the calculated fertilizer requirements increased progressively with the yield target from 10 to 50 q ha⁻¹. Similar trends were observed for maize and soybean. The ready reckoners therefore provide a practical means of translating soil-test values and yield targets into crop-specific fertilizer recommendations.

Fertilizer recommendations at varying soil-test values

The developed reckoner further demonstrated the effect of soil-test nutrient status on fertilizer requirement for specific yield targets. In maize, for example, increasing soil-test N, P and K levels resulted in progressively lower fertilizer requirements for the specified

yield targets. This confirms the importance of accounting for the indigenous nutrient-supplying capacity of soil when determining fertilizer doses.

Practical implication of the STCR approach

The results indicate that STCR-based fertilizer recommendations can provide a more precise alternative to uniform fertilizer application. By integrating soil fertility status with crop yield targets, the developed equations and ready reckoners can facilitate balanced nutrient application and improve the efficiency of applied fertilizers. The source manuscript also emphasizes that appropriate soil sampling and suitable timing, method and dose of fertilizer application are essential for achieving higher nutrient-use efficiency.

Discussion

The STCR approach developed in this study provides a quantitative framework for integrating soil nutrient-supplying capacity with crop nutrient requirements. The fertilizer adjustment equations show that the required fertilizer dose changes with both the desired yield target and the soil-test status of the respective nutrient. Consequently, the same yield target does not necessarily require the same fertilizer dose in soils with different fertility levels. Earlier these results reported by Bharamappanavara et al. (2020), Brajendra, et al. (2020), Caon, and Vargas, (2017), Gopal et al. (2014).

The ready reckoners further translate the equations into practical fertilizer recommendations for low-, medium- and high-fertility soils. As soil-test nutrient availability increases, the fertilizer requirement generally decreases for a given yield target. This relationship demonstrates the value of soil testing in improving the precision of fertilizer management and avoiding unnecessary nutrient application.

Table 4. Ready reckoner for fertilizer application to soybean based on soil N, P and K fertility status

Target yield (q ha ⁻¹)	Low NPK soil			Medium NPK soil			High NPK soil		
	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O	N	P ₂ O ₅	K ₂ O
5	3.05	None	1.55	None	None	None	None	None	None
10	12.1	10.9	24.1	3.1	None	3.1	None	None	None
15	21.15	38	46.65	12.15	None	25.65	None	None	4.65
20	30.2	65.1	69.2	21.2	21.8	48.2	6.2	0.15	27.2
25	39.25	92.2	91.75	30.25	48.9	70.75	15.25	27.25	49.75

Note: “None” indicates that no fertilizer nutrient was required according to the corresponding target-yield equation and soil-test fertility class.

Earlier these results reported by Gorlapalli et al. (2022), Kale et al. (2021), Kale et al. (2020), Parmar et al. (2022).

The equations and ready reckoners developed for rice, maize and soybean can therefore serve as decision-support tools for balanced fertilization under the conditions represented by the experiments. Their practical use depends on appropriate soil sampling, correct interpretation of soil-test results and adoption of suitable fertilizer source, dose, timing and placement practices. Earlier these results reported by Rathod et al. (2021), Sahoo et al. (2022), Srilatha et al. (2019), Tuti et al. (2022).

Conclusion

STCR-based fertilizer adjustment equations were developed for rice, maize and soybean using soil-test values, crop nutrient uptake and targeted-yield relationships established under field conditions at Umiam, Meghalaya. The resulting equations and ready reckoners provide a scientific basis for adjusting fertilizer doses according to soil fertility status and yield targets. Adoption of these soil-test-based recommendations can promote balanced fertilizer use, improve nutrient-use efficiency and support sustainable crop production. Accurate soil sampling and appropriate fertilizer application methods, timing and doses are essential for realizing the benefits of the STCR approach.

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