Research Article
The J. Res. PJTAU 52 (3&4) 31-36, 2024

BRIDGING THE NITROGEN-POTASSIUM IMBALANCE: STCR-BASED FERTILIZER PRESCRIPTIONS BOOST MAIZE YIELD AND FARM INCOME IN TELANGANA

KRISHNA CHAITANYA ANANTHA[1*], J. RAVINDER[1], A. MADHAVI[2], K. PAVAN CHANDRA REDDY[2] and B. BALAJI NAIK[1]

[1]Regional Sugarcane and Rice Research Station, Rudrur, Nizamabad-503188, PJTAU
[2]AICRP on STCR, Soil Health Unit, Rajendranagar, Hyderanad-500030, PJTAU

Date of Receipt: 17-09-2024 Date of Acceptance: 25-09-2024

ABSTRACT

Imbalanced and indiscriminate fertilizer use remains a major constraint from realising the yield potential of maize (*Zea mays* L.) in the expanding, non-traditional growing tracts of Telangana, India. The present study evaluated the Soil Test Crop Response (STCR) approach for popularising soil-test-based fertilizer recommendations among maize farmers of Kamareddy district. Pre-sowing soil analysis of six farmers' fields revealed low available nitrogen (87.8–138.0 kg ha{ ^{1}), low-to-medium phosphorus (11.6–14.6 kg ha{ ^{1}) and medium potassium (194–237 kg ha{ ^{1}) status. Using targeted-yield equations for an economic yield target of 4,500 kg ha{ ^{1}, field-specific STCR prescriptions (133.4–153.4 kg N, 44.9–49.5 kg P, O… , 29.1–36.0 kg K, O ha{ ^{1}) were generated and compared against prevailing farmers' practice, which applied disproportionately high nitrogen and no potassium. STCR-based nutrition increased mean seed yield by 7.5% (3,773 to 4,057 kg ha{ ^{1}) while reducing fertilizer cost by about 33%, driven primarily by correction of the nitrogen-potassium imbalance. Consequently, the benefit-cost ratio improved from 1.53 to 1.76, delivering an additional net benefit of approximately Rs 9,000 ha{ ^{1} across farmers. These results confirm that field-specific, balanced nutrient management under STCR offers a scientifically sound and economically superior alternative to blanket fertilizer recommendations for maize in Telangana's semi-arid soils.

Key words: STCR, Target yield, maize, economics

Maize (*Zea mays* L.), often referred to as the "queen of cereals" owing to its highest genetic yield potential among cereal crops, occupies a pivotal position in India's food and nutritional security architecture. The major maize-producing states of Karnataka, Rajasthan, Madhya Pradesh, and Telangana contribute significantly to the country's total corn output, with 16 million Indian farmers cultivating it (IIMR, 2023-24). With 12.74 lakh acres, maize is the third most significant crop in Telangana. The state's corn production increased significantly during the 2022–2023 harvest, reaching 28.65 lakh tons (DES, 2022–2023). This expansion, however, has not been matched by a commensurate improvement in nutrient management practices and productivity in many of these newer maize-growing tracts continues to lag behind the crop's demonstrated genetic potential.

A major constraint underlying this yield gap is the progressive deterioration of soil fertility under intensive, continuous cereal-based cropping systems. Years of monocropping, minimal organic matter recycling and inadequate replenishment of nutrients removed in harvested produce have left many smallholder fields - particularly in Kamareddy district of Telangana — depleted in nitrogen and phosphorus, even where potassium reserves remain moderately adequate. Compounding this depletion is the persistence of blanket, generalised fertilizer recommendations that fail to account for field-to-field variability in indigenous nutrient supply. Farmers, in the absence of site-specific guidance, tend to over-apply nitrogen in pursuit of visible vegetative vigour while almost entirely neglecting potassium, despite its substantial uptake and removal by high-yielding maize hybrids. This imbalance not only caps attainable yield but also erodes profitability through unnecessary fertilizer expenditure and over time accelerates the very nutrient mining it is meant to prevent - a self-reinforcing cycle that blanket recommendations are structurally unable to break.

The Soil Test Crop Response (STCR) approach was conceived precisely to address this shortcoming. Building on the foundational premise articulated by Truog (1960) that fertilizer application should be calibrated to a defined yield target, Ramamoorthy et al. (1967) established the theoretical and experimental basis

Email: krch3737@gmail.com

demonstrating that Liebig's law of the minimum operates equally for nitrogen, phosphorus and potassium under Indian soil and crop conditions. Unlike blanket recommendations, the STCR framework integrates pre-sowing soil nutrient status, crop-specific nutrient requirement per unit of economic yield and the efficiency of nutrient contribution from soil, fertilizer and organic sources into empirically derived targeted-yield equations, allowing fertilizer doses to be prescribed on a truly field-specific and balanced basis.

Over the decades since its inception, the STCR approach has been validated across a wide range of crops and agro-ecologies including aerobic rice, sweet corn, beetroot and dryland cereals on Alfisols and Vertisols of southern and peninsular India - consistently demonstrating superior yield, nutrient use efficiency and economic returns relative to both blanket general recommendations and farmers' conventional practice. Frontline demonstrations on maize in Karnataka, have reported yield advantages of 15-17% over farmers' practice when STCR-based balanced nutrition replaced nitrogen-skewed conventional application. Despite this accumulated evidence base, systematic on-farm validation of STCR-based maize nutrition remains sparse in the semi-arid red and black soil tracts of northern Telangana, where the crop's rapid area expansion has outpaced the extension infrastructure needed to deliver site-specific nutrient advisories.

Against this backdrop, the present study was undertaken with the objectives of (i) characterising the initial soil nutrient status of maize-growing farmers' fields in Kamareddy district, (ii) generating STCR-based fertilizer prescriptions for a defined target yield using the targeted-yield equation approach and (iii) evaluating the resultant yield, cost and profitability outcomes of STCR-based nutrition relative to prevailing farmers' practice, with a view to generating field-level evidence for popularising soil-test-based fertilizer recommendations among maize growers of the region.

MATERIAL AND METHODS

The study was conducted during the kharif season on the fields of six representative maize-growing farmers selected from the Varni and Banswada mandals of Kamareddy district, Telangana, under TSP programme of AICRP on STCR, Hyderabad. The selected fields fall within the semi-arid tropical agro-climatic zone of the Northern Telangana Zone, characterised by medium soils and a monsoon-dependent cropping pattern. Farmers were purposively selected in consultation with local agricultural extension functionaries to represent the range of prevailing soil fertility and management conditions typical of the maize-growing tracts of the district.

Soil sampling and analysis

Prior to sowing, composite surface soil samples (0–15 cm depth) were collected from each of the six farmers' fields following a random zig-zag sampling pattern to account for within-field variability. Samples were air-dried, processed and passed through a 2 mm sieve prior to laboratory analysis. Available nitrogen was estimated by the alkaline potassium permanganate method (Subbiah and Asija, 1956), available phosphorus by Olsen's sodium bicarbonate extraction method (Olsen et al., 1954) and available potassium by the neutral normal ammonium acetate extraction method followed by flame photometry (Jackson, 1973). The soil test values so obtained (Table 1) formed the basis for generating field-specific fertilizer prescriptions.

Treatments and crop management

For each of the six farmers, two nutrient management practices were compared under actual field conditions: (i) the farmer's existing practice (FP), representing the prevailing conventional fertilizer application pattern in terms of source, dose and timing; and (ii) the STCR-based targeted yield recommendation, applying the field-specific N-P, O… -K, O doses derived as above. Fertilizers were applied through urea, DAP and muriate of potash as basal and top-dressed splits following standard agronomic recommendations for maize, with nitrogen applied in two to three split doses and the entire quantity of phosphorus and potassium applied as basal dose. All other agronomic practices including seed rate, spacing, plant protection and irrigation were kept uniform and followed the farmer's normal cultivation schedule to isolate the effect of nutrient management alone.

STCR-based fertilizer prescription

Fertilizer doses for each farmer's field were computed using the targeted yield equations developed under the Soil Test Crop Response (STCR) approach (Ramamoorthy et al., 1967), which integrate the nutrient requirement per unit of economic yield, the percent contribution of nutrients from soil and the percent contribution of nutrients from fertilizer, following pre-calibrated coefficients available for maize under this agro-ecological zone.

FN= 4.19 T-0.40 SN

FP_2O_5= 1.50T- 1.55 SP

FK_2O= 4.93 T- 0.16SK

A common economic yield target of 4,500 kg ha^{-1} was adopted across all six fields and the resultant field-specific N, P, O… and K, O doses are presented in Table 2.

Economic analysis

The economics of the two nutrient management practices was evaluated in terms of cost of fertilizers applied (Rs ha^{-1}), gross income (Rs ha^{-1}, based on prevailing farm-gate price of maize) and benefit-cost (B:C) ratio, computed as the ratio of gross returns to the cost of cultivation attributable to fertilizer input. The incremental benefit of the STCR approach over farmers' practice was further quantified in terms of difference in yield, difference in gross income, difference in fertilizer cost and overall net economic benefit per hectare.

Table 1. Initial nutrient status of soil in farmer's fields under maize

Farmer No	Farmer name	Village	Mandal	District	Soil nutrient status (kg ha^{-1})		
					Available N	Available P	Available K
1	Lakavath Narayana	Konapr	Varni	Kamareddy	100.4	14.6	218
2	Rohith	Hanmajipet	Varni	Kamareddy	100.4	12.6	206
3	Ganesh	Chalkatanda	Varni	Kamareddy	125.4	12.1	227
4	Maloth Santhosh Kumar	Koyyagutta	Banswada	Kamareddy	87.8	13.4	194
5	Maloth Prakash	Koyyagutta	Banswada	Kamareddy	125.4	11.6	233
6	Maloth Rukmabai	Koyyagutta	Banswada	Kamareddy	138	12.6	237

Table 2. nutrients recommended on STCR based fertilizer recommendations and farmer practice

S.No.	Farmer	STCR based fertilizer nutrient recommendations (kg ha^{-1})			Farmers' practice (kg ha^{-1})		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O
1	Farmer-1	148.4	44.9	32.2	205	50	0
2	Farmer-2	148.4	48.0	34.1	127	75	0
3	Farmer-3	138.4	48.7	30.7	166	63	0
4	Farmer-4	153.4	46.7	36.0	154	50	0
5	Farmer-5	138.4	49.5	29.8	154	50	0
6	Farmer-6	133.4	48.0	29.1	154	50	0

Data recorded

Cob yield was recorded at harvest from a net observation area within each treatment plot on every farmer's field and expressed on a kg ha^{-1} basis. Prevailing market prices of fertilizers and produce at the time of the demonstration were used to compute the cost of fertilizer application and gross income for both treatments.

RESULTS AND DISCUSSION

Initial soil fertility status of farmers' fields

The pre-experimental soil analysis of the six farmers' fields revealed a distinct nutrient imbalance typical of intensively cropped maize belts of the semi-arid Deccan Plateau (Table 1). Available nitrogen ranged from 87.8

to 138.0 kg ha^{-1} (mean 112.9 kg ha^{-1}), placing all fields in the low category, a consequence of continuous cereal cropping without adequate organic replenishment and the inherently rapid mineralisation-immobilisation turnover characteristic of red and black soils of Telangana. Available phosphorus varied narrowly between 11.6 and 14.6 kg ha^{-1} , corresponding to the low-to-medium range, while available potassium (194–237 kg ha^{-1}) fell in the medium category. This N-deficient, P-limited but K-adequate status is a widely reported in Telangana's maize-growing tracts and provided the technical justification for moving away from blanket fertilizer recommendations toward a site-specific, soil-test-based approach.

STCR-based fertilizer prescriptions

Fertilizer doses generated through the targeted yield equations (Ramamoorthy et al., 1967) for an economic yield target of 4,500 kg ha^{-1} ranged from 133.4 to 153.4 kg N ha^{-1}, 44.9 to 49.5 kg P, O…ha^{-1} and 29.1 to 36.0 kg K, O ha{ ¹ across the six fields (Table 2). The inter-farmer variation in prescribed doses, despite a common yield target, reflects the field-specific calibration inherent to the STCR approach, which adjusts fertilizer quantity to the soil's existing nutrient supplying capacity rather than applying a uniform rate across heterogeneous fields. Notably, the prescribed N doses were substantially lower than what farmers were conventionally applying, while a meaningful K, O dose was recommended in every field a nutrient farmers had been omitting entirely under their existing practice.

Impact of STCR-based nutrition on maize yield

Seed yield under the STCR approach ranged from 3,920 to 4,320 kg ha^{-1} (mean 4,057 kg ha^{-1}) compared with 3,620 to 4,030 kg ha^{-1} (mean 3,773 kg ha^{-1}) under farmers' practice (Table 3), representing a consistent yield advantage of 7.5% across all six locations, with individual gains ranging from 240 kg ha^{-1} (Farmer-2) to 330 kg ha^{-1} (Farmer-4) (Table 4). This uniform positive response, despite STCR involving markedly lower nitrogen input, corroborates the principle that yield is governed by the nutrient in least supply relative to crop demand (Liebig's law of the minimum) rather than by the absolute quantity of any single nutrient applied. The correction of the K deficit entirely absent from farmers' practice (0 kg K, O ha^{-1} in all six fields) despite continuous K removal by maize grain and stover appears to have been the principal factor unlocking the yield response, since farmers' N-P-only regimes had reached a point of diminishing and imbalanced returns. This finding is consistent with earlier frontline demonstrations of STCR-based maize nutrition in Karnataka, where yield advantages of 15–17% over farmers' practice were reported when soil-test-based balanced doses replaced conventional N-heavy applications and with validation trials on maize-based STCR-IPNS models in Vertisols of northern Karnataka, which similarly attributed yield gains to correction of neglected nutrients rather than to higher overall fertilizer input.

The 7.5% STCR yield advantage found here is somewhat more conservative than frontline demonstrations in Karnataka, where STCR-based fertilizer prescriptions gave a 15–21% yield advantage in maize over farmers' practice (Goswami, 2022), 25-29% yield increase in greengram (Rangaiah et al., 2025) and 46.8% in soybean (Raghava *et al*., 2019). However, similar results were recorded by Madhavi et al. (2020) 8.9 % yield advantage in maize crop, Srijaya *et al.* (2020) with 7.1% in paddy. The response is best explained by potassium correction rather than higher overall input, consistent with reviews showing that K is the most neglected primary nutrient in farmers' fertilization schedules nationally, with farmers' practice consistently producing large negative K balances (Das *et al*., 2022). This neglect has driven a substantial national resource deficit, with India's soils registering a net negative K_2O balance of about 14.8 million tonnes in 2015–16 and omitting K altogether has been shown to reduce system productivity by roughly 20% relative to K-inclusive treatments in cereal systems. Similar STCR-IPNS validation work on maize in Vertisols of northern Karnataka reached comparable conclusions by explicitly correcting soil-fertilizer-manure imbalances rather than raising total nutrient dose. Together, this supports a Liebig's-law reading: once N and P approach sufficiency, K becomes the binding constraint, so a targeted K correction not overall input intensity drives the yield gain, reinforcing calls to give K management parity with N and P in soil-test-based recommendations.

Economics of STCR vis-à-vis farmers' practice

The economic analysis reinforces the agronomic case for STCR adoption (Table 3, Table 4). Fertilizer cost under STCR (Rs 5,857–6,442 ha^{-1}, mean Rs 6,132 ha^{-1}) was 30–43% lower than under farmers' practice (Rs 8,350–11,175 ha^{-1}, mean Rs 9,225 ha^{-1}), a direct outcome of eliminating the nitrogen over-application that characterised the farmers' conventional regime (farmers' N rates of 127–205 kg ha^{-1} against STCR's 133–153 kg ha^{-1}). This cost saving occurred simultaneously with a yield gain, producing gross income advantages of Rs 5,016–6,897 ha^{-1} over farmers' practice. Consequently, the benefit-cost ratio improved from a mean of 1.53 under farmers' practice to 1.76 under STCR a relative improvement of about 15%. When the combined effect of reduced fertilizer expenditure and higher returns is expressed as overall net benefit, STCR delivered an additional Rs 8,136–10,321 ha^{-1}(mean ~Rs 9,015 ha^{-1}) across the six farmers, with the largest gains recorded on fields with the highest degree of pre-existing nitrogen over-application and potassium neglect (Farmer-2 and Farmer-3).

These results align with the broader literature on STCR performance under on-farm conditions, where balanced, soil-test-calibrated nutrition has consistently outperformed farmers' practice in both productivity and profitability across crops including rice, wheat, Jute (Ray et al., 2000, Pradeep Kumar and Parmanand. 2018) in soybean (Reddy *et al.,* 2018) and where the economic superiority of STCR has been attributed primarily to more efficient nitrogen use rather than higher total nutrient investment.

CONCLUSION

The study demonstrated that maize productivity in the Kamareddy belt is constrained more by nutrient imbalance than by inadequate fertilizer use. STCR-

Table 3. Yield, cost of fertilizers and gross returns in targeted yield with chemical fertilizers

S.No.	Farmer	Seed yield (kg ha^{-1})		Cost of fertilizers (Rs ha^{-1})		Gross income		B:C ratio	
		Farmers' practice	STCR (T-4500 kg ha^{-1})	Farmer's practice	STCR (T-4500 kg ha^{-1})	Farmers' practice	STCR (T-4500 kg ha^{-1})	Farmers' practice	STCR (T-4500 kg ha^{-1})
1	Farmer-1	3650	3920	9025	6069	76285	81928	1.48	1.76
2	Farmer-2	3730	3970	11175	6336	77957	82973	1.45	1.70
3	Farmer-3	3820	4120	10100	6049	79838	86108	1.52	1.78
4	Farmer-4	3620	3950	8350	6442	75658	82555	1.49	1.69
5	Farmer-5	4030	4320	8350	6039	84227	90288	1.65	1.86
6	Farmer-6	3790	4060	8350	5857	79211	84854	1.56	1.76
	p- value	0.0078		0.000084		0.0078		0.00012	
	T value	-3.31		6.34		-3.31		-6.04	

Table 4. Difference in yield income, fertilizer cost and over all benefit by STCR practice on FP

S.No.	Farmer Name	Difference in yield over FP (kg ha^{-1})	Difference in yield income over FP(Rs ha^{-1})	Difference in fertilizer cost over FP(Rs ha^{-1})	Overall benefit over FP (Rs ha^{-1})
1	Farmer-1	270	5643	-2956	8599
2	Farmer-2	240	5016	-4839	9855
3	Farmer-3	300	6270	-4051	10321
4	Farmer-4	330	6897	-1908	8805
5	Farmer-5	290	6061	-2311	8372
6	Farmer-6	270	5643	-2493	8136

based fertilizer prescriptions corrected excessive nitrogen use and restored balanced nutrient application, particularly potassium, resulting in an average 7.5% increase in grain yield while reducing fertilizer costs by nearly one-third. Consequently, net returns increased by approximately Rs 9,000 ha^{-1}, with the mean benefit-cost ratio improving from 1.53 under farmers' practice to 1.76. The consistent performance across all farmers highlights the robustness and scalability of the STCR approach, emphasizing the need to strengthen soil-testing and advisory services for its wider adoption.

REFERENCES

Das, D., Sahoo, J., Raza, M.B., *et al.* 2022. Ongoing soil potassium depletion under intensive cropping in India and probable mitigation strategies: A review. *Agronomy for Sustainable Development*. 42:4.

Directorate of Economics and Statistics (DES). 2022–23. *Directorate of Economics and Statistics*. Government of Telangana.

Gowswami, B. 2022. A comparative study on STCR based fertilizer application and farmer's fertilizer practice (FFP) on *Zea mays*. *IOSR Journal of Agriculture and Veterinary Science*. 15(5):21–24.

Indian Institute of Maize Research (IIMR). 2023–24. *Indian Institute of Maize Research*. Government of India.

Jackson, M.L. 1973. *Soil Chemical Analysis*. Prentice Hall of India (Pvt.) Ltd., New Delhi.

Madhavi, A., Srijaya, T., Surendra Babu, P. and Dey, P. 2020. Popularization of STCR targeted yield for optimum fertilizer use and enhanced yields of maize crop through field level demonstrations. *International Journal of Current Microbiology and Applied Sciences*. 9(8):2209–2214.

Olsen, S.R., Cole, C.W., Watanabe, F.S. and Dean, L.A. 1954. *Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate*. United States Department of Agriculture Circular No. 939.

Pradeep Kumar and Parmanand. 2018. Evaluation of soil test crop response approach for sustainable crop production of rice in Baladobazar–Bhatapara district of Chhattisgarh. *International Journal of Current Microbiology and Applied Sciences*. Special Issue 7:3513–3518.

Raghav, R.S., Singh, Y.V., Kumar, M., Dey, P. and Dubey, S. 2019. STCR based nutrient management in soybean (*Glycine max*) for higher productivity and profitability. *Indian Journal of Agricultural Sciences*. 89(10):1660–1663.

Ramamoorthy, B., Narsimhan, R.L. and Dinesh, R.S. 1967. Fertilizer application for specific yield targets of Sonora-64 (wheat). *Indian Farming*. 25(5):43–45.

Rangaiah, K.M., Nagaraju, B., Kasturappa, G., *et al.* 2025. Assessment of fertilizer prescription equations, crop and soil performance with different nutrient management practices for green gram (*Vigna radiata*) in Southern India's Alfisols. *Scientific Reports*. 15:31954.

Reddy, T.P., Madhavi, A., Srijaya, T. and Vijayalakshmi, D. 2018. Field validation of soil test and yield target based fertilizer prescription equation for soybean on Vertisol. *Journal of Pharmacognosy and Phytochemistry*. 7(6):1159–1162.

Srijaya, T., Madhavi, A., Prabhakar Reddy, T., Surendra Babu, P., Bharath, T. and Dey, P. 2020. Fertilizer prescription equation demonstration for targeted yield of rice in farmer fields of Telangana State. *Chemical Science Review and Letters*. 9(36):916–921.

Subbaiah, B.U. and Asija, G.L. 1956. Rapid procedure for the estimation of the available nitrogen in soil. *Current Science*. 25:259–260.

Truog, E. 1960. Fifty years of soil testing. *Transactions of the 7th International Congress of Soil Science*. III–IV:36–45.