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Validation of Soil Test and Yield Target based Fertilizer Prescription Equation for Sugarcane on Vertisols of Northern Telangana Zone

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ABSTRACT: A soil test-based fertilizer prescription minimises over- or under-application of fertilizer inputs, improving crop production and fertilizer use effectiveness. By conducting field experiments of the sugarcane plant crop for three years between 2017–18 and 2019–20 on Vertisols at Regional Sugarcane and Rice Research Station, Rudrur, Nizamabad district, Telangana state, the validity of the soil test crop response (STCR) equation was examined. For a yield target of 110 t ha^{-1}, the treatments comprise farmers' fertilizer practises, RDF, and STCR-based fertilizer recommendations. Based on the initial soil test results of the individual locations, the N, P, and K fertilizers for the yield target were computed. According to the findings, STCR (110 t ha^{-1}) increased yield on average by 1.0% above blanket (100% RDF) and 3.7% over farmer's practise. The findings showed that the intended yield was attained by 5% after fertilizer application to the sugarcane crop in accordance with the yield target of 110 t ha^{-1}. A net reduction in the amount of P_2O_5 and K_2O fertilizers needed to achieve the current recommended dose of 41 kg and 37 kg ha^{-1}, respectively, and a saving of Rs. 2,275 in fertilizer costs per application per year. The STCR recommendations' (2.30) stronger benefit-to-cost ratio compared to those for farmers' practises (2.18). The sugarcane plant crop's fertilizer prescription equation was created, and it was determined to be suitable for achieving the target sugarcane yield of 110 t ha^{-1}.

Keywords: Field trails, STCR equation, sugarcane plant crop, validation.

INTRODUCTION

With a production of 22.17 lt and a productivity of 63.3 t ha^{-1}, sugarcane (*Saccharum officinarum* L.) is a significant cash crop in India and is planted on an area of 49.54 lha (Anonymous, 2018–19). With a production of 3950 lt and productivity of 79.80 t ha^{-1}, sugarcane is produced on an area of 0.35 lakh hectares in the Telangana region (Anonymous, 2018). Sugarcane is a massive crop that produces enormous amounts of biomass, so it often requires more water and nutrients. The application of sufficient levels of the fertilizer nutrients nitrogen, phosphorus, and potassium is crucial for producing increased cane and sugar yields on a sustainable basis, as shown by a vast number of research tests. Sugarcane is one of the most photosynthesis-efficient C4 plants, making it a high biomass generator.

The application of the proper amount of fertilizer, one of the most expensive inputs in agriculture, is essential for farm profitability and environmental conservation. By properly prescribing fertilizers to crops and maintaining soil fertility, soil testing becomes one of the crucial tools in enhancing agricultural production.Application of plant nutrients based on a soil test aids in achieving a higher response ratio and benefit: cost-to-benefit ratio because the nutrients are applied in accordance with the severity of a nutrient deficiency and the restoration of nutrient imbalance in the soil, which aids in utilising the synergistic advantages of balanced fertilization (Rao and Srivastava 2000).

For the purpose of prescribing fertilizers based on the results of soil testing and obtaining the desired yield of crops, soil test crop response (STCR) studies contribute to the development of fertilizer adjustment equations and calibration charts. It is now possible to create a fertilizer schedule that is yield target oriented and is based on the idea that crops should receive balanced nutrition. This is done by taking into account the soil fertility status, crop nutritional needs, efficiency of the soil and fertilizers, and the cultivator's financial situation (Velayutham *et al.,* 1984). Truog (1960); Ramamoorthy *et al.* (1967) established the theoretical foundation and practical evidence in India for the application of Liebig's rule of minimum to N, P, and K. For targeted yields, this serves as the foundation for fertilizer application.

A nutritional imbalance caused by the excessive and indiscriminate use of inorganic fertilizers reduces productivity and raises the cost of cane production. Sugarcane productivity would undoubtedly increase with greater soil health if enough inorganic fertilizers are used, coupled with organic manures and biofertilizers according to soil test results (Sakarvadia *et al.,* 2021). The target yield concept was reported to be superior to other approaches for various crops by Milap *et al.* (2006); Khosa *et al.* (2012); Sahu *et al.* (2017) because it produced greater yields, net benefits, and optimal economic returns. More or less successfully, the researchers are able to produce the desired yield of sugarcane (Potdar *et al.*, 2014; Kadu and Sonar 2007).

In studies comparing the responses of maize and fennel to soil tests, Singh *et al.* (2015); Singh *et al.* (2018) found greater correlation. In a study on direct seeded paddy, Vidyavathi and Kammar (2017) created soil test-based crop response correlation. For achieving desired yield targets, soil test-based fertilizer recommendations have been developed and validated in various crops grown in India, including cassava (Raghavaia *et al.*, 2008), finger millet (Kadu and Bulbule 2007), wheat (Sharma and Singh, 2005), potatoes (Chatarje *et al.*, 2010), onions (Saxena *et al.*, 2008; Meena *et al.*, 2001), and jute (Fertilizer prescription equations have been developed and validated for medicinal crops like ashwagandha (Santhi *et al.,* 2010) and glory lily (Sellamuthu *et al.,* 2015) under IPNS based on this concept.

Validation of the suitability of soil test-based fertilizer equations produced for a certain soil type and climate is necessary before using them in similar soil and climate circumstances. If the validation differs by more than 10%, it may be possible to refine the constant values used in the fertilizer equations by modifying the efficacy of the fertilizer, the soil test, and the organic source that was utilised for the study by using the nutrient missing plot technique.

Thus, the neutral to slightly alkaline Nizamabad (Telangana) Vertisols were used in the current study of sugarcane. The study's findings can be extrapolated if they are tested and confirmed at farmer holdings. Therefore, it is crucial to confirm a proper fertilizer prescription model in order to increase sugarcane yield and maintain soil health.

MATERIALS AND METHODS

Regional Sugarcane and Rice Research, Rudrur, conducted field tests for three years between 2017–2018 and 2019–2020. Below are provided the fertilizer prescription equations created for the specified sugarcane yield target.

A. STCR Equation for sugarcane plant crop

$FN=5.40\ T-1.42\ SN$ (1)

$FP_2O_5=1.80\ T-4.37SP$ (2)

$F\ K_2O=1.70\ T-0.33\ SK$ (3)

Where N, P, and K fertilizers, expressed in kg ha^{-1}, are indicated by FN, FP_2O_5, and FK_2O. T stands for the desired yield in tha^{-1}; SN, SP, and SK represent the soil's available N, P, and K, respectively, in $kgha^{-1}$. For a production target of 110 t ha^{-1}, the treatments comprise farmers' fertilizer practises, RDF, and soil test crop response (STCR) based fertilizer dose.

Initial soil samples were taken from each location and analysed for NH_4OAc-K, Olsen-P, and alkaline $KMnO_4$-N (Subbiah and Asija 1956). (Hanway and Heidal 1952). Initial analysis of native fertility showed that soils had little responsiveness to non-saline natural conditions. 189–201, 28–34, and 308–342 kg ha^{-1}, respectively, of available N, P, and K were classified as low, medium to high, and medium to high, respectively (Table 1). From Eksali 2017–18 through Eksali 2019–20, the sugarcane variety 83 R 186 used for the test crop was grown. BCR (B:C ratio) was calculated using the protocol (Gittinger, 1982). Periodically, cultivation procedures were carried out, and at harvest, cane production was reported.

Using fundamental information that was previously generated from fertility gradient field studies for sugarcane, adjustment equations were utilised to calculate fertilizer doses for sugarcane based on the availability status of nutrients. Velayutham*et al.* have provided a full description of the process (1984). The range of N, P_2O_5, and K_2O application rates under various treatments showed that STCR recommendations for N, P_2O_5, and K_2O were higher than those recommended by farmers. Fertilizer recommendations for sugarcane under various treatments over a three-year period showed that farmers typically practise N, P_2O_5, and K_2O recommendations of 325, 120, and 90 kg ha^{-1}, respectively, while STCR typically practise N, P_2O_5, and K_2O recommendations that ranged from 319, 59, and 83 kg ha^{-1}, respectively (Table 1). 250-100-120 kg N-P_2O_5-K_2O ha^{-1} of fertilizer should be applied to the sugarcane crop in the Telangana region.

Table 1: Fertilizer recommendations for sugarcane under different treatments (Pooled over three years).

Sr. No.	Name of the Farmer	Fertilizer recommendations (kg ha^{-1})		
		N	P_2O_5	K_2O
T_1	Farmer's practice	325	120	90
T_2	General Recommendation of fertilizers (RDF)	250	100	120
T_3	Sugarcane yield Target with chemical fertilizers	319	59	83

RESULTS AND DISCUSSION

In contrast to the goal sugarcane yield of 110 t ha^{-1}, the results showed that the cane yield in STCR's suggestion is 111 t ha^{-1}. According to the farmer's use of the recommended fertilizer, the yield is 107 t ha^{-1}, but the output from RDF is 110 t ha^{-1}. When compared to STCR and RDF recommendations, the cane yield obtained from farmers who followed fertilizer recommendations was lower. The average yield increase resulting from STCR (110 t ha^{-1}) was 1.0% above RDF (100% RDF) and 3.7% over farmer's practise. The findings showed that the sugarcane crop's desired yield was attained with a margin of 5% following fertilizer treatment in accordance with the production target of 110 t ha^{-1} (Table 2).

Table 2: Cane yield and Benefit Cost Ratio of sugarcane under different treatments (Pooled over three years).

Treatments	Name of the Farmer	Cane Yield (t ha^{-1})	Benefit- Cost Ratio
T_1	Farmer's practice	107	2.18
T_2	General Recommendation of fertilizers (RDF)	110	2.26
T_3	Target yield with chemical fertilizers	111	2.30

As evidence of the validity of the equations, Reddy and Ahmed (2000) validated the STCR equation for hybrid maize and reported that STCR-based fertilizer recommendations with the targeted yield were reached with a 10% deviation or less. Santhi *et al*. (2011) for beetroot, Sharma *et al.* (2015) for pearl millet, Bhatt *et al.* (2021) for Brinjal, Pogula *et al.* (2016) for French Bean; Madhavi *et al.* (2020) for seasmum all reported results that were comparable. Velayutham *et al.* (1984) discovered that the equations are determined to be valid if the targeted yield was attained within a 10% fluctuation. The validation experiment's findings on soybeans made it abundantly clear that the percent achievement was higher than 10% (72–91%). Variation was not achieved at any of the locations needed for validation. The desired soybean crop yield (Reddy *et al.,* 2020).

Using the input cost and output value, the benefit cost ratio of the therapies was calculated. Applying fertilizer economically using a targeted strategy resulted in a benefit cost ratio of 2.30. RDF and farmers' fertilizer use have equivalent values of 2.26 and 2.18, respectively (Table 2). The results show that the targeted yield strategy has a greater benefit-to-cost ratio than RDF and farmers' practises for applying fertilizer recommendations. Thetreatment of targeted yield found the most economic treatment as compared to farmer practices and general recommendation reported by Dey (2015).

Fig. 1. Overall view of the experimental site at Regional Sugarcane and Rice Research, Rudrur.

The sugarcane plant crop's fertilizer prescription equation was created, and it was determined to be suitable for achieving the target sugarcane yield of 110 t ha^{-1}. A net reduction in the amount of P_2O_5 and K_2O fertilizers needed to achieve the current recommended dose of 41 kg and 37 $kgha^{-1}$, respectively, and a saving of Rs. 2,275 in fertilizer costs per application per year.

CONCLUSION

The formulae for recommending fertilizer doses for sugarcane on vertisols were validated by the fact that the percentage of the planned yield was achieved with a variance of less than 5%. The development and maintenance of soil fertility as a result of the IPNS fertilizer recommendation based on soil test results were indicated by the post-harvest soil available N, P, and K status. For the Vertisols of the Nizamabad District to achieve a yield target of 110 t ha^{-1}, the STCR equation (FN=5.40 T-1.42 SN; FP_2O_5=1.80 T-4.37 SP; FK_2O=1.70 T-0.33 SK) developed for sugarcane plant crop can be advised, and it can be extrapolated to other districts of Telangana on similar and related soil types.

FUTURE SCOPE

STCR equations should be developed for different kinds of soils and can be extrapolated to other locations.

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Conflict of Intrest. None.

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