International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2021; 9(1): 3462-3468

Received: 07-10-2020
Accepted: 19-11-2020

T Sreelatha
Principal Scientist, Department of Soil Science, Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India

DV Ramana Reddy
Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India

CH S Ramalakshmi
Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India

Corresponding Author:
T Sreelatha
Principal Scientist, Department of Soil Science, Regional Agricultural Research Station, Anakapalle, Andhra Pradesh, India

Soil test based fertilizer prescriptions for specific targeted yield of sugarcane (*Ratoon*) in clay loam soils (*Inceptisols*) of north coastal Andhra Pradesh, India

T Sreelatha, DV Ramana Reddy and CH S Ramalakshmi

DOI: https://doi.org/10.22271/chemi.2021.v9.i1aw.11769

Abstract
Study on Soil Test Crop Response (STCR) was conducted on Sugarcane (ratoon) from 2009-10 to 2013-14 in clay loam soils (*Inceptisols*) of Regional Agricultural Research Station, Anakapalle of Andhra Pradesh with an objective of developing soil test based fertilizer recommendations for attaining yield targets under IPNS for North Coastal Andhra Pradesh. Field experiments *viz.* fertility gradient development with maize and test crop experiment with sugarcane (var. 2001A63) for two years were conducted from 2009-10 to 2013- 14.With the help of nutrient uptake, soil test values and average basic information necessary for establishment of fertilizer recommendations to different sugarcane production levels (70 t ha^{-1} and 80 t ha^{-1}) for ratoon crop were calibrated. The basic data was transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on initial values of soil testing by the procedures laid by Ramamoorthy *et al*. (1967) [14] and Velayudham and Rani Perumal (1976). The pooled equations for targeted yields developed from these basic data were FN=4.17T–0.43SN–0.03PMC N; FP_2O_5=1.05T–1.54SP–0.03PMC P; FK_2O=2.83T–0.36SK–0.03PMC K. Ready reckoner was prepared for fertilizer doses at different soil test values to grow sugarcane crop (*ratoon*) with interpretation of the devoloped equations for a range of soil test values and for targeted yields of 70 t ha^{-1} and 80 t ha^{-1} for sugarcane (*ratoon*). In the present study, there was a marked yield response was observed with the application of NPK fertilizers. However, the magnitude of response was higher under NPK with Press mud cake when compared to NPK alone. The prescription of fertilizer application can be extended to according to the soil nutrient status as indicated in the ready reckoner without extrapolation for sugarcane (ratoon) in the in clay loam soils (*Inceptisols*) of North Coastal Andhra Pradesh.

Keywords: Sugarcane, ratoon, soil test crop response studies, fertilizer prescription equations, press mud cake

Introduction
Sugarcane (*Saccharum officinarum*) is the most important sugar crop accounting for approximately 80 percent of world's sugar production (Islam *et al*., 2018; Sharma and Chandra, 2018) [7, 20]. It is also a crop with commercial importance in tropics and subtropics (35º N to 35º S) grown for sugar production on wide range of soils and also one of the major cash crops grown in India. Sugarcane crop involves less risk and farmers are assured about return up to some extent even under adverse condition. Sugarcane provides raw material for sugar industry which is the second biggest agro-based industry in India after textile industry. The sugar industry is instrumental in generating considerable employment in the rural sector directly and indirectly through its ancillary units. Therefore, sugar industry in India has been considered as vital consign with respect to socio-economic development in rural areas through mobilization of rural resources, employment generation and farm income enhancement.
In Andhra Pradesh during 2016-17, sugarcane is grown over an area of 1.03 lakh hectares with 78.3 lakh tonnes of annual cane production and productivity of 76.0 t ha^{-1} (Anonymous, 2017) [1]. It is also an important agro industrial commercial crop grown in North Coastal Andhra Pradesh, India. However, nutrient management play key role in productivity enhancement of sugarcane.

Fertilizer is considered as major costlier agricultural input and its application in efficient and effective means is found critical in increasing agricultural profitability. The hike in fertilizer prices insist on the right quantity of fertilizer application which is considered as fundamental for farm profitability as well as protection of environment. The fertilizer requirement changes from crop to crop due to variations in production potential, soil nutrients drawing ability in mineralized form and nutrient additions through fertilizers. Soil testing is an important pre-requisite to recognize nutrient imbalance in the soils in order to supply required amounts of the nutrients to correct the imbalance, soil health maintenance, optimization of the crop nutrition for getting higher yields and also to fetch lucrative profits. In recent studies it has been revealed that severe depletion of soil nutrient reserves are occurring due to continuous use of sub-optimal doses of plant nutrients in exhaustive cropping system. Therefore, this system of fertilizer application causing multiple nutrient deficiencies in long run (Jones *et al.,* 2013; Lal, 2015) [9, 11]. No single dose of plant nutrient supplied through fertilizers, organic manures, crop residues or bio-fertilizers can meet the entire crop nutrient requirement in modern intensive agriculture (Gangwar *et al.,* 2016; Jemila *et al.,*2017a; Udayakumar and Santhi, 2017; Sekaran *et al.,* 2018) [6, 8, 26, 19]. Rather, use of all nutrient sources in integrated manner by following a management technology which is practicable, socially acceptable, economically viable and ecologically sound. It is possible to restore and sustain soil fertility as well as crop productivity, preventing secondary and micronutrient deficiencies, fertilizer use economy and improvement in nutrient use efficiency by adaptation of STCR based integrated plant nutrition system (IPNS).This system adoption can also create positive effect on the soil physical, inorganic and biological health (Udayakumar and Santhi, 2017; Singh *et al.,* 2012) [26, 21].

Fertilizer requirement to any crop mainly depends upon the initial soil nutrient status and the targeted yields to be achieved. Hence, to achieve targeted crop yield, a specific amount of nutrients to that particular crop must be applied and this requirement of nutrients may be calculated by captivating the contribution of available nutrients supplied from soil and nutrients applied through fertilizers for total uptake into consideration, which forms the base for fertilizer recommendation to attain targeted yield of crops (Subba Rao and Srivastava, 2001) [23].

For the plant soil system, this type of approach is also inimitable as it provides key scientific basis for evenhanded fertilization not only available soil nutrients but also among the fertilizer nutrients themselves (Deshmukh, 2008) [5]. Such considerations may hold good for huge soil fertility variation from field to field. Therefore, the theory specific prescription based fertilizer recommendation to a crop for a specified environment and for a specified soil was proposed through equations based on targeted yield which were developed by Truog (1960) [25] to overcome this constraint. Among the different methods of fertilizer recommendations, the one i.e. based on targeting the yield is exclusive as this method not only consider the crop yield of that particular cultivator can attain if good agronomic management practices are followed to raise the crop but also soil test based fertilizer dose into consideration.

Soil test calibration is projected to establish correlation between the crop response to fertilizers and the soil nutrient levels observed in the field as estimated in the laboratory which permits balanced fertilization for crops (Rao and Srivastava, 1999) [16]. The great intricacy in the soil test and crop response accrues due to variation of soils, climates, crops and management practices. Therefore, a well recognized soil test calibration will be helpful for application of fertilizers in accurate amounts and also to obtain high fertilizer use efficiency, thereby maximum achievable yield in an agricultural eco-system. However, the targeted crop yield approach based on soil test and crop correlation studies which was developed by Ramamoorthy *et al.* (1967) [14] has been adopted effectively for the first time in India all the way through the results from Soil Test Crop Response Correlation studies obtained from the national net work project of All India Coordinated Research Project on Soil Test Crop Response Correlation studies. However, the basic experimental data required to formulate crop fertilizer recommendations based on targeted yield approach are the contribution (%) from available soil nutrients; nutrient requirement in kgq^{-1} produce (economic produce *viz*., grain, cane etc.,) and contribution (%) from the fertilizer nutrients.

Sugarcane is exhaustive crop with 10 - 14 months duration, which produce large quantum of biomass and removes substantial quantity of soil nutrients for its growth and development. Further, it has been calculated that sugarcane of 100 tonnes that produced from a hectare land, remove 140, 34 and 332 kg of NPK ha^{-1}, respectively, from the soil (Bokhtiar *et al.,* 2001) [3]. A number of researchers have established the positive effect of collective use of organic and chemical fertilizers for mitigating the deficiencies of several secondary and micro nutrients in field that continuously received only N, P and K fertilizers for several years, without application of either micronutrients or organic manures. Bokhtiar *et al.* (2015) [2] emphasized that collective application of enriched/ raw press mud along with chemical fertilizers enhanced sugarcane yield and the cumulative effect was much distinct at elevated fertilizer levels (100% Recommended Dose of Fertilizers). Ramalakshmi *et al*. (2011) [15] observed that integrated use of both manures (organic) and fertilizers(inorganic) produced not only sustainable higher cane yields but also maintained the soil fertility.

In Andhra Pradesh, fertilizer equations for targeted crop yields were developed for majority field crops (Reddy and Ahmed, 2000; Reddy *et al*., 1999; Khadke and Ahmed, 2000; Sreedevi *et al*., 2001; Meena *et al*., 2001; Swetha, 2006 and Chhetri Binoy, 2006) [10, 17, 10, 22, 12, 24, 4]. The results of all these experiments were encouraging and the equations derived for the targeted yields were tested and found to be satisfactory on farmer's fields also.

Ratooning is distinctive natural peculiarity associated with the majority of the crops like red gram, banana, cotton, sugarcane, jowar. Nevertheless, it is explored commercially in sugarcane under Indian circumstances. The typical features of a crop grown as ratoon is such that when shoot segment is harvested, the remaining root system will upshot into fresh tillers from secondary shoots and one more crop can be harvested in the subsequent year. General false impression among the sugarcane farmers is that the ratoon yields are at all times lower than the maiden/ plant crop. Due to this impression, least interest is paid for all cultural and nutrient management practices for the ratoon cane crop. On contrary, though not superior, at least equal yields can be obtained from the ratoon crop by inclusion of certain essential management strategies. Before suggesting the new technology for ratoon yield enhancement, it is high time to address the situation and probe into the management practices which are actually responsible for lower yields. Obviously, against the myth prevailing among the growers, nutrient requirements higher for the ratoon crop, therefore the fertilizer application must be scheduled in order to congregate the enhanced demand by the succeeding ratoon crop (Prasanna and Pattar, 2014) [13]. Hence, in order to generate information to provide fertilizer recommendations based on the soil testing for sugarcane ratoon crop, an experiment on sugarcane was conducted from 2009- 10 to 2013-14 in clay loam soils (*Inceptisols*) of RARS, Anakapalle of North Coastal Andhra Pradesh.

Materials and Methods

Soil Test Crop Response (STCR) studies were conducted on Sugarcane (ratoon) from 2009- 10 to 2013-14 in clay loam soils (*Inceptisols*) of Regional Agricultural Research Station, Anakapalle of Andhra Pradesh with an objective of developing fertilizer recommendations based on soil testing for attaining targeted yields under IPNS. With the help of nutrient uptake, soil test results and average basic data (i.e nutrient requirement of N,P and K percent contribution of N,P & K from soil, fertilizer and Press mud cake) required for creating fertilizer recommendations for different sugarcane production levels (70 t ha^{-1} and 80 t ha^{-1}) for ratoon crop were calibrated. The basic data was transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on soil test values (initial) by the procedures laid by Ramamoorthy *et al*. (1967) [14] and Velayudham and Rani Perumal (1976) [27].

The major aim of the experiment on Soil Test Crop Response was to produce a group of data points with a wide range of values for each controllable variable of NPK fertilizers at different levels of soil available which are uncontrollable fertility variables. To accomplish this objective, an experiment on fertility gradient was conducted to maximize homogeneity within each soil fertility gradient and heterogeneity between different fertility gradients with respect to soil available nutrients, management practices adopted under prevailing climatic conditions.

Field experiments *viz*. fertility gradient development with maize and test crop experiment with sugarcane (var. 2001A63) for four years were conducted at Regional Agricultural Research Station, Anakapalle from 2009 to 2014 to develop the Soil Test Based Target Yield Equations for sugarcane on clay loam soils (*Inceptisols*). The experimental site is located geographically at 17° 40' 48.00" N latitude and 83° 01' 12.00" E longitude and at an altitude of 29 meters above the mean sea level. Composite soil sample was drawn from 0 to 30 cm depth at random in a zig zag manner, in the entire field prior to initiation of the experiment and the sample was analyzed for different soil physico–chemical properties by adopting standard analytical procedures. Initial soil properties of first season field was found neutral and non-saline in reaction have a pH of 7.26 and Electrical Conductivity of 0.09 dSm^{-1}. There was medium organic carbon content of 0.52 per cent. The fertility status of experimental field in terms of available nitrogen was 239, available P_2O_5 was 32.10 and available K_2O was 252 $kgha^{-1}$. The field selected for second season experimentation was in close proximity to the first season field. The second season field soil was also clay loam in texture. Initial soil properties of second season field was found neutral and non-saline in reaction have a pH of 7.25 and Electrical Conductivity 0.29 dSm^{-1} and low organic carbon content of 0.49 per cent. The fertility status with respect to available nitrogen was 240, available P_2O_5 recorded was 34.56 and available K_2O 281 kg ha^{-1}. P fixation capacity of the soil calculated was 75 percent.

Thus, in the gradient experiment, the experimental plot was equally divided into three strips, the first strip not received any fertilizer` ($N_0P_0K_0$), second and third strips which received one ($N_1P_1K_1$) and two ($N_2P_2K_2$) times the standard recommended dose of N, P_2O_5 and K_2O, respectively. Maize was grown as gradient crop during late *kharif* 2010-11 in order to develop fertility gradients. These strips were named as OX, 1X and 2X depending on the amount of fertilizers added. Collected soil samples from each fertility strip after harvest and the samples were estimated for available soil nutrient status and P fixing capacity of soil. The P fixation capacity was done in this soil before P fertilizer application. The quantity of P_2O_5 to be applied in different strips was arrived such that to give 20 ppm, and 40 ppm available P in 1X and 2X strips respectively taking into consideration of P fixation capacity of the soil. Quantity of fertilizers added to develop fertility gradients were as follows.

Treatments adopted

S. No.	Fertility gradient strip	Doses of fertilizers applied (kg ha^{-1}) N	K
1	0X	0	0
2	1X	150	200
3	2X	300	400

Soil samples were collected at 0-15 cm depth from each plot for estimation of available N, P and K before imposing treatments. After exhaust crop (Maize) harvesting at tasselling stage, the land was prepared without unsettling the fertility gradient strips. Each fertility gradient strip was sub-divided into 21 sub-plots with plot size of 40 sq. m and 80 cm (row to row) spacing. Out of which 18 sub-plots were received selected treatmental combinations from three levels of N, three levels of P_2O_5, three levels of K_2O and three plots as control and the experimental design was Mixed Factorial RBD. The combined levels of NPK and three unfertilized controls were randomly allocated in every fertility gradient strip for soil test crop response trial in accordance with the commendation by the All India Coordinated Research Project on soil test crop response correlation studies (www.iasi, res.in). As per the treatments, fertilizers were applied to the plots and the treatments were combination of Four levels each of N, P and K. Test crop(sugarcane)/ main trial was conducted with three levels of chemical fertilizers N (0, 56,112 and 168 kg ha^{-1}), P_2O_5 (0, 50, 100 and 150 kg ha^{-1}) and K_2O (0, 60,120 and 180 kg ha^{-1}) and with three levels of PMC (0, 6 and 12 t ha^{-1}).The treatments *viz*., NPK alone, NPK+ PMC @ 6 t ha^{-1} and NPK+PMC @ 12 t ha^{-1} were superimposed across the strips. First year sugarcane crop was planted on 02.05.2011 and harvested on 15.03.2012 and second year sugarcane crop was planted on 25.04.2012 and harvested on 08.03.2013. Left for ratoon after harvest of main crop and ratoon crops were harvested on 22.12.2012 and 10.12.2013 for first year and second year ratoons, respectively. The fertilizers were applied to the plots as per the treatments to ratoon crop and treatments were Four levels of each N, P and K in combination. Test crop (sugarcane ratoon)/ main experimentation was conducted with three levels of chemical fertilizers N (0, 112,224 and 336 kg ha^{-1}), P_2O_5 (0, 50, 100 and 150 kg ha^{-1}) and K_2O (0, 60,120 and 180 kg ha^{-1}) and with three levels of PMC (0, 6 and 12 t ha-1). The treatments *viz*., NPK alone, NPK+ PMC @ 6 t ha^{-1} and NPK+PMC @ 12 t ha^{-1} were superimposed across the strips. Plant samples (cane & leaf) collected at harvest were analyzed for percent N, P and K. Cane as well as leaf dry matter yield from each treat mental plot was recorded and calculation was done for uptake of nutrients. The details of cane yield, soil test values and uptake of nutrients are presented in Appendix I and II. The basic parameters (Three) required to compute the targeted yield were worked out by following the method laid out by Ramamoorthy *et al*. (1967) [14] as follows.

Nutrient Requirement (N, P and K) for Sugarcane Production

$$\text{Kg of nutrient required to produce one quintal of economic produce (NR)} = \frac{\text{Total uptake of nutrient (kg)}}{\text{Cane yield (q ha}^{-1}\text{)}}$$

Percent Nutrient Contribution from Soil (CS)

$$\text{Percent Contribution of Nutrient from Soil (CS)} = \frac{\text{Total uptake in control plots (kg ha}^{-1}\text{) X 100}}{\text{Soil test values of nutrient in control plots (kg ha}^{-1}\text{)}}$$

Percent Nutrient Contribution from Fertilizers (CF)

$$\text{\% Contribution of nutrients from fertilizers} = \frac{\left(\text{Nutrient uptake kg/ha}\right) - \left(\text{Available soil test value kg/ha} \times \text{\% contribution of nutrients from soil}/100\right)}{\text{fertilizer nutrient applied kg/ha}} \times 100$$

Targeted Yield Equation: It was worked out as follows

$$T = \left(\frac{\text{Nutrient requirement}}{\text{\% contribution from fertilizer}} \times T\right) - \left(\frac{\text{\%contribution from soil}}{\text{\%contribution from fertilizer}} \times \text{Soil test value for available nutrient}\right)$$

Calculation of Fertilizer Dose

The basic data are transformed into workable adjustment equation as follows:

$$\text{Fertilizer dose} = \frac{\text{Nutrient required in kg/q of grain}}{\text{\% CF}} \times 100 \times T - \frac{\text{\% CS}}{\text{\% CF}} \times \text{Soil test value}$$

Results and Discussion

The ferstilizer prescription concept for desired yield based on soil available nutrients was developed by Truog (1960) [25] and later on tested in India by Ramamoorthy *et al*., (1967) [14] based on the assumption that the relationship between yield of sugarcane and uptake of nutrients follow linear relationship. Therefore, the requirement of fertilizer can be estimated through the basic data. In the present investigation, the basic data on nutrient requirement to produce for every kg of sugarcane (ratoon) and N P K contribution from the soil and through fertilizers was presented in Table 1.

Table 1: Basic Experimental Data on Nutrient Requirement, Soil and Fertilizer Efficiency of Sugarcane (Ratoon)

Nutrient	2012-13				2013-14			
	NR (kgq^{-1})	SE (%)	FE (%)	OME (%)	NR (kgq^{-1})	SE (%)	FE (%)	OME (%)
N	3.24	32.92	77.81	1.12	3.32	33.84	78.71	4.12
P	0.90	214.32	87.62	1.42	0.94	54.36	89.38	3.42
K	3.56	45.76	195.2	1.46	3.64	46.65	95.2	4.46
Response yard- stick (kg/kg)	14.35				10.98			

The sugarcane ratoon crop required 3.24 kg N, 0.90 kg P and 3.56 kg K ha^{-1} to produce one quintal of sugarcane during the first year ratoon i.e. 2012-13. The requirement of these nutrients was 3.32 kg N, 0.94 kg P and 46.65 kg during the second year ratoon (2013-14). The efficiency of soil was estimated to be 32.92 percent for soil available N during the first year and 33.84 per cent in the second year. However, the N contribution through fertilizer was calculated to be 77.81 per cent and 78.71 per cent in first and second years, respectively. Whereas, the contribution of N through the organic manures (PMC) was 1.12 percent and 4.12 percent during first and second years, respectively. The efficiency of the soil supplied P for the formation of cane was 214.32 percent in the first year and 54.36 percent in the second year. The fertilizer contributed 87.62 and 89.38 percent P and the organic manure (PMC) contribution was 1.42 and 3.42 during 2012-13 and 2013-14, respectively. The efficiency of soil to supply potassium was 45.76 and 46.65 percent of its available content during the two years i.e. during 2012-13 and 2013-14, respectively. The contribution of potassium through the fertilizer was 195.2 per cent in the first year and 95.2 percent in second year. Whereas, the contribution of potassium through the organic manure (PMC) recorded was 1.46 percent during the first year and 4.46 percent during second year. The response yard stick (kg output /kg input) was found to be 14.35 and 4.46 during two years i.e. 2012-13 and 2013-14, respectively based on target yield coefficients. Adjustment equations were generated based on the basic data, to predict the nutrient requirement for the targeted yield of 70 and 80 tha^{-1} sugarcane yields for different soil test ranges created inside the experiment during every year and the data was pooled up for the two years (Table 2).

Table 2: Targeted yield equations obtained from basic data for Sugarcane Ratoon crop

2012-13	2013-14	Pooled
FN=4.11T – 0.42 SN– 0.01 PMC N	FN=4.22 T– 0.43 SN– 0.05 PMC N	FN=4.17T–0.43SN–0.03PMC N
FP_2O_5=1.03T–2.45 SP–0.02PMC P	FP_2O_5=1.07T–0.62SP–0.04PMC P	FP_2O_5=1.05T–1.54SP–0.03PMC P
FK_2O=1.83T– 0.23SK –0.01 PMC K	FK_2O=3.82T– 0.49SK–0.05PMC K	FK_2O=2.83T–0.36SK–0.03PMC K

Ready Reckoner developed for Soil Test based Fertilizer Recommendations

The basic experimental data was transformed into simple workable fertilizer prescription equations for calculating fertilizer doses based on initial soil test values by the procedures laid by Ramamoorthy *et al*. (1967) [14] and Velayudham and Rani Perumal (1976) [27]. Ready reckoner of fertilizer doses (Table3) at different soil test values for sugarcane (ratoon) was prepared using these equations for a wide range of soil test values and for the yield targets of 70 t ha^{-1} and 80 t ha^{-1} for sugarcane (ratoon). Ready reckoner for fertilizer requirement was also developed for Chemical fertilizers alone and Chemical fertilizers + Pressmud cake @ 6 t ha^{-1}. Where, FN, FP_2O_5 and FK_2O are fertilizer N, P_2O_5 and K_2O in kg ha^{-1}, respectively; T is yield target in q ha^{-1} and SN, SP and SK, respectively are soil available N, available P and available K in kg ha^{-1}.

Table 3: Ready reckoner developed for fertilizer doses at different soil test values for sugarcane ratoon crop

Soil nutrients kg ha^{-1}			**Target = 70 t ha^{-1}**			**Target = 80 t ha^{-1}**		
SN	**SP**	**SK**	**FN**	**FP**	**FK**	**FN**	**FP**	**FK**
Only Chemical fertilizers								
150	6	150	225	57	92	266	68	111
175	8	175	214	52	86	256	63	105
200	10	200	204	47	81	245	58	99
225	12	225	193	42	75	235	53	93
250	14	250	183	37	69	225	48	87
275	16	275	173	33	63	214	43	82
300	18	300	163	28	57	204	38	76
325	20	325	152	23	52	193	33	70
350	22	350	142	18	46	183	29	64
Chemical fertilizers + Pressmud cake @ 6 t ha-1								
150	6	150	225	57	92	266	67	111
175	8	175	214	52	86	255	62	105
200	10	200	204	47	81	245	57	99
225	12	225	193	42	75	234	52	93
250	14	250	183	37	69	224	47	87
275	16	275	172	32	63	214	43	82
300	18	300	162	27	57	204	38	76
325	20	325	151	22	51	193	33	70
350	22	350	141	17	45	183	29	64

The ready reckoner devoloped for fertilizer application to attain desired yield level of 70 and 80 T cane yield of sugarcane (ratoon) for varying soil nutrient test values ranging from 150 to 350 kg Nitrogen, Phosphors from 6 to 22 and Potassium from 150 to 350 kg ha^{-1} for application of Chemical fertilizers alone and Chemical fertilizers + Pressmud cake @ 6 t ha^{-1} is furnished in table 3. For achieving yield target of 80 T ha^{-1} of sugarcane (ratoon) with a soil test value of 200, 10 and 200 kg ha^{-1} of available N, available P and available K, the fertilizer N, P_2O_5 and K_2O doses required were 245, 58 and 99 kg ha^{-1}, respectively with NPK alone and the requirement was further reduced with NPK + PMC @ 6 t ha^{-1}.

The previous experimental results conducted by several investigators indicated that nutrient requirement needed to produce one ton of sugarcane/ratoon considerably varied even for the same sugarcane crop. By taking the basic experimental data as base, generated adjustment equations to envisage the nutrient requirement for the targeted cane yield (70 and 80 t ha^{-1}) of sugarcane ratoon for different soil test ranges created within the experiment during both the years. The ready reckoner for prescription of optimum level of fertilizers based on available soil nutrients was not consistent during two repeated years. Hence, composite adjustment equation was devoloped by pooling the basic data over the two years and a ready reckoner for fertilizer prescriptions to 70 and 80 t ha^{-1} cane yield of sugarcane ratoon in the clay loam soils (*Inceptisols*) of North Coastal Andhra Pradesh is furnished.

Rao and Srivasthava (1999) [16] in their critical and exhaustive review, reported that the adjustment equation devolope for a particular crop or variety of a crops varied in different seasons or years due to weather changes. Therefore, the soil test calibrations derived from the equations were also found varying from year to year. Therefore, they suggested that the promising approach to overcome this problem is to create a composite adjustment equation by pooling the basic experimental data over the years. The fertilizer recommendations that were derived from such an approach may be more suitable and less subjected to fluctuations due to seasonal or weather related changes.

Summary

The results on valuation of fertilizer responses highlighted the effectiveness to apply liberal dose of nutrients up to 266 kg N, 68 kg P_2O_5 and 111 kg K_2O ha^{-1} to realize high cane yield and considerable profits. In the present study, there was a noticeable response to the application of NPK fertilizers; the magnitude of response was higher under NPK with Press mud cake as compared to NPK alone. The percent reduction in NPK fertilizers under application of NPK alone and NPK in addition with Press mud cake also amplified with increasing soil fertility levels. These may perhaps be achieved by integrated use of Press mud cake along with NPK fertilizers. The targeted yield equations were considered more realistic to provide ready reckoner for fertilizer application rates that are conservative and evenhanded for desired yield goals of 70 or 80 t ha^{-1} to suit the highly variable soil available nutrients that vary from field to field and the investment capacity of the farmer. The prescription of fertilizer application rates even can be extended to the soil available nutrients indicated in the ready reckoner without any extrapolation in the clay loam soils (*Inceptisols*) of North Coastal Andhra Pradesh.

Appendix I: Cane yield, soil test values and uptake of nutrients for First season sugarcane ratoon crop Location: RARS, Anakapalle Season/Year: Ratoon crop 2012-13 Date of harvest: 22.12.2012

Sl. No.	Cane Yield (t ha-1)	Total uptake (kg ha^{-1})			Soil test values			Press mud cake (t ha-1)	Fertilizer doses (kg ha^{-1})		
		N	P	K	$KMnO_4$-N (kg ha^{-1})	Olsen's P (kg ha^{-1})	Amm. Ac.K (kg ha^{-1})		N	P_2O_5	K_2O
1	31.85	70.2	26.2	92.1	229	12.8	202.6	0	0	0	0
2	71.55	253.8	69.1	268.9	254	15.5	247.4	0	336	50	60
3	72.51	228.4	60.5	262.4	257	15.3	262.3	0	336	100	120
4	68.65	239.6	65.7	267.4	246	16.1	267.3	0	224	100	60
5	66.50	226.5	59.2	251.2	242	16.3	262.3	0	112	50	60
6	70.57	256.5	70.2	269.4	251	15.5	244.9	0	224	150	180
7	70.17	255.1	71.8	269.0	249	15.9	264.8	0	224	50	120
8	33.50	73.2	28.2	94.2	232	13.3	200.1	6	0	0	0
9	72.16	257.2	70.2	270.5	256	15.9	250.7	6	336	100	60
10	71.26	238.6	63.2	261.5	248	15.8	267.3	6	112	100	120
11	73.17	243.5	66.4	266.5	248	16.2	271.5	6	224	150	120
12	71.99	254.1	69.9	269.0	249	16.5	269.0	6	224	50	60
13	68.54	229.5	62.2	252.3	243	15.9	247.4	6	112	50	120
14	73.39	256.5	71.5	271.1	259	16.3	269.0	6	336	150	120
15	38.10	73.8	32.1	95.3	233	14.0	205.0	12	0	0	0
16	72.49	262.4	72.6	271.1	251	16.1	254.0	12	336	150	60
17	72.85	266.4	73.5	272.6	253	16.0	270.6	12	224	100	120
18	76.06	250.8	68.5	269.6	250	16.2	274.8	12	336	100	180
19	72.24	231.2	64.1	253.4	245	16.6	271.5	12	224	100	180
20	69.88	240.7	65.2	264.4	251	16.2	252.4	12	112	100	60
21	76.24	265.3	73.5	272.2	261	17.2	279.8	12	336	150	180

Appendix 2: Cane yield, soil test values and uptake of nutrients for Second season sugarcane ratoon crop Location: RARS, Anakapalle Season / Year: Ratoon crop 2013-14 Date of harvest: 10.12.2013

Sl. No.	Cane yield (t ha^{-1})	Total uptake (kg ha^{-1})			Soil test values			Pressmud cake (t ha^{-1}) N	Fertilizer doses (kg ha^{-1})		
		N	P	K	$KMnO_4$-N (kg ha^{-1})	Olsen's P (kg ha^{-1})	Amm. Ac.K (kg ha^{-1})		N	P_2O_5	K_2O
1	35.50	70.8	26.4	96.2	237	14	197.3	0	0	0	0
2	76.56	248.5	70.2	270.1	265	16	243.7	0	336	150	60
3	71.50	229.4	59.2	258.8	258	16.6	247.1	0	224	100	120
4	75.40	240.5	65.5	264.1	262	17.1	247.9	0	336	100	180
5	72.15	251.7	69.4	266.2	257	17.2	256.2	0	224	100	180
6	70.15	226.4	59.2	250.1	252	17.5	247.1	0	112	100	60
7	75.75	253.5	71.2	267.4	268	17.9	257.9	0	336	150	180
8	39.85	74.2	28.2	98.3	241	14.7	200.6	6	0	0	0
9	75.65	258.8	68.4	267.4	268	18.3	249.6	6	336	50	60
10	77.10	234.7	61.2	259.7	267	16.8	247.9	6	336	100	120
11	74.50	241.6	66.2	265.3	258	17.3	247.9	6	224	100	60
12	71.85	230.6	60.2	253.2	260	17.4	266.2	6	112	50	60
13	76.63	254.5	73.1	271.2	255	17.7	250.4	6	224	150	180
14	72.81	256.4	73.5	270.5	260	16	252.9	6	224	50	120
15	41.55	75.1	31.1	99.4	243	15.3	204.7	12	0	0	0
16	78.20	259.5	71.5	269.3	265	16.6	252.9	12	336	100	60
17	74.65	256.3	74.2	272.3	260	17.5	253.7	12	112	100	120
18	78.3	244.5	68.4	267.3	261	17.4	264.5	12	224	150	120
19	76.15	230.8	63.2	254.3	261	17.5	257.9	12	224	50	60
20	72.50	238.1	64.3	263	257	17.6	252.9	12	112	50	120
21	78.72	262.2	74	271.6	272	18.5	261.2	12	336	150	120

Funding: This study was funded by Acharya NG Ranga Agriculture University and All India Co-ordinated Research Project on Soil Test Crop Response studies.

Conflict of Interest: The authors declaring that we have no conflict of interest.

Acknowledgements: The authors are thankful to the Associate Director of Research, Regional Agricultural Research Station, Anakapalle and Principal Scientist (Sugarcane) for providing facilities for conducting the experiment at Regional Agricultural Research Station, Anakapalle and for their valuable suggestions in preparing the research paper.

References

1. Anonymous. Agricultural Statistics at a glance. Department of Agriculture and Cooperation, Directorate of Economics and Statistics, Ministry of Agriculture, Government of India 2017.
2. Bokhtiar S, Roksana MS, Moslehuddin AZM. Soil fertility and productivity of sugarcane influ-enced by enriched pressmud compost with chemical fertilizers. SAARC Journal of Agriculture 2015;13(2):183-197.

3. Bokhtiar SM, Paul GC, Rashid MA, Rahman ABM. Effect of press mud and oganic nitrogen on soil fertility and yield of sugarcane grown in high Ganges river flood plain soils of Bangladesh. Indian Sugar 2001;L1:235-240.
4. Chhetri Binoy. Soil test crop response correlation studies in Indian mustard M. Sc (Ag). Thesis submitted to the Acharya N G Ranga Agricultural University, Rajendranagar, and Hyderabad 2006.
5. Deshmukh AK. Response of chilli (*Capsicum annuum* L.) to site specific nutrient management through targeted yield approach in northern transition zone of Karnataka. M. Sc. (Agri.) Thesis, Univ. Agric. Sci., Dharwad, Karnataka (India) 2008.
6. Gangwar S, Naik KR, Jha A, Bajpai A. Soil properties as influenced by organic nutrient management practices under rice-based cropping systems. Res. Crops 2016;17:8-12.
7. Islam MS, Yang XP, Sood S, Comstock JC, Wang JP. Molecular characterization of genetic basis of sugarcane Yellow Leaf Virus (SCYLV) resistance in *Saccharum* spp. Hybrid. Plant breeding 2018;137:598-604.
8. Jemila C, Saliha BB, Udayakumar S. Evaluating the effect of phosphatic fertilizers on soil and plant P vailability and maximising rice crop yield. *Oryza* 2017a;54:305-13.
9. Jones DL, Cross P, Withers PJA, DeLuca TH, Robinson DA, Quilliam RS *et al*. Nutrient stripping: The global disparity between food security and soil nutrient stocks. J Appl. Ecol 2013;50:851-62.
10. Khadke KM, Ahmed S, Riazuddin. Soil test based fertilizers doses for targeted yield of rainfed castor grown on alfisols. Journal of Oilseeds Research 2000;17(2):265-270.
11. Lal R. Restoring soil quality to mitigate soil degradation. Sustainability 2015;7:5875-95.
12. Meena A, Ahmed Riazuddin S, Reddy Chandrasekhara K, Prasad BRC. Soil test crop response calibration studies on onion (*Allium cepa*) in Alfisols. Journal of the Indian Society of Soil Science 2001;49(4):709-716.
13. Prasanna SM, Pattar PS. Successful Ratoon Management in Sugarcane. Research and Reviews: Journal of Agriculture and Allied Sciences 2014;3(4):39-47.
14. Ramamoorthy B, Narasimhan RL, Dinesh RS. Fertilizer application for specific yield targets of Sonara-64. Indian Farming 1967;5:43-45.
15. Ramalakshmi Ch S, Sreelatha T, Usha Rani T, Rao SRK, Naidu NV. Effect of organic manures on soil fertility and productivity of sugarcane in North coastal zone of Andhra Pradesh. Indian Journal Agricultural Research 2011;45(4):307-313.
16. Rao Subba A, Srivastava Sanjay. Experiences on current status of crop responses to fertilizers in different Agro-climatic Zones as learnt from all India coordination research project on soil test crop response correlation. Fertilizer News 1999;44(4):83-95.
17. Reddy K, Chandrasekhar, Ahmed S, Riazuddin. Soil test based fertilizer recommendation for groundnut grown in rice fallow (Inceptisols) of Jagtial in Andhra Pradesh. Journal of Oilseeds Research 1999;16(2):257-262.
18. Reddy K, Chandrasekhar, Ahmed S, Riazuddin. Soil test based fertilizer recommendation for maize growth in Inceptisols of Jagtiyal in Andhra Pradesh. Journal of the Indian Society of Soil Science 2000;48(1):84-89.
19. Sekaran U, McCoy C, Kumar S, Subramanian S. Soil microbial community structure and enzymatic activity responses to nitrogen management and landscape positions in switchgrass (*Panicum virgatum* L.). Gcb Bioenergy 2018. https://doi.org/10.1111/gcbb.12591.
20. Sharma A, Chandra A. Identification of new leuconostoc species responsible for post-harvest sucrose losses in sugarcane. Sugar Tech 2018;20:492-496.
21. Singh M, Dwivedi BS, Datta SP. Integrated nutrient management for enhancing productivity, nutrient use efficiency and environmental quality. Soil Science in the Service of Nation' (ed. Goswami, N. N.), New Delhi 2012, 55-67.
22. Sreedevi C, Ahmed Riazudin S, Rao BRC, Prasad, Reddy Chandrasekhar K. Soil test based fertilizer prescription for maximum yield and profit in sunflower (*Helianthus annuus* L.) in vertisols of Andhra Pradesh. Journal of Oilseeds Research 2001;18(2):220-223.
23. Subba Rao A, Srivastava S. Soil Test-based Fertilizer Recommendations for targeted Yield of Crops. Indian Institute of Soil Science, Bhopal, Madhya Pradesh, India 2001, 326.
24. Swetha G. Soil test crop response correlation studies in cabbage. M.Sc (Ag). Thesis submitted to the Acharya N G Ranga Agricultural University, Rajendranagar, Hyderabad 2006.
25. Troug E. Fifty years of soil testing, transactions of 7th International Congress of Soil Science. Vol. III, Commission IV. Paper No. 1960, 746-53.
26. Udayakumar S, Santhi R. Soil test based integrated plant nutrition system for pearl millet on an Inceptisol. Res. Crops 2017;18:21-28.
27. Velayudham, Rani Perumal. Fertilizer Use under Multiple Cropping Systems. U.S. Department of Agriculture, National Agricultural Library, Volume 89, Issues 11-89, 1976.