Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.5418

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **5 (6):** 408-415 (2017)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Nutrient Requirements of Maize Based on Soil Test Crop Response Correlation Approach

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Received: 10.08.2017 | Revised: 28.09.2017 | Accepted: 1.10.2017

ABSTRACT

*Field experiment on maize was conducted at College Farm, Acharya NG Ranga Agricultural University (Now PJTSAU), Rajendranagar, Hyderabad, Telangana state, India, using 18 fertilized and 3 unfertilized (control) combinations of N, P_2O_5, K_2O and VC. The basic parameter viz., nutrient requirement (NR Kg/q) per cent contribution from soil (%CS) and per cent contribution from fertilizers, were calculated and using these basic parameters, fertilizer prescription equations for target yield targeting in kharif maize were developed. The result shows the correlation between yield (grain and dry matter) and other parameters like soil, plant uptake and fertilizer nutrients applied in maize. The grain yield had a significant correlation with soil N (0.58**), soil P (0.71**) and soil K (0.30**). The plant uptake N (0.93**), uptake P (0.91**) and uptake K (0.86**), similarly the grain yield had a high and significant correlation with fertilizer N (0.78**), fertilizer P (0.72**) and fertilizer K (0.67**).*

Key words: *Correlation studies, maize, fertilizer prescription, nutrient requirement, %CS, %CF, STCR.*

INTRODUCTION

Soil test crop response of crops to an applied fertilizer nutrient is related to the available status of that nutrient in the soil. In India, the soils are deficient in several nutrients and the efficiency of added fertilizers cannot be obtained by general recommendations. There is a need for a national basis for evolving fertilizer schedules for different crops and areas based on soil testing and analysis for different nutrients. Ramamurthy *et al.*[7], described on the use of fertilizer doses based on soil test values for attaining different yield targets of crops. An attempt is made in this paper to optimize the fertilizer doses of N, P and K based on available soil test values for attaining yield targets of maize in semi-arid alfisol in Hyderabad.

Cite this article: Giri, Y.Y., Reddy, D.V.R., Thakur, H.V., Mote, K.J. and Singh, H., Nutrient Requirements of Maize Based on Soil Test Crop Response Correlation Approach, *Int. J. Pure App. Biosci.* **5(6):** 408-415 (2017). doi: http://dx.doi.org/10.18782/2320-7051.5418

MATERIAL AND METHODS

Experimental details

A field experiment was conducted on maize (*Zea mays*) 'DHM-117' variety with 21 fertilizer N, P_2O_5, K_2O and vermicompost treatments during *kharif* 2012 in a semi-arid alfisol in the College Farm, Acharya NG Ranga Agricultural University (Now PJTSAU), Rajendranagar, Hyderabad, Telangana state, India. The site is geographically situated at 17019' N Latitude, 780 28' E Longitude and at an altitude of 542.3 meters above mean sea level. It falls under Southern Telangana agro-climatic zone of Andhra Pradesh. The study was conducted with the objective of developing soil test based fertilizer doses for attaining different yield targets. The treatments were selected based on 4 levels of N @ 0, 60, 120, 180; P_2O_5 @ 0, 30, 60, 90; K_2O @ 0, 20, 40, 60 kg/ha and VC @ 0, 2.5 and 5 t/ha. The treatments comprised of 18 fertilized and 3 unfertilized (control) combinations of N, P_2O_5, K_2O and VC. The N, P_2O_5 and K_2O were applied through urea, single super phosphate and muriate of potash respectively. One third of N and full dose of P_2O_5 and K_2O were applied as a basal dose and remaining N was applied as top dressing at 30 days after sowing (DAS). Shallow furrows were opened at 75 cm apart with the help of a pickaxe. The seeds were dibbled at 20 cm apart in the furrows and were covered immediately after sowing. Optimum plant population was maintained by gap filling and thinning operations keeping one healthy seedling per hill at an intra-row spacing of 20 cm. Hand weeding was carried out twice at 15 and 25 DAS and one inter cultivation operation was carried out at 40 DAS. Monocrotophos @ 1.5 ml/ litre of water was sprayed at 30 DAS for controlling the stem borer. Sowing was taken up immediately after receipt of rains. Later on irrigations were given at 0.7 IW/CPE depending on the rainfall.

Initial soil samples (0-15 cm depth) were collected from the field and dried in the shade, pounded and passed through 2 mm sieve and preserved in polythene bags after labelling. These samples were analyzed for soil parameters by adopting standard methods. The soil pH (1:2.5 of soil: water) was analysed based on pH meter with Glass electrode assembled Elico Model[2]. The electrical conductivity (dS m^{-1}) was analysed based on soluble bridge method[2]. The soil organic carbon (%) was analysed based on Walkley and Black's modified method (1934) and N was analysed based on alkaline permanganate method[12], the available P_2O_5 of soil was extracted with 0.5 M $NaHCO_3$ (Olsen *et al.,* 1954). The content of P in the extract was determined by ascorbic acid reductant method using spectrophotometer at 660 nm wave length[3]. The soil K_2O was determined based on neutral ammonium acetate method using Flame photometer[2]. The soil P_2O_5 and K_2O were also determined based on ABDTPA method. After shelling the cobs, the grain yield per net plot was recorded and the yield/ha was calculated. The stover yield per net plot area was weighed after complete sun drying and it was converted to stover yield/ha. Grain and straw samples of individual treatment were dried in an oven at 60 to 70º C till constant weight was obtained and ground to fine powder in Willey mill with stainless steel blades. The powdered plant samples were used for nutrient analysis. Nitrogen content of plant sample was estimated by adopting the modified Microkjeldahls method[3]. The phosphorus content in the digested plant samples was determined by Vanadomolybdo phosphoric acid yellow colour method using Spectrophotometer at 420 nm wave length[3]. The potassium content in the digested samples was determined by Flame Photometer after making proper dilutions[3].

Statistical analysis

The analysis of variance of effects of fertilizer treatments on maize grain yield, dry matter yield, plant uptake of nutrients and soil test values could be carried out as described by Gomez and Gomez. The estimates of correlation of grain and dry matter yield with soil test values, plant uptake and applied fertilizer N, P_2O_5, K_2O and vermicompost could be derived for assessing the relationships of variables.

Basic data and Targeted yield equations

The basic data required for formulating fertilizer recommendation for attaining a targeted yield are (i) nutrient requirement in kg q-1 of grain or other economic produce; (ii) percent contribution from the soil available nutrients; (iii) percent contribution from the applied fertilizer nutrients[7].

Nutrient requirement of N, P and K for grain production (NR)

$$\text{Kg of nutrient / q of grain} = \frac{\text{Total uptake of nutrient in kg ha}^{-1}\ \text{(Grain + Straw)}}{\text{Grain yield in q ha}^{-1}}$$

% contribution of nutrient from soil

$$\%\ \text{Contribution from soil (CS)} = \frac{\text{Total uptake in control plots (kg ha}^{-1})}{\text{Soil test value of nutrient in control plot (kg ha}^{-1})} \times 100$$

% contribution of nutrient from fertilizer

$$\%\ \text{Contribution of nutrient from fertilizers (CF)} = \frac{\text{Total uptake of nutrient in fertilized plots in kg ha}^{-1} - \left(\text{Available soil test value of nutrients in fertilized plots in kg ha}^{-1} \times \frac{\text{\% contribution of nutrient from soil}}{100}\right)}{\text{Fertilizer nutrient applied in kg ha}^{-1}} \times 100$$

% contribution of nutrient from organics

$$\%\ \text{Contribution of nutrient from organics (CO)} = \frac{\text{Total uptake of nutrient in organic plots in kg ha}^{-1} - \left(\text{Available soil test value of nutrients in organic plots in kg ha}^{-1} \times \frac{\text{\% contribution of nutrient from soil}}{100}\right)}{\text{Amount of nutrient added as organics in kg ha}^{-1}} \times 100$$

Targeted yield equation

$$F = \frac{NR}{CF/100} \times T - \frac{CS}{CF} \times S - \frac{CO}{CF} \times M$$

F = Fertilizer dose of N, P_2O_5 and K_2O in kg ha^{-1}

NR = Nutrient requirement in kg/q of grain

CF = Per cent contribution of nutrient from fertilizer

T = Yield target in q ha^{-1}

CS = Per cent contribution of nutrient from soil

S = Soil test values for available nutrient in kg ha^{-1} (N, P or K)

CO = Per cent contribution of nutrient from organics

M = Nutrient content in organic matter in kg ha^{-1} (N, P or K)

RESULTS AND DISCUSSION

Table 1: Estimates of correlation between yield, soil, plant uptake and fertilizer nutrients in maize (Pooled over 0X, 1X and 2X gradients)

	VC	FN	FP	FK	GY	DMY	SN	SP	SK	UN	UP	UK
VC	1.000											
FN	0.000	1.000										
FP	0.000	0.708**	1.000									
FK	0.000	0.573**	0.699**	1.000								
GY	0.391**	0.782**	0.717**	0.671**	1.000							
DMY	0.590**	0.620**	0.570**	0.550**	0.931**	1.000						
SN	0.220	0.658**	0.453**	0.310*	0.576**	0.540**	1.000					
SP	0.631**	0.454**	0.605**	0.432**	0.711**	0.770**	0.588**	1.000				
SK	0.376**	0.078	0.113	0.318*	0.298*	0.350**	0.122	0.418**	1.000			
UN	0.466**	0.717**	0.598**	0.524**	0.932**	0.921**	0.673**	0.791**	0.326**	1.000		
UP	0.430**	0.688**	0.551**	0.516**	0.909**	0.890**	0.639**	0.691**	0.277*	0.920**	1.000	
UK	0.493**	0.588**	0.601**	0.651**	0.864**	0.887**	0.532**	0.780**	0.365**	0.871**	0.65**	1.000

Table r-value (5% level & 61 degrees of freedom) = 0.250

Table r-value (1% level & 61 degrees of freedom) = 0.325

Effect of vermicompost treatments on grain and dry matter yield of maize and post-harvest soil nutrients values of NPK

The mean values of grain and dry matter yield of maize and post-harvest soil test values at different level of applied vermicompost as OM1 as control, OM2 @ 2.5 t ha^{-1} and OM3 @ 5.0 t ha^{-1} of vermicompost at different fertility gradient as 0X, 1X and 2X respectively. The treatment plots of OM3 @ 5.0 t ha^{-1} of vermicompost at different fertility gradient gives the mean yield of 5290 kg ha^{-1} followed by 5006 kg ha^{-1} in OM2 treatment which shows the increase in grain yield over the control plots 4470 kg ha^{-1} same trends is also observed in dry matter yield as given in Table 1.

The grain and stover yield of maize increased with improvement in soil fertility gradient and the level of fertilizer application. The crop produced a mean of grain yield of 5096 kg ha^{-1} in the 2X fertility gradient as compared to 4648 kg ha^{-1}. Thus additional grain yield of 448 kg ha^{-1} was realized due to change in the fertility gradient of the soil. The crop also produced the additional stover yield of 814 kg ha^{-1} due to the residual fertility in the 2X than in the 0X gradient. Such inferences recording more grain and stover yield of maize due to the residual fertility status in the soil were also drawn by Dev and Sarma[1], Sarma *et al*[9], Singh and Sarkar[10], Kumar and Singh[5], Sutlaliya and Singh[13], Verma *et al*[14], Sahoo and Mahapatra[8], Singh and Chaudhary[11] and Kumar *et al*[4].

The post-harvest soil test values of NPK also show significant different between the applied vermicompost levels in various fertility gradients i.e. 0X, 1X and 2X strip. The control plots give the mean of 276.6, 38.3 and 369.3 (NPK) kg ha^{-1}. The OM2 @ 2.5 t ha^{-1} of vermicompost gives 281.6, 43.1 and 387.6 (NPK) kg ha^{-1} and OM3 @ 5 t ha^{-1} of vermicompost give 292.3, 48.7 and 429 kg ha^{-1}

it shows increase in the nutrient status of soil from 0X to 1X and 1X to 2X respectively.

Basic parameters

Using the data of maize grain yield, dry matter yield, plant uptake and soil test values of N, P and K, fertilizer doses of N, P_2O_5 and K_2O, basic data viz., nutrient requirement (kg q^{-1}), soil efficiency (%), fertilizer efficiency (%) and vermicompost efficiency (%) have been derived. Using the basic data, targeted yield equations of N, P and K nutrients have been derived for computing optimal fertilizer doses for attaining yield targets of 50 and 60 q ha^{-1}. The basic data and targeted yield equations were derived for 0X, 1X and 2X gradients and also for pooled data over gradients. Using the basic data, the response ratio of maize per kg application of fertilizer was derived. The fertilizer prescription equations under IPNS for desired yield target of maize were formulated using the basic parameters and furnished in given table 2.

Table 2: Basic data and Targeted yield equations

Nutrient	Basic data				Targeted yield equations	Response ratio (kg/kg)
	NR (kg/q)	SE (%)	FE (%)	VCE (%)		
0X gradient						
N	2.4	18.0	55.6	37.3	FN = 4.40* T - 0.32* SN -0.67* VC	13.96
P_2O_5	1.5	65.5	88.1	18.6	FP_2O_5 = 1.71* T - 0.74* SP_2O_5 - 0.21* VC	
K_2O	2.2	15.4	211.6	51.0	FK_2O = 1.04* T - 0.07* SK_2O – 0.24* VC	
1X gradient						
N	2.69	22.6	73.3	56.0	FN = 3.67* T - 0.31* SN -0.67* VC	16.14
P_2O_5	1.69	87.2	107.2	88.6	FP_2O_5 = 1.58* T - 0.81* SP_2O_5 - 0.83* VC	
K_2O	2.23	9.6	234.2	51.2	FK_2O = 0.95* T - 0.04* SK_2O – 0.22* VC	
2X gradient						
N	2.86	24.2	80.5	56.0	FN = 3.55* T - 0.30* SN -0.70* VC	16.53
P_2O_5	1.71	102.7	105.1	88.6	FP_2O_5 = 1.63* T - 0.98* SP_2O_5 - 0.84* VC	
K_2O	2.39	8.9	273.8	51.2	FK_2O = 0.87* T – 0.03* SK_2O – 0.19* VC	
Pooled over gradients						
N	2.67	21.6	69.8	47.5	FN = 3.83* T - 0.31* SN -0.68* VC	15.60
P_2O_5	1.64	85.2	100.1	59.0	FP_2O_5 = 1.64* T - 0.85* SP_2O_5 - 0.59* VC	
K_2O	2.27	11.3	239.9	51.1	FK_2O = 0.95* T - 0.05* SK_2O – 0.21* VC	

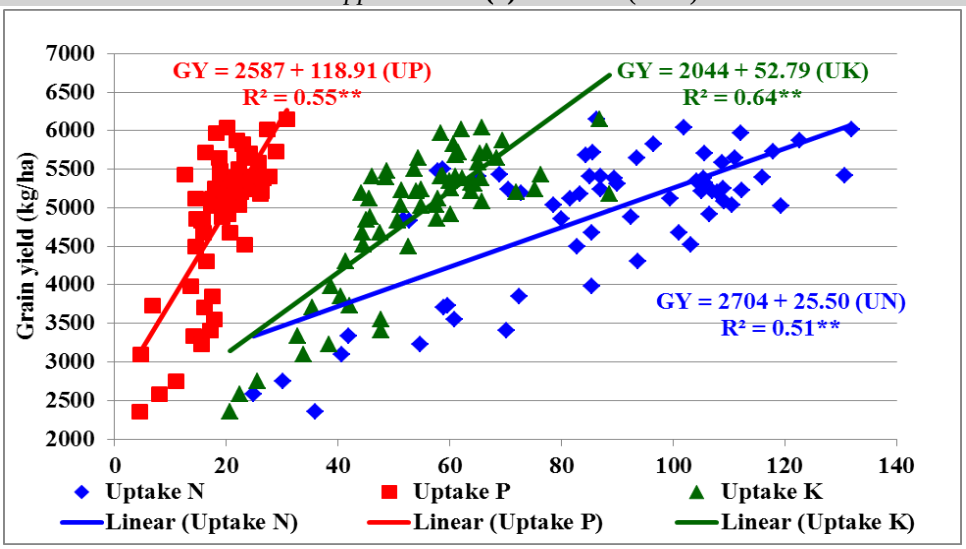

Fig 1: Relationship between uptake of N, P and K with grain yield of maize in different gradients

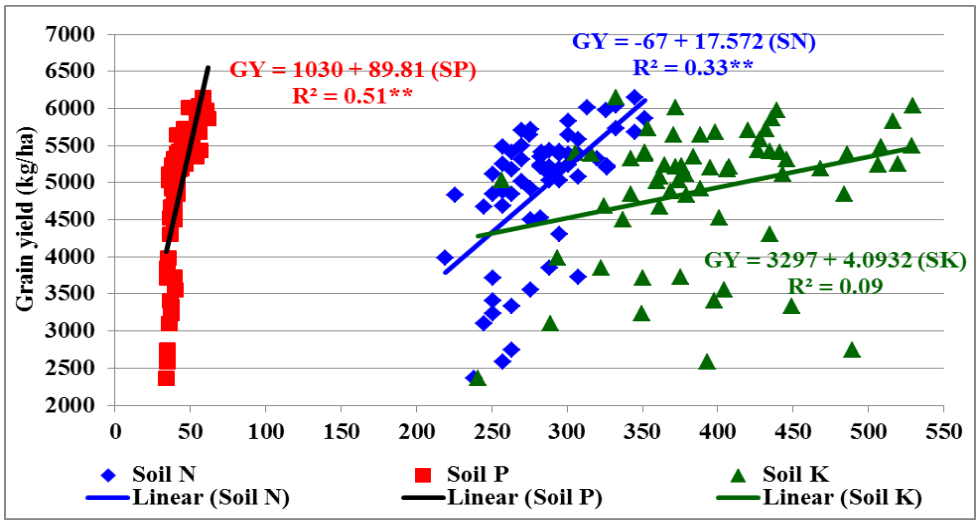

Fig 2: Relationship between soil N, P and K with grain yield of maize in different gradients

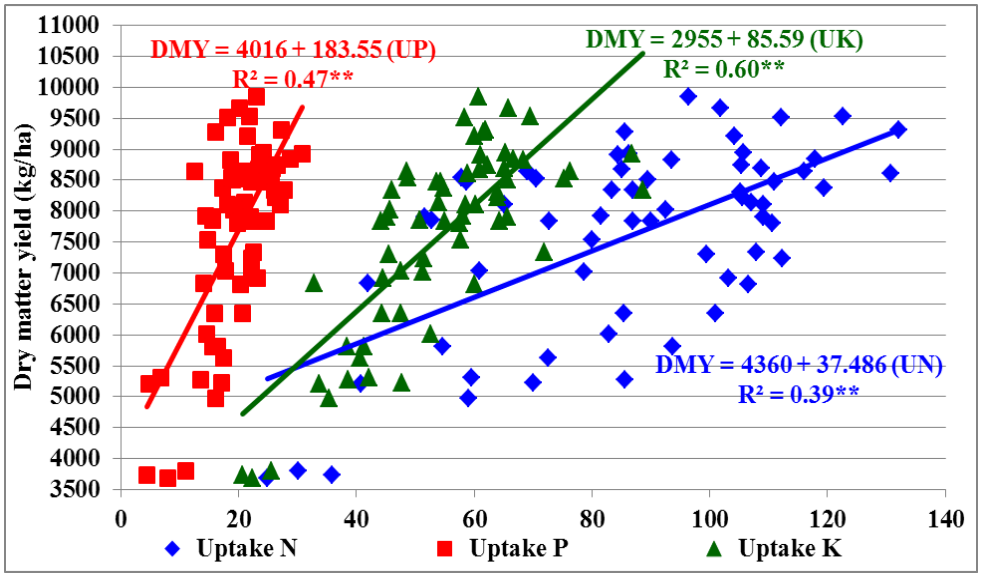

Fig 3: Relationship between uptake N, P and K with DM yield of maize in different gradients

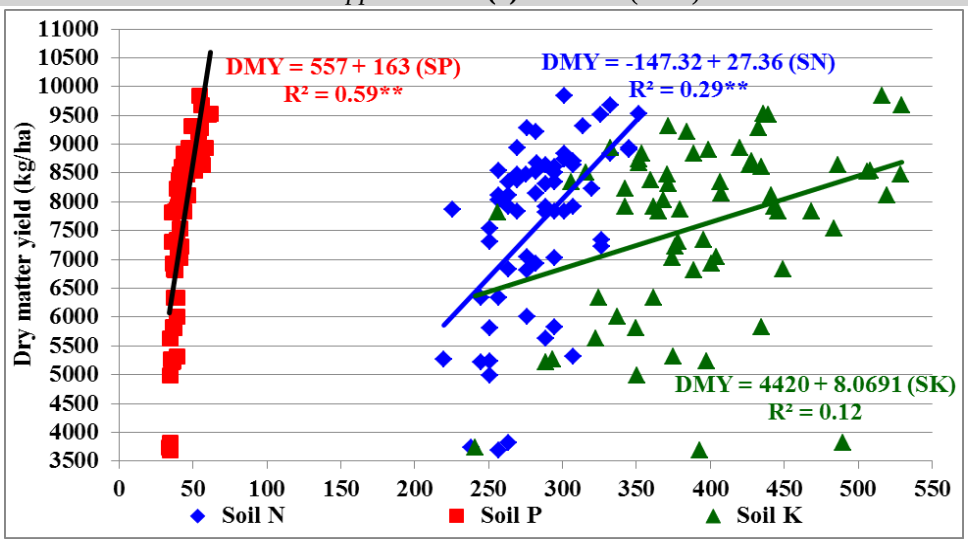

Fig 4: Relationship between soil N, P and K with DM yield of maize in different gradients

CONCLUSIONS

In the present study, the integrated plant nutriyion system based on soil test crop response correlation studies was developed for maize on alfisol soils of Telangana State (South India) taking into account the nutrient requirement, contribution of NPK from the internal and external nutrient sources *viz.*,soil, fertilizer and vermicompost. This envisages a balanced supply of nutrients in an integrated manner through IPNS for desired yield target of maize.

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