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Influence of soil test based fertilization on soil fertility and productivity of maize

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Abstract
In a field experiment conducted during the kharif season of 2015-16 in farmer's field at Shinganhalli village in Dharwad taluka. The status of soil nutrients, their depletion, build-up and crop productivity on Vertisol was studied. The differences in the values of available N, P_2O_5 and K_2O in soil at 20 cm depth and crop productivity were found to be very marked. The data on yield shows that the application of balanced fertilizer dose of N, P and K as per STCR treatment with farm yard manure @ 10.0 t/ha helped in sustaining the yield of maize at higher. The inclusion of FYM in the treatment schedule maintaining the status of available N, P and K in soil thereby, sustaining the soil health. The under dosing of plant nutrients has caused a depletion in the available nutrients status of soil.

Keywords: Vertisol, crop productivity, targeted yield, maize

Introduction
Maize is the third most important crop of our country after rice and wheat. Its grain is used as feed, food and industrial raw material. It is cultivated around the year, however more than 80 percent is grown in rainy or *kharif* season. The most important maize growing states are Karnataka, Andhra Pradesh, Uttar Pradesh and Madhya Pradesh, which account for more than 80 percent of the total maize area of the country and also account for similar share in production. In maize, both area and production have been steadily increasing. In India since 1950, area under maize has increased from 3.31 to 9.0 million ha and production from 1.73 to 24.4 million tonnes in 2013-14.
The increase has been very rapid during the last 10 years as a result of increase in productivity and expansion of area due to spread of its cultivation in non traditional areas of Karnataka and Andhra Pradesh. In Karnataka, it is estimated that maize demand will continue to increase because of its diversified uses. To meet the growing demands, enhancement of maize yield in coming years across both traditional and non traditional areas is a big challenge in the era of climate change. Meeting such challenge will only be possible through science-based technology interventions like single cross hybrid technology and application of novel production techniques in maize improvement, specifically the nutrient management.
The soil test crop response (STCR) is cost effective and plant need based approach. The STCR approach provides principles and tools for supplying crop nutrients as and when needed to achieve higher yield. The STCR approach not specifically aims to either reduce or increase fertilizer use. Instead, it aim to apply nutrients at optimal rates and time to achieve higher yield and higher efficiency of nutrient use by the crop, leading to more net returns per unit of fertilizer invested. Soil test calibration permits balanced fertilization through right kind and amount of fertilizers. In this regard, targeted yield approach had been found to be beneficial recommending balanced fertilization considering the soil available nutrient status and crop needs (Ramamoorthy *et al.*, 1967) [4].

Material and methods
The experiment was conducted in farmer's field (Survey No. 197) at Shinganalli village in Dharwad taluka on *Vertisol* (medium black soil). A composite surface soil sample upto 20 cm depth was collected from the experimental area before initiating the experiment and was analyzed for physico-chemical properties and fertility status. The results are presented in Table 1.
The experiment consists of 9 treatments namely T_1-100 percent Recommended dose of fertilizers, T_2- 150 percent Recommended dose of fertilizers, T_3- 200 percent Recommended

dose of fertilizers, T_4 - STCR approach 8 t ha^{-1} yield target, T_5- STCR approach 8 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate, T_6- STCR approach 9 t ha^{-1} yield target, T_7 - STCR approach 9 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate, T_8 - STCR approach 10 t ha^{-1} yield target, and T_9 – STCR approach 10 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate each replicated in three locations in a randomized block design. Recommended dose of fertilizer for maize was 100:75:37.5 kg of N, P_2O_5 and K_2O per hectare. The amount of fertilizer (Nitrogen, phosphorus and potassium) for STCR treatments was calculated by using standardised STCR equations as mentioned below.

F.N = 4.62 T – 0.340 S.N
$F.P_2O_5$ = 2.33 T – 1.75 $S.P_2O_5$
$F.K_2O$. = 3.27 T – 0.480 S. K_2O

Where,
T = Targeted yield (q ha^{-1})
FN = Nitrogen supplied through fertilizer (kg ha^{-1})
FP_2O_5 = Phosphorus supplied through fertilizer (kg ha^{-1})
FK_2O = Potassium supplied through fertilizer (kg ha^{-1})
SN, SP_2O_5 and SK_2O are initial available N, P_2O_5 and K_2O kg ha^{-1}, respectively.

Half of nitrogen and entire dose of phosphorus and potassium in the form of urea, diammonium phosphate (DAP) and muriate of potash (MOP) were applied as per treatments at 4-5 cm deep and 5 cm away from the seed as basal dose. Remaining half dose of nitrogen in the form of urea was top dressed at 45 days after sowing (DAS). Initially and at harvest of crop soil samples (0 15cm depth) were collected and analyzed for different parameters by following standard procedures for organic carbon (Sparks, 1996) [6], available nitrogen by alkaline potassium permanganate oxidation method as outlined by Subbiah and Asija (1956) [7], Available soil phosphorus was estimated by Olsen's method as outlined by Sparks (1996) [6] and Available soil potassium was estimated by flame photometer (Sparks, 1996) [6].

Results and Discussion

In the present study results showed that, the effect of nutrient application through targeted yield approach exerted significant influence on the grain yield of maize (Table 2). The grain yield increase over 100 percent recommended dose of fertilizer was highest (34.07%) in treatment (T_7) STCR approach 9 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate followed by (T_9) STCR approach 10 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate (30.75%), (T_8) STCR approach 10 t ha^{-1} yield target (30.19%), (T_6) STCR approach 9 t ha^{-1} yield target (23.27%), (T_5) STCR approach 8 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate (22.58%), (T_3) 200 percent recommended dose of fertilizer (22.44%), (T_4) STCR approach 8 t ha^{-1} yield target (15.37%), (T_2) 150 percent recommended dose of fertilizer (8.45%).

The grain yield of maize was recorded significantly higher (9.68 t ha^{-1}) with treatment receiving STCR approach 9 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate as compared to 100 percent recommended dose of fertilizer (7.22 t ha^{-1}), 150 percent recommended dose of fertilizer (7.83 t ha^{-1}), 200 percent recommended dose of fertilizer (8.84 t ha^{-1}), STCR approach 8 t ha^{-1} yield target (8.33 t ha^{-1}), STCR approach 8 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate (8.85 t ha^{-1}), STCR approach 9 t ha^{-1} yield target (8.90 t ha^{-1}) and it was found on par with (T_8) STCR approach 10 t ha^{-1} yield target (9.40 t ha^{-1}) and (T_9) STCR approach 10 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate (9.44 t ha^{-1}). Similarly, Tegegnework *et al.* (2015) [8] conducted experiment in medium black soil with clay loam texture on sunflower and revealed that nutrient application on the basis of targeted yield approach principles resulted in significantly higher grain yields over farmer practice and recommended dose of fertilizers. The studies are also confirmed with the findings of Deshmukh *et al.* (2012) [2]

Available N, P_2O_5 and K_2O

The nutrient status of different plots after the harvest was dependent on both supply of nutrients through various approaches and uptake by crops. Compared to recommended dose of fertilizer soil status, the STCR approach treatments tended to increase available nitrogen, phosphorus and potassium status of soil. The available nitrogen, phosphorus and potassium in soil after harvest of the crop (Table 3) differed significantly with different nutrient management approaches at the end of harvest of maize crop. The balance of nutrients was highest with treatment receiving STCR approach.

Available nitrogen was significantly higher (311.41 kg ha^{-1}) with treatment receiving STCR approach 10 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate followed by STCR approach 10 t ha^{-1} yield target (305.14 kg ha^{-1}). It could be due to enhanced nutrient pool at elevated fertility level which might have contributed to higher residual nutrient status of soil by retaining part of external applied nutrients in soil. Similar opinion of elevated fertility levels increased the available nutrient status of the soil after harvest of crop by several researchers. Nutrients in soil were more with STCR treatments. The results are also in accordance with Tomar *et al.* (1990) [9].

Available phosphorus was significantly higher (43.00 kg ha^{-1}) in treatment receiving STCR approach 10 t ha^{-1} yield target. This was due to the residual effect of applied nutrients, which were applied at a higher rate in this treatment. Similar results were reported in chilli crop by Vadhana (2003) [10] in Vertisol. Available phosphorus was recorded lowest in (T_1) 100 percent recommended dose of fertilizer (15.95 kg ha^{-1}) as fertilizers were applied at a lower rate in this treatment. These findings indicated that integrating the use of fertilizers with manure could enhance the available phosphorus content of soil as build-up of available phosphorus. These results are in conformity with the findings of Yaduvanshi (2001) [11] who attributed the appreciable increase in available P content of soil to the influence of organic manure which could have enhanced the labile phosphorus in soil by complexing the cation like Ca and Mg

Similar results were obtained in case of available potassium and higher available potassium (442.4 kg ha^{-1}) was observed with treatment receiving STCR approach 10 t ha^{-1} yield target + 25 kg ha^{-1} of each zinc sulphate and iron sulphate as compared to 100 percent recommended dose of fertilizer (408.5 kg ha^{-1}) which was lowest. It could be due to enhanced nutrient pool at elevated fertility level which might have contributed to higher residual nutrient status of soil by retaining part of external applied nutrients in soil. This is in consonance with the findings of Bandana Singh Chandel *et al.* (2014) [1] who has also observed similar effects on available potassium status of soil.

Table 1: Initial physiochemical properties of gradient experiment soil

Sl. No.	Particulars	Value
1.	Soil pH (1:2.5 soil water suspension)	8.10
2.	EC (dS m^{-1}) (1:2.5 soil water extract)	0.17
3.	Organic carbon (g kg^{-1})	5.10
4.	Bulk density (Mg m^{-3})	1.34
5	Available nitrogen (kg ha^{-1})	213
6	Available phosphorus (kg ha^{-1})	26
7	Available potassium (kg ha^{-1})	271
9.	DTPA – extractable micronutrients (mg kg^{-1})	
i.	Copper	1.21
ii.	Iron	5.03
iii.	Manganese	7.85
iv.	Zinc	0.45

Table 2: Response of nutrients in maize crop

Treatments	Grain yield (t ha^{-1})	% response over 100%RDF
T_1: 100% RDF	7.22	-
T_2: 150% RDF	7.83	8.45
T_3: 200% RDF	8.84	22.44
T_4: STCR approach 8 t ha^{-1} yield target	8.33	15.37
T_5: T_4 + 25 kg ha^{-1} of each zinc sulphate and iron sulphate	8.85	22.58
T_6: STCR approach 9 t ha^{-1} yield target	8.90	23.27
T_7: T_6 + 25 kg ha^{-1} of each zinc sulphate and iron sulphate	9.68	34.07
T_8: STCR approach 10 t ha^{-1} yield target	9.40	30.19
T_9: T_8 + 25 kg ha^{-1} of each zinc sulphate and iron sulphate	9.44	30.75
S.Em. $\pm$	1.35	
C.D. (0.05)	0.40	

Table 3: Changes in available nutrient status of soil

Treatments	Soil available nutrient Status (kg ha^{-1})		
	N	P_2O_5	K_2O
T_1: 100% RDF	234.08	15.95	408.53
T_2: 150% RDF	244.53	19.93	412.00
T_3: 200% RDF	259.16	26.77	422.40
T_4: STCR approach 8 t ha^{-1} yield target	252.89	27.05	425.60
T_5: T_4 + 25 kg ha^{-1} of each zinc sulphate and iron sulphate	250.8	25.63	412.00
T_6: STCR approach 9 t ha^{-1} yield target	271.7	29.33	429.10
T_7: T_6 + 25 kg ha^{-1} of each zinc sulphate and iron sulphate	277.97	31.61	421.23
T_8: STCR approach 10 t ha^{-1} yield target	305.14	43.00	434.47
T_9: T_8 + 25 kg ha^{-1} of each zinc sulphate and iron sulphate	311.41	40.44	442.40
S.Em. $\pm$	3.89	1.85	3.89
C.D. (0.05)	11.65	5.54	11.67

Note: RDF -150:75:37.5 N, P_2O_5 and K_2O kg ha^{-1}
FYM @ 10 t ha^{-1} common to all treatments

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