Phosphorus Recommendation for Yield Targets of Kharif Maize Based on Soil Test Crop Response Studies

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ABSTRACT: A maize experiment was conducted in an alfisol at Hyderabad with 21 NPK treatments and vermi compost (VC) for deriving soil test based fertilizer doses for attaining yield targets. Treatments consisted of 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 (Randomized Block Design). Based on fertilizer effects on yield, soil and plant nutrients, nutrient requirement (NR), contribution from soil (SE), fertilizer (FE) and vermi compost (VCE) were derived. Using this basic data i.e., NR, SE, FE and VCE, fertilizer adjustment equations were derived for prescribing phosphorus doses based on soil test values of phosphorus for attaining yield targets. There was considerable reduction in the quantities of fertilizer P_2O_5 due to IPNS.

Key words: STCR, maize, fertilizer adjustment equations, FP prescriptions

Introduction

Maize (*Zea mays,* L.) is one of the valuable crop plants that has high diversity, high adaptability and great nutrient value is in the row of the most important food crop in the world [6] (Nurmohammadi *et al*, 2005). Maize has more genetic diversity compare than other cereals. According to World Food Agriculture Organization (FAO) in 2008, the area under maize cultivation was 93.6 million hectares that it was 9.8 percent of the total cultivated area of the world. Phosphorus is considered an essential nutrient for plant growth and productivity. It is component of nucleic acid, nucleic protein and energy rich compounds such as Adenosine Triphosphates (ATP), through which plants store energy to fuel other chemical processes. Also, P is a constituent of numerous carbohydrates and nitrogenous compounds and it is a part of certain coenzymes [5] (Mengel and Kirkby, 1987). As Ozanne (1980) reported, P is one of the most yield limiting factors in many tropical and sub-tropical soils [8]. To mitigate this problem, the application of commercial fertilizers was the most common recommendation. However, there are various concerns associated with the use of commercial fertilizers in general and p fertilizers in particular. These concerns are firstly, the resource-poor farmers of tropics and sub tropics are unable to use fertilizers due to lack of money and/or unavailability of fertilizers [2] (Egle *et al*., 1999). Secondly, due to the prevailing adverse chemical properties of tropical and sub-tropical soil (acidity and alkalinity) P is rapidly transformed to hardly available form even after fertilizer application [4] (Marschner, 1995). The third reason is the increase of legislative regulations than restrict the use of commercial fertilizers, so as to minimize environmental hazards due to run-off and leaching [12] (Sattelmacher *et al*., 2007). The above mentioned limitations of commercial fertilizers on one hand and the increase world population that has led to the cultivation of marginal land on the other hand necessitated the look for the most potential solution.

The fertilizer requirement of a crop depends to a larger extent on the native soil fertility and hence, the prescription of doses should always be made by examine the relationships of soil test values with applied fertilizer doses and crop yield by Velayutham *et al.*, 1976 [13]. It is estimated that P availability to plant roots is limited in two thirds of the cultivated soil in the world (Batjes, 1997) [1]. Phosphorus application is essential to minimize yield loss on the soil. However, most of the P applied to the soil can be converted into unavailable forms that cannot be easily utilized by plants. Application of phosphate fertilizer based on soil test values is very important due to above reasons; hence the study is conducted to get the phosphate application based on soil available nutrient to achieve the target yield of *kharif* maize under semi-arid condition of aflisol soil.

Material and methods

A field experiment was conducted on maize (DHM-117) during *kharif* 2012 at College Farm, Acharya NG Ranga Agricultural University (Now PJTSAU), Rajendranagar, Hyderabad, Telangana state, India, which was based on STCR- fertility gradient approach developed by Ramamoorthy *et al.* [9]. The site is geographically situated at $17^0$19' N Latitude, 78^0 28' E Longitude and at an altitude of 542.3 meters above mean sea level. To develop fertility gradient, the field was divided into 3 equal strips *viz.*, I, II and III. An exhaust crop of sorghum (CSH-9) was grown to enable through interaction between the nutrients in the soil and added fertilizers. After the harvest, each gradient strip was divided into 21 plots. The treatments consisted of 4 levels of each N @ 0, 60, 120, 180; P2O5 @ 0, 30, 60, 90; K2O @ 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 (Randomized Block Design). Maize (DHM-117) was grown as test crop by proper recommended cultural practices. The available P_2O_5 of soil was extracted with 0.5 M NaHCO3 (Olsen *et al.*, 1954) [7]. The content of P in the extract was determined by ascorbic acid reductant method using spectrophotometer at 660 nm wave length (Jackson, 1973) [3]. At harvest, by using grain yield, P_2O_5 uptake, initial soil P_2O_5 status and fertilizer doses applied, the basic data *viz.*, nutrient requirement (NR) kg q^{-1}, per cent contribution from soil (SE), fertilizer (FE) and vermi compost (VCE) were estimated for making phosphorus recommendation as described by Reddy *et al.* [11].

Results and Discussion

The initial soil available P_2O_5 value was 42 Kg ha^{-1} after fertility gradient experiment, the soil available phosphorus values recorded in strip I, II and III were 38, 47 and 52 P_2O_5 Kg ha^{-1} respectively. The range and mean values of post-harvest soil test available P_2O_5, uptake P_2O_5, grain and dry matter yield of maize crop are given in Table 1. The Post-harvest soil test available phosphorus ranged from 33.9 to 61.6 kg ha^{-1} with mean of 40.5 kg ha^{-1} in strip I, 43.1 kg ha^{-1} in strip II and 46.2 in strip III. The P_2O_5 uptake ranged between 4.5 to 28.9 kg ha^{-1} from strip I to III. The range of grain yield from strip I to III was 23.6 to 60.4 q ha^{-1} with mean of 46.4 q ha^{-1} in strip I, 50.04 q ha^{-1} in strip II and 50.90 q ha^{-1} in strip III. The range of dry matter yield from strip I to III was 37.4 to 98.4 q ha^{-1}. Enhancement in the yield is due to direct contribution of plant nutrients from vermi compost to the crop and improving properties of soil which enhance the efficiency of soil and fertilizer nutrient.

The basic data for fertilizer requirement for targeted yield of maize are furnished in Table 2. The NR (kg q^{-1}), SE %, FE % and VCE % values for phosphorus were 1.5, 65.5, 88.1 and 18.6 for strip I, 1.69, 87.2, 107.2 and 88.6 for strip II, 1.71, 102.7, 105.1 and 69.8 for strip III and for the pooled over gradient were 1.64, 85.2, 100.1 and 59.0 respectively. The data have been transformed in the form of simple equations and depicted in Table 2. The study indicated that based on the basic data and targeted yield equations, we could attain response of 15.6 kg of maize yield per kg of phosphorus applied in alfisols. The results are in convergence with those reported by Ramamurthy *et al*., (1967) [9], Rani *et al*., (1991) [10]. The results indicates that phosphorus contributions from fertilizer sources are more than from the soil.

Using fertilizer adjustment equations a ready reckoner showing fertilizer phosphorus recommendation at varying soil test values for attaining yield target of 50, 60 and 70 q ha^{-1} of maize is given in Table 3. The results clearly indicate that when the initial soil available phosphorus status were range from 15 to 90 kg ha^{-1} the sole FP doses were range from 69 to 6 kg ha^{-1} for 50 q ha^{-1}, 86 to 22 kg ha^{-1} for 60 q ha^{-1} and 103 to 38 kg ha^{-1} for 70 q ha^{-1}. These phosphorus doses were getting reduced when vermi-compost applied @ 2.5 t ha^{-1} and 5 t ha^{-1}.

Conclusion

A study was conducted on maize with 18 fertilized and 3 unfertilized treatments of N, P_2O_5, K_2O and VC for deriving soil test based optimum phosphorus doses for attaining different yield targets. Based on the effects of fertilizer treatments on maize grain and dry matter yield, soil test values and plant uptake of phosphorus nutrient, estimates of nutrient requirement (NR, kg/q), contribution from soil (SE, %), contribution from fertilizer (FE, %), and contribution from vermi compost (VCE, %) were derived. Using NR, SE, FE and VCE, fertilizer adjustment equations of phosphorus were derived. The mean NR was 1.64 kg of P_2O_5 for attaining one quintal of yield. The SE was found to be 85.2% compared to FE of 100.1% and contribution from VC of 59% for phosphorus nutrient. We could attain a response of 15.6 kg of maize yield per kg of application of fertilizer nutrient based on the study. The soil test based optimum fertilizer doses could be used for attaining maize yield targets of 50, 60 and 70 q/ha under similar soil and agro climatic conditions anywhere in the country.

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Table 1: Post-harvest soil test available P_2O_5 status, Plant P uptake and grain and dry matter yield of maize crop

Strip	Post-harvest Soil test P_2O_5 (kg ha^{-1})		Plant P_2O_5 Uptake (kg ha^{-1})		Grain Yield (q ha^{-1})		Dry matter Yield (q ha^{-1})	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
I	33.9-53.9	40.5	4.5-27.7	17.5	23.6-57.1	46.48	37.4-89.4	71.76
II	34.4-58.5	43.1	8.0-30.9	21.1	25.8-61.5	50.04	36.9-93.2	76.66
III	34.9-61.6	46.2	6.8-28.9	20.1	27.5-60.4	50.96	38.1-98.4	79.90

Table 2: Basic data and Targeted yield equations of maize

Nutrient	Basic data				Targeted yield equations	Response ratio (kg/kg)
	NR (kg/q)	SE (%)	FE (%)	VCE (%)		
Strip I						
Phosphorus	1.5	53.6	62.5	64.5	$FP_2O_5 = 1.71* T - 0.74* SP_2O_5 - 0.21* VC$	13.96
Strip II						
Phosphorus	1.69	51.5	63.4	58.4	$FP_2O_5 = 1.58* T - 0.81* SP_2O_5 - 0.83* VC$	16.14
Strip III						
Phosphorus	1.71	56.8	64.7	57.9	$FP_2O_5 = 1.63* T - 0.98* SP_2O_5 - 0.84* VC$	16.53
Pooled over gradients						
Phosphorus	1.64	53.9	63.5	60.2	$FP_2O_5 = 1.64* T - 0.85* SP_2O_5 - 0.59* VC$	15.60

Where, FP- Fertilizer phosphorus (kg ha^{-1}), SP- Soil available phosphorus (kg ha^{-1}), VC- Vermi-compost, T- Targeted yield (q ha^{-1}), NR- Nutrient requirement, SE- Soil efficiency, FE- Fertilizer efficiency, VCE- vermi-compost efficiency.

Table 3: Fertilizer Phosphorus prescription (kg ha^{-1}) at varying soil available P_2O_5 status for attaining yield targets of 50 q ha^{-1}, 60 q ha^{-1} and 70 q ha^{-1} of Maize

SP (kg/ha)	Fertilizer P doses (kg/ha)for attaining yield targets								
	T = 50 q/ha			T = 60 q/ha			T = 70 q/ha		
	FP Alone	FP+VC (2.5 t ha^{-1})	FP+VC (5 t ha^{-1})	FP Alone	FP+VC (2.5 t ha^{-1})	FP+VC (5 t ha^{-1})	FP Alone	FP+VC (2.5 t ha^{-1})	FP+VC (5 t ha^{-1})
15	69	56	43	86	72	59	103	88	75
20	65	52	38	81	68	55	97	84	71
25	61	47	34	77	64	51	93	80	67
30	57	43	30	73	60	46	89	76	62
35	52	39	26	69	55	42	85	71	58
40	48	35	21	64	51	38	80	67	54
45	44	30	17	60	47	34	76	63	50
50	40	26	13	56	43	29	72	59	45
55	35	22	9	52	38	25	68	54	41
60	31	18	4	47	34	21	63	50	37
65	27	13	0	43	30	17	59	46	33
70	23	9		39	26	12	55	42	28
75	18	5		35	21	8	51	37	24
80	14	1		30	17	4	46	33	20
85	10	0		26	13	0	42	29	16
90	6			22	9		38	25	12