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Revised Soil Phosphorus Test Ratings (RSPTR), Critical Limits (CL) and Phosphorous Recommendation for Maize

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A B S T R A C T

The current soil test phosphorous ratings of low, medium and high fertility classes and critical limits were revised by studying the response of maize in 24 soils of varied initial P fertility, treated with graded levels of P. The revised SPTR were <15.50, 15.51-28.00, 28.10-48.50 and >48.50 kg P_2O_5 ha^{-1}, VL: L: M: H, respectively. CL for soil was 17.0 kg P_2O_5 ha^{-1} and 0.12 per cent for plant. Maize yield can be maximized by recommending phosphorous @ 150, 125, 100 and 75 percent of the recommended dose in the respective soils of VL: L: M: H fertility ratings.

Introduction

Phosphorus, the basic raw material rock phosphate available in the country is 10 per cent of the total requirement and therefore depends on imports, which is being increased for the balance of remaining 90 per cent. In the world, there will be a rapid decline in rock phosphate availability by 2030 onwards.

Indian fertilizer industry is self-sufficient in meeting the requirement of N, but in case of P. The rating chart for soil test data used by the soil testing laboratories have been generated 50 years ago on a very limited data for fertilizer recommendation which is based on few pot culture correlation experiments and the results of a few field trials conducted at IARI (Muhr *et al.*, 1965). In majority of the soil testing laboratories of rainfed areas, the interpretation of the soil test results are done based on the critical nutrient concept proposed by Cate and Nelson (1965).

The soil test ratings of low, medium and high fertility classes for nutrients are currently

adopted by the soil testing laboratories need a fresh look as significant responses to applied nutrients have been recorded in soils with high fertility status in many crops. In alluvial soils of U.P. on soils classified as high in available P, 60 kg P_2O_5 ha^{-1} increased the wheat yield by 653 kg ha^{-1} or 10.9 kg grain per kg P_2O_5. Even at the current high price of P_2O_5, this underscores the need to revise soil fertility limits (Tiwari, 2002).

Critical limit is the level below which economic responses are possible to applied phosphates. Knowing the initial soil test value and response of crop to applied level of nutrient, will be possible to work out the amount of fertilizer phosphorus needed to buildup the soil phosphate to a given critical limit. If the initial soil phosphorus level is high, then maintenance application will be enough (Anonymous, 2012).

A pot experiment was conducted using maize (*Zea mays* L. is one of the important cereals cultivated in India and it ranks fourth after rice, wheat and sorghum) as a test crop grown on soils of different P fertility applied with graded levels of P with the objective is to revalidate the soil available phosphorus test ratings and critical limits for soil and maize plant.

Materials and Methods

Experiment was conducted on 2012 at ZARS, GKVK, UAS, Bangalore. Surface (0-30 cm) soils were collected in bulk from different locations of Eastern Dry Zone of Karnataka *viz.*, GKVK, Bangalore rural and Doddaballapura. Soils were subjected to processing followed by analysis for available nutrients using standard procedures (Piper, 1966) and tentatively categorized as Very Low, Low, Medium and High classes if the available soil phosphorus <15, 16-30, 31-45 and 46-60 kg ha^{-1}, respectively.

Initial soil available phosphorus content (Table 1) based, six different locations or soils from each very low, low, medium and high category were selected separately. Totally, 648 individual polythenes filled ten kg soil for three replications from all the four P fertility status. Treatments were nine graded levels of P with and without NK&FYM *viz.*, T_1: Absolute control; T_2: Rec. N&K only (no P); T_3: Rec. N&K only + Rec. FYM; T_4: Package of practice (NPK+FYM); T_5: 100 % Rec. N, P &K (no FYM); T_6: 75 % Rec. P + rec. dose of N&K (no FYM); T_7: 75 % Rec. P + Rec. dose of N&K only + Rec. FYM; T_8: 125 % Rec. P + Rec. dose of N&K (no FYM); T_9: 125 % Rec. P + Rec. dose of N&K + Rec. FYM. Maize (Variety: Nithya shree -NAH 2049) was grown in pots imposed with P as per the treatments and RDF @ 100-50-25 kg $N-P_2O_5-K_2O$ ha^{-1} and Recommended dose of FYM @ 7.5 t ha^{-1} during summer in CRD technique.

RDFYM was mixed with soil in the pot five days prior to sowing. Recommended dose of N through urea and K as muriate of potash and graded levels of phosphorus through single super phosphate were given as basal. After sowing maize in each pot keeping the soil moisture at field capacity followed by two plants were maintained after a week after thinning. Weed management, plant protection measures and a regular irrigation were taken up as per the package of practices. Plants were harvested separately from each pot at 60 days after sowing and dry matter weight was recorded followed by subjected to total P content estimation using standard procedure[5] to know the uptake of P. Soils samples were analyzed for available P content using standard procedure.

Data were analyzed using ANOVA (One-Way) of Fisher's method of analysis and variance technique at 5 % probability level of significance. Correlation coefficient (r) were

calculated and tested for their significance (Panse and Sukhatme, 1985). Plotting the initial soil available phosphorus in different phosphorus fertility levels on X-axis and relative yield on the Y-axis in a graphical method critical limits were identified. A transparent overlay with a vertical line and an intersecting horizontal line was drawn so as to maximize the number of points in the first and third quadrants and minimum number of points in the second and fourth quadrants.

The initial soil test phosphorus corresponding to the relative yield was marked in such a way that, below which response to applied P would be maximum and was taken as critical value for phosphorus (Cate and Nelson, 1965) both in soil and plant. Revalidation of Soil Phosphorus Test ratings (SPTR) in to very low, low, medium and high were categorized by ploting of relative per cent yield at harvest of maize on Y- axis and the initial available phosphorus content on X-axis by adopting continuous calibration curve method (Cope and Rouse, 1973)

Results and Discussion

Soil phosphorus content after harvest of maize

Irrespective of soil P fertility and levels of P addition, application of FYM increased the available phosphorus content of the soil (Table 2). Treatments with graded levels of P and rec. N&K along with manures recorded significantly higher available P content which may be due to beneficial effect of manure as it provided the congenial environment for better microbial activity and released the nutrients and also keeps them in soil solution. Absolute control pot recorded lower nutrient values as compared to initial could be due to utilization of native soil nutrients. Venkatesh *et al.*, (2002) observed increased available P status with increased rate of P application.

Dry matter yield, shoot P concentration and uptake of P by maize

Soils of different P fertility levels applied with graded levels of phosphorus noticed significant difference in dry matter yield, phosphorus concentration in plant (Table 3) and uptake (Table 4) which were increased with the increase in initial soil P fertility along with graded levels of P application. Application of 125% rec. P + rec. N&K + rec. FYM noticed higher yield, P contents and uptake. This may be due to higher amount of available P, which helped in better root growth lead to increased photosynthetic rate there by enhanced the P uptake resulted in higher dry matter yield. Concentration of P in plant was slightly decreased in soils of high P fertility applied with graded levels of P due to lower response of crop to applied P. which might be due to fixation of P with Fe and Ca, reduced the movement and availability of P in soil. And also due to negative interaction between P and Zn, might have restricted the translocation and uptake of P by the plant.

Relative yield and P uptake increased as the available P status changed from very low to low, low to medium and medium to high. However, total P uptake response was higher in very low and low P soils than in medium and high P soils. Similar results were reported by Ghosh and Singh (2002). Addition of N and K only, but not P recorded increased dry matter yield with increase in initial soil P highlighted the role of P nutrition, its effect pronounced more on P uptake rather than on dry matter. Lower the dose, lower was the yield recorded, which emphasize the importance of supplying adequate level of P for higher yields through organic manures along with inorganic fertilizers. Similar effect of interaction between soils and phosphorus on dry matter yield and P uptake observed by Laxminarayana (2007). Majumdhar *et al.*, (2007) noticed increased phosphorus uptake

with P alone or with FYM over control and maximum uptake due to SSP @ 60 kg P_2O_5 ha^{-1} whereas Arya and singh (2001) observed higher dry matter accumulation with phosphorus @ 39.6 kg ha^{-1} in maize.

Phosphorous @ 125 per cent of recommended dose along with N and K recorded significantly higher dry matter yield compared to 75 and 100 per cent of RDP. FYM given with 75, 100 and 125 per cent RDP along with N and K increased the dry matter yield over no FYM which might be ascribed to the adequate availability of nutrients and this facilitated greater accumulation of photosynthates in the shoots. Tariq Aziz *et al.,* 2010 noticed better shoot growth, phosphorus and potassium content due to application of organic manures. Similarly, the relative yield and shoot P uptake by sunflower increased at all P doses with increase in initial P status from low to high (Muralidharudu *et al.,* 2003)

Critical limits of soil and plant phosphorus for maize and revalidation of P fertility ratings

Percentage of yields obtained on the unfertilized control soil relative to the maximum yield achieved on the phosphorus fertilized soil. Relative per cent yield was plotted against available soil P as shown in Figures 1 to 3 represent critical limit of available soil phosphorus, maize shoot phosphorus content and revalidation of available soil phosphorus fertility ratings, respectively.

Initial soil available phosphorus as well as graded levels of phosphorus influenced maize greatly the yield in check pots and maximum yield, respectively (Table 5). However, yield in check pot increased as the available phosphorus increased (range: 60.87 to 188.39 g pot^{-1}) and also yields were maximum at higher rate of phosphorus doses (range: 118.96 to 199.65 g pot^{-1}). Yield increase is the difference between maximum yields in treated pot to yield in check pot showed decreasing trend as the initial available phosphorus content increased (range: 7.28 to 65.38 g pot^{-1}). Relative per cent yield (range: 4.57 to 96.14 per cent) was a dependent variable on yield increase which was higher at lower values of yield increase and vice-versa. Average relative yield per cent was lower in very low P fertility soil (23.89) and higher in high P fertility soils (91.90). Phosphorus content in check pot ranged 0.07 to 0.32 per cent and it showed increasing trend of increase in concentration with increase in available phosphorus content of soil.

Fig.1 Critical limit of available soil phosphorus for maize

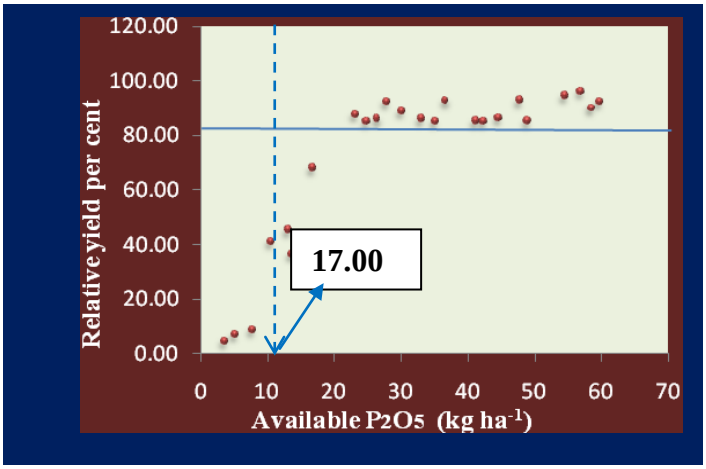


Fig.2 Critical limit of plant phosphorus content in maize shoot

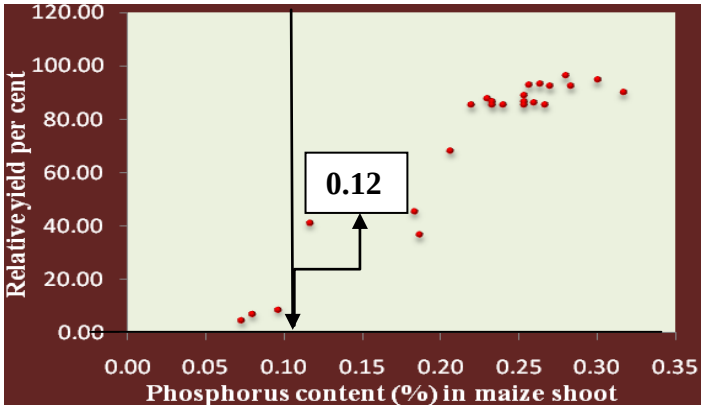
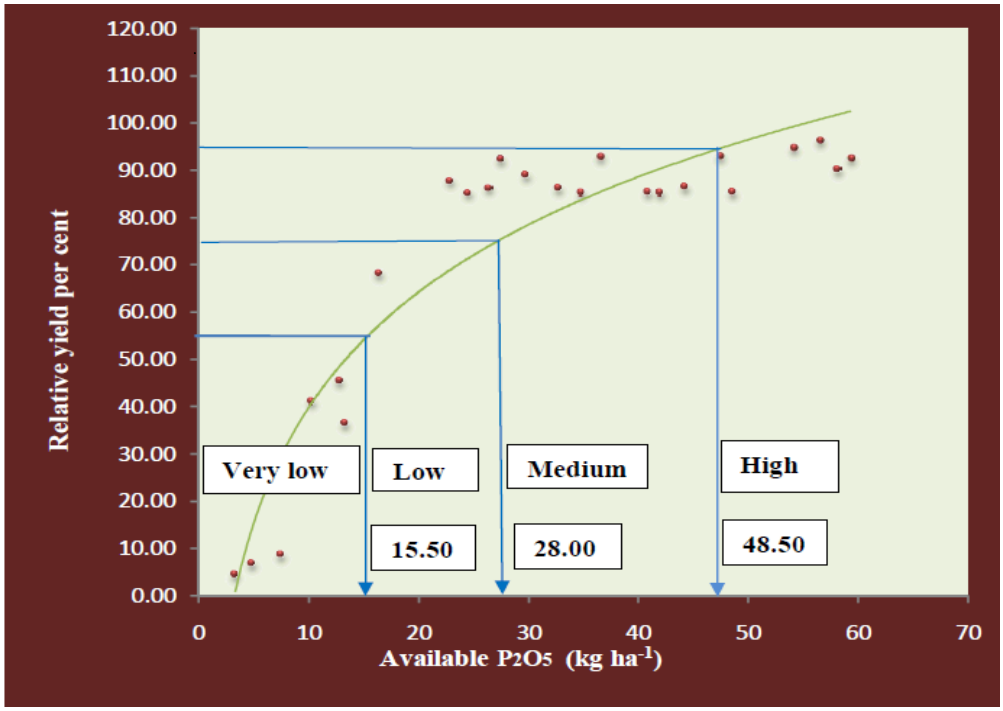


Fig.3 Revalidation of available soil phosphorus fertility ratings



Fertility ratings	**Available phosphorus (P_2O_5)**
Very low (VL)	<15.50 kg ha^{-1}
Low (L)	15.51-28.0 kg ha^{-1}
Medium (M)	28.10- 48.50 kg ha^{-1}
High (H)	>48.50 kg ha^{-1}

Table.1 Initial properties of the soils used in pot culture experiment

Sl. No.	pH (1:2.5)	EC (dS m^{-1})	Organic Carbon (%)	Available N (kg ha^{-1})	Available P_2O_5 (kg ha^{-1})	Available K_2O (kg ha^{-1})	DTPA-Fe (mg kg^{-1})	DTPA-Zn (mg kg^{-1})
Very low phosphorus (< 15 kg P_2O_5 ha^{-1})								
Location 1	5.61	0.21	0.38	210.12	10.22	291.16	49.74	1.86
Location 2	6.03	0.23	0.36	232.06	12.74	116.76	68.76	1.72
Location 3	5.32	0.25	0.35	222.66	3.30	240.0	52.32	1.91
Location 4	6.66	0.26	0.41	179.56	13.29	273.6	70.82	1.15
Location 5	5.82	0.29	0.32	219.52	7.47	285.60	70.04	2.32
Location 6	5.99	0.28	0.37	203.84	4.83	172.0	59.34	2.08
Low phosphorus (16-30 kg P_2O_5 ha^{-1})								
Location 7	5.15	0.22	0.58	200.14	16.37	145.55	68.82	1.66
Location 8	6.16	0.23	0.43	231.09	22.85	215.59	53.64	1.47
Location 9	6.27	0.26	0.44	228.67	24.5	191.12	48.14	1.33
Location 10	6.14	0.16	0.52	189.58	26.37	110.77	48.36	1.56
Location 11	5.52	0.11	0.59	209.12	27.47	163.89	67.94	1.37
Location 12	5.47	0.26	0.36	203.84	29.77	240.0	68.26	1.66
Medium phosphorus (31-45 kg P_2O_5 ha^{-1})								
Location 13	5.32	0.15	0.42	196.5	44.23	221.65	63.30	2.07
Location 14	5.88	0.23	0.37	251.0	32.74	315.69	69.26	2.21
Location 15	6.53	0.25	0.54	238.77	41.97	391.13	50.22	1.14
Location 16	6.20	0.12	0.60	280.88	40.87	410.77	50.44	1.43
Location 17	6.11	0.27	0.51	109.16	36.58	363.89	55.26	1.42
Location 18	6.70	0.24	0.49	303.84	34.83	247.43	48.20	1.29
High phosphorus (46-60 kg P_2O_5 ha^{-1})								
Location 19	5.31	0.18	0.48	211.19	48.56	145.05	66.34	1.82
Location 20	5.83	0.16	0.38	151.88	59.34	385.66	64.44	2.30
Location 21	6.52	0.29	0.29	238.84	58.12	191.13	48.32	1.47
Location 22	5.60	0.19	0.47	290.85	47.44	310.0	71.06	1.60
Location 23	6.12	0.27	0.52	169.16	54.13	163.77	52.04	2.42
Location 24	5.82	0.23	0.38	323.14	56.51	200.05	63.34	1.98

Table.2 Changes in available phosphorus (kg ha^{-1}) content of soil after harvest of maize (60 DAS) grown on soils of different phosphorus fertility status applied with graded levels of phosphorus

P status/ Soils/ Treatments	Very low							Low						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
T_1	7.09	9.43	2.55	10.61	4.29	2.88	**6.14**	11.28	16.43	18.09	19.76	18.10	22.17	**17.64**
T_2	5.74	8.07	1.89	8.07	3.07	1.56	**4.73**	8.07	13.41	15.74	17.74	15.70	18.41	**14.85**
T_3	9.86	11.86	6.86	13.60	7.53	7.86	**9.59**	15.60	20.27	22.60	25.93	24.60	26.27	**22.54**
T_4	45.33	48.66	35.52	54.89	42.33	37.52	**44.04**	56.56	56.23	57.89	60.56	58.56	61.56	**58.56**
T_5	39.41	44.08	27.35	46.00	36.41	24.75	**36.33**	47.00	43.33	47.67	49.33	50.33	55.33	**48.83**
T_6	28.46	33.12	20.27	34.76	26.42	20.27	**27.22**	36.76	35.89	36.89	38.56	38.23	41.56	**37.98**
T_7	38.68	40.21	27.93	40.21	33.26	27.93	**34.70**	41.21	42.12	43.78	46.45	47.12	48.78	**44.91**
T_8	52.49	54.15	38.67	55.49	49.49	37.67	**47.99**	56.49	56.49	58.15	61.49	64.15	66.82	**60.60**
T_9	57.48	60.15	45.22	61.82	55.48	44.78	**54.16**	64.15	68.15	69.48	72.15	71.15	70.31	**69.23**
Mean	**31.62**	**34.41**	**22.92**	**36.16**	**28.70**	**22.80**	**29.43**	**37.46**	**39.15**	**41.15**	**43.55**	**43.11**	**45.69**	**41.68**
F	***S***	***S***	***S***	***S***	***S***	***S***		***S***	***S***	***S***	***S***	***S***	***S***	
***S.Em*±**	1.61	2.14	1.65	1.31	1.39	1.51		1.39	2.90	2.56	2.13	2.05	2.01	
CD *(p=0.05)*	4.98	6.58	5.07	4.04	4.27	4.65		4.27	8.94	7.89	6.58	6.32	6.20	
CV	8.85	10.75	12.44	6.27	8.36	11.45		6.41	12.84	10.78	8.49	8.23	7.63	

S1, 2……6: Soil 1 to 6

T_1: Absolute control; **T_2:**Rec. N & K only; **T_3:** Rec. N & K + rec. FYM;
T_4: Package of Practice (rec. NPK+FYM); **T_5:** 100 per cent rec. N, P &K (no FYM); **T_6:** 75 per cent rec. P + rec. N&K (no FYM);
T_7: 75 per cent rec. P + rec. N&K+ rec. FYM; **T_8:** 125 per cent rec. P + rec. N&K (no FYM); **T_9:** 125 per cent rec. P + rec. N&K + rec. FYM

Table.2 cont…

P status/Soils/ Treatments	Medium							High						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
T_1	38.17	25.06	35.83	33.09	28.76	27.43	**31.39**	42.50	51.17	52.83	40.83	47.17	48.83	**47.22**
T_2	34.41	23.07	31.90	29.90	25.07	24.04	**28.07**	41.41	49.40	50.42	37.87	46.41	44.42	**44.98**
T_3	44.27	29.34	34.17	33.50	32.67	29.34	**33.88**	49.60	56.27	57.60	43.60	52.60	50.93	**51.77**
T_4	77.56	68.67	72.52	74.19	70.67	69.30	**72.15**	83.56	90.89	93.23	82.89	92.56	90.89	**89.00**
T_5	69.33	62.43	64.98	63.31	63.76	63.24	**64.51**	77.33	81.67	83.67	76.52	83.67	81.33	**80.70**
T_6	55.89	51.23	51.68	49.68	54.23	52.56	**52.54**	62.89	69.89	71.23	63.89	76.23	76.89	**70.17**
T_7	64.64	59.64	63.40	60.28	62.97	63.97	**62.49**	70.31	74.97	75.97	70.47	82.64	81.31	**75.94**
T_8	82.82	73.82	75.28	73.61	77.49	76.15	**76.53**	77.49	76.82	77.49	75.89	79.15	76.15	**77.17**
T_9	88.64	81.01	87.16	90.00	80.19	81.85	**84.81**	88.19	86.85	88.85	86.65	89.52	86.19	**87.71**
Mean	**61.75**	**52.70**	**57.43**	**56.40**	**55.09**	**54.21**	**56.26**	**65.92**	**70.88**	**72.36**	**64.29**	**72.22**	**70.77**	**69.41**
F	***S***	***S***	***S***	***S***	***S***	***S***		**S**	***S***	**S**	**S**	***S***	***S***	
***S.Em*±**	2.44	2.39	3.98	4.22	2.68	3.07		2.75	4.06	3.80	2.64	3.62	3.37	
CD *(p=0.05)*	7.53	7.36	12.27	13.02	8.24	9.45		8.47	12.52	11.70	8.14	11.16	10.40	
CV	6.86	7.85	12.01	12.97	8.41	9.80		7.22	9.93	9.09	7.12	8.68	8.26	

S1, 2……6: Soil 1 to 6

T_1: Absolute control; **T_2:**Rec. N & K only; **T_3:** Rec. N & K + rec. FYM;
T_4: Package of Practice (rec. NPK+FYM); **T_5:** 100 per cent rec. N, P &K (no FYM); **T_6:** 75 per cent rec. P + rec. N&K (no FYM);
T_7: 75 per cent rec. P + rec. N&K+ rec. FYM; **T_8:** 125 per cent rec. P + rec. N&K (no FYM); **T_9:** 125 per cent rec. P + rec. N&K + rec. FYM

Table.3 Plant total phosphorus concentration (per cent) at harvest (60 DAS) of maize grown on soils of different phosphorus fertility status applied with graded levels of phosphorus

P status/ Soils/ Treatments	Very low							Low						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
T_1	0.09	0.15	0.06	0.16	0.08	0.06	**0.10**	0.16	0.19	0.18	0.19	0.20	0.17	**0.18**
T_2	0.12	0.18	0.07	0.19	0.10	0.08	**0.12**	0.21	0.23	0.25	0.26	0.27	0.25	**0.25**
T_3	0.20	0.21	0.10	0.26	0.15	0.14	**0.18**	0.26	0.27	0.28	0.29	0.29	0.29	**0.28**
T_4	0.27	0.34	0.26	0.35	0.29	0.29	**0.30**	0.31	0.33	0.35	0.34	0.37	0.39	**0.35**
T_5	0.22	0.27	0.23	0.28	0.23	0.21	**0.24**	0.25	0.28	0.30	0.30	0.34	0.34	**0.30**
T_6	0.21	0.27	0.21	0.26	0.19	0.20	**0.22**	0.24	0.26	0.28	0.29	0.30	0.34	**0.29**
T_7	0.26	0.33	0.24	0.32	0.27	0.27	**0.28**	0.29	0.30	0.32	0.28	0.35	0.35	**0.32**
T_8	0.23	0.29	0.25	0.29	0.25	0.26	**0.26**	0.27	0.29	0.31	0.26	0.35	0.38	**0.31**
T_9	0.29	0.36	0.29	0.39	0.30	0.31	**0.32**	0.33	0.35	0.36	0.37	0.39	0.41	**0.37**
Mean	**0.21**	**0.27**	**0.19**	**0.28**	**0.21**	**0.20**	0.22	**0.26**	**0.28**	**0.29**	**0.29**	**0.32**	**0.32**	**0.29**
F	***S***	***S***	***S***	***S***	***S***	***S***		***S***	***S***	***S***	***S***	***S***	***S***	
***S.Em*±**	0.01	0.01	0.01	0.02	0.01	0.01		0.01	0.02	0.02	0.02	0.01	0.02	
CD *(p=0.05)*	0.04	0.03	0.04	0.06	0.03	0.02		0.03	0.05	0.07	0.06	0.04	0.06	
CV	11.23	7.13	13.02	12.23	8.99	5.53		7.58	11.10	12.98	11.84	6.27	10.39	

S1, 2……6: Soil 1 to 6

T_1: Absolute control; **T_2:**Rec. N & K only; **T_3:** Rec. N & K + rec. FYM;
T_4: Package of Practice (rec. NPK+FYM); **T_5:** 100 per cent rec. N, P &K (no FYM); **T_6:** 75 per cent rec. P + rec. N&K (no FYM);
T_7: 75 per cent rec. P + rec. N&K+ rec. FYM; **T_8:** 125 per cent rec. P + rec. N&K (no FYM); **T_9:** 125 per cent rec. P + rec. N&K + rec. FYM

Table.3 cont...

P status/Soils/ Treatments	Medium							High						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
T_1	0.21	0.20	0.20	0.21	0.22	0.20	**0.21**	0.25	0.26	0.28	0.24	0.26	0.26	**0.26**
T_2	0.25	0.23	0.22	0.24	0.26	0.23	**0.24**	0.27	0.28	0.32	0.26	0.30	0.28	**0.29**
T_3	0.28	0.25	0.25	0.25	0.27	0.25	**0.26**	0.30	0.32	0.34	0.28	0.33	0.34	**0.32**
T_4	0.39	0.39	0.38	0.37	0.36	0.35	**0.37**	0.34	0.36	0.40	0.37	0.36	0.38	**0.37**
T_5	0.36	0.34	0.35	0.34	0.35	0.34	**0.35**	0.33	0.34	0.33	0.29	0.35	0.35	**0.33**
T_6	0.35	0.31	0.33	0.34	0.34	0.33	**0.33**	0.34	0.33	0.34	0.31	0.32	0.34	**0.33**
T_7	0.39	0.37	0.35	0.36	0.38	0.34	**0.37**	0.34	0.37	0.40	0.39	0.36	0.39	**0.38**
T_8	0.38	0.33	0.34	0.36	0.36	0.35	**0.35**	0.35	0.31	0.34	0.31	0.35	0.35	**0.34**
T_9	0.40	0.41	0.39	0.38	0.40	0.39	**0.40**	0.37	0.35	0.37	0.38	0.38	0.39	**0.37**
Mean	**0.35**	**0.34**	**0.33**	**0.34**	**0.35**	**0.33**	**0.34**	**0.32**	**0.33**	**0.35**	**0.31**	**0.33**	**0.34**	**0.33**
F	***S***	***S***	***S***	***S***	***S***	***S***		**S**	***S***	**S**	**S**	***S***	***S***	
***S.Em*±**	0.02	0.02	0.02	0.02	0.01	0.02		0.02	0.02	0.02	0.02	0.02	0.01	
CD *(p=0.05)*	0.07	0.05	0.06	0.05	0.05	0.06		0.06	0.05	0.07	0.06	0.05	0.05	
CV	12.93	9.72	11.40	10.71	9.03	12.45		10.13	8.46	11.54	10.46	9.02	7.67	

S1, 2……6: Soil 1 to 6

T_1: Absolute control; **T_2:**Rec. N & K only; **T_3:** Rec. N & K + rec. FYM;
T_4: Package of Practice (rec. NPK+FYM); **T_5:** 100 per cent rec. N, P &K (no FYM); **T_6:** 75 per cent rec. P + rec. N&K (no FYM);
T_7: 75 per cent rec. P + rec. N&K+ rec. FYM; **T_8:** 125 per cent rec. P + rec. N&K (no FYM); **T_9:** 125 per cent rec. P + rec. N&K + rec. FYM

Table.4 Uptake of phosphorus (g pot^{-1}) at harvest (60 DAS) of maize grown on soils of different phosphorus fertility status applied with graded levels of phosphorus

P status/ Soils/ Treatments	Very low							Low						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
T_1	0.05	0.09	0.02	0.13	0.03	0.02	**0.06**	0.13	0.18	0.18	0.19	0.23	0.20	**0.19**
T_2	0.10	0.18	0.04	0.19	0.07	0.05	**0.11**	0.23	0.29	0.32	0.34	0.36	0.34	**0.31**
T_3	0.20	0.24	0.09	0.32	0.15	0.12	**0.19**	0.35	0.37	0.40	0.39	0.41	0.42	**0.39**
T_4	0.39	0.54	0.43	0.61	0.53	0.43	**0.49**	0.46	0.48	0.53	0.52	0.54	0.62	**0.53**
T_5	0.27	0.37	0.27	0.45	0.30	0.25	**0.32**	0.35	0.39	0.44	0.44	0.48	0.50	**0.43**
T_6	0.25	0.36	0.22	0.40	0.24	0.23	**0.28**	0.32	0.35	0.41	0.42	0.42	0.50	**0.41**
T_7	0.36	0.50	0.38	0.53	0.47	0.37	**0.44**	0.41	0.44	0.47	0.42	0.50	0.56	**0.47**
T_8	0.32	0.43	0.30	0.49	0.34	0.34	**0.37**	0.39	0.40	0.44	0.39	0.50	0.57	**0.45**
T_9	0.49	0.61	0.48	0.69	0.58	0.49	**0.56**	0.49	0.53	0.54	0.59	0.56	0.65	**0.56**
Mean	**0.27**	**0.37**	**0.25**	**0.42**	**0.30**	**0.26**	**0.31**	**0.35**	**0.38**	**0.41**	**0.41**	**0.44**	**0.49**	**0.41**
F	***S***	***S***	***S***	***S***	***S***	***S***		***S***	***S***	***S***	***S***	***S***	***S***	
***S.Em*±**	0.02	0.02	0.02	0.03	0.02	0.01		0.03	0.02	0.03	0.03	0.02	0.03	
CD *(p=0.05)*	0.06	0.08	0.05	0.08	0.06	0.03		0.08	0.07	0.09	0.09	0.06	0.11	
CV	13.17	11.71	10.86	11.16	11.72	6.72		12.73	9.59	12.75	12.51	8.08	12.48	

S1, 2……6: Soil 1 to 6

T_1: Absolute control; **T_2:**Rec. N & K only; **T_3:** Rec. N & K + rec. FYM;
T_4: Package of Practice (rec. NPK+FYM); **T_5:** 100 per cent rec. N, P &K (no FYM); **T_6:** 75 per cent rec. P + rec. N&K (no FYM);
T_7: 75 per cent rec. P + rec. N&K+ rec. FYM; **T_8:** 125 per cent rec. P + rec. N&K (no FYM); **T_9:** 125 per cent rec. P + rec. N&K + rec. FYM

Table.4 cont...

P status/Soils/ Treatments	Medium							High						
	S_1	S_2	S_3	S_4	S_5	S_6	Mean	S_1	S_2	S_3	S_4	S_5	S_6	Mean
T_1	0.26	0.22	0.24	0.21	0.23	0.21	**0.23**	0.29	0.32	0.33	0.27	0.32	0.32	**0.31**
T_2	0.39	0.33	0.34	0.38	0.38	0.34	**0.36**	0.45	0.52	0.57	0.48	0.56	0.53	**0.52**
T_3	0.50	0.39	0.45	0.46	0.42	0.40	**0.44**	0.57	0.63	0.66	0.54	0.63	0.65	**0.61**
T_4	0.69	0.66	0.71	0.66	0.57	0.59	**0.65**	0.67	0.72	0.80	0.74	0.71	0.74	**0.73**
T_5	0.59	0.56	0.62	0.61	0.55	0.57	**0.58**	0.64	0.67	0.65	0.57	0.69	0.68	**0.65**
T_6	0.56	0.51	0.57	0.61	0.53	0.54	**0.55**	0.66	0.66	0.66	0.60	0.63	0.67	**0.65**
T_7	0.67	0.61	0.63	0.64	0.60	0.57	**0.62**	0.66	0.74	0.79	0.78	0.72	0.76	**0.74**
T_8	0.68	0.54	0.62	0.64	0.58	0.59	**0.61**	0.68	0.60	0.66	0.62	0.68	0.68	**0.65**
T_9	0.74	0.69	0.73	0.70	0.65	0.66	**0.70**	0.72	0.69	0.73	0.73	0.72	0.72	**0.72**
Mean	**0.57**	**0.50**	**0.54**	**0.55**	**0.50**	**0.50**	**0.53**	**0.59**	**0.62**	**0.65**	**0.59**	**0.63**	**0.64**	**0.62**
F	***S***	***S***	***S***	***S***	***S***	***S***		**S**	***S***	**S**	**S**	***S***	***S***	
***S.Em*±**	0.04	0.03	0.03	0.03	0.03	0.02		0.04	0.03	0.04	0.04	0.03	0.04	
CD *(p=0.05)*	0.11	0.09	0.09	0.08	0.08	0.06		0.13	0.10	0.12	0.13	0.11	0.11	
CV	12.72	11.56	11.36	9.79	10.83	7.52		11.92	9.26	10.36	12.14	9.62	9.54	

S1, 2……6: Soil 1 to 6

T_1: Absolute control; **T_2:**Rec. N & K only; **T_3:** Rec. N & K + rec. FYM;
T_4: Package of Practice (rec. NPK+FYM); **T_5:** 100 per cent rec. N, P &K (no FYM); **T_6:** 75 per cent rec. P + rec. N&K (no FYM);
T_7: 75 per cent rec. P + rec. N&K+ rec. FYM; **T_8:** 125 per cent rec. P + rec. N&K (no FYM); **T_9:** 125 per cent rec. P + rec. N&K + rec. FYM

Table.5 Initial available P_2O_5 content in soil (AVP), PPC (Plant Phosphorus Content) in check pot, CY (Yield in Check pot), YI (Yield Increase), PRY (Per cent Relative Yield) and MY (Maximum Yield) at harvest(60 DAS) of maize grown on different phosphorus fertility status soils of EDZ of Karnataka as influenced by graded levels of applied phosphorus

Phosphorous fertility status	Soils	AVP (Kg ha^{-1})	PPC in check plant (per cent)	CY (g pot^{-1})	MY (g pot^{-1})	YI* (g pot^{-1})	PRY** (per cent)	Average PRY** (per cent)
Very Low (< 15 kg ha^{-1})	01	10.22	0.12	86.67	137.67	51.00	41.15	23.89
	02	12.74	0.18	97.07	150.00	52.93	45.47	
	03	3.3	0.07	60.87	118.96	58.09	4.57	
	04	13.29	0.19	102.55	167.65	65.10	36.51	
	05	7.47	0.10	71.62	137.00	65.38	8.71	
	06	4.83	0.08	68.00	131.28	63.28	6.94	
Low (16- 30 kg ha^{-1})	01	16.37	0.21	110.33	145.45	35.12	68.17	84.72
	02	22.85	0.23	125.92	141.39	15.47	87.71	
	03	24.5	0.25	126.66	145.43	18.77	85.18	
	04	26.37	0.26	130.24	148.25	18.01	86.17	
	05	27.47	0.27	133.37	143.76	10.39	92.21	
	06	29.77	0.25	135.54	150.65	15.11	88.85	
Medium (31- 45 kg ha^{-1})	01	44.23	0.25	158.54	180.00	21.46	86.46	86.89
	02	32.74	0.23	145.67	165.76	20.09	86.21	
	03	41.97	0.22	156.55	179.62	23.07	85.26	
	04	40.87	0.24	157.35	180.34	22.99	85.39	
	05	36.58	0.26	149.98	160.85	10.87	92.75	
	06	34.83	0.23	145.76	167.23	21.47	85.27	
High (46- 60 kg ha^{-1})	01	48.56	0.27	170.00	194.87	24.87	85.37	91.90
	02	59.34	0.28	185.52	199.65	14.13	92.38	
	03	58.12	0.32	178.67	196.43	17.76	90.06	
	04	47.44	0.26	184.22	197.33	13.11	92.88	
	05	54.13	0.30	186.65	196.76	10.11	94.58	
	06	56.51	0.28	188.39	195.67	7.28	96.14	

YI = (MY- CY) **PRY = [{1- (YI/CY)} X 100]

Initial available phosphorus (AVP) and plant phosphorus content in check plant (PPC), yield in check plant (CY), maximum yield (MY), and per cent relative yield (PRY) were correlated positively significant (0.857**, 0.980**, 0.927** and 0.813**, respectively). However, yield increase (YI) was negatively correlated significantly with AVP, PPC, CY, MY and PRY (-0.794**, -0.887**, -0.854**, -0.564** and -0.960**, respectively). Similarly, PRY correlated with PPC, CY and MY positively and significantly (0.944**, 0.888** and 0.651**, respectively).

The critical limits found were 17.0 kg P_2O_5 ha^{-1} for available soil phosphorus (Fig. 1) and 0.12 per cent (Fig. 2) for maize shoot phosphorus content. The relationship between relative per cent yield with available P initial and total phosphorus in maize shoot showed positive and maximum R^2 value was noticed for plant phosphorus (R^2=0.89). Wortmann *et al.,* (2009) reported similar results.

The revalidation of P fertility ratings based on the per cent relative yield (PRY = [{1-(YI/CY)} X 100]) for soils of different P fertility levels in EDZ of Karnataka was done using continuous calibration curve method (Fig. 3). PRY below 55 per cent was considered as very low in available phosphorus, 55 to 75 per cent was considered as low, 75 to 95 per cent was considered as medium and above 95 per cent was categorized as high in available phosphorus fertility ratings, the corresponding available phosphorus limits were as follows:

Dhillon *et al.,* (1987) reported the rating limits for available P were <10.10, 10.10 – 21.10 and >21.10 kg ha^{-1} for low, medium and high category respectively.

Thus, based on the response of maize in soils of varied initial P fertility applied with graded levels of phosphorous and also based on revised phosphorous fertility ratings, the recommended dose of phosphorous at the rate of 150 per cent in Very low (VL), 125 per cent in Low (L), 100 per cent in Medium (M) and 75 per cent in High (H) phosphorous fertility ratings is the best management practices in soils of Eastern Dry zone of Karnataka as it reduces buildup of phosphorous there by sustains soil nutrient balance apart from cost effective.

The critical limit for available soil phosphorus (P_2O_5) was 17.0 kg ha^{-1} below which response to applied P would be maximum. The revised four SPTR *viz.,* VL: L: M: H i.e., < 15.50; 15.51-28.0; 28.10- 48.50; >48.50 kg P_2O_5 ha^{-1} provide the basis for planning soil based P fertilizer recommendation at the rate of @ 150, 125, 100 and 75 percent of the recommended dose in the soils of respective P fertility ratings for precision agriculture.

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