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## Study of distribution of various fractions of Phosphorous as influenced by long term nutrient management practices in *Vertisol*

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### Abstract

A long term field experiment was conducted at Instructional Farm of College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh to evaluate the effect of long term nutrient management practices on distribution of various fractions of Phosphorous in *Vertisol*. The experiment was consisted 5 treatment replicated four times in a randomised block design. The treatments were T1 (control), T2 (GRD), T3 (YT 5t ha<sup>-1</sup>), T4 (YT 6t ha<sup>-1</sup>) and T5 (YT 6t ha<sup>-1</sup> with FYM). Fertilizer prescription equation for rice developed in previous under STCR project as FN =4.05T-0.57SN-0.78 ON, FP = 1.46 T - 3.09 SP-0.31 OP and FK = 1.61 T - 0.10 SK -0.14 OK were used to calculating the fertilizer doses for yield targeted treatments. Initial soil value of phosphorus under different treatments was varied from 6.13 to 25.40 kg ha<sup>-1</sup> due to long term nutrient management practices. All the P fractions were significantly higher in T2 followed by T5, T4, T3 and lowest in T1. All P fractions (Saloid, Al, Red, Fe, and Ca P) were recorded higher values with the treatment T2 (GRD) due addition of a large amount of phosphorous applied in soil. The sequential order of dominance of different forms of phosphorus in *Vertisol* were "Ca-P > Red-P > Fe-P > Al-P > Saloid-P". The percentage contribution of different fractions to the total P was in the order of "Ca-P > Red-P > Fe-P > Al-P > Saloid-P". The highest grain and straw yield were recorded in T5 (YT 6t ha<sup>-1</sup> with FYM) followed by T4 (YT 6t ha<sup>-1</sup>), T2 (GRD) and lowest in T1 (control). Among different P fractions, Red-P was found the most important P fractions contributing toward grain yield with 'R<sup>2</sup>' values 0.88.

**Keywords:** Phosphorus fractions, different forms, management

### Introduction

Phosphorus is the most essential nutrient in out of 18 essential plant nutrients and its importance is next to nitrogen nutrient from crop production. It is impossible to grow the crops normally and neither achieves yield potential without the phosphorus element. The role of phosphorus is very essential in many physiological processes such as photosynthesis, root development, energy conservation and transformation, carbon metabolism, redox reactions and enzyme activation, (Tarafdar *et al.*, 2006) [13]. It is an essential part of ADP and ATP and plays a vital role in the protein synthesis and transfer of energy (Hao and Chang, 2008) [2]. The total phosphorus concentration in soil is not small quantity but it is not available for plant uptake from compound P in soil. The soil ability to transfer phosphorus to the soil solution and its concentration in soil solution (intensively) is an important factor for the availability of P. Phosphorus is found in organic and inorganic form in soil. Only 10 to 30 per cent phosphorus is used by crop plants from out of freshly applied phosphorous and the rest goes into the formation of various P compounds of varying solubility which later serve as a potential source of P for plants (Kanwar, 1976) [5]. Soil P maintaining an adequate amount by adding inorganic and organic P is critical to the sustainability of the cropping system (Sharpley *et al.*, 1994) [10]. Plants required for phosphorus depend mainly on an inorganic form of phosphorus. Saloid-P, Al-P, Fe-P, R-P, and Ca-P is the major inorganic fractions of the soil, and their relative proportion depends on various factors (Jaggi, 1991) [3]. The availability and fractions of soil P may change due to the long-term continuous P fertilization beside its yield increasing effects (Fan *et al.*, 2003) [1]. The changes in P and K fractions in soil are influenced by Integrated Nutrient Management in a *Vertisol*.

Maximum portion of applied P was transformed in Ca-P followed by Red-P, Fe-P and Al-P. The combined use of chemical fertilizer with FYM, GM and BGA resulted in build-up of all soil P fractions. Ca-P and Al-P were played a major role in controlling the P availability during both seasons. P uptake controlled in Ca-P by rice in both seasons and by wheat in the first season, whereas Al-P by rice in first season only (Joshi 2006)<sup>[4]</sup>.

### Materials and Methods

A long-term field experiment was conducted at Instructional Farm of College of Agriculture, Indira Gandhi Agricultural University, Raipur, Chhattisgarh. The study was conducted in Kharif Season in 2019. The treatments were T1 (control), T2 (GRD), T3 (YT 5t ha<sup>-1</sup>), T4 (YT 6t ha<sup>-1</sup>) and T5 (YT 6t ha<sup>-1</sup> with FYM). Fertilizer prescription equation for rice developed in previous under STCR project as FN = 4.05T - 0.57SN - 0.78ON, FP = 1.46 T - 3.09 SP - 0.31 OP and FK = 1.61 T - 0.10 SK - 0.14 OK were used to calculating the fertilizer doses for yield targeted treatments. The soil of experimental field comes in the soil's order of *Vertisol*, locally known as *Kanhar*. The soil sample were collected from surface (0-15cm) after the harvesting of rice from all plot were analyzed. Fractions of phosphorus in soil was determined by the sequential method described by Chang and Jackson (1957) modified by Peterson and Corey (1966)<sup>[7]</sup>.

### Results and Discussions

#### Phosphorus fractions

The mean values of various fractions of phosphorous were significantly affected by nutrient management practices. The distribution of all various fractions of phosphorous (Saloid-P, Al-P, Red-P, Fe-P and Ca-P) were recorded higher values with the treatment T2- GRD (100:60:40) followed by T5 (YT 6t ha<sup>-1</sup> +FYM), T4 (YT6t/ha), T3 (YT 5t/ ha) and lowest in T1 (control) treatment.

The available P content of the soil varied from 6.13 to 25.40 kg ha<sup>-1</sup> after harvesting of rice. Among the treatments, available P was higher in T2 (GRD) followed by T5 (YT 6t ha<sup>-1</sup> +FYM), T4 (YT6t/ha), T3 (YT 5t/ ha) and lowest in T1 (control). The higher available P under treatment T2 (GRD) was due to continuous application of 60 kg/ha fertilizer P since last 13 years in rice and wheat season. Other treatments were received P fertilizer based on the soil test to achieve a definite yield target of the crop. Similar trend was also observed by Verma (2002)<sup>[15]</sup>.

Maximum concentration of saloid-P was recorded as 7.38 kg ha<sup>-1</sup> in T2 (GRD) followed by 6.85 kg ha<sup>-1</sup> T5 (YT 6 t/ha with FYM) treatment and lowest in control (2.20 kgha<sup>1</sup>). The results indicate that the status of saloid-P increased with increasing doses of fertilizer. However, the percentage distribution of this fraction was around 0.15 per cent under P application plots whereas this fraction was around 0.07 per cent under control treatment. Similar trends in P fraction of applied P were also reported by other researchers like Sihag *et al.*, (2005)<sup>[11]</sup>.

The observation on Al-P ranged from 20.57 to 51.19 kg ha<sup>-1</sup> and significantly influenced by different fertilization practices. The lowest value was recorded in control (20.57kg ha<sup>-1</sup>) and highest value 51.19 kg ha<sup>-1</sup> in T2 (GRD) followed

by 47.57 kg ha<sup>-1</sup> T5 (YT 6t ha<sup>-1</sup> +FYM). Among the yield target based fertilizer P applications, the Al-P fraction were almost the similar values and statistically at par. The percentage distribution of Al-P was recorded lowest from control treatment (0.67%) and almost the same (1.10 per cent) fraction from the total in all P treated plots. Similar results were reported by Tiwari *et al.* (2012)<sup>[14]</sup> and Nayak (2013)<sup>[6]</sup>. Reductant soluble -P (Red-P) content in the soil ranged from 57.27 to 108.97 kg ha<sup>-1</sup>. The highest value of Red-P was recorded in T2 GRD (108.97 kg ha<sup>-1</sup>) followed by T5 YT 6t ha<sup>-1</sup> with FYM (103.79 kg ha<sup>-1</sup>) and lowest value in control (57.27 kg ha<sup>-1</sup>). The values of Red-P were lower than of Ca-P but higher than the Al-P and Fe-P which may be attributed to the low sesquioxides. The percent contribution of Red- P of total-P was ranged from 1.85 to 2.36 per cent, therefore higher percent found in fertilizer treated and lowest in control. The Fe-P ranged from 33.13 to 70.94kg ha<sup>-1</sup> and it increased with addition of fertilizer P with FYM and decreased with no P application (control). The Fe-P was found highest in the treatment T2 GRD (70.94 kg ha<sup>-1</sup>) followed by T5 YT 6t ha<sup>-1</sup> with FYM (65.40 kg ha<sup>-1</sup>) which were at par statistically. The treatments that received the fertilizer P for yield target based did not vary significantly and their per cent distribution were also not much differed. The higher Fe-P was recorded in T2 (1.53per cent) and the lower value in control (1.07 per cent).

The Ca-P fraction in soil ranged from 106.43 to 176.24 kg ha<sup>-1</sup>. The maximum content of Ca-P was recorded in T2 GRD (176.24 kg ha<sup>-1</sup>) followed by T5 YT 6t ha<sup>-1</sup> with FYM (167.55 kg ha<sup>-1</sup>) and minimum with T1 control (106.43 kg ha<sup>-1</sup>). The results indicate clearly that as the P fertilizer dose increased, the status of Ca-P also increased. Calcium-P was found to be the dominant P fraction among various inorganic P forms present in *Vertisol*. The percent content of Ca-P ranged from 3.44 to 3.80 per cent in soil. The highest value of Ca-P was recorded in T2 (GRD) (3.80 per cent) followed by T4 YT6t/ha (3.79 per cent) and lowest in control (3.44 per cent). The total-P fractions within the soil varied from 3092.20 to 4640.28 kg ha<sup>-1</sup> and associated soils have high content of total P. Higher concentration of Total-P was recorded in T2 GRD (4640.28kg ha<sup>-1</sup>) followed by T5 YT 6t ha<sup>-1</sup> with FYM (4483.72 kg ha<sup>-1</sup>) and T4 YT6t/ha (4328.56kg ha<sup>-1</sup>) treatments. The lowest value of total-P was observed in control (3092.20 kg/ha). The results indicate clearly that as the P fertilizer dose increased, the status of total-P also increased which is the sum total of all P fraction including available P.

Higher value of Ca-P and Red-P were recorded in T2 (GRD). The Ca-P was the important inorganic P fraction in all the treatment plot because calcareous soils are reported to have large amounts of P as Ca-P, irrespective of nature and kind of applied fertilizer due to the more stabilized nature of calcium system under high pH. The Ca-P and Red-P were dominated in *Vertisol*. The order of dominance of P fractions in *Vertisol* were Ca-P > Red-P > Fe-P > Al-P > Saliod-P. Contribution of different fractions of P to the total P indicated that substainal contribution of Ca-P followed by Red-P and lowest in Saoid-P. All the forms of P increased due to application of P fertilizer in rice-wheat cropping sequence, hence the total P content also increased. Similar results were also observed by Nayak (2013)<sup>[6]</sup>, Roy *et al.* (2016)<sup>[8]</sup>, Sudhakaran (2018)<sup>[12]</sup>.

**Table 1:** Effect of nutrient management practices on distribution of Phosphorus fractions (kg/ha)

Treatments	Treatments details	Available-P (kg/ha)	Saloid-P (kg/ha)	Al-P (kg/ha)	Red-P (kg/ha)	Fe-P (kg/ha)	Ca-P (kg/ha)	Total-P (kg/ha)
T1	Control	6.13	2.20 (0.07)	20.57 (0.67)	57.27 (1.85)	33.13 (1.07)	106.43 (3.44)	3092.20
T2	GRD*	25.40	7.38 (0.16)	51.19 (1.10)	108.97 (2.35)	70.94 (1.53)	176.24 (3.80)	4640.28
T3	YT 5t ha <sup>-1</sup> **	19.83	5.79 (0.14)	46.03 (1.08)	100.73 (2.36)	62.91 (1.47)	161.32 (3.78)	4266.08
T4	YT 6t ha <sup>-1</sup> ***	20.92	6.77 (0.16)	46.07 (1.06)	101.65 (2.35)	65.38 (1.51)	163.91 (3.79)	4328.56
T5	YT 6t ha <sup>-1</sup> + FYM****	24.36	6.85 (0.16)	47.57 (1.10)	103.79 (2.31)	65.40 (1.46)	167.55 (3.74)	4483.72
	CD(p=0.05)	2.11	0.70	4.37	7.21	6.32	11.51	388.08

#Values given in parenthesis is % over of the total P

\*GRD for rice (100:60:40),\*\*5 t ha<sup>-1</sup> YT – Yield target 5 t ha<sup>-1</sup> for rice,\*\*\*6 t ha<sup>-1</sup> YT – Yield target 6 t ha<sup>-1</sup> for rice,\*\*\*\*6 t ha<sup>-1</sup> YT + FYM- Yield target 6 t ha<sup>-1</sup> for rice

### Grain yield of rice crop

The highest grain and straw yields of rice (59.58 q ha<sup>-1</sup>, 79.84 q ha<sup>-1</sup>) were recorded in T5 (YT 6t ha<sup>-1</sup> + FYM) followed by T4 and T2 and lowest in T1(14.36 q ha<sup>-1</sup>, 18.75 q ha<sup>-1</sup>). The targeted yields of rice and wheat crops were nearly achieved with + 10 percent acceptable limit of variations under those treatments where nutrients applied on the basis of soil test (Ramamoorthy *et al.* 1967). Similar results were reported by Santhi *et al.* (2004) [9].

**Table 2:** Effect of nutrient management practices on Grain and Straw Yield (q/ha)

Treatments	Treatments details	Grain Yield (q/ha)	Straw Yield (q/ha)
T1	Control (000)	14.36	18.75
T2	GRD(100:60:40)	53.5	70.77
T3	YT 5t ha <sup>-1</sup>	50.16	62.22
T4	YT6t ha <sup>-1</sup>	57.22	74.95
T5	YT 6t ha <sup>-1</sup> + FYM	59.58	79.84
	CD (p=0.05)	4.81	5.42

### Relationship between rice yield and P fractions

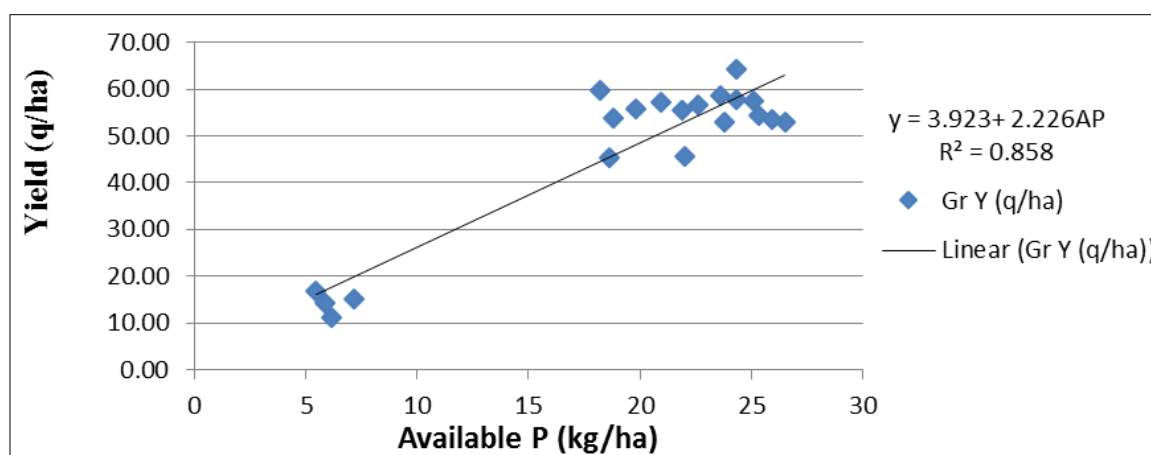
Among different P fractions, Red-P was the most important P fractions contributing toward grain yield with 'R<sup>2</sup>' values 0.88. A critical examination of this equation ((Table 3 and figures 1

to 7) indicated that Red-P was the most important variable computed to the yield variation observed by regression analysis. Reductant soluble P or occluded P is highly insoluble and this fraction is very important for rice soil under submergence. The R<sup>2</sup> value indicated that about 88% variations in grain yield were attributed only to this fraction of P. The second most important variable was Saloid-P in (87%) followed by Available-P (85.8%) and lowest in Total-P (77%). Similar results found in Verma (2002) [15], Sepehya (2011)

**Table 3:** Regression model for yield variation of rice with P fractions

S. No.	Regression equation	R <sup>2</sup>
1	Y = 3.923+2.226AP	0.858
2	Y = -0.984+8.270SP	0.879
3	Y = -11.33+1.378AIP	0.85
4	Y = -31.05+0.825 RP	0.889
5	Y = -19.49 + 1.116FeP	0.848
6	Y = -46.79 + 0.604CaP	0.844
7	Y = -57.28 + 0.025TP	0.77

Where, AP – Available Phosphorus, SP – Saloid Phosphorus, AIP – Aluminium Phosphorus, RP – Reductant Phosphorus, FeP – Iron Phosphorus, CaP – Calcium Phosphorus, TP – Total Phosphorus

**Fig 1:** Rice grain yield response to Available-P

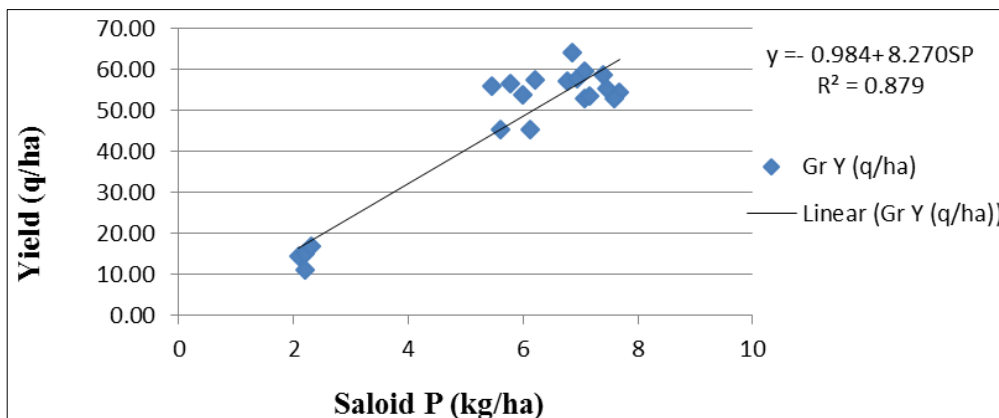


Fig 2: Rice grain yield response to Saloid-P

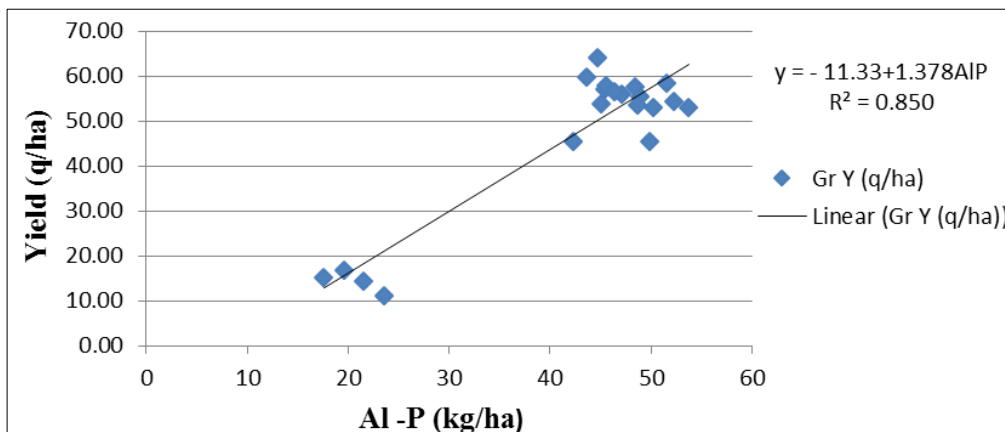


Fig 3: Rice grain yield response to Al-P

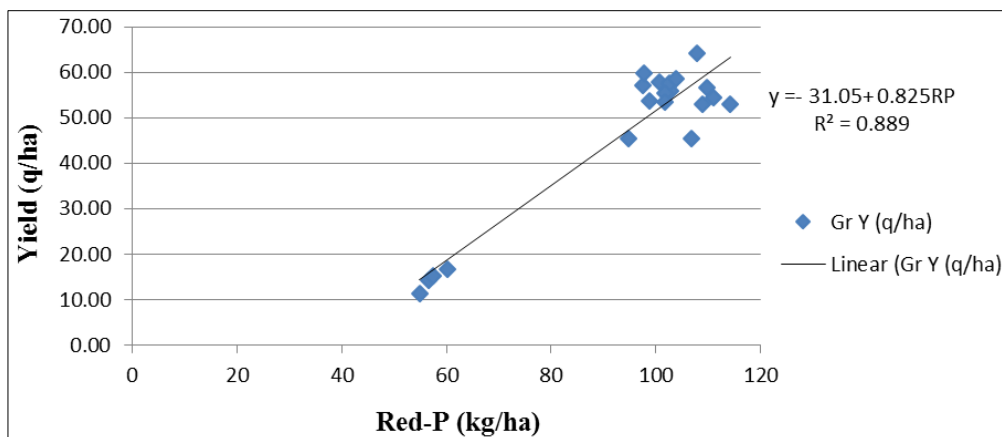


Fig 4: Rice grain yield response to Red-P

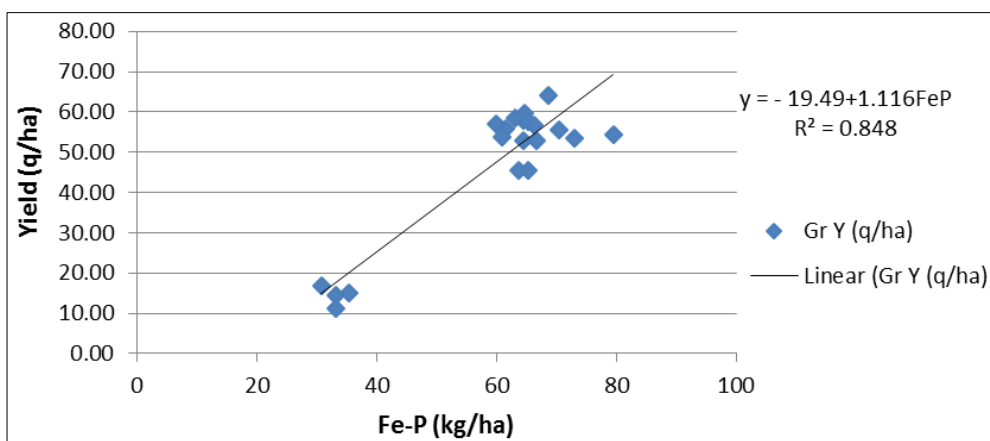


Fig 5: Rice grain yield response to Fe-P

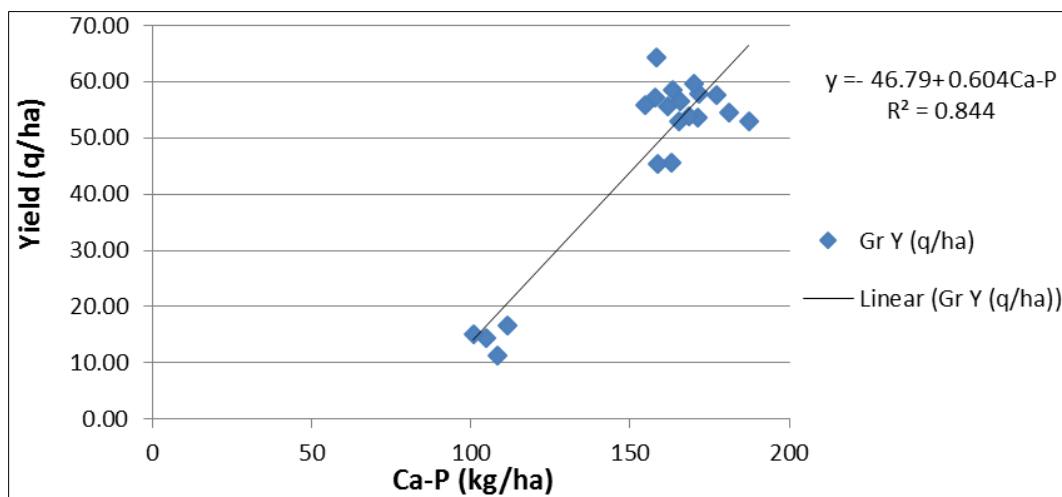


Fig 6: Rice grain yield response to Ca-P

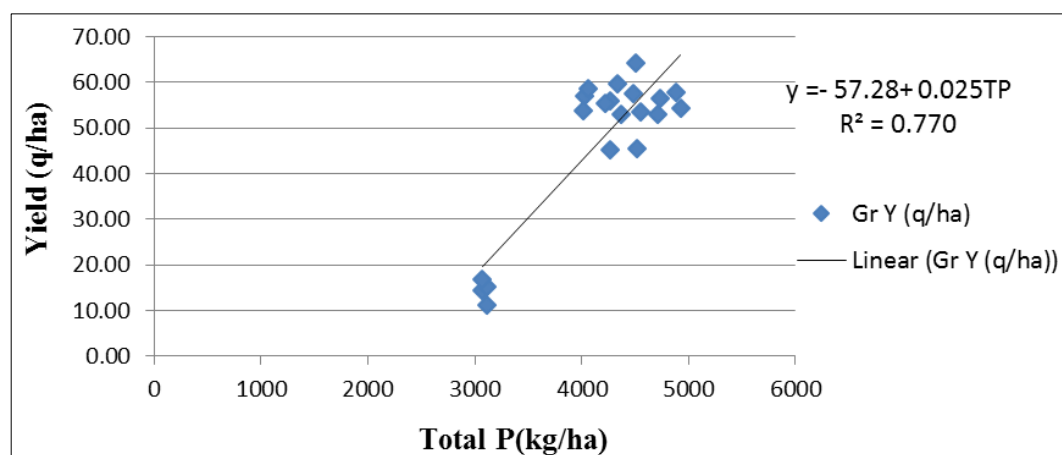


Fig 7: Rice grain yield response to Total-P

### Conclusion

All P fractions (Saloid, Al, Red, Fe, and Ca P) were recorded higher values with the treatment T2 (GRD) followed by T5 (YT 6t/ha with FYM), T4 (YT 6t/ha), (T3 YT5t/ha) and lowest in T1 (control) treatment. The order of dominance of P fractions in *Vertisol* is Ca-P followed by Red-P, Fe-P, Al-P and lowest in Saloid-P. Contribution of different fractions of P to the total P indicated that substantial contribution of Ca-P followed by Red-P and lowest in Saoid-P. Among different P fractions, Red-P was the most important variable computed to the yield variation observed by regression analysis.

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