Effect of phosphorous application in combination with organic soil conditioner on growth of low land rice.

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ABSTRACT

Soils of Pakistan are deficient in available P, due to high pH, which leads to immediate fixation of added P. An experiment was conducted to check growth and yield of low land rice as affected by P application along with an organic soil conditioner (OSC). The experiment was laid-out according to Complete Randomized Design (CRD) with four replications. There were 6 treatments as, control (0 kg P acre^{-1}), 15 kg P acre^{-1}, 30 kg P acre^{-1} , OSC @ 300g acre^{-1} + 15 kg P, OSC @ 300g acre^{-1} + 30kg P and OSC @ 300g acre^{-1}. Plants were harvested after 50 days of transplanting. The results revealed that plant height, shoot dry weight, photosynthetic rate, phosphorus concentration in roots and shoot and phosphorus uptake was increased by the combined application of OSC and phosphatic fertilizer.

Key words; organic matter, phosphorous, rice and organic soil conditioner

Introduction

Rice is used as staple food in whole world and ranks 2nd in food grain crops in Pakistan. The quality of Pakistani rice is very good so it was grown on an average area of 2571 thousand hectares. In Pakistan, farmers mostly use N, while P is not used at recommended rate [1].

Phosphorus (P) is an essential plant nutrient which plays a number of important roles in photosynthesis, energy transfer and also an important component of biomolecules [2]. Its deficiency mostly affects plant growth and metabolism[3,4].

Mostly in Pakistan, rice is grown on alkaline soil with moderate to severe P deficiency [5]. There are many factors like pH, texture, organic matter and source of phosphatic fertilizer which affects the availability of P to the crops [6]. Additionally P resources are non renewable which needs to be used judicially. Scientists have realized that increasing cost of phosphatic fertilizers have decreased the efficiency of these fertilizer, so we have to improve efficiency of added P [7].

The best option to cope this deficiency is application of organic matter for crop production [8]. Mostly organic matter, in agriculture is used for the improvement in nutrient availability to the crops [9]. Organic inputs are used as an alternative of mineral fertilizers. Organic inputs application can increase the growth and yield of different crops such as sugarcane and wheat [10].

We hypothesized that addition of P along with organic soil conditioner can improve P availability in soil and thus would improve P uptake by rice through changes in rhizosphere chemistry and biology. Therefore, following project was designed to study the effect of P application in combination with organic soil conditioner on growth of low land rice.

Material and Methods

The research work presented in this manuscript was conducted in wire-house of Institute of Soil and Environmental Sciences, University of Agriculture, Faisalabad during summer 2012. The soil used for this experiment was loam in nature (Table 1). Bulk soil samples were collected from Agronomy field, UAF. Sampling site had been fallow from last 15 to 20 years. The soil was thoroughly mixed for homogenized and uniform experimental material.

There were 6 treatments used as control (0 kg P acre^{-1}), 15 kg P acre^{-1}, 30 kg P acre^{-1} , OSC @ 300 g acre^{-1} + 15 kg P, OSC @ 300 g acre^{-1} + 30 kg P and OSC @ 300g acre^{-1} (Table 2). Each treatment was replicated four times. All the treatments were applied and soil was thoroughly mixed before pot filling. Uniform rates of N and K were applied in each pot @ 30 mg N and 20 mg K in the form of urea and sulfate of potash respectively. Phosphorus was applied only in two treatments with 15 and 30 kg P ha^{-1}. The organic soil conditioner applied was taken from market which is commercially available.

Rice seeds were first soaked in distilled water over the night. Seeds were transplanted in the trays for minimum 20 days for nursery growing. After the nursery was grown, plants were transplanted in the pots where recommended doses of N, P, K and organic soil conditioner were applied.

Irrigation was done by the application of distilled water collected from distillery situated in institute of soil and environmental sciences. Rice cultivar (KAINAT) was used as test crop. Different agronomic parameters like plant height, fresh and dry weight of shoot, root dry weight and total biomass were recorded.

Data collection and Analysis

Plant P and K concentrations were determined in shoot and root part. Shoot and root P concentration (mg g^{-1}) were determined by taking 0.2 g sample and digesting in di acid. Phosphorus uptake by shoot was also determined. K concentration in shoot and root was determined by taking reading through flame photo meter.

Results

Plant height is an important parameter for plant growth and development. Maximum plant height (96 cm) was recorded in treatment T_2 where P was applied @ 15 kg $acre^{-1}$ (Fig-1). But, an increase in rate of P did not affect plant height. Other treatments (T_4, T_5, T_1, T_3 and T_6) were not different to each other. Plant height was lowest in T_6 (81 cm) in which only organic soil conditioner was applied @ 300g $acre^{-1}$. Maximum shoot dry weight was produced in T_4 (5.14 g pot^{-1}) in which OSC @ 300g $acre^{-1}$ along with P were applied (Fig). Treatment 5 (T_5) in which OSC @ 300g $acre^{-1}$ + 30kg P was applied also showed higher shoot dry weight as compared to control. The results showed that application of organic soil conditioner in combination with half dose of synthetic fertilizer increased the dry matter production as compared to other treatments. Minimum dry weight was produced in T_6 in which only organic soil conditioner was applied. The photosynthetic rate is a parameter which determines the growth rate of plants. Photosynthetic rate is mostly affected by increase in specific leaf area. The maximum photosynthetic rate (Fig-3) was recorded in T_4 (0.53 µmol m^{-2} s^{-1}) where OSC @ 300 g $acre^{-1}$ + 15 kg P was applied as compared to control (0 kg P $acre^{-1}$). There was a significant difference in T_4 and T_6. Minimum photosynthetic rate was seen in Treatment 3 (0.3225 µmol m^{-2} s^{-1}) where full dose of P was applied without any amendment with OSC. There was 8% increase in photosynthetic rate by the application of OSC and phosphatic fertilizer in combination. The treatment in which only OSC was applied also showed an increase in photosynthetic rate. Transpiration is the evaporation of water through aerial parts of a plant. Transpiration rate is mostly regulated by stomata opening. Maximum (Fig-4) increase was shown in T_6 (0.20 mmol $m^{-2}s^{-1}$) where only OSC was applied. The results showed that application of OSC in combination with phosphatic fertilizer decreased the transpiration rate to some extent. Minimum transpiration rate was recorded in treatment 4 where half dose of P along with OSC was applied. Phosphorous including all macro nutrients is essentially required for the activities of enzymes, protein synthesis, integrity of cell wall and plasma membrane and also as components of proteins, DNA and RNA. Due to low P concentration in tissues, organics cannot supply sufficient P for crop growth. The results showed that there was more P availability in treatments where only organic fertilizer was applied. Maximum concentration of P (Fig-5) in shoot was in T_6 (2.05 mg g^{-1}) where OSC @ 300 g $acre^{-1}$was applied as compared to T4 (0.83 mg g^{-1}) where OSC and phosphatic fertilizer were applied in combination. The highly significant results of various treatments regarding P concentration in roots are shown in fig-6. The results indicated that T_5 (2.2 mg g^{-1}) where OSC @ 300g $acre^{-1}$and full dose of P was applied showed more P concentration in roots as compared to control in which no P was added. While T_3 (0.928 mg g^{-1}) where full P was applied showed lowest P concentration as compared to other treatments. The results showed that

T_1, T_2 and T_4 were not significantly different with each other. Maximum P uptake (Fig-7) was observed (8.07 mg pot^{-1}) in treatment 1 where no phosphatic fertilizer was applied. The results also showed that P uptake was also higher in treatment 2 (7.57 mg pot^{-1}) where half dose of phosphatic fertilizer was applied. There was no significant difference in T_1, T_3, T_5 and T_6. Minimum P uptake was shown in T_4 (4.75 mg pot^{-1}) where OSC and half dose of phosphatic fertilizer were applied. It was also seen that T_2 (7.5 mg pot^{-1}) was significantly different from T_4 (4.25 mg pot^{-1}).

Discussion

The results showed that P application increased plant height. Treatment 2 was 13% higher in plant height than control. This may be due to more absorption of nutrients by roots. These results were in similar with those of [11] who concluded that application of P increased the plant height of wheat and rice crops. According to results the application of OSC in combination with different doses of fertilizer increased the shoot dry weight by 24% and 22% in T_4 and T_5 respectively as compared to control. Our results were in similar with [12] who reported that shoot dry weight of maize crop was increased by the combined application of cow dung and chemical fertilizer. Application of organic soil conditioner enhanced photosynthetic rate than other treatments. Our results were similar with [13], who studied the growth of highbush blueberry affected by the application of forest litter as an organic soil amendment. They reported that amendment of soil with an organic conditioner increased photosynthetic rate as compared to non-treated. But alone application of OSC increased the transpiration rate than other treatments and it was about 9% increase in T_6 than control. Our results were similar to [14] who reported that transpiration rate was increased by application of compost when applied to maize. These results about P concentration in shoot are in agreement with those of [15] who used different levels of poultry manure as soil amendment. Their results showed that P concentration was increased in treatments where only poultry manure was applied as an organic source. Our results about P concentration in roots were in similar with those of [16] who reported that combined effect of organic and mineral fertilizer influenced P concentration. [17] Also reported that the maximum P concentration in roots of rice grown in soil treated with organic manure and mineral P fertilizer. Maximum P uptake was found in control treatment which showed that plant roots try to uptake more P by increasing root surface area. The results of this study showed that combined application of organic and inorganic fertilizer sources could be a good source for crop productivity.

References

[1] NFDC. Balanced fertilization through phosphate promotion at farm level. Final report on three phases of trials (1987-2005).National Fertilizer Development Centre.Islamabad Pakistan., 2010-11.

[2] P. Marschner. Marschner's Mineral Nutrition of Higher Plants. Ed. 3. Academic Press., 2012.

[3] S. Abel, C. A. Ticconi and C. A. Delatoree. Phosphorus sensing in higher plants. *Plant Soil* 150: 279-287., 2002.

[4] M. Shu-Jie, Q. Yun-Fa, H. Xiao-zeng and M. Aan. Nodule formation and development in soybean *(Glycine max* L.*)* in response to phosphorus supply in solution culture. *Pedosphere*. 17(1): 36-43., 2007.

[5] N. Ahmad and M. Rashid. Fertilizer and their use in Pakistan. Government of Pakistan,

Planning and Development Division, NFDC, Islamabad, Pakistan., 2004.

[6] D. W. Dibb, P. E. Fixen and L. S. Murphey. Balanced fertilization with particular reference to phosphates: interaction of phosphorus with other inputs and management practices. *Fert. Res.* 26: 29-52., 1990.

[7] I. T. Twyford. Fertilizer use and crop yields.pp 47-71. In: Proceedings 4th National Congress of Soil Science. Islamabad., 1994.

[8] M. Naeem, F. Khan and W. Ahmad. Effect of farmyard manure, mineral fertilizers and mung bean residues on some microbiological properties of eroded soil in district Swat. *Soil Environ.* 28: 162-168., 2009.

[9] L. P. Jennifer, R. T. Koide and A. G. Stephenson. Effects of mycorrhizal infection and soil phosphorus availability on in vitro and in vivo pollen e performance in Lycopersicon Esculentum (Solanaceae). *Am. J. Bot.* 88(10): 1786-1793., 2001.

[10] B. A. D. Hetrick, G. W. T. Wilson and T. C. Todd. Mycorrhizal response in wheat cultivars: relationship to phosphorus. *Can. J. Bot.* 74(1): 19-25., 1996.

[11] K. Rahmatullah, A. R. Gurmani, A. H. Gurmani and M. S. Zia. Effect of phosphorus application on wheat and rice yield under wheat-rice systems. *Sarhad. J. Agric.* 23 (4): 851-855., 2007.

[12] E. Aspasia, D. Bilalis, A. Karkanis and B. F. Williams. Combined organic/inorganic fertilization enhances soil quality and increased yield, photosynthesis and sustainability of sweet maize crop. *Aus. J. Crop Sci.* 4 (9): 722-729., 2010.

[13] Q. Y. Wei, B. L. Goulart, K. Demchak and Y. Li. Interactive effects of mycorrhizal inoculation and organic soil amendments on nitrogen acquisition and growth of highbush blueberry. *J. Amer. Soc. Hort. Sci.* 127 (5): 742-746., 2002.

[14] A. Noah, O. Cofie, K. G. Ofosu-Budu, J. Ofosu-Anim, K. B. Laryea and D. Foster. Effect of N- enriched co-compost on transpiration efficiency and water used efficiency of maize under controlled irrigation. *Agricul. Water Manag.* 97: 995-1005., 2012.

[15] M. W. Heidi, Z. He and M. S. Erich. Effects of poultry manure amendment on phosphorus uptake by rye grass, soil phosphorus fraction and phosphatase activity. *Boil. Fertile. Soils* 47 (4): 407-418., 2011.

[16] J. M. Dusberg, M. S. Smith and J. W. Doran. In Dynamics of SOM in Tropical Ecosystems. Univ. of Hawaii, USA., 1989.

[17] G. Shipra and G. S. Bahl. Phosphorus availability to maize as influenced by organic manure and fertilizer P associated phosphatase activity in soils. *Bioresource Technol.* 99 (13): 5773-5777., 2008.

Table 1. Physical and chemical properties of used soil for experiment

Parameters	**Units**	**Value**
Sand	%	33.60
Silt	%	39.48
Clay	%	26.92
Textural class	----------	Loam
pH_s	----------	7.43
Saturation percentage	%	22
EC_e	dS m^{-1}	2.50
Cation exchange capacity	$Cmol_{c\ kg}^{-1}$	14.5
SAR	$mmol_c L^{-1}$	7.86
Olsen' P	mg kg^{-1}	9.49

Table 2. Various combinations of treatments are as follows

Treatments No.	**Treatments**
T1	Control
T2	15 kg P ha^{-1}
T3	30 kg P ha^{-1}
T4	Organic Soil Conditioner+15 kg P ha^{-1}
T5	Organic Soil Conditioner +30 kg P ha^{-1}
T6	Organic Soil Conditioner @ 300 g ha^{-1}

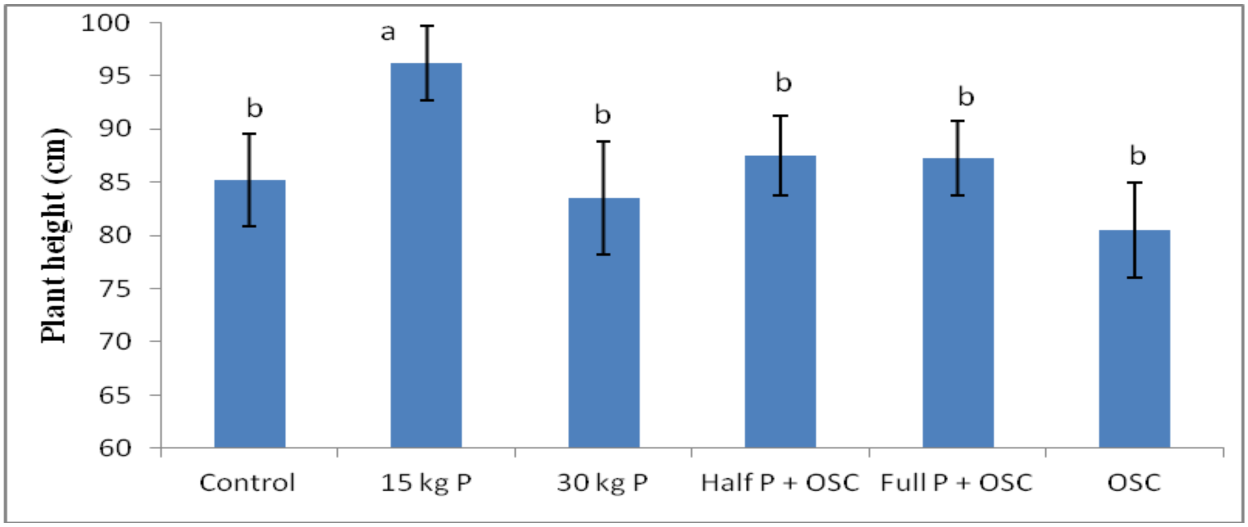

Fig. 4.1 Plant height (cm) of rice grown with different P rates along with organic soil conditioner

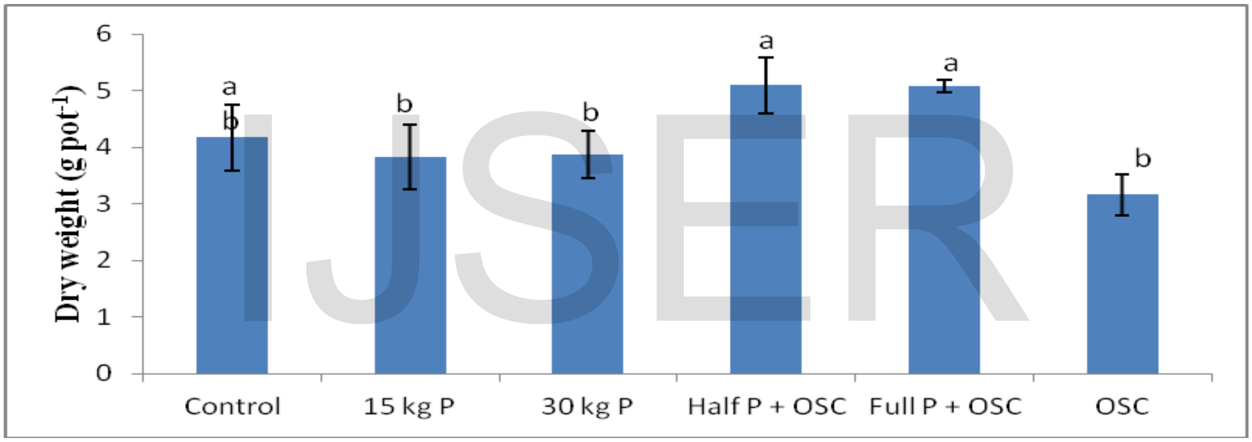

Fig. 4.2 Dry weight (g pot^{-1}) in rice grown with different P rates along with organic soil conditioner

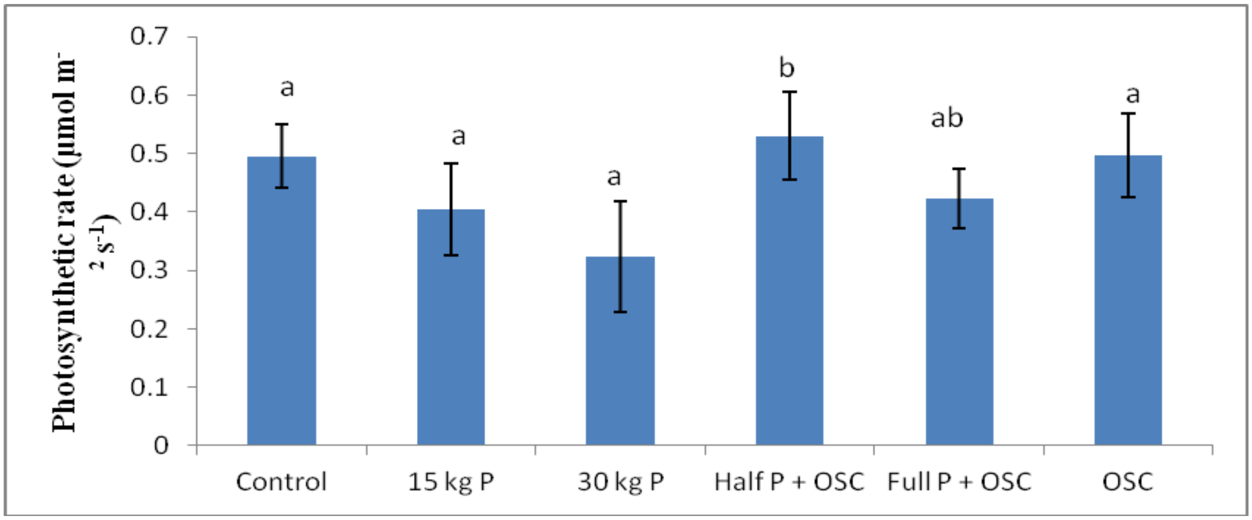

Fig. 4.3 Photosynthetic rate (µmol m^{-2} s^{-1}) in rice grown with different P rates along with organic soil conditioner

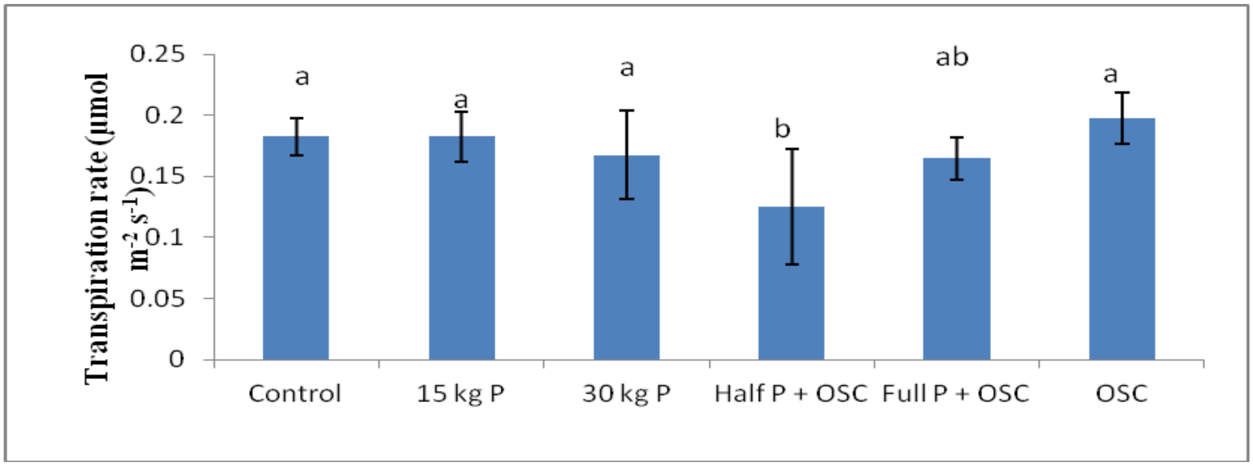

Fig. 4.4 Transpiration rate rate (µmol m^{-2} s^{-1}) in rice grown with different P rates along with organic soil conditioner

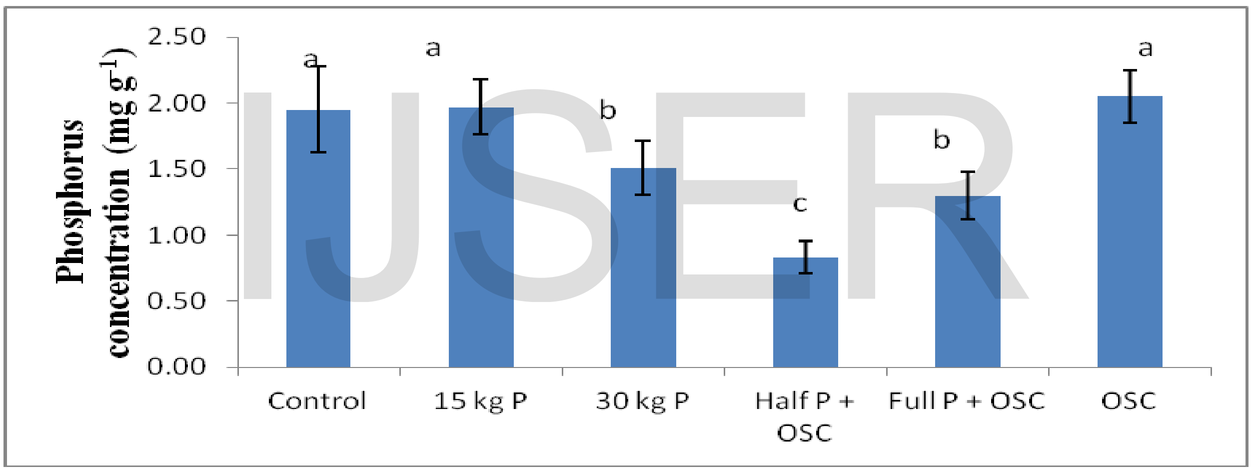

Fig. 4.5 Phosphorus concentration in shoot (mg g^{-1}) in rice grown with different P rates along with organic soil conditioner

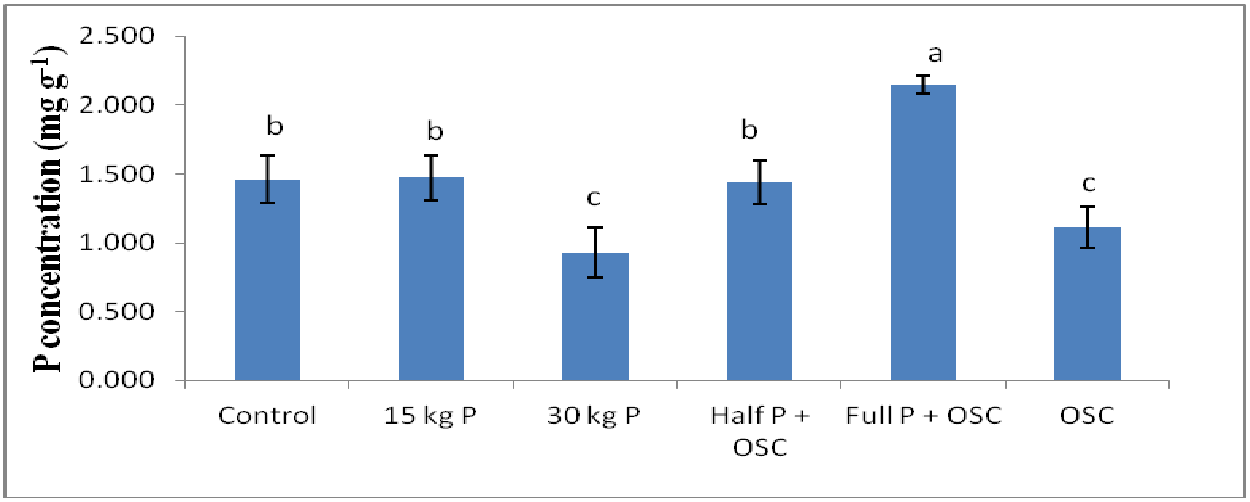

Fig. 4.6 Phosphorus concentration in root (mg g^{-1}) in rice grown with different P rates along with organic soil conditioner

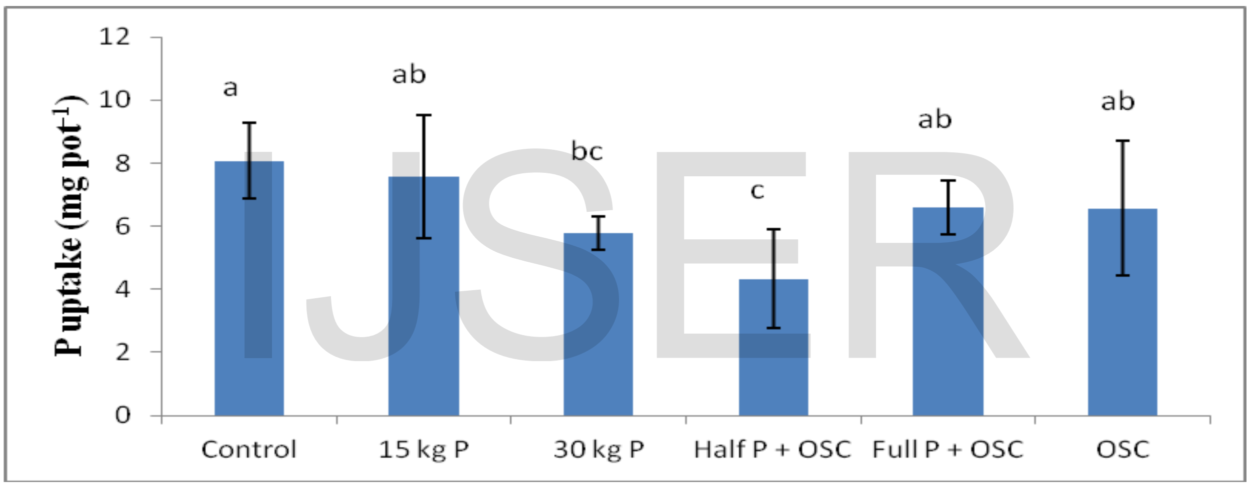

Fig. 4.7 Phosphorus uptake in shoot (mg g^{-1}) in rice grown with different P rates along with organic soil conditioner