Research Article

Assessment of Formulated Phosphorus Enriched Compost on Rice Followed Wheat Crop Yields

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Abstract | Field experiments were conducted for two seasons to investigate the direct and residual effect of phosphorus enriched compost (PEC) prepared by composting poultry litter (PL) with rock phosphate (RP) and inoculating with effective microorganisms (EM) on the wheat during 2010-11. Both experiments were conducted consecutively, in the same lay out of randomized complete block design with three repeats. Various doses of PEC (6, 4, 2 Mg ha^{-1}) were compared with simple poultry-litter compost (PLC) as 8 Mg ha^{-1}, single super phosphate (SSP) fertilizer as 100 kg P_2O_5 ha^{-1} and control. The results showed that PEC at 6 Mg ha^{-1}gave 14.7% and 7.7% increased paddy yield and 14.7% and 11.9%-increased total dry matter yield over PLC at 8 Mg ha^{-1} and SSP, respectively. The highest soil post-harvest extractable P content of 5.42 mg $kg^{-1}$and rice-plant P uptake (17.50 kg ha^{-1}) were also recorded in the treatment PECat 6 Mg ha^{-1} as compared to other treatments. The residual effects of PEC applied at the rate of 6 Mg $ha^{-}$was superior by producing 36.2%, 14.2% and 7.0%increased grain yields over those of control, PLC and SSP, respectively. The post-harvest soil extractable P value and plant P uptake were significantly higher in the treatment where PEC was applied to the previous crop at 6 Mg ha^{-1} over rest of the treatments. It was concluded that PEC has the potential to improve yield of two consecutive crop i.e. rice and wheat yields when applied at 6 Mg ha^{-1}.

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Introduction

Regular application of phosphate fertilizers has now become indispensable part of crop production system in Pakistan where soils are phosphorus (P) deficient (Rashid et al., 2005). Out of the 22.75 million hectares (Mha) of cropped area of Pakistan, 19.08 M.ha are irrigated(GoP, 2018), where 1.279million nutrient ton P fertilizers were consumed (Fertilizer Review, 2018)High price of fertilizers could be one of the reasons of under-dose application of P fertilizers, hence, increasing price trend and growing foods demand emphasized the need for looking alternative sources of P fertilizer. Animal waste in the form of dungs and slurry could be seen as one of the valuable source of P fertilizers, it is estimated that1328 million tons of wet animal wastes produced in Pakistan during the year (Anonymous, 2013). It is estimated that 4.181 million tons P can be obtained from this waste as compared to1.279-million-ton take-off of phosphate fertilizer (Ahmad et al., 1997; ASP, 2013) paving the way for its potential use as bio-fertilizer. Research has shown that this organic waste can be utilized as organic fertilizer and can be enriched with

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various essential nutrients after proper processing/ composting (Akande et al., 2005).

Preparation and application of composts to the crops to substitute or supplement the costly chemical fertilizers could not get popularity due to its lower plant nutrients contents coupled with lengthy process of decomposition. An alternate approach is required to be developed for enriching the manure with essential nutrients and simultaneously, decrease the time-span of their decomposition. The enrichment of composts with P by adding rock phosphate seems to be a viable option. The insoluble P content of rock-phosphate (RP) may be converted to the soluble form through biological solubilization, an environment-friendly approach (Alexander, 1976). The organic acids convert tri-calcium phosphate (TCP) to di- and mono-basic phosphates hence, increasing plant P availability (Sharma, 2005). The mixing of RP with organic materials such as animal feces and plant residues along with the inoculation of acid-producing microbes may enhance its P solubility (Gaind et al., 2006). During decomposition of organic materials, organic acids produced by the microbes (HNO_3 and H_2CO_3) may solubilize the fix P from RP which could be accelerated by the addition of acid-creating micro-organisms. The positive impacts of adding RP with farmyard manure on plants P uptake have been reported elsewhere (Gaind et al., 2006; Mishra and Banjar 1986; Singh and Amberger, 1995). The RP blended with compost showed a comparable result with a P fertilizer as well as cost effective (Sekhar et al., 2005).

Investigations of our previous study (Khan and Sharif, 2012) show significant temporal increase of P (0.15% -1.60%) where RP, PL and acid creating microbes were applied in combination, followed 1.02%PL + RP viz a viz control (0.30%).It was hypothesized that the higher available P content of the PEC and its slow release nature will enhance the yield of two consecutive crops by fulfilling their P requirements.

Material and Methods

Experiments were conducted to determine the direct and residual effect of prepared P-enriched compost (PEC)on the soil extractable P, N and P uptake, rice and wheat grain, biomass yields. The experiments were conducted at Arid Zone Research Institute, Dera Ismail Khan during Kharif 2010 and Rabi 2010-11 comprising six treatments; control, simple poultry-litter compost (PLC) as 8 Mg ha^{-1}, PEC as 6 Mg ha^{-1}PEC as 4 Mg ha^{-1}, PEC as 2 Mg ha^{-1} and SSP as 100 Kg P_2O_5 ha^{-1}and laid out as Randomized Complete Block Design with three replications and plot sizes 10×2.5m^2. Analyses of composts is given in Table 1. Soil samples were randomly collected before onset of experiment and analyzed for various physico-chemical characteristics (Table 2). A buffer-belt of 1 m was kept among the treatments, and each treatment was surrounded by proper embankment to avoid cross transfer of nutrients. The irrigation channel was designed to irrigate each treatment separately. Equal amount of irrigation water was applied to each treatment by noting time of irrigation. The recommended dose of N and K_2O was applied at 120 kg ha^{-1} and 60 kg ha^{-1}from Urea and Sulphate of Potashas basal dose. The amount of N and K_2O for every compost treatment was calculated on the basis of the nutrient content of the composts and any deficiency was compensated by applying respective chemical fertilizer. Before the transplantation of rice seedlings field was puddled and rice seedlings (variety cv. *IRRI-6*) were manually transplanted maintaing25 cm row to row and 20 cm plantto plant distance. Yields data were collected by harvesting three central rows of each treatment and crop was harvested at maturity.

Table 1: *Analysis of compost used in the experiment.*

Compost	pH	C:N	TOC	Available P	Total N
P-Enriched Compost	7.36	11.55	15.82	1.60	1.37
Poultry Litter Compost	7.60	12.35	18.05	0.30	1.47

Table 2: *Pre-sowing physico-chemical characteristics of soil.*

Property	Unit	Values
Textural Class	-	Clayey
pH (1:5)	-	7.86
Soil Organic Matter	%	0.7
ABDTPA ext. NO_3	mg kg^{-1}	4.58
ABDTP ext. P		6. 05
Total P	%	0.37
K	mg kg^{-1}	130
Zn		0.7

The residual effect of PEC applied to the previous crop of rice was investigated on consecutive wheat (*Triticumaestivum L*) crop conducted in the same layout of rice experiment. The characteristics of the post-harvest soil of the previous rice crop were assumed as the pre-sowing soil status for wheat. The soil samples were collected at 0-15 cm depth from each treatment after the rice harvest and analyzed for physico-chemical properties. The soil was ploughed and flood irrigation was applied to each treatment separately. Half dose of N (60 kg ha^{-1}) from urea was applied at the field capacity level of the soil, followed by ploughing and planking and sown by wheat variety "*Oqaab*" The second half-dose of N was applied to the crop in February 2011 during the rainy period. The field was irrigated only once by the end of December 2010. No other inputs except for N were applied to the crop. The rainfall received during the season was 77.5mm. The affective rainfall was received in February 2011 (55.8 mm) followed by April 2011 (Table 3). All of the cultural practices were uniformly performed for all of the treatments.

Table 3: *Agro-meteorological data of experimental site.*

Month/Year	Av. T. (°C)	Av. R.H. (%)	P.E. (mm day^{-1})	Rainfall (mm)
November 2010	18.0	67.5	2.25	0
December 2010	12.0	68.5	1.39	0
January 2011	10.0	69.0	1.31	2.5
February 2011	14.0	67.0	1.94	58.0
March 2011	19.5	41.0	3.33	5.5
April 2011	25. 0	54.5	4.76	11.5
Total	-	-	-	77.5

Av. T.= Average Temperature, Av. R.H.= Average Relative Humidity, P.E.= Pan Evaporation.

PEC samples for determination of N, P, TOC and pH were collected after 120 days of the composting. The analysis of NO_3-N and total N was determined following Kjeldahal (Rayan et al., 2001) and wet digestion methods (Jackson, 1973), respectively. Available or extractable P was analyzed through Mehlic-3 method, (Mehlic, 1984). TOC was determined by the procedure as given by Nelson and Somers (1982). The total P content was determined by the procedure of Olsen and Sommers (1982).

The plants' N and P concentrations were determined by the Kjeldahl Method (Ryane et al., 2001) and the Wet-Digestion Method (Jackson, 1973), respectively. the TOC was determined with Loss on Ignition method (Tandon et al., 2005). The total P concentration in the RP and the FYM was determined by the procedure of Olsen and Sommers (1982). The pH of all of the soil and plant samples was determined as per procedure prescribed by McClean (1982). The soil texture class was determined by the Dispersion Method as prescribed by Koehler (1984). For the determination of NO3-N, extractable P and K in the soil, a multi-element determination extractant of Ammonium Bicarbonate –Diethylene Triamine Penta Acetic Acid (AB-DTPA) was used (Soltanpour and Schwab, 1977). Organic matter in the soil was determined by the Titration Method (Nelson and Sommers, 1982). The moisture content in the soil and compost samples was determined by the Gravimetric Method as prescribed by Gardner (1986).

Results and Discussion

Effect of PEC on rice crop

Tillers $plant^{-1}$: Significant ($p \leq 0.05$) increase in the number of tillers $plant^{-1}$ was recorded in the treatments where various sources of P fertilizers were applied. The number of tillers $plant^{-1}$ ranged from 6 to 11 (Table 3). The significantly-highest number of tillers $plant^{-1}$ was recorded in the treatment receiving PEC at 6 Mg ha^{-1}, against lowest in in the control treatment. The treatments that received SSP at 100 kg P_2O_5 ha^{-1}, PEC at 4 Mg ha^{-1} and PLC at 8 Mg ha^{-1} gave significantly at par number of tillers $plant^{-1}$.

Paddy yield: The paddy yield of the IRRI-6 variety ranged from 3,233 to 5,515 kg ha^{-1}amongthe treatments. The highest grain yield of 5,515 kg ha^{-1} was recorded in the treatment where PEC was applied at 6Mg ha^{-1}, while the lowest yield in the control (Table 3). The second-highest grain yield of 5,122 kg $ha^{-1}$was noted for SSP at 100 kg P_2O_5 ha^{-1}, followed by PEC at 4Mgha^{-1} which produced 4,960 kg ha^{-1} with non-significant difference. The PLC at 8 Mg ha^{-1} remained inferior to the PEC at 6 Mg ha^{-1} in the grain-yield production of the paddy. The results showed that PECat6 Mgha^{-1}gave a yield increase of 84%, 14.7% and 7.7% over the Control, PLCat 8 Mgha^{-1} and SSP at100 kg P_2O_5 ha^{-1} respectively. The treatment can be arranged in order of increase in yield as PEC (6 Mg ha^{-1}) > SSP at> PEC (4 Mgha^{-1})> PLC > PEC (2Mg ha^{-1}) >control. The increase in paddy yield might also be attributed to the increase in number of tillers $plant^{-1}$. Though some research work have already been done however, in the wake of increasing prices of fertilizer and to tap fertilizer applied P in the soil for plant uptake, it is increasingly realized that enriched compost could not only increase P availability but also help conserve resources and come up with environment friendly and economically viable solutions.

Dry matter yield: The dry matter yield (DM) of paddy significantly ($p \leq 0.05$) increased across all treatments in this study. The yields ranged from 5.1 to 7.5 Mg ha^{-1}. The highest DM yield of 7.5Mg $ha^{-1}$was obtained with application of PECat6 Mg ha^{-1}, followed by 7.3 Mg $ha^{-1}$and 7.2 Mg ha^{-1} with application of PEC at4 Mg $ha^{-1}$and SSP respectively.

Post-harvest soil chemical properties: The NO_3-N was generally higher in the treatments containing higher amounts of compost, irrespective to its type (Table 4). The PLCapplication and PEC at6 Mgha^{-1}gave significantly higherNO_3-N of 3.3% and 3.1%, overall of the other treatments, including the control. The general trend of increase in residual NO_3-N in soil may be demonstrated as PLCat8 Mg ha^{-1}> PEC at6 Mgha^{-1} >control > PEC at4 Mgha^{-1}> PEC at2Mg ha^{-1}> SSP. The Post-harvest soil extractable P showed significant ($p \leq 0.05$) variation among the treatments. The maximum soil P concentration of 5.4mg kg^{-1} was recorded with application of PEC at the rate of6 Mg ha^{-1} followed by PEC applied at the rate of4Mg ha^{-1} with 4.94 mg $kg^{-1}$with clear statistical difference. The lowest value of 2.5mg kg^{-1} P was recorded in the control (where no P was applied), followed by SSP with 3.4 mg kg^{-1}.

Table 4: *Effect of P-enriched compost on the yield and yield attributes of rice.*

Treatment	No. of Tillers Plant^{-1}	Dry-Matter Yield (Mg ha^{-1})	Paddy Yield (Kgha^{-1})
Control	5.60 d	5.10 d	3233 e
PLC at 8 Mg ha-^{1}	10. 00 b	6.83 c	4809 c
PEC at 6 Mg ha^{-1}	10.93 a	7.52 a	5515 a
PEC at 4 Mg ha^{-1}	10.13 b	7.27 ab	4960 b
PEC at 2 Mg ha^{-1}	8.60 c	6.55 c	4493 d
SSP 100at kg P_2O_5 ha^{-1}	10.13 b	7.15 b	5122 b
CV	3.73	2.36	3.70
LSD	0.627	0.290	317. 09

PLC= Poultry-litter compost; PEC= Phosphorus Enriched Compost; SSP=Single superphosphate; CV=Coefficients of Variation; Means followed by different letter (s) are significantly different from each other at p≤ 0.05.

Plant uptake of N and P: Plant P and N uptake shows that the maximum N accumulation (182kgha^{-1}) was recorded in the treatment where PEC was applied @6 Mg ha^{-1}followed by 176 kg ha^{-1} with PEC applied @4Mg ha^{-1}, while the plant uptake of P varied significantly ($p \leq 0.05$) among the treatments (Table 5). The highest P-uptake of22.6 kgha^{-1} was recorded in the treatment where PEC was applied at6 Mg ha^{-1}followed by SSP treatment giving 19.8 kgha^{-1}. The lowest uptake of 6.0 kgha^{-1}was recorded in the treatment where no P was applied (control). The trend of P uptake was PECat6 Mg ha^{-1}>SSP>PEC at 4 Mg ha^{-1}> PEC at2 Mg ha^{-1}>Control.

Table 5: *Effect of P-enriched compost on soil chemical properties and rice plant N and P uptake.*

Treatment	Soil Chemical properties			Plants uptake (kg ha^{-1})	
	NO_3-N (%)	Available P (mg kg^{-1})	pH (1:1)	N	P
Control	2.63 B	2.47 F	7.83	94.46 E	6.04 F
PLC 8 Mg ha^{-1}	3.26 A	3.63 D	7.83	129.11 D	11.86 D
PEC 6 Mg ha^{-1}	3.11 A	5.42 A	7.83	182.37 A	22.60 A
PEC 4 Mg ha^{-1}	2.61 B	4.94 B	7.82	175.80 B	17.40 C
PEC 2 Mg ha^{-1}	2.32 B	4.21 C	7.82	142.50 C	9.38 E
SSP 100 kg P_2O_5 ha^{-1}	2.18 B	3.35 E	7.83	169.87 B	19.76 B
CV	9.4	3.32	0.17	4.46	7.85
LSD	0.459	0.2392	NS	12.081	2.0727

Means followed by different letters are significantly different from each other at P≤ 0.05.

Residual effects of PEC on wheat crop

Tiller per Plant: The residual effects of PEC, PLC and SSP showed significant (P≤0.05) increase in the number of tillers per plant (Figure 1). The maximum number of tillers plant^{-1} (4.22) was recorded in the treatment where PEC was applied at 6 Mg ha^{-1} to the previous crop, followed by PEC at the rate of 4 Mg ha^{-1} and 2 Mg ha^{-1} producing 3.97 and 4.0 tillers plant^{-1}, respectively. The application of SSP, PEC at 4 Mg ha^{-1} and PLC at of 8 Mg ha^{-1} produced the second-highest and at-par number of tillers plant^{-1}. The lowest number of tillers plant^{-1} was recorded in the control treatment.

Grain yield of wheat: The residual effects of PEC, PLC and SSP showed significant increase in the grain yield of wheat crop that was grown after rice. The significantly (P≤ 0.05) highest wheat grain yield of 3,867 kg ha^{-1} was recorded in the treatment where PEC was applied at of 6 Mg ha^{-1} to the previous crop of rice (Figure 2). The second-highest value of 3,722 kg ha^{-1} was recorded with the application of PEC at 4 Mg ha^{-1} to the previous crop. The SSP and PEC at 2 Mg ha^{-1} showed statistically at-par grain yield of 3,616 and 3,521 kg ha^{-1} respectively. The lowest grain yield was obtained from the 'Control' where no source of P was applied to the previous crop. The results showed that the application of PEC at the rate of 6 Mg ha^{-1} to the previous crop gave better residual effects by producing 36.2%, 14.2% and 7.0%-increased grain yields over those of the 'Control', the PLC and the SSP, respectively.

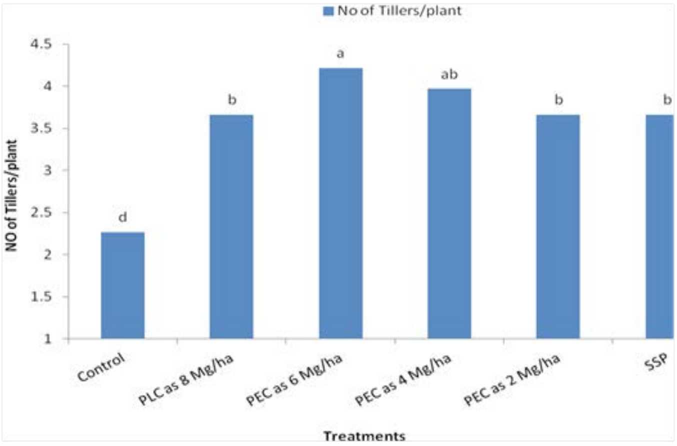

Figure 1: *Residual effects of p-enriched compost on number of tillers plant^{-1} of wheat.*

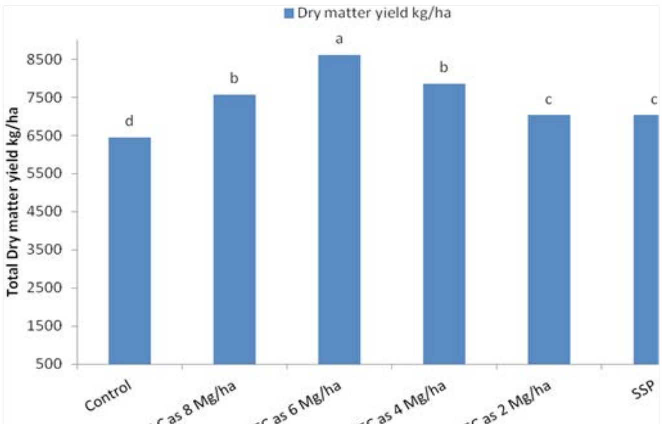

Figure 2: *Residual effects of p-enriched compost on grain yield of wheat.*

Total dry matter yield of wheat: The total dry-matter yield of wheat was significantly improved with the residual effects of composts and SSP applied to the previous crop of rice (Figure 3). The significantly (p≤0.05) highest dry-matter yield of 8,610 kg ha^{-1} was recorded with the application of PEC at 6 Mg ha^{-1} to the previous crop, followed by PEC at 4 Mg ha^{-1} and PLC at 8 Mg ha^{-1} with total dry-matter yields of 7,850 and 7,570 kg ha^{-1} respectively.

Soil Analysis after harvest

Soil NO_3-N content: The soilNO_3-N, P and pH show significant increase(p≤0.05). The maximum N (1.63 mg kg^{-1}) was recorded with PLC applied at 8 Mg ha^{-1}, followed by PEC applied at 6 Mg ha^{-1} (1.48 mgkg^{-1}) lowest soil NO_3-N (1.2 mg kg^{-1}) with SSP and control (1.37 mg kg^{-1}) applied previously to rice crop (Figure 4). The increase in NO_3-N in treatments receiving high compost rate may be ascribed to slow release of NO_3-N from compost previously applied to rice crop.

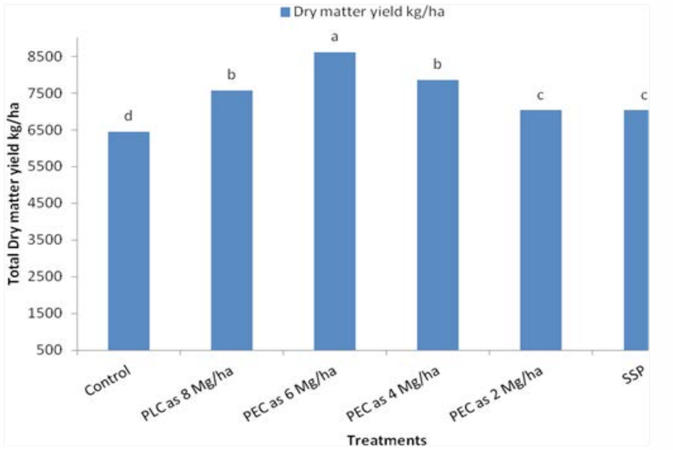

Figure 3: *Residual effects of p-enriched compost on total dry-matter yields of wheat.*

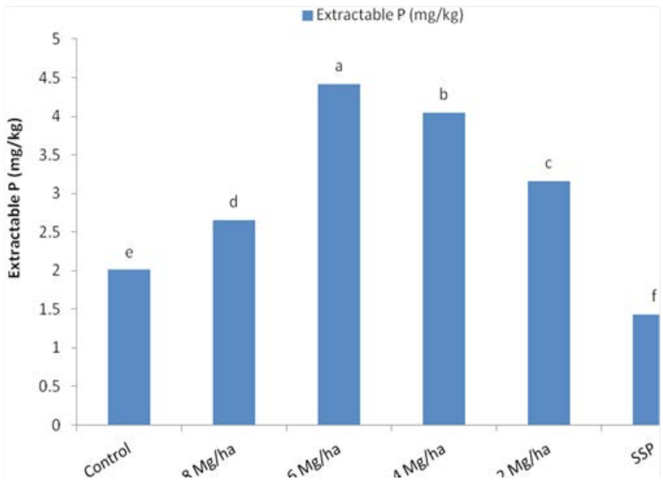

Figure 4: *Residual effects of p-enriched compost on post-harvest soil NO_3-N.*

Soil extractable P content: The availability of P in the post-harvest soil was also significantly increased (p≤0.05) by the application of various levels of P to the previous crop of rice (Figure 5). The maximum P of 4.42 mg kg^{-1} was recorded in the treatment where PEC was applied to the previous crop of rice at 6 Mg ha^{-1}followed by 4.05 mg kg^{-1}. The lowest soil extractable P as1.43 mg kg^{-1} was recorded in the treatment where SSP was applied to the previous crop of rice followed by 2.01 mg kg^{-1} in the control.

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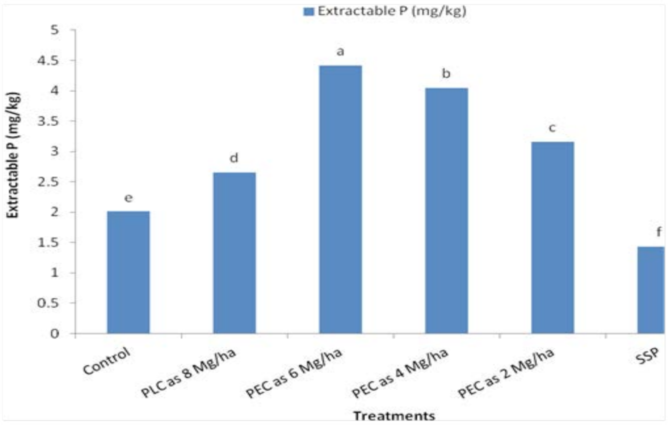

Figure 5: *Residual effects of pec on post- harvest soil extractable P.*

Plants N and P uptake: Significantly ($p \leq 0.05$) higher N uptake (114 kg ha^{-1}) was recorded with application of PEC at 6 Mg ha^{-1}followed by the SSP application at the rate of 70 kg ha^{-1}against as low as 59 kg ha^{-1}, in control (Figure 6). The application of PLC at 8 Mg ha^{-1} and PEC at 4 Mg ha^{-1} produced statistically at par yields of N uptake such as 92.5 and 88.2 kg ha^{-1} respectively. The amount of compost applied to the previous crop, irrespective of the kind, positively affected the crop N uptake. The plant N uptake of the treatment that received PEC at 6 Mg ha^{-1} in the previous crop superseded all of the treatments by showing N uptake of 93, 63 and 23.2%increased N uptake over the control, the SSP and the PLC treatments at 8 Mg ha^{-1} which were applied to the previous crop.

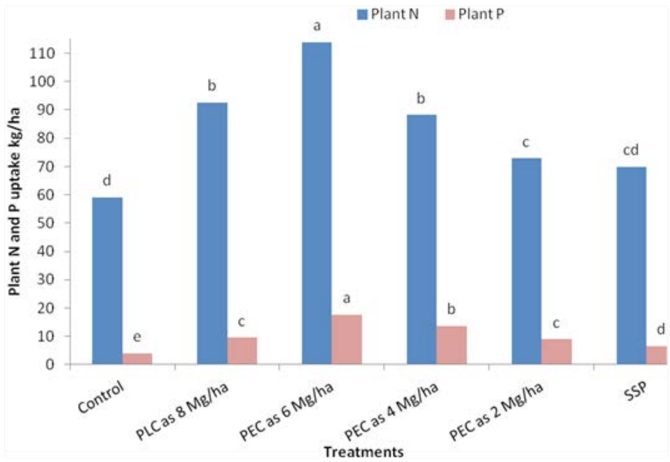

Figure 6: *Residual Effects of P-Enriched Compost on N and P Uptake of Wheat-Plants.*

Significant ($p \geq 0.05$) increase in plant P uptake was recorded with the application of various treatments (Figure 6). Results show that) highest P uptake (17.50 kg ha^{-1}) was recorded with the application of PEC at 6 Mg ha^{-1}, while the lowest of 3.91 kg ha^{-1}in control treatment where no P was applied to the previous experiment with the rice crop). The results showed that the treatment received the compost, irrespective of the kind, showed better results of P uptake than those of the SSP and the control. The treatment that received the PEC at 6 Mg ha^{-1} gave increase P uptake of 348%, 170% and 84.2% over the control, SSP and PLC treatments at 8 Mg ha^{-1}, respectively.

During decomposition of the organic materials, the release of organic acids such as citric acid and oxalic acid help promote solubilization of P from RP (Kumari et al., 2008). Similarly, carbonic acid and nitric acid produced from evolution of carbon dioxide (CO_2) and ammonium dissolved in moisture of the compost also play role in P solubilization (Das, 2005). The released humus substances in P-enriched compost might have chelated P for slow and prolonged availability to the plant resulting in higher yields. The decomposition of carbonaceous materials remains continue till the presence of carbon in compost, (Alexander, 1976), hence, slow release of P from the PEC significantly enhances crop yields of rice and wheat. The fixed P/ RP in PEC or organic materials may enhancen on-labile P in soil (Chavarria, 1981). The release of P from this pool might have enhanced the soil available P in the time span resulting better yields of rice and wheat crops. Akande et al. (2005).

The PEC at 6 Mg ha^{-1} remained superior on PLC at 8 Mg $ha^{-1}$and other treatments for grain-yield production of both crops. Finding of the study are in line with earlier work of Sharif et al. (2011) who reported similar findings with the application of RP and compost to the maize. Such increase in crop yield and nutrients availability could be ascribed to the possible role of organic matter derived from the composts that keep nutrients particularly P binding and make it available to plant uptake. (Datta, et al., 1982; Molla and Chowdhury, 1984). Xu et al. (2000) recorded higher grain and biomass yields of sweet-corn plants with the application of organic fertilizer rather than chemical fertilizer. Similarly, Chalk et al. (2002) concluded that application of RP with FYM increased the dry-matter yield of wheat over the DAP-applied. Though some research work have already been done (Newbery et al., 1995; Hussaini et al., 2008) however, in the wake of increasing prices of fertilizer and to tap fertilizer applied P in the soil for plant uptake, it is increasingly realized that enriched compost could not only increase P availability but also help conserve resources and come up with environment friendly and economically viable solutions.

According to the general guidelines of interpreting the status of a soil nutrients (Ryan, 2001), the treatments with PEC were marginal in extractable P, while others were deficient at the time of the post-harvest of the both crop. The addition of organic matter in the soil helps chelate extractable P from fixing and enhances its availability to the plant for longer time. The addition of organic matter in the soil helps chelate P from fixing and enhances its availability to the plant. The PEC may have played a role of chelating P for enhanced availability to the plant, resulting in higher yields. (Datta et al., 1982; Molla and Chowdhury, 1984). Application of P to the crop enhanced a vigorous growth of roots which absorbed more nutrients, resulting in less residual nutrients in the soil (Shafiq, 2007).

The increased value of NO_3-N particularly in treatment where high compost rate were applied could be ascribed to the slow release of NO_3-N effect of the compost applied. These studies show that application of compost at higher rate is likely to increase availability of N in the soil for plant uptake. The results showed that the treatment that received the compost, irrespective of the kind, showed better results of P uptake than those of the SSP and the control. The increased residual NO_3-N in the control as compared to the SSP and other treatments might be due to the P interaction with the N uptake. The treatments which received some P along with N showed a better N- uptake by plants and less residual N than those treatments which did not receive P. Newbery et al. (1995) and Hussaini et al. (2008) have all reported similar types of interaction between N and P.

Conclusions and Recommendations

Preparation of P enriched compost by addition of RP in PL before start of composting is a viable option to enhance the P content of compost. Based on our research it can be concluded that PEC may enhances the yields of rice as well as economical in comparison to use of traditional fertilizers hence paving the way for lesser dependence on P fertilizers and help in utilization of indigenous RP reserves.

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Author's Contribution

Matiullah Khan, Main researcher of the project conceived, executed all the experiments and drafted paper; Motsim Billah, Maintenance of experiments, data collection and compilation; Shoaib Ahmad, Review collection, data analysis; Raza Ullah Khan, Proof reading and technical input; Muhammad Sarwar, Overall supervision and guidance.

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