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EFFECT OF ROCK PHOSPHATE COMPOSTED WITH ORGANIC MATERIALS ON YIELD AND PHOSPHORUS UPTAKE OF WHEAT AND MUNG BEAN CROPS

MUHAMMAD SHARIF[1*], TANVIR BURNI[2], FAZLI WAHID[1], FARMANULLAH KHAN[1], SAEED KHAN[1], AMJAD KHAN[1] AND AZIZULLAH SHAH[3]

[1]*Department of Soil and Environmental Sciences, The University of Agriculture Peshawar, Pakistan*
[2]*Department of Botany, Peshawar University, Peshawar, Pakistan*
[3]*Pakistan Agricultural Research Council, Islamabad, Pakistan*
[*]*Corresponding author's email: msharif645@yahoo.com*

Abstract

Field experiments were conducted to determine the effect of composts prepared from different organic materials with rock phosphate (RP) on yield and P uptake of wheat and their residual effect on mung bean crops during 2010-2011. Wheat variety saran with a seed rate of 100 kg ha^{-1} was grown in Randomized Complete Block Design (RCBD) with three replications. There were 11 treatments, each of 3×5 m^2 size. Composts prepared from RP fed FYM, simple FYM, organic waste and city garbage were applied at the rate based of their P concentrations. The composts were enriched with phosphorus by mixing different organic material with rock phosphate (RP). Fertilizers were applied at the rate of 120-90-60 kg ha^{-1} N, P and K, respectively in the form of urea, SSP or composts and K_2SO_4. Nitrogen was applied in three split applications whereas all P and K were applied at sowing time. Composts significantly ($p \leq 0.05$) increased grains, total dry matter, straw yield and 1000 grains weight of wheat over control. Significantly ($p \leq 0.05$) increased grains yield of 5274 Kg ha^{-1}, total dry matter yield of 8533 Kg ha^{-1}, straw yield of 3585 Kg ha^{-1} and thousand grains weight of 40.5 g of wheat were produced by the compost of organic waste and half dose of SSP. Residual effect of the prepared composts was determined on yield and plant P uptake of mung bean (*Vigna radiate*). The experiment was conducted in the same layout of wheat. Fertilizers N and K were applied at the rate of 30 and 60 kg ha^{-1}, respectively in the form of urea and sulphate of potash. No P was added to this crop. Maximum and significantly ($p \leq 0.05$) higher mung bean grain yield, total dry matter yield and straw yield of 858 kg ha^{-1}, 8167 kg ha^{-1} and 7309 kg ha^{-1}, respectively were recorded by the residual effect of compost of RP fed dung with half dose of SSP. Thousand grains weight of 44 g was noted in the treatment of residual effect of compost of simple dung with half dose of SSP. Post harvest soil N and P concentrations improved with composts. Significant ($p \leq 0.05$) increases in N and P uptake by wheat and mung bean plants were observed with composts addition. Results suggest that the use of composts prepared from different organic materials with RP are economical, environmental friendly and have potential to improve crops yield and plants N and P uptakes.

Introduction

Nitrogen and Phosphorus are the primary constituents of plants and animals life playing active role in many metabolic processes and phenology of crops and vegetables (Muhammad *et al*., 2013). Phosphorus has functions of a structural nature in macromolecules such as nucleic acids and of energy transformation as adenosine tri phosphate in metabolic pathways of biosynthesis and degradation (Barber, 1995). Type of soil, crops, water, P-fertilizer, management practices and climatic conditions of an area are important factors to be considered when attempting to formulate sound P-fertilizer source and application for adequate crops yield response (Amanullah *et al*., 2010).

Composting is a biological process in which microorganisms like bacteria, fungi and other organisms convert organic materials, such as leaves, manure, sludge, paper, grass clippings and food wastes into a soil like material called compost or humus (Stan *et al*., 2009). During composting microbes utilize carbon of organic material as a source of energy and for synthesis of new microbial cells. Carbon serves as both building block and an energy source for microbes. The use of composts offer several potential benefits including manure handling, enhance soil fertility and reduce environmental risk, enlarge the air spaces in soil, improve its permeability for air and water circulation, improve soil texture, help to retain soil moisture, facilitate the mechanical treatment of heavy clay soil, add nutrients to the soil, stimulate biological activities, encourage vigorous plant rooting system, helps to bind nutrients and prevent them from being leached out of the soil (Bertoldi *et al*., 1983; Sarwar *et al*., 2007 and 2008). Organic materials have beneficial effects on fertility and physical properties of soil (Hoitink & Grebus, 1994). The physical properties of soil play an important role in influencing plant growth thereby contributing to efficient crop production (Zheljazkov & Warman, 2004). Mulching soil surface with different organic materials improves soil biological activities, retain soil moisture for longer time and helps to control weeds (Saima *et al*., 2013). Farm yard manure (FYM) on an average contains 0.5% N, 0.2% P_2O_5 and 0.5% K_2O (Brannon & Sommers, 1985). Application of organic materials to the soil reduces the dependence on chemical fertilizers and helps microorganisms to produce polysaccharides, which improve the soil conditions (Guar, 1994; Sharif *et al*., 2003).

Wheat (*Triticum aestivum* L.) is grown as a major winter crop throughout Pakistan. The total area occupied by wheat was 9046 thousand ha, which produced 24033 thousand tones food grain, while in Khyber Pakhtunkhwa province, the total area occupied by wheat was 769 thousand ha, which produced 1205 thousand tones. Total area under mung bean (*Vigna radiata*) production was 2197 ha with production of 157 ton and 716 kg ha^{-1} in Pakistan, while in Khyber Pakhtunkhwa province the total area was 7 ha with production of 4 ton and 620 kg ha^{-1} (Anon., 2008-09). Keeping in view the importance of P in crops production and improving its solubility from RP through composts, this study was planned to determine and compare the effect of composts prepared from different organic materials with RP on yield and P uptake of wheat and their residual effect on mung bean crops.

Materials and Methods

Experiments were conducted in field to determine and compare the effects of composts prepared from different organic materials with RP on yield and P uptake of wheat and their residual effect on mung bean crops. The wheat variety saran with a seed rate of 100 kg ha^{-1} was grown in Randomized Complete Block Design with three replications. There were 11 treatments, each of 3×5 m^2 size. The row to row distance of wheat plants was 25 cm. Composts prepared from City Garbage, Organic waste, Simple FYM and RP fed FYM mixed with RP at the ratio of 2.0 part of organic materials and 1.0 part of RP were applied at the rate of 9912, 8380, 4529 and 4444 kg ha^{-1}, respectively on the basis of their P concentration to provide 90 kg P ha^{-1}. Chemical fertilizers were applied at the rate of 120-90-60 kg ha^{-1} N, P, K, respectively in the form of urea, SSP or RP and SOP. Nitrogen was applied as split application whereas all P and K were applied at sowing time. The mung bean variety NM-92 with a seed rate of 20 kg ha^{-1} was grown on same layout of wheat. Fertilizers N and K were applied at the rate of 30 and 60 kg ha^{-1}, respectively in the form of urea and SOP. Nitrogen as starter dose and all K was applied at sowing time. No P was applied to this crop. Residual effect of P applied at the rate of 90 kg ha^{-1} to wheat crop in form of SSP and composts were determined on current mung bean crop. Data on grains yield, total dry matter yield, straw yield and thousand grains weight of wheat and mung bean were recorded after crop harvest.

A composite soil sample (0-20 cm depth) was collected from the experimental site before seed sowing and fertilizers application. Soil samples at the depth of 0-20 cm were also collected from each treatment after crop harvest. Soil samples were air dried, ground, sieved through 2mm sieve and packed in labeled plastic bags for laboratory analysis. Representative plant samples at maturity stage were collected randomly from each treatment to evaluate effect of different treatments on plants N and P uptake. Soil Texture was determined by (Koehler *et al*., 1984). Soil pH (McClean, 1982), SOM (Nelson & Sommers, 1982), Lime by (Richard, 1954). AB-DTPA extractable P was determined by (Soltanpour & Schwab, 1977), while total N by Kjeldhal method as described by Bremner (1996). Plant samples from each treatment were analyzed by wet digestion method for the determination of N and P concentrations. Total dry matter, grain and straw yields and thousand grain weight were recorded after threshing the bundles of wheat and mung bean plants from each treatment. The data collected were analyzed statistically according to the procedure as given by Steel & Torrie (1980) using MSTATC package and Least Significant Difference (LSD) test was used for any significant difference among the treatments.

Results and Discussion

Soil under investigations was alkaline calcareous in nature, low in organic matter contents (0.6%), with silty clay loam texture, low in available P (5.35 mg kg^{-1}) and total N (0.09%) concentrations. The prepared composts were analyzed for N and P concentrations. Total N concentration in the compost of RP fed FYM under investigations was 1.291%, Simple FYM 1.269%, Organic waste 1.257% and City garbage 1.36%. There were 2.03%, 1.99%, 1.07% and 0.91% P concentrations in these composts with pH values of 8.2, 8.2, 10.2 and 8.8, respectively.

Wheat grain yield: Data shows that composts prepared from different organic materials with RP significantly ($p \leq 0.05$) enhanced the wheat grain yield. Maximum wheat grains yield of 5274 kg ha^{-1} was observed with 178% increase over control in treatment where compost of organic waste was applied and was statistically similar with compost of RP fed FYM + RP + half dose of SSP and city garbage + RP. The Minimum grains yield of 1896 kg ha^{-1} was noted in control treatment which was statistically comparable with the treatments of N and K fertilizers (Table 1).

Kucy (1987) and Ibrahim *et al*., (2008) stated that wheat grains yield enhanced significantly when RP was mixed with various organic materials. Jan *et al*., (2011) reported that wheat yield was increased when organic source of N was used with inorganic sources. Phiri *et al*., (2010) studied the effect of blended RP and organic residues and found a significant increase in maize grain yield.

Table 1. Wheat grain, total dry matter and straw yields and thousand grains weight as affected with composts of different organic materials.

Treatments	Grains yield (kg ha^{-1})	Total dry matter yield (kg ha^{-1})	Straw yield (kg ha^{-1})	1000 grains weight (g)
Control (No fertilizer)	1896 e*	3318 c*	1422 bc*	26.33 d*
N and K fertilizer	3022 d **	4763 c	1741 c	34.13 abc
Compost of RP fed FYM (C-I)	4267 c	7585ab	3318 a	33.37 bc
Compost of simple FYM (C-II)	4563 bc	7822ab	3259 a	37.57 ab
Compost of organic waste (C-III)	4326 c	7585ab	3259 a	34.37 abc
Compost of city garbage (C-IV)	4467 bc	8059 ab	3592 a	36.37 abc
C-I + half dose of SSP	5126 a	7303 ab	2178 abc	37.27 ab
C-II + half dose of SSP	4317c	7467ab	3150 ab	35.60 abc
C-III + half dose of SSP	5274 a	8533 a	3259 a	40.53 a
C-IV + half dose of SSP	4592 bc	8178 a	3585 a	38.47 ab
Full dose of recommended SSP.	4618 ab	7985 ab	3367 a	37.47 ab
LSD≤0.05	623	2086	1782	6.60

Means with different letter(s) in columns are significantly different at $p \leq 0.05$

Wheat total dry matter yield: Maximum wheat dry matter yield of 8533 Kg ha^{-1} with 157% increased was found with the compost of organic waste applied with half dose of SSP and was statistically comparable with composts of city garbage, Simple FYM and RP fed FYM. Minimum total dry matter yield of 3318 kg ha^{-1} was noted in control, which was similar statistically to the N and K fertilizer treatment with full dose of SSP (Table 1). Khan *et al*., (2009) observed wheat dry matter yield was enhanced significantly ($p \leq 0.05$) by combination RP with organic materials. Majumdar *et al*., (2007) noted that with application of RP with organic materials increased dry matter yield of wheat. Khan *et al.,* (2009) reported that total dry matter yield improved with the application of organic materials with rock phosphate.

Wheat straw yield: Data showed that 152% enhanced straw yield of wheat of 3585 Kg ha^{-1} was observed with compost of city garbage applied with half dose of SSP, which was statistically at par with the treatments of compost of RP fed FYM + RP, Simple FYM +RP, Organic waste + RP and Organic waste + RP + half dose of SSP (Table 1). Similar result was shown by Shah & Ishaq (2006) recorded that wheat straw yield improved by the application of composts prepared from different organic materials.

Wheat thousand grains weight: Thousand grains weight was significantly influenced with compost of organic materials. Maximum wheat 1000 grains weight of 40.5 g was found with compost of organic waste applied with half dose of SSP and is similar to the treatment of compost of city garbage +half dose of SSP, Simple FYM and RP fed FYM + half dose of SSP (Table 1). This result was similar with Ibrahim *et al*., (2008) who noted that wheat 1000 grains weight affected significantly with combined application of chemical and organic materials.

Post harvest soil organic matter, pH and ECe: Effect of composts of different organic materials on post harvest soil organic matter contents (SOM), pH values and ECe of soil under wheat are presented in Table 2.

Data in Table 2 show that higher EC of 0.23 dSm^{-1} was observed in the treatment of compost of city Garbage and half SSP. Data indicated that soil pH decreased due to mineralization and releasing of hydrogen H^+ with composts of different organic materials**.** These results are similar to Mbkaya *et al.*, (2004) who recorded that the pH values decreased slightly with different organic materials in soil because of the release of H^+. Maximum soil organic matter contents of 1.63% was observed in treatments where compost of city garbage and half dose of SSP were applied, followed by the treatments of compost of organic waste and half dose SSP and Simple FYM (Table 2). Similar result was shown by Tomayo *et al*., (1997) observed that the combination of RP with organic manure enhanced the organic matter content of soil.

Post harvest soil N and P concentrations of wheat crop: Data regarding post harvest soil N and P concentrations of each treatment are shown in Table 3. Data indicate that highest N concentration of 1979.2 mg kg^{-1} was observed in those treatments where the compost of organic waste and half dose of SSP were applied followed by the compost of simple FYM and half dose of SSP which were at par with each others. These results are in consistency with Majumdar *et al*., (2007) noted that the combination of rock phosphate with organic materials improved soil total N concentration. Post harvest soil P concentration data show that maximum concentration of P of 10.29 mg kg^{-1} was noted in treatments where the compost of city garbage and half dose of SSP were applied, followed by the treatment of compost of organic wastes and half SSP and were statistically at par with each others. Majumdar *et al*., (2007) found that with the application of RP mixed with different organic materials increased the concentration of phosphorus.

Table 2. Post harvest soil organic matter content, ECe and pH values as affected by the composts of different organic materials.

Treatments	SO.M (%)	E.C (dSm^{-1})	pH values (1:5)
Control (No fertilizer)	0.25 d*	0.12 d*	7.81 a*
N and K fertilizer	0.65 c	0.13 cd	7.78 a
Compost of RP fed FYM (C-I)	0.86 bc	0.14 bcd	7.72 ab
Compost of simple FYM (C-II)	1.04 b	0.15 bcd	7.77 a
Compost of organic waste (C-III)	0.97 bc	0.17 bc	7.74 ab
Compost of city garbage (C-IV	0.87 bc	0.16 bcd	7.73 ab
C-I + half dose of SSP	0.91 bc	0.18 b	7.57 abc
C-II + half dose of SSP	0.92 bc	0.19 ab	7.52 bc
C-III + half dose of SSP	1.13 b	0.17 bcd	7.58 abc
C-IV + half dose of SSP	1.63 a	0.23 a	7.41 c
Full dose of recommended SSP.	0.84 bc	0.18 b	7.64 abc
LSD ≤ 0.05	0.349	0.045	0.248

*Means with different letter(s) in columns are significantly different at $p \leq 0.05$

Table 3. Post harvest soil N and P concentrations of wheat as effected by the composts of different organic materials.

Treatments	Total soil N ($mg\ kg^{-1}$)	AB-DTPA Extractable soil P ($mg\ kg^{-1}$)
Control (No fertilizer)	662.5 d	1.34 d
N and K fertilizer	775.0 cd	1.98 cd
Compost of RP fed FYM (C-I)	1283.3 abcd	5.63 bcd
Compost of simple FYM (C-II)	991.7 bcd	6.07 abc
Compost of organic waste (C-III)	1404.5 abc	7.24 ab
Compost of city garbage (C-IV	1366.7 abc	5.95 abcd
C-I + half dose of SSP	1190.8 bcd	8.87 ab
C-II + half dose of SSP	1662.5 ab	4.77 bcd
C-III + half dose of SSP	1979.2 a	9.07 ab
C-IV + half dose of SSP	1395.8 abc	10.29 a
Full dose of recommended SSP.	1354.2 abc	6.18 bcd
LSD≤0.05	711.28	4.6454

Means with different letter(s) in columns are significantly different at $p \leq 0.05$

Table 4. Plants N and P uptakes as affected with the compost of different organic materials.

Treatments	Plant N ($kg\ ha^{-1}$)	Plant P ($kg\ ha^{-1}$)
Control (No fertilizer)	12.3 e*	2.44 e*
N and K fertilizer	20.6 de (68)**	4.1 abc (68)
Compost of RP fed FYM (C-I)	65.7 bcd (436)	4.3 de (76)
Compost of simple FYM (C-II)	71.8 bcd (486)	7.7 bcd (216)
Compost of organic waste (C-III)	71.2 bc (481)	6.1 bcde (150)
Compost of city garbage (C-IV	53.7 de (337)	5.4 cde (121)
C-I + half dose of SSP	91.0 ab (642)	9.1 ab (273)
C-II + half dose of SSP	51.4 e (318)	8.1 abc (232)
C-III + half dose of SSP	49.3 cde (302)	9.9 abc (306)
C-IV + half dose of SSP	124.7 a (916)	12.2 a (400)
Full dose of recommended SSP.	64.76 b (428)	6.8 abc (220)

* Means with different letter(s) in columns are significantly different at $p \leq 0.05$

** Parenthesis value indicate the percent increase of plants uptakes over control

Nitrogen and phosphorus uptake by wheat plants: Data on N and P uptake by wheat plants show significantly ($p \leq 0.05$) increased plants N uptake of 124.7 Kg ha^{-1} with 916% increased over control treatment was recorded by the compost of city garbage and half dose of SSP followed by the treatment of compost of RP fed FYM and are statistically at par with each others (Table 4). Awaad *et al*., (2009) observed that plant N uptake improved by the application of RP mixed with organic materials. Jan *et al*., (2010) showed an increase in plant N uptake by the combined application of organic and inorganic sources of N. Data reveal that maximum plant P uptake of 12.2 Kg ha^{-1} was recorded by the application of compost of city garbage and half SSP with 400% increase over control. This improved P uptake was followed by the compost of organic waste applied with half dose of SSP. Erdal *et al*., (2000) noted that accumulation of plant P enhanced with combined application of P fertilizer and organic materials. Taalab *et al*., (2008) recorded the plants N and P uptakes were increased by the combination of RP with organic materials.

Economic analysis of the applied fertilizers: Economic analysis of the prepared composts used in this experiment is presented in Table 5. Value cost ratio (VCR) of 7.2 with net return of Rs. 81,887 ha^{-1} was obtained by the compost prepared from city garbage, followed by the VCR of 6.1 showed by the compost of organic wastes applied with half dose of SSP with a net return of Rs. 84,843 ha^{-1} indicating economical significance for profitable wheat yield (Table 5).

Yield and yield components of mung bean: Data regarding the residual effect of composts on grains, total dry matter and straw yields and thousand grains weight of mung bean are presented in Table 6.

The data indicate that the highest 157% grain yield of 858 kg ha^{-1} was noted in the treatment of composts of RP fed dung applied with half recommended dose of SSP over control. Lowest mung bean grains yield of 333.3 kg ha^{-1} was found in control, which was statistically similar to the treatments of N and K fertilizers (Table 6). Kucy (1987) found that application of composts of different organic materials with RP increased grains yield of wheat significantly. Phiri *et al*., (2010) observed that application of organic materials with RP increased the maize grains yield. Maximum dry matter yield of 8167 kg ha^{-1} was produced in the same treatment. Khan *et al*., (1993) stated that as a result of residual effect of composts of different organic materials with RP, total dry matter yield of crops enhanced significantly. Maximum straw yield of 7309 kg ha^{-1} was also observed in the same treatment. Rezvi *et al*., (1985) reported that the straw yield of wheat and maize affected significantly with residual effect of phosphorus. Maximum grains weight of 44.0 g was noted with the residual effect of compost of simple dung mixed with half dose of SSP (Table 6).

Table 5. Economic analysis of the composts prepared from different organic materials.

Treatments	Yield (Kg ha^{-1})	Yield increase (Kg ha^{-1})	Increased yield value (Rs.ha^{-1})	Cost of fertilizers (Rs.ha^{-1})	Net return*	VCR**
Control (No fertilizer)	1896	-------	--------	-------	------	-------
N and K fertilizer	3022	1126	33783	12830	20460	2.6:1
Compost of RP fed FYM (C-I)	4267	2371	71121	15306	55815	4.6:1
Compost of simple FYM (C-II)	4562	2666	79980	14147	65833	5.6:1
Compost of organic waste (C-III)	4326	2430	72897	12729	60168	5.7:1
Compost of city garbage (C-IV)	5067	3171	95121	13234	81887	7.2:1
C-I + half dose of SSP	5126	3230	96897	19556	77341	5.0:1
C-II + half dose of SSP	4317	2421	72633	18397	54236	3.9:1
C-III + half dose of SSP	5274	3378	101340	16479	84843	6.1:1
C-IV + half dose of SSP	4593	2697	80895	17484	63426	4.6:1
Full dose of SSP.	4118	2222	66672	21320	58172	3.1:1

Price of wheat = Rs, 30 kg^{-1}, FYM = Rs. 500 ton^{-1}, RP = Rs. 4.50 kg^{-1} and SSP = Rs. 850 bag^{-1}, SOP= Rs. 3500 bag^{-1}, Urea= Rs.850 bag^{-1}, City garbage= Rs. 0.28 kg^{-1}, Organic waste = Rs. 0.46 kg^{-1}, *Net Return = Value of increased yield – Cost of fertilizers
**VCR =Value of increased yield / Cost of fertilizer

Table 6. Residual effect of the prepared composts on yield and yield components of mung bean.

Treatments	Grains yield (kg ha^{-1})	Total dry matter yield (kg ha^{-1})	Straw yield (kg ha^{-1})	1000 grains weight (g)
Control	333 f*	4400.0 d*	4067 f*	30.7 c*
N and K fertilizer	424 ef	5033 d	4610 ef	36.0 bc
Compost of RP fed dung (C-I)	729 b	6833 bc	6104 bcd	39.7 ab
Compost of simple dung (C-II)	595 cd	6167 c	5571 de	43.3 a
Compost of organic waste (C-III)	594 cd	7500 ab	6906 ab	40.3 ab
Compost of city garbage (C-IV)	513 de	6667 bc	6154 abcd	36.0 bc
C-I + half dose of SSP	858 a	8167a	7309 a	40. ab
C-II + half dose of SSP	589 cd	7333 ab	6744 abc	44. a
C-III + half dose of SSP	668 bc	7167 b	6499 abc	41.3 ab
C-IV + half dose of SSP	783 ab	7333 ab	6550 abc	43.7 a
Full dose of recommended SSP	770 ab	7333 ab	6563 cd	43.0 a
LSD	120.75	956.69	963.32	5.85

* Means with different letter(s) in columns are significantly different at $p \leq 0.05$

Post harvest soil N and P concentrations: Data regarding post harvest soil N and P concentrations as affected by the residual effect of composts are presented in Figs. 1 and 2. Maximum N concentration of 1533.3 mg kg^{-1} was found with the compost of organic wastes applied with half dose of SSP. The results are in consistency with Esilab *et al*., (2000) who observed that maize yield and soil N concentration improved by the application of organic fertilizers. Soil P concentration increased significantly ($p \leq 0.05$) with the application of prepared composts. Maximum soil P concentration of 3.73 mg kg^{-1} was recorded in the same treatment of compost of organic wastes applied with half dose of SSP (Fig. 2). Majaumdar *et al*., (2007) found that phosphorus concentration enhanced by the addition of RP mixed with organic materials.

Nitrogen and phosphorus uptake by mung bean: Nitrogen and phosphorus uptakes by mung bean plants as influenced by the residual effect of composts prepared from different organic materials with RP are given in Figs. 3 and 4.

Data revealed that maximum N uptake of 131 kg ha^{-1} was noted in the treatment of compost of RP fed dung applied with half dose of SSP, which was significantly ($p \leq 0.05$) increased over control. Awaad *et al.,* (2009) reported that combined application of organic materials with rock phosphate increased N uptake of plants significantly as a synergistic effect of improved P on N availability. Plants P uptake by mung bean increased significantly ($p \leq 0.05$) over control. Maximum plants P uptake of 18 kg ha^{-1} with 271% increase over control was noted in treatment of compost of organic waste applied with half SSP. Erdal *et al*., (2000) stated that by the application of organic materials with chemical fertilizers increased the N and P accumulation in plants. Eghball *et al*., (2003) observed that with the residual effect of N- based compost, the P uptake of crop increased significantly.

Pakistan has RP deposits in Hazara area of Khyber pakhtunkhwa province. The reserves are wide spread in Kakul, Galdaman, Tarnawai and Lagerban villages of District Abbottabad. The so far reported exploration indicates that total reserves are about 35.7 million tones. Out of which 14.7 million tones are of proven quality which contains 26-31% P_2O_5. The remaining reserves of 21 million tones are of inferred quality. The proven reserves at Tarnawai have a potential sustained annual production of 60,000 tonnes for a period of 30 years. Crops yields increased by the addition of RP with HA and organic fertilizers (Malik & Azam, 1985). It is often reported that the application of FYM and other organic materials increases the efficiency of RP (Pillai *et al*., 1985). Microorganisms in soil produce organic acids like carbonic acids, acetic acids, citric acids etc. These acids create favorable environment for the enhancement of P solubility from the applied RP.

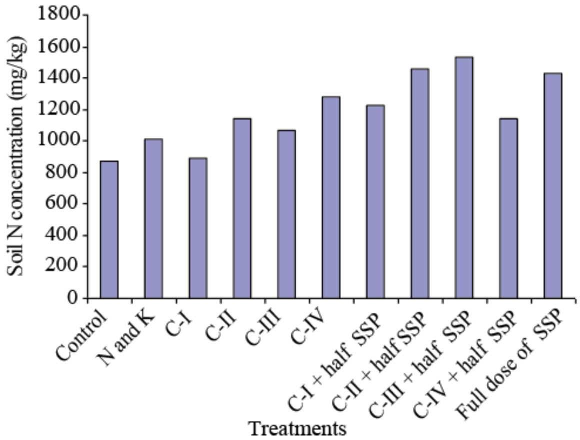

Fig. 1. Residual effect of composts on post harvest soil N concentration.

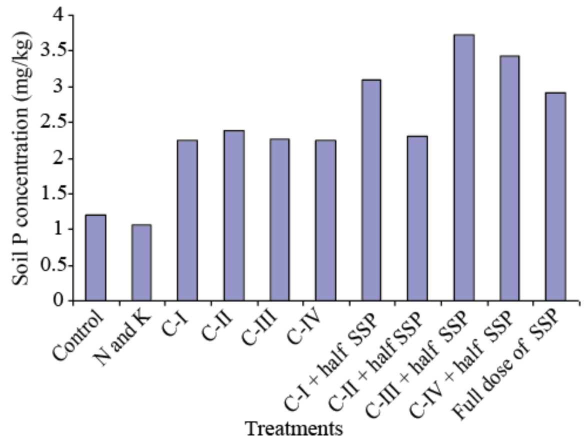

Fig. 2. Residual effect of composts on post harvest soil P concentration.

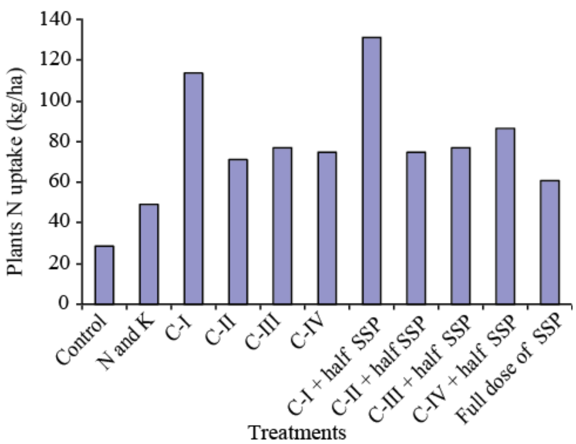

Fig. 3. Residual effect of composts on plants N uptake.

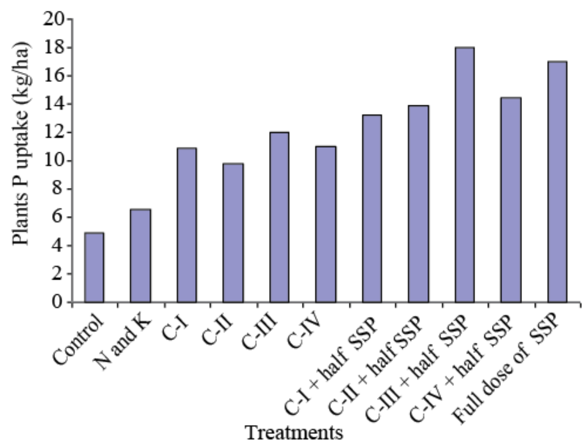

Fig. 4. Residual effect of composts on plants P uptake.

The availability of P from RP can be increased by several means. The RP is basically complex of tri-calcium phosphates $[Ca_3\ (PO_4)_2]_3.CaCo_3$ insoluble in water. Its soluble form is monocalcium phosphate $Ca\ (H_2PO_4)_2$. The solubility can be enhanced by treatment with mineral acids, organic acids, mixing with organic materials and biological treatments. Biological solubilization of RP is more environments friendly and economical than acidulation. There is a need therefore to develop microbial process that will make phosphorus available for plant use with minimum pollution to the environment. Composting organic materials with RP enhance the solubility of P (Singh and Amberger, 1991; Mishra & Bangar, 1986) and it mostly practiced to increase the value of fertilizers and manures (Mahimairaja *et al*., 1995). Govi *et al.,* (1996) noted that compost of organic waste alone and in combination (25% of volume) with a substrate from straw bedded horse dung is good compost for better crops growth and improved P availability. Rajan *et al*., (1996) argued that RP has the potential to improve soil fertility and increase agriculture production as P fertilizer do, but the extent of suitability varies with soil, crop, climatic conditions and mineral composition of RP. Biswas *et al*., (1996) studied the long term effect of application of fresh cow dung with pyrite P and observed that P solublization increased significantly from low grad RP. Composts with RP released more amounts of acid and alkaline phosphates in soil as compared to other common composts, which enhanced the solublization of P for long time. Legumes may be able to liberate more P from rock phosphate with rhizosphere acidification during N_2 fixation, converting it into available forms in the soil as well as incorporating it as biomass (Vanlauwe *et al.,* 2000).

Conclusion

Composts prepared from city garbage, organic waste, farm yard manures with RP are cheap and indigenous source of P and have potential to improve crop production and plants N and P uptake when applied with half dose of SSP. Maximum grains, total dry matter, and straw yield and thousand grains weight were produced by the treatment where the compost of organic waste was applied with half dose of SSP. Post harvest soil N and P concentrations increased by the addition of composts of different organic materials. Maximum and significantly ($p \leq 0.05$) increased mungbean grain yield, total dry matter and straw yield of 858 kg ha^{-1}, 8167 kg ha^{-1} and 7309 kg ha^{-1}, respectively were observed by the residual effect of composts of RP fed dung applied with half dose of SSP. Further research is needed to prepare composts of some more organic materials with RP on large scale to enhance their P solubility and to determine their direct and residual effects on the growth of different crops at different agro-ecological zones of Pakistan.

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