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Effect of Phospho-compost on crop yield, quality and soil nutrient balance under rice-wheat cropping system

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Abstract
A field experiments was conducted for three consecutive years (2000-2003) at the agriculture form of Sheila Sheila Dhar Institute of Soil Science, Allahabad with an objective to study the preparation of phospho-compost and its effect on productivity of rice-wheat cropping system. The prepared phosphorus enriched compost and ordinary compost were analyzed for C, N, C: N, total phosphorus, water soluble phosphorus, citrate soluble phosphorus besides major and micronutrient content. The phosphor-compost was found to be superior to FYM, ordinary compost in terms of organic carbon and total and N, Ca, Mg, K, Fe, Mn, Zn, and Cu content, and can supplement single super phosphate in field trial with rice and wheat crop. The application of phospho-compost for supplementing inorganic P source and part of N and K was found to be effective and recorded comparable result in rice and wheat crop for plant population, grain yield, protein per cent, N and P content in crop plant and available nutrients and their balances in soil after harvesting.

Keywords: phospho-compost, quality, rice-wheat cropping system and yield

Introduction
Many researches have evaluated the direct and residual effect of different dose of phospho-compost in meeting the phosphorus requirement of crop. Combined application of organic source with phospho-compost has also been evaluated in neutral to alkaline soil. In incubation studies rock phosphate application with farm yard manure has been found to improve the available phosphorus status in soil. Rock phosphate applied along with farm yard manure, compost or sludge increased the soil available phosphorus. The dynamis of phosphorus solubility in a puddled rice soil will be significantly different compared to normal soil because of change of pH, EC and theumod yhamics reduction sequence. Composting of agricultural wastes with rock phosphate is known to increase the solubility of the phosphate ion and availability of other major and micro elements (Tian and Kolawole 2004) [10]. An attempt was made in the present study to quantify the yield and yield attributes, quality of rice and wheat crop and nutrient balance in the puddle soil when supplemented by phospho-compost @ 5 or 10 t/ha at different proportion (1/3, ½, 2/3 & full) of recommended N and K fertilizers and was compared with the application of ordinary compost.

Materials and Methods
The field experiment was conducted during 200-2003 at the agriculture farm of Sheila Dhar Institute of Soil Science, Allahabad University, at the Institute research farm (82.52^0 longitudes and 25.10^0 N latitude), Allahabad. The detailed chemical analysis of soil and plant sample was carried out at Indian Institute of Vegetable Research, Varanasi during 2003-04. The soil of the experimental site was sandy loam, typic ustochrept. Important properties of the soil are: pH (1:2.5)-7.8, E.C at 25 ^{0}C -0.45 (dSm^{-1}), C.E.C -7.9 cmol (P^+) kg^{-1}, A.E.C -1.1 cmol (e^-) kg^{-1}, organic C -0.47%, clay-13.5%, silt-35.5%, sand-49.0%, free $CaCO_3$ -1.5%, Ca^{+2}+Mg^{+2} - 4.6 cmol (p^+) kg^{-1}, percent base saturation-69.5, available nitrogen -218 kg ha^{-1}, available potash-371 kg ha^{-1}, available phosphorus 12 kg ha^{-1}, water holding capacity -20.8%, non occluded Aluminum and Iron bound phosphorus 57.9 mg kg^{-1}, phosphorus occluded within iron oxides and hydrous oxides-10 mg kg^{-1}, calcium-bound phosphorus-315.8 mg kg^{-1}, Smectite-9%, Chlorite-18%, Illite-45%, Kaolinite-26%, Vermiculite-1%. Low cost, easily available inputs like decomposable farm waste+ urine and fresh cow dung, green weeds + water hyacinth,

rice and wheat straw at the ratio 80:10:10 was used as substrate and allowed for composting with Missouri rock phosphate (MRP) @2 per cent P_2O_5 (MRP) kg per 100 kg substrate for 120 days. The prepared phosphorus enriched compost and ordinary compost were analyzed for carbon, nitrogen, C: N ratio, total and different fraction of phosphorus, besides major and micro nutrients. The detailed methodology on preparation of phospho-compost (PC) and analysis of physio-chemical properties has been described elsewhere (Sahu and Jana 2000). The compost sample obtained after 120 days of decomposition were used to quantity its effect on the yield of rice and wheat in field experiment during the Kharif and Ravi season. A set of eleven treatment combinations comprising recommended nitrogen, phosphorus and potash level, 33%, 50% and 75% of recommended nitrogen, potash and no inorganic phosphorus fertilizer, supplemented by phospho-compost (PC) either @ 5t/ha or @ 10t/ha alone or combination were tested in a randomized block design with three replications. The size of each plote was $5m^2$ recommended agronomic practices and plant protection measures were fallowed. The treatment details were as follows: Tc, Compost @ 5t/ha, T_1, phospho-compost @ 10 t/ha, T_2, Nitrogen: Phosphorus: Potash @ 120:60:60 kg/ha, T_3, Nitrogen & Potash @ 120 and 60 kg + phospho-compost @ 5 t/ha, T_4, Nitrogen & Potash @ 120 and 60 kg + phospho-compost @ 10 t/ha, T_5, Nitrogen & Potash @ 60 and 30kg + phospho-compost @ 5 t/ha, T_6, Nitrogen & Potash @ 60 and 30 kg + phospho-compost @ 10 t/ha, T_7, Nitrogen & Potash @ 40 and 20 kg + phospho-compost @ 5 t /ha, T_8, Nitrogen & Potash @ 40 and 20 kg + phospho-compost @10 t/ha, T_9, Nitrogen & Potash @ 80 and 40 kg + phospho-compost @5 t/ha T_{10}, Nitrogen & Potash @80 and 40 kg + phospho-compost @ 10 t/ha. The test crop varieties Saket-4 of rice and K-68 of wheat. The standard agronomical practice irrigation and crop management were followed to raise a good crop stand. Observation on panicle length (cm), number of grain/ panicle, 1000 seed weight and yield recorded following the standard methodology. The above ground parts of the plant were harvested and the weight of grain and straw were recorded separately for each treatment. The soil samples were collected from field before start of the experiment and after harvesting of the crop. The phosphorus content in different stage, nitrogen and phosphorus content in grain and straw were determined. The plant and soil samples were digested in di-acid mixture in an automated digester following standard methodology (Novozamsky *et al.*, 1983). The N content in grain and straw and protein content in grain was determined by digestion, micro Kjeldhal distillation and titration following the standard methodology in a kjeldhal-N analyzer (Foss-Tecator) system. The protein content in grain and straw was estimated by multiplying N content with a conversion factor of 6.24. The phosphorus content was determined by phospho-molybdic blue color method (Jackson, 1973) [3]. The potassium content was measured on a flame photometer (Chemito, India). using neutral 1N NH_4OAC as extracting. The statistical analysis of the data was carried procedure describe by.

Results and Discussion

Effect of P-enrichment on quality of phosphor-compost

The physico-chemical properties of P-enriched compost and ordinary compost were significantly different. The P-enrichment with rock phosphate during composting enhanced the concentration of Ca, Mg and micronutrients particularly Fe and Mn in phospho-compost. A significantly high water soluble P (42.6%), organic carbon (16.7%), total Ca (28.6%), total Mg (50%), and 1.5 to 2.8 fold increase in micronutrient (Zn, Cu, Mn and Fe) content was noted in phosphor-compost as compared to ordinary compost (Table1). This was primarily due to the presence of calcium carbonates and salts of Fe, Mg, Zn, Cu and Mn in the rock phosphate, and microbial dissolution via formation of organic acids (Sreenivas and Narayanasamy, 2003) [9].

Effect of phosphor-compost on yield attributes and yield

The effect of phospho-compost on yield attributes of rice and wheat viz. plant population/m^2, Panicle length (cm), number of grain/ panicle, 1000 seed weight and yield were significantly higher when treated with recommended N K@120: 60 kg/ha plus phospho-compost @ 10t/ha as compared to recommended NPK @ 120:60:60 kg/ha level of nutrition. Application of recommended dose NK and 10 tones /ha of phosphor-compost increased the panicle length (cm) 44.2 and 40.17%, number of grain/ panicle 20.84 and 31.45%, 1000seed weight by 34.77 and 32.23%, plant population/m^2 38.3 and 58.06%, grain yield by 76.35 and 46.98% and straw yield by 72.57 and 68.53% over the control i.e. compost @ 5t/ha. The yield and yield attributes of rice and wheat was significantly effected by partial or complete supplementation of nutrient N, P and K by incorporation of phospho-compost @ 5 or 10t/ha in combination with inorganic N and K fertilizer (Table 2), which corroborate with the findings of Whitbread et. al. 1999 [2], Tian and Kalawole, 2004 [10]. Application of phospho-compost @ 10 t/ha could supplement 33% of recommended inorganic N and K and 100% of P fertilizer as evidenced through at par grain and straw yield. The yield performance under combined application of phospho-compost @ 5t/ha with 2/3rd of recommended N, K was at par to ½ of recommended N, K indicating that a maximum of 50% recommended dose of N, K and 100% of inorganic P fertilizer could be supplemented by addition of phospho-compost @ 5t/ha. A comparison of yield data indicated that application of low input i.e. half of recommended dose of N&K with phospho-compost @ 5t/ha could fetched 90% of actual yield realized under recommended N, P & K fertilization in rice and wheat (Table-2). Similar results regarding application of phospho-compost or single super phosphate has been also reported by Nazirkar *et al.*, 2004 [7].

Effect of phosphor-compost on nutrients uptake

The phosphorus and nitrogen uptake by grain and straw was found to follow the similar trend of P content in grain and straw and was correlated significantly with their respective yield. The N and P content in grain and straw at different stage of growth as influenced by alone or combined application or phospho-compost with inorganic N&K fertilizers have been presented. (Table 3). The steady decrease in available soil P and successive increase in P content in rice plant tissue from active tillering to grain development stage in the present study was in conformity with earlier works of Waigwa *et al.*, 2003 [11]. The increased uptake of phosphate ions by plants from active tillering to grain development stage was further evidenced in the higher P content in grain as compared to straw in rice crop. The N content in grain was significantly higher than the N content in straw. Phosphorus nutrition had significant impact on protein content (31.37 and 21.81% increase) of rice and wheat grain when applied nutrient levels proved sufficient to meet the need of the crop and luxury consumption resulted in increased root growth, plant growth, enzyme activation, better resistance in plant to insect-pests and diseases as compared to a P deficient crop (Phongpan *et al.* 2002) [1].

No significant variation in protein content of rice and wheat grain unlike yield was evidenced when exposed to different treatment combination of phosphor-compost alone or in combination with inorganic N&K fertilizer. However, the protein content was significantly higher (31.37 and 21.81%) in crop when treated with N, K recommended + phosphor-compost @10t/ha and compared with the treatment control i.e. only compost @ 5t/ha. A significant variation in P content and no variation in N content either in grain or in straw was evidenced across the applied treatments under which the crop grown. The result indicated that the protein content in rice grain was improved significantly only when the nutrients available in the labile pool crossed a minimum threshold value for ready uptake by the crop (Rahman *et al*., 2003) [8].

Effect of phosphor-compost on soil nutrients status

There was a buildup in soil-nutrient status in succeeding crop under treatments where phosphor-compost was added @ 10t/ha in combination with inorganic fertilizers (Table-4). The nutrient balance sheet for available N, P and K was marginally on positive side with supplementation of phospho-compost @ 5t/ha plus half of recommended N&K. A negative nutrient balance was evidenced when the crop was grow under lone application of compost @ 5t/ha and /or phospho-compost @10t/ha or combined application of 1/3rd recommended N&K with phospho-compost @5t/ha. The organic carbon content in soil was increased under addition of phospho-compost @ 10t/ha over the recommended N&K level. These findings are agreement with the earlier works of Mishra *et al*., 2002 [6], and Manna *et al*., 2003 [4].

Table 1: Physico-chemical properties of ordinary compost and phosphor-compost

Nutrient status	Ordinary compost	Phospho-compost	% increase
pH	6.70	7.1	6
Organic carbon (%)	13.76	16.07	17
Total N (%)	0.58	0.76	31
Total K (%)	0.89	0.96	8
Total P (%)	0.63	2.28	262
Water-soluble P (%)	0.061	0.087	42.1
Citrate soluble P (%)	0.069	0.67	71
Total Ca (%)	1.78	2.29	29
Total Mg (%)	0.32	0.48	50
Fe (ppm)	5072	12700	150
Mn (ppm)	178	498	180
Zn (ppm)	56	86	50
Cu (ppm)	9	22	140

Table 2: Effect of phosphor-compost supplementation on yield and yield attributes of rice-wheat crop.

Treatment details	Plant Population/m^2		Panicle Length (cm)		No of Grain/ Panicle		1000 seed Weight (g)		Yield q/ha Grain		C: B ratio	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Compost @ 5 t/ha	250	62	17.42	6.82	78.35	41.24	13.92	33.85	20.3	24.9	1:1.39	1:1.6
PC @ 10 t/ha	286	70	20.34	7.02	85.37	43.17	1561	36.27	22.5	28.5	1:1.62	1:2.1
N P K @ 120:60:60	319	86	23.97	8.65	88.12	48.54	15.74	38.56	34.35	33.9	1:2.46	1:2.8
N120, K60 & PC @ 5 t/ha	340	81	20.65	8.11	87.76	46.97	16.95	37.74	30.4	32.7	1:1.79	1:2.6
N120, K60 & PC @ 10 t/ha	3521	98	25.12	9.56	94.68	54.21	18.79	44.76	35.8	36.6	1:1.80	1:2.5
N60, K60 & PC @ 5 t/ha	310	84	21.67	7.21	83.11	46.89	15.68	36.95	28.1	30.4	1:2.31	1:2.8
N60, K60 & PC @ 10 t/ha	332	88	22.39	7.82	87.68	48.75	16.57	39.75	30.6	31.1	1:1.97	1:2.0
N40, K20 & PC @ 5 t/ha	28	79	19.54	7.00	8125	44.20	14.32	36.41	24.5	26.9	1:1.99	1:2.1
N40, K20 & PC @ 10 t/ha	293	82	20.86	7.50	84.36	48.12	14.97	38.64	26.6	28.8	1:1.87	1:1.9
N80, K40 & PC @ 5 t/ha	325	89	21.22	7.91	87.43	40.85	16.26	40.86	34.4	30.2	1:2.22	1:2.7
N80, K40 & PC @ 10 t/ha	338	93	23.87	8.61	86.78	41.51	17.68	41.51	35.1	33.5	1:2.12	1:2.2
CD at 5%	28.23	-	2.07	-	1032	-	1.08	2.34	0.624	1.77		

Table 3: Effect of phosphor-compost supplementation on nitrogen, phosphorus, and protein content (%) in rice and wheat crop.

Treatments Details	Protein content in Grain (%)		P Content percent				N Content percent			
			Grain		Straw		Grain		Straw	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Compost @ 5 t/ha	5.1	12.24	0256	0.20	0.046	0043	1.22	1.02	0.20	0.09
PC @ 10 t/ha	5.7	13.12	0277	021	0053	0052	1.24	1.04	0.19	0.11
N P K @ 120:60:60	6.1	13.16	0298	023	0.079	0078	1.36	1 16	0.27	0.19
N120, K60 & PC @ 5 t/ha	6.1	13.62	0.310	0.25	0.054	0.050	122	1.12	0.24	0.9
N120, K60 & PC @ 10 t/ha	6.7	14.91	0.350	0.26	0.086	(J.081	1.19	1.09	029	0.17
N60, K60 & PC @ 5 t/ha	60	12.85	0.285	0.23	0057	0052	1.17	107	02()	0.10
N60, K60 & PC @ 10 t/ha	6.1	12.76	0.315	024	(J054	0053	1.24	1 14	0 30	0.20
N40, K20 & PC @ 5 t/ha	5.3	13.01	0275	0.21	0.043	0.045	1.29	121	0.29	0.14
N40, K20 & PC @ 10 t/ha	5.6	12.81	0.300	0.23	0.051	0.048	1.26	I 16	0.28	0.16
N80, K40 & PC @ 5 t/ha	6.1	12.95	0.320	024	0.065	0.061	1.28	120	0.24	0.15
N80, K40 & PC @ 10 t/ha	6.3	13.52	0.338	0.26	0.070	66	121	1.15	0.27	0.17
SE	0.41	0.58	0.023	0.025	0.0031	00025	0.029	0028	0.018	
CD at 5%	1.82	2.15	0.058	0.053	O,()O48	00053	0.062	0059	0.033	

Table 4: Nutrients in soil after harvesting of rice-wheat

Treatments details	pH	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potash (kg/ha)
Compost @ 5 t/ha	7.4	0.54	80.15	19.15	213.64
PC @ 10 t/ha	7.2	0.58	118.97	15.87	226.85
N P K @ 120:60:60	7.2	0.60	130.52	15.95	237.58
N120, K60 & PC @ 5 t/ha	7.3	0.67	135.98	22.31	244.62
N120, K60 & PC @ 10 t/ha	7.1	0.73	161.54	24.65	252.31
N60, K60 & PC @ 5 t/ha	7.2	0.63	128.83	21.00	235.41
N60, K60 & PC @ 10 t/ha	7.3	0.66	137.48	22.41	238.64
N40, K20 & PC @ 5 t/ha	7.1	0.62	121.94	15.32	229.81
N40, K20 & PC @ 10 t/ha	7.2	0.62	123.51	16.52	231.94
N80, K40 & PC @ 5 t/ha	7.2	0.66	138.46	21.85	240.68
N80, K40 & PC @ 10 t/ha	7.5	0.69	142.12	23.96	248.10
LSD 0.05	0.31	0.52	10.11	0.28	15.21

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