



Acidulates performance for the better efficacy of rock phosphate in wheat (*Triticum aestivum*)

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ABSTRACT

Fixed plot field experiments were conducted at G B Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 2009–10 to 2012–13, to screen acidulates for better utilization of rock-phosphate in wheat (*Triticum aestivum* L.). Acidulates used were gypsum, SSP, FYM, pressmud (PM) and phosphorus solubilizing bacteria (PSB), in different ratio with rock phosphate. The experiment was conducted in RBD with eight treatments replicated thrice. Results revealed that RP acidulated with gypsum gave maximum grain yield (44.2 q/h) and straw yield (68.2 q/h) which were found significantly higher than the other treatments except pressmud acidulation. Plant height, spike length, number of fertile and sterile spikelet/spike and 1000 grain weight were found non-significant due to the treatments but maximum value was obtained with gypsum acidulation. Tillers and dry matter accumulations were also significantly higher in gypsum acidulated plots than the other treatments. Maximum soil available N was noticed in pressmud and PSB acidulated plot, which was found at par with FYM and pressmud treatments. Soil available P was found maximum in gypsum acidulated RP plots which was found at par with FYM+PSB acidulates RP and significantly higher than other treatments. In case of soil available K, SSP acidulated RP gave maximum value which was significantly higher than the other treatments. Nutrient uptake in gypsum acidulated RP was higher as compared to other treatments. Highest gross return (₹ 65678.3 h), net return (₹ 44504.5 h) and benefit:cost ratio (2.10) was also recorded in gypsum acidulates.

Key words: Acidulates, Rock phosphate, Wheat

Phosphorus involved in several physiological and biochemical activities like photosynthesis, transformation of sugar to starch of the plants and its deficiency in soil is a serious constraint to increased crop productivity. Indian soils are generally poor in phosphorus and its fixation process reduces its recovery rate, results in low phosphorus use efficiency 20–25% (Thakur *et al.* 2014). India loses foreign currency to import phosphatic fertilizers however, a good rock phosphate reserve is available in India. It is estimated that about 260 million tonnes of rock phosphate (RP) deposits are available in India (FAI 2012), but mostly they are categorized as low-grade because of their low P content and unsuitable for commercial production of P-fertilizer. Rock phosphate contain about 50% of its total

P₂O₅ as tri-calcium phosphate, which is neither water soluble nor citrate soluble, this limits the opportunity to utilize rock phosphate as P nutrition. The solubility of rock phosphate can be increased by adding acids or acid forming substances. These acid forming substances may come from organic matter decomposition by releasing CO₂, citric acid, malonic acid, fulvic acid and other organic acids. Acids targets insoluble tri-calcium phosphate present in rock phosphate and convert them in to water and citric acid soluble form. Phosphate solubilizing bacteria having ability to solubilize rock phosphate can be used for solubilization of rock phosphate (Yadav *et al.* 2014). Microorganism like *Bacillus megatherium* var *phosphaticum* also enhances the phosphorous availability (Katewa *et al.* 2012). The other acid release materials like farmyard manure, crop residue and pressmud are receiving greater attention in these days. This process not only compensates the higher cost of manufacturing of fertilizers in industries but, also increases nutrient mobility in soil (Chaturvedi *et al.* 2011). Keeping above in view experiments were conducted to study the effect of acidulated for better efficacy of rock phosphate in wheat cultivation which an important food crop of tarai belt of our country.

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MATERIALS AND METHODS

Fixed plot field experiments were conducted during 2009–10 to 2012–13, to assess the performance of acidulates applied along with rock phosphate in wheat crop. The site of experiment was at Norman E. Borlaug Crop Research Center in Pantnagar, India, which is located at 29° N latitude, 79.29° E longitude and an altitude of 243.84 m amsl. Experimental soil was silty loam in texture with slightly alkaline in reaction (pH 7.9) having medium organic carbon (0.61%) and low in available nitrogen (251 kg/h) and potassium (107 kg/h), medium in available phosphorous (22.5 kg/h). The experiment consisted of eight treatments which were executed in randomized block design with three replications. The treatments were T1:Control; T2:Single super phosphate @188 kg/h; T3: Gypsum @300 kg/h; T4-Phosphorus solubilizing bacteria (PSB) @2 L/ha; T5: FYM @300 kg/h; T6: Pressmud @300 kg/h; T7: FYM @300 kg/h+PSB @2 L/ha; T8: Pressmud @300 kg/h+PSB @2 L/h. Rock phosphate (RP) was applied @300 kg/ha in all the treatments except T2 where the dose of rock phosphate was 150 kg/ha. In control treatments (T1) rock phosphate was applied @300 kg/ha without acidulates. The desired quantity of rock phosphate were thoroughly mixed with acidulates as per treatments and this practice was done just before sowing of the crop. The optimum moisture conditions were ensured by applying irrigations at desired crop growth stages. These experiments were conducted in *rabi* season however, during *kharif* moong was taken as a commercial crop grown in individual plots. Standard package and practices were followed to raise moong crop. Wheat variety PBW-550 was sown in second week of November and harvested in April during all the years. Recommended dose of fertilizers (nitrogen, phosphorous and potassium @150:60:40 kg/h) were applied to all treatments. One-third of nitrogen, full dose of phosphorous and full dose of potassium was applied as basal. One-third of nitrogen was top dressed just after first irrigation and remaining nitrogen was top dressed at first node formation stage. Irrigation was applied on the basis of critical physiological stages.

Climatic data regarding monthly temperature, humidity and rainfall were collected from the meteorological observatory located at N E Borlaug crop research center, Pantnagar. The observations on important characters were taken at harvest stage. These observations include plant height, no. of tillers, dry matter accumulation,

yield attributing characters, grain yield, and straw yield. Economics was calculated as per the standard procedure. The soil samples were collected from each plot after harvesting of wheat crop grown under moong-wheat rotation. These soil samples were subjected for the analysis of soil organic carbon, pH, available nitrogen, phosphorous and potassium by standard procedure.

RESULTS AND DISCUSSION

Wheat crop grown during four years of experimental period showed similar trends in temperature and humidity (Table 1), there was no much variation in the data. Temperature was the highest in the month of April and lowest in January. Similarly humidity was recorded highest during January and lowest during April without much variation throughout the four seasons. Rainfall pattern was much frequent in the year 2010–11 than the rest where it was slightly less frequent. The results indicated that weather did not significantly influence the performance of treatments subjected to the wheat crop.

Crop growth, yield attributes and yield: Number of tillers per m² was maximum in gypsum acidulated RP treatment which was at par with FYM, PM and PM+PSB treatments but significantly higher than the other treatments. When gypsum acidulates RP was applied, it gave significantly higher dry matter than rest of the treatment. 1000 grain weight was also observed maximum in gypsum treatment though it varied non-significantly with other treatments except control. When rock phosphate (RP) acidulated with gypsum (T3) recorded maximum grain yield (44.2 q/h) and straw yield (68.23 q/h) and found at par with PM treatment (T6) but significantly higher than rest of the treatments (Table 2). As per the research findings gypsum acidulated RP gave the maximum grain yield it might be due to the cumulative effect of more number of tillers per m², more number of spikes per m², and maximum test weight (Table 2). Crop growth and yield totally dependent on the amount of nutrient, they are getting to support their physiology. Low bioavailability of P in soil from the applied phosphatic fertilizers due to fixation/precipitation is considered as the most critical factor in limiting optimum crop yields. Being the cheap source of P the only limitation with RP is that it cannot be used directly as a soil amendment because of its very poor water solubility (0.1%). However, the bioavailability of RP-P can be enhanced by complexing it with acidulates

Table 1 Monthly climatic data of the experimental area

Month	Temperature (°C)				Humidity (%)				Rainfall (mm)			
	2009-10	2010-11	2011-12	2012-13	2009-10	2010-11	2011-12	2012-13	2009-10	2010-11	2011-12	2012-13
November	19.31	20.63	19.80	18.57	65.59	65.28	71.31	62.75	1.14	0.40	0.00	0.13
December	15.05	14.93	15.08	14.23	69.35	67.94	74.54	73.98	0.00	0.47	0.00	1.00
January	11.69	11.43	13.07	10.66	82.64	78.72	76.29	84.00	0.12	0.78	0.81	10.30
February	16.30	20.53	15.19	15.93	51.71	69.89	65.37	74.00	16.10	1.18	0.00	33.02
March	22.89	20.94	20.58	20.81	61.40	61.07	63.43	57.37	0.20	0.49	0.12	13.40
April	28.97	25.94	26.63	25.51	40.74	48.96	53.23	50.61	0.00	0.21	0.24	8.40

(Saleem *et al.* 2013). Gypsum made the phosphorous available to the plant by creating acidic condition through the formation of sulphuric acid in the presence of sufficient soil moisture. It is due to the acidulating materials, there was reduction in the phosphorous fixation capacity of soil and makes them available to plants. Straw yield was also recorded maximum when RP acidulated with gypsum. It may be due to more availability of P to the plant for better growth and development. P is responsible for good root establishment and proliferation which leads to the better absorption of other plant nutrients also, which leads to better shoot growth as it has significant role in plant metabolic functions like photosynthesis, transformation of sugar to starch and transportation of genetic material. The higher availability of soil P in gypsum treatment might be due to good acidulating effect of gypsum. Similar results were found in the studies done by Saleem *et al.* (2013), where they reported that RP cannot be used directly due to its poor water solubility but when applied with acidulating material gives better results. All this leads to more uptake of P and simultaneously increases the translocation of P from straw to grain. Chaudhary *et al.* (2015) and Chaudhary *et al.* (2017) also reported similar results.

Postharvest soil nutrient status in soil: Organic carbon, available N, P and K were significantly influenced by the treatments (Table 2). There was no significant effect on soil pH (Table 2). Sharif *et al.* (2013) reported that pH of soil will decrease when organic matter was applied in the field. Organic carbon was found maximum (0.65%) when rock phosphate was given in combination with gypsum followed by RP+PSB (0.64%) combination. Both the treatments showed non-significant results but significantly higher than rest of the treatments. Sharif *et al.* (2013) reported that application of compost enriched with RP treatment

gave higher organic matter content in soil. Available N was found maximum in PM+PSB which was also at par with FYM, PSB and PM and significantly higher than rest of the treatments. Available P was found highest when RP acidulated with gypsum. It showed at par results with RP+FYM and RP+FYM+PSB, while found significantly higher than rest of the treatment. Available K was found significantly high in RP+SSP treatment. The application of RP+SSP treatment changes the soil pH which might be responsible for more available K in such treatments. This might be due to the acidulation effect of the treatments which convert the non-exchangeable form of K to the exchangeable form of K (Verde *et al.* 2013).

Nutrient uptake by crop: Total N, P and K uptake varied with the treatments (Table 2). Total N uptake was found maximum with PM+PSB acidulated RP (Table 2), which was found at par with gypsum and PM and significantly higher than the other treatments. Total P and K uptake was found maximum when rock phosphate was acidulated with gypsum. In case of total P uptake the gypsum acidulated plots gave statistically similar results as obtained with SSP, FYM, PM + PSB acidulates. In case of total K uptake, gypsum acidulated plots gave statistically higher value of total K uptake as compared to the other treatments. These results are in close conformity of Zhang *et al.* (2011) and Yadav *et al.* (2017).

Economics: RP acidulated with gypsum (T3) gave maximum gross return (₹ 65678/h), net return (₹ 44504/h) and benefit:cost ratio (2.10) (Fig 1). This higher gross and net return is due to more grain and straw yield which fetched more income from the market. The highest cost of cultivation was recorded in RP with FYM + PSB and RP with PM + PSB which is due to the additional cost inputs.

So It can be concluded that rock phosphate acidulated

Table 2 Crop performance and soil status in relation to rock phosphate and acidulates application (mean or pooled data of four years)

Acidulates	Tillers/ m ²	DMA (g/m ²)	Spike length (cm)	1000 grain wt (g)	Grain yield (q/h)	Straw yield (q/h)	Total nutrient uptake (kg/h)			pH	OC (%)	Av. N (kg/h)	Av. P (kg/h)	Av. K (kg/h)
							N	P	K					
Control (T1)	336	1098	8.8	36.6	37.3	62.5	94.7	19.9	140.9	7.48	0.57	149.72	25.22	96.19
SSP (T2)	407	1244	9.4	38.8	36.4	61.4	99.1	21.9	125.7	7.57	0.59	144.00	24.84	129.82
Gypsum (T3)	443	1605	9.7	41.5	44.2	68.2	107.8	23.3	151.8	7.53	0.65	144.47	28.44	101.98
PSB (T4)	378	1131	9.6	41.3	39.3	63.3	90.1	19.2	136.6	7.42	0.58	156.99	24.58	99.89
FYM (T5)	416	1308	9.5	38.6	39.7	65.1	98.2	22.3	141.6	7.35	0.64	158.56	27.09	112.26
PM (T6)	431	1398	9.4	38.7	42.1	67.8	104.7	20.9	133.5	7.52	0.59	151.37	24.65	100.43
FYM+PSB (T7)	407	1237	9.1	39.1	40.7	63.5	98.3	20.2	143.0	7.36	0.59	149.33	27.50	99.57
PM+PSB(T8)	420	1230	9.4	39.1	40.9	63.9	111.6	21.0	137.8	7.51	0.61	160.75	20.54	97.69
SEm±	11.3	47.3	0.3	1.2	1.1	0.9	3.1	0.7	5.2	0.07	0.01	2.5	0.6	4.1
CD (P=0.05)	33.6	140.6	NS	NS	3.2	2.8	9.4	2.0	15.5	NS	0.02	9.5	1.2	7.6
Initial value										7.9	0.61	181.0	22.5	107.0

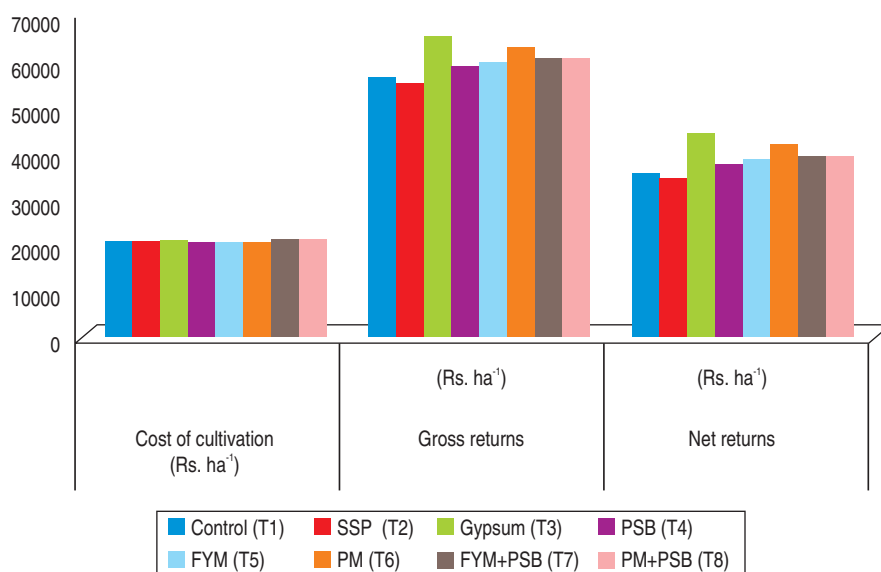


Fig 1 Effect of acidulates with rock phosphate on the economics of wheat.

with gypsum each 300 kg/h found best in terms of recording crop growth, grain yield, biological yield and benefit:cost ratio, and can be use as alternate source of phosphatic fertilizers.

REFERENCES

- Chaturvedi Sumit, Kumar Rajeew, Bhatnagar Amit, Tewari Salil and Kausal Rajesh. 2011. Enriched rock phosphate as an alternative P-nutrition for improving wheat productivity and soil health in poplar + wheat system. *Journal of Tree Science* **30** (1-2): 54–9.
- Chaudhary S K, Hasim Mohammad, Saquib Mohammad and Singh C B. 2017. Yield, NPK content and nutrient uptake of wheat as influenced by the application of acidulated rock phosphate. *Bangladesh Journal of Botany* **46**(1): 187–94.
- Chaudhary, Santosh Kumar, Kumar Rajeew, Singh A K and Kumar Rakesh. 2015. Effect of acidulated rock phosphate on growth yield attributes and yield of wheat (*Triticum aestivum* L.). *Indian Journal of Agriculture Research* **49**(6): 574–76.
- FAI. 2012. Fertilizer Statistics. 2011–2012. The Fertilizer Association of India, New Delhi.
- Katewa M K, Sekhar D M R and Shaktawat M S. 2012. PROM Khad an efficient source of P to replace the costly chemical phosphatic Fertilizer. *Nature Proceeding*.
- Saleem M M, Arshad M and Yaseen M. 2013. Effectiveness of various approaches to use rock phosphate as a potential source of plant available P for sustainable wheat production. *International Journal of Agriculture and Biology* **15**: 223–30.
- Sharif M, Burni T, Wahid F, Khan F, Khan S, Khan A and Shah A. 2013. Effect of rock phosphate composted with organic materials on yield and phosphorus uptake of wheat and mung bean crops. *Pakistan Journal of Botany* **45**(4): 1349–56.
- Thakur D, Kaushal R and Shyam V. 2014. Phosphate solubilising microorganisms: role in phosphorus nutrition of crop plants- A Review. *Agricultural Reviews* **35**:159–71.
- Verde, Benvindo Serafim, Danga, Benjamin Oginga and Mugwe, Jayne Njeri. 2013. Effects of manure, lime and mineral P fertilizer on soybean yields and soil fertility in a humic nitisol in the Central Highlands of Kenya. *International Journal of Agricultural Science Research* Vol. **2**(9): 283–91
- Yadav H, Gothwal R K, Sujata M and Ghosh P. 2014. Bioactivation of Jhamarkotra rock phosphate by a thermo tolerant phosphate-solubilizing bacterium *Bacillus* spp. BISR-HY63 isolated from phosphate mines. *Archive of Agronomy and Soil Science* **61**: 1125–35.
- Yadav Hemendra, Fatima Rukhsar, Sharma Ankita and Mathre Sujata. 2017. Enhancement of applicability of with phosphate in alkali soil by organic compost. *Jorunal of Applied Soil Ecology* **113**: 80–5.
- Zhang H, Wu X, Li G and Qin P. 2011. Interactions between arbuscular mycorrhizal fungi and phosphate-solubilizing fungus (*Mortierella* sp.) and their effects on *Kosteletzkyavirginica* growth and enzyme activities of rhizosphere and bulk soils at different salinities. *Biology and Fertility of Soils* **47**: 543.