

Effect of diammonium phosphate and mussoorie rock phosphate on productivity and economics of potato (*Solanum tuberosum*)*

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Potato (*Solanum tuberosum* L.) is an important food crop and presently being cultivated on an area of 1.786 million ha and with a production of 34.46 million tonnes during 2007–08 in India (FAI 2009). Potato being a short-duration crop having sparse root system is highly responsive to applied nutrients. Studies have shown that its phosphorus requirement is almost double than that of the cereal crops. The phosphorus content of the Indian soils is becoming lower and lower year after year. Motsara (2002) reported that 60% soils of Indian soils are low to medium in available phosphorus. Added inorganic phosphorus as water soluble phosphate fertilizers undergoes complex exchanges between various soil phosphorus pools. Consequently, large amounts of fertilizer phosphorus are needed to attain reasonable crop yields. In India, the price of phosphorus fertilizer is the highest; the cost of 1 kg P₂O₅ varies from Rs 16.22 through diammonium phosphate to Rs 16.88–26.88 through single superphosphate as against Rs 10.5 for 1 kg nitrogen through urea and Rs 7.43 for 1 kg K₂O through muriate of potash. Because of high cost small and marginal farmers in India generally skip phosphorus fertilization. The N:P₂O₅ consumption ratio in India was 2.3: 1 (FAI 2008–09) as against the desirable ratio of 2:1 for sustainable crop production (Tiwari 2002). The high cost of phosphorus in India is because bulk of the phosphate rock for making phosphate fertilizers is imported. However, there are substantial deposits of low-grade rock phosphate in India which can partly meet the crop demands for phosphorus. One such deposit is mussoorie rock phosphate. Attempts have been made in the past to use finely ground mussoorie rock phosphate directly in soil of pH 7 and above with the help of phosphate-solubilizing microorganisms and pyrites (Sharma and Prasad 2003, Sharma *et al.* 2009). The present investigation was, therefore, undertaken to study the effect of residue incorporation on

the relative efficiency of diammonium phosphate and mussoorie rock phosphate at varying rate of application on growth, yield and economics of potato.

The field experiments were conducted during 2001–04 at New Delhi (28° 38' N latitude, 77° 11' E longitude and 228.6 m above mean sea level). The soil was sandy clay loam, having 52.5% sand, 21.0% silt and 26.5% clay. It contained 12.0 Mg/ha organic carbon, 1.3 Mg/ha Kjeldahl nitrogen, 16.0 kg/ha 0.5 M NaHCO₃ extractable phosphorus and 500 kg/ha 1 N NH₄OAC extractable potassium and had a pH of 8.3 at the start of experiment. The experiments were laid out in a split-plot design with 6 replications. The treatments consisted of 2 crop residue practices (no residue and residue incorporation) in main plots and 6 phosphorus treatments (control, 40 kg P₂O₅/ha as diammonium phosphate, 40 kg P₂O₅/ha as mussoorie rock phosphate, 80 kg P₂O₅/ha as diammonium phosphate, 80 kg P₂O₅/ha as mussoorie rock phosphate and 120 kg P₂O₅/ha as mussoorie rock phosphate) in sub-plots. The treatments were continued for 3 years in the same plots. The main plot size was 25 m × 23 m and sub plot size was 7.5 m × 7.0 m. Commercial grade granulated diammonium phosphate containing 18% N and 20% phosphorus and mussoorie rock phosphate containing 8.3% phosphorus were used. Of the total phosphorus in mussoorie rock phosphate, 12% was soluble in neutral ammonium citrate. Mussoorie rock phosphate plots were inoculated with phosphates-solubilizing bacteria *Pseudomonas striata*. For inoculation with phosphates-solubilizing bacteria, a slurry was prepared by dissolving 200 g brown sugar in 250 ml water and then warming it for 15 min. at 40°C. The slurry thus prepared was diluted 10 times with water and a packet of phosphates-solubilizing bacteria culture obtained from the Microbiology Division, Indian Agricultural Research Institute, New Delhi was added to diluted slurry. Inoculation in potato crop was done by dipping the tubers in culture slurry.

Response of potato to diammonium phosphate was significant at 40 kg P₂O₅/ha in first two years and at 80 kg P₂O₅/ha in third year (Table 1). Application of mussoorie

*Short note

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Table 1 Effect of rates and sources of phosphorus on tuber yield (tonnes/ha) of potato as influenced by residue incorporation

Treatment	2001–02			2002–03			2003–04		
	NR	RI	Mean	NR	RI	Mean	NR	RI	Mean
Control	21.2	24.2	22.7	23.3	27.2	25.3	22.2	23.0	22.6
40 kg P ₂ O ₅ /ha as DAP	26.2	26.6	26.4	25.0	31.1	28.0	23.8	24.6	24.2
40 kg P ₂ O ₅ /ha as RP	25.9	26.1	26.0	14.4	30.0	27.2	23.0	24.6	23.8
80 kg P ₂ O ₅ /ha as DAP	28.4	28.8	28.6	26.7	31.1	28.9	26.1	26.2	26.2
80 kg P ₂ O ₅ /ha as RP	26.0	27.8	26.8	24.4	30.0	27.2	25.4	25.8	25.6
120 kg P ₂ O ₅ /ha as RP	27.8	29.4	28.6	24.4	30.5	27.5	26.1	27.0	26.6
Mean	25.9	27.1		24.7	30.0		24.5	25.2	
CD (P=0.05)									
Phosphorus (P)		2.76			2.23			3.22	
Residue (R)		NS			1.77			NS	
P × R		NS			3.16			3.96	

NR, No residue; RI, residue incorporation; DAP, diammonium phosphate; MRP, Mussoorie rock phosphate

rock phosphate increased potato yield significantly during first and third year. Potato yield increased significantly when rate of mussoorie rock phosphate was increased from 0 to 40 kg P₂O₅/ha during first year and from 0 to 120 kg P₂O₅/ha during third year. Residue incorporation increased tuber yield in second year. The interaction between residue and phosphorus was significant during last two years. During second year, diammonium phosphate at 40 and mussoorie rock phosphate at 80 kg P₂O₅/ha significantly increased tuber yield of potato only when residue was incorporated. During

third year, P application had no significant effect on potato yield without residue incorporation, whereas with residue incorporation mussoorie rock phosphate at 120 kg P₂O₅/ha significantly increased potato yield over the control.

The response of potato to diammonium phosphate was linear in all the 3 years except during 2003–04 without residue incorporation, whereas response to mussoorie rock phosphate was linear in first and third year and quadratic in second year (Table 2). The economic optimum dose was worked out to be 53.2 kg P₂O₅/ha for diammonium phosphate and

Table 2 Response equation, economic optimum dose and yield and response of potato at economic optimum dose of different sources of phosphorus

Source	Response equation	Economic optimum dose (kg/ha)	Yield at economic optimum dose (tonnes/ha)	Response at economic optimum dose (kg tuber/kg P ₂ O ₅)	Returns	
					Rs/ha	Rs/Re invested
<i>Without residue incorporation (2001–02)</i>						
Diammonium phosphate	Y=216.7+0.9000X					
Rock phosphate	Y=220.4+0.5300X					
<i>With residue incorporation (2001–02)</i>						
Diammonium phosphate	Y=242.3+0.5750X					
Rock phosphate	Y=242.8+0.4325X					
<i>Without residue incorporation (2002–03)</i>						
Diammonium phosphate	Y=233.3+0.4175X					
Rock phosphate	233.8+0.2809X-0.0017X ²	72.3	24.53	15.8	1778	3.51
<i>With residue incorporation (2002–03)</i>						
Diammonium phosphate	Y=272.2					
Rock phosphate	Y=287.2+0.6679-0.0035 X ²	90.4	31.90	35.1	5721	9.04
<i>Without residue incorporation (2003–04)</i>						
Diammonium phosphate	Y=222.0+0.3125-0.0022 X ²	53.2	23.20	12.4	1646	1.97
Rock phosphate	Y=220.0+0.3530X					
<i>With residue incorporation (2003–04)</i>						
Diammonium phosphate	Y=232.0+0.6000X					
Rock phosphate	Y=231.2+0.3300X					

MRP, Mussoorie rock phosphate

72–90 kg P₂O₅/ha for mussoorie rock phosphate and potato gave higher response to mussoorie rock phosphate (16–35 kg tuber/kg P₂O₅) than the diammonium phosphate (12 kg tuber/kg P₂O₅). Residue incorporation had no significant effect on the response to both diammonium phosphate and mussoorie rock phosphate. Agronomic efficiency of diammonium phosphate was higher than that of mussoorie rock phosphate at both 40 and 80 kg P₂O₅/ha in all the years of study (Table 3). Residue incorporation resulted in the reduction in agronomy efficiency of both the sources in first year, whereas in second and third years residue incorporation increased the agronomic efficiency of diammonium phosphate as well as mussoorie rock phosphate. The agronomic efficiency of diammonium phosphate and mussoorie rock phosphate decreased with the increase in rate of phosphorus application. Haulm yield of potato increased significantly when rate of phosphorus application increased from 0 to 120 kg P₂O₅/ha as mussoorie rock phosphate in 2001–02, whereas in 2002–03 and 2003–04 phosphorus application had no significant effect on haulm yield of potato (data not shown). Residue incorporation increased the haulm yield only in second year. The interaction between residue and phosphorus was not significant in any year.

During 2001, diammonium phosphate and mussoorie rock phosphate at 40 kg P₂O₅/ha significantly increased gross income of potato over control (data not shown). Further increase in rate of diammonium phosphate and mussoorie

rock phosphate had no significant effect on gross returns of potato. During 2002–03, gross returns of potato increased significantly when rate of phosphorus was increased from 0 to 40 kg P₂O₅/ha in case of diammonium phosphate and from 0 to 120 kg P₂O₅/ha in case of mussoorie rock phosphate. During 2003–04 gross returns of potato increased significantly when rate of phosphorus was increased from 0 to 80 kg P₂O₅/ha in case of diammonium phosphate and 0 to 120 kg P₂O₅/ha in case of mussoorie rock phosphate. Residue incorporation increased gross returns of potato only in second year. Similarly, interaction between phosphorus and residue was significant only in third year and it indicated that phosphorus application either through diammonium phosphate or mussoorie rock phosphate had no significant effect on gross returns of potato when no residue was incorporated. When residue was incorporated mussoorie rock phosphate at 120 kg P₂O₅/ha significantly increased the gross returns over control. Cost of potato cultivation ranged from Rs 27 551 to 30 848/ha (data not shown). Application of diammonium phosphate at 40 and 80 kg P₂O₅/ha increased cultivation cost over the control by 2.4 and 4.8%, respectively, whereas application of mussoorie rock phosphate at 40, 80 and 120 kg P₂O₅/ha increased cost of cultivation over control by 1.6, 3.0 and 4.5% respectively. Residue incorporation accounted for 6.8% increase in the cost of cultivation of potato. Net returns of potato increased by 12–30 and 22–47% with the application of 40 and 80 kg P₂O₅/ha as

Table 3 Effect of rates and sources of phosphorus on agronomic efficiency of phosphorus (kg tuber/kg P₂O₅) in potato crop as influenced by residue incorporation

Treatment	2001–02			2002–03			2003–04		
	NR	RI	Mean	NR	RI	Mean	NR	RI	Mean
40 kg P ₂ O ₅ /ha as DAP	125.0	60.0	92.5	41.7	97.5	69.6	40.0	40.0	40.0
40 kg P ₂ O ₅ /ha as RP	117.5	47.5	82.5	26.7	69.5	48.1	20.0	40.0	30.0
80 kg P ₂ O ₅ /ha as DAP	90.0	57.5	73.8	41.7	48.5	45.1	48.7	40.0	44.3
80 kg P ₂ O ₅ /ha as RP	60.0	45.0	51.3	13.4	34.7	24.0	40.0	35.0	37.5
120 kg P ₂ O ₅ /ha as RP	55.0	43.3	49.2	8.9	27.7	18.3	32.5	33.3	32.9

NR, No residue; RI, residue incorporation; DAP, diammonium phosphate; MRP, mussoorie rock phosphate

Table 4 Effect of rates and sources of phosphorus on net returns (Rs/ha) of potato as influenced by residue incorporation

Treatment	2001–02			2002–03			2003–04		
	NR	RI	Mean	NR	RI	Mean	NR	RI	Mean
Control	25 841	31 532	28 686	31 141	39 095	35 118	28 441	28 520	28 480
40 kg P ₂ O ₅ /ha as DAP	37 797	36 895	37 346	34 752	48 207	41 479	31 824	31 911	31 867
40 kg P ₂ O ₅ /ha as RP	37 230	35 833	36 531	33 471	45 667	39 569	30 012	32 115	31 063
80 kg P ₂ O ₅ /ha as DAP	42 617	41 700	42 158	38 360	47 548	42 954	36 926	35 239	36 082
80 kg P ₂ O ₅ /ha as RP	37 052	39 726	38 389	33 059	45 280	39 169	35 608	34 734	35 171
120 kg P ₂ O ₅ /ha as RP	41 208	43 348	42 278	32 639	46 120	39 379	36 977	37 340	37 158
Mean	36 957	38 172		33 903	45 319		33 298	33 309	

NR, No residue; RI, residue incorporation; DAP, diammonium phosphate; MRP, mussoorie rock phosphate

diammonium phosphate, respectively (Table 4). Similarly, application of mussoorie rock phosphate at 40, 80 and 120 kg P₂O₅/ha increased net returns of potato over the control by 9–27, 12–34 and 12–47% respectively. Residue incorporation resulted in 0.03 to 33.7% increase in net returns of potato; however residue had no definite trend on the response of potato to diammonium phosphate and mussoorie rock phosphate.

SUMMARY

The field experiments conducted during 2001–04 at New Delhi to study the effect of crop residue incorporation on the relative efficiency of diammonium phosphate and mussoorie rock phosphate at varying rate of application on growth, yield and economics of potato (*Solanum tuberosum* L.). Results showed phosphorus application significantly increased growth and yield parameters, yield (mean tuber yield 28.6, 27.5 and 26.6 tonnes/ha during 2001–02, 2002–03 and 2003–04 respectively) and gross and net returns (mean Rs/ha 42 278; 39 379 and 37 158 during 2001–02, 2002–03 and 2003–04, respectively) of potato. Mussoorie rock phosphate as 80 kg P₂O₅/ha was at par with 40 kg P₂O₅/ha as diammonium phosphate in terms of yield and gross and net returns of potato. Residue incorporation significantly

increased the efficiency of diammonium phosphate and mussoorie rock phosphate. The study shows that the mussoorie rock phosphate along with phosphates-solubilizing bacteria inoculation and residue incorporation can be used for phosphorus fertilization in potato crop for increasing productivity and higher net returns.

REFERENCES

- FAI. 2009. *Fertilizer Statistics 2008–09*. The Fertilizer Association of India, New Delhi, India.
- Motsara M R. 2002 Available nitrogen, phosphorus and potassium status of Indian soils as depicted by soil fertility maps. *Fertilizer News* 47(8): 15–21.
- Sharma S N, Prasad R. 2003. Yield and P uptake by rice and wheat grown in a sequence as influenced by phosphate fertilization with diammonium phosphate and mussoorie rock phosphate with or without crop residue and phosphate solubilizing bacteria. *Journal of Agricultural Science, Cambridge* 141: 359–69.
- Sharma S N, Prasad R, Shivay, Y S, Dwivedi M K, Kumar S and Kumar D. 2009. Effects of rates and sources of phosphorus on growth, yield and economics of rice (*Oryza sativa*) as influenced by crop residue. *Indian Journal of Agronomy* 54(1): 42–46.
- Tiwari K N. 2002. Nutrient management – Issues and Strategies. *Fertilizer News* 47(8): 23–49.