International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2019; 7(5): 2024-2027

Received: 01-07-2019
Accepted: 03-08-2019

Tshering Palden Bhutia
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

N Surbala Devi
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

T Sanahanbi Devi
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

Correspondence
Tshering Palden Bhutia
Department of Soil Science and Agricultural Chemistry, College of Agriculture, Central Agricultural University, Imphal, Manipur, India

Effect of rock phosphate in presence or absence of organic manures and lime on phosphorus availability and dry matter yield of soybean (*Glycine max*)

Tshering Palden Bhutia, N Surbala Devi and T Sanahanbi Devi

Abstract
A pot experiment was carried out to study the effect of rock phosphate in presence or absence of organic manures and lime on soil phosphorus availability, plant concentration and dry matter yield of soybean (var. JS-335). Results showed that the accumulation of available P in soil, plant P concentration and dry matter yield were affected by rock phosphate, manures and lime application. Liming enhanced organic P mineralization thereby increasing P availability. Among the different treatments, significantly higher available P was accumulated in T_9 (Soil + RP + VC @ 10 t ha^{-1} + lime) followed by T_8 (Soil + RP + compost @ 10 t ha^{-1} + lime) on 30th and 60th DAS. However on 90th DAS and at harvest, T_9 (Soil + RP + VC @ 10 t ha^{-1} + lime) was statistically at par with T_8 (Soil + RP + compost @ 10 t ha^{-1} + lime). Results further examined that concentration of P in soybean was found in T_3 (soil + RP + FYM @ 10 t ha^{-1}) showing parity with T_2 (Soil + RP) while T_9 (soil + RP + VC @ 10 t ha^{-1} + lime) showed significantly higher dry matter yield than other treatments at the time of harvest. Effectiveness of rock phosphate as a P source for crop production is enhanced by the solubility effect of organic manures and lime application.

Keywords: Available phosphorus, P concentration, dry matter yield, soybean

Introduction
Phosphorus has been called the key to life because it is directly involved in most life process. It is a component of every living cell and tends to be concentrated in seeds and in the growing point of plants which affects the overall growth of plants by influencing the key metabolic processes such as cell division and development, energy transport (ATP, ADP), signal transduction, macromolecular biosynthesis, photosynthesis and respiration. Application of phosphorus fertilizer is often necessary for crop production. Options for P inputs are organic materials, mineral P fertilizers or phosphate rocks (PR). P availability in soil is often a limiting factor for plant growth, even though the total amount of soil P may be great. Its availability is governed by solubility and how readily phosphorus becomes fixed in soils (Onwonga *et al.*, 2013 and Manimaran, 2014) [14, 12]. Phosphorus availability is enhanced by application of organic or inorganic amendments such as manures, composts, crop residues, rock phosphates or various inorganic P fertilizers (Das *et al.*, 1991; Trivedi *et al.*, 1995 and Onwonga *et al.*, 2013) [5, 18, 14]. The quantum of P fertilizer needed depends not only on the crop P requirements, but also on the amount of extractable soil P and the P fixing capacity of the soil. Assessment of P availability in soils and precise prediction of P fertilizer requirements is the key to sustainable agriculture and protection of environment from the detrimental effect of excess P (Wang *et al.*, 2001) [20]. The high cost of soluble phosphate fertilizer such as single or triple super phosphate has generated considerable interest in the utilization of rock phosphate. Rock phosphate is considered as slow releasing P source and commonly cannot supply P in the rate as per crop requirement (Bhattacharya and Singh, 1990) [3]. But its solubility can be enhanced by acid fixation or combination with organic matter (Akande *et al.*, 2005 and Aloud, 2011) [1, 2]. In association with phosphate solubilizing microorganisms and organic manure, RP could be used as a P source in many crops ((Manjunath *et al.*, 2006; Onwonga *et al.*, 2013 and Wahid *et al.*, 2015) [13, 14, 19].
Soils with inherent pH values between 6 and 7.5 are ideal for P-availability, while pH value below 5.5 and between 7.5 and 8.5 limits P-availability to plants due to fixation by aluminum, iron, or calcium often associated with soil parent materials (Bhattacharya and Singh, 1990) [3].

Liming can increase phosphate availability by stimulating mineralization of soil organic phosphorus (Condron *et al.*, 1993 and Jokubauskaite *et al.*, 2015) [4, 9]. Keeping these, the present investigation was carried out to study the effect of rock phosphate in presence or absence of organic manures and lime on soil phosphorus availability, plant concentration and dry matter yield of soybean.

Materials and Methods

Materials used

A pot experiment was conducted in the Department of Soil Science and Agricultural Chemistry, College of Agriculture, CAU, Imphal during kharif season of 2016. The experimented soil was clayey in texture and acidic reaction with pH 5.5 having high organic carbon (1.22%), medium nitrogen (363.77 kg ha^{-1}) and high potassium (258.5 kg ha^{-1}) content. The different treatments used in the study were T_1 = Soil (control), T_2 = Soil + RP (Rock phosphate), T_3 = Soil + RP (Rock phosphate) + FYM @ 10 t ha^{-1}, T_4 = Soil + RP (Rock phosphate) + compost @ 10 t ha^{-1}, T_5 = Soil + RP (Rock phosphate) + VC @ 10 t ha^{-1}, T_6 = Soil + RP (Rock phosphate) + lime, T_7 = Soil + RP (Rock phosphate) + FYM @ 10 t ha^{-1} + lime, T_8 = Soil + RP (Rock phosphate) + compost @ 10 t ha^{-1} + lime, T_9 = Soil + RP (Rock phosphate) + VC @ 10 t ha^{-1} + lime.

Methods adopted

Four kg of air dried soil was taken in each of a series of pots. Rock phosphate (RP) was applied to each pot based on the recommended dose phosphorus for the test crop soybean (variety JS-335). According to different sets of treatments, FYM, compost and VC were mixed thoroughly with the soil at the rate of 10 t ha^{-1}. Based on lime requirement determination by SMP buffer method (Shoemaker *et al.*, 1961) [16], liming was done two weeks ahead and allowed to react with soil mass according to different sets of treatments. Recommended dose of nitrogen and potassium were added at the rate of 20 kg N ha^{-1} and 40 kg K_2O ha^{-1} in the form of urea and muriate of potash, respectively to each pot as basal application. To each pot, five to six seeds of soybean (variety JS-335) were sown and after germination, three seedlings were maintained throughout the experiment. The soils of each treatment were moistened to 60% of water holding capacity throughout the experiment. The loss of moisture was replenished by the periodic addition of sterile distilled water by weight difference.

Rhizosphere soil samples were periodically collected on 0^{th}, 30^{th}, 60^{th}, 90^{th} DAS and at harvest for determination of available phosphorus content in soil. Available phosphorus content was determined spectophotometrically by Bray and Kurtz No.1 method as described by Jackson (1973) [8]. The whole plants were used to record the dry matter yield on 30^{th}, 60^{th} and 90^{th} DAS and at harvest. These plant samples were dried at 65 to 70°C to constant dry weight. Dry weight was recorded at each stage to assess total dry matter production and expressed in grams per plant. Then, the plant samples were ground and used for the determination of phosphorus content. Di-acid (HNO_3: $HClO_4$) extracts of plant samples were subjected to analysis of P using the vanadomolybdate phosphoric acid yellow colour (ammonium molybdate + ammonium metavanadate) method (Jackson, 1973) [8].

Statistical Analysis

The experiment was carried out under randomized block design (RBD). Altogether there were 9 treatment combinations replicated thrice. The data pertaining to the investigation were statistically analysed through analysis of variance technique for comparing the treatments effects as described by Gomez and Gomez (1984) [6]. The significance of various effects was tested at 5% level of probability.

Result and Discussion

Available P

Results revealed that the available P increase up to 30^{th} DAS and decline till harvest irrespective of different treatments (Fig. 1). There was significant increase in available P in rock phosphate fertilized soil in presence or absence of organic manures and lime over the control. Increase in phosphorus availability due to rock phosphate application was also reported earlier by Laskar *et al.* (1990) [11] and Aloud (2011) [2]. Among the different treatments, significantly higher available P was accumulated more in T_9 (Soil + RP + VC @ 10 t ha^{-1} + lime) followed by T_8 (Soil + RP + compost @ 10 t ha^{-1} + lime) on 30^{th} and 60^{th} DAS. However on 90^{th} DAS and at harvest, T_9 (Soil + RP + VC @ 10 t ha^{-1} + lime) accumulated more available-P which was statistically at par with T_8 (Soil + RP + compost @ 10 t ha^{-1} + lime). This showed that liming can increase phosphate availability by stimulating mineralization of soil organic phosphorus (Haynes, 1982; Singh and Diwakar, 2002 and Jokubauskaite *et al.*, 2015) [7, 17, 9]. Reports were also given regarding solubility effect of organic manures thereby enhancing phosphorus availability from rock phosphate (Akande *et al.*, 2005; Aloud, 2011 and Das *et al.* 1991) [1, 2, 5].

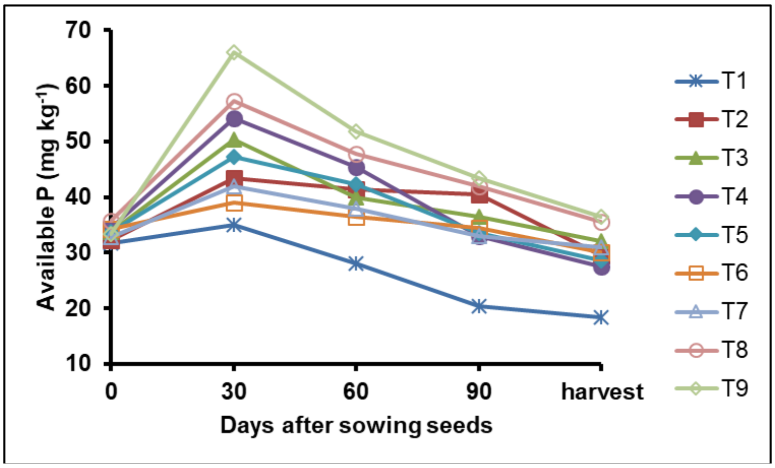

Fig 1: Changes in Available P (mg kg^{-1}) in soybean grown rock phosphate fertilized soil in presence or absence of organic manures and lime

Phosphorus (P) concentration in Plant

Results showed that irrespective of different treatments, P concentration in soybean decline up to 90th DAS with slight increase at harvest with exception in untreated control showing decrease up to 60th DAS and then again increase till harvest (Table 1). Exhibition of P decline with crop growth was also reported earlier by Setia and Sharma (2007) [15]. Closer examination of the results revealed that P concentration in soybean plant was significantly more in soybean grown in soil treated with rock phosphate in presence or absence of organic manure and lime over control at different growth stages of the plant. Among the treatments, comparatively higher P concentration was observed in T_9 (soil + RP + VC @ 10 t ha^{-1} + lime), T_6 (soil + RP + lime) and T_3 (soil + RP + FYM @ 10 t ha^{-1}) which showed equal effect with T_6 (soil + RP + lime) and T_9 (soil + RP + VC @ 10 t ha^{-1} + lime), respectively on 30th and 60th DAS of crop growth. However, on 90th day, P concentration was significantly more in T_6 (soil + RP + lime) followed by T_9 (soil + RP + VC @ 10 t ha^{-1} + lime) and at harvest, T_3 (soil + RP + FYM @ 10 t ha^{-1}) accumulated more P content in soybean showing statistically at par with T_2 (Soil + RP).

Table 1: Changes in total P concentration (mg kg^{-1}) in soybean grown in rock phosphate fertilized soil in presence or absence of organic manures and lime

Treatments	Days after sowing seeds			
	30	60	90	harvest
T_1	5749.49	4537.82	4688.86	5400.84
T_2	6671.56	5831.09	5733.17	6899.88
T_3	6907.71	6340.68	6009.57	7015.71
T_4	6451.24	6071.40	5817.18	6771.40
T_5	6606.28	5684.21	5602.61	5996.04
T_6	7169.32	6581.80	6483.89	6705.96
T_7	6320.69	5798.45	5549.65	5816.52
T_8	6769.48	5969.81	5619.09	6338.76
T_9	7208.04	6363.40	6194.12	6701.63
S.E.d(±)	151.19	134.88	130.02	147.45
$CD_{0.05}$	320.52	285.95	275.64	312.59

Dry matter yield

There was an increasing trend of dry matter yield up to 90th DAS with slight decline at harvest (Table 2). In general, comparatively higher dry matter yield of soybean was observed in soil treated with rock phosphate in presence or absence of organic manures and lime over the untreated control at different growth stages. Enhanced agronomic effectiveness of rock phosphate was reflected in increased dry matter yield (Kerra *et al.,* 1994) [10]. Critical examination of data revealed that comparatively higher dry matter yield of soybean was found in T_9 (soil + RP + VC @ 10 t ha^{-1} + lime) which is at par with T_7 (soil + RP + FYM @ 10 t ha^{-1} + lime) on 30th DAS. However, on 60th and 90th days T_9 was at par with T_8 (soil + RP + compost @ 10 t ha^{-1} + lime). Detail study of the data revealed that at harvest, T_9 (soil + RP + VC @ 10 t ha^{-1} + lime) show significantly higher dry matter yield which is followed by T_8 (soil + RP + compost @ 10 t ha^{-1} + lime). Application of rock phosphate and organic manures in presence of lime enhanced dry matter yield of soybean than the corresponding soil without lime.

Table 2: Dry matter yield (g $plant^{-1}$) of soybean fertilized with rock phosphate in presence or absence of organic manures and lime

Treatments	Days after sowing seeds			
	30	60	90	harvest
T_1	2.58	4.58	4.79	4.25
T_2	2.78	5.50	5.62	4.87
T_3	3.71	4.63	5.24	4.95
T_4	2.93	5.06	5.38	4.78
T_5	3.11	5.00	5.67	5.34
T_6	3.67	4.72	4.92	4.80
T_7	3.85	5.05	5.76	5.51
T_8	3.21	5.62	6.08	5.58
T_9	3.96	5.65	5.97	5.86
S.E.d(±)	0.07	0.12	0.12	0.11
$CD_{0.05}$	0.16	0.25	0.27	0.25

Conclusion

Irrespective of crop growth, significant increase in available P in soil, plant P concentration and dry matter yield of soybean was observed in rock phosphate fertilized soil in presence or absence of organic manures and lime over the control. Available P in soil and dry matter yield of soybean increase upto 30th and 90th DAS, respectively and decline till harvest in both the parameters. However, P concentration in soybean decline up to 90th DAS with slight increase at harvest with exception in untreated control. Among the different treatments, significantly higher available P content in soil was accumulated in T_9 (Soil + RP + VC @ 10 t ha^{-1} + lime) on 90th DAS and at harvest which was statistically at par with T_8 (Soil + RP + compost @ 10 t ha^{-1} + lime). While significantly higher P concentration in soybean was found in T_3 (soil + RP + FYM @ 10 t ha^{-1}) showing parity with T_2 (Soil + RP). Soil treated with T_9 (soil + RP + VC @ 10 t ha^{-1} + lime) recorded significantly higher dry matter yield than other treatments at the time of harvest. Effectiveness of rock phosphate as a P source for crop production is enhanced by the solubility effect of organic manures and lime application. Liming enhanced organic P mineralization thereby increasing P availability as well as dry matter yield.

References

1. Akande MO, Adediran JA, Oluwatoyinbo FI. Effects of rock phosphate amended with poultry manure on soil available P and yield of maize and cowpea. African Journal of Biotechnology. 2005; 4(5):444-448.
2. Aloud SS. Improving phosphorus availability from phosphate rock in calcareous soils by amending with: organic acid, sulfur, and/ or organic manure. Ozean Journal of Applied Sciences. 2011; 4(3):227-235.
3. Bhattacharya NG, Singh B. Transformation of applied phosphorus and its availability in acid soils. Two and a Bud. 1990; 37(1):24-30.
4. Condron LM, Tiessen H, Trasar-Cepeda C, Moir JO, Stewart JWB. Effects of liming on organic matter decomposition and phosphorus extractability in an acid humic Ranker soil from northwest Spain. Biology and Fertility of Soils. 1993; 15:279-284.
5. Das M, Singh BP, Ram M, Dwivedi BS, Prasad RN. Effect of phosphorus fertilizer amended organic manures on P nutrition of crops under mid altitude or Meghalaya. Annals agnc. Research. 1991; 12:134-141.
6. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley and Sons. Inc. London, UK, 1984.
7. Haynes, RJ. Effect of liming on phosphate availability in acid soils. A critical review, Plant and Soil. 1982; 68(3):289-308.
8. Jackson ML. Soil Chemical Analysis. Prentice Hall of India Pvt. Ltd. New Delhi, 1973.
9. Jokubauskaite J, Karcauskiene D, Antanaitis S, Mazvila J, Slepetiene A, Koncius D *et al*. The distribution of phosphorus forms and fractions in Retisol under different soil liming management. Zemdirbyste-Agriculture. 2015; 102(3):251-256.
10. Kerra TWD, Mnkeni PNS, Singh BR. Effects of added compost and farmyard manure on P release from Minjingu phosphate rock and its uptake by maize. Norwegian Journal of Agricultural Sciences. 1994; 8:13-23.
11. Laskar BK, De GK, Debnath NC, Basak RK. Phosphorus availability and transformation from Mussoorie rockphosphate in acid soils. Environmental and Ecology. 1990; 8:612-616.
12. Manimaran M. Dynamics of phosphorus in soil under the influence of inorganic phosphorus supply. International Journal of. Information Research and Review. 2014; 12:79-80.
13. Manjunath MN, Patil PL, Gali SK. Effect of organics amended rock phosphate and P solubilizer on P use efficiency of French bean in a Vertisol of Malaprabha Right Bank Command of Karnataka. Karnataka Journal of Agricultural Sciences. 2006; 19(1):36-39.
14. Onwonga RN, Lelei JJ, Macharia JK. Comparative effects of soil amendments on phosphorus use and agronomic efficiencies of two maize hybrids in acidic soils of Molo County, Kenya. American Journal of Experimental Agriculture. 2013; 3(4):939-958.
15. Setia RK, Sharma KN. Dynamics of forms of inorganic phosphorus during wheat growth in a continuous maize-wheat cropping system. Journal of Indian Society of Soil Science. 2007; 55:139-146.
16. Shoemaker HE, McLean EO, Pratt PF. Buffer methods for determining lime requirement of soils with appreciable amounts of extractable aluminium. Proceeding of Soil Science Society of America. 1961; 25:274-277.
17. Singh RN, Diwakar PS. Transformation of added phosphorus in some Alfisols and Vertisols. Journal Research. 2002; 14(2):159-164.
18. Trivedi BS, Bhatt PM, Patel JM, Gami RC. Increasing efficiency of fertilizer phosphorus through addition of organic amendments in groundnut. Journal of Indian Society of Soil Science. 1995; 43(4):627-629.
19. Wahid F, Sharif M, Khan MA, Ali A, Khattak AM, Saljoqi AR. Addition of rock phosphate to different organic fertilizer influences phosphorus uptake and wheat yield. Ciência e Técnica Vitivinícola Journal. 2015; 30 (3):90-100.
20. Wang CQ, Wei CM, Li TQ, Sun FQ. Effect of different zero tillage on the crop yield and soil property. Journal of Sichuan Agricultural University. 2001; 19(2):152-155.