IMPACT OF DISSOLVING AGENTS ON SOIL AVAILABILITY AND PLANT CONTENT OF PHOSPHORUS FROM EPPAWALA ROCK PHOSPHATE

S. Modshayini and P. Premanandarajah
Department of Agricultural Chemistry, Faculty of Agriculture, Eastern University, Sri Lanka
asmodsha1991@gmail.com

ABSTRACT: *Phosphorus deficiency is a major problem in tropical soil and it directly influence the productivity of crops. Sandy regosol is a major group of soil in Batticaloa District, Sri Lanka. Productivity of most legume crops limited in the sandy regosol due to the lack of the availability of phosphorus. Usually Phosphorus deficiency can be managed by using a proper phosphorus source in sandy regosol. Eppawala rock phosphate is a cheap and available source of phosphorus in Sri Lanka and due to its low solubility, it has been confirmed as a constrain of direct use to annual crops as a phosphate source and it was limited only to perennial crops. A study was conducted from July to September 2017 to increase the solublility of various rates of Eppawala rock phosphate to give 18kg P_2O_5/ha, 36kg P_2O_5/ha and 54kg P_2O_5/ha solely (control) and in combination with dissolving agents compost, sulphuric acid and triple super shosphate (TSP). These 12 treatments replicated three times in a Completely Randomized Design (CRD) in a factorial manner. Soil and plant phosphorus contents were recorded at 2 weeks interval upto harvesting. The data were statistically analyzed using SAS and difference between treatment means was compared using Duncan's Multiple Range Test (DMRT). Results revealed that the application of ERP with dissolving agents increased soil phosphorus content from 90.12mg/kg to 465.998 mg/kg (at eighth week). Among all applications 54kg P_2O_5/ha in the form of ERP with dissolving agent triple super phosphate proved to be the best to increase soil and plant phosphorus content. The results of this study suggested that incorporation of triple super phosphate and ERP could be used as effective way to increase the phosphorus availability in soil.*

Key words: Eppawala Rock Phosphate, Phosphorus content, dissolving agent

1. INTRODUCTION

Rock phosphate is one of the basic primary resource for phosphate fertilizer production. It is one of the complex fertilizer and most of them are low in solubility. The phosphorus deposit at Eppawala in Anuradhapura district was discovered and late mapped by geological survery in 1971 (Hewawasam ,20 13). The eppawala rock phosphates are characterised by low silica (≤0.41%), high phosphorous (≤10.58%) and high strontium content (2,960–6,819 ppm) (Pitawala et al,2003)**.** The Dushyantha et al. (2017) reported the respective phosphate content of eppawala rock phosphate, average concentrations of P_2O_5, cao and K_2O in downstream lake were respectively 0.80%, 0.44% and 0.25%. In upstream lake sediments, the respective values were 0.45%, 0.26% and 0.12%. Methods used to dissolve rock phosphate partial acidulation with Inorganic acids, amendment with organic matter and blending with water soluble fertilizers. In recent years, attempts have been made to increase the phosphorus availability of natural rock phosphate by using organic manure (Deshpande, 2015). The evolution of CO_2 and production of organic acid during the organic matter decomposition will dissolve some of the rock phosphate and increase its phosphorus availability therefore phosphorus concentration in the vicinity of decomposable organic matter is likely to be higher than in the rest of the soil (Hosseini et al, 2010). Triple super phosphate was one of the first high analysis phosphate fertilizer, that became widely used in the 20th century. One possible way to improve the solubility of phosphate rock is by co-composting it with organic substances Four variants of composts were made in a biomass composting bioreactor. Speir et al. (2004) reported that samples grown the field trial, soil total C, N, P and Olsen phosphorus were increased markedly with increasing the compost application rate. Rock phosphate with compost recorded lower olsen phosphorus at the initial period of incubation study than di ammonium phosphate, but improved significantly with the progress of time. Products of the metabolism of microorganisms which decompose organic matter break down phosphate, releasing plant available phosphate compounds in soil (Korzeniowskaor et al,2013). The sulphuric acid plays a major role in the solubility of rock phosphate. Sulphuric acid converts the P_2O_5 into soluble form of phosphorus such as single super phosphate(SSP) by the acidulation with apatite. (Matiullah khan &Shahid Ahmad,2012). Sandy regosols is one of the major soil groups in Batticaloa district and cowpea is cultivated over a wide area. Legumes are phosphorus loving plants, they require phosphorus for growth and seed development. Selection of cowpea lines that produce good yield under low soil phosphorus or those with high phosphorus use efficiency can be a low input approach to solving this problem (Nkaa et al., 2014).

2. METHODOLOGY

This study was conducted from July to September 2017 to investigate the effect of various rates of eppawala rock phosphate to give 18kg P_2O_5/ha, 36kg P_2O_5/ha and 54kg P_2O_5/ha solely (control) and in combination with dissolving agents compost, Sulphuric acid and triple super phosphate (TSP). These 12 treatments replicated three times in a Completely Randomized Design (CRD) in a factorial manner. Both soil and compost were analyzed for Initial phosphorus content using borax extraction method (Murphy and Riley,1962). The soil used for this experiment was sandy regosol soil (Sand 91.8 %, Silt 4.9 % and Clay 3.3 %) having a pH of 6.43, porosity- 44.7%, bulk density -1.46 gcm^{-3} and initial phosphorus content 90.12mg/kg.

A bulk soil sample was collected. It was processed and air dried and sieved by using 2mm mesh sieve, for homogeneity. Each polyethylene bag was filled with eight (8) Kg of processed soil. Then they were properly labelled and arranged according to the design. According to the treatment combinations of phosphorus source and dissolving agents were incorporated with soil in each bag at the recommended rate. Details of the treatments given are described below,

Table1. Details of Treatments

Treatment	Details
T1	Compost (1ton/ha) + ERP (50kg/ha)
T2	Compost (1ton/ha) +ERP (100kg/ha)
T3	Compost (1ton/ha) +ERP (150 kg/ha)
T4	Sulphuric acid (60lit/100kg) +ERP (50kg/ha)
T5	Sulphuric acid (60lit/100kg) +ERP (100kg/ha)
T6	Sulphuric acid (60lit/100kg) +ERP (150 kg/ha)
T7	TSP (100kg/ha) + ERP (50kg/ha)
T8	TSP (100Kg/ha) +ERP (100kg/ha)
T9	TSP (100Kg/ha) +ERP (150 kg/ha)
T10	ERP (50kg/ha). (control)
T11	ERP (100kg/ha). (control)
T12	ERP (150 kg/ha). (control)

Cowpea seeds (waruni variety) were planted in pots and agronomic and cultural practices were practiced according to the recommendation by the Department of the Agriculture.

2.1 Quantitative Approach

a. Soil Phosphorus Content

Soil sample from each treatment was collected at 2 weeks interval and its phosphorus content was analyzed.

b. Plant Phosphorus Content

Plants were uprooted at harvesting and its phosphorus content was analyzed

The data from experimental pots were statistically analyzed using Analysis of Variance (ANOVA) to detect the significance if any at treatment level. The difference between treatment means was compared using Duncan's Multiple Range Test (DMRT).

3. DISCUSSION AND RESULTS

1. Effects of eppawala rock phosphate with dissolving agents on soil phosphorus availability.

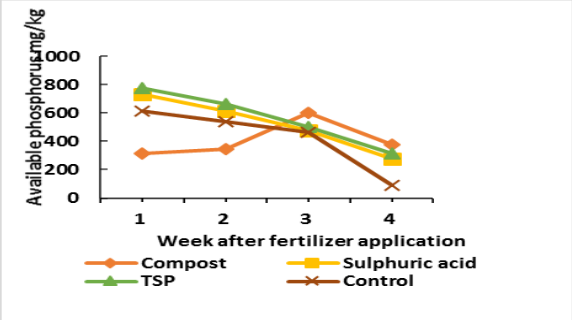

Figure :1 Periodical Changes in Available Phosphorus Content in Soil in 50kg/ha ERP ($18kgP_2O_5/ha$) Rate with Dissolving Agent Combinations

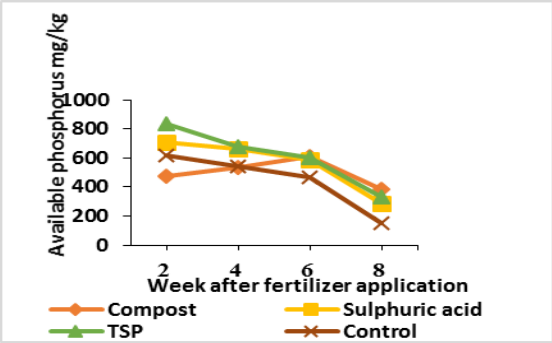

Figure :2 Periodical Changes in Available Phosphorus Content in Soil in 100kg/ha ERP (36kg P_2O_5/ha) Rate with Dissolving Agent Combinations

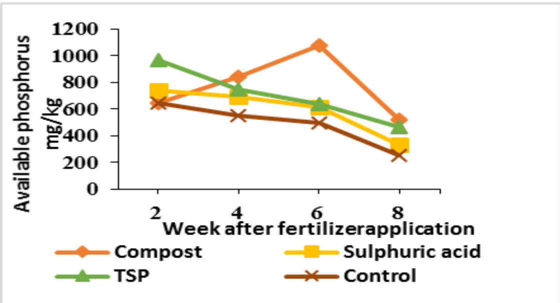

Figure :3 Periodical Changes in Available Phosphorus Content in Soil in 150kg/ha ERP (54kg P_2O_5/ha) Rate with Dissolving Agent Combinations

The break through curves obtained at two weeks interval regarding phosphorus availability in soil for eppawala rock phosphate application rates with dissolving agent is shown in figure: 1, 2 & 3. The available phosphorus content was higher at 2 weeks after fertilizer application in the combinations receiving triple super phosphate and sulphuric acid at all three rates of eppawala rock phosphate application.

It might be due to the immediate effect of sulphuric acid on enhancement of the solubility of eppawala rock phosphate and thereby it may be converted into easily available form. Khan et al. (2012) reported that the application of sulphuric acid at the rate 60L/100kg with the 50% of dilution can yield better kind of single super phosphate from Hazara rock phosphate and Straaten (2002), reported that sulphuric acid was used to produce the single super phosphate fertilizer from the rock phosphates. It may be the reason for the increase of phosphorus content in soil solution.

Triple super phosphate also one of the easily soluble phosphatic fertilizer therefore it may also release additional amount of phosphorus in to the soil solution. Kulasinghe et al. (2013) supported the result that the soil only treated with triple super phosphate supplied sufficient phosphorus to soil than other treatments in calcareous soil. It might increase the phosphorus content in soil at initial condition (after 2weeks of fertilizer application). Ayodele & Oso (2014) illustrated that the triple super phosphate fertilizer contains mainly water-soluble form of phosphorus, being 95-98% in readily available form.

The available phosphorus content was increased and reached to a peak at the 6weeks after fertilizer application in the compost combination at all the rate of eppawala rock phosphate. It may be due to the decomposition and release of available nutrients and organic acids by the compost. Yadav et al. (2017), reported a maximum soluble phosphorus content in combination of rock phosphorus and compost. But due to the slow solubility of the compost with eppawala rock phosphate the release may be at the latter stage. Kulasinghe et al. (2013) supported the slow release of organic phosphorus during the decomposition of organic matter in the coconut palm. Solubility of ground phosphate rock was increased resulting from co-composting with organic substances, (Korzeniowska et al, 2013).Which may be due to the increase in the bioavailability of phosphorus.

There was a sudden reduction in soil phosphorus content during 6weeks to 8 weeks after fertilizer application. It might be due to peak losses of phosphorus from soil. This result was supported by Haruna (2011). The lowest soil phosphorus content was recorded at 8weeks after fertilizer application. It might be due to the fixation of the available phosphorus with soil particle and was change as unavailable form (Srinivasamurthy,2014). Among the treatments, 54kg P_2O_5/ha eppawala rock phosphate rate was received the highest phosphorus content and was followed by 36kgp_2o_5/ha, 18kgp_2o_5/ha. This indicated that the significant influence of rate of application on phosphorus availability. The phosphorus availability in soil may get increase with increasing rate of eppawala rock phosphate application. Changes in the values of the phosphorus fractions in soils were affected significantly by phosphorus source and rate of application (Akintokun, 2001).

2. Effect of eppawala rock phosphate application and dissolving agents on phosphorus content in cowpea plant at harvest (P %) was significantly influenced by dissolving agent with eppawala rock phosphate as p value is less than 0.05.

Table 2. Effect of ERP and dissolving agents on phosphorus content in cowpea plant (P %) at harvest.

The values are means of replicates ± standard error

Treatment	Rate of ERP		
	18kg P_2O_5/ha	**36kg P_2O_5 /ha**	**54kg P_2O_5 /ha**
Compost	0.194 ± 0.558^a	0.214 ± 0.873^a	0.249± 0.581^a
Sulphuric acid	0.198 ± 0.918^a	0.227± 0.349^a	0.271 ± 0.218^a
Triple superphosphate (TSP)	0.205 ± 0.833^a	0.234 ± 0.530^a	0.306 ± 0.481^b
Control	0.159± 1.740^a	0.187 ± 0.486^a	0.245 ± 0.916^a
	Dissolving agent	$P<0.05$	
	ERP	$P<0.05$	
	Interaction	$P>0.05$	

Means with the same letter(s) are not significantly different from each other according to the Duncan multiple range test at 5% significant level.

Here 50kg/ha,100kg/ha and 150kg/ha rate of ERP contain 18kg P_2O_5 /ha,36kg P_2O_5 /ha and 54kg P_2O_5 /ha respectively.

The results (Table 2) pertaining to phosphorus content in plant at the harvest stage indicated that there was a significant influence of eppawala rock phosphate rate on phosphorus content in plant. Among the treatments, 54 kg P_2O_5 /ha eppawala rock phosphate rate recorded highest value and was followed by 36kg P_2O_5 /ha. It may increase the plant uptake phosphorus content with increased the phosphorus source application rate. But there is no highly significant influence of eppawala rock phosphate rate on the phosphorus content in plant. It may be due to the phosphorus uptake ability was limited to the particular plant species. Among the treatments, triple super phosphate combination recorded the highest value. It may be due to phosphorus content was high in the soil solution as a plant available form. Ghosal & Chakraborty (2012) reported that triple super phosphate was a one of the phosphatic fertilizer in highly soluble form and easily released the phosphorus into soil solution. The relative efficiency of phosphorus sources fertilizers content as a high degree of water soluble phosphorus encourages early season growth in small cereals (Ali et al, 2015).

Among the treatments second highest value was in the sulphuric acid and was followed by compost. It may be the higher soluble phosphorus in the sulphuric acid than the compost. It may be the due to the acidulation reaction of sulphuric acid with eppawala rock phosphate and convert into plant available form. Hammond et al. (1986) reported that a proportion of sulphuric acid was used in partial acidulation of phosphate rocks (PAPR) by the acidulation. This technology provides a portion of the phosphorus in a readily available form. Phosphorus uptake was increased with soluble/easily available form in soil solution until reach the crop demand for the phosphorus. But cowpea plants are phosphorus loving plants (Sanginga et al, 2000). Ahlawat et al. (1999) reported that phosphorus is needed in relatively large amounts by legumes for growth.

There is no highly significant influence of dissolving agents on phosphorus content in plant. It may be due to the phosphorus uptake ability was limited to the plant species.

But comparatively the result was obtained in the soil phosphorus content in this study in high range of value than the plant phosphorus content value. Phosphorus content in cowpea plant was in this range 0.306-0.159% depend on table 2 value. The plant might be responsible to the plant available phosphorus form within the particular range.

Havlin et al, 2005 reported that phosphorus concentration in plants ranges between 0.1-0.5% and plants also absorb soluble, low molecular weight organic phosphorus compounds and Akande et al. (2005) stated percentage concentrations of phosphorus in maize and cowpea leaves sampled after treatment, Significant differences were observed in phosphorus content in the leaves for both crops as 0.18–0.36% and 0.15–0.28% respectively.

4. CONCLUSION

Highest phosphorus content in soil and plant was recorded in the combination of 54kg P_2O_5/ha (ERP) with triple super phosphate. But in soil, combination of 54kg P_2O_5/ha (ERP) with compost treatment phosphorus content was reached maximum at 6 weeks after fertilizer application. Among them highest was in compost with 54kg P_2O_5/ha (ERP).

REFERENCES

Ahlawat, P.S. and Kashturikrishna,S. (1999).Growth and yield response of pea (Pisum sativum) to moisture stress, phosphorus, sulphur and zink fertilizers. Indian Journal of Agronomy, 44: 588-596.

Akande, M.O., Adediran, J.A. and Oluwatoyinbo, F.I. (2005). Effects of rock phosphate amended with poultry manure on soil available P and yield of maize and cowpea. African Journal of Biotechnology. 4(5): 444-448.

Akintokun, O.O., Adetunj, M.T., and Akintokun, P.O. (2001). Phosphorus availability to soybean from an indigenous phosphate rock sample in soils from southwest Nigeria, Nutrient Cycling in Agroecosystems, 65, 35–41.

Alil, M., Ali, L., Din, M.U., Sattar,M.,Waqar,M.Q.,Ali,M.A.,Khalid,L.(2015).Compara tivePerformance of Wheat in Response to Different Phosphatic Fertilizers. International Journal of Research in Agriculture and Forestry, 2: 1-9.

Ayodele, O.J., andOso, A.A. (2014). Cowpea responses to phosphorus fertilizer application at Ado-Ekiti, south-west Nigeria, Journal of Applied Science of Agriculture, 9, 485–489.

Deshpande, A.N., Dalavi, S.S., Pandey, S.H., Bhalerao, V.P., and Gosavi, A.B. (2015). Effect of Rock Phosphate along with Organic Manures on Soil Properties, Yield and Nutrient Uptake by Wheat and Chickpea, Journal of the Indian Society of Soil Science, 63, 93-99.

Edwards, T., Withers, P., Bradley, R.S., and Jones, J. (2015). Research Review No. 83: Routes to improving the efficiency of phosphorus use in arable crop production, Agriculture and Horticulture Development Board(AHDB).

Ghosal, P.K., Chakraborty, T. (2012). Comparative Solubility Study of Four Phosphatic Fertilizersin Different Solvents and the Effect of Soil. Agricultural and Ecological Research Unit,Indian Statistical Institute, Kolkata, 700108, India, 2: 175-179.

Hammond, L.L., Chien, S. H. and Mokwunye, A.U. (1986). “Agronomic value of unacidulated and partially acidulated phosphate rocks indigenous to the tropics”.Advances in Agronomy, **40:**.89-140.

Haruna, I.M., and Aliyu, L. (2011). Yield and economic returns of sesame (Sesamuindicum.L.) as influenced by poultry manure, nitrogen and phosphorus at Samaru, Nigeria, American-Eurasian Journal of Agricultural and Environmental Sciences,10, 561-568.

Havlin, J.L.,Beaton,J.D.,Tisdale,S.L.andNelson,W.L.(2005).Soil Fertility and Fertiliz ers. edited by Ghosh,A.K, Prentice Hall of Indian,New Delhi (7th Edi., 161).

Hewawasam, T. (2013). Tropical weathering of apatite-bearing rocks of Sri Lanka: major element behaviour and mineralogical changes, Journal of Geological Society of Sri Lanka, 15,31-46.

Hosseini, M.H., Khayami, S., Besharati, H.,and Bybordi, S. (2010). Study of the effects of rock phosphate application with phosphate solublizing Bacteria on P availability for corn,19th World Congress of Soil Science.

Khan, M., Ahmad, S., Sharif, M., and Aslam, M. (2012). Formulation of Single Super Phosphatefertilizer from rock phosphate of Hazara,Pakistan, Academic Journal Soil & Environment, 31, 96.

Korzeniowskaor, J., Glubiak, E.S., Hoffmann, J., Gorecka, H., Jozwiak, W., and Wisniewska, G. (2013). of the solubility of rock phosphate by co-composting it with organic components, Polish Journal of chemical Technology, 15, 10 -14.

Kulasinghe, K.P.N., Wijebandara, D.M.D.I., Nugawela, A., and Fernandopulle, M.N.D. (2013). Performance of Eppawala Rock Phosphate with Organic Manure as a Phosphate Source for Adult Coconut Palms in Dry Zone (DL3), Department of Plantation Management, Faculty of Plantation Management,Wayamba University of Sri Lanka, Makandura, Gonawila (NWP), 180-184.

Murphy, J., Riley, J.P. (1962). A modified single solution method for the determination of phosphate in natural waters, Anal Chim Acta, 27,31–36.

Nkaa, F.A.l., Nwokeocha, O.W., Ihuoma, O. (2014). Effect of Phosphorus fertilizer on growth and yield of cowpea (Vigna unguiculata). IOSR Journal of Pharmacy.

Pitawala, A., Schidlowski, M., Dahanayake, K., and Hofmeister, W.(2003). Geochemical and petrological characteristics of Eppawala phosphate deposits, Sri Lanka, Mineralium Deposita, 38, 505-515.

Sanginga, N. L.O. and Singh,B.B. (2000).Phosphorus use efficiency and nitrogen balance of cowpea breeding lines in low P soil of the derived savanna zone in West Africa,pp119–128.

Speir, T.W., Horswell, J., Schaik, A.P.V., McLaren, R.G., and Fietje, G. (2004). Composted bio solids enhance fertility of a sandy loam soil under dairy pasture, Biology and Fertility of Soils, 40,349–358.

Srinivasamurthy, R., and Dayamani, K.J. (2014). Influence of Mineral Phosphate SolubilizingGram-Positive Bacteria on growth and yield of cowpea (vigna ungucuilata), International Journal of Scientific and Research Publications, 4(8), 2250-3153.

Straaten, P.V. (2002). Rocks for crops:Agrominerals of sub-Saharan Africa, ICRAF, Nairobi, Resources, 5, 2252-5211.

Yadav, H., Fatima, R., Sharma, A., and Mathur, S. (2017). Enhancement of applicability of rockphosphate in alkaline soils by organic compost.Elsevier, Applied Soil Ecology , 113, 80-85.

Abbreviations

ERP-Eppawala Rock Phosphate, TSP-Triple Super Phosphate