Review Article

Phosphorus fractions in soil: A review

Abstract

The different nutrient element in soil are exist in different fractions in the soil. The available form of nutrients is responsible for the change in yield of crop significantly. The availability of different pools involves not only their physico-chemical nature but also the ability of the plant to forage them with plant root system. In Indian soil total phosphorus ranges from 100 to 2000 ppm but the available phosphorus ranges from 2 to 20 ppm. The forms of phosphorus present in soil *viz.* organic and inorganic. The inorganic form of phosphorus constitute about 30-35 per cent of total phosphorus. The inorganic P consist of different pool such as aluminum, iron and calcium bound phosphorus constitutes active form of inorganic P. The reductant-soluble and occluded forms of phosphorus are relatively less active. Different types of phosphorus are interrelated and add to the pool of plant-accessible P as per their physical and chemical properties such as surface area, composition and solubility.

Keywords: Phosphorus, fractions, soils.

Introduction

Soils having widely ability to supply phosphorus to plants. The total phosphorus in which only small fractions is available to the plants. The forms in which the availability depends on various factors as applied nutrients through fertilizers, method of application, soil pH, moisture, texture and content of lime. Phosphorus present in soil is classified into the four gatherings *viz.* Phosphorus in soil solutions, adsorbed phosphorus on inorganic surface of soil, crystalline minerals phosphorus and phosphorus bound with organic matter (Barber 1984). The common soil phosphate minerals given in table 1.

The knowledge of the total content of phosphorus as well as its fractions in soil can also aid the identification of a eutrophication threat in the environment (Esteller et al. 2009) because each fraction of this element is different with regard to its potential mobilisation and circulation in nature (Pakuła and Kalembasa 2008). The distribution and amount of phosphorus in soils should provide the consideration of the requirements of phosphorus for different crops. The different fractions of phosphorus is varied due to hereditary contrasts among soils (Chang and Jackson, 1958; Bapat *et al.*, 1965). The factors such as organic matter, sesqui-oxides and calcium carbonate affect the distribution of different pools of phosphorus in soil (Mishra and Ojha, 1969).

The different forms of calcium, aluminium and iron phosphates in which decreased order of phosphorus availability as Ca-P>Al-P>Fe-P (Basu and Mukharjee, 1969). Availability of phosphorus in soil solution is less than 0.1 ppm except in heavily fertilized and sodic soil. The major contributor of plant available phosphorus under moist soil are Fe-P and Al-P fractions. The Ca-P is most abundant fraction of phosphorus in alkaline or basic soils and Al-P or Fe-P are in acidic soils. The Al-P was found to be most important fraction of available phosphorus, followed by residual phosphorus and saloid bound phosphorus (Agrawal *et al.,* 1987; Subramanian and Kumaraswamy, 1989) The inorganic phosphorus fractions have integrated effect on available phosphorus of soil (Doharey *et al.*, 1980).

The total phosphorus content in soil is poorly correlated with available phosphorus, so total phosphorus would not be used to evaluate soils phosphorus fertility status (Patel *et al.* (1994). The residual phosphorus fraction would be major contributor for replenishing fractions of available phosphorus (Koria *et al.* 2000).

The total p were observed maximum in soil developed from parent material as gneiss, granite followed by shale, lime stone and quartzite (Tiwari, 2002). The flow diagram of different forms of soil phosphorus is given in Fig. 1.

Factor affecting on availability of phosphorus in soils

The different factors such as soil pH, content of organic matter, calcium carbonate content, nature and amount of clay, heavy metallic ions, soil moisture, fertilizer application and cropping pattern govern the nutrient supplying capacity of the soil. In addition to phosphorus organic manuring and inorganic fertilization, incorporation of legumes in the cropping system also increased the status of available phodphorus in soil (Singh and Singh, 1969 and Singh and Faroda, 1987). The availability of phosphorus is increased by addition of inorganic phosphatic fertilizers and pyrites in soil in which the fertilizer P was transformed into calcium phosphorus (Tomar *et al.* 1987). The addition of FYM either alone or in combination with phosphorus in soil was found to enhance the available phosphorus status in soil. (Singh *et al.*, 1983; Bhriguvanshi, 1988; Havanagi and Mann, 1970; Mandal and Mandal, 1973). Phosphorus availability depends on many of the properties of soil. The universal has to be found that the addition of phosphorus through different sources increases the availability of phosphorus in soil (Sharma and Meelu, 1975; Anand Swarup and Ghosh, 1979). The available phosphorus in soil was decreases, if addition of nitrogen alone (Bajwa and Paul, 1978). The increased rate of phosphorus application has resulted to increase the status of available phosphorus in soil. (Singh and Balasubramanian, 1983; Campbell *et al.*, 1984; Rao *et al.*, 1984; Patel *et al.*, 1989)

Kalbasi and Karthikeyan (2004) concluded that application of neutral and mineral fertilizers to slightly acidic soils for several years resulted in phosphorus being accumulated mainly in compounds with aluminium. Incorporation of green manures and crop residues were positive effect on the available phosphorus status (Badanur *et al.*, 1990). Tiwari *et al*. (2002) and Vats *et al.* (2001) found that improvement of available status of phosphorus was significant under 100% NPK in combination with organic matter treatment, organic manure increasing the available phosphorus in soil through cations like Ca^{2+}, Mg^{2+}, Fe^{3+} and Al^{3+} and this cations are helpful for phosphorus fixation. The three types of phosphatic fertilizers used in the agriculture are water soluble, citric acid soluble and water and citric acid insoluble phosphatic fertilizers (Barreto *et al.* 2018). The single super phosphate, double super phosphate and triple super phosphate are most soluble source of phosphorus in soil and provide highest efficiency to the crops than the other sources.

Status of phosphorus in soils

The 0.28 % of phosphorus was reported in lithosphere (Clarke, 1920), which is comparatively higher than the soils of India. The content of total phosphorus in the soils of India are in range 0.01 to 0.2 percent (Tandon 1987). The concentration of phosphorus and its uptake depends on lime content, which were to be increased the phosphorus content also increased (Sutaria and Patel, 1987). This occurred in groundnut act as legume which retains high calcium in doing as such same part of Ca may be disintegrated from sparingly dissolvable calcium phosphates. The total organic phosphorus content in Gujarat state ranges between 15 to 164, 16 to 107, 18 to 92 ppm and 7 to 90 for medium black, deep black, alluvial (sandy loam) and alluvial (sandy) soils, respectively (Kanzaria, 1970).

The fertility status of 220 soil samples, available P_2O_5 were varied from 2.21 to 85.7 with an average value of 28.6 kg ha^{-1} (Rajput and Polara, 2012). Gajare *et al.* (2013) collected 140 soil samples from the Latur district during 2009-10 and found that available P_2O_5 were 0.2 to 21.15 kg ha^{-1} with mean value of 7.42 kg ha^{-1}.

Forms of phosphorus in soils

The constitute of Ca-P in calcareous soils was 40-50% or even more of total phosphorus depending up on the native lime content and available phosphorus of the soil (Savani, 1981). Agarwal *et al.* (1987); Subramanian and Kumaraswamy (1989) and

Udayasoorian and Sree Ramulu (1991) reported the phosphorus pools in calcareous and neutral soils, Al-P, Ca-P and Fe-P would be the dominant fraction. The lime application expanded obviously the Al-P (100.1%), trailed by Ca-P (68.5 %), Fe-P (39.3 %), natural P (36.2 %) and Saloid-P (25.6 %) (Sood and Bhardwaj, 1992). The impact of phosphorus application was increasingly articulated in natural and all out phosphorus develop than that of lime application. The effect of phosphorus application was more pronounced in organic and total phosphorus build up than that of lime application. Increased the activities of different fractions of phosphorus due to increasing levels of phosphorus (Santhy, 1995). Tarafdar *et al.* (2006) stated that the status of available phosphorus was less in arid soil (0.3-0.9 % of total P).

The $NaHCO_3$ extractable fraction of P reported maximum phosphorus (46.3-59.6 % of total P) trailed by HCl extractable portions (24.4-41.2 % of total P). The extensive decrease in water dissolvable P, $NaHCO_3$-P and HCl extractable-P was seen because of contrasts in vegetation. The Al-P fraction of phosphorus was higher than Fe-P fraction. The average content of Ca-P, Al-P, Fe-P and Saloid-P were 243, 20.0, 5.3 and 2.9 mg Kg^{-1}, respectively (Singh and Sharma, 2007). The secondary phosphorus minerals including aluminum (Al), calcium (Ca), and iron (Fe) phosphates vary in their dissolution rates, depending on soil pH and size of mineral particles (Pierzynski *et al.*, 2005; Oelkers and Valsami-Jones, 2008).

Depletion and increase of, phosphorus under intensive cropping

The phosphorus evacuation by yield is negligible when contrasted with other two essential supplements and subsequently the centralization of all out p was expanded because of constant expansion of phosphatic composts in soil (Jones and Ruckman, 1973; Ryan and Zahard, 1980). The Fe-P and Ca-P were converted to Saloid-P and Al-P after harvesting of wheat due to exudation of HCO_3^- and H^+ by roots of wheat, which useful for conversion of Fe-P and Ca-P to Saloid-P and Al-P. (Jain and Sarkar, 1979). The improvement of total phosphorus was significant when phosphorus fertilizers were applied with combination of FYM (Rahate *et al.*, 1979). Dhillon and Dev (1988) found that in a calcareous soil, the low phosphorus soils, the Saloid-P improved on cropping and depleted in high phosphorus soils. The content of Saloid-P was brought down after *Kharif* crops such as maize, rice and pearl millet and enhanced developing *rabi* crop as wheat. Iron-P was drained because of rice however improved after maize and pearl millet. The Ca-P kept on diminishing because of developing of these yields and the decay was more in rice-wheat system. Tomar *et al.* (1987)

reported that without excrement a noteworthy part of the manure P was changed into Ca-P and pre-hatching of phosphatic composts with cows fertilizer and pyrites expanded the accessibility of P.

Tripathi and Minhas (1991) found that phosphorus transformation occurred due to addition of FYM. While expansion of larger amounts of N effectively affected P (Upadhyay *et al.*, 1991). Dakhore *et al.* (1993) explored that under unmanured cultivating, the inorganic P forms consumption in the order as: Saloid-P > Al-P > Fe-P > Ca-P in sandy mud *Entisol*. The both the forms of phosphorus are improved by reduced the application of nitrogen and potassium in soil. Gupta *et al.* (1999) examined that use of P alone and in blend with FYM extended the total phosphorus content and distinctive phosphorus pools. The expansion of FYM beneficially affected grain and straw yields and content and uptake of phosphorus (Saha *et al.* 2000).

The use of phosphorus (17.5 or 135 Kg P ha-1) improved all the pools of phosphorus, independent of various phases of development, while 120 and 180 kg nitrogen ha-1 and 0 and 33.2 kg potassium ha-1 caused exhaustion of phosphorus pools (Setia and Sharma, 2007). Shabir and Narinder (2009) reported that the treatment of 100 % RDF of NPK + PSB+ Vermicompost + Zinc improved available P from 13.0 to 19.1 Kg ha^{-1}.

Conclusion:

In soils, mainly two forms of phosphorus present as organic and inorganic forms, the inorganic forms of phosphorus are bound with iron (Fe-P), aluminum (Al-P) calcium (Ca-P) and phosphate as $H_2PO_4^-$, HPO_4^{-2} and PO_4^{-3}, and in soil solution and constitutes the major forms of inorganic phosphorus. The occluded and inositol phosphate are less active forms of inorganic phosphorus. In all soils, exist all forms of phosphorus but in acid soils the more abundant form are Al-P and Fe-P (8-10 % of total P), whiles Ca-P dominates in calcareous soils. The organic form comprises with inositol phosphate esters.

References

Agarwal, S.; Singh, T. A. and Bhardwaj, V. 1987. Inorganic soil phosphorus fractions and available phosphorus as affected by long-term fertilization and cropping pattern in Nainital Tarai. *Journal of the Indian Society of Soil Science*, **35**: 25-28.

Agarwal, S.; Singh, T. A. and Bhardwaj, V. 1987. Inorganic soil phosphorus fractions and available phosphorus as affected by long-term fertilization and cropping pattern in Nainital Tarai. *Journal of the Indian Society of Soil Science*, **35**: 25-28.

Anand Swarup and Ghosh, A. B. 1979. Effect of intensive fertilizers use based on soil test on the available phosphorus status of soil. In: Phosphorus in Soil, Crops and Fertilizers.

Badanur, T. P.; Poleshi, C. M. and Naik Balachandra K. 1990. Effect of organic matter on crop yield and physical and chemical properties of a *Vertisol*. *Journal of the Indian Society of Soil Science*, **38:** 426-429.

Bajwa, M. S. and Paul, J. 1978. Effect of continuous application of N, P, K and Zn on yield and nutrient uptake of irrigated wheat and maize and on available nutrients in a tropical arid brown soil. *Journal of the Indian Society of Soil Science,* **26:** 160-165.

Bapat, M. V.; Padole, G. C.; Totey N. G. and Badekar, V. G. 1965. Forms of phosphorus in vidarbha soils. *Journal of the Indian Society of Soil Science,* **13:** 31-36.

Barber, S. A. 1984. *Soil Nutrient Bioavailability: A Mechanistic Approach*, Wiley Inter science, John Wiley and Sons, New York, USA.

Barreto, M.S.C.; Mattiello, E.M.; Santos, W.O.; Melo, L.C.A.; Vergütz, L.; Novais, R.F. 2018. Agronomic efficiency of phosphate fertilizers produced by the re-use of a metallurgical acid residue. Journal Environment Management, **208**: 1–7

Basu, S. N. and Mukharjee, S. K. 1969. Phosphorus availability from different forms of iron, alluminium and calcium phosphate. *Journal of the Indian Society of Soil Science,* **17:** 391-399.

Campbell, C. A.; Read, D. W. L.; Winkleman and Andrew, D. W. Mc. 1984. Frist 12 years of a long term rotation study in south Western Saskatchewan- Bicarbonate- P distribution in soil and P uptake by the plant. *Canadian Journal Soil Science,* **4:** 125-137.

Chang, S. C. and Jackson, M. L. 1958. Soil phosphorus fractions in some representative soils. *Journal of Soil Science*, **9:** 109-119.

Clarke, P. W. 1920. *Data of Geochemistry*. U.S. Geol. Survey Bulletin 695

Dakhore, A. K.; Nayak, P.; Katyal, V.; Sagar, R. L. and Mandal, A. K. 1980. Relation of inorganic P fractions with soil available P, yield and P uptake by Jute (*Corchorus Ccapsularis* L.). *Journal of the Indian Society of Soil Science*, **28:** 110-112.

Dillon, N. S. and Dev, G. 1988. Transformation of soil inorganic P fractions under various crop rotations. *Journal of the Indian Society of Soil Science,* **36**: 709-313.

Doharey, A. K.; Nayak, P.; Katyal, V.; Sagar, R. L. and Mandal, A. K. 1980. Relation of inorganic P fractions with soil available P, yield and P uptake by Jute (*Corchorus Ccapsularis* L.). *Journal of the Indian Society of Soil Science*, **28:** 110-112.

Esteller, M.V., Martinez-Valdes H., Garrido, S., and Uribe, Q. 2009. Nitrate and phosphate leaching in a Phaeozem soil treated with biosolids. Composted biosolids and inorganic fertilizers. *Waste Management*, **29**:1936–1944

Gajare, A. S.; Dhawan, A. S.; Ghodke, S. K. And Bhor S. D. 2013. Available sulphur and Phosphorus status of soybean growing soils of Latur district, *An Asian Journal of Soil Science,* **8:**94-97.

Gupta, J. P.; Khanna, Y. P.; Surishta Devi and Devi, S. 1999. Effect of phosphorus and farmyard manure on changes in phosphorus fractions in a rice soil. *Madras Agriculture Journal,* **86:** 359-362.

Gupta, J. P.; Khanna, Y. P.; Surishta Devi and Devi, S. 1999. Effect of phosphorus and farmyard manure on changes in phosphorus fractions in a rice soil. *Madras Agriculture Journal,* **86:** 359-362.

Havanagi, G. V. and Mann, H. S. 1970. Effect of rotations and continuous applications of manures and fertilizers on soil properties under dry farming conditions. *Journal of the Indian Society of Soil Science,* **18:** 45-47.

Jain, J. M. and Sarkar, M. C. 1979. Transformation of inorganic phosphorus under field conditions and its effect on P uptake and grain yield of wheat. *Bulletin of the Indian society of Soil Science,* **12:** 460-464.

Jones, M. B. and Ruckman, J. E. 1973. Long-term effect of phosphorus, sulfur and molybdenum on a subterranean clover pasture. *Soil Science,* **155:** 343-348

Kanzaria, M. V. 1970. Soils of Gujarat. *Fertilizer News,* **15:** 56

Kalbasi, M. and Karthikeyan, K.G. 2004. Phosphorus dynamics in soils response to dairy manure and inorganic fertilizer applications. *Soil Science,* **161**:436–443.

Koria, R. G.; Patil, R. G.; Gundalia, J. D. and Patel M. S. 2000. Phosphorus Fractions and their distribution in the profiles of dry farming research station in Saurashtra. *Journal of Gujarat Society of Agronomy and Soil Science,* **3:** 1-6.

Kumaraswamy, K. 1989. Relative contributions of inorganic P fractions to the labile P status of soils and uptake by rice. *Journal of Indian Society of Soil Science*, **39:** 308-315.

Mandal, L. N. and Mandal, K. C. 1973. Influence of organic matter and lime on the transformation of applied phosphate in acidic lowland rice soils. *Journal of the Indian Society of Soil Science,* **21**: 57-62.

Mishra, S. G. and Ojha, S. K. 1969. P distribution in black and red soils of U.P. *Madras agriculture Journal*, **56:** 455-462.

Nunes, R.S., De Sousa, DMG., Goedert, W.J., De Oliveira, L.E.Z., Pavinato, P.S and Pinheiro, T.D. 2020. Distribution of Soil Phosphorus Fractions as a Function of Long-Term Soil Tillage and Phosphate Fertilization Management. *Fronties in Earth Science,* 8:350

Oelkers EH, Valsami-Jones E (2008) Phosphate mineral reactivity and global sustainability. Elements **4**: 83–87.

Patel, M. L.; Gani, R. C.; Patel, P. V.; Patel, N. K. and Patel, H. C. 1989. Balance of total nitrogen, available phosphorus and potash in *Vertisol* of Gujarat under intensive cropping and fertilizer constrains. *Gujarat Agric. University Res Journal,* **15:** 1-10.

Patel, M. S.; Meisheri, M. B.; Patel, J. C.; Hadavani, G. J.; Shobhana, H. K. and Talavia, B. P. 1994. Potassium response and nutrient use efficiency under intensive cropping in a calcareous soil. *Journal of Potassium Research,* **10**: 155-162.

Pierzynski GM, Sims JT, Sharpley AN McDowell RW, Sims JT (2005) Chemistry, cycling, and potential moment of inorganic phosphorus in soils. *In* Sims JT, Sharpley AN, eds, Phosphorus: Agriculture and the Environment.American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, Inc.,Madison, WI, pp 53–86.

Rahate, G. Z.; Puranik, R. B.; Bapat, M. V.; Kohadas, N. S. and Joshi, R. P. 1979. Effect of long term application of manures and fertilizers on phosphorus status in vertisols and yields of Jower and Wheat; phosphorus in soils, crops and fertilizers, *Bulletin of the Journal of the Indian Society of Soil Science,* **12:** 216-224.

Rajput, S. G. and Polara K. B. 2012. Fertility status of cultivated soils in coastal Bhavnagar district of Saurashtra region of Gujarat. *Journal of the Indian Society of Soil Science,* **60**:317-320.

Rao, P. N.; Singh, A. P.; Singh, S. and Singh, B. 1984. Effect of application of phosphorus and manganese on their availability in soil under wheat- green gram rice sequence. *Journal of the Indian Society of Soil Science,* **32:** 763-765.

Ryan, J. and Zahard, M. L. 1980. Phosphorus transformation with age in a Calcareous soil. *Soil Science Society of America journal,* **44:** 168-169.

Saha, A. K.; Saha, N. and Pal, S. K. 2000. Influence of farmyard manure and fertilizer phosphorus on transformation of inorganic phosphates and its uptake by wheat. *Indian Agriculturist,* **44:** 185-191

Santhy, P. 1995. Studies on organic matter, NPK fractions and other influence on soil fertility and crop yield under long tern fertilization. *Ph.D. Thesis,* Tamil Nadu Agricultural University, Coimbatore.

Savani, R. P. 1981. Nutrition of groundnut in relation to phosphorus and sulphur in calcareous soils of Saurashtra, *M.Sc. (Agri.) Thesis*, Gujarat Agricultural University, Sardar Krushinagar.

Setia, R. K. and Sharma, K. N. 2007. Dynamics of forms of inorganic phosphorus during wheat growth in a continuous maize-wheat cropping system. *Journal of the Indian Society of Soil Science,* **55:** 139-146.

Shabir Ahmad Rather and Narinder Lal Sharma 2009. Effect of integrated nutrient management (INM) in wheat on soil properties and fertility status. *An Asian Journal of Soil Sci*ence, **4**: 55-57.

Sharma, K. N. and Meelu, O. P. 1975. Effect of long term application of P, K and FYM on the Zn content of soil. *Journal of the Indian Society of Soil Science,* **23:** 76-82.

Singh Gurinderbir and Sharma, K. N. 2007. Characterization of inorganic soil P forms in soils representing different Agro-ecological zones of Punjab *Journal of the Indian Society of Soil Science,* **54:** 171-173.

Singh, B. and Singh, M. 1969. Sulphur status of Hissar soils and availability of sulphur and phosphorus affected by fertilizer application. *Haryana Agricultural University Journal of Research,* **5:** 222-230.

Singh, K. N. B.; Sharma, D. S.; Jodhi J. S.; Rana and Kapur, M. D. 1983. Available phosphorus and potassium and soil organic matter content as influenced by long-term application of fertilizers and farmyard manure to wheat maize rotation *Journal of the Indian Society of Soil Science,* **31:** 491-494.

Singh, L. and Balasubramanian, V. 1983. Direst and residual effect of P and K on crop yield, nutrient uptake and soil properties at Kadawa, Nigeria. *Fertilizer and Agriculture,* **84:** 39-47.

Singh, R. C. and Faroda, A. S. 1987. Influence of cropping systems and fertility levels of the changes in nitrogen and phosphorus contents of soil. *Haryana Agricultural University Journal of Research,* **17:** 229-233.

Sood, R. D. and Bhardwaj, R. K. 1992. Effect of liming and phosphorus fertilization on the P-fraction in an acid *Alfisol*. *Journal of the Indian Society of Soil Science,* **40:** 299-301.

Subramanian, K.S. and Kumaraswamy, K. 1989. Effect of continuous cropping and fertilization on the chemical properties of soil. *Journal of the Indian Society of Soil Science,* **37:** 171-173.

Sutaria, G. S. and Patel, M. S. 1987. Yield of groundnut and nutrient uptake as influenced by phosphorus, sulphur, zinc and iron under medium black calcareous soils. *Indian Journal of Agricultural Chemistry.*

Tandon, H. L. S. 1987. *Phosphorus research and agricultural production in India.* Fertiliser development and consultation organisation, New Dilhi.

Tarafdar, J.C.; Yadav, R.S.; Meenu bareja and Singh, G. 2006. Phosphorus fraction under crops, trees and grasses. *Journal of the Indian Society of Soil Science,* **54:** 171-173.

Tiwari, K. N. 2002. '*Phosphorus'* Fundamantals of soil science, *Indian Society of Soil Science.* IARI, New Delhi. pp 353-368.

Tomar, N. K.; Sharma, A. K. and Gupta, A. P. 1987. Effect of pre-incubated phosphates, manure and pyrites on the phophorus transformation in a sodic soil. *Journal of the Indian Society of Soil Science*, **35:** 432-440.
Tomar, N. K.; Sharma, A. K. and Gupta, A. P. 1987. Effect of pre-incubated phosphates, manure and pyrites on the phophorus transformation in a sodic soil. *Journal of the Indian Society of Soil Science*, **35:** 432-440.
Tripathi, D. and Minhas, R. K. 1991. Influence of fertilizer phosphorus and farm yard manure on transformation of inorganic phosphate. *Journal of the Indian Society of Soil Science,* **39: 472**-476.

Udiyasoorian, C. and Sree Ramulu U. S. 1991. Effect of continuous manuring and fertilizer on soil phosphorus fractions in an *Alfisol* under rice-rice cropping system. *Madras agriculture Journal*, **78:** 264-266.

Upadhyay, R. M.; Singh, B. and Katiyar, S. K. 1991. Effect of nitrogen, Phosphorus and Sulphur application to black gram yield and fate of P in an inceptisol. *Journal of the Indian Society of Soil Science*, **39:** 298-301.

Vats, M. R.; Sehgal, D. K. and Mehta, D. K. 2001. Integrated effect of organic and inorganic manuring on yield sustainability in long-term fertilizer experiments. *Indian Journal of agricultural Research,* **35:** 19-24.

Table 1: Common soil phosphate minerals

Calcium phosphate	
(i)	Fluorapatite [$Ca_{10}(PO_4)_6 F_2$] $Ca_3(PO_4)_2$, CaF_2
(ii)	Hydroxyapatite[$Ca_{10}(PO_4)_6OH_2$] $Ca_3(PO_4)_2$, $Ca(OH)_2$
(iii)	Tricalcium phosphate [$Ca_3 (PO_4)_2$]
(iv)	Octacalcium phosphate [$Ca_3 H_2 (PO_4)_{6,}$ 5 H_2O]
(v)	Dicalcium phosphate [$Ca HPO_4$]
(vi)	Dicalcium phosphate dihydrate [$Ca HPO_{4,}$ 2 H_2O]
Aluminium phosphates	
(i)	Variseite [$AlPO_4$, 2 H_2O]
(ii)	Potassium taranakite [$H_6K_3 Al_5 (PO_4)_{8,}$ 18 H_2O]
(iii)	Berlinite [$AlPO_4$]
Iron phosphate	
(i)	Strengite [$FePO_4$, 2 H_2O]
(ii)	Vivianite [$Fe_3 (PO_4)_2$, 8 H_2O]

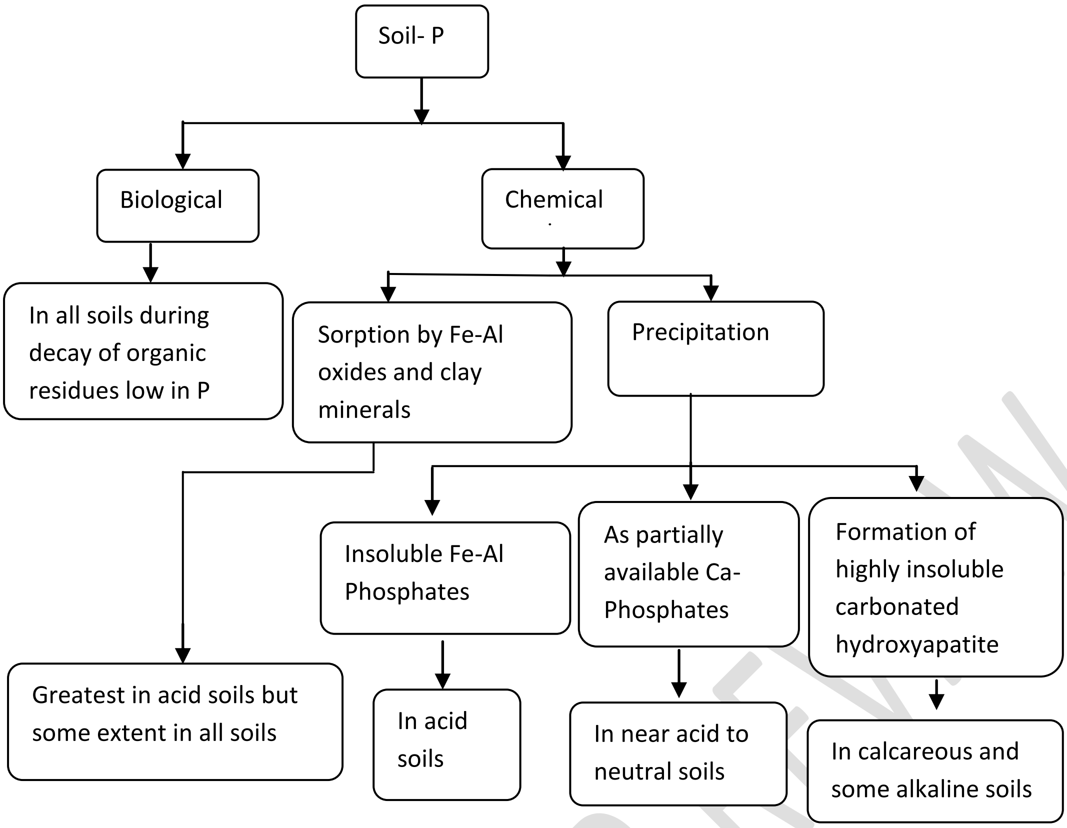

Fig.1: Schematic presentation of phosphorus transformation in soils