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Soil Reaction and Phosphorous Availability

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Phosphorus is an important macronutrient involved in most of the vital metabolic processes in plants. Its availability in soil is often limited because of its high reactivity. There will be reduction in solubility of native and added P due to sorption and precipitation processes, termed as P fixation. This tends to reduce the water soluble and labile P fraction in soil, though total P may be abundant. One of the major factors responsible for P fixation is soil reaction. Soil phosphorus is mainly present in plant available, sediment bound and organic bound forms. Plant available form *i.e.*, soil solution phosphorus consists of different ortho-phosphate anions. Primary minerals are the most stable form of P which replenishes solution phosphorus by weathering. P adsorbed on mineral surfaces like clays, Fe and Al oxides, carbonates and Secondary P compounds (CaP, FeP, MnP, AlP) also supply the phosphorus through desorption and dissolution respectively. Plant uptake, leaching of ions, run off and erosion are the important processes through which P is lost from the soil.

Transformation of P in soil

Soil phosphorus is classified into three reactive pools such as solution P, Labile P and stable P. Among them mineral P fraction is far greater than labile P than solution P. Ortho phosphate ions are the most readily available form of P that are released from other forms and it makes up the solution P pool. Labile P consists of phosphate ions adsorbed on the solid phase and is held in equilibrium with the solution P. Mineral P is the unavailable and most stable P fraction in the soil, which form the nonlabile P pool. When the phosphorus is removed from the solution P, it is replenished from labile P, further from non-labile P. Hence these pools are interconverting with each other. Soil pH Phosphates are absorbed by plants mostly as primary and secondary orthophosphate ions. Amount of each species of orthophosphate ions are controlled mainly by the soil pH of the solution. At pH 7.2, there are almost equal amounts of primary and secondary orthophosphate ions. Below this pH value, plant uptake of P is in the form of HPO_4^{-2} due to its dominance and above which $H_2PO_4^{-1}$ is dominating. In acidic condition, solubility of Fe and Al phosphate is poor and hence it is precipitated whereas in alkaline condition precipitation is in the form of Ca phosphates due it's low solubility. Hence a soil pH of 6-6.5 is considered to be the best for optimum availability of phosphorus.

Phosphorus fixation

The reduction of solubility of native and added P due to sorption and precipitation reaction is termed as P fixation. It was recognized by Thomas Way in 1850.The main factor affecting P fixation is soil pH. The fixation can take place in two types of reactions. One is phosphate sorption on the surface of the soil minerals known as sorption reaction and the other is phosphate precipitation by free $Al^{3+}$and Fe^{3+}, known as precipitation reaction. For this

reason, P become fixed and unavailable to plants. In acidic soils, the protonated/ nonprotonated surfaces of Al/ Fe hydroxides and oxides results in P sorption and formation of complex thus decreasing its availability in soil solution. The fractionation studies of P by Kiflu et al. (2017) in acidic soil indicated higher amount of Al and Fe- P as compared to labile and solution P. Further, application of lime increased the solution and labile P owing to the transformation of P associated with Fe & Al fraction and maximum availability was observed with application of lime @ 9.75 ton ha -1 . of phosphatic fertilizer application on availability of P in acid soils. Application of rock phosphate & superphosphate in 1:3 proportions maintained relatively higher P availability throughout the incubation time (90 days) as compared to sole application. Similarly, Yu et al. (2013) reported decreased sorption of P in acid soils due to application of organic matter. In alkaline soils, P retention is dominated by precipitation reactions with Ca, generating dicalcium phosphate (slowly available to plants), into more stable unavailable forms viz., octacalcium phosphate, tricalcium phosphate and hydroxyapatite. Further, adsorption of P on the surface of calcium carbonate may aggravate P deficiency in calcareous soil (Shariatmadari et al., 2007). Ullah et al. (2013) revealed that application of elemental sulfur along with inoculation of Thiobacillus is helpful in decreasing P fixation in calcareous soil. The low availability of phosphorus in soil is mainly influenced by the soil reaction that is associated with Al and Fe oxides and hydroxides in acid soils and Ca in alkaline soils. Suitable management practices such as liming of acids soil, use of organic manure and bio-inoculants are helpful in reducing P fixation.

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