Popular Article

Popular Kheti

Volume -2, Issue-4 (October-December), 2014

Available online at www.popularkheti.info

ISSN: 2321-0001

Technologies for Sustainable Phosphorus Management

Sunita Gaind

Division of Microbiology, Indian Agricultural Research Institute, New Delhi-110012

Email: sugaind175@rediffmail.com

Phosphorus (P) is a key nutrient for crop growth but its low mobility in soil is a major constraint that limits the growth of plants and crop productivity. High cost of chemical P fertilizer and its consistently depleting non-renewable source, demands adoption of some alternate strategies that involve the effective use of available P resources. Optimizing agricultural practices while exploring innovative approaches for sustainable use of P can enhance the long-term supply of this major plant nutrient and reduce the environmental pressures.

Introduction

More than 80 % of the phosphate demand is primarily for the agricultural production and a smaller fraction (7 %) is for animal feed additive and 2-3 % for food additive (Fig 1). The remaining 8 % goes to industrial application such as use in detergents and metal treatments (Prud'Homme, 2010). The detergent fraction has decreased in recent years due to phosphate pollution of surface water causing eutrophication. The global demand for consumption of P fertilizer for agricultural production is likely to increase further as productivity needs to be enhanced for providing food security to the growing population. Reducing P losses and adopting sustainable P management strategies may help to reduce the input of chemical P fertilizer. Animal manures and agricultural residues represent a huge source for nutrients. The commonly practiced and preferred option for recycling animal manures is by land spreading whereas agricultural residues are burnt on-in the field itself to prepare them for plantation of succeeding crops. The low N:P ratio of animal manure results in over application of P in soil than is required by the crop plants. About 65 % of total P in animal manure occurs in organic form which is colloidal in nature and doesn't get readily fixed in the soil. Thus, manure P is more prone to leaching than inorganic P from synthetic fertilizers. The runoff and leaching of P to surface and ground waters result in eutrophication, affecting the marine community. On the other hand, burning of crops residues result in loss of plant nutrients such as nitrogen (N), phosphorus (P), potassium (K) and sulphur (S), besides emission of greenhouse gases such as carbon dioxide, methane and nitrous oxide. The

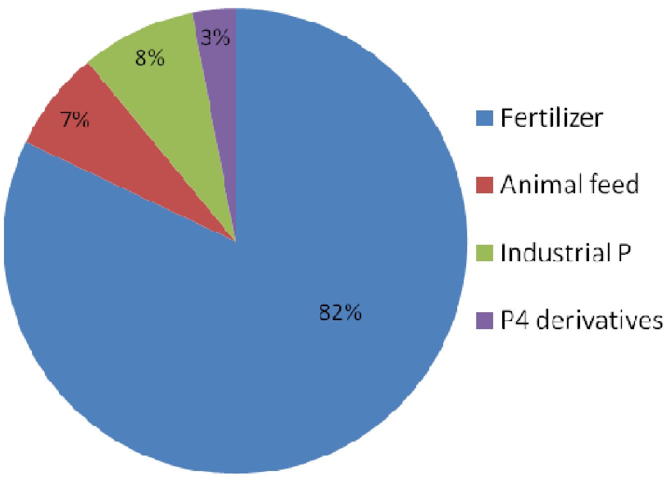

Fig 1. Breakdown of phosphorus end uses, indicating the overwhelming demand for fertilizers (Source: Prud'Homme, 2010)

tappable potential of N, P and K from crops residue, human excreta and livestock dung has been estimated to be about 7.75 million tonnes by 2025. The effective management of livestock manure and crop residues for reduced loss of P and improved environment quality is important while recycling farm wastes as soil amendments.

Co-composting of Animal Manure and Crops Residue

Compared with direct application of animal manure on farm land, its composting results in elimination of pathogens and weed seeds, removes odours and leads to microbial stabilization of the finished product. However, the excess moisture, low porosity, low C: N ratio and high pH values are some of the chemical characteristics of animal manures that could limit the efficiency of composting process. Therefore, mixing of bulking agent such as cereal straw, farm residues, hay, cotton wastes, leaves, saw dust with animal manure can optimize the composting mixture properties such as air space, moisture content, C:N ratio, particle density, pH and mechanical structure (Bernal et al. 2009). Phosphorus mineralization from crop residues depends upon the rate of decomposition of crops residue and microbial immobilization of P. If P in crops residue is less than 0.2 to 0.3 %, net immobilization of P occurs. During initial stages of crops residue decomposition, net immobilization of P can conserve substantial amount of P in slowly available organic form. The C:N ratio of cereal straw (paddy/wheat straw) is as high as 78:1. Thus, a blend of paddy straw and animal manures such as poultry manure/cattle manure/ farm yard manure each added separately as a source of N and P can bring down the C:N ratio of composting mixture, to initiate decomposition and prevent P immobilization (Gaind 2014). The inoculation of composting mixture with phytate mineralizing microorganisms that have phosphate hydrolyzing enzymes can release inorganic phosphate from phytate bound P (that constitutes about 65% of the total organic P) present in crop residues and animal manures. The resulting compost will have high content of available P and its application to soil will reduce the input of chemical P fertilizer.

Table 1. Total nutrient content (% dry weight) of commonly used animal manures

Solid manure	N	P	K	Ca	Mg
Cattle manure	2.4	0.7	2.1	1.4	0.8
Swine manure	2.1	0.8	1.2	1.6	0.3
Sheep manure	3.5	0.6	1.0	0.5	0.2
Poultry manure	4.4	2.1	2.6	2.3	1.0
Paddy straw	0.5	0.25	2.6	-	-

(Source: Hue and Silva 2000; Gaind 2014)

Supplementation of Live-Stock Diets with Phytase

The vegetable oil cakes, meals, cereals, their by-products, grains and their by-products constitute the feed of monogastric animals. Phosphorus availability from such feedstuffs is only about 30%. The lack of phytate digesting enzyme restricts the ability of mammals and non-ruminants to absorb phytate-P present in feed. Thus, there is need to either remove phytate P or reduce its content in animal feed, otherwise feed has to be supplemented with inorganic P to meet the nutritional needs of animals. Globally ~7 % of the P demand is for animal feed supplementation (Fig. 1). The increased P input via feed additives reduces the relative utilization of P within the animals and results in production of manure with higher P content. The excretion of P in manure can be reduced by supplementing the animal feed with phytase enzyme. Phytase lowers the phosphorus excreted in manure by releasing the phytate-bound phosphorus found naturally in grains and soybeans used as animal feed. The supplementation of feed with phytase can increase the assimilation efficiency of phytate-P by

30-40% in pig feeds and 40-58% in poultry and duck feeds. Phytase not only improves mineral and trace element utilization, but also enhances the protein digestibility and energy utilization. By adding the enzyme to the diet of poultry and swine feed, more P becomes available to the animal, which lowers the amount of supplemental P required and the amount that goes undigested.

Preventing Loss of phosphorus

Depletion of phosphorus from soil occurs not only by growing crops but also by erosion that includes wind erosion, water erosion and tillage erosion. Water erosion is more common in areas of higher rain fall whereas wind erosion occurs in belt of sandy soils. However, tilled erosion occurs when crop cultivation leaves the soil uncovered for longer period (e.g. potato, sugar beet, maize and sunflower). The important measures to prevent P losses from soil include minimum tillage without removal of crop residues (mulching), ridge tillage, sub soiling, terracing, contour ploughing, buffer striping, cover crop establishment and conversion of arable land to grass land. Improving the infiltration capacity of soil to run off can prevent the loss of phosphorus. Spreading of fertilizer combined with mandatory incorporation of manure on bare soils also reduces the risk of phosphorus loss.

Maintaining Soil Quality

The high content of total P in soil is not a guarantee for its high productivity. The soil characteristics are more important for its higher availability. These characteristics include right pH (6.0-7.0), organic matter content, resilience against physical and biological perturbations and microbial diversity. If the soil pH is suboptimal or if soil contains too little or too much moisture, or if it is highly compact, more P will be needed to attain a certain crop yield. Returning crop residues to soil and its subsequent decomposition by natural microbial flora will improve the soil structure and stimulate the soil life and improve microbial diversity. Microbial flora also helps in solubilising the insoluble forms of P and brings it in soil solution for plants uptake. Optimizing soil quality can improve the availability of bound P and reduce the consumption of chemical P fertilizer. Using organic amendments, synthetic phosphate fertilisers can be saved and over fertilization due to direct application of livestock manure on the agricultural fields is prevented. This realisation of efficient phosphorus recovery not only generates valuable products from an otherwise wasted residue, but at the same time achieves environmentally friendly residue recycling.

Conclusion

The long-term availability of phosphorus for food production is of prime importance to provide food security to the growing population. Environmental solutions that improve nutrient management and recycling minimize phosphorus losses due to soil erosion, and foster sustainable production and consumption can promote wise use of this finite resource.

References

Bernal MP, Alburquerque JA and Moral R.. 2009. Composting of animal manures and chemical criteria for compost maturity assessment. A review. *Bioresource Technology*, **100**, 5444-5453.

Gaind Sunita 2014. Effect of fungal consortium and animal manure amendments on phosphorus fractions of paddy-straw compost. *Int. Biodeterioration and Biodegradation*, **94**: 90-97.

Prud'homme M. 2010. World phosphate rock flows, losses and uses. Paper presented at the Phosphates March 2010 Conference and Exhibition, Brussels,

Hue NV and Silva JA. 2000. Organic soil amendments for sustainable agriculture: organic sources of nitrogen, phosphorus, and potassium. Plant Nutrient Management in Hawaii's Soils, Approaches for Tropical and Subtropical Agriculture.