Tackling the 'P' problem

Present Scenario

Applied water soluble 'P' is, on an average, used @ 12-9-6-3% from year of application. So considerable (70%) part of applied 'P' is locked in the soil first as tricalcium phosphate (TCP) and finally as apatite. The P in TCP is unavailable but can be used by plants in association with Mycorrhizae and to some extent by Phosphobacteria.

However in paddies, under heavy soils, considerable part of applied 'P' gets converted into apatite. Apatite formed in the soil will be lost forever. So SRI cultivation is one way of reducing apatite formation, in heavy soils growing paddies.

As in Rayalaseema (Andhra Pradesh) if DAP was over-applied, the available 'P' after taking groundnut crop was high to very high. So residual available 'P' would be enough for a year or two in such cases.

Set-line or band application leads to improved use efficiency of the applied 'P' as against broadcast application. In fact the use of phosphate solubulizing bacteria and reducing water soluble 'P' application could be feasible in such instances.

Future Course

As phosphate rock is a non-renewable resource, a two-pronged approach is segregated. It includes (a) improving use efficiency and tapping the locked in P (with the use of P-fertilizers) and (b) tapping the difficulty available P-forms for use by crops.

Details are P management are furnished hereunder.

The crop requirements

In the case of phosphorus requirements for crops, it is best done by applying adequate quantities to build up the soil available P to set 'critical' levels above which responses would be uneconomical. Examples of such critical levels are as follows (Table – 1)

Table – 1: Soil critical values for phosphorus for different groups of crops

Level of P requirement	Crop group	Critical level of P (P_2O_5)
Low	Pastures, grasses, small grains, field corn, soybean, etc.	35
Moderate	Cotton, sweet corn, tomato etc.	60
High	Potato, onion etc.	90

How to suggest fertiliser dose for different crops

It is already seen that different crops have different adequacy limits and the availability of applied P varies as for the soil type. Then the fertilizer P recommendation depends on these two considerations.

Example :

A) **Given**

i.	Adequacy limit for the crop	:	35 Kg P_2O_5/ha
ii.	Soil test	:	35 Kg P_2O_5/ha
iii.	Soil type	:	Alfisols, Vertisols
iv.	Clay content	:	10%, 50%

B) **Calculation of the dose**

i.	Additional build up of P_2O_5 needed	:	35-15 = 20 Kg P_2O_5
ii.	Recovery of applied P	:	Alfisols : (100-2x10) = 80% Vertisols : (100-50) = 50%
iii.	Fertiliser P needed	:	Alfisols : (20x100/80) = 25 Kg P_2O_5/ha Vertisols : (20 x 100/50 = 40 Kg P_2O_5/ha

Thus, the fertiliser P requirements even for the same crop varies depending on the soil type and clay content. Even if the soil type is Vertisol, if clay is 30 and 60%, the fertiliser P_2O_5/ha requirements for a crop with 35 Kg P_2O_5/ha and initial soil test value of 15 Kg P_2O_5/ha would be 28 and 50 Kg P_2O_5/ respectively.

Two important considerations relating to phosphorus management are :

i. The mycorhizal associations for increased availability

ii. Contradictory responses to phosphates irrespective of soil test values

Some details are discussed below.

Mycorhizal associations

Of the various soil microorganisms, perhaps the most is known about mycorrhizal fungi. Of these the vesicular-arbuscular mycorrhizal fungi (VAM) are the most common type. The fungal hyphae enter the root cells causing no noticeable structural changes on the outside of the roots. The name, vesicular arbuscular, comes from structures which are found within the root cortical cells : vesicals, which are thaught to be the storage or reproductive structures ; and arbuscles, branched multiple tipped hyphal structures within the plant cells. VAM fungi associate with both legumes and cereals. The extent to which the roots are colonized by the VAM is one of the key determinants of a roots ability to acquire nutrients from the surrounding soil. Mycorrhizae improve seedling growth and survival by enhancing the uptake of nutrients and water and increasing the root life span. VAM also helps in protecting the root against other microorganisms and other environmental stresses such as heavy metal toxicity or soil salinity. They are thought to be crucial for acceptable growth and survival of plants in many cases such as nutrient deficient soils or degraded habitats, arid ecosystem and drought.

VAM activities can be affected by the level of soil fertility, which in turn is "modified" by the VAM by changing the ability of a plant to use the nutritional potential of a given soil. He further stated that the "VAM effect" is mainly accounted for by the changes they induce in the phosphate uptake properties of the root system. The VAM mycelia grow beyond the zone depleted of slowly diffusing nutrients. Thus, VAM leads to a better exploitation of soil phosphates and to more efficient use of fertiliser phosphorus.

It is clear that VAM can be harnessed to improve the productivity in agriculture, horticulture and forestry by (i) reducing the input of fertiliser and (ii) by enhancing the plant survival, thus saving environmental and ecological costs.

Contradictions in phosphorus

In Vertisols several instances are reported where there is no response inspite of the being poor in available phosphorus and vice versa. It is argued that each situation has to be individually assessed as Vertisols are derived from various parent materials under different climatic and physiographic situations.

A basic tenet is to see that there should be no other limiting factor in the production of a crop. This should be particularly ensured in Vertisols. Among others the possible limiting factors could be

i. Amongst the nutrients, nitrogen is universally limiting and in most trials this aspect is given due attention. But more often, the widespread Zinc deficiency is ignored and it could as well be a limiting factor in showing response to applied P

ii. At lower levels or production, the native phosphorus itself may be adequate and thus no response to applied P

iii. Some elements may become toxic (e.g. Boron). Subsoil salinity could be another factor

iv. With temporary or transient water logging or wet regime, Fe^{3+} iron (from inter lattice zones of the Smectite or from the free oxides of iron) may be reduced to Fe^{2+} leading to possible precipitation of phosphates

v. The organic acids released by the legumes (Pscidic acid from pigeonpea roots) would solubilise phosphates or chelate metal irons like Ca^{2+}, Fe^{2+} liberating part of the bound phosphorus. The VAM fungi may also accentuate the availability of phosphorus.

vi. VAM and other fungal bodies associated with roots improve the availability of difficulty available phosphates

vii. Method of application is important in enhancing fertiliser P use efficiency. Placement, in association with ammonical nitrogen is very effective. If crops are grown through drip irrigation, fertiliser P @ 40 mg P/litre can be applied in Vertisols. In P-deficit soils, application of phosphates trigger microbial activity leading to decomposition of the native organic matter releasing both N and P. Thus, synergestic effects would be seen with the application of phosphates

Ways and Means to achieve the above include:

- Band application P as needed based on soil test and the crop in question.
- With high intensity of cropping and with increased N-application, application of fertiliser is a MUST.
- Placement of fertiliser P reduces contact with soil and increases its availability.
- At low production system, P application may not be necessary.
- VAM enhances fertiliser as well as native soil P uptake.
- There cannot be more than a fortnight delay in fertiliser application after seeding/planting any crop.
- The recommended fertiliser P depends on the amount of clay percent.
- Correct all the other constraints before applying fertiliser P.
- Organic form of P can be exploited using fungal associations.
- Fertiliser P can be applied through fertigation.
- Move to SRI cultivation in heavy soils and apply needed P through band application.
- Tap the residual P using phosphobacteria
- The apatite (phosphate rock) of low quality as well as bones can be calcined, powdered arid used alongwith Phosphobacteria
- Mycorrhizal associations, wherever feasible, need be encouraged, particularly in MPTs and Fruit trees
- Tap the excess residual available P (as in groundnut of Rayalaseema) for subsequent year or two

All such approaches can only delay the “dooms day” of high cost and restricted availability of Phosphate Rock from 2033 to a later year.

So the future lies in “recycling” through organic / ecological farming.