SOIL SCIENCE Section

Course No. : **SOIL-122**

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Credit : 3(2+1)

Course Teacher : **Dr. Ganesh D. Sakore**
Assistant Professor
Shramshakti College of Agriculture,
Maldad

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Phosphatic Fertilizers

(6 %)

Sub-topics/ Key points

- Classification,
- Composition,
- Properties and their reaction soil.

Phosphatic Fertilizers

- The plant nutrient content of all phosphatic fertilizer is expressed in terms of percentage of phosphorous pentaoxide (P_2O_5).
- Phosphorous is an element of which there are several forms.
- When it burns it is converted into phosphorous pentaoxide (P_2O_5), which is readily dissolve in water to give metaphosphoric acid.

$$P_2O_5 + H_2O \rightarrow 2HPO_3$$

(metaphosphoric acid)

In warm water, it changes into

$$HPO_3 + H_2O \rightarrow H_3PO_4$$

(orthophosphoric acid or phosphoric acid)

Orthophosphoric acid, commonly known as **phosphoric acid** contains three replaceable hydrogen atoms. One, two or all the three of these atoms are replaced giving rise to three salts,

$$H_3PO_4 \rightarrow H_2PO_4^- \rightarrow HPO_4^{2-} \rightarrow PO_4^{3-}$$

All crop plants absorb phosphorous in the form of negative charged ions as $H_3PO_4^{2-}$ **or** $H_2PO_4^-$

These three ions combine with calcium to form three salts, which are sold to cultivators as commercial phosphatic fertilizer,

1) **Monocalcium phosphate $Ca(H_2PO_4)_2$,**
2) **Dicalcium phosphate $CaHPO_4$**
3) **Tricalcium phosphate $Ca_3(PO_4)_2$.**

H_3PO_4 →	**$H_2PO_4^-$ →**	**HPO_4^{2-} →**	**PO_4^{3-}**
Orthophosphoric acid	Primary Orthophosphate	Secondary Orthophosphate	Tertiary Orthophosphate
	↓	↓	↓
Present in →	**Acid soil**	**Neutral soil**	**Alkaline soil**
	↓	↓	↓
Commercially →	**Monocalcium phosphate** $Ca(H_2PO_4)_2$	**Dicalcium phosphate** $CaHPO_4$	**Tricalcium phosphate** $Ca_3(PO_4)_2$

Classification of Phosphatic fertilizer :

The phosphatic fertilizers can be classified into three groups, depending on forms in which orthophosphoric acid or phosphoric acid is combined with calcium.

1) Phosphatic fertilizers containing water soluble phosphoric acid or Monocalcium phosphate $Ca(PO_4)_2$

e.g.

Single superphosphate (SSP) : (16% P_2O_5)

Double superphosphate : (32% P_2O_5)

Triple superphosphate : (48 % P_2O_5)

Ammonium phosphate : (20% N & 20% P_2O_5 or 16 N)

Monoammonium Phosphate (MAP) : 16% N, 48% P_2O_5

Diammonium Phosphate (DAP) : 18% N, 46% P_2O_5

Characteristics :-

- They contain water soluble phosphoric acid which can be absorbed quickly.
- Thus the nutrient in this fertilizer is available to plant in the young stage when the root system is not fully developed.
- Water soluble phosphoric acid is rapidly transformed in the soil into a water insoluble form. Hence, there is little danger of loss of nutrient by leaching.
- These fertilizer should be used **on neutral to alkaline soils** but **not** on **acidic soil.** Under acidic condition, they get converted into unavailable iron and aluminium phosphate.

2) Phosphatic fertilizer containing citric acid soluble phosphoric acid or Dicalcium phosphate $Ca_2H_2(PO_4)_2$

e.g.

Dicalcium phosphate : (34 to 40 % P_2O_5)

Basic slag (Thomas) : (14 to 18 % P_2O_5)

Rhemmonia phosphate : (23 to 26 % P_2O_5)

Characteristics :-

- The fertilizers of this group are **suitable for the acidic soil**. Because with low pH, citric acid soluble phosphoric acid gets converted in to monocalcium phosphate or water soluble phosphates and there are less chances of phosphate getting fixed as iron and aluminium phosphates.

3) Phosphatic fertilizers containing phosphoric acid which is not soluble in water or citric acid or insoluble phosphoric acid or Tricalcium phosphate $Ca_3(PO_4)_2$

e.g.

Rock phosphate : (20 to 30% P_2O_5)

Raw bone meal : (20 to 25% P_2O_5 & 3 to 4 % N)

Steamed bone meal : (20 to 30% P_2O_5)

Characteristics :-

- These fertilizers are well suited for **strongly acidic soils** or **organic soil** which require large quantities of phosphatic fertilizers to raise the soil fertility.
- The availability of such fertilizers is also increased if these are ploughed under with green manuring crops or organic materials.

- **Manufacturing processes and properties of phosphoric fertilizers :**

1) Single superphosphate :- Rock Phosphate + Conc. H_2SO_4

Superphosphate is manufactured as follows -

Approximately equal amount of rock phosphate and concentrated sulphuric acid are weighed separately and mixed for about one minute in mechanical rotator.

The warm mixture then transferred into a big den, where chemical reaction continue. The mixture is left in den for 12 hrs to harden and cool down.

Thereafter, it removed by a crane and deposited in a large shed to mature. After some weeks, it is ready for use.

Before bagging, grind the fertilizer, because during maturation it hardens into a compact mass.

The following chemical reactions takes place in den.

$$2Ca_3(PO_4)_2 + 6\,H_2SO_4 = 4H_3PO_4 + 6CaSO_4$$

Rock phosphate — Phosphoric acid — Calcium sulphate (Gypsum)

During this reaction, a large amount of heat is given out and phosphoric acid is produced.

Phosphoric acid acts with tricalcium phosphate (present in rock phosphate) to form water soluble monocalcium phosphate,

$4H_3PO_4$	+	$Ca_3(PO_4)_2$	=	$3Ca(H_2PO_4)_2$
Phosphoric acid		Tricalcium phosphate		Monocalcium phosphate

Thus, two most important ingredients of super phosphate are **monocalcium phosphate and gypsum.**

- When super phosphate is applied to moist soil, the monocalcium phosphate dissolved in the soil moisture.
- The roots of growing plant easily take up this form of phosphoric acid.

- In the meanwhile, the solution of monocalcium phosphate is precipitated in the soil pores and depending on the soil pH, different phosphate compounds are formed.
- These new compounds are not soluble in water and thus super phosphate is not leached from the soil by rain water.
- In natural and calcareous (alkaline) soils and slightly acidic soils, monocalcium phosphate present in superphosphate is converted into dicalcium phosphate and tricalcium phosphate.

1) $Ca(H_2PO_4) + Ca(HCO_3)_2 = 2CaHPO_4 + 2H_2CO_3$

Monocalcium phosphate — Calcium bicarbonate — Dicalcium phosphate (Present in soil) — Carbonic acid

2) $Ca(H_2PO_4)_2 + Ca(HCO_3)_2 = Ca_3(PO_4)_2 + 2H_2CO_3$

Monocalcium Phosphate — Calcium bicarbonate — Tricalcium phosphate (present in soil) — Carbonic acid

Dicalcium phosphate slowly dissolved in water containing carbonic acid and becomes available to plant, while tricalcium phosphate, being insoluble and remains in the soil as fixed phosphate.

In highly acidic soils, the dissolved monocalcium phosphate combines with iron and aluminium to form Fe and Al phosphate.

$$2Ca(H_2PO_4)_2 + Fe_2O_3 = 2FePO_4 + 2CaHPO_4 + 3H_2O$$

Iron oxide — Iron phosphate — Dicalcium phosphate

Thus, in acidic soil, superphosphate is immediately converted into insoluble forms.

mixer, then bagged.

2) Enriched superphosphate :-

- The term enriched superphosphate is a product obtained by the acidification of rock phosphate with a mixture of sulphuric and phosphoric acid.
- It is essential to ground the superphosphate into powder.
- The phosphoric acid & sulphuric acid should be properly diluted and added into the powder and mixes in mixer, then bagged.

3. Triple super phosphate (TSP) :- Rock Phosphate + Phosphoric acid

Properties

- For maximum yield of short season fast growing crops like high yielding varieties of cereals, potatoes and certain vegetable crops, TSP is superior to citrate soluble sources.
- TSP will enable the short duration crop with weak root system to establish in the soil immediately on release of phosphate by its granules.

3. Triple super phosphate (TSP) :- Rock Phosphate + Phosphoric acid

Properties

- Even during early growth period for most of the crops, application of fertilizer containing high proportion of water soluble phosphate like TSP, may be important in establishing a good stand.
- Like any other concentrated fertilizer, TSP will be a relatively cheaper fertilizer on unit nutrient cost basis.
- By using TSP, farmers may cut down further expenditure on transportation, storage and application.

4) Bone meal :-

Bone meal is both phosphatic manure and fertilizer. It is a cheap source of phosphorus but it is slowly available to crop. It is obtained in the two forms:

1) Raw bone meal or untreated bone meal:

- The bones collected from city slaughter houses are dried and crushed without treatment which is used as manures.
- It contains 2-4 % organic Nitrogen and 20 to 25 % P_2O_5.
- Nitrogen is present in the organic form which becomes slowly available crops on decomposition in the soil.

4) Bone meal :-

2) Steamed bone meal or treated bone meal:

- The bones may be steamed under pressure and the fats, greases, nitrogen and glue making substances may be removed when the availability of phosphorus increases.
- Steamed bones are more brittle and can be readily ground.
- Bone meals having particles not larger than 3/32 inch in size is considered suitable for use as fertilizer.
- Steamed bone meal contains 1-2% N and 25-30% Phosphorus.
- Bone meal is rather slowly available to plants.

Uses of bone meal :

- Bone meal is suitable for application to all crops and to a wide variety of soil.
- It is well suited for acidic soils and for long duration crops like sugarcane and fruit crops.
- Bone meal can be applied in large amounts and yet produce no harmful effects on crop growth.
- It may applied to the soil either at sowing time or before sowing. But it should not be applied as top dressing. It may be either drilled or broadcasted.

5. Basic slag/Thomas slag (1877, S. G. Thomas)

- Basic slag is a by-product of the steel industry.
- It is rich in available phosphorus. It contains from 14-18% phosphorus.
- Basic slag is a greyish black powder with a very high specific weight alkaline nature and is especially suitable for acidic soils.

Uses

- Basic slag is suitable for application to all crops and to a wide variety of soil, mostly acid soil.
- It should be mixed thoroughly with the soil.
- Because it hardly moves at all in soil.
- It must be pulverized before application for its effective use.

6) Rock phosphate:-

- Rock phosphate contains 20 to 30 % P_2O_5 depending on the quality of raw rock phosphate.
- When finely ground rock phosphate is applied to acidic soil or soils containing high percentage of organic matter, carbonic and nitric acid present in the soil act on rock phosphate and converted unavailable phosphate to monocalcium phosphate or water soluble phosphate.

$$[Ca_3(PO_4)_2]_3CaCO_3 + 6H_2CO_3 = 3Ca(H_2PO_4)_2 + 7CaCO_3$$

Rock phosphate (tricalcium phosphate)	Carbonic acid	Monocalcium phosphate	Calcium carbonate

$$[Ca_3(PO_4)_2]3CaCO_3 + 14HNO_3 = 3Ca(H_2PO_4)_2 + 7Ca(NO_3)_2 + H_2CO_3$$

Nitric acid — Calcium nitrate

Legumes, which have a high calcium requirement, respond more to rock phosphate than non legume.

Sources:

- '**Mussorie-Phos**' is an indigenous Rock Phosphate.
- It is an economical and effective natural phosphatic fertilizer for direct application in acidic, neutral and alkaline soils under different agro-climatic conditions.
- Rock phosphate is a trade name of mineral phosphates which denotes the product obtained from mining and subsequent metallurgical (not chemical or thermal) processing of phosphorus containing ores.

Advantages 'Mussouri Phos'

- It is a chief source of phosphorus.
- Mussorie deposits are exclusively of sedimentary origin and should, therefore, have relatively higher reactivity amongst the known Indian deposits. It increases the fertility of acid soils.
- It releases gradually plant assimilable forms of Phosphorus reserves, concurrently with the growth of plant. As such split application of phosphorus is not needed. Whereas in phosphatic fertilizers containing water soluble form of phosphorus, instant ingestion of soluble forms of phosphates leads to quick and continuous reversion in soils from soluble to insoluble form.

- Besides macronutrients such as Phosphorus, Magnesium and Sulphur, it contains micronutrients *viz.*, Copper, Molybdenum and Boron.
- Phosphorus that becomes fixed in acid soil, it makes it available to plant.
- It can constitute an effective substitute for Superphosphate in acid soils of India for a variety of crops.
- Use of Mussorie phos would help us to utilize our national resources most profitably and would save foreign exchange needed for the import of raw materials for manufacture of soluble phosphatic fertilizers.
- It is soluble in both organic and inorganic-acids present in the soil.

7) Dicalcium Phosphate

- Dicalcium phosphate is a component of many phosphate materials containing Calcium.
- It is generally prepared by neutralizing Sulphuric acid extract of Rock Phosphate with limestone.
- It contains about 33-40% of citrate soluble phosphate.
- The soluble phosphate will not turn into Tricalcium Phosphate or insoluble form as rapidly as Monocalcium Phosphate.

Management of phosphatic fertilizer :

1) Water soluble phosphatic fertilizer are suitable for slightly acidic, neutral or alkaline soils.
2) Water soluble phosphatic fertilizer are applied to soils when crop require a quick start.
3) Water soluble fertilizer are suitable for short duration crop like paddy, wheat, jowar, maize, ragi, soybean, cabbage, cualiflower, potato, gram, etc.
4) Citrate soluble phosphatic fertilizers are suitable for moderately acidic soil, long duration crop like sugarcane, tapioca, tea, coffee, legume and pastures.

Management of phosphatic fertilizer :

5) Insoluble phosphatic fertilizers are suitable for soil which is strongly to extremely acidic and long duration fruit crops.

6) Single superphosphate should be applied to the soil just before sowing in single dose.

7) SSP unsuitable for top dressing due to slow mobility for short duration crops and it should not be used in acidic soils.