COURSE NO : ELE-SSAC-364

Course Title : Agrochemicals

Course Credits : 3 (2+1)

SEMESTER VI (New)
(Part –I)

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Teaching Schedule

A. THEORY

Lesson	Topic	Weightage (%)
1	Introduction to agrochemicals, their type and role in agriculture	2
2	Effect of agrochemicals on environment, soil, human and animal health. Merits and demerits of their uses in agriculture, management of agrochemicals for sustainable agriculture.	4
3	Fertilizers and their classification	3
4 & 5	N fertilizers : classification, manufacturing process and properties, their fate and reaction	4
6 & 7	Phosphatic fertilizers, manufacturing process and properties	4
8	Potassic fertilizers and complex fertilizers, their fate and reaction in soils.	3
9 & 10	Secondary nutrients and fertilizers, their type, composition, reaction in soils and effect on crop growth.	4
11	Micronutrient fertilizers, their type, composition, reaction in soils and effect on crop growth.	4
12	Liquid fertilizers	3
13	Handling and storage of fertilizers	3
14	Biofertilizers and their role in crop production	4
15	Fertilizer control order	2
16	Introduction and classification of insecticides: Different types of Classification of insecticides. (Based on toxicity, mode of entry, mode of action, chemical nature)	4
17 & 18	Inorganic and organic insecticides Organochlorine, Organophosphates, Carbamates, Synthetic pyrethroids Neonicotinoids, Biorationals.	5
19	Insecticide Act and rules. Insecticides banned, withdrawn and restricted use,	2
20	IGRs and Biopesticides. Reduced risk insecticides	2
21	Botanicals, plant and animal systemic insecticides their characteristics and uses.	3
22	Mode of action of insecticides (Pyrethroids, organophosphates, Carbamates and Chitin synthesis inhibitor)	4
23	Fate of insecticides in soil & plant.	3
24	Insecticide resistance and its management	3
25	Pesticide residue- Definition, steps involved in determination of residue.	3
26 & 27	Copper fungicides, formulation of Bordeaux mixture and Bordeaux paste. Chemical reaction involved merits and demerits of Bordeaux mixture. Mode of action of copper fungicides	5
28	Sulfur fungicides: Organic and inorganic sulfur fungicides their	4

Lesson	Topic	Weightage (%)
	classification and mode of action. Preparation of lime sulfur mixture and chemical reaction involved.	
29	Benzimidazle fungicides, their chemical nature, mode of action and their use	3
30	Introduction to new generation fungicides. Viz Metalaxyl, fosetyl Al, Triazoles and shawbilirin fungicides	4
31	Herbicide- Classification, Formulations, Methods of application.	3
32	Mode of action of herbicide- Translocation and absorption	3
33	Persistence and fate of herbicides, Residual effect of herbicides	3
34	Introduction to selectivity of herbicide	2
35	Compatibility of herbicides with other Agrochemicals	2
36	Introduction to adjuvants and their use in herbicides	2
	Total	100

Suggested Readings :

1) Mariakulandi and Manickam (1975) Chemistry of fertilizers and manures.
2) Tandon H. L. S. (1994) Recycling of crop, animal, human and industrial Wastes in Agriculture. FDCO, Delhi
3) Rakshit A. (2015) Manures Fertilizers and Pesticides Paperback – Import. CBS Publishing; 1ST edition, pp. 266.
4) Havlin, John L, Samuel L. Tisdale (Author), Werner L. Nelson (Author), James D. Beaton (2004) Soil Fertility and Fertilizers (8th Edition). Published July 23rd 2004 by Prentice Hall. pp. 528.
5) Havlin, John L. (2004) Soil Fertility and Fertilizers: An Introduction to Nutrient Management Published July 23rd 2004 by Prentice Hall. pp. 528.
6) ISSS (2009) Fundamentals of Soil Science. 2nd Ed. Indian Society of Soil Science, New Delhi- 110 012. pp. 728.
7) Das D. K. (2011) Introductory Soil Science, 3rd revised and Enlarged Ed, Kalyani Publisher, Ludhiana. pp. 645.
8) ICAR Handbook of manures and fertilizers (1971) publication.
9) Tisdale, S. L. and Nelson, W. L. and Beaqton, J. D. (2010) Soil Fertility and fertilizers. 7th Ed. Macmillan Publishing Company, 445 Hutchinson Avenue, Columbus.
10) Yawalkar, K. S., Agarwal, J. P. and Bokde, S. (1967) Manures and Fertilizers. Agri-Horticultural Publication.
11) Hand book of fertilizers use (1980) FAI publication
12) A Fertilizer control order (1985) The fertilizer Association of India
13) The Pesticde manual A world compendium (1995) – British crop production council, UK
14) Chemistry of insecticide: Sree Ramulu US (1991)
15) Fungicide in plant disease control: Nene YL and Thapliyal
16) Principles of weed science: Rao VS (1992)

Lesson No. 1

Introduction to agrochemicals, their type and role in agriculture

Agrochemicals : The chemicals used in agriculture to maintain or to increase the crop production.

Types of pesticides and their role in Agriculture :

1) Acaricides - Control of ticks and mites e.g. Sulphur and lime sulphur.
2) Algicides - Control of algae and other aquatic vegetation e.g. Copper sulphate.
3) Antiseptics - Non metal from microorganisms e.g. Phenol, mercuric chlorosis.
4) Arboricides - Undesirable arborell (vegetative part) and bushy vegetation e.g. Sulphuric acid, copper sulphate.
5) Bactericides - Control of bacteria and bacterial diseases e.g. Penicillin, streptomycin.
6) Fungicides - Plant diseases caused by various fungi e.g. Bordeux mixture, thiram.
7) Herbicides - Control of weeds e.g. 2,4-D, 2,4,5-T, diurea.
8) Insecticides - Control of harmful insects e.g. Endosulphan, carboryl.
9) Molluscides - Soft bodies insects like snails and slug. e.g. Metal dehyde.
10) Nematicides - Control of nematodes e.g. Methyl bromide and other fumigants.
11) Rodenticides - Control of rodents e.g. Zinc phosphate, vartarin.

Fertilizers in Agriculture :

- ✓ Nitrogenous fertilizers
- ✓ Phosphatic fertilizers
- ✓ Potassic fertilizers
- ✓ Complex fertilizers
- ✓ Mixed fertilizers
- ✓ Micronutrient fertilizers
- ✓ Customized fertilizers

Lesson No. 2

Effect of agrochemicals on environment, soil, human and animal health. Merits and demerits of their uses in agriculture, management of agrochemicals for sustainable agriculture.

Healthy environment is prerequisite of healthy life for us. The contamination of the physical and biological components of the earth/ atmosphere system has existed for centuries but only started to be significant following the industrial revolution and green revolution in the 19^{th} century.

Any unfavorable or undesirable change in physical, chemical and biological characteristics of natural ingredients (viz. air, water and soil) of environment that may be harmfully affect human life is called pollution. The substance which causes the pollution are denoted as pollutant. The solid, liquid or gaseous substances present in such a concentration which may be injurious to environment are called as pollutant.

Effect of fertilizers on soil and water :

1. Due to excess use of fertilizers causes addition of Cd, Cu, Zn and Ni.
2. Due to excess use of fertilizers causes accumulation of salts in soil.
3. Soils heavily fertilized above the recommended levels and soils naturally high infertility are potential source of nitrate contamination in ground or run off water.
4. Excess NO_3 concentration in drinking water causes the disorder 'methaemoglobinaemia' or 'blue baby disease' in young infants.
5. As per WHO (World Health Organization) NO_3 concentration < 10 mg L^{-1}
   Water > 20 mg L^{-1} NO_3 concentration not acceptable for drinking.
6. Excess amount of N and P causes nutrient enrichment of lakes and rivers called 'eutrophication'.

Remedies :

1. Split application of fertilizers as per crop growth stage.
2. Use of advanced technology like fertigation.
3. Use of nitrification inhibitors for N-fertilizers.
4. Avoid excess use of compost prepared from sewage sludge, distillery effluents or other industries.

Pesticides

The pesticides used to control insects, fungi and weeds are normally directed to plants, although the major portion is deposited on the surface of the soil. Only 20 to 30 % pesticides reaching the target remaining 80 % reaches the non-target source.

Insecticides :

- Organochlorine insecticides are highly persistant and remains active in soil for maximum period i.e. up to 10 yrs.
  eg. DDT (Dichloro Diphenyl Trichloro ethane), Aldrin, Dieldrin
- Organiphosphate insecticides are more toxic to the animals as compared to the organochlorine but still preferred more due to their less persistent in soil.
  eg. Parathion, Malathion
- Carbamate insecticides are readily breakdown by the microorganisms.

Fate of pesticides in soil :

The most common fates are listed below :

1. **Absorption** is the uptake of pesticide molecules into plant tissues. This action removes the pesticide from the environment, and prevents the pesticide from becoming a water contaminant.
2. **Adsorption** is the physical binding of pesticide molecules to soil particles. The strength of the bonds depends on the interaction of the pesticide's chemical properties, its concentration in the soil water, the soil pH and the composition of the soil (percent sand, silt, loam, clay, and organic matter).
3. **Erosion** is the movement of soil particles from the application site by heavy rains or excess irrigation. If the pesticide is adsorbed to the soil particle, the pesticide is also being moved off site.
4. **Movement in runoff water** occurs when soluble or insoluble pesticides move from the application site across the soil surface, either dissolved or suspended in runoff waters.
5. **Leaching to groundwater** occurs when soluble pesticides move downward through the soil to the groundwater. A highly soluble pesticide will tend to readily leach into groundwater.

6. **Degradation:** As soon as the pesticide is applied, it begins to break down or degrade into simpler compounds which are usually less toxic. Each pesticide has its own speed of degradation, which depends on the active ingredient, the formulation, and environmental conditions. Most microorganisms-a category which includes bacteria, viruses, fungi, algae, and protozoa-live in the upper foot of soil where they find warm temperatures, moisture, and organic matter, and where they do most of their work degrading pesticides. Microorganisms are most active in soils having high organic matter.
7. **Volatilization:** A liquid chemical on a plant or soil surface can be converted into a vapor, which escapes into the atmosphere. Pesticide vapors that drift through the air may be hazardous to plants, humans, and animals. Applicators should read the label carefully to find warnings that will tell them that the pesticide is volatile. Look for a statement like this in the Environmental Hazards section of the label: “Vapors from this product may injure susceptible plants in the immediate vicinity.”

Remedies :

1. Use optimum dose.
2. Apply FYM for adsorption.
3. Ploughing of contaminated land to dilute toxic residues.
4. Crop rotation to avoid repeated use of particular chemicals.
5. Use of bio agents rather using chemicals.
6. Bio degradation using specific microorganisms

Lesson No. 3

Fertilizers and their classification

Fertiliilzers : Any organic or inorganic material of natural or synthetic origin added to a soil to supply certain element essential for the growth of plants.

Fertilizers are classified on the basis of major nutrient content.

1. Nitrogenous fertilizers ;

1. Nitrate fertilizers : Nitrogen is in. oxidised form i.e. NO_3
2. Ammoniacal fertilizers: Nitrogen is in reduced form i.e. NH_4-N
3. Nitrate and ammonium fertilizers : Nitrogen is in the form of NO_3-N + NH_4-N e.g.
4. Amide fertilizers: Organic nitrogenous fertilizers nitrogen, in amide (NH_2) form

2. Phosphatic fertilizers :

1. Water soluble/Monocalcium phosphate: $Ca(H_2PO_4)_2$
2. Citric acid soluble/Dicalcium phosphate ($CaHP0_4$)
3. Insoluble/Tricalcium phosphate - $Ca_3(PO_4)_2$ Acid soluble

3. Potassic fertilizers

1. Fertilizers having K in the chloride form e.g. KCl
2. Fertilizers having K in non-chloride form e.g. K_2SO_4 and KNO_3.

Lesson No. 4 and 5

N fertilizers : classification, manufacturing process and properties, their fate and reaction

Classification of nitrogenous fertilizers : Nitrogenous fertilizers are classified into four groups on the basis of chemical form in which nitrogen is combined with other elements.

1. Nitrate fertilizers: Nitrogen is in. oxidised form i.e. NO_3

e. g. a) Sodium nitrate ($NaNO_3$) - 16 % N

b) Calcium nitrate [($Ca(NO_3)_2$)] -- 15.5 % N

2. Ammoniacal fertilizers: Nitrogen is in reduced form i.e. NH_4-N

e.g. i) Ammonium sulphate [$(NH_4)2SO_4$] --- 20 % N

ii) Ammonium chloride (NH_4CI) -- 26 % N

iii) Anhydrous ammonia - 82 % N

iv) Ammonium phosphate ($NH_4H_2PO_4$) - 20% N + 20 % P_2O_5

16 % N + 20 % P_2O_5

3. Nitrate and ammonium fertilizers : Nitrogen is in the form of NO_3-N + NH_4-N e.g.

i) Ammonium nitrate (NH_4NO_3) --- 34% N

ii) Calcium ammonium nitrate ---- 26 %N

iii) Ammonium sulphate nitrate --- 26 % N

4. Amide fertilizers: Organic nitrogenous fertilizers nitrogen, in amide (NH_2) form e.g.

i) Urea [$CO(NH_2)_2$] ------- 46 % N

ii) Calcium cynamide ($CaCN_2$) ----- 21 %

Sources of nitrogen : Mineral deposits, rain water, soil organic matter, atmospheric N and industrial source.

Manufacturing of Urea :

Urea is manufactured by reacting anhydrous ammonia and carbon dioxide gas under very high pressure in the presence of suitable catalyst.

i) $2NH_3 + CO_2 = NH_2COONH_4$

(an unstable intermediate product)

ii) $NH_2COONH_4 = CO(NH_2)_2 + H_2O$

The urea solution is concentrated to 99% and is sprayed into a chamber where urea crystal are formed.

Manufacturing of Ammonium sulphate $(NH_4)_2SO_4$:

In India, it is manufactured by two processes,

i) *by gypsum process* and

ii) as a *by product of coal and steel industries*.

a. Gypsum process

The main raw material required in the gypsum process are ammonia, pulverized calcium sulphate, carbon dioxide and water. Briefly the process consists of,

i) making ammonia by the synthesis of nitrogen and hydrogen, and

ii) making ammonium carbonate by reacting ammonia with carbon dioxide gas.

Finally, ground gypsum is reacted with a solution of ammonium carbonate to produce ammonium sulphate and calcium carbonate.

$3H_2 + N_2 = 2NH_3$

$2NH_3 + H_2O + CO_2 = (NH_4)2CO_3 + H_2O$

$(NH_4)2CO_3 + CaSO_4 = (NH_4)2SO_4 + CaCO_3$

b. By product of coal and steel industries

Coal contains on an average 1 % nitrogen. When coal is distilled in closed ovens, a portion of nitrogen is volatilized as ammonia and ammonium salts are retained in the wash water. Slaked lime (ammoniacal liquor) is added to this water, which is then distilled and the ammonia produced is absorbed in sulphuric acid. Ammonia and sulphuric acid combine to give ammonium sulphate.

Coal/NH_3 gas/ With $H_2O/(NH_4)_2CO_3 + CO_2$

$(NH_4)_2CO_3 + Ca(OH)_2 = 2NH_3 + 2H_2O + CaCO_3$

$2NH_3 + H_2SO_4 = (NH_4)_2SO_4$

Fate of nitrogen in soil:

- Nitrate nitrogen of the soil, added or formed by nitrification, may be loss in four ways,

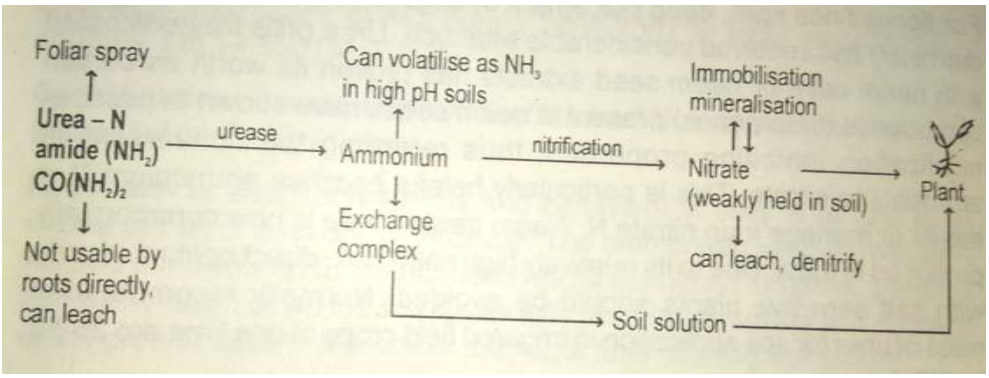
i) Volatilization loss

ii) Leaching loss

iii) Denitrification

iv) Used by microorganisms and weeds

Fate of urea in soil:



Management of nitrogenous fertilizers:

1. For paddy , ammonical and ammonia forming fertilizers should be used.
2. For all other field crops, a II nitrogenous fertilizers are equally effective.
3. On acid soils or soils low in lime/calcium, continued use of ammonium sulphate, urea, ammonium chloride and ammonium sulphate nitrate should be avoided.
4. A nitrate fertilizer like sodium nitrate is suited for top dressing and side dressing when growing crops need nitrogen immediately.
5. Since nitrate fertilizers are easily leached, they should not be applied in large quantities in light sandy soils or during the rainy season. In sandy soils, the entire recommended dose of nitrogen should be applied in split doses.
6. In the winter or rabi season, the nitrogenous fertilizer should be selected on the basis of cheapness per unit kg of nitrogen; as all nitrogenous fertilizers are equally effective and loss of nitrogen due to leaching does not usually occur.

Lesson No. 6 and 7

Phosphatic fertilizers, manufacturing process and properties

Phosphatic fertilizers : Manufacturing process and properties of single super phosphate, enriched super phosphate, ammonium phosphate, ammonium polyphosphate

Classification of phosphatic fertilizers : Phosphatic fertilizers are classified into three groups, depending *on* the *form* in .which orthophosphoric acid/phosphoric acid is combined with calcium.

1. Water soluble/Monocalcium phosphate: $Ca(H_2PO_4)_2$

i) Single super-phosphate - 16% P_2O_5

ii) Double super-phosphate - 32 % P_2O_5

iii) Triple super-phosphate - 48 % P_2O_5

iv) Ammonium phosphate - 11 %N + 52% P_2O_5

Characteristics:

- It is available to the plants quickly.
- It rapidly transformed into water- insoluble form, thus little loss of nutrient by leaching.
- Suitable to use on neutral to alkaline soil – in acidic soil it is converted to Fe and Al phosphates.

2. Citric acid soluble/Dicalcium phosphate ($CaHP0_4$)

i) Basic slag - 14 to 18 % P_2O_5

ii) Tricalcium phosphate - 34% to 39 % P_2O_5

Characteristics:

- The fertilizer of this group is suitable for acid soils.

- Because with low pH, citric acid soluble phosphoric acid gets converted into monocalcium phosphate or water soluble phosphate and there are less chances of phosphate getting fixed as iron and aluminium phosphates.

3. Insoluble/Tricalcium phosphate - $Ca_3(PO_4)_2$ Acid soluble

i) Rock-phosphate - 20 to 40 % P_2O_5

ii) Raw bonemeal - 20 to 25 %10 P_2O_5

iii) Steamed bonemeal - 22 % P_2O_5

Characteristics:

- These fertilizers are well suited for strongly acidic soils or organic soils which requires 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 other organic materials.

Manufacturing of single super phosphate:

- Approximately equal amounts of rock phosphate and Conc. Sulphuric acid (70 %) are weighed separately and mixed for about one minute in mechanical rotators.
- The warm mixture is then falls through a flap into a huge den where chemical reactions continue.
- The mixture is left in den for 12 hrs to harden and cool down.
- Then, it is removed by a crane and deposited in a large shed to mature.
- After some weeks, it becomes ready for use.
- Before bagging, it is necessary to grind the fertilizer.
- Thus, two important ingredients of superphosphate are Monocalcium phosphate and Gypsum.

Reactions of single super-phosphate in soils :

a) Neutral soils

$$Ca(H_2PO_4)_2 + Ca(HCO_3)_2 \text{ ----- } 2CaHPO_4 + 2H_2CO_3$$

b) Alkaline soils

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

2) $Ca(H_2PO_4)_2 + 2Ca(HCO_3)_2 = Ca(PO_4)_2 + 4H_3CO_3$

c) Acidic soils:

$$2Ca\ (H_2PO_4)_2 + Fe\ _2O_3 = 2\ Fe\ PO_4 + 2\ CaHPO_4 + 3\ H_2O$$

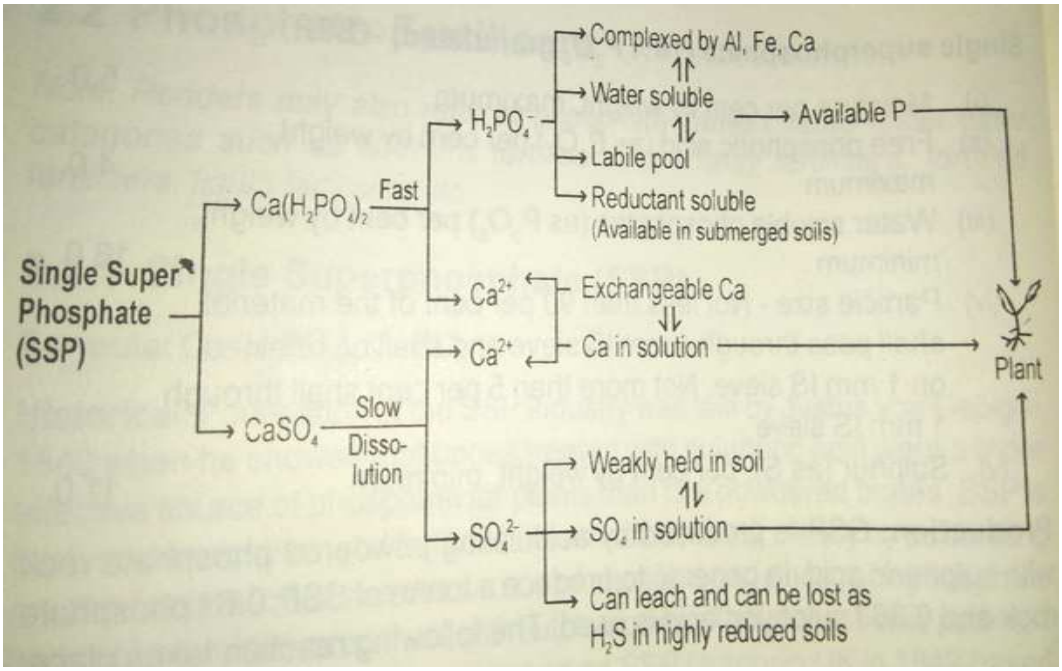
Reactions of Rock-Phosphate in soils :

a) Acidic soils

i) $[Ca_3(PO_4)\ _2]\ 3CaCO_3 + 6H_2CO_3 = 3Ca(H2PO_4)_2 + 7CaCO_3$

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

Fate of SSP in soil



Management of phosphatic fertilizers:

1. Water soluble phosphatic fertilizers are suitable for slightly acidic, neutral or alkaline soils.
2. W.S.P. fertilizers are applied to soils when crop requires a quick start.
3. W.S.P. fertilizers are suitable for short duration crops like paddy, wheat, jowar, ragi, maize, soybeans, cabbage, cauliflower, potato, gram & Vegetable crops.
4. Citrate soluble phosphatic fertilizers are suitable for moderately acidic soils, long duration crops like sugarcane, tapioca, tea, coffee, legume & pastures.
5. Insoluble phosphatic fertilizers are suitable for the soil which is strongly to extremely acidic & long duration fruits crops.
6. SSP should be applied to the soil just before sowing in single dose.
7. SSP is unsuitable for top-dressing due to slow mobility for short duration crops and it should not be used in acidic soils.

Lesson No. 8

Potassic fertilizers and complex fertilizers, their fate and reaction in soils.

Classification of Potassic fertilizers

Potassic fertilizers are mainly classified into

1) Fertilizers having K in the chloride form e.g. KCl

2) Fertilizers having K in non-chloride form e.g. K_2SO_4 and KNO_3.

Source of potassic fertilizers : Mainly from water soluble potash minerals, and small extent from brine. The potash containing soluble minerals are

1) Sylvite KCl 63.1 % K_2O

2) Carnallite KCl. $6H_2O$ 17.0 % K_2O

3) Kainite KCl. $MgSI_4.3H_2O$ 18.9 % K_2O

4) Langbeinite $K_2SO_4 2MgSO_4$ 22.6 % K_2O

5) Sylvinite (mixture) 20.3 % K_2O

Classification and properties of potassic fertilizers

1) Potassium chloride / muriate of potash (KCl)

- K with Cl as anion chloride containing fertilizer.
- K_2O content 55 – 50 %
- Mineral used sylvite and carnalite

2) Potassium sulphate (K_2SO_4)

- Non chloride fertilizer
- Pure salt content – 54 % K2O
- Commercial salt content – 48 % K2O
- Mineral used kainite and longbeinite

3) Shoenite : K_2SO_4. $MgSO_4.6H_2O$

- It is double salt of SO_4 with K and Mg
- It is by product of marine salt works
- K_2O 25-30 %
- MgO 10-12 %

Manufacturing of MOP

It is manufactured from potash bearing minerals mainly by two processes,

i) Crystallization: The principle involved in this process is that KCl is much more soluble in hot water than cold. While, the solubility of NaCl is not vary with temperature.

ii) Floatation: This method is based on the differences in specific gravity of KCl and NaCl. KCl having less Sp. Gravity floating on top of NaCl.

Manufacturing of SOP

i) By dissolving langbeinite in water and adding a conc. solution of KCl. The potassium sulphate is precipitate out and is separated by decantation.

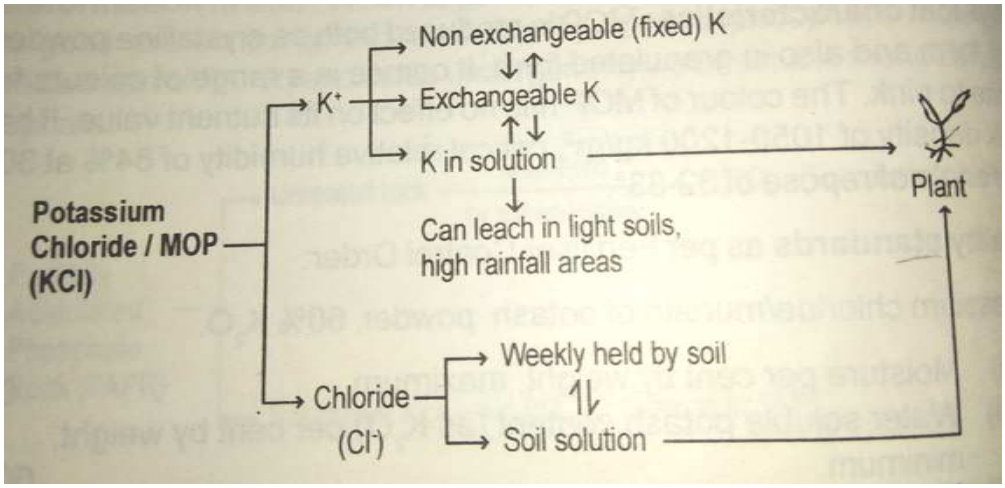
$$K_2SO_4.2MgSO_4 + 4KCl = 3K_2SO_4 + 2MgCl_2$$

langbeinite

ii) By treating KCl with Conc. H_2SO_4

$$2KCl + H_2SO_4 = K_2SO_4 + 2HCl$$

Fate of MOP in soil



Management of potassic fertilizers :

KCl is cheaper fertilizer and extensively used by the cultivators for all crops except where no chloride is desired in the fertilizer, e.g. Tabacco.

K_2SO_4 is some what costlier on the basis of per unit of K as compared to KCl and used for the crops like potato, tobacco and tomato.

Complex fertilizers

The commercial fertilizers containing atleast two or more of the primary essential plant nutrients (N, P, K) are called complex fertilizers. When the fertilizer contains only two of the primary nutrients it is designated as incomplete complex fertilizer, while one containing all three primary major nutrients (N, P and K) is designated as complete complex fertilizer.

These fertilizers are manufactured in general by :
a) Chemical reaction and b) Purely mechanical mixing *of* straight fertilizers.

Characteristics of complex fertilizer :

1. High analysis fertilizers
2. Have Uniform grain size
3. Cheaper on the basis of nutrient content per Kg.
4. Transport and distribution cost is less
5. Safe for storage
6. Desirable as these contain balanced nutrients *for* applications.
7. Non caking and non hygroscopic.

Advantages of complex fertilizers :

1. Easy application
2. Balanced crop nutrition.
3. High fertilizer efficiency
4. Even distribution of nutrients
5. Saving of Iabour and time
6. Safe for storage.

High analysis fertilizer : Fertilizers have a high content of total plant nutrients more than 30 kg per 100 kg of fertilizer.

Manufacture, properties and nutrient content of complex fertilizers

Nitrophosphate : Manufacture :

1. Nitro carbonic process

2. Nitro-separation process
3. Process involving nitric acid & phosphoric acid
4. Process involving nitric acid.

Properties of nitrophosphates :

1. Granulated fertilizer containing stabilizer
2. Contains Nitrogen as well as phosphorus
3. Excellent physical conditions during storage and handling.

RCF (Trombay) manufactures three types of nitrophosphates

1) Suphala (20:20:0) 2) Suphala 3) Suphala (15:15:15).

Ammonium phosphate : Manufactured by combing ammonia with phosphoric acid. Monoamonium phosphate. (MAP). Diaimmonium phosphate (DAP) is popular having 11 :52:0 and 18:46:0 grades respectively.

Characteristics of Ammo. Phosphates:

1. Slightly grey material
2. Slightly acidic to neutral
3. Produce acidity in soil if used continuously and require 80 Kg of $CaCO_3$ to counteract its acidity
4. It is least hygroscopic.

Various grades of ammonium phosphates are manufactured. NPK Complex fertilizers: Complex fertilizers containing various composition of N, P and K. These are manufactured for application to various crops.

Value of complex fertilizers : The value of complex fertilizers is dependent on the following considerations.

1. Their content of individual nutrients and ratio of N, P, K.
2. Form in which individual nutrients are present
3. The resultant basic or acidic residual effect.
4. These contain trace elements and contamination substances viz. chlorides, sulphates etc.

Lesson No. 9 and 10

Secondary nutrients and fertilizers, their type, composition, reaction in soils and effect on crop growth

Secondary nutrients fertilizers : Gypsum, magnisium sulphate, Dolomite, elemental sulphur are used as secondary nutrients fertilizers.

Calcium :

- The neutral and slightly alkaline soils of India are rich in calcium.
- The acid soils of India are low in calcium, particularly in high rainfall areas.
- Among the various fertilizers and soil amendments containing calcium, superphosphate and calcium ammonium nitrate are used on large scale.
- Legumes are generally more responsive to Ca than cereals.

Fertilizers supply calcium

- Calcium nitrate …….. 19.5 % Ca
- Calcium ammon. Nitrate… 8.1 % Ca
- Superphosphate …… 19.5 % Ca
- Dicalcium phosphate ……. 22.9 % Ca
- Limestone ……..32.3 % Ca
- Gypsum ……..…..29.2 % Ca

Magnesium :

- Magnesium deficiency can be problem in leached, acid soils under high rainfall.
- It is indirectly applied to the soil through commercial fertilizers and soil amendments, as some of these materials contain Mg.

Fertilizers supply magnesium

- Dolomite limestone …….. 4.0 - 10.6 % Mg
- Calcium ammon. Nitrate… 4.5 % Mg
- Basic slag …… 3.4 % Mg
- Superphosphate …… 0.3 % Mg

Sulphur:

- Sulphur is considered as the fourth major nutrient for plant growth.
- Sulphur plays an important role in improving the quality and marketability of the produce.
- Increases oil content in seed by synthesis of S containing amino acids and protein percent.
- Increases starch content of tubers.
- Improve baking quality of wheat.
- Increase sugar recovery in sugarcane etc.

Fertilizers supply sulphur :

- Elemental sulphur ……. 90 % S
- Bentonite sulphur ……... 80-90 % S
- Ammonium sulphate …….. 24 % S
- Superphosphate ……..... 12 % S
- Potassium sulphate …….. 18 % S
- Gypsum …….. 13-18 % S

Soil Amendments :

Management of acid soil

Acid soils can be managed in two ways

1. By growing, crops suitable for particular soil pH
2. By ameliorating the soils through the application of amendments, which will counteract soil solids

Lime requirement of acid soils :

The amount of lime required to be added to acidic soil to raise the pH to a desired value.

Liming materials are :

1. Calcic limestone ($CaCO_3$)
2. Dolomite limestone ($Ca\ Mg\ (CO_3)_2$)
3. Quicklime (CaO)
4. Hydrated (Staked) lime ($Ca\ (OH)_2$)
5. Chalk ($CaCO_3$)
6. Basic Slag

Amendments used for reclamation of sodic soil

1. Soluble calcium salts : Gypsum and calcium chloride – Reaction with equation.
2. Acids or acidic formers : Sulphur, Sulphuric acid, iron sulphates, iron pyrites with equations.

Lesson No. 11

Micronutrient fertilizers, their type, composition, reaction in soils and effect on crop growth

Micronutrient : Micronutrient is a chemical element necessary only in extremely small amounts (usually less than 50 ppm in plants) for growth of plants. Fe, Mn, Zn, Cu, Mo, B and Cl are essential micronutrients.

Micronutrient fertilizers : The carriers used as fertilizers to supply, micronutrients are called as micronutrient fertilizers.

Classification of micronutrient fertilizers

1. Straight inorganic salts
2. Natural and synthetic chelates as carriers of micronutrients .

1. Straight inorganic salts :

Micro Nutrients	Name of salt	Nutrient	Rate of application	
			Soil	Spray
Iron (Fe)	Ferrous sulphate $FeSO_4.7H_2O$	20 % Fe	10 kg/ha $FeSO_4$	0.4 %
Zinc (Zn)	Zinc sulphate $ZnSO_4.7H_2O$	22 to 35 % Zn	40 to 50 kg/ha $ZnSO_4$	0.5 %
Copper (Cu)	Copper sulphate $CuSO_4.5H_2O$	25 to 35 % Cu	10 to 50 kg/ha $CuSO_4$	0.1%
Mangnese (Mn)	Mangnese sulphate $MnSO_4.4H_2O$	23 % Mn	10-15 kg/ha $MnSO_4$	0.6 %
Boron (B)	Borax (Sodium Borate) $Na_2B_4O_7.10H_2O$	10.6 % B	5-20 kg/ha Borax	0.2 % Boric acid
Molybdenum (Mo)	Ammonium molybdate $(NH_4)_6 Mo_7 O24, 4H_2O$	52 % Mo	0.14 kg/ha Mo or 1.12 kg/ha amino Molybdate (0.0) to 2.37	0.05 % Ammo. Molybdate

2. Synthetic and natural chelates :

Chelates : It is a term applied to compounds which tightly hold certain cations that are attracted towards them and release them slowly for utilisation by plants.

Chelates are generally organic compounds that combine with cations like Fe, Mn, Zn, Cu in complex ring structure.

Chelating compounds or agents :

EDTA, DTPA, EDDHA, CDTA, NTA

Natural chelates : FYM and other organic manures contain the organic substances which acts as chelating compound. Therefore micronutrient salts applied through FYM and manures are slowly released and made available to plants.

Effects on crop growth :

1. Essential nutrients for life & growth of plants
2. Help to form enzymes or vitamins
3. Aid in keeping another element reduced or oxidised.
4. Increase the resistance to diseases
5. Interact with secondary and major plant nutrients.
6. Directly influence the activity of micro organisms.
7. Excess of micronutrients may create toxicity in plants.

Reactions of micronutrient / fertilizers in soil :

The different soil conditions influence the availability of micronutrients. The soil acidity, alkalinity, organic matter content, temporary water logging conditions, application of phosphotic and potassic fertilizers in soil are important factors which reduce or increase the availability of applied micronutrients.

When soil contains more lime, there is a iron deficiency. Excess phosphate fertilization induced iron chlorosis and Zn deficiency and favors molybdenum availability (Antagonistic effect).

High potassium application creates manganese deficiency. Boron does not normally occur in toxic quantities on most arable soils.

Decrease in acidity generally reduces the availability of copper. An increase in pH brings about a conversion of bivalent Mn compound to unavailable MnO.

Fate of micronutrients in soil :

1. Micronutrient cations interact with silicate clays in two ways,
   a) They may be involved in cation exchange reactions much like those of Ca or H.
   b) They may be more tightly bound or fixed to certain silicate clays (2:1 type).
2. Zinc, manganese, cobalt and iron ions are found as elements in the crystal structure of silicate clays.
3. Depending on the conditions, they may be released from the clays or fixed. The fixation may be serious in the case of cobalt and sometimes zinc.
4. The uptake of both Fe and Zn may be reduced in the presence of excess phosphates.
5. The micronutrient cations may be held in organic combination. The organic compounds in which these cations are combined include proteins, amino acids, humus, citric and tartaric acid.
6. When an inorganic iron salt such as ferric sulphate is added to a calcareous soil, most of the iron is quickly unavailable by reaction with hydroxide.

   Fe^{3+} + $3OH^-$ → FeOOH + H_2O

   available unavailable
7. If the iron is added in the form of an iron chelate, such as FeEDDHA, the iron remains in the chelate form, which is available for uptake by plants.

   FeEDDHA + $3\ OH^-$ → FeOOH + $EDDHA^{3-}$ + H_2O

   available unavailable
8. If a Zinc chelate is added to a soil with significant quantities of available iron, the following reaction may occur,

   Zn chelate + Fe^{2+} → Fe chelate + Zn^{2+}

Lesson No. 12

Liquid fertilizers

Application of fertilizer in liquid form :

I. Foliar application : A dilute solution of fertilizer is sprayed on plants in standing crop. One or many nutrients are sprayed together. The effect of foliar application is more than soil application.

II. Application with irrigation water : Soluble NPK fertilizers are added in irrigation channel from which nutrients reach with irrigation water in whole field.

III. Direct use of fertilizer solution : The use of fertilizer solution is limited in our country.

IV. Direct use of liquid fertilizer : Fertilizers in liquid form available, used directly in field.

Fertigation equipments :

i. Vacuum injection (Venturi)
ii. Fertilizer tank
iii. Pump injection

Sources of NPK water soluble fertilizers :

Sr. No.	Ferilizer	Content
Nitrogenous fertilizers		
1.	Urea	46 – 0 – 0
2.	Ammonium sulphate	21 – 0 – 0
3.	Ammonium nitrate	34 – 0 – 0
4.	Calcium nitrate	15 – 0 – 0
Phosphatic fertilizers		
1.	Mono ammonium phosphate(MAP)	12 : 61 : 0
2.	Phosphoric acid	0 : 85 : 0
Potassic fertilizers		
1.	Muriate of potash (MOP)	0 : 0 : 60
2.	Nitrate of potash (NOP)	13 : 0 : 46
3.	Sulphate of potash (SOP)	0 : 0 : 50

Lesson No. 13

Handling and storage of fertilizers

Fertilizers differ in their ability to become moist or hygroscopic, as such they have to be handled during rainy season.

Main features from storage point of view are as below

i. Ammonium chloride : Excellent, no difficulty in storage and handling

ii. Ammonium nitrate : Storage properties satisfactory but fertilizer is hygroscopic. So bags are firmly tied. As it is fire hazardous handle carefully. It is bagged in polythene lined jute bags as it is hygroscopic.

iii. Urea : Storage properties satisfactory. Hygroscopic, store in polythene lined jute bags in dry place.

iv. Ammonium sulphate : Storage properties good,

v. Sodium nitrate : no difficulties in handling & storage.

Phosphatic fertilizers:

1) Single super phosphate:

i) It contains small amount of acid. which deteriorate gunny bags, hence it should be stored in polythelene lined gunny bags.

ii) Cakes formation in moist condition.

2) Dicalcium phosphate - Excellent physical condition.

Potassic fertilizers:

Potassium sulphate Excellent physical condition for

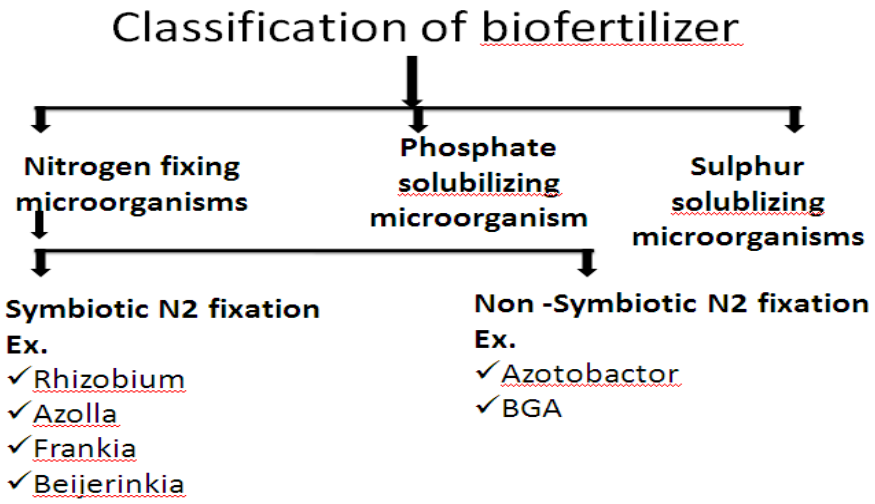
Potassium chloride storage and handling.

Protect all fertilizer bags from moisture, water and rains. Protect bags against excessive sunshine and heat by making use to shade of trees structures & covers.

Lesson No. 14

Biofertilizers and their role in crop production

Biofertilizers : are defined as the preparation containing live or latent cells of efficient strains of nitrogen fixing, phosphate solubilizing or cellulolytic microorganisms used for the application to seed, soil or composting areas with on objective of increasing numbers of such microorganisms and to accelerate certain microbial processes to augment the extent of availability of nutrients in a form which can be easily assimilated by plants.



Rhizobium

- Belong to family rhizobiaceae
- Symbiotic in nature
- Associated with legume only.
- Enters into root through root hairs.
- Pink colour of nodules due to legheamoglobin
- Ex.Soybean-*Rhizobium japonicam*

Azotobacter

- Belong to familly azotobacteriaceae
- Hetrotopic in nature and free living
- Non symbiotic in nature

- To fixes upto 20-40 kg N /ha
- To produce growth promoting substance like vit-of B group, IAA and GA-3
- Used for cereals,millets,cotton,sugarcane,vegetables at 25gm/kg of seed

Azospirillum

- Associative in nature
- Belong to familly sprilacae
- Chemoheterotropic in nature
- To produce growth promoting substance
- To fixes upto 20-40 kg N /ha
- They save nitrogen fertilizers by 25-30 percent
- 15-30 percent increase of crop yield
- Eg.rice,mazie,wheat,cotton,sunflower

PSM

- PSM are microorganisms and mainly bacteria and fungus
- Save upto 30 kg P2O5/ha
- To produce harmones like IAA,GA,and cytokinins
- Bacteria-Bacillus, Pseudomonas
- Fungi- Aspergillus , Penicillium

BGA

- Phototrophic in nature
- It uses sunlight for energy and water for photosynthesis
- To produce the Auxins,IAA,and GA-3
- To fixes upto 20-30 kg N /ha
- To increase paddy yield about 15-20 percent

Azolla

- Symbiotic in nature
- Suitable only for flooded rice
- Fixes upto 40-80 kg N/ha
- To increase yield upto 40-80 kg/ha

- Use as green manures
- Most important species found in india is pinnata

Method of application of biofertilizer

1) Seed Treatment
2) Seedling Inoculation
3) Set Inoculation
    A) Pasting of Eye Buds
    B) Sugarcane Set Inoculation
4) Soil Inoculation
5) Seed Pelleting

Contribution of biofertilizers in Agriculture :

1. They supplements fertilizer for meeting the nutrient needs of crops.
2. They can add 20-200 kg N/ ha under optimum condition and stabilizes / mobilize 30-50 kg P_2O_5 / ha.
3. They liberate growth promoting substances and vitamins and help to maintain soil fertility.
4. They suppress the incidence of pathogens and control diseases.
5. They increase crop yield by 10-50 %.
6. They are cheaper and pollution free.
7. They improve soil physical properties, tilth and soil health in general.

Lesson No. 15

Fertilizer control order

Fertilizer control order :

An order issued by the Government of India under powers conferred by Section 3 of the Essential Commodities Act 1955, under the powers, the Government controls the production, marketing, price and quality of fertilizers. There are **39 Clauses** of this order covering definitions, prices, registration of dealers and fertilizer mixtures, regulation on manufacture cell packing requirement, disposal of non-slandered fertilizers, enforcement authority, analysis of samples, etc. The schedule I of the order includes detailed specifications of fertilizers covered by it. In schedule II detailed procedure regarding sampling technique and methods of analysis is given.

Urea

Particular	**Specification**
Moisture per cent by weight, maximum	1.0
Total nitrogen per cent by weight (on dry wt basis) minimum	46.0
Biuret per cent by weight, maximum	1.5
Particle size – Not < 90 % of the material shall pass through 2.8 mm sieve and not < 80 % by weight, shall retained on 1 mm sieve.	

Ammonium sulphate

Particular	**Specification**
Moisture per cent by weight, maximum	1.0
Ammonical nitrogen per cent by weight, min.	20.6
Free acidity (as H_2SO_4) per cent by weight, maximum	0.025
Arsenic as (AS_2O_3) per cent by weight, maximum	0.01
Sulphur (as S), per cent by weight, minimum	23.0

Single super phosphate

Particular	Specification
Moisture per cent by weight, maximum	5.0
Free phosphoric acid (as P_2O_5) per cent by weight, maximum	4.0
Water soluble phosphates (as P_2O_5) per cent by weight, minimum	16.0
Sulphur (as S), per cent by weight, minimum	11.0
Particle size – Not < 90 % of the material shall pass through 4 mm sieve and be retained on 1 mm sieve. Not > 5 % shall be below 1 mm sieve.	

MOP

Particular	Specification
Moisture per cent by weight, maximum	0.5
Water soluble potash (as K_2O) per cent by weight, minimum	60.0
Sodium (as NaCl), per cent by weight, minimum	3.5
Particle size – Minimum 65 % of the material shall pass through 1.7 mm sieve and be retained on 0.25 mm sieve.	

Compiled by…….

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