COURSE NO : SSAC-353

Course Title : Manures, Fertilizers and Soil Fertility Management

Course Credits : 3 (2+1)

SEMESTER V (New)

(Part –II)

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Teaching Schedule (Part II)

A. THEORY

Lesson	Topic	Weightage (%)
22 & 23	Secondary &micronutrient fertilizers: Types, composition, reaction in soil and effect on crop growth. Soil amendments.	5
24	Handling and storage of fertilizers: Fertilizer control order.	3
25 & 26	Mechanism of nutrient transport to plants: Factors affecting nutrient availability to plants. Measures to overcome deficiencies and toxicities.	6
27,28 & 29,	Chemistry of soil N,P, K, calcium, magnesium, sulphur and micronutrients.	6
30 & 31	Soil fertility evaluation and different approaches.	6
32	Soil Testing (Available nutrients) : Chemical methods and critical levels of different nutrients in soil.	6
33	Plant analysis methods : Critical levels of nutrients, DRIS approach, rapid tissue test, indicator plants. Soil test based fertilizer recommendations to crops.	6
34 & 35	Methods and scheduling of nutrient applications for different soils and crops grown under rain fed and irrigated conditions.	6
36	Factors influencing nutrients use efficiency (NUE) in respect of N, P, K, S, Fe and Zn fertilizers.	5

Suggested Readings :

1) ISSS (2009) Fundamentals of Soil Science. 2nd Ed. Indian Society of Soil Science, New Delhi- 110 012. pp. 728.
2) Havlin, John L, Samuel L. Tisdale (Author), Werner L. Nelson (Author), James D. Beaton (2004) Soil Fertility and Fertilizers (8th Edition) 8th Edition. Published July 23rd 2004 by Prentice Hall. pp. 528.
3) 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.
4) Tandon, HLS (2008) Fertilizers : Their composition, characteristics, quality, transformation and application. Fertilizer Development and Consultation, New Delhi, India pp. 137.
5) Yawalkar, K. S., Agarwal, J. P. and Bokde, S. (1967) Manures and Fertilizers. Agri-Horticultural Publication.
6) Das D. K. (2011) Introductory Soil Science, 3rd revised and Enlarged Ed, Kalyani Publisher, Ludhiana. pp. 645.
7) Tandon H. L. S. (1994) Recycling of crop, animal, human and industrial Wastes in Agriculture. FDCO, Delhi

Lesson No. 22 and 23

Secondary & micronutrient fertilizers: Types, composition, reaction in soil and effect on crop growth. Soil amendments.

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

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.

Reactions of micronutrients in soil:
1. Micronutrient cations interact with silicate in two ways
   a) They may be involved in cation exchange reaction Ca of H
   b) They may be more tightly bound or fixed to certain silicate clays (2:1 type).
2. Zn, Co, Mn & Fe ions are found as elements in crystals of silicate clay.
3. Depending on the conditions they may be released from the clays or fixed.
4. The fixation may be serious in the case of cobalt and sometimes Zn.
5. The uptake of Fe & Zn may be reduced in the presume of excess P.
6. Micronutrient cations may be held in the Organic Cemlimation (Protein, aminoacids, Humus, citric and tartaric acid).
7. When an. inorganic iron salt such as $FeSO_4$ is added to calcareous soil most of the Fe is quickly rendered unavailable by reaction with hydroxide.

   $Fe^{3+} + 3OH^- \text{----------} \rightarrow FeOOH + H_2O$

   Available ←---------- Unavailable
8. If iron is added in the form of Fe chelate the iron remains in the chelate form which is available to plant.

FeEDDHA + 3 OH ------→ FeOOH + EDDHA-3 +
Available ←----- Ethyl Diomine Dihydroxy pheylactic acid. H_2O.

9. In chelate is added to a soil with significant quantities of available Iron.
   Zn Chelate + Fe -----→ Fe chelate + Zn

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

Amelioration (Reclamation) of acid soil

The application of substances containing calcium and magnesium such as lime, limestone, dolomite, etc. is the common practice for the improvement of acid soils.

$CaO + H_2O \longrightarrow Ca(OH)_2$

$Ca(OH)_2 + 2\,CO_2 \longrightarrow Ca(HCO_3)_2$

$CaCO_3 + H_2O + CO_2 \longrightarrow Ca(HCO_3)_2$

$CaMg(CO_3)_2 + 2\,H_2O + 2CO_2 \longrightarrow Ca(HCO_3) + Mg(HCO_3)_2$

Soluble bicarbonates that reast with the soil colloids

H_2 – Clay + $Ca(HCO_3)_2 \longrightarrow$ Ca – Clay + $2H_2CO_3$

H^+[Colloid] + H_2O + $Ca(OH)_2 \longrightarrow Ca^{++}$ + [Calloid] + $2H^+$

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
7. Fly ash

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. 24

Handling and storage of fertilizers: Fertilizer control order.

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.

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.

Lesson No. 25 and 26

Mechanism of nutrient transport to plants: Factors affecting nutrient availability to plants. Measures to overcome deficiencies and toxicities.

Mechanism of Nutrient transport to plants
Mechanism of transport of ions from soil to roots

1) Mass flow 2) Diffusion 3) Root interception.

1) **Mass flow -** movement of solutes alongwith water to root surfaces in response to hydraulic gradient.

2) **Diffusion –** Originally conceived by Grahm and Fick. It is the process of transport of ions or molecules in response to concentration gradient

Equationally = Dq = dc /dt x dc / dx
Where dc = rate of diffusion (change in conc. C with time)
dt = time
dx = Concentration gradient (Change in concentration with distance)
Dc = effective diffusion coefficient
A = Cross-sectional area through which the ions diffuse
Fick's law = state that the rate of diffusion is proportional to the concentrations gradient

3) Root interception - Ions in the soil that are intercepted by the growth of the root through the soil and hence do not have to move to the root before absorption.

Important considerations

1) The mass flow and diffusion are the major components that supply nutrients simultaneously close to the roots.

2) Nutrient supply depends on the ability of solid phase of soil to supply liquid phase with these ions.

3) Nutrients are supplied first by mass flow and then by diffusion .

Factors affecting ion transport.

1) Physical or passive ion uptake (Non- metabolic process)

2) Active ion uptake (metabolic process)

1) Physical or passive uptake - It involves following hypothesis
i) Mass flow hypothesis ii) Diffusion along concentration gradient
iii) Molecular sieve hypothesis iv) The lipoid solubility hypothesis
v) Ion exchange vi) Donnan's equilibrium

vii) Adsorption
2) Active uptake
i) Landegardh's hypothesis ii) Protein synthesis hypothesis
iii) Protein folding-unfolding iv) Carrier hypothesis
v) Cation and anion pumps

Factors affecting nutrient uptake :

1) Supply of respiratory sub substances 2) Temperature

2) Concentrations of nutrient ions 4) Moisture content

Factors affecting nutrient availability to plants. Measures to overcome deficiencies and toxicities.

Following factors are affecting nutrient availability to plants

1) Soil texture	2) Soil structure
3) Soil reaction	4) Temperature
5) Moisture supply	6) Composition of soil air
7) Supply of mineral nutrient elements	8) Total nutrient content of soil
9) Microbial activity	10) Organic matter content

Measures to overcome deficiencies and toxicities.
Deficiencies can be corrected by appropriate addition of suitable source, may be organic or inorganic fertilizer.
Toxicities are due to more solubility of nutrient toxicities can be control

Lesson No. 27, 28 and 29

Chemistry of soil N,P, K, calcium, magnesium, sulphur and micronutrients.

1. Macronutrients: used in large quantities by the plant
    1. Structural nutrients: C, H, O

    2. Primary nutrients: N, P, K

    3. Secondary nutrients: Ca, Mg, S

2. Micronutrients: used in small quantities by the plant
    1. Fe, B, Cu, Cl, Mn, Mo, Zn, Co, Ni

Plants require eighteen elements found in nature to properly grow and develop. Some of these elements are utilized within the physical plant **structure**, namely **carbon (C), hydrogen (H), and oxygen (O)**. These elements, obtained from the air (CO_2) and water (H_2O), are the basis for carbohydrates such as sugars and starch, which provide the strength of cell walls, stems, and leaves, and are also sources of energy for the plant and organisms that consume the plant.

Elements used in large quantities by the plant are termed **macronutrients**, which can be further defined as **primary** or **secondary**. The primary nutrients include **nitrogen (N), phosphorus (P), and potassium (K)**. These elements contribute to plant nutrient content, function of plant enzymes and biochemical processes, and integrity of plant cells. Deficiency of these nutrients contributes to reduced plant growth, health, and yield; thus they are the three most important nutrients supplied by fertilizers. The secondary nutrients include **calcium (Ca), magnesium (Mg), and sulfur (S)**.

The final essential elements are used in small quantities by the plant, but nevertheless are necessary for plant survival. These **micronutrients** include iron (Fe), boron (B), copper (Cu), chlorine (Cl), Manganese (Mn), molybdenum (Mo), zinc (Zn), cobalt (Co), and nickel (Ni).

The table on the next page lists the essential elements, their status as macro- or micronutrients, their uptake forms, and their plant mobility.

Nutrient	Macro/micro	Uptake form	Mobility in Plant	Mobility in Soil
Carbon	Macro	CO_2, H_2CO_3		
Hydrogen	Macro	H^+, OH^-, H_2O		
Oxygen	Macro	O_2		
Nitrogen	Macro	NO_3^-, NH_4^+	Mobile	Mobile as NO_3^-, immobile as NH_4^+
Phosphorus	Macro	HPO_4^{2-}, $H_2PO_4^-$	Somewhat mobile	Immobile
Potassium	Macro	K^+	Very mobile	Somewhat mobile
Calcium	Macro	Ca^{2+}	Immobile	Somewhat mobile
Magnesium	Macro	Mg^{2+}	Somewhat mobile	Immobile
Sulfur	Macro	SO_4^-	Mobile	Mobile
Boron	Micro	H_3BO_3, BO_3^-	Immobile	Very mobile
Copper	Micro	Cu^{2+}	Immobile	Immobile
Iron	Micro	Fe^{2+}, Fe^{3+}	Immobile	Immobile
Manganese	Micro	Mn^{2+}	Immobile	Mobile
Zinc	Micro	Zn^{2+}	Immobile	Immobile
Molybdenum	Micro	MoO_4^-	Immobile	Somewhat mobile
Chlorine	Micro	Cl^-	Mobile	Mobile
Cobalt	Micro	Co^{2+}	Immobile	Somewhat mobile
Nickel	Micro	Ni^{2+}	Mobile	Somewhat mobile

Lesson No. 30 and 31

Soil fertility evaluation and different approaches.

Soil fertility - The quality of soil that enables it to provide essential chemical elements in quantities and proportions for the growth of specified plants.
Soil fertility evaluation - It is the assessment of nutrient supplying capacity of soil.
Different approaches for soil fertility evaluation

I) Chemical methods

A) Soil analysis
- 1) For total nutrients
- 2) For available nutrients (i.e. rapid soil testing)

B) Plant analysis
- 1) Total elemental analysis
  - a) Crop log technique b) 'A' value technique
- 2) Tissue testing

II) Biological methods

A) Using higher plants
- 1) Neubauer Seedling
- 2) Pot culture experiments
- 3) Field experiments
- 4) Mitscherlich technique
- 5) Jenny's pot culture test
- 6) Sunflower & Lettuce technique.

B) Using micro-organisms
- 1) Azotobactor
- 2) Aspergillus Niger
- 3) Cunninghamella plaque method.

III) Visual symptom method : diagnosis of deficiency symptoms of nutrients by visual observations in fields.

Different Approaches of Soil Fertility

Evaluation for Fertilizer Recommendations

1. General recommendations / Agronomic approach
2. Soil fertility cum soil survey approach
3. Integrated soil testing approach
4. Fertility gradient approach
5. Soil analysis and correlation approach
6. Critical level approach
7. Targetted yield approach
8. Site Specific Nutrient Management (SSNM)

Lesson No. 32

Soil Testing (Available nutrients) : Chemical methods and critical levels of different nutrients in soil.

Chemical method
A) Soil analysis

1) For total nutrient

2) For available nutrients (i.e. rapid soil testing)

Objectives of soil testing
Critical level values varies according to different soils and analytical methods.

Nutrients	**Soil**	
	Limits	**Range**
Nitrogen	Below 250 kg /ha 250 – 500 kg/ha Above 500 kg/ha	Low Medium High
P	Below 10 kg P/ha 10-20 kg P/ha Above 20 kg P/ha	Low Medium High
K	Below 100 kg P/ha 100-250 kg P/ha Above 250 kg P/ha	Low Medium High
S	Below 10 ppm hot water soluble	-
Ca	Below 50 % of CEC ammo. acetate	Extractable
Mg	Below 4% of CEC Ammo. acetate	Extractable
Zn	Below 0.6 ppm DTPA extractable (0.5-1.2 ppm)	Extractable
Fe	2.5 –4.5 ppm DTPA Below 2 ppm ammo. acetate	Extractable
Mn	Below 2 ppm DTPA	Extractable
Cu	Below 0.2 ppm DTPA	Extractable
B	Below 0.5 ppm hot water soluble	--
Mo	Below 0.2 ppm Ammo. oxalate extractants	--
Cl	Below 2.0 ppm water soluble	--

Chemical methods for soil testing
a) Total element analysis

1. Total N analysis Kjeldhal method

2. Total P, Ca, Mg, Zn, Cu, Fe, Na_2CO_3 fusion method/$Helo_4$ method/

3. H.F. Digestion

b) Available Nutrient

1. N : Alkaline permagnate method (Subbhia Asija)

2. P : Acidic Soil – Bray's method – Alkaline Soil – Olsen method

3. K – Amm. Acetate Method/Flame potometer

4. Ca, Mg, Na, K-Amonium acetate (Hanway and Heidan method, 1952).

5. S-calcium dihydrogen – phosphate/turbidity method

6. Fe, Mn, Zn, Cu – DTPA method

C) Available Nutrient

2) Fe – 4.5 ppm, Mn-3.0 ppm, Zn-0.8 ppm, Cu-0.2 ppm

3) B-Hot water soluble dictionary < 0.1 ppm 1 to 2 normal > 2 high

4) MoO4 – Grigg and tamm method buttered at pH 3.0 470 nm 0.04 to 0.20 ppm.

Lesson No. 33

Plant analysis methods : Critical levels of nutrients, DRIS approach, rapid tissue test, indicator plants. Soil test based fertilizer recommendations to crops.

Plant analysis - Purpose of analysis

1) Total elemental analysis
   a) Crop log technique
   b) 'A' value technique (i.e. tracer technique)
2) Tissue testing

Critical levels of nutrients in plants.

Definition of critical nutrient Range - It is defined as the range of nutrient concentration at a specified growth stage above which the crop is amply supplied and below which the crop is deficient.

Nutrient	Deficient	Sufficient or Normal	Toxic
N (%)	-	1-5	-
P (%)	-	0.1-0.4	-
K (%)	-	1-5	-
Ca (%)	-	0.2-1	-
Mg (%)	-	0.1-0.4	-
S (%)	-	0.1-0.4	-
Fe (Mg/kg)	<50	100-500	>500
Mn(Mg/kg)	15-25	20-300	300-500
Zn (Mg/kg)	10-20	27-150	100-400
Cu (Mg/kg)	2-5	5-30	200-100
B (Mg/kg)	5-30	10-20	50-200
M (Mg/kg)	0.03 – 0.15	0.1-2.0	>100
Cl (Mg/kg)	< 100	100-500	500-100
Ni (Mg/kg)	< 0.1	0.1-1.0	>1.0

Soil test based fertilizer recommendation to crops

Due to adoption of multiple cropping and introduction of high yielding varieties of principal crops in our country, soils are depleted in nutrients at a much faster rate than in the care of old cropping system. As a result, crop production has become highly fertilizer oriented. Modern approaches of soil fertility evaluation are mainly focussed towards increasing fertilizer use efficiency. The approaches may be as follows :

1. Soil analysis and correlation

2. Critical soil test level approach

3. Agronomic approach

4. Soil fertility cum soil survey

5. Inductive approach based on soil test and crop response correlation.

6. Deductive approach based on soil test crop response correlation and

7. Targeted yield concept approach.

The purpose of different approaches is to utilize soil and fertilizer nutrient judicious and effectively in a manner best suited to different agro climatic conditions.

General equation

1. Nutrient requirement (NR)
2. Contribution from soil (s)
3. Contribution from fertilizer (f)
4. % contribution from fertilizer

The format of soil test report should contain

1) The information about cultivator and field

2) Soil test values with corresponding classification in 6 tier system of each of the nutrients

3) Nutrient does as per requirements of the crop.

Lesson No. 34 and 35

Methods and scheduling of nutrient applications for different soils and crops grown under rain fed and irrigated conditions.

Fertilizer application of kharif crops

I. Time of application of manures and fertilizers :

Manures should be applied before sowing so that preliminary decmposition takes place. There should be sufficient moisture in the soil for proper decomposition of organic manures.
The crop has three or four critical growth stages when its water and nutrients requirements should be adequately met for satisfactory growth.

a) Germination and early growth stage

b) Advance tillering or grand growth or branching stage.

c) Peak flowering and fruiting stage.

Nitrogen is required throughout the growing period of crop. Nitrogen requirement is moderate in the beginning and increases rapidly as the crop enters grand growth stages and fruiting stage and reduces thereafter.
Phosphorus is required more in early growth period while Potash is required throughout the growing period but in small quantities.
Nitrogen is mobile and can move rapidly in any direction within the soil. Further N is lost due to leaching and volatilization and hence N is applied in split doses. Phosphorus and potassium as they become available slowly and get fixed in later stage and hence they are applied in single dose.

II) Method of fertilizers application
Manures should be broadcasted uniformly before last barrowings so that it can be mixed well into the soil. The nitrogenous fertilizers are applied either by broadcasting drilling or foliar sprays, phosphorus and potassic fertilizers are usually applied by localized placement.

Top dressing
Application of fertilizers in standing crop is known as Top dressing. However, under irrigated conditions N is splited up in two-three doses. Generally broadcasting, band placement or side dressing does top dressing. When small quantity of nitrogen or micronutrient is to be applied foliar application should be followed.

Recommended dose of manures and fertilizers to *Kharif* crops

Sr. No.	Crop	Recommended doses		Time of application		Remakrs
		Manures (t/ha)	N.P.K. (kg/ha)	Basal dose	Top dress	
	Sorghum rainfed	6-7.5	50-25-0	50-25-0	60	NPK at sowing
	Irrigated / assured Rainfall	12-15	120-60-30	60-60-60	60	60 kg N at 30 Days
	Maize	10-12	80-40-40	40-40-40	40	40 kg N at 30 Days
	Rainfed	10-15	90-40-40	45-40-40	45	45 kg N at 30 Days
	Irrigated	12-15	120-60-40	40-60-40	40	40 kg N at 30 days 40 kg N at 50 days
	Fodder	10-12	120-40-20	80-40-20	40	40 kg N at 30 days
	Paddy local	10-15	50-25-25	50-25-25	-	NPK at sowing
	Improved High yielding	10-15	100-50-50	40-50-50	40	At tillering
	Bajara Rainfed	8-10	50-25-0	50-25-0	-	NP at Sowing
	Irrigated millets	10-15	75-37-25	37.5-37-25	37.5	At 30 days
	Hill millets (Rainfed)	5-10	25-25-0	25-25-0	-	At sowing
	Irrigated	5-10	60-40-20	30-40-20	30	At 30 days
	PULSES					
	Tur, Mung, Blackgram, Cowpea, Beans	5-10	10-40-0 25-50-0	10-10-0 25-50-0		At sowing for high soils for irrigated on black soils
	Oilseeds					
	Groundnut rainfed and Dryland	5-7.5	12.5-25-0	12.5-25-0		At sowing only
	Irrigated & assured rainfall	5-7.5	25-50-0	25-50-0		At sowing only
	General	5-7.5	20-40-0	20-40-0		At sowing only
	Sunflower					
	Assured	5-7.5	60-30-30	30-30-30	30	At 30 days
	Rainfall	-	50-25-0	25-25-0	25	At 30 days
	Dryland	5	20-20-0	20-20-0		At sowing
	Niger	5	20-20-0	20-20-0		At sowing
	Sesamum	5	30-60-30	20-60-30	10	At flowering
	Soybean	5	25-50-0	12.5-50-0	12.5	N at 30 days
	Castor	5	75-100-0	37.5-100-0	37.5	At 40 days
	Fiber crops					
	Cotton rainfed	7.5	50-25-25	50-25-25		NPK at sowing

	(Deshi)					
	American cotton	7.5	90-40-40	22.5-40-40	45	At square formation 22.5 At Flowering
	Irrigated	15	100-50-50	20-50-50	40	At square formation 40 At Flowering
	Jute	7.8	60-30-30	30-30-30	15	At 6 weeks 15 at 10 weeks
	Decanhemp	-	60-30-30	30-30-30	15	At 6 weeks
	Sunhemp	-	0-25-0	0-25-0	15	At 10 weeks
	Commercial crops					
	Tobacco	10-15	100-60-40	50-60-40	50	At 4 weeks
	Turmeric	20-25	125-37-37	0-37-37	62.5 62.5	At 6 weeks At 12 weeks
	Ginger	15-20	120-100-90	0-100-90	60	At 6 weeks
	Coffee	10-25	150-100-150	40-30-40 40-30-40 40-30-40	- - -	In march In August In October
	Tea	10-25	120-120-90	60-60-45	-	In may
	Forage Crops					
	Pearl millet	5	60-30-20	30-30-20	30	At 30 days
	Maize	5	30-30-20	40-40-20	40	At 30 days
	Sorghum	5	120-30-30	80-30-20	40	At 30 days
	Cowpea	5	15-90-30	15-90-20	-	At sowing
	Stylo	10	10-60-0	10-60-0	-	At sowing
	Velvebean	5	15-60-20	15-60-20	-	At sowing
	Sirato	10	10-40-0	10-40-0	-	At planting
	Clusterbean	5	10-30-10	10-30-10	-	At planting
	Gajaraj	10	50-40-20	50-40-20	20	At each cutting
	Napier	10	50-40-20	50-40-20	20	At each cutting
	Paragrass	-	60-0-0	40-0-0	20	At each cutting
	Guinea grass	5	60-60-20	40-60-20	20	At 30 days
	Marval	5	50-20-0	50-20-0		In June
	Dinanath	5	50-40-30	50-40-30		At planting
	Anjan	5	50-30-0	25-30-0	25	At 30 days
	Dongri Gavat	5	50-0-0	25-0-0	25	At 30 days
	Pavana	5	50-0-0	25-0-0	25	At 30 days
	Blue Panie	-	50-25-0	50-25-0	-	At sowing
	Subabul	5	20-50-20	20-50-20		At sowing
	Shevari	5	20-50-20	20-50-20		At sowing
	Hadaga	5	20-50-20	20-50-20		At sowing

Fertilizers application to rabi / summer crops.
To know time, method and quantity of manures and fertilizers required to be applied for rabi/summer crops.

I) Time of application of manures and fertilizers
Manures should be applied before sowing to that preliminary decomposition takes place. There should be sufficient moisture in the soil for proper decomposition of organic manures.
The crop has three or four critical growth stages when its water and nutrients requirements should be adequately met for satisfactory growth.

a) Germination and early growths stage.

b) Advance tillering or grand growth or branching stage.

c) Peak flowering and fruiting stage.

Nitrogen is required throughout the growth period of crop. Nitrogen requirement is moderate at beginning and increases rapidly as the crop enters grand growth stage and fruiting stage and reduces thereafter.
Phosphorus requirement is more in early growth period while potash is required throughout the growing period but in small quantities.
Nitrogen is mobile and can move rapidly in any direction within the soil. Further 'N' is lost due to leaching, denitrification and volatilisation and hence 'N' is applied in split doses. Phosphorus and potassium as they become slowly available and get fixed in the soil at later stage and hence they are applied in single dose.

II) Method of fertilizers application
Manures should be boradcasted uniformly before last harrowing so that it can be mixed well into the soil. The nitrogenous fertilizers are applied either by broadcasting, drilling or foliar sprays. Phosphatic and potassic fertilizers are usually applied by localized placement.

Top dressing :
Application of fertilizers in standing crop is known as 'Top Dressing'. The most of the *rabi* crops are fertilized at sowing only no splitting of 'N' due to limitation of soil moisture. However, under irrigated conditions N is split up in two-three doses. Generally top dressing of fertilizers is done by broadcasting band placement or side dressing. When small quantity of nitrogen or micronutrient is to be applied foliar application should be followed.

Recommended dose of manures and fertilizers to rabi/summer crops

Sr. No.	Crop	Recommended doses		Time of application		Remakrs
		Manures (t/ha)	N.P.K. (kg/ha)	Basal dose	Top dress	
1	Wheat					
	Irrigated A) Timely sown	10-15	120:60:40	60:60:40	60: - : -	Top dressing of N at 21 DAS
	a) Dwarf mexican	10-15	100:50:50 120:60:60	50:50:50 60:60:60	50: - : - 60: - : -	-do-
	b) Tall Niphad	10-15	75:50:50	37.5:50: 50	37.5: - : -	-do-
	c) Under limited irrigation	10-15	60 : 30 : -	60 : 30 :-	30 :-:-	-do-
	B) Late sown	10-15	80:40:30	40:40:30	40	-do-
	C) Rainfed	5-6	40:20:-	40:20:-	-	-do-
2.	Sorghum (Rabi)					
	A) Irrigated hybrids					
	i) Deep soils	8-12	100:50:50 120:60:60	50:50:50 60:60:60	50:-:- 60:-:-	To dressing of N at 30 DAS
	ii) medium soils	8-12	80:40:40	40:40:40	40:-:-	-do-
	B) Rainfed					
	i) Deep soils	6-8	50:25:-	50:25:-		
	ii) Light soils	6-8	25:15.5:-	25:15.5:-		
3.	**Barley**					
	A) Irrigated	8-10	40:20:20 50:25:25	20:20:20 25:25:25	20 :- : - 25:-:-	Top dressing of N at 25 to 30 DAS
	B) Rainfed	5-6	30:20:20	30:20:20		
II	**Pulses**					
1.	**Chickpea**					
	A) Irrigated	6-7	25:50:-	25:50:-		
	B) Assured rainfall	6-7	20:40:-	20:40:-		
	C) Rainfed	5-6	12.5:25:-	12.5:25:-		
2.	Peas	10-12	25:40:-	25:40:-		
3.	Lentil	3-5	20:50:-	20:50:-		
4.	Field bean	3-5	25:50:-	25:50:-		

Lesson No. 36

Factors influencing nutrients use efficiency (NUE) in respect of N, P, K, S, Fe and Zn fertilizers.

Nutrient Use Efficiency: Kilograms of yield per kilogram of applied nutrient.
Fertilizer Use Efficiency : Kilograms of yield per kilogram of applied fertilizer..
Yield obtained with fertilizer – Yield obtained without fertilizer/ Yield obtained without fertilizer X 100
Ex Yield obtained with fertilizer = 1800 kg
Yield obtained without fertilizer = 1100 kg
1800-1100/1100 X100 = 63.63%

Factors influencing Nutrient Use Efficiency (NUE)
Crop Characteristics

- Crop variety/ hybrid
- Temperature
- Plant population
- Tillage practices
- Pest control
- Root Characteristics
- Species and variety differences
- Nutrient extraction power

Soil Characteristics

- Soil Type
- Soil Moisture Bulk density
- OM content
- Acidity and Alkalinity
- Plant nutrient content
- CEC
- Nutrient level and their balance in soil

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