# SAC 301 – SOIL FERTILITY, FERTILZERS AND MANURES (2+1)

# Lec. 1. Soil Fertility and Productivity

**Soil Fertility:**

Soil fertility is the ability of the soil to provide all essential plant nutrients in available forms and in a suitable balance.

**Soil productivity:**

The capability of soil to produce specified crop yield under well defined and specified systems of management of inputs and environmental conditions.

**Factors Governing Soil Fertility:**

**Parent material:**

Fertility of a soil depends on the chemical composition of parent material from which it derived.

**Topography:**

Soils on the upper slope are less fertile than the soils on lower slope because high leaching and erosion on upper slope.

**Climate:**

In tropical climate decomposition of organic matter is faster than temperate climate. Thus soils of tropical regions are less fertile when compared to temperate region.

**Depth of Soil Profile:**

Deep soils are more fertile than the shallow soils and the roots are spread well enough in deep soils than the shallow soils.

**Physical Condition of Soil:**

The soil texture and soil structure influence the soil fertility.

**Artificial Factors:**

i. Water logging

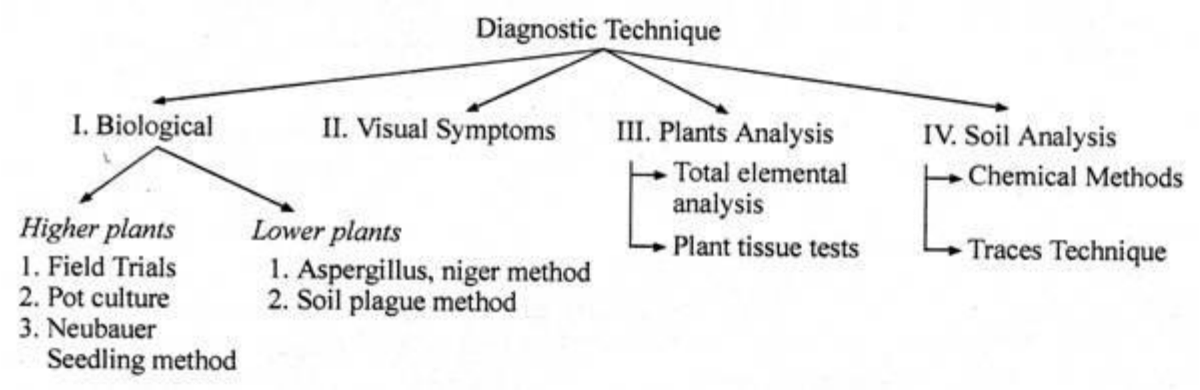
ii. Cropping system

iii. Toxic chemicals and pesticides in the soil.

**Difference between Soil Fertility and Productivity:**

| **Soil Fertility** | **Soil Productivity** |
|---|---|
| 1. It is an index of available nutrient to plants | 1. It is used to indicate crop yields. |
| 2. Influenced by the physical, chemical and biological factors of the soil. | 2. Depends upon fertility and location. |
| 3. It is the function of available nutrients of the soil. | 3. It is the function of soil fertility, management and climate. |
| 4. All fertile soils are not productive. | 4. All productive soils are fertile. |
| 5. It is an inherent property of the soil. | 5. It is not the inherent property of the soil. |

**Soil Fertility Evaluation:**
It is the assessment of nutrient supplying capacity of the soil.




**Soil Fertility Evaluation:**
It is assessment of nutrient supplying capacity of the soil

**I. A. Biological Methods** (using higher plants as indicator):

**1. Field Trials:**

Direct way to assess the nutrient status in soil.

i. Trials with graded doses of nutrients will determine the exact requirement.

ii. The effect is very much location specific.

iii. Expensive and time consuming and growth condition can't be fully controlled.

**2. Pot Culture Methods:**

i. Same as field trials except that plants grown in pots with small volume of soil or under controlled field condition like greenhouse.

ii. Limitations Preferential root growth Limited volume of soil Problems during packing of soil.

**3. Neubauer Seedling Method:**

i. Soil is exhausted of the available nutrients and entire plant is then analysed for the uptake.

**II. B. Biological Methods** (using Micro organism as indicator):

**1. Aspergillus Niger Method:**

i. For P, K and Mg in soils.

ii. The amount of 'k' extracted in mycelium compares favourably with the content of exchangeable 'k' in soil under investigation.

**2. Soil Plaque Method:**

By sockett and stewart for study of mineral deficiencies in soil.

i. If soil is deficient in 'k' or 'p' or both, the calories of the Azotobactor will not develop.

ii. The intensity of growth of calories indicates the degree of deficiency.

**3. Visual Symptoms:**

i. Indicator plants

ii. Hidden hunger.

**III. Plant Analysis Method:**

**1. Total Elemental Analysis:**

i. Leaf Analysis widely used.

ii. Approach

Visual Symptoms

Deficiency

Toxicity

Critical nutrient level (CNL)

'CNL' is a range of concentration at which growth of plants is restricted in comparison with that of plant at a higher nutrient level.

2. Plant Tissue Tests/Rapid Chemical Analysis.

i. The conductive tissue consisting un assimilate nutrients in sap or extracts are analysed.

ii. N, P and K have been tested by this technique.

**IV. Soil Analysis:**

**1. Chemical Methods:**

(a) Phosphorous – Olsen's method,

(b) Micro nutrient – Chelate DTPA

(b) Gypsum requirement – Schoonover's method

**2. Tracer Technique:**

i. The plants of few supplied the phosphatic fertilizers with P.

ii. The harvested plants tested for total 'P' as well as $^{32}P$.

$A = B (1 – Y / Y)$

Where, A – available 'P' in soil

B – Amount of fertilizer ‘P’

Y – Fraction of ‘P’ in plant desired from fertilizer ‘P’

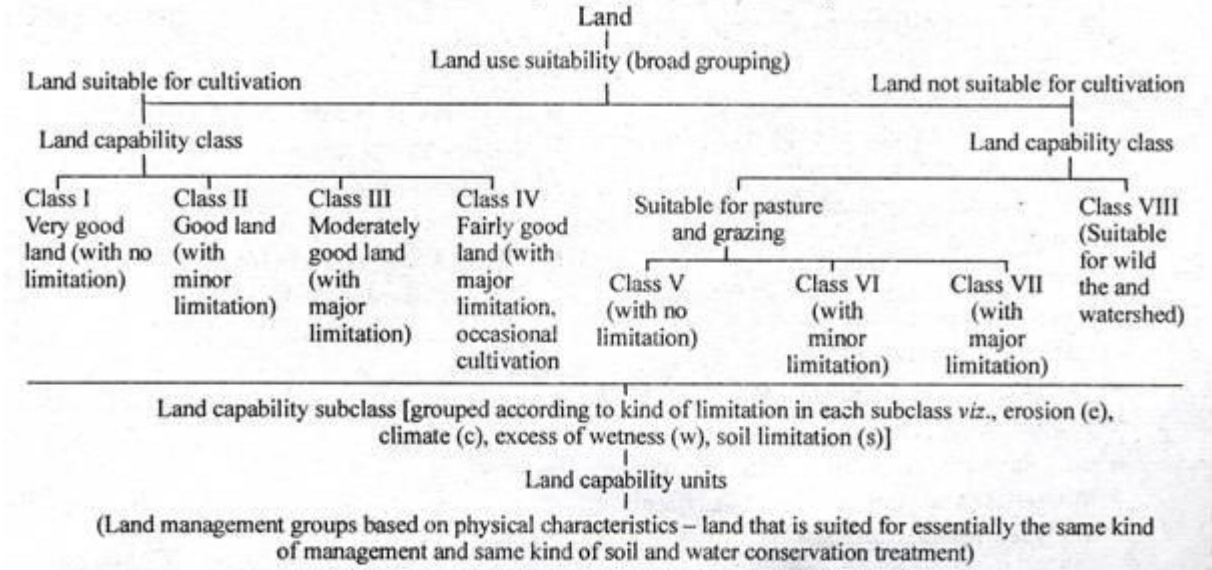
(1 – Y) – Fraction desired from soil.

**Land Capability Classification:**

Evaluation of land for land use planning is a consequent step following the soil survey and mapping process. In the recent years, it has been popularised in almost every land development programme. The system of land capability classification requires that every acre of land be used in accordance with its capability and limitations. The land capability classification is a broad grouping of soils based on their limitations and also serves as a guide to assess suitability of the land for cultivation, grazing and forest plantation.

The land capability classification scheme developed by soil conservation service. United States Department of Agriculture (USDA).The classification scheme has four categories namely land suitability class, land capability classes (comprising eight classes). Land capability subclass and land capability units.

**Table 1 : Land Capability Classification System**




## Lec. 2. INTEGRATED NUTRIENT MANAGEMENT

Integrated Nutrient Management refers to the maintenance of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired productivity through optimization of the benefits from all possible sources of organic, inorganic and biological components in an integrated manner.

**Concepts**

1. Regulated nutrient supply for optimum crop growth and higher productivity.
2. Improvement and maintenance of soil fertility.
3. Zero adverse impact on agro – ecosystem quality by balanced fertilization of organic manures, inorganic fertilizers and bio- inoculant

**Determinants**

1. Nutrient requirement of cropping system as a whole.
2. Soil fertility status and special management needs to overcome soil problems, if any
3. Local availability of nutrients resources (organic, inorganic and biological sources)
4. Economic conditions of farmers and profitability of proposed INM option.
5. Social acceptability.
6. Ecological considerations.
7. Impact on the environment

**Advantages**

1. Enhances the availability of applied as well as native soil nutrients
2. Synchronizes the nutrient demand of the crop with nutrient supply from native and applied sources.
3. Provides balanced nutrition to crops and minimizes the antagonistic effects resulting from hidden deficiencies and nutrient imbalance.
4. Improves and sustains the physical, chemical and biological functioning of soil.
5. Minimizes the deterioration of soil, water and ecosystem by promoting carbon sequestration, reducing nutrient losses to ground and surface water bodies and to atmosphere

**Components:**

**Soil Source:**

Mobilizing unavailable nutrients and to use appropriate crop varieties, cultural practices and cropping system.

**Mineral Fertilizer :**

Super granules, coated urea, direct use of locally available rock $PO_4$ in acid soils, Single Super Phosphate (SSP), MOP and micronutrient fertilizers.

**Organic Sources :**

By products of farming and allied industries. FYM, droppings, crop waste, residues, sewage, sludge, industrial waste.

**Biological Sources :**

Microbial inoculants substitute 15 - 40 Kg N/ha

## Lec. 3. SOIL SURVEY, ITS SCOPE AND OBJECTIVES – METHODS OF SOIL SURVEY

**History of Soil Survey in India**

- 1846 – Geological Survey started
- 1880 – Dept. Of Agriculture formed
- 1889 – Dr . J.A. Volecker visited India
- 1893 – Central and provincial Agrl. Dept. started soil studies for growing of crops
- 1904 – Dr. Leather visited India. Grouping of soils as Alluvial, Black cotton, Red and Laterite

1928 - Royal commission on Agriculture was started. Dokuchaiev's concept of classification introduced. Pre Irrigation Survey was conducted at lower Bhavani and Cauvery Soil fertility Survey at Cauvery, Godavari and Krishna

1955 - Ministry of Agriculture, Government of India set up the All India Soil Survey and Land Use organization for taking up standard soil survey In the country. This was expanded in 1958. It had four regional centres based on the soil type viz.,

| | | |
|---|---|---|
| Alluvial soil | - | Delhi |
| Black soil | - | Nagpur |
| Red and laterite soil | - | Calcutta |
| Red and laterite soil | - | Bangalore |

This regional centre collaborate with the state centres.

- 1978 - A new Directorate of National Bureau of Soil Survey and Land Use Planning (NBSS & LUP) was organized for imparting training in soil survey. This is functioningunder ICAR. The head quarters is at Nagpur with six regional centresat Nagpur,Delhi, Calcutta, Bangalore, Udaipur and Jorhat. After the formation of NBSS & LUP, the All India Soil Survey and Land Use Organization was renamed as All India Soil and Land Use Survey.

**Systematic Study of Soils of Tamil Nadu**

(a) Soils of Cauvery Delta was studied for their fertility status (1912)
(b) Soils of the irrigation projects including Lower Bhavani project, Toludur Project, Cauvery – Mettur projects (1934-36) were studied
(c) Soil mapping of individual taluks of Tamil Nadu (1965-1986)
(d) Studies on Coastal soils of Tamil Nadu (1980-84)
(e) Soil resource mapping of Tamil Nadu jointly by NBSS&LUP and State Soil Survey Organisation (1994-97).

**Soil Survey**

Soil survey is essentially a study and mapping of soils in their natural environment. It is the systematic examination, description, classification and mapping of soils of an area.

Soil survey comprises a group of interlinked operations involving.

I. Field work to study the important characteristics of soils and the associated external land features such as landform, natural vegetation, slope etc.
II. Laboratory analysis to support and supplement the field observations
III. Correlation & classification of soils into defined taxonomic units.
IV. Mapping of soils
V. Soil survey interpretations, that is predictions about the potential of soils for alternate uses and management
VI. Transfer of technology from research stations to farmers fields through soil taxa

**Importance of soil survey**

Soil is the most valuable life supporting natural resource and must be properly used. Improper use result in degradation consequently food security questioned. Rational planning in land use ensures effective exploitation of soils on its potentialities and limitations. It is necessary to prepare an inventory of this resource so that, optimum land use and conservation plans can be developed. Such plans will be useful while preparing National policies and it's execution. It also useful at other levels viz., state, town, farm, watershed development, Agricultural Research Station, Research laboratories etc.

**Objectives of soil survey**

- Prompt application of new discoveries in soil and crop management
- Determining the potential distribution and adaptability of individual crops and soil management practices
- Planning agricultural research and extending its result
- Developing rural land classification and public land management

- Planning engineering works, highways and airport and those for flood control, drainage, irrigation and conservation.
- Correlating soil conditions in the country with those of other countries and trying the discoveries on our soils.

**Scope of soil survey- Case studies**

- Though black and red soils of Central and South India are rich in clay of 40-60%, the former has montmorillonite clay with rich fertility and the latter has kaolinite clay with poor fertility and their land use varies necessitating soil survey to determine their nature and behaviour
- Citrus plantations in Punjab failed where a hard calcic horizon was observed in the subsoil.
- Engineering structures collapsed in Iraq where soils contained high amount of gypsum.
- Underground pipelines broke down in areas having high amounts of swell –shrink clay minerals.

**Purposes of soil survey**

**Fundamental**

Soil survey helps in expanding our knowledge and understanding of different soils, with regard to their properties, genesis and classification for sustainable development.

**Applied**

I. Soil survey and soil maps help in making predictions about the behavior of different soils for agriculture, forestry, engineering, urban development etc.

II. Transferring technology by correlating the characteristics of soils of known behavior and predicting their adaptability to various uses and productivity under defined set of management practices.

III. Providing information needed for developing optimum land use plans and for bringing new areas under irrigation and drainage net works

IV. Delineating the degraded soils, such as saline - alkali, water logged or flood prone, eroded etc. and suggesting soil and water conservation measures.

V .Delineating disease infested areas and may provide indirect help in controlling the diseases.

Soil survey is an integral part of an effective agricultural research and advisory programmes.

**Method and types of soil survey – free and grid survey – Reconnaissance, Detailed and Semi detailed ,Exploratory and Rapid reconnaissance survey.**

To carry out the survey work the following base maps are required

**Base maps**

The base maps commonly used for soil survey are cadastral maps (1:5000 to 8000 scale), topographical maps (1:25,000 to 1:2,50,000), aerial photographs (1:10,000 to 1:50,000) or Indian Remote sensing data (IRS) (1:25,000 to 1:2,50,000)

**Cadastral maps**

It is prepared by Department of survey and Land records. It shows location of individual holding, ponds, roads and streams. The physiographic features and contour lines are not available. Map scale is 24" = 1 mile to 8" = 1 mile or 4" = 1 mile in plain areas and 52.8" = 1 mile in hilly areas.

**Topo sheets or topographical maps**

It is prepared by surveyor General of India. Dehradun. Published on the scale of 1:25,000, 1:50,000 and 1:250000. It shows roads, tracks, streams, water source along with contour lines and physiography features.

**Aerial photographs**

Photographs of land surface taken from air craft usually in vertical angle. For interpretation, air photos are viewed stereoscopically, to give a three dimensional view. Landforms, vegetation, land use, roads and tracks can be directly seen. While soil properties, geology and other land properties require indirect interpretation. They range in scale from 1:8000 to 1:60,000.

**Earth resources satellite or Landsat Imagery**

Gives synoptic view of large areas (185 x 185 km) on one image.

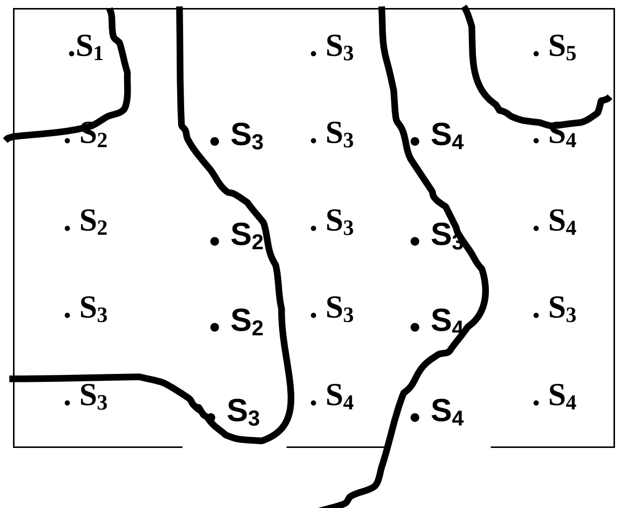
**Methods of soil survey**

Soil surveys are being conducted for diagnosing the nature and extent of distribution of different soils, including normal and problem soils. There are two methods of survey.

1. Grid survey
2. Free survey

**Grid survey**

The procedure is adopted for mapping small areas, such as a micro watershed or agricultural research station. The traverse lines are located on a grid pattern and the density of mapping is adjusted according to the area surveyed so that the number of observations per $cm^2$ of the final map is independent of the scale. Generally four or five observations per ha are recommended. Points of comparable observations are drawn. In this computer age, grid survey at georeferenced points (with latitude and longitude) have been found to be of great value in digitizing the database and generating several thematic maps of practical value. Such surveys are expensive and recommended for experimental stations from where the agro technology generated is transferred to other areas having comparable soil-site characteristics. The most important limitation is the validity of interpolated boundaries. Further that some of the grid points may fall in sites such as roads, building, field boundaries, which the survey is intended to exclude.




**Grid survey for traversing**

**(Boundaries separate soils with varying salinity levels)**

**Free survey**

In free survey, the surveyor chooses observation points on the assumption that changes in physiography, as such observed by aerial photo or satellite imagery interpretation and other surface features, such as colour, vegetation and land use are indicative of differences in soil characteristics. The density of observations can be varied as the mapper concentrates on confirming the inferred boundaries and checking the uniformity of the soil within each boundary. On small scale, the inferred boundaries are often accepted as soil boundaries. On large scale, several new boundaries within the physiographic boundaries are recognized depending upon the scale of mapping.

On small scale (1:2,50,000 or smaller), the inferred boundaries are accepted as soil boundaries and limited efforts are made to find variations within the physiographic boundaries. On large scale (1:50,000 or larger), several new boundaries within the physiographic boundaries are recognized, depending upon the scale of mapping. Based on the differences in various units such as physiography, parent material, drainage class and profile development , the soils are grouped into defined soil units.

For large areas such as a state or country, the mapping is generally undertaken on small scale (1:250,000 or 1:1 M) depending on the terrain complexity, purpose and time available for mapping.  Ex. Soil resource map of India.  A three tier approach comprising of land sat imagery interpretation, field and laboratory investigations, cartography and printing was adopted.

These maps provide information and database on various attributes used for mapping and laboratory investigations. These database stored in computer are potentially useful for extension staff, planners, scientists, administrators and decision – makers. By using these database and digitizing the soil map, several thematic maps for practical applications were generated. Such maps are not only easily understood by the land users but also help in determining fertilizers, amendments and other needs for optimizing land use.

And in most modern soil survey involving 5000 ha and above, this is usually the type of survey methodology adopted. The advantage is that it is cheaper because there is less number of observation points. However, because it depends largely on the experience of the surveyor, it can be very inaccurate ,since boundary placement is more difficult.

**Types of soil survey**

Depending upon the objective, method, type of base map available and intensity of observations following types of soil surveys are recognized. They are,

1. Reconnaissance
2. Detailed
3. Detailed - reconnaissance

**Reconnaissance**

The reconnaissance survey is undertaken to prepare resource inventory of large areas. It identifies broadly, the kinds of soils and their extent of distribution. It enables to asses broad potentialities of soils and recognition of areas of promise that are suitable for intensive agriculture and that requiring priority treatment for amelioration. It is low intensity soil survey.

The survey relies on aerial photo or remotely - sensed data interpretation to develop soil physiographic relationship. The soil map provides information needed for broad or regional level planning in respect of land use. This kind of mapping proceeds detailed soil survey of potential areas.

**Detailed**

This type of survey is undertaken in priority areas, such as pilot projects, agricultural research stations, micro water sheds and areas in urban development. The traverse lines are on grid pattern. The survey enables identification of soil units up to phases of series for planning development of individual parcels of land. The resulting soil map provides sufficient information for interpretation of various kinds of soils and for understanding their pedogenic evolution. Such a survey is very time consuming and expensive. The detailed soil survey is of two types ie low and high intensity.

**Detailed - Reconnaissance**

This kind of survey combines both the detailed and reconnaissance surveys as above and is undertaken for understanding distribution of basic soil classes of series / families and their phases. First RSS is conducted for the whole study area and this is followed by DSS in selected areas such as intensively cultivated areas, problem soil areas, wasteland development, polluted soil areas or potential areas for a particular crop variety.

Ex. If the problem soils of Coimbatore is to be studied, RSS is to be undertaken for the whole area and DSS in those problematic areas identified.

## PROBLEM SOILS AND THEIR MANAGEMENT

Soil is a natural finite resource base which sustains life on earth. It is a three phase dynamic system that performs many functions and ecosystem services and highly heterogeneous. Soil biota is the biological universe which helps the soil in carrying out its functions. Often soil health is considered independently without referring to interlinked soil functions and also based on soil test for few parameters. Physical condition of soil and biological fertility are overlooked in soil health management which needs revisiting of soil users. Recognising the importance of soil health in all dimensions, 2015 has been declared as the International Year of Soils by the 68th UN General Assembly. Food and Agriculture organisation of the United Nations has formed Global soil partnership with various countries to promote healthy soils for a healthy life and world without hunger. India, the second most populous country in the world faces severe problems in agriculture. It is estimated that out of the 328.8 m ha of the total geographical area in India, 173.65 m ha are degraded, producing less than 20% of its potential yield (Govt. of India, 1990).

Soil heterogeneity is the reasons for the diverse nature of cropping and production pattern. Soil heterogeneity is the case where soil in a relatively small area varies greatly in texture, fertility, topography, moisture content, drainage etc. If it exists in large scale due to the parent material or manmade activities, then the problem of soil suitability to agriculture arises.

**Types of problem soils**

Physical problem soils

Chemical Problem soils

Biological Problem soils

Nutritional problem soils as a result of above constraints

**1. Soils with Physical problems**

**1.1. Slow permeable soils/Impermeable soils and their management**

**Occurrence and Causes**

In Tamil Nadu, the area under slow permeable soils is around 7,54,631 ha (7.5% of TGA). Slow permeable soil is mainly due to very high clay content, infiltration rate < 6cm/day, so more runoff which eventually leads to soil erosion and nutrient removal. Since the capillary porosity is high it leads to impeded drainage, poor aeration and reduced conditions.

**Remedial measures**

(i) Incorporation of organics: Addition of organics namely FYM/composted coir pith/press mud at 12.5 t ha-1 found to be optimum for the improvement of the physical properties

(ii) Formation of ridges and furrows: For rainfed crops, ridges are formed along the slopes for providing adequate aeration to the root zone.

iii) Formation of broad beds: To reduce the amount of water retained in black clay soils during first 8 days of rainfall, broad beds of 3-9 m vide should be formed either along the slope or across the slope with drainage furrows in between broad beds.

iv). providing open/ subsurface drainage

v). Huge quantity of sand /red soil application to change the texture

vi). Contour /compartmental bunding to increase the infiltration

vii). Application of soil conditioners like vermiculite to reduce runoff and erosion

**1.2. Soil surface crusting**

**Occurrence and Causes**

In Tamil Nadu, surface crusting is prevalent in Trichy, Thanjavur, Pudukottai, Cuddalore and Sivaganga districts and mostly in red soil areas. In Tamil Nadu, the area under soil crusting is around 4,51,584 ha ( 4.49% TGA). Surface crusting is due to the presence of colloidal oxides of iron and aluminium in soils which binds the soil particles under wet regimes. On drying it forms a hard mass on the surface. It is predominant in Alfisols but also occur in other soils too.

Impact on soil properties

Prevent germination of seeds and retards root growth

Results in poor infiltration and accelerates surface runoff Creates poor aeration in the rhizosphere

Affects nodule formation in leguminous crops

**Remedial measures**

When the soil is at optimum moisture regime, ploughing is to be done. Lime or gypsum @ 2 t ha-1 may be uniformly spread and another ploughing given for blending of amendment with the surface soil.

Farm yard manure or composted coir pith @ 12.5 t ha-1 or other organics may be applied to improve the physical properties of the soils

Scraping the surface soil by tooth harrow will be useful.

Bold grained seeds may be used for sowing on the crusted soils.

More number of seeds/hill may be adopted for small seeded crops.

Sprinkling water at periodical intervals may be done wherever possible.

Resistant crops like cowpea can be grown.

**1.3. Sub soil hard pan**

**Occurrence and Causes**

Sub soil hard pan is commonly found in red soils. Though soil is fertile, crops cannot absorb nutrients from the soil which leads to reduction in crop yields. In Tamil Nadu, it is prevalent in Coimbatore, Erode, Dharmapuri, Trichy, Cuddalore, Villupuram, Pudukottai, Sivagangai, Madurai and Salem districts particularly under rainfed conditions. In Tamil Nadu, the area under subsoil hardpan is around 10, 54,661 ha (10.48% TGA) The reasons for the formation of sub surface hard pan in red soils is due to the illuviation of clay to the sub soil horizons coupled with cementing action of oxides of iron, aluminium and calcium carbonate. Impact on soil physical properties The sub soil hard pan is characterized by high bulk density(>1.8 Mg m-3 ) which in turn lowers infiltration, water holding capacity, available water and movement of air and nutrients with concomitan

Chiselling technology to overcome the sub soil hard pan The field is to be ploughed with chisel plough, a tractor drawn heavy iron plough at 50 cm interval in both the directions. Chiselling helps to break the hard pan in the sub soil besides it ploughs up to 45 cm depth. Farm yard manure or press mud or composted coir pith at 12.5 t ha-1 is to be spread evenly on the surface. The field should be ploughed with country plough twice for incorporating the added manures. The broken hard pan and incorporation of manures make the soil to conserve more moisture.

**1.4. Shallow soils**

**Occurrence and Causes**

In Tamil Nadu, shallow soils occur over an area of around 1,16,509 ha ( 1.16.% TGA). Shallow soils are formed due to the presence of parent rocks immediately below the soil surface ( 15-20 cm depth). Impact The shallow soil restricts root elongation and spreading. Due to shallowness less volume of soil is available exhaustive soil nutrients.

**Management**

Growing shallow rooted crops.• Frequent renewal of soil fertility• Growing crops that can withstand shallowness(Mango, country• goose berry, fig, tamarind, ber and cashew etc)

**1.5. Highly permeable soils**

**Occurrence and Causes**

Sandy soils containing more than 70 per cent sand fractions occur in coastal areas, river delta and in the desert belts. Such soils occur in Coimbatore, Trichy, Kanyakumari, Tuticorin, Thanjavur and Tirunelveli districts and in part of coastal areas in Tamil Nadu. A total area of 24,12,086 ha in Tamil Nadu are affected by excessively permeable soils Impact Excessive permeability of the sandy soils results in poor water retention capacity, very high hydraulic conductivity and infiltration rates. These soils being devoid of finer particles and organic matter, the aggregates are weakly formed, the non-capillary pores dominating with very poor soil structure. So whatever the nutrients and water added to these soils are not utilized by the crops and subjected to loss of nutrients and water. In addition, it is not providing anchorage to the crops grown.

**Management technology**

The soils should be ploughed uniformly. Twenty four hours after a good rainfall or irrigation, the soil should be rolled 10 times with 400 kg stone roller of 1 m long or an empty tar drum filled with 400 kg sand at optimum moisture (13 %) Then shallow ploughing should be given and crops can be raised. Application of clay soil up to a level 100 t ha-1 based on the severity of the problem and availability of clay materials Application of organic materials like farm yard manure, compost, press mud, sugar factory slurry, composted coir pith, sewage sludge etc Providing asphalt sheet, polythene sheets etc. below the soil surface to reduce the infiltration rate Crop rotation with green manure crops like Sunhemp, sesbania, daincha, kolinchi etc Frequent irrigation with low quantity of water Frequent split application of fertilizers and slow release fertilizers like neem coated urea

**1.6. Heavy clay soils**

Clay soils are referred as heavy soils. To be classified as clay soil, it should be made up of about 40% clay particles, the finest particles found in soil. This is also slowly permeable soils. Main production constraints Heavy have very hard consistence when dry and very plastic and sticky ("heavy") when wet. Therefore the workability of the soil is often limited to very short periods of medium (optimal) water status. However, tillage operations can be performed in the dry season with heavy machinery. Mechanical tillage in the wet season causes serious soil compaction. They are imperfectly to poorly drained, leaching of soluble weathering products is limited. This is due to the very low hydraulic conductivity. Once the soil has reached its field capacity, practically no water movement occurs. Flooding can be a major problem in areas with higher rainfall. Surface water may be drained by open drains. Most of the heavy clay soils belonging to Vertisols are chemically rich and are capable of sustaining continuous cropping. They do not necessarily require a rest period for recovery; because the pedoturbation continuously brings subsoil to the surface. However, the overall productivity normally remains low, especially where no irrigation water is available. Nitrogen is normally deficient as well as phosphorus. Potassium contents are variable. Secondary elements and micronutrients are often deficient. In semi-arid areas free carbonate and gypsum accumulations are common.

**1.7. Fluffy paddy soils**

**Occurrence and Causes**

In Tamil Nadu, fluffy paddy soils are prevalent in Cauvery delta zone and in many parts of the state. It is formed due to the continuous rice-rice cropping sequence. In Tamil Nadu about 25,919 ha of land is affected by fluffiness (0.26 % of TGA). The traditional method of preparing the soil for transplanting rice consists of puddling which results in substantial break down of soil aggregates into a uniform structure less mass. The solid and liquid phases of the soil are thus changed. Under continuous flooding and submergence of the soil for rice cultivation in a cropping sequence of rice-rice-rice, as in many parts of Tamil Nadu, the soil particles are always in a state of flux and the mechanical strength is lost leading to the fluffiness of the soils. This is further aggravated by in situ incorporation of rice stubbles and weeds during puddling.

**Impact of fluffiness**

Sinking of draught animals and labourers is one of the problems during puddling in rice fields which is an invisible drain of finance for the farmers due to high pulling power needed for the bullocks and slow movement of labourers during the puddling operations. Further, it leads to low bulk density and very rapid hydraulic conductivity which in turn affects anchorage to the roots and the potential yield of crops is adversely affected.

**Management Methodology**

Irrigation should be stopped 10 days before the harvest of rice crop

After the harvest of rice, when the soil is under semi-dry condition moisture level, compact the field by passing 400 kg stone roller or an empty tar drum filled with 400 kg sand 8 times. Usual preparatory cultivation is carried out after compaction.

**2. Chemical Problem soils**

**2.1. Salt - affected soils**

The salt-affected soils occur in the arid and semiarid regions where evapo-transpiration greatly exceeds precipitation. The accumulated ions causing salinity or alkalinity include sodium, potassium, magnesium, calcium, chlorides, carbonates and bicarbonates. The saltaffected soils can be primarily classified as saline soil and sodic soil.

**Saline soils**

Saline soils defined as soils having a conductivity of the saturation extract greater than 4 dS m-1 and an exchangeable sodium percentage less than 15 Saline soils defined as soils having a conductivity of the saturation extract greater than 4 dS m-1 and an exchangeable sodium percentage less than 15. The pH is usually less than 8.5. Formerly these soils were called white alkali soils because of surface crust of white salts.

**Formation**

The process by which the saline soil formed is called Salinization. Saline soils occur mostly in arid or semi arid regions. In arid regions saline soils occur not only because there is less rainfall available to leach and transport the salts but also because of high evaporation rates, which tend further to concentrate the salts in soils and in surface waters Major production constraints Presence of salts leads to alteration of osmotic potential of the soil solution. Consequently water intake by plants restricted and thereby nutrients uptake by plants are also reduced. In this soil due to high salt levels microbial activity is reduced. Specific ion effects on plants are also seen due to toxicity of ions like chloride, sulphate, etc.

**Management of saline soils**

The reclamation of saline soils involves basically the removal of salts from the saline soil through the processes of leaching with water and drainage. Provision of lateral and main drainage channels of 60 cm deep and 45 cm wide and leaching of salts could reclaim the soils. Sub-surface drainage is an effective tool for lowering the water table, removal of excess salts and prevention of secondary salinisation. of ions like chloride, sulphate, etc.

**Management of saline soils**

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**Irrigation management**

Proportional mixing of good quality (if available) water with saline water and then using for irrigation reduces the effect of salinity. Alternate furrow irrigation favours growth of plant than flooding. Drip, sprinkler and pitcher irrigation have been found to be more efficient than the conventional flood irrigation method since relatively lesser amount of water is used under these improved methods.

**Fertilizer management**

Addition of extra dose of nitrogen to the tune of 20-25% of recommended level will compensate the low availability of N in these soils. Addition of organic manures like, FYM, compost, etc helps in reducing the ill effect of salinity due to release of organic acids produced during decomposition. Green manuring (Sunhemp, Daincha, Kolingi) and or green leaf manuring also counteracts the effects of salinity.

**Soil / cultural management**

Planting the seed in the centre of the raised bed / ridge may affect the germination as it is the spot of greatest salt accumulation. A better salinity control can be achieved by using sloping beds with seeds planted on the sloping side just above the water line. Alternate furrow irrigation is advantageous as the salts can be displaced beyond the single seed row. Application of straw mulch had been found to curtail the evaporation from soil surface resulting in the reduced salt concentration in the root zone profile within 30 days.

**2.2. Alkali / Sodic soils**

Alkali or sodic soil is defined as a soil having a conductivity of the saturation extract less than 4 dS m-1 and an exchangeable sodium percentage greater than 15. The pH is usually between 8.5 – 10.0. Most alkali soils, particularly in the arid and semi-arid regions, contain $CaCO_3$in the profile in some form and constant hydrolysis of $CaCO_3$ sustains the release of OH ions in soil solution. The OH ions so released result in the maintenance of higher pH in calcareous alkali soils than that in non – calcareous alkali soils.

**Formation**

Soil colloids adsorb and retain cations on their surfaces. Cation adsorption occurs as a consequence of the electrical charges at the surface of the soil colloids. While adsorbed cations are combined chemically with the soil colloids, they may be replaced by other cations that occur in the soil the soil colloids. While adsorbed cations are combined chemically with the soil colloids, they may be replaced by other cations that occur in the soil solution. Calcium and magnesium are the principal cations found in the soil solution and on the exchange complex of normal soils in arid regions. When excess soluble salts accumulate in these soils, sodium frequently becomes the dominant cation in the soil solution resulting alkali or sodic soils.

**Major production constraints**

Excess exchangeable sodium in alkali soils affects both the physical and chemical properties of soils. a) Dispersion of soil colloids b) Specific ion effect

**Reclamation of alkali / sodic soils**

**Physical Amelioration**

This is not actually removes sodium from exchange complex but improve physical condition of soil through improvement in infiltration and aeration. The commonly followed physical methods include  Deep ploughing is adopted to break the hard pan developed at subsurface due to sodium and improving free-movement water. This also helps in improvement of aeration.  Providing drainage is also practiced to improve aeration and to remove further accumulation of salts at root zone.  Sand filling which reduces heaviness of the soil and increases capillary movements of water. Profile inversion – Inverting the soil benefits in improvement of physical condition of soil as that of deep ploughing.

**2.3. Saline-alkali/ sodic soils**

Saline-alkali / sodic soil is defined as a soil having a conductivity of the saturation extract greater than 4 dS m-1 and an exchangeable sodium percentage greater than 15. The pH is variable and usually above 8.5 depending on the relative amounts of exchangeable sodium and soluble salts. When soils dominated by exchangeable sodium, the pH will be more than 8.5 and when soils dominated by soluble salts, the pH will be less than 8.5.

**Formation**

These soils form as a result of the combined processes of salinisation and alkalization. If the excess soluble salts of these soils are leached downward, the properties of these soils may change markedly and become similar to those of sodic soil.

**Management of saline alkali soils**

The reclamation / management practices recommended for the reclamation of sodic soil can be followed for the management of saline – sodic soil.

**2.4. Acid soils**

Soil acidity refers to presence of higher concentration of H+ in soil solution and at exchange sites. They are characterized by low soil pH and with low base saturation.

In acid soil regions (ASR) precipitation exceeds the evapotranspiration and hence leaching is predominant causing loss of bases from the soil. When the process of weathering is drastic, the subsoil and in many cases, the whole profile becomes acidic.

**Occurrence**

Acid soils occupy approximately 60% of the earth land area and are arise under humid climate conditions from carbonaceous less soil forming rocks in all thermal belts of the earth.

• World wide – 800 M ha

• India - 100 M ha

• Tamil Nadu - 2.6 M ha (20% of GA)

95% of soils of Assam and 30% of geographical area of Jammu and Kashmir are acidic. In West Bengal, 2.2 M ha, in Himachal Pradesh, 0.33 M ha, in Bihar, 2 Mha and all hill soils of erstwhile Uttar Pradesh come under acid soils. About 80% of soils in Orissa, 88% in Kerala, 45% in Karnataka and 20% in Maharastra are acidic. The laterite zone in Tamil Nadu is covered with acid soil and about 40,000 ha are acidic in Andhra Pradesh.

**Sources of soil acidity**

Leaching due to heavy rainfall Acidic parent material and alumina silicate minerals Acid forming fertilizers Humus and other organic acids Carbon dioxide and hydrous oxides Acid rain

**Production constraints**

Increased solubility and toxicity of Al, Mn and Fe Deficiency of Ca and Mg,

Reduced availability of P and Mo and Reduced microbial activity

**Management of acid soils**

Management of the acid soils should be directed towards enhanced crop productivity either through addition of amendments to correct the soil abnormalities or by manipulating the agronomic practices depending upon the climatic and edaphic conditions.

**Soil amelioration**

Lime has been recognized as an effective soil ameliorant as it reduces Al, Fe and Mn toxicity and increases base saturation, P and Mo availability of acid soils. Liming also increases atmospheric N fixation as well as N mineralization in acid soils through enhanced microbial activity. However, economic feasibility of liming needs to be worked out before making any recommendation.

**Liming materials**

Commercial limestone and dolomite limestone are the most widely used amendments. Carbonates, oxides and hydroxides of calcium and magnesium are referred to as agricultural lime. Among, the naturally occurring lime sources calcitic, dolomitic and stromato litic limestones are important carbonates. The other liming sources are marl, oyster shells and several industrial wastes like steel mill slag, blast furnace slag, lime sludge from paper mills, pressmud from sugar mills, cement wastes, precipitated calcium carbonate, etc equally effective as ground limestone and are also cheaper. Considering the efficiency of limestone as 100%, efficiencies of basic slag and dolomite are 110 and 94 % respectively. Basic slag and pressmud are superior to calcium oxide or carbonates for amending the acid soils. Fly ash, a low- density amorphous ferro-alumino silicate, also improves pH and nutrient availability.

## Lec. 4. BALANCED USAGE OF FERTILIZERS

- The blanket recommendation for rice is 100: 50: 50 kg NPK /ha.

  The soil test value is 150 kg N/ha, 8 Kg P /ha (Olsen's P) and 420 Kg K/ha.

  Calculate soil test based nutrient prescription and calculate the rate of fertilizers to be applied in terms of Urea, SSP, and MOP.

  **Soil test fertilizer based prescription**

| Nutrients rating | Nitrogen | Phosphorus | Potassium |
|---|---|---|---|
| Low | 100 % | 100 % | 125 % |
| Medium | 75% | 75% | 100% |
| High | 50% | 50% | 75% |

The soil test value says that Nitrogen is low, phosphorus is low and potassium is high. As per the soil test value the fertilizer prescription for rice crop is 100: 50: 37.5 Kg NPK /ha.

The rate of fertilizers to be applied for maize crop through straight fertilizers is

For giving 46 kg of nitrogen, 100 kg of urea should be applied (urea contains 46 % of N)

Therefore for giving 100 kg of nitrogen

**Urea** = $\frac{100}{46} \times 100 = 217$ Kg

**217 Kg of Urea should be applied (4 bags and 17 Kg)**

For giving 16 kg of phosphorus, 100 Kg of phosphorus should be applied (SSP contains 16 % of P)

Therefore for giving 50 Kg of P

**SSP** = $\frac{100}{16} \times 50 = 312.5$ Kg

**312.5 Kg of SSP should be applied (6 bags and 12.5 kg)**

For giving 60 kg of Potassium, 100 kg of MOP should be applied (MOP contains 60% of K)

Therefore for giving 37.5 Kg of K

MOP = $\frac{100}{60} \times 37.5 = 62.5$ Kg

62.5 Kg of MOP should be applied (1 bag and 12.5 Kg)

**xxxx**

- The fertilizer recommendation for tomato var. PKM -1 is 75:50:50 Kg NPK /ha. Soil analysed result says that N is 120 Kg/ha, P is 10 Kg/ha (Olsen's P) and K is 400 Kg/ha. Give the recommendations if the farmer is having Urea, DAP and MOP as per soil test values

**Soil test fertilizer based prescription**

| **Nutrients rating** | **Nitrogen** | **Phosphorus** | **Potassium** |
|---|---|---|---|
| Low | 100 % | 100 % | 125 % |
| Medium | 75% | 75% | 100% |
| High | 50% | 50% | 75% |

The soil test value says that nitrogen is low, phosphorus is low and potassium is high. As per the soil test value the fertilizer prescription for tomato crop is 75: 50: 37.5 Kg NPK /ha.

The rate of fertilizers to be applied for tomato crop is (First the rate of complex fertilizers should be calculated)

For giving 46 Kg of P, 100 Kg of DAP should be applied (DAP contains 46 % of P)

Therefore for giving 50 kg of phosphorus

**DAP** = $\frac{100}{46} \times 50 = 108$ Kg

**108 Kg of DAP should be applied (2 bags and 8 kg)**

From the above 108 Kg of DAP, we can produce 19.44 kg of Nitrogen to tomato (DAP contains 18 % of N)

Hence the balance amount of N to tomato = 75-19.44 = 55.56 Kg

Therefore for giving 55.56 Kg of N to tomato the rate of urea will be

$\frac{100}{46} \times 55.56 = 120.78$ Kg

**120.78 Kg of Urea to be applied to crop (2 bags & 27.8 Kg of Urea)**

For giving 60 kg of Potassium, 100 kg of MOP should be applied (MOP contains 60% of K)

Therefore for giving 37.5 Kg of K

$$MOP = \frac{100}{60} X 37.5 = 62.5 Kg$$

**62.5 Kg of MOP should be applied (1 bag and 12.5 Kg)**