ACHARYA N.G.RANGA AGRICULTURAL UNIVERSITY

DIPLOMA IN AGRICULTURE

PRACTICAL MANUAL

Soil Chemistry and Fertility

(Course No.DA-121)
(Credit hrs: 3 (2+1)
[2021]

Fig. 1. Soil sampling in *zigzag* manner. Fig. 2. Uniform slice of soil sampling. Fig. 3. Methods of soil sample reduction.

Fig. 4. Discard of soil samples. Fig. 5. Processing of soil samples. Fig. 6. Soil sample relevant information form.

Dr. D.SRINIVAS
Professor
Dr. M.LATHA
Associate Professor
Dr. P. MOHANA RAO
Assistant Professor
Dr. I. USHA RANI
Assistant Professor
Dr. A. LALITHA KUMARI
Professor & Head

Department of Soil Science and Agricultural Chemistry
Agricultural College, Bapatla.

ACHARYA N G RANGA AGRICULTURAL UNIVERSITY

ANGRAU

CERTIFICATE

Certified that this is a bonafide record of practical work done by

Mr./Ms.________________________________I.D.No.________________

in course No.__________of title “ ________________________________

____’’ during

the First/Second Semester of the Academic Year _____________

pertaining to Diploma in Agriculture/ Seed Technology/ Organic farming.

Date: ***Course-in-charge***

S. No.	Date	Title of the Experiment	Page No.	Signature

Course title: SOIL CHEMISTRY AND FERTILITY

Course No: DA- 121

Credit Hours: 3(2+1)

Practical Lecture Outlines

S.No.	Name of the Experiment	Page No.
1.	Importance of soil testing –tool used in soil sample collection	
2.	Collection, processing and storage of soil sample	
3.	Determination of soil bulk density by core sampler method	
4.	Determination of particle density of soil	
5.	Determination of soil texture by feel method	
6.	Determination of soil moisture by Gravimetric method	
7.	Determination of pH of soil	
8.	Determination of Electrical conductivity of soil	
9.	Determination of organic carbon content in soil	
10.	Determination of available nitrogen in soil	
11.	Determination of available phosphorus in soil	
12.	Determination of available potassium in soil	
13	Identification of deficiencies symptoms on nutrients in the field followed by diagnosis and interpretation	
14.	Study of soil profile	
15.	Visit to the soil of different textures to study their properties	
16.	Interpretation of soil tests and fertilizer recommendations	

Expt. No.: 1 **Date :**

IMPORTANCE OF SOIL TESTING- TOOLS USED IN SOIL SAMPLE COLLECTION

Objectives of Soil Testing:

1. To evaluate the fertility status of soil for making fertilizer recommendations.
2. To predict the probable crop response for the applied nutrients.
3. For the preparation of soil fertility groups.
4. To identify the degree of soil related problems like salinity, alkalinity, acidity.
5. To suggest appropriate reclamation measures.

Factors need to be considered while soil sampling:

Depth of sampling:

- For annual crops the sample should be drawn from 0-15 cm depth (or) plough depth or deep rooted crops like sugarcane the sample is taken from different depths i.e. 0-15 cm, 15-30 cm, 30-60 cm etc. for perennial crops or orchard crops the composite sample is prepared by collecting the soil from different depths of 0-30, 30-60, 60-100 cm & up to 2 m.
- For saline and alkaline soil the salt crust which is visible on the surface should be sampled separately.
- In case when sampling is done in deeper layers the depth should be clearly indicated.

Time of sampling: Any season, when soil moisture is optimum. However, the ideal time for collection of soil sample is summer, always the samples should be collected when soil is dry.

Number of sub samples: 15 to 20 samples must be collected from each homogeneous unit. Sampling in a standing crop: For horticultural or field crops sample must be collected between crop rows.

Sampling tools:

- Sample can be drawn with the help of tube auger, screw auger, post hole auger, spade (or) *kurpi.*
- A screw type auger is more convenient for sampling on hard & dry soils, while tube auger for soft and moist soils.
- In case of normal soils a 'V' shaped cut may be made with *kurpi* (or) spade to plough layer depth and uniform 2 cm thick slice is taken from both sides of pit.

Expt. No.: 2 **Date :**

COLLECTION, PROCESSING AND STORAGE OF SOIL SAMPLE

Soil Sampling Procedure:

Soil sampling is the most vital step for soil testing. The validity of soil analysis depends to the extent of 70% on soil sampling. Since very small fraction of huge soil mass is used for analysis it becomes extremely important to collect a true representative soil sample of the field.

- For collecting a representative soil sample the following procedure must be followed.

i) A large heterogeneous field can be divided into small homogeneous units through imaginary lines considering the variations in slope, soil texture, colour, pest management, cropping pattern, fertilizers and manures applied etc.

ii) A field can be considered as a single sample unit if it is uniform. Generally an area exceeding 0.5 hectares and approximately one hectare is taken as one sample unit.

- For making composite soil sample small portion of soil up to desired depth is collected using suitable sampling tools from 15-20 well distributed points moving in zig-zag manner in the field (sample unit) after removing the surface litter. In case of field having standing crop the samples are to be drawn in between the rows.
- The soil is mixed and spread on a clean cloth or paper or polythene sheet
- The bulk of the soil sample is reduced to around half kg by quartering method.
- Quartering: Quartering is a technique followed to reduce the size of composite sample into required quantity of sample. To carry out this, pour the composite sample on a clean paper or cloth or polythene sheet and mix it thoroughly. Remove any pebbles, roots and other coarse materials. Spread the soil in round or square shape and divide in to four parts (quarters). Reject the two diagonally opposite quarters and mix the remaining two quarters and repeat the procedure until a sample size of approximately 1/2 to 1kg soil is obtained.

Precautions in collection and storage of soil sample:

Special care in collection and handling them is required for preventing contamination. The following precautions should be taken.

- Avoid sampling in recently fertilized fields, bunds, channels, marshy parts and areas near wells, trees, compost heaps etc.
- The area of 2-3 meter along the field bund should not be sampled.
- Avoid contact of soil sample with chemicals, manures and fertilizers.
- Use stainless steel tools instead of rusted iron *kurpi (*or) spade for sampling, particularly when sampling is done for micronutrient status.
- Don't use bags (or) boxes which are previously used for storing fertilizer, salt (or) any chemical.
- Store the soil sample preferably in clean cloth bag (or) polythene bags.
- Use glass (or) porcelain jars for long duration storing of the sample.

Labeling of sample:

- Soil sample should be labeled for identification using a thick paper.
- Identification mark and other details should be furnished on the label and should be kept inside the sample bag.
- Another label with similar information should be pasted on the bag.
- In case of wet soil sample the label should be written with black pencil.
- In addition to the location, field number, name of the farmer and identification marks, relevant information about slope, drainage, previous cropping history, fertilizers and manures applied must be recorded and sent to the laboratory.

Processing of soil sample for analysis:

1. Sample must be air dried in shade and are ground with the help of wooden hammer.
2. Sample is to be sieved through 2 mm stainless steel sieve.
3. The plant residue, gravel and other materials retained on sieve must be discarded.
4. If the gravel content is substantial it should be recorded as % of sample, for analysis of texture.
5. For organic carbon estimation the sample has to be sieved through 0.2 mm sieve.
6. Before analyzing, the sample has to be thoroughly mixed.

Expt No.: 3 **Date:**

DETERMINATION OF SOIL TEXTURE BY FEEL METHOD

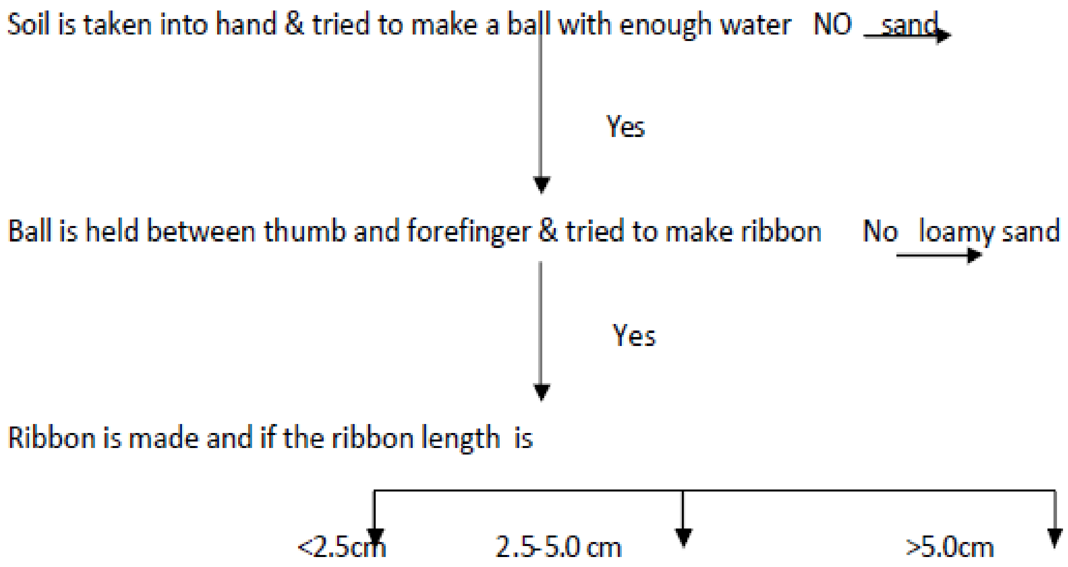
Aim: To determine the texture of given soil by feel method in field.

Procedure:

- A small quantity of dry soil is moistened with water and mixed thoroughly so as to form a soft ball and then it is kneaded between thumb and fore finger to make a ribbon.
- The feel to fingers, ease of forming ball, stickiness or grittiness, whether forming soil ribbons or merely crumbling on squeezing etc., are observed.
- The texture is classified as follows.

S. No.	Textural class	Behavoiur of moist bolus
1	Sand	No coherence (no ball formation), Single grain adheres to fingers
2	Loamy sand	Slight coherence (ball can be formed), ribbon of 6 mm or less. discolors fingers
3	Sandy loam	Just coherent, Very gritty Sand grains visible, < 2.5 cm ribbons
4	Loam	Coherent, neither gritty nor smooth, ribbon of < 2.5 cm length
5	Silty Loam	Coherent, very smooth, ribbon of < 2.5 cm length
6	Sandy clay loam	Coherent, gritty, sand grains visible, ribbon of 2.5to 5.0 cm length
7	Silty clay loam	Coherent, smooth, ribbon of 2.5to 5.0 cm length
8	Clay loam	Coherent, neither gritty nor smooth, finger prints visible, ribbon of 2.5to 5.0 length
9	Sandy clay	Coherent and plastic, sand grains visible, gritty, ribbon of > 5.0 cm length
10	Silty clay	Coherent and plastic, smooth ribbon of > 5.0 cm length
11	Clay	Coherent and plastic, neither gritty nor smooth, ribbon of > 5.0 cm length.

Flow chart to determine soil texture by feel method:



	<2.5cm	2.5-5.0 cm	>5.0cm
If gritty -	sandy loam	sandy clay loam	sandy clay
If smooth & silky -	silty loam	silty clay loam	silty clay
If neither gritty nor smooth –	loam	clay loam	clay

Observations:

Ball formation: Yes or No

Ribbon formation : Yes or No

If Yes, length of the ribbon:

Feel: Smooth/ Gritty

Result: The texture of given soil sample is ______________________

Expt No: 4 **Date:**

DETERMINATION OF SOIL BULK DENSITY BY CORE SAMPLER METHOD

Bulk density is defined as mass per unit volume of soil (including pore space). The volume here includes both solid space and pore space. It indicates the degree of compactness of the soil. It is expressed as Mg m^{-3} or g cc^{-1}, similar to particle density. The bulk density of a sample depends upon type of soil, organic matter content, depth of soil, tillage etc. The bulk density values vary from 1.0 to 1.8 Mg m^{-3} in different soils. Unlike particle density, it varies with management practices. The bulk density value of soil is useful in calculating porosity and void ratio of soils.

Aim:

To determine the bulk density of the soil using core sampler.

Apparatus:

Core sampler, hammer, balance, oven, aluminium boxes and oven.

Principle:

A metallic core of known volume is driven into soil i.e., undisturbed soil sample have to be collected. The soil sample is weighed after oven drying the soil. The volume is calculated from the core dimensions used for drawing the soil sample. By substituting the values in the formulae, bulk density is calculated.

$$\text{Bulk Density} = \frac{\text{weight of soil}}{\text{volume of soil (including pore space)}}$$

Procedure:

- Smoothen the soil surface by removing the loose surface soil, where bulk density is to be determined Initially determine the volume of core sampler by measuring the length and diameter of the core tube.
- Drive the metallic core into the soil using a hammer. Carefully remove the core containing soil sample by excavating soil from the sides, using a crow bar.
- Remove the excess soil with a knife on either side of the core.
- Transfer the soil sample from core into pre weighed aluminium box
- Dry the soil in oven for 24 hr at 105°C later cool it and determine oven dry weight (W g) of the soil sample.

- Measure inner dimensions i.e., radius and height of the core and find out its volume.

Observation and calculation:

Height of the core = h cm

Diameter of the core = d cm

Radius of the core = r cm (d/2)

Volume of the core = $V = \pi r^2 h$ cm^3

Weight of the dry soil = W g

$$\text{Bulk density of the soil} = \frac{\text{Oven dry weight of soil}}{\text{volume of the core}} \ g\ cm^{-3} \ (or)\ Mg\ m^{-3}$$

Precautions:

- The soil sample should not be collected in very wet or dry soil.
- Always use dent free cores
- Core should be driven straight (not inclined) in to the soil
- Core should be driven gently and uniformly to avoid shattering or compaction of soil.
- Sample should be dried at temperature not exceeding 105^0c till constant weight is obtained

Calculation of porosity

% solid space = Bulk density / particle density x 100

% pore space + % solid space = 100

% pore space = 100 - % solid space

= 100 – (B.D/P.D) x 100

= 100 [1-BD/PD]

Result:

Bulk density and Porosity of the given soil sample is …………………. Mg m^{-3} and ………………. Percent respectively

Expt No: 5 **Date:**

DETERMINATION OF PARTICLE DENSITY OF THE SOIL

Particle density is the mass per unit volume of soil solids and is expressed as Mg m^{-3} or g cc^{-1}. Soils exhibit a very narrow range of values of 2.65 to 2.75with an average value of 2.65 Mg m^{-3} Soils rich in organic matter may have low density, while soils with high quantities of heavy minerals like hematite, hornblende etc., may have high values. Particle density can't be changed by management. It is useful in understanding mass-volume relationship of soils like porosity and void ratio.

Aim:

To determine the Particle density of the soil using Pycnometer or specific gravity bottle.

Apparatus:

Pycnometer or specific gravity bottle, balance.

Principle:

In obtaining the true density of the soils, the mass and volume of soil solids have to be estimated. Mass is estimated by taking dry weight of the sample and volume of solids is estimated by measuring the displacement of water by soil particles considering that when some soil is immersed in a definite volume of water, air is expelled out, it displaces volume of water equal to its own.

Procedure:

- Take a clean and dry specific gravity bottle and weigh it with stopper (Wl).
- Take about 20 g of soil in the specific gravity bottle and find out its weight (W2).
- Add little quantity of water to the soil in the bottle and shake the contents well by closing the mouth of the bottle for about 5 minutes so as to facilitate the water to occupy the pore spaces.
- Now fill the bottle completely with water and find out its weight (W3) after wiping with a blotting paper.
- Now discard the soil and water from the bottle.
- Clean the bottle and fill it with only water and find out its weight (W4) after wiping with a blotting paper.

Observations and Calculations:

Weight of empty specific gravity bottle = W_1 g

Weight of specific gravity bottle + soil = W_2 g

Weight of specific gravity bottle + soil +water = W_3 g

Weight of water present along with soil = W_3 - W_2 g

Weight of specific gravity bottle + water = W_4 g

Weight of water present alone = W_4-Wl g

Volume of water in the specific gravity bottle = VmL (50)

Volume of W3-W2 g of water = $\frac{W_3-W_2}{W_4-W_1} \times V = A$ cc

Volume of solids = V-A cc

Particle density of the soil = $\frac{\text{mass of soil}}{\text{volume of solids}} = \frac{(W_2 - W_1)}{(V-A)}$ g/cc

Result:

The particle density of the given sample is ……………………….Mg/m^{-3}.

Expt No: 6 **Date:**

ESTIMATION OF SOIL MOISTURE CONTENT BY GRAVIMETRIC METHOD

Aim: To determine the moisture content present in the soil by gravimetric method.

Apparatus: Screw auger, moisture cans, oven, balance.

Principle:

A fresh soil is dried in an oven and the loss of water on drying is determined and per cent moisture is calculated using the formula

$$\text{\% Moisture Content} = \frac{\text{Weight of fresh soil - Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

Procedure:

- Collect the soil sample with the help of screw auger from the field.
- Transfer the soil sample in to a clean weighed moisture can (W_1 g) and weigh the sample along with moisture can (W_2 g).
- Place the beaker in an oven at a temperature of 105°C for 24 hrs and dry the soil to a constant weight.
- Remove the soil from oven along with the can, cool it and weigh it

Observations and calculations:

Weight of moisture can = W_1 g

Weight of moisture can + fresh soil = W_2 g

Weight of moisture can + dry soil = W_3 g

$$\text{\%Moisture Content} = \frac{\text{Weight of fresh soil-Weight of dry soil}}{\text{Weight of dry soil}} \times 100$$

$$= \frac{(W_2-W_1) - (W_3-W_1)}{W_3-W_1} \times 100$$

Result:

The moisture content of the given soil sample is ……………………per cent.

Expt No: 7 **Date:**

DETERMINATION OF pH OF SOIL

Aim: To determine the pH of given soil sample

Apparatus : 100 ml beaker, a measuring cylinder, pH meter and an ordinary filter paper

Reagents : pH buffer tablets of 4.0, 7.0 and 9.2 are available

The pH is determined by electrometric method:

In this method the pH is determined by using pH meter, which is provided with two electrodes.

1. Calomel electrode (Reference electrode)
2. Glass electrode (Indicator electrode)

Calomel electrode: This develops a constant potential. This electrode is filled with saturated solution of potassium chloride (KCl).

Glass electrode: This is made up of sensitive glass. This develops the potential depending upon the solution and gives the pH of the solution under test.

Principle:

A potential will be developed between the two electrodes when the electrodes are immersed in the solution. This potential is called electromotive force (EMF). The glass electrode develops the potential depending upon the solution where as the reference electrode gives a constant potential. The potential developed is applied across the higher resistance and is amplified, which passes to the galvanometer, then a deflection is detected. The deflection indicates the function of pH of solution.

Procedure

- Weigh 20g of air dried soil into a 100 ml beaker
- To this add 50ml of water and stir the contents with glass rod intermittently for 30 minutes.
- Switch on the pH meter and allow for 20 minutes for warm up.
- Calibrate the instrument using the buffer solutions of pH either 4.0 or 7.0 or 9.2.
- Rinse the glass and calomel electrodes or combined electrode with distilled water and place them into a beaker of distilled water.

- After rinsing, dry the electrodes with a filter (or) tissue paper.
- Dip the electrode into the soil water suspension.
- Record the pH of the sample.

Result : pH of the given soil sample is -----------------------------------.

Expt No: 08 **Date:**

DETERMINATION OF ELECTRICAL CONDUCTIVITY OF SOIL

Introduction:

Salinity, which is caused due to the total soluble salt content is determined by measuring the electrical conductivity (EC). It is a measure of the ability of a solution to carry electric current by the migration of ions under the influence of an electric field. EC is determined by electrical conductivity meter.

Aim: To determine the electrical conductivity of soil

Apparatus : 100 ml beaker, a measuring cylinder, EC meter and an ordinary filter paper

Reagents : 0.1N KCl or 0.01NKCl solution

Description of conductivity meter:

The solubridge has two fixed resistances i.e., R_1 and R_2 and variable resistance R_v connected in a branched circuit to conductivity cell having resistance R_x. The variable resistance R_v is adjusted in such a way that no current passes between the points A and B as indicated by the maximum deflection in electric eye. At this stage points A and B attain same potential and the voltage drop between A & B is equal to B and D (Fig.)

This can be expressed as = $\frac{R_2}{R_1} = \frac{R_x}{R_v}$

Therefore $R_x = \frac{R_2 \times R_v}{R_1}$

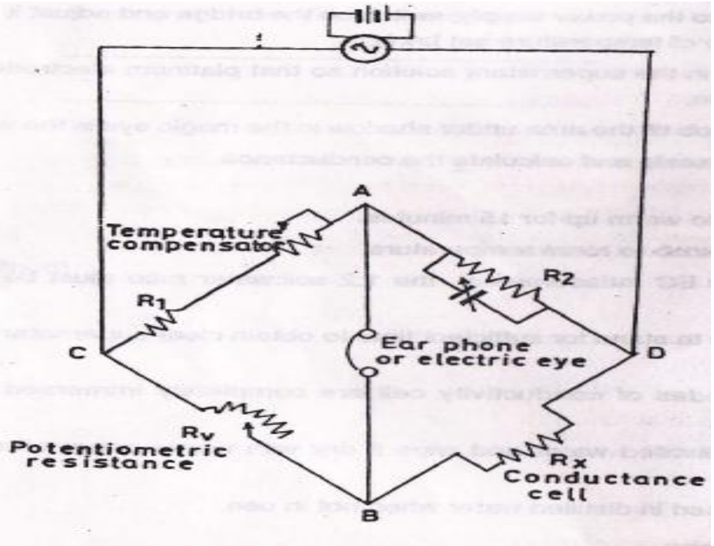


Fig. 3 Schematic diagram of salt conductivity bridge

Principle:

Solutions offer some resistance to flow of electrical current through them, depending upon the salt concentration and the type of ions present. Higher the salt content, lesser the resistance to the flow of current or enhance the conductivity. Hence electrical conductivity (EC) serves as an index of salt concentration. This obeys Ohm's law.

According to Ohm's law, the strength of the current (I) flowing through a conductor is directly proportional to the potential difference (E) applied across the conductor and inversely proportional to the resistance (R) of the conductor.

$$I = \frac{E}{R} \quad \text{or} \quad R = \frac{E}{I}$$

where E = Potential in Volts
I = Current in Amperes
R = resistance in Ohms

The electrical conductivity or conductance is the reciprocal of resistance

$$\text{E.C} = \frac{1}{R} = \frac{1}{\text{Ohm}} = \text{Ohm}^{-1} = \text{Mhos}$$

The unit of resistance is "Ohm". Since reciprocal of the resistance is termed as electrical conductivity (EC) or conductance. It is expressed as reciprocal of Ohm i.e., Mho. SI units is d Sm^{-1}. Percentage of soluble salts in soil = 0.064 x EC (in dS m^{-1})

Apparatus: 100 ml beaker, a measuring cylinder, a glass rod, a conductivity meter.

Procedure

- Weigh 20g of air dried soil into a 100 ml beaker
- To this add 50ml of water and stir the contents with glass rod intermittently for 30 minutes and then allow it to stand to obtain clear supernatant solution.
- Connect the salt bridge to the power supply, switch on the bridge and adjust it to the room temperature with the help of temperature setting knob.
- Calibrate the conductivity bridge with the help of standard KCl solution (0.1 N or 0.01N KCl) If we use 0.1N KCl, EC will be 14.14 dS m^{-1}, if we use 0.1N KCl, EC will be 1.414 dS m^{-1}.
- Rinse the conductivity cell with distilled water and then with the sample.
- Dip the conductivity cell into the supernatant solution in such a way that the platinum electrodes should not come in contact with soil.
- Record the Electrical conductivity of the sample.

Result: EC of the given soil sample is ------------------- dS m^{-1}.

Expt No: 09 **Date:**

ESTIMATION OF ORGANIC CARBON CONTENT IN SOILS

Aim:

To estimate the organic carbon content and organic matter content of the soil by Walkley and Black's rapid oxidation method (1934).

Apparatus:

Erlenmeyer flask (500mL), burette, pipette, measuring cylinder, balane

Reagents:

- Standard Potassium Dichromate (1N): Dissolve exactly 49.04 g reagent grade $K_2Cr_2O_7$ in distilled water and dilute to 1 litre in volumetric flask
- Standard ferrous ammonium sulphate (0.5N=0.5M): Dissolve 140g of $FeSO_4.7H_2O$ or 196.1g reagent grade $FeSO_4.(NH_4)_2.6H_2O$ in about 800 ml distilled water, add 20mL conc. H_2SO_4, cool and dilute to 1 litre in a volumetric flask.
- Diphenylamine indicator: Dissolve 0.5g diphenylamine in a mixture of 20mL water and 100ml distilled water
- Orthophosphoric acid (85%)
- Sodium fluoride
- Concentrated sulphuric acid

Principle:

When a known quantity of soil is treated with a known excess quantity of potassium dichromate, the organic carbon in the soil gets oxidized by potassium dichromate in the presence of concentrated H_2SO_4 utilizing the heat of dilution of sulphuric acid. The excess of dichromate not utilized for oxidation of organic carbon is determined by back titration with ferrous ammonium sulphate.

$$K_2Cr_2O_7 + 4H_2SO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3(O) + H_2O$$

$$C + 2(O) \rightarrow CO_2$$

$$K_2Cr_2O_7 + 7H_2SO_4 + 6FeSO_4 \rightarrow K_2SO_4 + Cr_2(SO_4)_3 + 3Fe_2(SO_4)_3 + 7H_2O$$

Using the experimental and blank titre values the amount of organic carbon and organic matter can be calculated.

Procedure:

- Take 1 gm of soil in to a dry 500ml clean and dry Erlenmeyer flask and add 10 ml of 1N potassium dichromate solution using a pipette.
- Then gently swirl the contents of the flask and keep on asbestos sheet.
- Add 20 ml of concentrated sulphuric acid and gently swirl the contents for 2-3 times.
- Allow the contents to stand for 30 minutes. After that add 200 ml of distilled water to stop the reaction.
- Then add 5ml of orthophosphoric acid followed by 0.5 g of sodium fluoride (to avoid the interference of Iron & Zinc in the titration) and around 1ml of diphenyl amine indicator (until the contents become dark blue or violet in colour).
- Titrate the contents against ferrous ammonium sulphate (FAS) till the blue or violet colour of the contents turns to green.
- Simultaneously run a blank experiment without soil sample.
- Note down the blank and experimental titre values.

Observations and Calculation :

1 ml of 1N $K_2Cr_2O_7$ reacts with = 0.003g of carbon

Blank titre value = B mL of 0.5 N FAS

Experimental titre value = X mL of 0.5 N FAS

$$\text{Per cent Organic carbon} = 10 \times \frac{B - X}{B} \times 0.003 \times \frac{100}{\text{Weight of Soil Sample}}$$

% organic matter (OM) = % OC X 100/58 = % OC X 1.724

Ratings:

Soil ratings for organic carbon content	
Soil Rating	**Organic Carbon (%)**
Low	< 0.5
Medium	0.5-0.75
High	> 1

Result : The Organic carbon content in the given soil sample is _________ &

categorized under __________

Expt No.: 10 **Date:**

DETERMINATION OF AVAILABLE NITROGEN IN SOIL

Aim: To determine available nitrogen content in soil sample

Apparatus: Macrokjeldhal distillation unit, Kelplus N analyzer, volumetric flask 1lt, conical flask 250ml, burette, pipette

Reagents:

1. 0.32% $KMnO_4$: Dissolve 3.2g of $KMnO_4$ in distilled water and make up the volume to 1litre
2. 2.5% NaOH: Dissolve 25g of NaOH in distilled water and make up the volume to 1 litre
3. 4% Boric acid (H_3BO_3): Weigh 40g of boric acid and dissolve in warm water and dilute to 1lt
4. Mixed indicator: 0.5g of Bromocresol green is mixed in 0.1g of methyl red in 100ml of 95% ethanol
5. Standard H_2SO_4 (0.02N): Dissolve 0.3ml of concentrated H_2SO_4 in 1litre solution

Principle:

The easily mineralizable N is estimated by using alkaline $KMnO_4$ which oxidizes and hydrolyses the organic N present in the soil. The liberated ammonia is condensed and collected in boric acid and is titrated against standard H_2SO_4 using mixed indicator to determine the amount of ammonia liberated. This method has been widely adopted for the estimation of available nitrogen content in the soil due to its rapidly and adopted for the estimation of available nitrogen content in the soil due to its rapidly and reproducibility. The process of oxidative hydrolysis requires uniform heating temperatures for better results.

Reactions during distillation:

$$2KMnO_4 + H_2O \xrightarrow{\text{alkaline}} 2KOH + 3(O)$$

$$RCH_2\text{-} NH_2COOH + (O) \xrightarrow{\text{Oxidative deamination}} R\text{-}COOH + NH_3$$

$NH_3 + HOH \text{-----------}\rightarrow NH_4OH$ (Codensation)

$2\ NH_4OH + 4\ H_3BO_3 \text{----------}\rightarrow (NH_4)_2\ B_4O_7.\ 7H_2O$ (bluish green)

Reactions during titration:

$(NH_4)_2\ B_4O_7 + H_2SO_4 + 6H_2O\text{-----------}\rightarrow (NH_4)_2SO_4 + 4\ H_3BO_3 + H_2O$

Ammonium Sulphate

Procedure:

Weigh 20g of soil sample into a 800ml of Kjeldhal flask. Moisten the soil with about 10ml of distilled water, wash down the soil adhering to the neck of the flask if any, add 100ml of 0.32% $KMnO_4$ solution. Add few glass beads or broken pieces of glass rod to avoid bumping and add 2-3 ml of paraffin liquid, to avoid contact with upper part of the neck of the flask. Measure 25ml of 4% boric acid containing mixed indicator in a 250 ml conical flask and place it under the receiver tube. Dip the receiver tube end in the boric acid. Run tap water in condenser. Add 100ml of 2.5% NaOH solution and immediately attach to the rubber stopper fitted in the alkali trap. Switch on the heaters and continue distillation until approximately 100ml of distillate is collected. First remove the conical flask containing distillate and then switch off the heater to avoid back suction. Titrate the distillate against 0.02N H_2SO_4 taken in burette until light red colour appears. Check the completion of distillation process, by using red litmus paper. If it remains same in red colour, it indicates distillation has completed. If it turns blue colour, then it indicates still ammonia is coming from the soil sample. Run a blank without soil with each set of samples. Carefully remove the kjeldhal flask after cooling and clean the flask.

Calculations:

Sample titre value = x ml of 0.02N H_2SO_4

Blank titre value = y ml of 0.02N H_2SO_4

Actual titre value = (x-y) ml of 0.02N H_2SO_4

Weight of soil taken = 20g

As per the law of equilibrium,

1 g equivalent of H_2SO_4 = 1g. Equivalent of Nitrogen

1000ml of 1N H_2SO_4 = 14g.of Nitrogen

(x-y) ml of 0.02N H_2SO_4 = $\frac{(x-y) \times 14 \times 0.02}{1000}$ g of N

20g of soil contains = $\frac{(x-y) \times 14 \times 0.02}{1000}$ g of N

So, 1000g (1kg) of soil contains = $\frac{1000 \times (x-y) \times 14 \times 0.02}{20 \times 1000 \times 1000}$ kg of N

(1 ha = 2.24 x 10^6 kg of soil)

One hectare of soil contains = $2.24 \times 10^6 \times \frac{1000 \times (x-y) \times 14 \times 0.02}{20 \times 1000 \times 1000}$ kg of N

= 31.36 X (x-y) kg ha^{-1} of nitrogen

Ratings:

Soil ratings for available nitrogen content	
Soil Rating	**Available N (kg ha^{-1})**
Low	< 280
Medium	280-560
High	> 560

Result : The available nitrogen content in the given soil sample is _________ & categorized under __________

Expt No.: 11 **Date:**

DETERMINATION OF AVAILABLE PHOSPHORUS IN SOIL

Aim: To determine available phosphorus content in soil sample by Olsen's method

Apparatus: Spectrophotometer, Conical Flask 250ml, Whatmann No.42 filter paper, volumetric flask 25ml, volumetric flask 1lt

Reagents:

1. 0.5M $NaHCO_3$: (Olsen's Reagent) Dissolve 84g of $NaHCO_3$ in water and make up to 2litre. Mix thoroughly. Adjust to pH 8.5 with 1M NaOH solution.
2. Reagent A: Dissolve 12g of ammonium molybdate in 250ml of distilled water. Dissolve 0.2908g of antimony potassium tartarate in 100ml of distilled water. Add these two solutions to 1000ml of 2.5M H_2SO_4, mix thoroughly and make to 2000ml. Store in pyrex glass bottle in a dark and cool place.
3. Reagent B: Dissolve 1.056g of ascorbic acid in 200ml of reagent A and mix. This does not keep for more than 24hr at room temperature. Prepare daily as required.
4. Sulphuric acid (2.5M): Dilu4te 140ml of Con.H_2SO_4 to 1litre.
5. Standard Stock P solution: Dissolve 0.439g of potassium dihydrogen orthophosphate (KH_2PO_4) in half a litre of distilled water. Add 25ml of 7N H_2SO_4 and make to one litre with distilled water. This gives 100ppm P standard stock solution. From this, a 2 ppm solution is made by diluting it 50 times.

Principle:

Olsen's reagent decreases the activity of Ca and prevents the release of phosphates from apatites and also releases the orthophosphates into the extract. The soluble phosphates form heteropoly complexes with molybdate forming ammonium phosphomolybdate which gives blue colour of both standards and sample solution will be measured in spectrophotometer at a wavelength of 660nm. The concentration of Phosphorus in soil extract is calculated from the standard graph.

Spectrophotometer working Principle:

It is based on the Lambert-Beer's law which states that the intensity of monochromatic light beam decreases exponentially as the concentration of the absorbing substance increases arithmetically, expressed below.

$$\text{Log } I_0/I = kC$$

Where I_o = intensities of the incident radiation

I = are the intensities of the transmitted radiation

C = Concentration in solution, k- Constant.

The above relationship holds good only when the light is of the wavelength at which the absorption is maximum by the sample.

Spectrophotometer works on the visible range from 375-750nm.

Preparation of Standard Curve:

Take 0, 1, 2, 3, 4 and 5ml of 2ppm standard P solution into a series of 25 ml volumetric flasks. To this add 5ml of extracting solution followed by 1 drop of para nitrophenol indicator that gives yellow colour. Discolour the contents by adding dilute H_2SO_4 (2.5M) drop wise to bring down the pH to around 5 at which pH, the formation of heteropoly complex of Phosphomolybdates is perfect. Add 4ml of reagent b and make up the volume to 25ml with distilled water. Shake the contents and measure the intensity of blue colour in spectrophotometer at a wavelength 660nm. Plot the standard graph for P taking absorbance values on Y-axis and concentration of P on X-axis.

Procedure:

Weigh 2.5g of soil into a 150ml of conical flask. Add a little of Darco G 60or P free activated charcoal. Add 50ml of extracting solution (Olsen's reagent) and shake on the reciprocating shaker for 3 min. Similarly, run a blank without soil. Filter through Whatman no.42 filter paper into a clean and dry beaker. Shake the flask immediately before pouring suspension into funnel. Place a 5ml of aliquot of the extract in a 25ml of volumetric flask and acidify with 2.5M H_2SO_4 to pH 5.0. Add distilled water to 25ml and then add 4ml of reagent B. After waiting for 10 min, read the intensity of blue colour on a spectrophotometer as described for standard curve above.

Calculations:

Spectrophotometer reading = x

Concentration of P from graph in the coloured solution = y ppm (or) (µg/ml)

1ml of the coloured solution contains = y µg of P

25ml of coloured solution contains = 25 X y µg of P

5 ml of extract contains = 25 X y µg of P

50ml of soil extract contains $= \dfrac{50 \times 25 \times y}{5}$ µg of P

2.5 g of soil contains $= \dfrac{50 \times 25 \times y}{5}$ µg of P

1000g (1kg) of soil contains $= \dfrac{1000 \times 50 \times 25 \times y}{5 \times 2.5}$ µg of P

(1ha= 2.24 X 10^6 kg of soil)

One hectare of soil contains $= \dfrac{2.24 \times 10^6 \times 1000 \times 50 \times 25 \times y}{5 \times 2.5}$ µg of P

$= \dfrac{2.24 \times 10^6 \times 1000 \times 50 \times 25 \times y}{5 \times 2.5 \times 10^9}$ kg of P

$= 224 \times y$ kg ha^{-1} of P

Ratings:

Soil ratings for available phosphorus content	
Soil Rating	**Available P (kg ha^{-1})**
Low	< 10
Medium	10-24.6
High	> 24.6

Available P_2O5 = Available P X 2.29

Result : The available phosphorus content in the given soil sample is _________ & categorized under __________

Expt No.: 12 **Date:**

DETERMINATION OF AVAILABLE POTASSIUM IN SOIL

Aim: To determine available potassium content in soil sample

Glass ware & Apparatus required:

Balance, mechanical shaker, conical flask, volumetric flasks, measuring cylinder, beaker, funnel and Flamephotometer

Reagents:

1. Neutral Normal ammonium acetate: Dissolve 77.09g of ammonium acetate in 800ml of distilled water, adjust the pH to 7.0 with ammonia solution or acetic acid and dilute to 1L with distilled water.
2. Standard solution of K (1000ppm): Dissolve 1.907g of KCl in distilled water and make the volume to 1L
3. Preparation of standard graph for K:
4. From the stock solution (1000ppm) different working standards are prepared as given below. Take aliquots of 0,1,2,3,4 and 5ml of 1000ppm K solution into a series of 100ml volumetric flasks and make up to the mark to prepare 0,10,20,30,40 and 50ppm K solutions respectively.

Principle :

A known weight of soil is taken and shaken with neutral normal ammonium acetate solution. Ammonium exchanges with K on the soil colloids and the extract contains exchangeable and water soluble K, the amount of which is determined by using a flame photometer by emission spectroscopy.

Working Principle of Flamephotometer :

Flame photometer is based on the principle of emission spectroscopy. When a liquid sample containing a metallic salt solution is introduced into a flame, the solvent is vaporized leaving the particles of the solid salt. The salt is converted into the gaseous state. A part or all of the gaseous molecules are progressively dissociated to give free neutral atoms or radicals. These neutral atoms are excited by absorbing the thermal energy of the flame. The excited atoms which are unstable and they return to normal or ground state by quickly emitting the absorbed energy in the form of photons. The emitted radiation is collected by a concave mirror from the flame and is then permitted to pass through a prism and slit. The radiation of the approximately selected wave length strikes a photo detector and the magnitude of the electrical signal developed is read out on a meter.

Procedure:

Weigh 5g of soil sample into a 250ml of conical flask. To this add 25ml of ammonium acetate (1N, pH=7.0). Shake the contents for 5 minutes and filter through whatman No.1 filter paper. The extract is aspirated to the flame and the flame photometer reading is noted down.

Observations:

Weight of soil taken = 5g
Flame photometer reading = A ppm (or) (μg/ml)
Volume of the extract = 25ml

Calculations:

Concentration of K in soil extract = A ppm
1ml of soil extract contains = A μg of K
25ml of soil extract contains = 25 X A μg of K
5g of soil contains = 25 X A μg of K
1 g of soil contains = $\frac{1}{5}$ X 25 X A μg of K
= 5 X A μg of K **/** g of soil
= 5 X A ppm
Available K in soil = 5 X A ppm
Available K in kg/ha = 5A X 2.24= 11.2 X A kg ha^{-1}

Available K$_2$O= Available K X 1.2

Ratings:

Soil ratings for available potassium content	
Soil Rating	**Available K (kg ha^{-1})**
Low	< 108
Medium	108-280
High	> 280

Result: The available potassium content in the soil is ____________ kg and the soil is rated as ____________

Expt No.: 13 **Date:**

DESCRIPTION OF SOIL PROFILE IN THE FIELD

Introduction:

A vertical section of soil through all its horizons and extending up to the parent material is termed as “soil profile". The study of soil profile helps in assessing the suitability of soils to agriculture. It also helps in classification of soils and delineation of problem soils like acidic, saline and alkali soils.

Aim: To dig and describe the soil profile in the field

Apparatus:

Digging tools like crowbar, spade, auger etc.; cutting knife, measuring tape, Munsell colour chart, magnifying lens, dilute HCl, water bottle, Phenolphthalein indicator, cloth bags, marker pens, Proforma for profile description.

Digging of soil profile:

Profile study should be carried out by digging profiles at representative sites. Representative sites are selected considering the variations in soil characters. Dig a pit of about 6'x 4'x 6' in case of deep soils, up to bed rock in case of shallow soils and up to water table in soils with high water table. Select east and west sides for study as they can get maximum light. Get in to the pit and draw horizon boundaries.

Description of the profile site and profile:

a) The profile site should be described in terms of its location (longitudes, latitudes and altitude) and site features (relief, climate, vegetation, land use, extent of erosion, drainage, presence of salt or alkali etc.,). Start collecting the soil samples from lower most horizons.

b) Describe the profile in terms of number of horizons, horizon sequence, depth of horizons and boundary between horizons. Examine and describe each horizon for colour (dry and moist), texture, structure (type, class and grade), consistence (dry, moist and wet), pores, roots, slickenside, cracks, hard pans etc,

Collection and preparation of profile samples:

a) Collect soil samples from all horizons scrapping the horizon. Put the samples in cloth bags with polythene lining. Label each sample with profile number and horizons number.

b) Air dry the soil samples and pound the dry samples with wooden hammer. Pass the pounded soil sample through 2mm sieve. Weigh the gravel retained by the sieve and express as percentage of total weight of soil sample. Store the sieved material in polythene lined cloth bags.

O Horizons: (Organic) It comprises of organic horizons that form above the mineral soil. They result from litter derived from dead plants and animals. 'O' horizons usually occur in forested areas and are generally absent in grassland regions.

A - Horizon: It is the top most mineral horizon. It contains a strong mixture of decomposed (humified) organic matter, which tends to impart a darker color than that of the lower horizons.

E - Horizon: It is an eluviated horizon. Clay and sesquioxides are invariably leached out, leaving a concentration of resistant minerals such as quartz. An 'E' horizon is generally lighter in color than the 'A' horizon and is found under 'A' horizon.

"B" – Horizon : (Illuvial) The sub -surface 'B' horizons include layers in which illuviation of materials has taken place from above and even from below. In humid regions, the B horizons are the layers of maximum accumulation of materials such as sesquioxides and silicate clays. In arid and semi-arid regions Ca CO_3, Ca SO_4 and other salts may accumulate in the B horizon.

'C' – Horizon: It is the unconsolidated material underlying the 'Solum' (A & B). It may or may not be the same as the parent material from which the solum formed. The 'C' horizon is out side the zones of major biological activities and is generally little affected by the processes that formed the horizons above it.

'R'- Layer : Underlying consolidated rock, with little evidence of weathering.

Sub – Ordinate Distinctions with in Master Horizons:

p: plough layer disturbance

h : illuvial accumulation of organic matter

n : accumulation of sodium

t : accumulation of silicate clays

s : illuvial accumulation of organic matter and sesquioxides

y : accumulation of gypsum

z : accumulation of soluble salts

Expt No.: 14. **Date:**

IDENTIFICATION OF DEFICIENCIES SYMPTOMS ON NUTRIENTS IN THE FIELD FOLLOWED BY DIAGNOSIS AND INTERPRETATION

Aim: To identify nutrient deficiency symptoms of crops in field

Introduction:

The three basic tools for diagnosing nutrient deficiencies are 1) Soil testing 2) Plant analysis and 3) Visual observations in the field. Both soil testing and plant analysis are quantitative tests that compare soil or plant concentrations to the sufficiency range for a particular crop. Visual observation is a qualitative assessment and is based on symptoms such as stunted growth or a yellowing of leaves occurring as a result of nutrient stress. This practical class focuses on visual nutrient deficiency symptoms observed in common crops.

Plants require essential nutrients for normal functioning and growth. A plant's sufficiency range is the range of nutrient amount necessary to meet the plant's nutritional needs and maximize growth. The width of this range depends on individual plant species and the particular nutrient. Nutrient levels outside of a plant's sufficiency range cause overall crop growth and health to decline due to either a deficiency or toxicity. Nutrient deficiency occurs when an essential nutrient is not available in sufficient quantity to meet the requirements of a growing plant.

Mobile and Immobile Nutrients

Identifying deficiency symptoms is to determine whether the deficiency is the result of a mobile or immobile nutrient based on where the symptom appears in the plant. Mobile nutrients are nutrients that are able to move out of older leaves to younger plant parts when supplies are inadequate. Mobile nutrients include N, P, K, Cl, Mg and molybdenum (Mo). Because these nutrients are mobile, visual deficiencies will first occur in the older or lower leaves and effects can be either localized or generalized.

Immobile nutrients [B, Ca, S, Cu, Fe, Mn, Ni, and Zn] cannot move from one plant part to another and deficiency symptoms will initially occur in the younger or upper leaves and be localized. Zn is a partial exception to this as it is only somewhat immobile in the plant, causing Zn deficiency symptoms to initially appear on middle leaves and then affect both older and younger leaves as the deficiency develops

Mobile Nutrients

1. **Nitrogen (N):**

- Chlorosis of lower leaves, stunted and slow growth and necrosis of older leaves in severe cases.
- N deficient plants will mature early and crop quality and yield are often reduced.
- In cereals, yellow discoloration from the leaf tip backward in the form of a 'V' is common. Insufficient amounts of N in cereals will result in few tillers, slender stalks, short heads and grain with low protein content. Fields deficient in N can be either uniform or patchy in appearance, depending on the cause of the deficiency. For example, fertilizer application 'misses' will result in uniform strips of deficiency, whereas N deficiency as a result of soil characteristics such as organic matter content will be patchy .

Fig.1 N deficiency symptoms in Barley crop

2. Phosphorus (P):

- Plants require P for the development of ATP (energy), sugars and nucleic acids. Cool soils during the early growing season may be a factor causing P deficiency.
- P deficiency symptoms are usually more noticeable in young plants, which have a greater relative demand for P than more mature plants.
- P deficient plants generally turn dark green (both leaves and stems) and appear stunted. Older leaves are affected first and may acquire a purplish discoloration due to the accumulation of sugars which favors anthocyanin synthesis; in some cases, leaf tips will brown and die. Plants suffering from P deficiency appear weak and maturity is delayed. P deficiency in corn is usually visible in young plants with leaves turning purple.

Fig.2 Phosphorus deficiency symptoms in maize crop

3. Potassium (K):

- K deficiency does not immediately result in visible symptoms (hidden hunger). Initially, there is only a reduction in growth rate, with chlorosis and necrosis occurring in later stages. Chlorotic symptoms typically begin on the leaf tip, but unlike the 'V' effect caused by N deficiency, K deficient chlorosis will advance along the leaf margins towards the base, usually leaving the midrib alive and green. As the deficiency progresses, the entire leaf will yellow.
- Reduced straw or stalk strength in small grains and corn, resulting in lodging problems, reduced disease resistance and reduced winter-hardiness of perennial or winter annual crops.

Fig.3 Potassium deficiency symptoms in Soybean & Maize crops

4. Magnesium (Mg)

- Symptoms of Mg deficiency include interveinal chlorosis and leaf margins becoming yellow or reddish-purple while the midrib remains green.
- Reduced Mg concentrations in wheat forage can lead to **grass tetany (low blood serum Mg)** in animals grazing on winter wheat.

Fig. 4 Magnesium deficiency symptoms in maize

<u>Immobile Nutrients</u>

1. Sulphur (S)

- S deficiency symptoms can be difficult to diagnose as effects can resemble symptoms of N and Mo deficiencies.
- In contrast to N or Mo deficiency, however, S deficiency symptoms initially occur in younger leaves, causing them to turn light green to yellow.

Fig.5 Sulphur deficiency symptoms in maize

2. Iron (Fe)

- Iron plays an important role in plant respiratory and photosynthetic reactions. Fe deficiency reduces chlorophyll production and is characterized by interveinal chlorosis with a sharp distinction between veins and chlorotic areas in young leaves. Zinc (Zn)

Fig.6 Iron deficiency symptoms in Maize

3. Zinc (Zn)

- Zn deficient leaves display interveinal chlorosis, especially midway between the margin and midrib, producing a striping effect; some mottling may also occur.
- Chlorotic areas can be pale green, yellow, or even white. Severe Zn deficiency causes leaves to turn gray white and fall prematurely or die. Because Zn plays a prominent role in internode elongation, Zn deficient plants generally exhibit severe stunting. Flowering and seed set is also poor in affected plants.

Fig.7 Zinc deficiency symptoms in maize

4. Calcium (Ca)

- Insufficient Ca can cause young leaves to become distorted and turn abnormally dark green. Leaf tips often become dry or brittle and will eventually wither and die. Stems are weak and germination is poor.

Fig.8 Calcium deficiency symptoms in Cotton & Tomato

5. Copper (Cu)

- Cu deficient plants display chlorosis in younger leaves, stunted growth, delayed maturity (excessively late tillering in grain crops), lodging and, in some cases, melanosis (brown discoloration). In the field, Cu deficiency symptoms occur in irregular patches with melanosis being the most obvious symptom, particularly in wheat stands. Similar to Zn deficiency, forage that is deficient in Cu can cause reduced reproductive efficiency in cattle.

Fig.9 Copper deficiency symptoms in wheat

6. Manganese (Mn)

- A common symptom of Mn deficiency is interveinal chlorosis in young leaves. However, unlike with Fe deficiency, there is no sharp distinction between veins and interveinal areas, but rather a more diffuse chlorotic effect.

  Ex: Grey speck in oats and marsh spot in peas, white streak in wheat and
  interveinal brown spot in barley are also symptoms of Mn deficiency

Fig.10 Manganese deficiency symptoms in Soybean

Interpretation:

By visual observation of deficiency symptoms in the fields, identify the symptoms and diagnose the correct problem through field visits.

Expt No. 15 **Date:**

VISIT TO THE SOIL OF DIFFERENT TEXTURES TO STUDY THEIR PROPERTIES

Expt No. 16 **Date:**

INTERPRETATION OF SOIL ANALYSIS DATA

Data pertaining to available nutrient status of soils are commonly referred to as soil test values. These values serve as input to (i) to develop site specific fertilizer recommendations and (ii) to monitor changes in soil fertility over time to know whether the soil fertility is being depleted, maintained or improved (built-up). Soil testing is mostly used as a tool to provide fertilizer recommendations for the use of farmers. The same information is also used to generate soil fertility maps.

Soil fertility categories

In most cases, the soils are categorized into different fertility classes which are used for making fertilizer recommendations and also for soil fertility mapping.

Rating limits for soil test values used in India

Nutrient	Low	Medium	High
Organic carbon for N (%)	Below 0.5	0.5-0.75	Above 0.75
Available N-$KMNO_4$ (kg/ha)	Below 280	280-560	Above 560
Available P (kg/ha)	Below 10	10-25	Above 25
Available K (kg/ha)	Below 108	108-280	Above280

Based on the soil fertility ratings , the nutrient requirement of various crops can be arrived and accordingly fertilizer recommendations can be suggested.

*****