PRACTICAL MANUAL

Fundamentals of Soil Science

HNR 131 2(1 + 1)

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Syllabus: Fundamental of Soil Science2(1+1)

Description of soil profile in the field.Collection and preparation of soil samples, estimation of moisture, EC, pH and bulk density.Textural analysis of soil by Robinson's pipette method.Quantification of minerals and their abundance. Determination of Soil colour using Munsell Chart. Estimation of water holding capacity and hydraulic conductivity of soils. Estimation of Infiltration rate using double ring infiltrometer method. Estimation of soil moisture using gypsum block and neutron probe method.Soil compaction measurement with Pentrometer. Determination of pore space of soil. Determination of filed capacity and permanent wilting point of soil. Determination of soil water potential characteristic curves by tensiometer and pressure plate apparatus. Aggregate size distribution analysis of soil. Air capacity of soil by field method.

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Contents

Experiment No. 1

Objective: Description of soil profile in the field.

The vertical section of the soil from the surface extending in to the parent material iscalled soil profile. The various layers, composing the soil, are called horizons. A soil horizon may be defined as a layer (of varying thickness) approximately parallel to the soil surface. The study of soil profile and its characteristics determines the agricultural value (orchard, forest & crop) of land and explain its behavior towards use and management. It is pre-requisite for classifying of soils. The horizons in profile can be designated as follows:

Exercise for the student

1. **What are the Materials required to study soil profile. Draw horizons in profile.**

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2. **Write the soil profile study procedure.**

A. Write down the selection procedure of site for soil profile study:

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B. Write down the procedure of digging of a soil profile

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C. Write down theexamination and description of soil profile

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D. Write down the general description of profile site in given Performa:

The general description of soil profile should include

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3. Precautions to be taken while study soil profile?……………………………………………

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Experiment No. 2

Objective: Collection and preparation of soil samples

Soil sampling is perhaps the most important step for analysis of soil. It includes collection of soil material by considering the variability of soils; handling and processing of soils and finally storing the processed soil in bag for its actual testing. A field can be treated as a single sampling unit if it is relatively uniform and does not generally exceed 0.5 hectare. If there is variation in slope, profile depth, landscape area, soil colour, texture, response to fertilizer treatment, crop growth, cropping pattern etc., separate composite soil samples need to be collected from each site.

1. Objectives of soil testing:

a) ....

b) ....

c) ....

d) ....

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2. Importance of soil sampling:…………………………………………………………………………………...

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3. Sampling tools required to collect soil samples: …………………………………………………………

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4. Collect soil sample from the field. Write the procedure of sampling, processing and storage.

a) Procedure of sampling

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Prescribed depth (cm) of soil sampling

Field crops	
Deep rooted crops	
Forage or pasture crops	
For immobile nutrients (P, K, Ca and Mg)	
Nitrate, Sulfate	
Saline alkali soils	

b)Procedure of processing

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c)Procedure of Storage

Transfer the sieved material in airtight plastic container and leveled the soil sample with having following information:

Name and address of the farmers :

Khasra No :

Identification of the field :

Area of field (hectare/Acre/Bigha) :

Sample depth (0-15 cm / 15-30 cm) :

Local name of the soil :

Date of collecting soil sample :

Name of previous crop (irrigated/ unirrigated) :

Fertilizer used in previous years :

Any other problem observed in the field :

For microbial analysis, soil samples should be analyzed immediately or otherwise stored in deep freezer for longer usage at 4-10°C.

5.What are the precautions one should take while collecting and processing of soil sample?…………

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Sketch a neat and clean representative soil sampling steps

Experiment No. 3

Objective: Estimation of pH of given soil sample

1. Principle:……………………………………………………………………………………………………

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2.Equipment’s and Apparatusrequired:

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3. Preparation of Standard buffer solution:

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4. Write procedure of soil pH determination.

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5. Result:

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Experiment No. 4

Objective: Estimation of Electrical Conductivity of given soil sample

Amount of soluble salts in a sample is expressed in terms of the electrical conductivity (EC) and measured by a conductivity meter. The instrument consists of an electrical resistance bridge and conductivity cell having electrodes coated with platinum black. The Instrument is also available as an already calibrated assembly (Solubridge) for representing the conductivity of solutions in dSm-1 (deci Siemen per meter) at 250C.

Exercise for the student

1. Principle:…………………………………………………………………………………………………..

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2.Equipment's and Apparatus required:…………………………………………………………………..

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4. Write the procedure of EC determination: …………………………………………………………………..

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5. Result:…………………………………………………………………………………………………...

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Experiment No. 5

Objective: Estimation of moisture content of given soil sample by gravimetric method.

Principle: Weighted soil sample is the placed in oven at 105° C and it is a dried to constant weight. The weight difference is considered to be water present in soil sample.

$$\textbf{Moisture (\%)} = \frac{\text{Weight of moisture present in the soil}}{\text{Weight of oven dry soil}} \times 100$$

1. Materials required: ……………………………………………………………………………………………

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2. Estimation of moisture content of given soil sample by gravimetric method.Write its procedure:

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3. Observation:

I	Weight of empty moisture box (g)	X g	
II	Weight of moisture box + fresh soil	Y g	
III	Weight of moisture box + oven dry soil	Z g	
a	Weight of moisture present in the soil	(Y-Z) g	
b	Weight of oven dry soil	(Z-X) g	

4. **Calculation:**……………………………………………………………………………………………..

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5.Result: ……………………………………………………………………………………………………

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Experiment No. 6

Objective: Estimation of bulk density of soil by core method.

Density is an expression of mass of the oven-dry soil per unit volume. Two types of densities are volume of solids and pore spaces, whereas bulk density and particle density. In bulk density total soil volume includes the solid and pore spaces, while volume of solids alone is consideredin particle density.

1. Estimation of bulk density of soil by core method. Write its principle.

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2. Apparatus and accessories required:

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3. Estimation of bulk density of soil by core method. Write its procedure:

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Observation:

I	Weight of empty moisture box	W_1 g	
II	Weight of moisture box + oven dry soil	W_2 g	
a	Weight of oven dry soil	(W_2-W_1)g	
b	Volume of the soil or Volume of core sampler	V ml	

Calculations:

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

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Result:

1. ....

2. ....

Experiment No. 7

Objective: Estimation of bulk density of soil by pycnometer method.

Principle:………………………………………………………………………………………………………...

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Draw a neat and clean sketch of soil system on the volume basis

$$\text{Bulk density of soil } (D_b)\ (\text{g cm}^{-3} \text{ or Mg m}^{-3}) = \frac{\text{Wight of oven dry soil}}{\text{Volume of Bulk soil (Solid+Pores)}}$$

Equipment's required: ……………………………………………………………………………………………....

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Procedure:……

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Observation:

I	Weight of empty pycnometer	W_1 g	
II	Weight of Pycnometer + oven dry soil	W_2 g	
a	Weight of oven dry soil	(W_2-W_1)g	
III	Volume of the soil or Volume of water needed to fill the pycnometer	V ml	

Calculation:

$$\text{Bulk density of soil (Db) (g cm}^{-3}\text{ or Mg m}^{-3}\text{)} = \frac{(W_2-W_1)\text{g}}{\text{V ml}}$$

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Result:………..................

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Experiment No. 8

Objective: Estimation of particle density of soil.

Principle: The mass of unit volume of soil solid is called particle density. It is determined by measuring the mass and volume of soil solid.

Equipment's required: ……………………………………………………………………………………………

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Procedure:………………………………………………………………………………………………………

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Observation:

I	Weight of empty pycnometer	W_1 g	
II	Weight of Pycnometer + water	W_2 g	
III	Weight of Pycnometer + water + oven dry soil	W_3 g	
IV	Weight of oven dry soil	W_4 g	10 g
V	Volume of water displaced by soil	Y ml	$(W_2 + W_4) - (W_3)$

Calculation:

$$\text{Particle density of soil (g cm}^{-3}\text{ or Mg m}^{-3}) = \frac{\text{Weight of oven dry soil}}{\text{Volume of water displaced by soil}}$$

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Result:……
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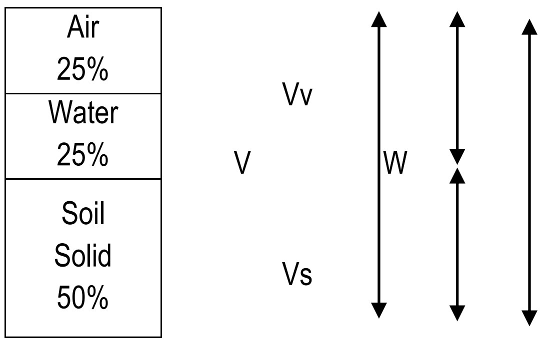
Experiment No. 9

Objective: Determination of pore space of soil.

Principle: Porosity of soil is the fraction of soil volume not occupied by soil particle (solids).



Whereas,

W=Ws, Ws=Weight of oven dry soil, Vs=Volume of soil solid, Vs=Volume of pores, V= Vs +Vv

$$\text{Bulk density of soil (g /cm3or Mg/ m3)} = \frac{Ws}{V}$$

$$\text{Particle density of soil (g cm} - 3 \text{ or Mg m} - 3) = \frac{Ws}{Vs}$$

Ws = Bulk density x V

Ws = Particle density x Vs

Ws = Ws

Bulk density x V = Particle density x Vs

$$\frac{BD}{PD} = \frac{Vs}{V}$$

$$\text{Percentage of solid space} = \frac{Vs}{V} \times 100$$

$$= \frac{BD}{PD} \times 100$$

$$\text{\% ofPorosity} = 100 - \left(\frac{BD}{PD}\right) X100$$

Apparatus required: ……………………………………..………………………………………………………

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Procedure:………

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Calculation:

$$\% \text{ of Porosity} = 100 - \left(\frac{BD}{PD}\right) X100$$

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Result:………

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Experiment No. 10

Objective: Textural analysis of soil by Robinson's pipette method.

Particle-size distribution is one of the stable soil characteristics. being little modified by cultivation or other practices. The particle-size distribution expresses the proportion of various sizes of particles in a soil, especially sand, silt and clay that determine soil texture. Soil texture can be related to soil physical properties such as water retention characteristics, surface area, swelling and shrinking, soil strength, and tillage properties. The two common methods of particle-size analysis are the pipette method and the hydrometer method.

Principle:………

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$$v = 2/9 \{r^2 (s - Pi)g\} n$$

Where, v = settling velocity of the particle (cm/s),

r = radius of the particle (cm),

Ps = density of the particle (g/cm^3),

pi= density of the liquid water (g/cm^3),

g = acceleration due to gravity (cm/ s^2), and

n = viscosity of the liquid water (g/cm/s).

Apparatus and Accessories: ………………………………………………………………………………

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Reagent: ………………………………………………………………………………………………………

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Procedure: ………

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Observations:

A. Description of the soil under study …………....
B. Weight of air dry soil ……………..g
C. Moisture percentage in air dry soil …………….%
D. Volume of Robinson pipette …………….ml
E. Weight of sesqui-oxide (step-7) …………….g
F. Weight of coarse sand (step-15) ……………….g
G. Suspension temperature (step-16) ………………˚C
H. Weight of fine sand (step-29) ………………g
I. Weight of silt + clay (step-22) ………………g
J. J. Weight of clay (step-23) ………………g

Calculations:

A. Course sand percentage in soil, (F x 100) / 10 ………… %
B. Weight of silt in soil, (I – J) (1000 / 20) = ……… g
C. Silt % in soil, (L x 100) / 10 = …………%
D. Weight of clay in suspension, (J/ 20) 1000 = ………….g
E. Weight of total clay in the soil, (O + E) = ……………….g
F. Clay % in soil (P x 100) / 10 = ………….. %

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Results:

Sand (coarse + fine sand) % =
Silt % =
Clay% =
Soil texture (Use texture triangle) =

Experiment No. 11

Objective: Determination of soil colour using Munsell Chart.

The color of soil is due to organic matter, mineral matter and mixture of these two. Red, brown and yellow color of soil is mainly due to compounds of iron. Silica, lime and salts provide white or light color to the soil. Organic matter gives black, grey and brown and other dark color to the soil. Minerals of manganese and titanium also enhance to dark coloration of the soil.

Apparatus and materials:……………………………………………………………………………………..

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Procedure:..…………………………………………………………………………………………………...

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Observation

Sample No.	Dry soil					Moist soil				
	Munsell notation					Munsell notation				
	Hue	Value	Chroma	Comb-ination	Color name	Hue	Value	Chroma	Comb-ination	Color name
1.										
2.										
3.										
4.										
5.										

Result:

1. Sample number =
2. Color of dry soil =
3. Name of the dry soil color =
4. Color of moist soil =
5. Name of the moist soil color =

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Experiment No. 12

Objective: Determination of maximum water holding capacity of soil.

Principle:

Maximum water holding capacity of a soil is referred to the maximum amount of moisture; a dry soil is capable of holding under saturated conditions. If the moisture content is further increased, percolation results *i.e.,* the excess water starts to flow down under theinfluence of gravity. This technique is based upon the capillary rise of water in the soil immediately above the water table resulting saturation of soil against the gravity. Thus, the water held in the soil at the point of saturation is determined.

Apparatus required:……………………………………………………………………………………………

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Procedure:……………………………………………………………………………………………………

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Observations:

Parameters	**Determination I**	**Determination II**
(a) Weight of Hilgard+ dry filter paper =		
(b) Weight of Hilgard+ wet filter+ saturated soil =		
(c) Weight of Hilgard+ filter paper+ oven dry soil =		

Calculation

(d) Moisture content of filter paper= $\frac{saturated weight of\ 5\ filterpaper - dry weight of\ 5\ filterpaper}{5}$

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Water holding capacity of soil = $\frac{\boldsymbol{b-c-d}}{\boldsymbol{c-a}} \times \mathbf{100}$

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Result:

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Experiment No. 13

Objective: Estimation of hydraulic conductivity of soils by Constant Head Method.

Hydraulic conductivity is an important soil property that determines the ability of soil to transmit water. A method of measuring hydraulic conductivity of saturated soil using undisturbed soil important soil property that determines the ability of a soil to core are described.

Determination of hydraulic conductivity of saturated soil:

Apparatus and accessories: ………………………………………………………………………………………

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Procedure: ………..

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Observations:

a.	Soil texture	----------------------
b.	Diameter of sample, (cm)	----------------------
c.	Length of sample, L, (cm)	----------------------
d.	Cross sectional area of sample, A, (cm^2)	------------------------
e.	Bulk density of sample, (g/cm^3)	-------------------------
f.	Water temperature, T, (°)	------------------------
g.	Sample number	I II III
h.	Outflow, Q. (cm^3)	--------------------------
i.	Elapsed time, (t_2-1), (s)	--------------------------
j.	Hydraulic head difference across the sample, ΔH, (cm)	--------------------------

Calculation:

$$K_T=(QL)/ A \Delta t \Delta H, (cm/s)$$

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Results

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Experiment No. 14

Objective: Estimation of Infiltration rate using double ring infiltrometer method.

The infiltration rate is generally determined in the field using the cylinder or the ring infiltrometer. This method measures the vertical rate of entry of water into the soil surface. It consists essentially of a metal ring or cylinder, which is hammered into the soil vertically downwards. Water is, then, poured into the ring. After water has penetrated into the soil to a depth, below the bottom of the ring, it will start spreading laterally as well as vertically. This will affect the infiltration rates, because water is moving laterally as well as downwards from the zone of the wetted soil. To minimize this effect, a buffer pond can be created by driving a larger diameter metal ring concentric with the ring infiltrometer. The use of two concentric metal rings to work out the infiltration characteristics is referred to as the 'double ring' infiltrometer method.

Apparatus/Equipment: ……………………………………………………………………………………………

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Procedure: ……………………………………………………………………………………………………

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Observation sheet (determination of infiltration rate)

SN	Local time (hr)	Time Interval (min)	Cumulative Time (min.)	Depth of water (cm)	Intake (cm)	Cumulative Intake (cm)	Intake rate (cm/hr)
1							
2							
3							
4							
5							
6							
7							
8							
9							
10							
11							
12							

Result:

The basic infiltration rate of the soil is ……………………………………………… cm hr^{-1}

Experiment No. 15

Objective: Measurement of soil compaction by using Penetrometer.

The cone index of resistance to penetration represents the resistance to pushing penetrometer into the soil layer. A high cone index is associated with a high bearing capacity an soil hardness. Bearing capacity of the plowed layer and plow sole layer determines the work as farm machines and root penetration in the soil. During puddling, the plowed soil becomes very the plow sole gets compacted by the farm machines. Upon desiccation, both puddled soil and he become hard enough to interfere with crop roots. The cone index of resistance to penetration by a penetrometer can be measured continuously from the surface to the full depth of the rod without hard to dig a pit.

Apparatus and Accessories: ....

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Procedure: ....

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Observations:

Soil depth (m)	Dial gauge reading for the cone (base cm^2 , angle…...............)			
	1	2	3	Average

Calculation

Calculate cone index q_c (Kgf/ cm^2) using the relation

$$q_c = [(F + W)/ A] = [(KR + W) / A]$$

Where F = applied force (Kgf),

A = cone base area (cm^2),

W = weight of the penetrometer (Kgf),

K = response coefficient of the dial gauge, and

R = dial guage reading.

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The direct reading, and well calibrated penetrometers are also available and can be used. Plot the relationship between cone index and depth for the test location.

Experiment No. 16

Objective: Determination of field capacity of soil.

The field capacity of a soil is defined as the amount of water held in soil after the excess of gravitational water w drained away under free drainage and minimum evaporation.

A. LABORATORY METHOD

Equipment: ....

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Procedure : ....

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B. FIELD METHOD

Equipment: ....

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Procedure : ....

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Calculations : $$\text{Porosity} = \frac{\text{particle density} - \text{bulk density}}{\text{particle density}}$$

Amount of water retained in upper 30 cm (θ) = $$\frac{Wi \times \rho bi}{100} + \cdots + \frac{Wn \times \rho bn}{100}$$

Where,

θ = volumetric moisture content in 30 cm depth

Wi = gravimetric moisture content (%) in 1st sub sample

Wn = gravimetric moisture content (%) in nth sub sample

ρbi= bulk density of 1st sub sample

ρbn = bulk density of nth sub sample

Depth of water in upper 30 cm = θ x 30 cm

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Experiment No. 17

Objective: Determination of soil permanent wilting point.

Permanent wilting point is the moisture content in percentage of a oven-dried soil at which nearly all plants wilt and do not recover in a humid dark chamber unless water is added from an outside source.

Objective: ....

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Equipments Required: ....

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Procedure: ....

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Observations:

A.	Weight of empty can (g)	1 _______	2 ________	3 _______
B.	Weight of can + air-dry soil (g)	1 _______	2 ________	3 _______
C.	Weight of can + soil wet to field capacity (g).	1 _______	2 ________	3 _______
D.	Water content in air-dry soil (g)	1 _______	2 ________	3 _______
E.	Oven-dry weight of soil (g)	1 _______	2 ________	3 _______
F.	Weight of can + wet soil at incipient wilting point, (g)	1 _______	2 ________	3 _______
G.	Oven-dry moisture content in soil at incipient wilting (g/g)	1 _______	2 ________	3 _______
H.	Weight of can + wet soil at permanent wilting point (g)	1 _______	2 ________	3 _______
I.	Oven-dry moisture content in soil at permanent wilting point (g/g)	1 _______	2 ________	3 _______

Calculation

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Experiment No. 18

Objective: Aggregate size distribution analysis of soil.

Water Stable Aggregates

The soil aggregates which can stand the disruptive forces of wetting by water are known as water stable aggregates.

Principle: ....

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Apparatus and accessories: ....

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Procedure: ....

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Observations:

A. Air dry weight of sample (g) = 100 g

B. Moisture percent in soil (%) =

C. Frequency of oscillation (min^{-1}) =

D. Stroke length (mm): =

E. Oven-dry weight of particles: a) aggregated (g): =

b) unaggregated (g): =

F. Oven-dry weight of sample (g) =

Calculations:

SN	Size range of aggregates (mm)	Weight of particle retained on the sieve (g)	Weight of aggregated particles	Per cent aggregation
1.				
2.				
3.				
4.				
5.				
6.				

$$\text{MWD} = \sum_{i=l}^{n} Xi\ Wi$$

Where,

Xi = mean diameter of size fraction i,

Wi = proportion of total sample weight occurring in the corresponding size fraction i,

n = number of size fractions.

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Results: ....

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Experiment No. 19

Objective: Determination of soil moisture by Neutron Probe Method (Indirect Method)

Neutrons emitted from a radioactive source (usually Radium-Berrylium or Americium-Beryllium) upon collision with a particle having mass nearly equal to its own, like hydrogen atom in the soil and release their energy and gets thermalized. The thermalized neutrons are detected by a detector and recorded on a scalar.

Materials required: ……………………………………………………………………………………………..

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1. **Write the procedure for installation and moisture detection by neutron probe.**

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2. Calculations

Standard count = SC
Actual count = AC
Count ratio CR = $\frac{AC}{SC}$
Constants of calibration curve = a and b
Volumetric water content ($\theta v = a + bCR$) m^3m^{-3}

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Write the precautions: ……………………………………………………………………………………

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APPENDICES

SAFETY IN THE LABORATORY

- Come prepared with the theory and the procedure of the experiment.
- Bring the geometrical instruments and notebook.
- Develop a positive attitude towards laboratory safety.
- Maintain a clean and safe work place.
- Avoid working alone but do not have a crowd at your working place.
- Learn laboratory first aid and what to do in case of emergency.
- Seek medical help immediately if affected by chemicals.
- Do not eat, drink or smoke in laboratory, do not store such things in the laboratory and do not use glassware for eating and drinking.
- Use forceps or tongs to handle hot containers.
- Use Fume hoods when handling conc. acids, bases and other toxic chemicals or use them in digestion room with proper ventilation.
- Use personal safety equipment such as apron, hand gloves, dust mask, eye glasses, face mask and foot protection shoes etc.
- Do not play with apparatus, instruments and utensils of the laboratory.

DESCRIPTION OF SOIL PROFILE

Materials required: Digging tools - Spade, pickaxe, khurpi ,Cutting knife with a strong wooden handle, Abney's level or inclinometer, Altimeter, Measuring scale / tape, Munsell's colour chart, Dilute hydrochloric acid (10%), Wash bottle (with distilled water), Magnifying lens, Indicator papers, Tray with shoulder, Profile description papers, Soil sample bags with polythene lining, Copying pencil/ ball pen

Write the identification procedure of soil profile.

1.1 Selection of area for profile study

- It is representative of the normal conditions prevailing in the area.
- It is away from tree an irrigation channel/ditch/river, roads, human inhabitation etc.
- It shows minimum of human interference, if, possible virgin area should be selected

1.2 **Digging of the profile:** Dig out a pit of size 2m x 2m to a depth of 2 m or upto the parent material. Provide steps, if necessary, on one side for getting into the pit.

1.3 Examine and description of soil profile

- Identify the horizons of the profile on that side of the pit which receives maximum daylight.
- Demarcate the horizons on the basis of characteristics that can be seen or measured in the field such as color, texture, structure, consistence, presence of carbonates etc.
- If the horizons are not properly differentiated as in case of alluvial and black soils, examination of soil should be done at a depth intervals of 15 cm down to 1 m depth and thereafter, at intervals of 15 cm up to 2m or up to the parent material, whichever occurs earlier.
- Location of the profile: Give longitude and latitude with distance and direction from a nearby bench-mark reference site.
- Parent material e.g. alluvium, mica schist, granite etc.
- Physiographic position of the site e.g. terrace, flood plain, depression, plateau, valley bottom etc.
- Land form of surrounding area and elevation (in meters above the mean sea level)
- Hydrology, drainage condition, depth of ground water, moisture condition in the profile and artificial drainage.
- Biological activity, root development etc
- Evidence of erosion and its intensity, presence of salts or alkali
- Human influence like tillage, levelling, use of amendments, heavy manuring etc.
- Presence of surface stones or rock out crop

2. Observations to be recorded during profile study

Horizon symbol, Depth of from the top to bottom of a particular horizon in centimeters, Nature of boundary with the horizon below, Color : Moist and dry –Munsell colour chart, Colour of mottling (if any), Texture: Feel method which will be explained in the field, Structure: Three feature of structure viz. grade, class and type, Consistence : wet, moist and dry, Cutans(ped coatings), pressure faces, slickensides , Roots traces : The quantity, size and location of roots in each horizon, Nodule concretions and cementation (if any), Pores Lithorelics: The content of rock and mineral fragments in each horizon, note down their percentage, Hard pans, Content of carbonates, soluble salts etc, Artefacts : The activity of man's activity, Soil reaction

3. Precaution taken during profile study

- Expose the profile at such a place that it is representative of the whole area.
- Do not expose it at elevated or depressed locations in field or in a direction directly facing the sun.
- Dig the profile at such a place that maximum visibility is obtained.
- Remove the plant cover if any before digging the pit in a manner so that the soil surface is not disturbed.
- Mark the soil sample bags properly indicating location, depth, horizon details, etc.
- Dig the profile pit in such a way that one side of it has steps for movement of the personnel.

COLLECTION AND PREPARATION OF SOIL SAMPLES

1. **Objectives of soil testing.**

   Evaluation of fertility status of soil
   Estimation of the available nutrient's status of soil
   Determination of problems soil and their remediations.

2. **Materials required for soil sampling.**

   Khurpi, Spade, Augers, Bucket, Scale, Wooden roller, Mortar and pestle, Sieve, Polythene/paper/cloth bags, Labels, Card-board cartons, Rack, Aluminium boxes.

3. **Write the sampling procedure of soil.**

- The sampling should be done in a zig-zag pattern across the field to get homogeneity.
- Scrap away the surface litter and insert the sampling auger to plough depth (15 cm)
- Take at least 15 samples randomly distributed over each area and put them in a clean bucket
- If a sampling auger is not available make a 'V' or 'U' shaped cut to a depth of 15 cm or to a required depth using a spade and remove 1.0 to 1.5 cm thick slice of soil from top to bottom of the exposed face of the 'V' or 'U' shaped cut and put in a clean bucket or basin and in similar manner collect the soil sample from all the spots.
- Thoroughly mix the soil samples taken from 15 or more spots of each area. Remove foreign bodies such as plant roots, stubbles, leaves, glass pieces, pebbles, stones or gravels.
- Quartering technique is done by dividing the thoroughly mixed soil into four equal parts and discarding two opposite quarters.
- Remix the remaining two quarters and again divide into four equal parts and reject the opposite two.
- Repeat this procedure until about ½ kg of soil is left

4. **Depth of soil sampling for different conditions**

Field crops	0-15 or 0-20 cm
Deep rooted crops	0-15, 15-30 and 30-60 cm (Sampling at different depths or layers is ideal)
Forage or pasture crops	0-10 cm
For immobile nutrients (P, K, Ca and Mg)	Sampling at tillage depth
Nitrate, Sulfate	60 cm (when the biological activity is low)
Saline alkali soils	Salt crust should be sampled separately and the depth of sampling should be recorded

5. Processing and storage of soil sample.

- The soil sample received at the laboratory is air-dried in shade and spread on a sheet of paper after breaking large lumps, if present, with a wooden mallet.
- The soil thus prepared is sieved through a sieve with round holes, 2 mm in diameter.
- The material on the sieve is again ground and sieved till all aggregate particles are fine enough to pass through and only stones and organic residues remain on the sieve.
- For micronutrients analysis nylon sieve should be used
- Transfer the sieved material in a airtight plastic container and leveled the soil sample

6. Precautions to be kept in mind during soil sampling

- Avoid sampling near bunds, irrigation channels, compost / fertilizer heaps, under trees (shade), damp areas.
- Any contamination with fertilizer, manure, salts, lime or any chemicals must be avoided.

- Rusted iron sampling tools, pestles and mortars or sieve must not be used for collection and processing of soil samples specially if micro nutrients need to be determined.

DETERMINATION OF pH

Materials required: pH meter, Beakers (100 ml), Glass rods, Electrical balance, Measuring cylinder, Washing bottle with distilled water

Preparation of standard buffer solution for pH calibration.

1. pH 4.0: Transfer one pH 4.0 buffer tablet into 100 ml volumetric flask. Add distilled water to dissolve the tablet and dilute in to 100 ml.
2. pH 7.0: Transfer one pH 7.0 buffer tablet into 100 ml volumetric flask and add distilled water to dissolve the tablet and dilute the solution to 100 ml mark with distilled water.
3. pH9.2: Transfer one pH 9.2 buffer tablet into 100 ml volumetric flask. Add distilled water to dissolve the tablet and dilute in to 100 ml

Procedure for the measurement of soil pH.

1. Take 10 g soil in 50 ml beaker.
2. Add 20 ml distilled water.
3. The suspension is stirred at a regular interval for 30 minutes. This time is required for the soil and water to attain equilibrium.
4. After half an hour again stir the soil suspension and measure the pH on a pH-meter and reading taken.

Interpretation

Soil pH Value	>4.5	4.5-5.0	5.0-5.5	5.5-6.0	6.0-6.5	6.5-7.5	7.5-8.0	8.0-8.5	8.5-9.5	>9.5
Interpretation	Extremely Acidic	Very Strongly Acidic	Strongly Acidic	Moderately Acidic	Slightly Acidic	Normal	Slightly Alkali	Moderately Alkali	Strongly Alkali	Very Strongly Alkali

What should be precaution during sample analysis

- Proper calibration of pH meter before testing of sample with the help of, 7.0 and 4.0 or 9.2 pH value buffer solution.

1. Never touch the glass electrode with bottom of the beaker.
2. The electrode must be washed with distilled water and dried with the tissue paper before each measurement.

ESTIMATION OF ELECTRICAL CONDUCTIVITY

Materials required: EC meter, Beakers (100 ml), Electrical balance, Measuring cylinder, Washing bottle with distilled water

Name the reagents required the calibration of EC meter.

- 0.01NPotassium chloride (KCl): Dissolve 0.7456 g dry potassium chloride (AR) in distilled water and make up the volume to 1000 ml. The electrical conductivity of this solution is 1.41 dSm^{-1} at 25^0C.

Write the procedure for determination of EC from soil sample.

1. Take 10 g of soil in 100 ml beaker.
2. Add 20 ml of distilled water and shake intermittently for 30 minutes and allow standing until clear supernatant liquid is obtained.
3. Adjust the instrument for temperature and cell constant accordingly.
4. Determine the conductivity of the supernatant liquid with the help of conductivity meter.

Interpretation

S. No.	Soil	EC (dS/m)	Total salt content (%)	Crop reaction
1	Salt free	0-4	<0.15	Salinity effect negligible except for more sensitive crop
2	Slightly alkaline	4-8	0.15-0.35	Yield of many crop restricted
3	Moderately saline	8-15	0.35-0.65	Only tolerant crops yield satisfactorily
4	Highly saline	>15	>0.65	Only very tolerant crops yield satisfactorily

What should be precaution during sample analysis

1. Allow the instrument to warm up for 30 minutes.

2. Set the temperature knob to room temperature.
3. Ensure that the conductivity cell should be completely dipped into soil: water suspension or extract.
4. Wash the conductivity cell with gentle stream of distilled water and wipe with tissue paper.
5. Keep the conductivity cell dip in to distilled water when not in use.

ESTIMATION OF MOISTURE CONTENT OF GIVEN SOIL SAMPLE BY GRAVIMETRIC METHOD

Materials required: Sample Auger/ Spad/ Khurpi, Moisture box, Hot air oven, Desiccator

Procedure

- Take weight of moisture box.
- Take soil sample of about 100g from required depth with help of Auger/ Spad/ Khurpi.
- Put the moist soil sample in the moisture box and close the box to prevent loss of water moisture by evaporation.
- Bring the moisture box containing the moist soil to the lab and weigh immediately.
- Place the moisture box in hot air oven till a constant weight at 105° C temperature. This take about 48 hours.
- Allow the sample to cool for some time in hot air oven. Then close the moisture box and put into the desiccator for further cooling now weigh the sample closed moisture box with the oven dry soil.

ESTIMATION OF BULK DENSITY OF SOIL BY CORE METHOD

Materials required: A core sampler with removable sample cylinder fitted inside, hydraulic or simple jack assembly, a shovel, straight edged knife, moisture box, cellophane tape, balance, and oven.

Write the procedure

1. Locate two grass-free and crack-free representative spots for duplicate sampling. .
2. Apply a heavy lubricant on the inside wall of the core sample cylinder.
3. Place the core sampler over the ungrassed, smooth soil surface in the middle of the jack assembly.
4. Attach the jack with the beam of the assembly and position the jack head with the center of the base plate over the handle of the core sampler and align the sampler stem with the jack head
5. Drive the jack slowly until the sampler is pushed to the desired depth.
6. Reverse the jack and remove the plate over the handle.
7. Tilt the sampler a little forward and backward to partly detach from the soil mass below and carefully lift the sample without any jerk and disturbance of natural structure.
8. Unscrew the lid over the outer core cylinder and carefully remove the sample holder (inner cylinder).
9. Trim the excess soil from each end of the sample holder with a straight-edged sample volume is the same as the volume of the sample holder.
10. Transfer the sample to a moisture box and seal with cellophane tape for transportation to the laboratory and oven dry at 105 °C for drying until constant weight.
11. Report bulk density along with moisture content in the sample.

ESTIMATION OF BULK DENSITY OF SOIL BY PYCNOMETER METHOD

Materials required: Pycnometer (RD bottle), 50cc capacity, Electronic balance, Burette and Hot air oven

Write the procedure

1. Weigh the dry empty pycnometer of 50cc capacity.
2. Fill it with soil flush upto bring tapping the bottle about 20 times and find it weight.
3. Remove the soil and now fill the bottle with water by burette and note the exact volume of water needed to fill the bottle.

ESTIMATION OF PARTICLE DENSITY OF SOIL

Principle: The mass of unit volume of soil solid is called particle density. It determined by the measuring the mass and volume of soil solid.

Equipments:

1. Pycnometer (RD bottle), 50cc capacity.
2. Electronic balance
3. Hot plate
4. Hot air oven

Procedure:

4. Weigh the pycnometer and fill it with water completely and fit stopper.
5. Wipe out all moisture from outside and find it weight.
6. Put 10g of oven dried soil into pycnometer, add 15- 20 ml of water, and boil it for a short time in order to expel all air.
7. Put the pycnometer for cooling up to the room temperature and fill completely by adding water and fit stopper.
8. Wipe out all moisture from outside and find it weight.

DETERMINATION OF PORE SPACE OF SOIL

Apparatus:

1. Pycnometer
2. Electronic balance
3. Burette

Procedure:

1. Determined the bulk density of soil using pycnometer.
2. Determined the particle density of soil.
3. Calculate the porosity using formula

Calculation:

$$\textbf{\% of Porosity} = \textbf{100 - }\left(\frac{BD}{PD}\right) X100$$

TEXTURAL ANALYSIS OF SOIL BY ROBINSON'S PIPETTE METHOD

Principle: The pipette and hydrometer methods of particle-size analysis are based on sedimentation principle. The pipette method utilizes sampling of a known volume of suspension from the sedimentation cylinder by a pipette at controlled depths and times. The hydrometer method measures the density of suspension or concentration of suspension in the sedimentation cylinder in g/liter at specified times. The time and depth of sampling is decided from the settling velocity of particles in the sedimentation cylinder under the influence of gravity. According to Stock's law, the settling velocity of spherical particles in a liquid of given density and viscosity in proportional to the square of the radius of the particles, and can be written as

Reagent: 0.1N HCl, 1% $AgNO_3$ solution, phenolphthalein indicator, 5% calgon solution in water ($NaPO_4$), and 30 % hydrogen peroxide (H_2O_2).

Procedure

1. Weigh 10 g of air-dry soil passed through a 2-mm sieve and transfer it to a 500 ml beaker. Oven dry the sample over night at 105 °C, cool it in a desiccator and reweigh. Add 30 ml of distilled water and stir the contents by swirling. Cover the beaker by watch glass.
2. Add 10 ml of 30 % H2O, and heat it on a hot water bath with occasional shaking of the beaker in a rotary motion by hand till it forms thick paste. Do not dry completely.
3. Repeat step 2 till no effervescence occur on addition of a fresh H2O2.
4. Allow the contents to cool and add N/ 10 HCl in drops with constant stirring till effervescence cease. Care should be taken to avoid loss of soil by frothing.
5. Add distilled water to make the volume of the contents of the beaker 250 ml and allow to stand for 2 hours with occasional stirring.
6. Filter through Whatman No. 42 paper. Use suction if necessary. Transfer the entire soil on fil paper in a Buchnner funnel and continue washing with distilled water till washings run free chloride. (Test the filtrate with AgNO3 solution).
7. Transfer the filtrate to a beaker with a little of HNO3 to oxidize ferrous compounds concentrate to about 100 ml. Boil for a couple of minutes and filter. After washing the precipitate free of chlorides, dry, ignite and weigh, and report as sesquioxide (R203) loss by solution.
8. Transfer the acid free soil from filter paper with a jet of distilled water into a 500 ml shake in bottle. The total volume should not exceed 300 ml.

9. Add 10 ml of calgon solution to the bottle to make the contents distinctly alkaline. Test a drop of solution on a porcelain tile against a drop of phenolphthalein indicator. (Sample10 ml calgon solution in a weighed bottle, dry overnight at 105 °C, cool and reweigh.)
10. Cover the mouth of the bottle with a rubber stopper and shake for 12 hours in a reciprocating shaker or for 16 hours on a rotary shaker.
11. Transfer the contents of the bottle through a 0.2 mm sieve placed on a funnel receiving the filtrate in a 1000 ml sedimentation cylinder.
12. Wash the residue on sieve with distilled water.
13. Make up the filtrate volume with distilled water to 1000 ml mark and place the sedimentation cylinder in a constant temperature room.
14. Transfer the residue left on the sieve with a jet of water into a weighed china dish.
15. Dry the residue first on a water bath and then in an oven at 105 °C and weigh. Report it as a coarse sand fraction of the soil.
16. Note the temperature of the soil water suspension and find out sedimentation time for silt and clay in the sedimentation cylinder.
17. Cover the cylinder with a rubber stopper and shake by hand thoroughly for one minute with repeated inversions.
18. Clamp a clean and dry 20 ml Robinson pipette in its holder.
19. Move the cylinder quickly under the pipette on the stand.
20. Lower the pipette tip to 10 cm below the surface of the suspension and withdraw 20 ml of suspension on expiry of the sedimentation time for the particles of 20-micron size
21. Transfer the suspension (sample) from the pipette into a weighed china dish.
22. Dry the suspension (sample) first on a water bath and then in an oven at 105 °C and weigh. Report it as a silt + clay fraction in the soil.
23. Sample the suspension again from 10 cm depth on the expiry of sedimentation time for silt and report it as a clay fraction in the soil.
24. Save fine sand at the bottom and decant away the suspension from the cylinder.
25. Transfer it to a tall beaker and fill with water to obtain a depth greater than 10 cm.
26. Stir the contents of the beaker with a policeman and allow it to stand for the time equal to the sedimentation time for fine sand.
27. Siphon out the top 10 cm supernatant liquid.
28. Repeat steps 25 to 27 till siphoned water runs clear.
29. Transfer the residue from beaker to a weighed china dish, dry it and report it as a fine sand fraction of the soil.
30. Find out moisture % in the air-dry soil sample.
31. Make correction for the loss due to organic matter, carbonates and soluble salts.

Sedimentation times for particles of 2, 5- and 20-micron diameter, settling through water for a depth of 10 cm

Temperature ^{0}C	Settling time with indicated particle diameter					
	2 micron		5 micron		20 micron	
	Hr.	Min.	Hr.	Min.	Min.	Sec.
20	8	0	1	17	4	48
21	7	49	1	15	4	41
22	7	38	1	13	4	35
23	7	27	1	11	4	28
24	7	17	1	10	4	22
25	7	7	1	8	4	16
26	6	57	1	7	4	10
27	6	48	1	5	4	4
28	6	39	1	4	4	0
29	6	31	1	4	4	55
30	6	22	1	1	13	49
31	6	14	1	0	3	44

DETERMINATION OF MAXIMUM WATER HOLDING CAPACITY OF SOIL

Procedure:

1. Take a Hilgard apparatus and fit a Whatman No. 1 filter paper in its perforated bottom. Weigh the Hilgard apparatus along with the filter paper.

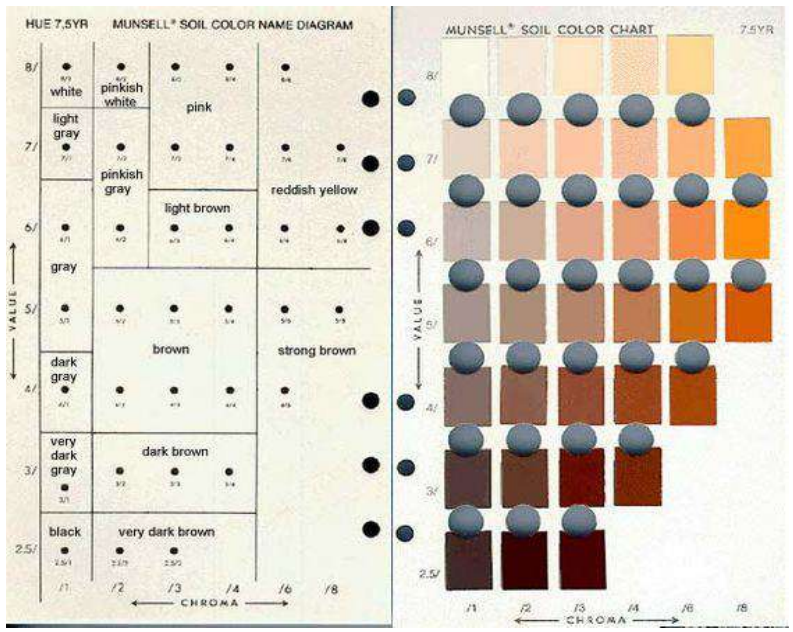
2. Fill the air-dry soil in the Hilgard box with repeated tapping (20-30 times) on the top of a table for complete and uniform packing. Level the surface of box with the help of a spatula.
3. Put the Hilgard in a soaking tray and slowly pour the water in the tray till the water level is about 1 cm above the base of the box. Keep it for saturation overnight.
4. Next day, remove the Hilgard apparatus from water, wipe the box dry from outside and weigh it quickly.
5. Now, put the Hilgard apparatus in an oven at 105°C and dry it to a constant weight Cool it in a desiccators and weight is taken.
6. Apply the correction for the amount of water absorbed by filter paper as follows: Weigh five filter papers together and saturate them with water. Now, roll gently a glass rod over them to squeeze out water uniformly and weigh it again. Calculate the average amount of water held by one filter paper.

DETERMINATION OF SOIL COLOR BY USING MUNSELL COLOR CHART

Materials required: Munsell soil color chart, Water bottle, Tube or post hole auger, Small clods of soil

Write the procedure for determination of soil color

- Take a small clod of soil and note its moisture condition, weather it is dry or moist.
- Match the color of the clods with the cards showing 'Hue' values.
- Note the 'Hue'.
- Place the clod below the hole of chip and match the nearest 'Value' and 'Chroma'.
- Note the Munsell notation.
- Write the color of the soil according to Munsell notation.
- Find out the color of soil at both dry and moist condition. If soil is dry first note the color of dry soil. Then moist the clod with few drops of water and note the color



ESTIMATION OF HYDRAULIC CONDUCTIVITY OF SOILS

Apparatus and accessories: A core sampler, sample cylinder (7.5 cm diameter and length), boards, mug, spatula, tape, spade. hydraulic or simple jack assembly, constant head perlmeameter assembly, falling head permeameter assembly, de-aerated water, stop watch, graduated cylinder, wash bottle, tray. muslin cloth, filter paper and Vaseline.

Procedure

1. Apply a heavy lubricant on the inside wall of the sample cylinder to ensure tight contact between the soil and the core cylinder wall.
2. Clean grasses and press the core sampler vertically into the soil layer to obtain natural soil core. In flooded fields, install boards, 'draw out the excess water and then use the core sampler. Use sampler of length greater than 0.15 m to avoid slippage of the puddled sample from the sample cylinder.
3. Remove 3 to 5 samples from each layer, avoiding micropores formed by cracks and decayed roots.
4. Use hydraulic jack assembly, if the soil is too hard to push the core sampler. Hammering the core sampler will form cracks and gaps between the soil and the sampler wall.
5. Use a sharp spatula to trim the surface of the sample.
6. To measure conductivity for horizontal flow, drive the sampler horizontally into the soil at the required depth from an excavated pit.
7. Fasten a muslin cloth over bottom end of the soil core cylinder. Attach an empty cylinder of the same size over the top of the soil core cylinder with the help of a rubber bandage. Saturate the soil core either by capillarity or by vacuum. To saturate by capillarity, put each soil core over a muslin cloth and place on a sand bed, in a tray. Pour deaerated water into the tray to a depth of few mm below the top of the soil sample. Leave the soil core for 24 h to soak up water. For more effective saturation,

place the soil core on a muslin cloth in a tray, put into a vacuum desiccator and apply vacuum not exceeding the boiling point of water. Pour water into the desiccator until the soil sample is covered, and then readmit air. Hold muslin cloth in the tray while shifting the soil core.

8. Transfer the sample over the funnel of the constant head assembly and place blotting paper over the soil surface. Slowly pour salt-free water into the cylinder and connect with water reservoir through a siphon tube.
9. After water starts dripping out, collect and measure the outflow in a graduated cylinder in a specified time t. Measurements should be repeated 3 to 4 times to ensure constant rate of outflow. Measure the hydraulic head difference ΔH and the temperature of the water.
10. Use falling head method if hydraulic conductivity is less than 10^{-3} cm/s.

ESTIMATION OF INFILTRATION RATE USING DOUBLE RING INFILTROMETER METHOD

Apparatus/Equipment

- Double ring infiltrometer (30 and 45 cm in diameter and 30 cm height) with hammer.
- Hook's gauge
- Timer
- Source of water
- Plastic or polythene sheet

Procedure

- The spot at which the infiltration rate is to be determined is carefully cleaned of vegetation and leveled.
- The two metal concentric rings (or cylinders) are gradually hammered into the soil in such a way that there is least disturbance to the soil surface. The rings should be pushed to a minimum depth of 10 cm into the soil.
- Pour water into the rings and maintain water in the buffer pond at about the same depth as inside the ring. While applying water initially into the inner ring, a piece of plastic or polythene is placed inside the ring to prevent any disturbance at or crusting of the soil surface. This sheet is subsequently removed and the initial reading of the water level is recorded immediately.
- The level of water in the rings is maintained between 6-8 cm or the depth of water, generally, existing during application of irrigation water.
- Take observations on the rate of entry of water, as visualised by decrease in water level at closer intervals initially, followed by wider intervals with the passage of time.
- Step 4 and 5 are repeated until two consecutive readings of same infiltration rates are obtained.

SOIL COMPACTION MEASUREMENT WITH PENTROMETER

Apparatus and Accessories

The cone penetrometer with dial guage, proving ring and handle. The vertical angle of the cones is usually 30° or 60˚C and the base area of the cone is 3.2 cm^2 or 6.4 cm^2.

Procedure

1. Attach the cone, proving ring with dial gauge, and handle to the rod.
2. Make supplementary depth markings on the rod with a marking pen because the engraved graduated lines are often covered by mud.
3. Adjust zero of the dial guage and calibrate the proving ring. To adjust zero, stand the cone penetrometer vertically on a hard ground, and set the dial gauge reading to zero.
4. To calibrate the proving ring and dial gauge, stand the cone penetrometer on a weighing platform and apply steadily the increasing force. Record and graph the relationship between applied force and resultant dial gauge readings.
5. Measure soil strength profile by pushing the penetrometer into the soil vertically over the measuring point, at a speed of about 1 cm/s. Read and record the dial gauge reading at each depth using the base of the cone as a reference point for measurement of the depth penetrated. Three persons are needed to measure with the equipment.
6. Measure at least three times for each point until successive results agree closely and average. The rod and cone should be wiped clean after each penetration.
7. Repeat measurements at 4 to 5 locations in a field.
8. Collect soil samples from each depth for moisture and texture determination and record the soil management practices.

DETERMINATION OF FIELD CAPACITY OF SOIL

A. LABORATORY METHOD

Equipment: 4 inch post hole auger, 2 mm sieve, Permeameter cylinder, 7.5 cm in diameter and 105 cm in length with cover, Metal tubes for collection of soil samples, Aluminum cans, Balance, Hot air oven

Procedure:

- Collect the soil in 15 cm depth intervals down to one-meter depth, when the soil is fairly dry with a post hole auger
- Air dry the soil and pass it through a 2 mm screen. Care should be taken not to break aggregates more than required
- Place a filter paper on the screen in the cylinder and fill it with the soil approximately to the same bulk density as in the field simulating a soil profile, moisten the soil to attain the desired bulk density and leave about 5 cm of the cylinder empty above the soil surface.
- Add enough water to wet the upper 30 cm of soil column in 4 to 5 lots.
- Cover the cylinder and let it come to equilibrium for 48 hours in a constant temperature room.
- Remove the soil from different depths with the help of metal tubes for the determination of the moisture content
- The amount of water retained in upper 30 cm of soil is equal to the field capacity of the soil.

B. FIELD METHOD

Equipment:

Water sprinkler (ii) Aluminum cans (iii) Screw type auger (iv) Balance (v) Oven (vi) Polyethylene plastic

Procedure:

- (Select a small 8 ft. by 8 ft. area, when the soil is dry.
- Raise a few inches high bund around the area.
- Determine the bulk density of the soil down to 2 ft. depth in the nearby area.
- Calculate the porosity of the upper 30 cm (or root depth) of soil and add enough water on the selected area to wet the upper 30 cm.
- Cover the area with polyethylene plastic to prevent evaporation.
- Allow the soil to drain for 48 hours, then remove the cover and take the soil samples down to the depth of wetting, and determine the moisture content.
- Use aluminum cans and the screw auger if a gravimetric procedure is used.
- Make at least five separate borings.

DETERMINATION OF SOIL PERMANENT WILTING POINT

Objective: By doing this practical the learner will be able to determine the permanent wilting point of soil.

Equipments Required: Five 800 g capacity cans with lids, sunflower seeds, glass tube (5 cm x 0.5 cm), sealing wax, moisture boxes, physical balance, hot air oven, bell jars, water trays and soil sampler.

Procedure

1. Clean, dry and weigh three 800 ml tin cans along with their lid having 25 mm diameter hole in the centre.
2. Fill the cans with air-dry processed soil leaving about 0.03 m space at the top end for watering. Weigh the can with soil and lid. Take a sample for water content determination so that the oven dry weight of the soil is known.
3. Put sufficient water or dilute nutrient solution to wet the soil to field capacity and enrich with nutrients required for optimum plant growth.
4. Open the lid and plant 3 viable seeds of dwarf sunflower near the centre and let them germinate in green house or under a cloth shed.
5. Retain one, the best, seedling when they are well established and clip off others from the base.
6. Lead the seedling out through the hole in the lid of the can.
7. Irrigate the cans as necessary for normal growth of the plant till 3 pair of leaves have developed.
8. Stop irrigation after final wetting to the initial value (field capacity) and plug the hole in the lid around the stem by cotton to reduce evaporation but allow adequate aeration.
9. Wait till lowest one or two pairs of leaves wilt.
10. Transfer the can to a dark, humid chamber. If the leaves regain turgidity during an overnight period return the can to the green house.
11. Repeat steps 9 and 10 until the lowest pair of the leaf fails to recover in the humid chamber. Water content of the soil at this stage of wilting is known as incipient wilting point. Clip off the plant from its base, weight the can and determine water content if incipient wilting is desired.
12. To determine permanent wilting point, repeat the process of wilting and humidification until all leaves are wilted beyond recovery. Water content at this stage is known as permanent wilting point.

13. When the permanent wilting point is attained, clip off the plant from its base and weigh the can and determine water content by oven drying.

Calculation

Average water content of soil at incipient wilting point,
Determine also by (F-A-E)/ E and compare with G. = ----------------- (g/g)
Average water content of soil at permanent wilting point,
{Also compare [(H-A-E)/ E] with I}. = -------------------- g/g

AGGREGATE SIZE DISTRIBUTION ANALYSIS OF SOIL

Water Stable Aggregates

Principle: The mean weight diameter (MWD) of water stable aggregates is a useful index to characterize the change in structure due to wetting of soil. The MWD is calculated as

$$MWD = \sum_{i=l}^{n} Xi\ Wi$$

Where,

Xi = mean diameter of size fraction i,

Wi = proportion of total sample weight occurring in the corresponding size fraction i,

n = number of size fractions.

Apparatus and accessories:

Standard sieves of diameter 12.7 cm and height 5 cm and hole of 8.0, 5.0, 1.0, 0.5, 0.25 and 0.1 mm (2 sets), Yoder apparatus, which raises and lowers the nests of sieves through water 3.8 cm, approximately 30 times per minute, atomizer, Physical balance, 105 °C oven, desiccator, 8 cm watch glasses, hydrogen peroxide, and N/10 hydrochloric acid.

Procedure:

1. Take about 200 g of air-dry soil clod. Pull apart clods of size, which will pass through 8.0 mm screen and be retained on 5.0 mm screen. Do not break them by hammer. Large gravels or roots should be removed.
2. Weigh 100 g aggregates of 5.0-8.0 mm size in three watch glasses. Keep one of them in oven at 105 °C for moisture determination and use the other two for analysis in duplicate,
3. Arrange two sets of six sieves in the order of 5.0, 2.0, 1.0, 0.5, 0.25 and 0.1 mm from top to bottom.
4. Spread the sample (100 g) of aggregates evenly over top 5 mm sieve and spray 5 to 10 ml of salt. free water on them. Wait for 3 to 5 minutes and spray another 5 to 10 ml of water.
5. Transfer the nest of sieves to the drum of the sieve shaker and clamp them in position. Fill the drum, with salt-free water up to a level slightly below the top screen when sieves are in highest position. Turn the pulley of the shaker slowly by hand to attain the highest position.
6. Lower the sieves to the lowest position and wet the aggregates for 10 minutes wet the aggregates for 10 minutes. Fill more water in the drum so that aggregates are just covered with water when sieves are again in highest position
7. Switch on the oscillator and let the sieves oscillate in water for 10 minutes with a frequency of 30 cycles per minute through a stroke length of about 3.8 cm.
8. Take out the nest of sieves, let the water drain, separate and place them on paper sheets, and let the aggregates on each sieve dry and harden in air.
9. Transfer the aggregates of each sieve in to separate moisture boxes. Find out their oven-dry weight.
10. Transfer the aggregates from the moisture boxes into 250 ml beakers separately and oxidize and disperse using H_2O_2 and sodium hexametaphosphate, respectively. Use mechanical stirrer for complete dispersion, pass the dispersed aggregates through the same sieves on which they were retained originally. Collect the unaggregated primary particles from each sieve and record their oven-dry weight. Subtract the weight of the primary particles from the weight of the aggregates obtained on respective sieves in step-9.
11. Calculate the percentage of aggregated soil particles on different sieves.
12. Plot a graph between accumulated percentage of soil remaining on each sieve as ordinate and upper limit of each size fraction as abscissa.
13. Calculate the mean weight diameter (MWD) of aggregates in mm and report the results as MWD and percent aggregation.

DETERMINATION OF SOIL MOISTURE BY NEUTRON PROBE METHOD (INDIRECT METHOD)

Materials required

- Neutron probe assembly consisting of probe, detector, scalar (counting device) and cable.
- Access tube of aluminium or steel of 20 gauze with 1.9 inch and 2.0 inch internal and outer diameter, respectively.
- Soil auger slightly smaller than the tube for drilling the access holes

Write the procedure for installation and moisture detection by neutron probe

- Prepare a plot measuring 1 m × 1 m in the field.
- Drill a hole with the help of auger and insert the access tube in the soil with little disturbance such that no bulge is created in the access tube. Keep the access tube 10-20 cm above the soil and cover with inverted can or close its opening with a rubber cork to prevent entry of trash. In order to prevent water entry into the tube, close the lower end of the access tube with rubber stopper.

- Turn on the scalar and allow it to warm up for few minutes.
- Place the probe on the top of the access tube and measure the counts, called standard counts. The normal counting time is one minute. The ‘background’ count thus obtained should not be much more than 100 counts per minute. Approximately, a 15 cm soil layer is characterized by a single measurement.
- Take readings at successive depth intervals starting at least 18-25 cm from the soil surface.
- Lower the probe in the access tube to a depth at which water content is to be determined and note the counts.
- Calculate the count ratio by dividing the observed counts at a depth by the standard counts.
- Determine the water content of that layer of soil gravimetrically and convert to volumetric water content by multiplying it with bulk density of the soil.
- Construct a calibration curve by filling a linear relation ($\theta v = a + bCR$) between volume water content (θv) and the count ratio (CR).

Precautions

- Use dent-free access tubes
- Always plug the lower end of the access tube
- Protect the neutron source from free water, otherwise it will get spoiled
- Do not touch open probe with hands
- Check the batteries of the probe and scalar before taking the instrument to the field.