Cover

IRRAD

Institute of Rural Research and Development

Training Manual on

Soil Health

For Grassroots Development Workers, Village Champions, Kisan Mitras,
Field Facilitators, Programme Facilitators , Skilled and Semi-skilled Agriculturists

IRRAD
Institute of Rural Research and Development

Training Manual on

Soil Health

FOR
GRASSROOTS DEVELOPMENT WORKERS, VILLAGE CHAMPIONS, KISAN MITRAS, FIELD FACILITATORS, PROGRAMME FACILITATORS , SKILLED AND SEMI-SKILLED AGRICULTURISTS

CONTENTS

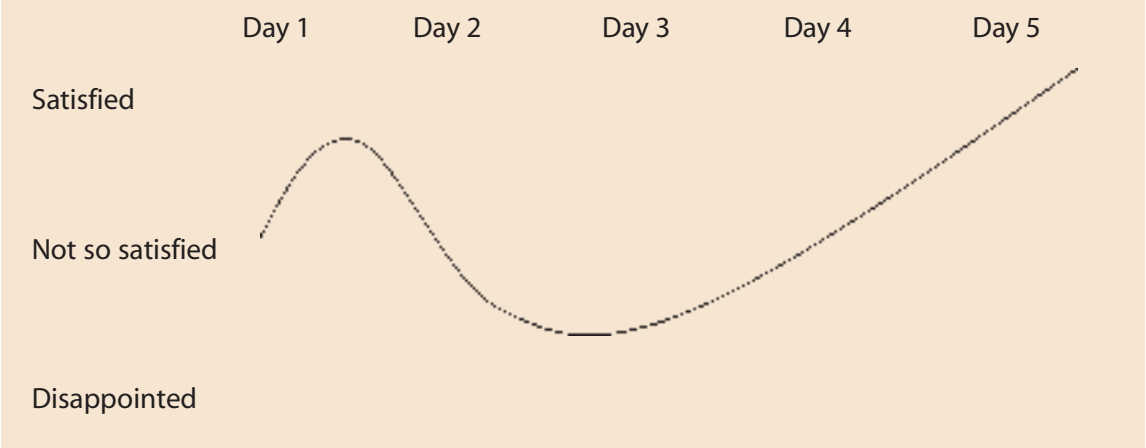
TIPS FOR THE FACILITATOR

The facilitator must:

1. Explain that particular subject modules for the orientation programme have been selected after assessing the needs related to the subject.
2. Explain that the programme is tightly structured, requiring everyone's uninterrupted attention. The training will be based on a participatory approach and each of us here are open to learn from the experiences of the peer group.
3. Clarify to the participants that there will be no teacher-student relationship instead it will be a flat and multi-directional flow of information fostering equal relationship.
4. Explain that the training will be using various methods and techniques from flip charts to picture aids. Discussions of case studies, movie screenings and role plays will make learning more interesting.
5. Two methods can be used to know the participant's satisfaction level for each day's session.

   i. Throughout the training, a satisfaction meter will be used to assess how participants feel about each session.

Satisfaction meter for a five-day workshop



   ii. Giving rating to each day's session from one to five. This will be a more precise method to know the participant's receptivity level and prove quite useful for the facilitator to modify the training technique.

Session Name	Rating (1-5)*
1.	
2	
3	
4	
5	

**1= Not Clear, 2=Poor, 3=Average, 4=Good, 5=Very Good.*

TIPS FOR THE FACILITATOR

The facilitator needs to take daily feedback on different sessions and if he/she feels that a particular session is not satisfactory to the participants, he/she needs to do a recap of the same the next day in brief or in detail (depending on the requirement). At the end of the training, the facilitator should take the average rating of participant's satisfaction level and should correlate it with the final feedback on quality, methodology, content of the training, facilities used in training, etc.

6. Brief the participants about the self-assessment tools given at the end of each session named Test Your Learning that helps to encapsulate the learning in the previous session before moving on to the next session.

The facilitator must keep in consideration the rules mentioned below:

1. Treat everyone with respect at all times.
2. Ensure and respect confidentiality.
3. Agreeing to respect and observe time keeping by beginning and ending the sessions on time.
4. Making sure that only one person speaks at a time so that there is no chaos.
5. Accept and give critical feedback taking care not to hurt anyone.
6. Keeping mobile phones on silent.
7. Creating opportunities for each participant to interact and share his/her experiences with the group.
8. Answer all the questions patiently without being prejudiced to any group or person. Do not allow favouritism to creep into the training.
9. Discuss if the participants have any issues that have been left unaddressed or any clarification on the topics covered.
10. Be very friendly with the participants and narrate examples from your own life, if any, as it creates a feeling of trust in the group.

DAY ONE

Session I

Total Time: 1 hour 10 minutes

Welcome and Introductory Session

Objective

- Welcome and registration of the participants; and
- Introduction of the participants and the Trainer/Facilitator.

Activity I

Welcome prayer and introduction of participants through a game.

The day will start with entering the participants' name in the register kept for attendance. The trainer will start from the word "Namaskar"/Good Morning, etc. The trainer will then welcome all the participants and start by singing a song – "Itni Shakti Hame Dena Data, Man ka Vishwas Kamzor Ho Na." The participants should stand for the prayer.

Distribute a spiral notebook of 50 pages and a Gel pen to the participants for preparing notes.

Introduction

It is a very important session and must be initiated with fun games so that all participants know each other and a friendly environment is developed at the end of the introductory session. Various methods can be used for introduction like; The first candidate will introduce himself and the next candidate will introduce himself and the first candidate, and so on. Second method of introduction could be pairing and matching of words.

Group Activity

Various games can be conducted for introduction like the matching of words, selection of partners etc. , like Taj Mahal – Agra, Laxmi Bai – Jhansi, etc. Ask each participant to find out their match and interact with their partners asking their name, organization, roles and one habit. Everyone will introduce their partner. The trainer should also participate in this game.

Material Required

Prepared cards with matching words.

DAY ONE

Session II

Total Time: 45 minutes

Introduction to IRRAD, its Activities and Areas of Working

This session can be imparted through Power Point presentation, posters and pamphlets, etc.

Material Required

LCD projector, flip charts, white board marker, etc.

Objective

- To understand the level of participants' expectations and its worries;
- Helpful for the trainer to prepare guidelines in advance to meet participants' expectations and remove apprehensions if any by the end of the training;
- To maintain discipline during the training;
- To enhance skill of the participants; and
- To make training more participatory.

Activity I

Understanding participants' expectations from this training.

Group Activity

Ask each participant to write their expectations and apprehensions on separate cards. In case of fewer participants, the facilitator can directly ask and write it down separately on the flip chart or chart paper.

Facilitator can then collect the cards and stick them separately on a chart in two columns; expectations and apprehensions OR write down on separate charts explaining expectations and apprehensions. Facilitator must assure participants that he will take care of their expectations and by the end of this training their apprehensions will vanish. This chart should be pasted at one side of the classroom till the end of the training.

Material Required: Cards of two different colours, flip charts, plain charts, sketch pens.

DAY ONE

Session II

Activity II

Formation of rules and regulations that will be followed by the participants during this training.

The trainer explains the facilities available in the campus and how to use them like water, electricity, food, etc. The trainer can ask participants to set out the rules that need to be followed during and after training hours. All participants will form the rules to be observed in the training room, campus and in the dining hall. If the participants are more than 10, form the groups of 2-3 members and if less than 10, give the responsibility to individual persons.

Participants can be divided into four groups as under:

Group 1. **Food Committee** – Responsible for timely availability, quality and quantity of breakfast, lunch and dinner and minimise wastage of food

Group 2. **Documentation Committee** – Responsible for preparing each day's report in the evening and present it in the next training session to recap the previous day's work

Group 3. **Recreation Committee** – Responsible for recreational activities during evening after completion of the day's session

Group 4. **Campus Committee** – Responsible for general management in the campus, time limit for moving out of the campus, electricity and water use, etc.

A chart should be prepared by the trainer for five days defining the group names, their duties on each day on a repetitive basis. In case of some problem, the trainer or centre in-charge should be informed.

DAY ONE

Session III

Total Time: 45 minutes

Introductory Session on Soil Health

Objective

- Participants should be able to think , talk and discuss about soil health; and
- Able to understand problems in soil health, importance and how to maintain the soil fertility to a maximum level.

Requirement:

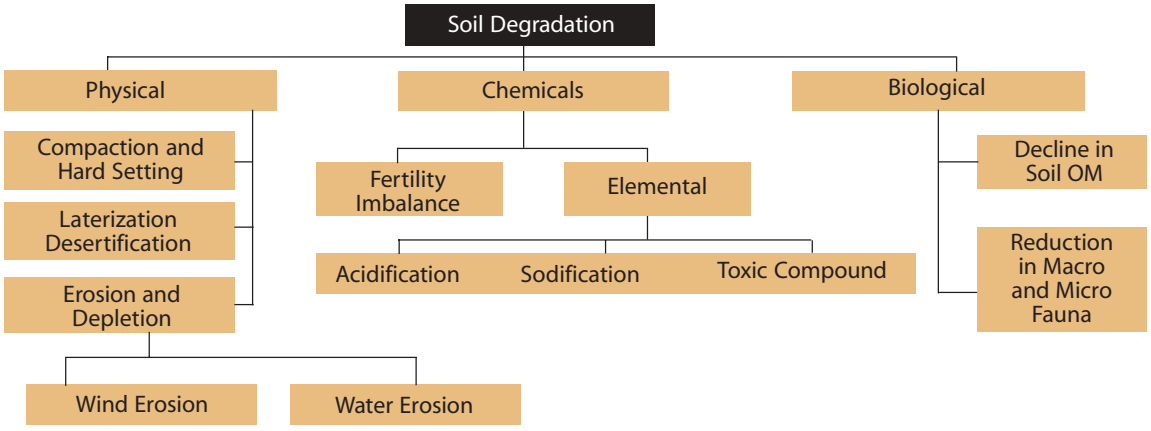
Photographs of various soils in distress situation, wasteland images and eroded land photographs.

Current soil health related issues
"Soil health is the wealth of farmers." Agricultural land is the asset of farmers and needs to be maintained at any cost. Soil quality decreases due to overuse of chemicals, fertilisers, faulty agricultural practices, negligible use of organic manures and leaving land uncultivated for a longer time. Water is the main cause of soil erosion.

Fact sheet
At the global level, 3.6 billion hac or 70% of dry land is affected by degradation and 145 MH or 30% of dry land is affected by various processes like water logging, Salinisation and Alkalisation. 59.1% of Indian dry land is degraded due to various other factors. In India, 45% of land is affected by water erosion, 4.1% through wind erosion and 8.4 % through chemical and physical factors.

The following chart should be explained to the participants.

This flow charts reflects the various causes of soil erosion and the factors that lead to soil degradation.



Kinds of Soil Erosion

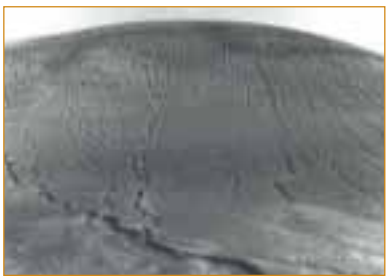
DAY ONE

Session III

Kinds of Soil Erosion

Water Erosion

Wind Erosion



Saline soil

Source: Internet

Summary

At the end of the day, the facilitator should tell the participants about the topics that will be covered in next four days:

- Soil Definition;
- Soil Profile/Horizons;
- Physical and Chemical Properties of Soil;
- Major Soil Types in India; and
- Methods of Improving Soil Health – Physical, Chemical and Biological.

Finally, the facilitator should summarise in brief/or in bullet points what has been discussed and ask if there is any query to be clarified. The trainer should remind the four groups to take care of the assigned responsibilities and prepare documentation for recap the next day.

DAY TWO

Session I

Total Time: 1 hour 30 minutes

Concept of Soil Health – Soil Definition, Soil Horizons

Objectives

At the end of this session, the participants will be able to:
1. Define the meaning of healthy soil.
2. Explain the functions of soil.
3. Define the major characteristics of healthy soil.

Start with the words "Namaskar" and welcome followed by the prayer – "Itni Shakti Hame Dena Data, Man Ka Vishwas Kamzor Ho Na."

After the song, the trainer should invite a participant for the recap of the previous day's work. At the end of the recap, ask from the participants if they want to add something to what was discussed yesterday and wasn't covered in the recap. Say thanks to the person and start the second day session. Describe in brief what is in store for discussion today.

Requirements

Flip charts, laptop/PC, LCD projector, sketch pens, etc., khurpi, scoop for field demonstration of horizons, etc.

Activity I

Before going into details, let's understand the participants' knowledge of soil. Ask the participants to tell what is the function of soil? The facilitator can write the answers on the flip chart.

Now, facilitator will include important points which were not covered by the participants and finally complete it as mentioned below:

Major Functions of Soil

- Adsorption, infiltration and holding of water;
- Retention and cycling of nutrients;
- Pest and weed suppressions;
- Strength to plants;
- Detoxification of harmful chemicals; and
- Production of food and fibre.

The soil quality is decreasing because of increasing population pressure, land division, imbalanced use of synthetic fertilisers and less use of organic matter. In old days, when land was sufficient, the soil quality was good as a result of high use of OM and minimum use of fertilisers. Also, less soil deterioration resulted in increased production. Nowadays, agriculture is a high-input cost profession.

DAY TWO

Session I

Activity II

The trainer asks the participants what they understand about soil health and make a list of characteristics of healthy soil. List out the points on a flip chart. Prepare the list of characteristics of healthy soil and summarize it by adding the following points. Trainer should finally explain the characteristics of healthy soil.

Characteristics of Healthy Soil

- Sufficient depth;
- Adequate supply of nutrients;
- Small population of plant pathogens and insects/pests;
- Good soil drainage;
- Large population of beneficial organisms;
- Low seed pressure;
- Free of chemicals and toxins that may harm the crop; and
- Resistance to degradation.

At the end of the session, the trainer should sum up the session and ask if anything needs clarification that can be taken up for further discussion.

Activity III

Individual Exercise

Ask the participants to develop linkages on:

How healthy soil helps farmers in increasing their income? What are the parameters that will be affecting positively and how?

Finally, with the help of participants, prepare a complete sketch of relationship as under.

Healthy Soil = Healthy Crops = Less Disease and Pest = Less Expenses on Chemicals and Labour = Less Expenses on Weeding and Cleaning = Less Overall Expenses on Crops Protection = High Production = High Income and Less Input and Maintenance Cost.

DAY TWO

Session II

Total Time: 3 hours 30 minutes

Soil Profile/Horizon

Objective

- To understand different soil layers and their functions; and
- Characteristics of each layer, their measurement, identification and functions of each layer.

Ask the participants whether they have seen different layers in the soil while digging the soil, if yes, what are these layers and what they understand about these layers, how are these layers formed, their importance and functions.

This is a verbal discussion and trainer should understand what is the participants' understanding of soil horizons.

> The facilitator should facilitate the session by showing pictures of various soil horizons and how to measure the depth of each layer and distinguish each profile. The participants should be able to describe these on their own after this topic.

- In deep soil, the soil profile is generally studied up to 150 cm and in other types of soil it is measured up to the parent materials. The horizons are generally designated "O," "A," "E," "B," "C," and "R."
- The clarity of each layer depends on the weathering process of the soil. In many soils, the identification of horizons is very difficult. It is not necessary that all soils have all horizons and their depth will also vary from one location to another.

> Formation of top one centimetre soil takes 1000 years and it is washed away in one hour, if no soil conservation measures are taken.

> O can be divided into O1 and O2; A can be divided into A1, A2, A3 and same in B horizons. The characteristics of each horizon should be described in detail and how to differentiate between different horizons should be done through field exposure.

"O" horizons or layers: Layers dominated by organic material, consisting of non-decomposed or partially decomposed litter, such as leaves, needles, twigs, moss and lichens, which have accumulated on the surface; may be on top of either mineral or organic soils. "O" horizons are not saturated with water for prolonged periods. The mineral fraction of such material is only a small percentage of the volume of the material and generally is much less than half of the weight. The depth of "O" horizon varies from place to place. In most agricultural fields it is absent whereas in forest soil it may vary from 2 cm to 30 cm. In temperate forest, the depth of "O" horizon is comparatively more than tropical forests. In tropical forests, it may vary from 5 cm to 10 cm whereas in temperate forest, the depth may go upto 30-40 cm.

DAY TWO

Session II

A horizons: Mineral horizons which are formed at the surface or below an O horizon, where all or much of the original rock structure has been removed and are characterised by one or more of the following:

- An accumulation of humified organic matter intimately mixed with the mineral fraction and not displaying properties and characteristics of E or B horizons;
- Properties resulting from cultivation, pasturing, or similar kinds of disturbance; or
- A morphology which is different from the underlying B or C horizon, resulting from processes related to the surface.

If a surface horizon has properties of both A and E horizons but the dominant feature is an accumulation of humified organic matter, it is designated an A horizon. Sometime "O" & "A" horizon is needed together and is also difficult to identify.

E horizons: Mineral horizons in which the main feature is loss of silicate clay, iron, aluminium, or combination of these, leaving a concentration of sand and silt particles, and in which all or much of the original rock structure has been obliterated.

An E horizon is usually, but not necessarily, lighter in colour than an underlying B horizon. In some soils, the colour is that of the sand and silt particles, but in many soils coatings of iron oxides or other compounds mask the colour of the primary particles. An E horizon is most commonly differentiated from an underlying B horizon in the same soil profile by colour of a higher value or lower chrome, or both; by coarser texture; or by a combination of these properties. An E horizon is commonly near the surface, below an O or A horizon and above a B horizon, but the symbol E may be used without regard to position in the profile for any horizon that meets the requirements and has resulted from soil genesis.

B horizons: Horizons that are formed below an A, E, O or H horizon, and in which the dominant features are the obliteration of all or much of the original rock structure, together with one or a combination of the following:

- Illuvial concentration, alone or in combination, of silicate clay, iron, aluminium, humus, carbonates, gypsum or silica;
- Evidence of removal of carbonates;
- Residual concentration of sesquioxides;
- Coatings of sesquioxides that make the horizon conspicuously lower in value, higher in chrome, or redder in hue than overlying and underlying horizons without apparent illuviation of iron;
- Alteration that forms silicate clay or liberates oxides or both and forms a granular, blocky, or prismatic structure if volume changes accompany changes in moisture content; or
- Brittleness;
- All kinds of **B** horizons are, or were originally, subsurface horizons; and
- Field exercise for better understanding of soil horizons.

DAY TWO

Session II

C horizons or layers: Horizons or layers, excluding hard bedrock, that are little affected by pedogenetic processes and lack properties of O, A, E, or B horizons. Most are mineral layers, but some siliceous and calcareous layers such as shells, coral and diatomaceous earth, are included. Some soils form in material that is already highly weathered, and does not meet the requirements of A, E or B horizons is designated C. Changes not considered pedogenetic are those not related to overlying horizons. Layers having accumulations of silica, carbonates, or gypsum, even if indurated, may be included in C horizons, unless the layer is obviously affected by pedogenetic processes; then it is a B horizon.

R layers: Hard bedrock underlying the soil.

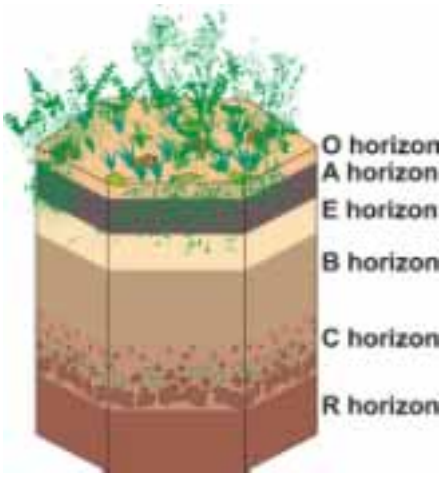
Granite, basalt, quartzite and indurated limestone or sandstone are examples of bedrock that are designated R. Air dry or drier chunks of an R layer, when placed in water, will not slake within 24 hours. The R layer is sufficiently coherent even when moisture makes hand digging with a spade impractical, although it may be chipped or scraped. Some R layers can be ripped with heavy power equipment. The bedrock may contain cracks, but these are so few and so small that few roots can penetrate. The cracks may be coated or filled with clay or other material.

Before the field demonstration/exposure, ask participants if they haven't understood something and need more clarification.

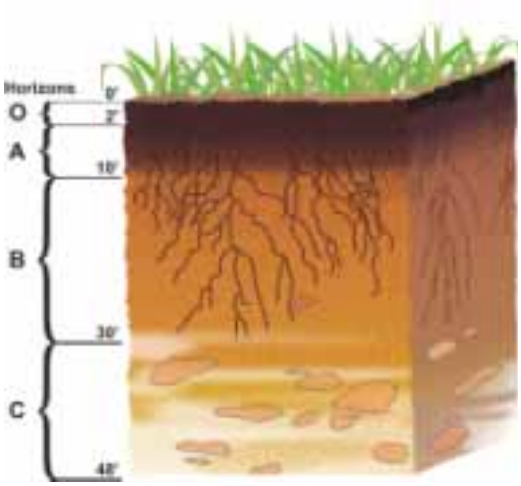
Source: FAO web site

DAY TWO

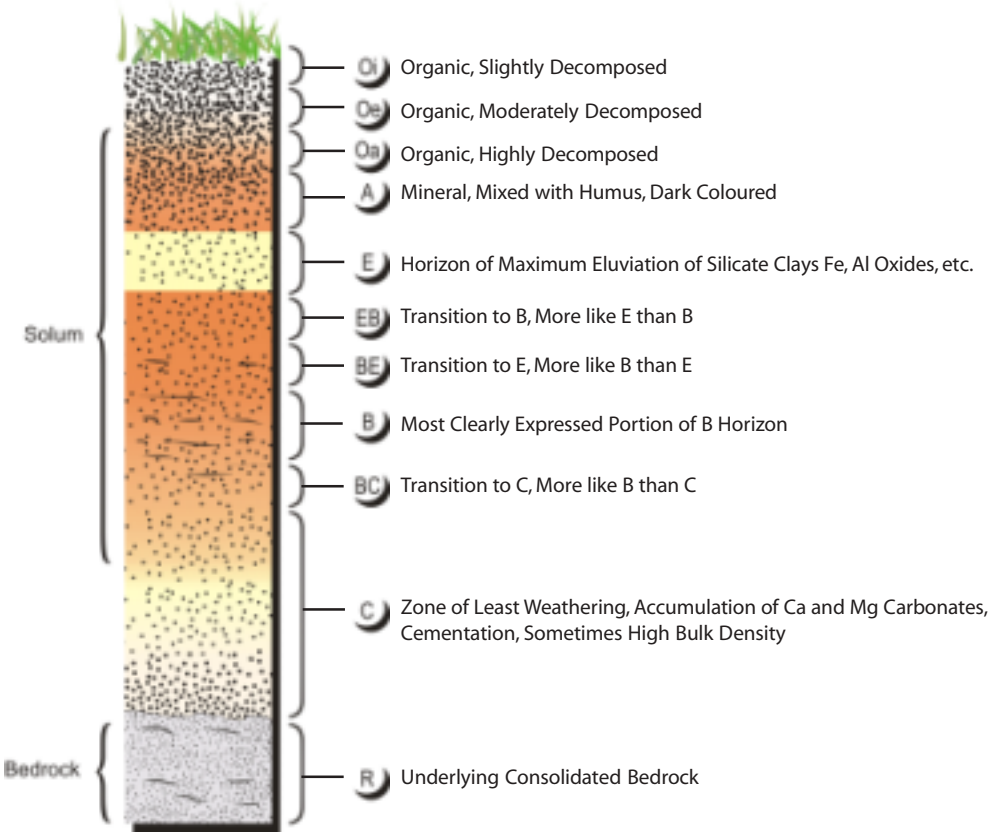
Session II



Source: K. A. Lemke (klemke@uwsp.edu)



Source: Internet



Source: Internet

DAY TWO

Session II

Activity I – Field Visit

After the session, the trainer should take all participants to field with equipment. A location needs to be identified where all the horizons are clearly visible without digging the soil much in depth.

Material Required

The trainer should explain in detail and show the different soil horizons, measuring the depth of each profile and their characteristics. Form to be filled up in field.

Field exercise: Following is the format that the participants need to fill up in the field.

Please form two groups (Group I & Group II) for two different sites (Site I & Site II).

Soil Horizons	Characteristics (colour/hardness/ material, etc.)	Depth	Type of Soil

** All the forms should be submitted to the trainer for documentation purposes.*

Summary

At the end of the day, the facilitator should summarise in brief/or in bullet points what has been discussed today and ask if there is any query and clarify it. Please remind the documentation group to prepare the notes for next day recap.

DAY THREE

Session I

Total Time: 2 hours

Physical Properties of Soil

Objective

At the end of the session, the participants will be able to:

- Understand the chemical and physical properties of soil.

Start with "Namaskar" and welcome prayer – "Itni Shakti Hame Dena Data, Man Ka Vishwas Kamzor Ho Na."

> After the song, invite one person for recap of the previous day's work. At the end of recap, ask the participants if they want to add something which is not covered in the recap. Say thanks to the person and start the second day's programme. Describe in brief what you are going to discuss today.

Activity I

This is purely a technical as well as subjective session and needs to be explained in a very simple way. The facilitator should write the properties of soil in separate charts and explain one by one in brief. Some soil samples could be taken to explain each property.

"Physical properties reflect the appearance of soil particle size, etc."

Physical properties of soil
List the physical properties of soil

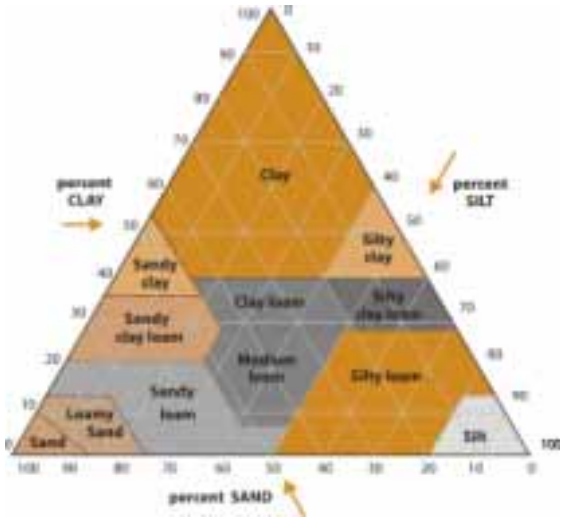
1. Soil texture.
2. Soil structure.
3. Bulk density.
4. Pore space.
5. Soil colour.
6. Soil temperature.

DAY THREE

Session I

Soil texture:

- The varying proportions of particles of different size groups in soil constitute soil texture; and
- The principal textural classes are clay, clay loam, sandy clay, silt clay, sandy clay loam, silt clay loam, sandy loam, silt loam, sand, loamy sand and silt.



Activity II

Handouts of following figures should be distributed to each participant. Give 15 minutes for reading. After 15 minutes, divide the participants into two/three/four groups and ask the group to give answers to the following questions. Each group presents the answer and if one group gives the wrong answer, the second group gets a chance to clarify the right answer. Each group will participate equally in the discussion. If something is not clear to the participants, the trainer will clarify it.

What are the percentage constituents of silt, clay and sand in the following soil types?

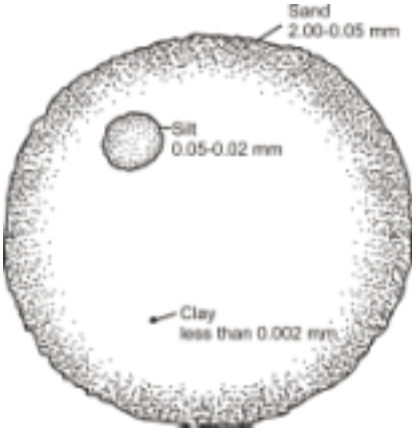
1. Sandy clay loam.
2. Sandy clay.
3. Silt clay.
4. Silt clay loam.
5. Clay loam.
6. Loamy sand.
7. Sandy loam.
8. Loam.
9. Silt loam.
10. Silt.

DAY THREE

Session I

Soil Particle Size

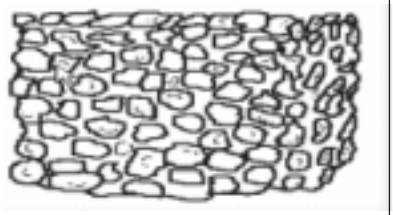
Soil Separate Fraction Name	Size Range (mm)
Very Coarse Sand	2.0 to 1.0
Coarse Sand	1.0 to 0.5
Medium Sand	0.5 to 0.25
Fine Sand	0.25 to 0.10
Very Fine Sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	<0.002



Soil particle size comparison

Soil structure:

- Platy – Horizontal Alignment;
- Prism-like – Columnar Type;
- Block-like – Angular or Sub-angular Types; and
- Spiroidal – Granular and Crumb Types.

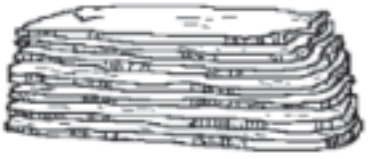


Granular: Resembles cookie crumbs and is usually less than 0.5 cm in diameter. Commonly found in surface horizons where roots have been growing.

Blocky: Irregular blocks that are usually 1.5-5.0 cm in diameter.

Prismatic: Vertical columns of soil that might be a number of cm long. Usually found in lower horizons.

Columnar: Vertical columns of soil that have a salt "cap" at the top. Found in soils of arid climates.



Platy: Thin, flat plates of soil that lie horizontally. Usually found in compacted soil.

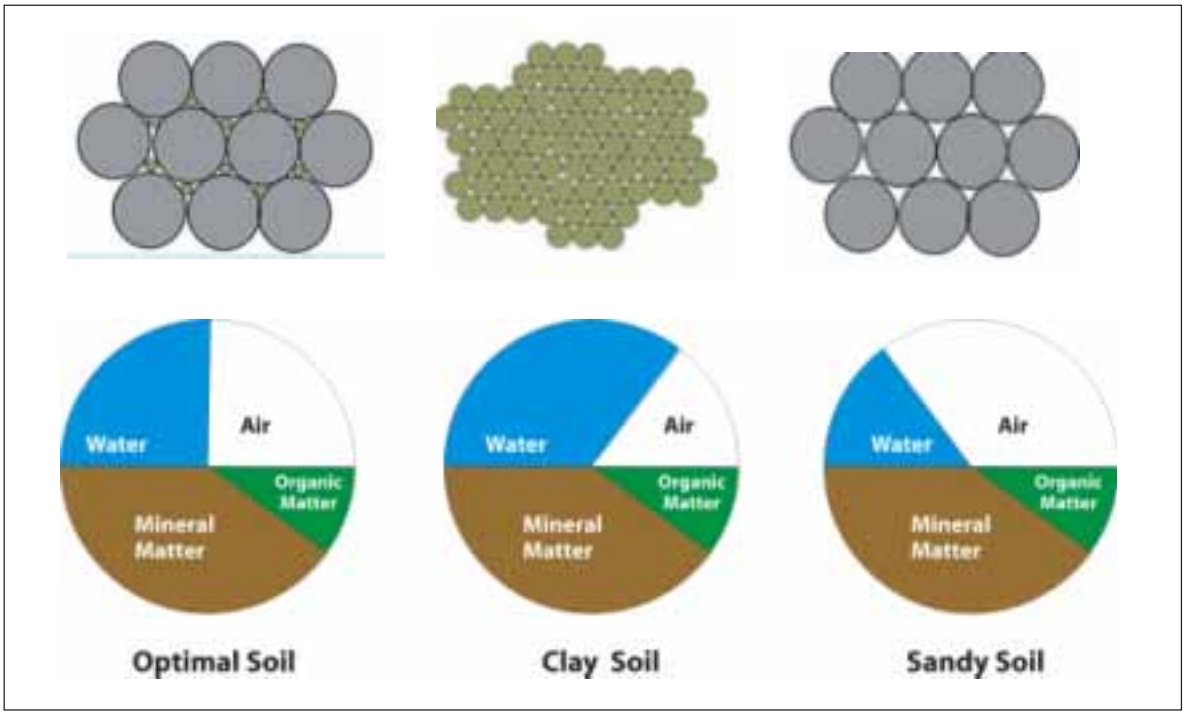
Single Grained: Soil is broken into individual particles that do not stick together. Always accompanies a loose consistence. Commonly found in sandy soils.

DAY THREE

Session I

Soil pores

Pores result from the irregular shape of soil particles or from pushing and aggregation forces. When pore space is very small, soil charges retain water and impede drainage, resulting in poor aeration. **"Pore size and pore space connectivity in the form of micro-joints is more important than total pore space."**



Soil pores determine the water holding capacity of soil

DAY THREE

Session II

Total Time: 1 hour 25 minutes

Chemical Properties of Soil

Activity I

Ask the participants about the relation between the particle size and water holding capacity. Ask them to fill up the format given below:

Please √ the appropriate

	Particle Size			Water Holding Capacity			Soil Pores			Particle Size in mm		
	Large	Medium	Small	High	Medium	Low	Large	Medium	Small	0.05 - 0.002 mm	<0.002 mm	2.00 - 0.05 mm
Clay												
Loam												
Sand												

**Format to be distributed to each participant.*

Ask the participants to check each other's answers. The trainer should finally tell the right answers for further clarification.

Soil colour
A colour designation system specifies three variables of colour:

Soil temperature
Soil temperature plays an important role in many processes, which take place in the soil such as chemical reactions and biological interactions. Soil temperature varies in response to exchange processes that take place primarily through the soil surface. These effects are propagated into the soil profile by transport processes and are influenced by such things as the specific heat capacity, thermal conductivity and thermal diffusivity.

DAY THREE

Session II

Chemical properties of soil

1. pH.
2. Salinity (EC).
3. Cation Exchange Capacity (CEC).
4. Organic matter.
5. C: N ratio (Carbon to Nitrogen).

1 pH

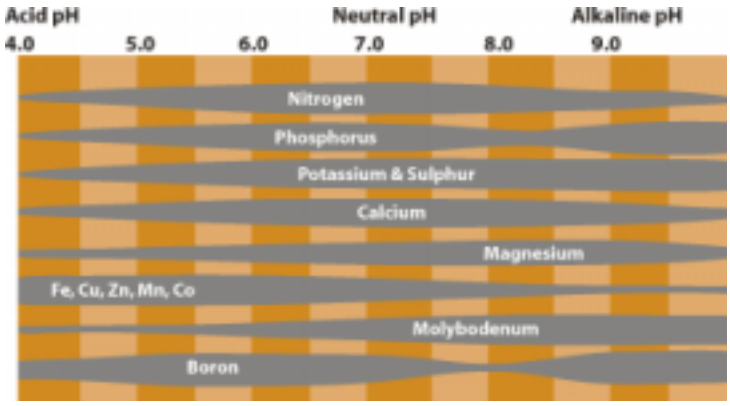
Percentage of hydrogen ion in the soil. This is a measure of the acidity or alkalinity of soil.

- Neutral = 7.0;
- Acidic < 7.0;
- Alkaline > 7.0; and
- Logarithmic scale which means that a 1-unit drop in pH is a 10-fold increase in acidity.

A Soil pH and plant growth:

- Affects availability of plant nutrients (in general, optimal pH is between 5.5-7.5);
- Low pH soils (<6.0) results in an increase in Al. Aluminium is toxic to plants;
- Affects availability of toxic metals (in general, more available in acidic soils);
- Affects the activity of soil micro organisms, thus affecting nutrient cycling and disease risk; and
- Use litmus paper for classroom demonstration.

B Effect of pH on nutrient availability



2 Soil salinity:

- Potential problem in irrigated soils due to high evaporation rates and low annual rainfall leaving salts to accumulate;
- Salts can come from irrigation water, fertilisers, composts and manure;
- Salts can be leached by slowly applying excess water;
  - Three inches removes about 50% of the soluble salts; and
  - Five inches removes about 90%.

DAY THREE

Session II

A. Soil salinity and interpretation

Conductivity (mmho/cm)	**Interpretation**
4 or Above	Severe accumulation of salts. May restrict growth of many vegetables and ornamentals.
2 to 4	Moderate accumulation of salts. Will not restrict plant growth, but may require more frequent irrigation.
Less than 2	Low salt accumulation. Will not affect plants.

3 Cation-exchange capacity

A cation is a positively charged ion. Most nutrients are cations: Ca2+, Mg2+, K +, NH4 +, Zn2+, Cu2+, and Mn2+. These cations are present in the soil solution and are in dynamic equilibrium with the cations absorbed on the surface of clay and organic matter. CEC is a measure of the quantity of cations that can be absorbed and held by soil. CEC is dependent upon the amount of organic matter and clay in soil and on the types of clay. In general, the higher OM and clay content, the higher the CEC.

4 Soil organic matter

Beneficial impacts of SOM on soil properties:

1. **Physical** – stabilises soil structure, improves water holding characteristics, lowers bulk density, dark colour may alter thermal properties.
2. **Chemical** – higher CEC, acts as a pH buffer, ties up metals, interacts with xenobiotics.
3. **Biological** – supplies energy and body-building constituents for soil organisms, increases microbial populations and their activities, source and sink for nutrients, ecosystem resilience, affects soil enzymes.

Fact sheet: Each year, about 1 to 4% of nutrients in the soil organic matter are released through microbial transformations to become available to plants. Release is highest under warm, moist conditions and slowest in cool dry climates. Microorganisms are the driving force for nutrient release to plants.

Soil micro flora and fauna

The trainer should explain participants that he/she will not go in depth of this topic and will cover only in bullet points. A handout should be provided to each participant for reading in the evening and, in case something is not clear, it can be asked in the next session.

DAY THREE

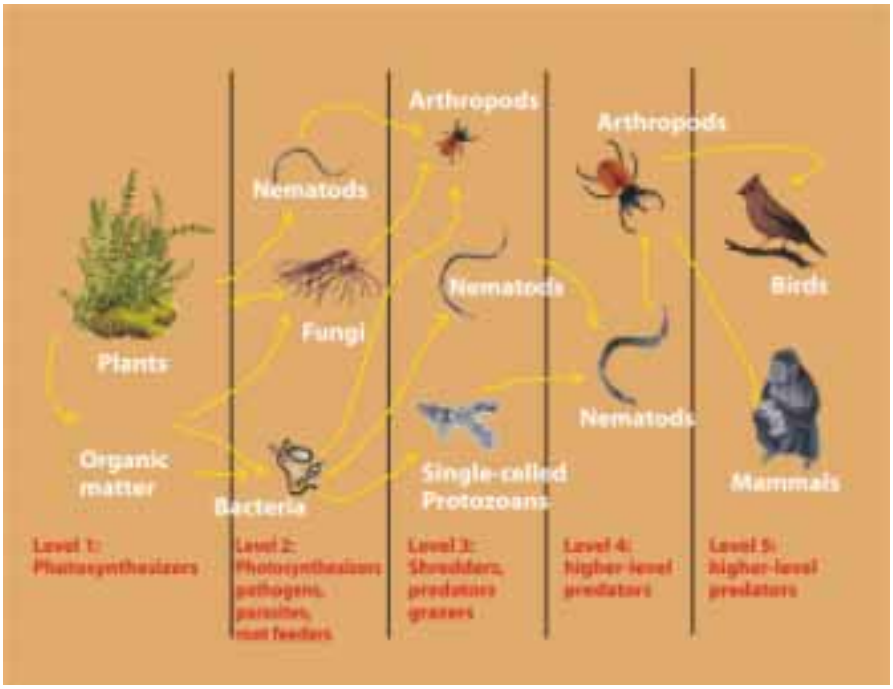
Session II

Activity II

The trainer should explain in detail the following picture and ask the participants to make observations after seeing the picture and correlate it with the soil, flora and fauna.

The details of flora and fauna, their activities and functions are given in the handouts.

The soil food web



Summary

At the end of this session, the trainer should summarise the session in bullet points and clarify, in case any doubts persist.

DAY FOUR

Session I

Total Time: 2 hours

Major Soil Types in India

Objective

After this session, the participant will be able to:

- Know the various types of soil existing in India and Haryana;
- Know the characteristics of each soil type; and
- Know the relativity of soil with selection of crop, agronomic practices, etc.

Start with "Namaskar" and welcome prayer – "Itni Shakti Hame Dena Data, Man Ka Vishwas Kamzor Ho Na."

> After the song, invite one participant for recap of the previous day's work. At the end of recap, ask the participants if they want to add something which is not covered in the recap. Say thanks to the person and start the day's programme. Describe in brief what is going to be discussed today.

The trainer should show the following soil map and explain various soil-dominated regions in India.

DAY FOUR

Session I

Classification of Indian soils

- There are eight major group of soils in India which are furnished below:

Red soils:

- Red colour is due to various oxides of iron. They are poor in N, P, K and have pH varying from 7 to 7.5. These soils are light textured with porous structure. Lime is absent with low soluble salts; and
- Red soils occur extensively in Andhra Pradesh, Assam, Bihar, Goa, parts of Kerala, Maharashtra, Karnataka, Tamil Nadu and West Bengal. Most of the red soils have been classified in the order "Alfisols."

Lateritic soils:

- Seen in high-rainfall areas, where silica releases and leaches downwards making the upper horizons of soils become rich in oxides of iron and aluminium. The texture is light with free drainage structure; and
- Clay is predominant and lime is deficient. pH 5 to 6 containing more humus. Being well drained, they are distributed in summits of hills of Deccan Karnataka, Kerala, Madhya Pradesh, Ghat regions of Orissa, Andhra Pradesh, Maharashtra and also in West Bengal, Tamil Nadu and Assam.

Alluvial soils:

- These are the most important soils from agriculture point of view. The soils are sandy loam to clay loam with light grey colour to dark colour; structure is loose and more fertile. But the soils are low in NPK and humus; and
- They are well supplied with lime; base exchange capacity is low, pH ranges from 7 to 8. These soils are distributed in the Indo-Gangetic plains, Brahmaputra Valley and almost all states of North and South.

Black soils:

- This is a well-known group of soil characterised by dark grey to black colour with high clay content;
- They are neutral to slightly alkaline in reaction. Deep cracks develop during summer; the depth of the soil varies from less than a meter to several meters. **Poor free drainage** results in the soils, base exchange is high with high pH and rich in lime and potash. Major black soils are found in Maharashtra, Madhya Pradesh, Gujarat and Tamil Nadu; and
- Cotton is the most favourable crop to be grown in these soils.

Forest soils:

- This group of soils occurs in the Himalayas. These soils are dark brown with more sub-soil humus content. They are more acidic.

DAY FOUR

Session I

Desert soils:

- These soils are mostly sandy to loamy fine sand with brown to yellow brown colour, contains large amounts of soluble salts and lime with pH ranging from 8.0 to 8.5. Nitrogen content is very low; and
- The presence of phosphate and nitrate makes the desert soils fertile and productive under water supply. They are distributed in Haryana, Punjab and Rajasthan.

Peaty and Marshy soils:

- These soils occur in humid regions with accumulation of high organic matter. During monsoons, the soils get submerged in water and the water recedes post-monsoon during which rice is cultivated. Soils are black clay and highly acidic with pH of 3.5. Free aluminium and ferrous sulphate are present;
- The depressions formed by dried rivers and lakes in alluvial and coastal areas some times give rise to waterlogged soils and such soils are blue in colour due to the presence of ferrous iron; and
- Peaty soils are found more in Kerala and marshy soils are found more in the coastal tracks of Orissa, West Bengal and South-East coast of Tamil Nadu.

Saline-sodic soils:

- Saline soils contain excess of natural soluble salts dominated by chlorides and sulphates which affects plant growth. Sodic or alkali soils contain high exchangeable sodium salts; and
- Both kinds of salt affected soils occur in different parts of India like Uttar Pradesh, Haryana, Punjab, Maharashtra, Tamil Nadu, Gujarat, Rajasthan and Andhra Pradesh.

Activity I

A small field trip should be arranged to demonstrate various types of soil.

DAY FOUR

Session II

Total Time: 1 hour 15 minutes

Soil Micronutrient

Objectives

At the end of this session, the participants will be able to:

1. Understand the different types of macro and micronutrients found in soil.
2. The status of micro and macro nutrient in India and Haryana soils.
3. Understand various myths about role of Soil Micronutrient.

Activity I

Ask the participants what they use in their soil and or do they know of any micronutrient used in soil. Prepare a list of micronutrients and finally add if any thing is left.

> The facilitator can explain by asking vitamins/nutrients required for human being, why human beings require vitamins, micronutrient and what they understand about the function/benefit of taking such micronutrient. This can be correlated with plants. Like human beings, plants also require these elements for their growth and development.

Definition of soil micronutrient: The nutrients required by the soil in very small quantities like in milligram, microgram.

Micronutrients				
Organic [1]	**Primary** [2]	**Secondary** [3]	**Micronutrients** [4]	**Functional** [5]
C Carbon	N Nitrogen	Mg Magnesium	Mn Manganese	Na Sodium
H Hydrogen	P Phosphorus	Ca Calcium	Zn Zinc	V Vanadium
O Oxygen	K Potassium	S Sulphur	Fe Iron	Co Cobalt
			Cu Copper	Si Silicon
			B Boron	Cl Chlorine
			Mo Molybdenum	

[1]*Available through atmosphere.*
[2]*Available through synthetic fertilisers.*
[3]*Available through application but quantity required is less than the NPK and more than the micronutrient.*
[4]*Required in small quantity and available through application.*
[5]*Functional micronutrient is the MN which is not required for growth of the plant but boosts biochemical activities and works as a catalyst in chemical reactions.*

DAY FOUR

Session II

Myth
In Mewat area, farmers are using plenty of gypsum. They consider it as micronutrient. The fact is that gypsum contains only one micronutrient, calcium, and is primarily used in saline soil to bring down the soil pH.

Fact Sheet 1 – The Present Condition of Micronutrient Deficiency in Indian Soil.

Extent of Micronutrient Deficiency in the Soils of India

State	No. of Soil Samples	Percent soil Samples Deficient			
		Zn	Cu	Fe	Mn
Bihar	19214	54.0	3	6	2
Haryana	21848	60.5	2	20	4
Punjab	16483	48.1	1	14	2
Uttar Pradesh	26126	45.7	1	6	2
West Bengal	6547	36.0	0	0	3
Total	**90218**	**50.6**	**2**	**10**	**3**

Source: Singh, 1999

Explanation
Out of the total sample collected, 50.6% of the sample is deficit in zinc, whereas 10% in iron and 3 % in manganese. The sample is collected in five states. The deficiency is highest in Haryana in the entire sample. Except copper, all samples are highly deficit in zinc and iron. We can say that Haryana soil is highly deficit in zinc and iron.

Fact Sheet 2 – Availability of Micronutrient

Total and Available Micronutrient Content of Indian Soils

Micronutrient	Total content (Mg/kg soil)	Available micronutrient (mg/kg soil)	
		Content	Mean
Zinc	2 to 1,019	0.2 to 6.9	0.9
Copper	1.9 to 960	0.1 to 8.2	2.1
Iron	2700 to 191.000	0.8 to 196	19.0
Manganese	37 to 11,500	0.2 to 118	21.0
Boron	3.8 to 630	0.08 to 2.6	–
Molybdenum	0.01 to 18.1	0.07 to 7.67	–

Source: Takkar, 1982; Singh, 1999

DAY FOUR

Session II

Explanation
All the micronutrients are highly deficit, whereas this deficiency is very high in zinc, iron and manganese.

Soil conditions causing Micronutrient Deficiency:

- Highly leached acidic sandy soils;
- Soils with a high water table;
- Soils with a very high content of organic matter, e. g., peat and muck soils of Kerala;
- Calcareous and saline-alkaline soils very high in pH in Uttar Pradesh, Punjab and Bihar;
- Intensively cropped soil with high doses of commercial fertilisers; and
- Application of high doses of lime at one time.

Fact Sheet 3 – Range of Micronutrient Concentrations Required for Normal Plant Growth

Trace Elements	Concentration in ppm (parts per million)
Fe (Iron)	0.5 to 5.0
Mn (Manganese)	0.1 to 0.5
B (Boron)	0.1 to 1.0
Z (Zinc)	0.02 to 0.2
Cu (Copper)	1. to 0.05
Mo (Molybdenum)	0.01 to 0.05

DAY FOUR

Session II

Fact Sheet 4 – Uptake of Plant Nutrient in Different Crops

Crop	Nutrient Removed (gm/tonne)					
	Zn	Cu	Fe	Mn	B	Mo
Foodgrains						
Wheat	56	24	624	70	48	2
Rice	40	18	153	675	15	2
Sorghum	72	6	720	54	54	2
Maize	130	130	1200	320	-	-
Barley	-	-	-	-	-	-
Oil Seeds						
Groundnut	110	36	705	93	-	-
Mustard	100	17	1122	95	-	-
Rai	59	21	635	169	-	-
Pulses Crops						
Chick Pea	39	11	868	70	-	-
Pigeon Pea	32	26	1200	11	-	-
Black Gram	-	-	-	-	-	-
Vegetable Crops						
Potato	9	12	160	12	50	0.3
Tomato	-	-	-	-	-	-
Cauliflower	-	-	-	-	-	-
Cabbage	-	-	-	-	-	-
Carrot	-	-	-	-	-	-
Onion	-	-	-	-	-	-
Fruit Crops						
Mango	-	-	-	-	-	-
Banana	-	-	-	-	-	-
Ziziphus (Ber)	-	-	-	-	-	-
Citrus	-	-	-	-	-	-
Guava	-	-	-	-	-	
Papaya	-	-	-	-	-	-

Source: Agriculture Handbook, IARI 2006

DAY FOUR

Session II

Application of Micronutrient-based Chemicals

Elements	Fertilisers Content	Range of Application (kg/ha)	
		Soil	Spray
Iron	Ferrous Sulphate – 19% Fe	16.8-56.0	5.6-7.8
Manganese	Manganese Sulphate – 30.5% Mn	16.8-33.6	4.5-9.0
Boron	Borax –10.50% B	5.5-56.0	2.3-22.4
Zinc	Zinc Sulphate – 21% Zn	2.3-56.0	0.56
Copper	Copper Sulphate – 24% Cu	5.6-33.6	–
Molybdenum	Ammonium Molybdate – 52% Mo	0.07-2.3	0.028-0.035

The common methods of micronutrient application are given below:*
Please explain the practical problems faced in each method.

Soils' application: The required quantity of materials are broadcast or placed by adding dry soil or fine sand before planting the crop., e.g., B, Cu, Zn.

Foliar application: Low doses of micronutrients are applied through sprays on plant foliage. Crops in younger stages require less solution, while crops with more foliage or fruit trees like oranges, require more solution for spraying, e.g., Fe, Mn, B.

Addition through mixed fertilisers: Uniform spreading of micronutrients essential for different regions is added to the spread fertiliser or to fertiliser mixture used, e.g., phosphates mixed with boron, molybdenum or zinc.

Seed soaking: Low concentration of micronutrient solution is used to soak the seed for about 12 hours before planting, e.g., Mo.

Seed coating: Micronutrient mixed with a small amount of soil made into a pest is coated around the seeds, dried and then used for sowing, e.g., Mo.

At the end of this session, the trainer should explain in brief/bullet points what they have discussed in this session and, if there is any query, it should be explained.

DAY FOUR

Session III

Total Time: 2 hours

Micronutrient Deficiency Symptoms

Objectives

At the end of this session, the participants will be able to:

1. Understand the functions and deficiency of various types of macro and micronutrient in vegetable and cereal crops.

Start with "Namaskar" and welcome prayer – "Itni Shakti Hame Dena Data, Man Ka Vishwas Kamzor Ho Na."

> After the song, invite one participant for recap of the previous day's work. At the end of the recap, ask the participants if they want to add something which is not covered in the recap. Say thanks to the person and start the day's programme. Describe in brief what you are going to discuss today.

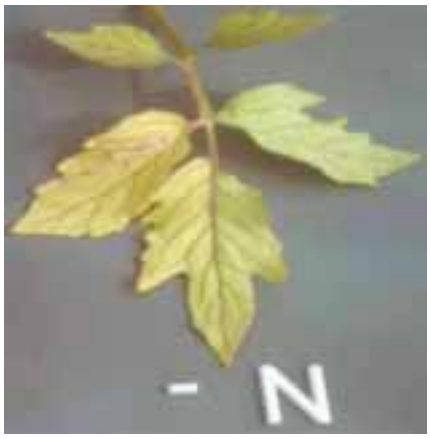
Nitrogen

Functions

Nitrogen plays an important role in plant metabolism, it being an essential constituent of several metabolically active compounds.

Deficiency

Nitrogen deficiency is observed in plants grown on soil, low in organic matter. Symptoms of its deficiency first appear on the older leaves which then move towards upper leaves, while the new leaves remain green. A pale yellow chlorosis develops near the tip of the leaf blade and advances towards the base in V shape.



Sorghum

Jowar

Wheat

DAY FOUR

Session III

Phosphorus

Function

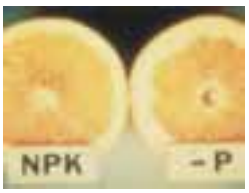
Phosphorus is an essential constituent of nucleic acid RNA and DNA, amino acid and proteins. It is necessary for cell division, meristematic growth, root, seed and fruit development as well as stimulating flowering.

Deficiency

Crops grown on acid soil, calcareous soils and coarse textured soil are low in phosphorus. Plants fail to make quick start, develop poor root systems and remain stunted. Leaves become dark to blue-green coloration starting from the tips towards the base.

Jowar

Wheat



Citrus fruit

Potassium

Function

Potassium is involved in regulating the opening and closing of stomata. It activates nearly 60 enzymes. It is important to regulate the fruit size and many metabolic activities.

Deficiency

The symptoms of chlorosis start from the leaf margins, followed by scorching and browning of tips and margin in potato, wheat, barley and maize.

Sugarcane

Wheat

Onion

DAY FOUR

Session III

Calcium

Function
Calcium is the essential component of a cell wall that maintains the integrity of cell membrane. It is involved in cell division.

Deficiency
It is amply found in soil and generally no deficiency is seen in the plant.

Magnesium

Function
It is an essential constituent of Chlorophyll. It regulates the activity of several enzyme systems involved in synthesis of nucleic acid and metabolism.

Deficiency
Magnesium deficiency is observed in plants growing in acid soils, leached soils and sandy soils. Mg deficient plants usually lack vigour and are stunted. Its deficiency is first observed in older leaves and advances upwards to younger leaves as interveinal chlorosis.


Wheat


Sugarcane


Corn

DAY FOUR

Session III

Iron

Functions
Helps in chlorophyll formation, absorption of other nutrients. Essential for the synthesis of proteins.

Deficiency
Causes chlorosis between the veins of leaves, although the veins remain green.


Tomato


Corn


Citrus

Manganese

Functions
Acts as catalyst in oxidation and reduction reactions within the plant tissues. Helps in chlorophyll formation, supports movement of iron in the plant, counteracting the bad effect of poor aeration.

Deficiency
Leads to chlorosis in the interveinal tissue of net veined leaves and parallel vein leaves. In cereals, it produces grey streak, white streak, dry spot and lip spot, marash spot, streak disease and pahala blight in sugarcane, yellow disease in spinach and beans.


Wheat


Citrus


Sugarcane

DAY FOUR

Session III

Boron

Functions
It is a constituent of cell membrane and essential for cell division. Acts as a regulator of potassium/calcium ratio in the plant, helps in nitrogen absorption and translocation of sugars in plant.

Deficiency
In Lucerne yellows and rosetting, snakehead in walnuts, dieback and corking in fruits, corking and pitting in tomatoes, hollow stem and bronzing of curd Cauliflower, brown heart disease in table beets, turnips, etc.


Sugarcane


Cauliflower

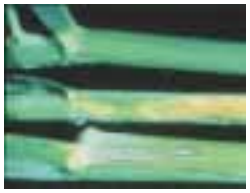

Peanuts

Zinc

Functions
Constituent of several enzyme systems which regulate various metabolic reactions in the plant. It is associated with water uptake and water relation in the plant.

Deficiency
Deficiency symptoms appear in younger leaves starting with interveinal chlorosis leading to a reduction in shoot growth and the shorting of internodes. Mottle leaf, little leaf, etc. In the case of trees, the buds of severely deficient maize plants become white, interveinal chlorosis and mottled leaf occur in citrus.


Tomato


Corn


Citrus

DAY FOUR

Session III

Copper

Functions
Acts as "electron carrier" in enzymes, helps in utilisation of iron in chlorophyll synthesis. It neutralises the harmful conditions in certain peat soils when applied in large quantity.

Deficiency
Variation in deficiency symptoms occurs in case of copper, e.g., multiple bud formation, staining and splitting of fruits, dieback of shoots, the marginal or spotted necrosis and chlorosis of leaves. The images of various micronutrient deficiencies will be shown to make this clear to the participants. All the images should be shown through LCD projector.


Citrus


Wheat


Onion

At the end of the session, the trainer should explain in brief/ bullet points what they have discussed in this session and if there is any query, it should be explained.

DAY FIVE

Session I

Total Time: 3 hours

Field Visit

Activity I

A small field trip will be made nearby to explore the deficiency in plants/vegetable crops.

DAY FIVE

Session II

Total Time: 30 minutes

Chemical Methods of Improving Soil Health – Chemical Fertilisers

At the end of this session, the participants will be able to:

1. Understand the different types of chemical fertilizers used in agriculture.
2. The availability and application of chemical fertilizers in plants.

Start with the "Namaskar" and welcome again words. All the participants will stand for the prayer – " Itni Shakti Hame Dena Data , Man Ka Vishwas Kamzor Ho Na."

After the song, invite one participant for recap of the previous day's work. At the end of the recap, ask the participants if they want to add something which is not covered in the recap. Say thanks to the person and start the day's programme. Describe in brief what you are going to discuss today.

Methods of Improving Soil Health

There are three ways to improve soil health, viz., chemical, physical and biological.

Activity I

Ask the participants what fertilisers they have heard of used in the field. Write down the names on a flip chart and categorise them into the following five categories.

Five types of chemical fertilisers:

a. Nitrogenous fertilisers – urea, CAN, ammonium chloride.
b. Phosphatic fertilisers – SSP, DAP, TSP, rock phosphate.
c. Potassic fertilisers – MOP, potassium sulphate.
d. N-P complex fertilisers – DAP MAP.
e. N-P-K mixed fertilisers – 10-26-26, 12-32-16, 19-19-19, 15-15-15.

NPK Contents in Different Fertilisers

	N	P	K	S	Ca	Mg
Urea	46					
CAN	25				10.2	7.5
Ammonium Chloride	25					
SSP		18		11	25	
DAP	18	46				
Rock Phosphate		20-38				
MOP			60			
Potassium Sulphate			50	17.5		

DAY FIVE

Session II

Pros and cons of using chemical fertilisers: Chemical fertilisers greatly enrich the soil over the short term, but they also have downsides, especially when used in excess:

- They pollute the air and the groundwater, which, in turn, harms human beings and animals;
- They reduce soil fertility over time;
- They contain only one or two macronutrients, and no secondary or micronutrients;
- They create salinity and alkalinity in the soil;
- They affect nutrient assimilation;
- They damage soil texture and reduce aeration; and
- They affect the keeping quality of fruits and vegetables.

Chemical Fertiliser Requirement

Fact Sheet – I

Fertiliser Requirements of Cereals in kg per acre

	DAP	Urea	Zinc	Gypsum
Mustard	25	60	10	4
Chick Pea	35			
Wheat	50	100	10	

Fact Sheet – II

Fertiliser Requirements of Vegetable Crops in kg per acre

	Nitrogen	Phosphorus	Potassium
Tomato	80	80	80
Cauliflower	60	40	38
Cabbage	60	40	38
Okra	50	30	30
Brinjal	80	80	80
Chilli	60	30	30
Ridge Gourd	20	20	10
Bottle Gourd	20	20	15
Capsicum	100	60	50
Coriander	20	20	15
Rice	40	25	25
Wheat	40	25	15
Mustard	12	12	8

DAY FIVE

Session III

Total Time: 2 hours

Organic Measures to Improve Soil Health

Objective

At the end of this session, the participant will be able to understand:
1. The importance and role of organic manure/FYM in enriching soil health.
2. Various types of organic manure.
3. Methods of preparing vermicompost.

Activity I

The trainer will ask the participants for various types of organic manures they have seen in the village and advantages of using FYM, and finally prepare a list of locally available organic compost in villages and explain some of them in details.

Organic manures
Any decomposed materials having minimum level of nitrogen and phosphorus with some amount of micronutrient and with pH ranges of 6-8 can be used and called as organic manures.

The properties and role of organic manures
1. Reduce the surface runoff thereby helping in reducing soil erosion through water.
2. Increase soil aeration and permeability by binding soil particles.
3. Increase water holding capacity of soil.
4. Organic matter serves and adds as a reservoir of essential nutrients which are released in harmony with the needs of plants.
5. It produces organic acids that help in dissolving unavailable potassium, phosphorus, micronutrients, etc., in soil.
6. Reduce evaporation loss.
7. Maintain soil temperature.
8. Reduce the termite attack in soil.
9. Reduce weed growth, etc.

Types of organic compost available in village
1. Cow dung heap.
2. Sewage and sludge.
3. HH waste heap.

DAY FIVE

Session III

Compost preparation – Vermicompost

Vermicompost: To carry out composting with worms, which eat organic material and leave behind fertile excreta.

Benefits of Vermicompost:
Compared to traditional compost, vermicompost:

- Is faster to produce, taking only 45 to 50 days compared to 12 months needed for traditional compost;
- Is richer in nutrients; and
- Requires a smaller preparation area.

However, vermicompost does not replace chemical fertilisers. It is one component of integrated nutrient management and must be used in conjunction with other methods, including chemical fertilisers.

Economic arguments:

- Cheap source of fertiliser;
- Savings on chemical fertilisers;
- Source of income as vermicompost and earthworms can be sold;
- Little labour required; and
- Earthworms reproduce and their number can triple in 12 months. Vermicompost production can thus be increased without having to buy more worms.

One vermicompost bed
Rs 1200 to 1500 investment
Produces 40 to 50 kg of vermicompost in 50 days
Sells at Rs 3 to 4 per kg of vermicompost
Earns Rs 120 to 200 per bed production
Selling of worms: Rs1 per worm

DAY FIVE

Session III

Vermicompost in practice:
The initial investment costs Rs 1200 for a simple vermicompost bed, and Rs 1500 for a vermicompost bed with a shed. There are no running costs.

Making vermicompost

- Find a shaded location (under a tree or shed) near a source of water, and close enough to the house to be able to keep watch on potential predators such as lizards and hen;
- Build a 10 feet long, 3 feet wide and 2 to 2.5 feet deep bed with cement, with a thin layer of cement at the bottom;
- Put in the bed a 3 inch thick layer of cow dung and wheat straw slurry;
- Add 50 kg of cow dung in the bed, and let it cool for three to five days, keeping it wet by sprinkling water on it. When the dung does not feel warm at a depth of six inches, it is cool enough;
- Release 1 kg, or 1000 earthworms into the bed;
- Add crop residue, dried leaves and organic garbage, all the way to the top of the cement bed. The worms will eat this layer, so refill it as it goes down;
- Cover the bed with a jute bag, a thin layer of rice straw, any other straw, and, if possible, a shed to protect the worms from the sun, rain, hens, birds and other predators;
- Splash a little water evenly over the last layer of bags or straw to maintain some moisture in the bed. The moisture level is right if a bit of liquid drips down when the cow dung is picked up and squeezed. Do not flood the bed;
- Every 15 days, turn over all the contents of the vermicompost bed;
- After 50 days, the worms will have digested the organic matter;
- Stop watering the bed and wait for two to three days for the worms to go down;
- Push all the bed's content to one side, so as to leave a 2 feet wide empty slot;
- Put in the empty slot a 3 inch thick layer of cow dung and wheat straw slurry;
- Add a 1 feet thick layer of fresh cow dung in the empty slot, and keep it moist;
- In three days, the worms will have migrated to the fresh cow dung;
- Remove the vermicompost from the side of the bed where it had been piled up;
- Gently sieve the vermicompost to ensure it contains no worms. Any worms found should be put back in the bed; and
- You can now start over the process, by putting the cow dung and wheat stock slurry.

DAY FIVE

Session III

Activity II

The trainer should take all the participants to the community centre and prepare a small compost pit as a practical learning lesson.

Material Required

Worms, cow dung, green leaf, jute mat, Fowda, water, etc.

Using Vermicompost:

Crop	Quantity	Timing
Tomatoes	2 to 3 q/acre	Before Transplanting
	3 to 4 q/acre	One Month after Transplanting
Cereals	1.5 q/acre	Before Sowing
Maize	2 q/acre	Before Sowing
Oil Seeds	1.5 q/acre	Before Sowing
Mango, Lemon and Other Fruit Trees	4 to 5 kg per plant	Between First and Fifth Year
	8 to 10 kg per plant	Fifth to Tenth Year
Bulb Crops (onion, garlic, turmeric and ginger)	4 q/acre	Before Sowing
Papaya	300 g/plant	1 to 1.5 Months after Transplanting
	250 g/plant	3 Months after Transplanting
Pomegranate, Orange, Sweet Lime	10 q/acre	Before Transplanting
	4 q/acre	One Month after Transplanting

Precautions:

- Never mix vermicompost with chemical fertilisers, as the beneficial bacteria contained in vermicompost would be killed. Apply chemical fertilisers at least eight days after applying vermicompost; and
- When applied on the field, the vermicompost should be immediately ploughed into the soil. If given time to dry up, it will loose all efficiency.

At the end of the day, the trainer should explain in brief what they have discussed during the day and summarise the day's work in bullet points. The trainer should also ask the participant if any topic needs clarification, that can be discussed again. Please remind the documentation group to prepare the notes for next day's recap.

DAY SIX

Session I

Total Time: 2 hours

Biological Measures to Improve Soil Health

Objective

At the end of this session, the participants will be able to know how to:

1. Use various measures like Green manuring, crop rotation and biofertilisers to improve the soil quality.

Start with "Namaskar" and welcome prayer – "Itni Shakti Hame Dena Data, Man Ka Vishwas Kamzor Ho Na."

After the song, invite one participant for recap of the previous day's work. At the end of the recap, ask from the participants if they want to add something which is not covered in the recap. Say thanks to the person and start the day's programme. Describe in brief what you are going to discuss today.

Green Manures:

Benefits of crop rotation:

- Replaces and holds nutrients in the soil;
- Reduces soil compaction from rain;
- Keeps soil moist, reducing the need for watering;
- Maintains a more even soil temperature;
- Less weed when the following crop is grown; and
- Improves soil condition.

Economic arguments:

- Reduces the need for fertilisers;
- Reduces the need for pesticides; and
- Improves yields.

Green manure in practice:

- Plant sun hemp, daincha, cow pea, horse gram, gliricidia and jayanti;
- Wait about 40 days for the crops to be two to three feet high. Do not wait longer as the crop must be cut when the stem is still soft, so that it decomposes easily; and
- Turn the crops into the soil with a tractor and a disc harrow.

DAY SIX

Session I

Timing:
Yearly, in the pre-monsoon season

Daincha sowing for Green manuring

Crop rotation
Many farmers practice sequential planting. They alternate between two field crops, one for the cool season, and one for the monsoon season. However, the same crop is always planted in the same season. Over time, the soil loses its fertility, and pest attacks and diseases increase.

> Crop rotation: Growing different crops in the same location in successive seasons or years.

Crop rotation helps tackle these problems. It limits nutrient depletion by alternating crops that require different kinds of nutrients, or in some cases, by planting crops that return nutrients to the soil. It also disrupts pests and diseases, which no longer find their preferred food.

Benefits of crop rotation:
- Improves or maintains soil fertility;
- Reduces pest attacks;
- Limits the risk of diseases;
- Limits soil erosion;
- Maintains soil moisture; and
- Deters weed.

Economic arguments:
- Reduces the need for fertilisers;
- Reduces the need for pesticides; and
- Improves yields.

DAY SIX

Session I

Crop rotation in practice:

Vegetables
Vegetables can be divided into four main categories:
- Leaves, such as spinach, deplete the soil of nitrogen;
- Fruits, such as tomatoes, deplete the soil off phosphorus;
- Roots, such as onions, deplete the soil off potassium; and
- Soil builders (legumes) and cleaners (corn and potatoes) fix nitrogen into the soil and use leftover fertilisers.

These categories can further be broken down into families:
- Squash family (melons, squash, cucumbers, pumpkins);
- Mustard family (broccoli, Brussels sprouts, cabbage, cauliflower, kohlrabi, kale, mustard, radishes, turnips);
- Tomato family (tomatoes, eggplants, peppers, potatoes);
- Beet family (beets, spinach, chard);
- Legume family (beans, peas);
- Onion family (onions, leeks, scallions, garlic, shallots);
- Carrot family (carrots, dill, parsnips, parsley);
- Daisy family (chicory, lettuce, artichoke); and
- Miscellaneous (corn, buckwheat, grazing rye).

In crop rotation, the combination of crops are designed taking into account each crop's nutrient requirements, depth of roots for water intake, and pest, disease and weed specifications. The vegetable plot is divided into sections that each hosts one family of crop over a set amount of time (season or year). The next season or year, the crops are rotated to the next plot.

	Year 1	Year 2	Year 3	Year 4	Year 5
Section 1	Cabbage Family **1**	Legume Family **2**	Onion Family **3**	Tomato Family **4**	Carrot Family **5**
Section 2	Legume Family	Onion Family	Tomato Family	Carrot Family	Cabbage Family
Section 3	Onion Family	Tomato Family	Carrot Family	Cabbage Family	Legume Family
Section 4	Tomato Family	Carrot Family	Cabbage Family	Legume Family	Onion Family
Section 5	Carrot Family	Cabbage Family	Legume Family	Onion Family	Tomato Family

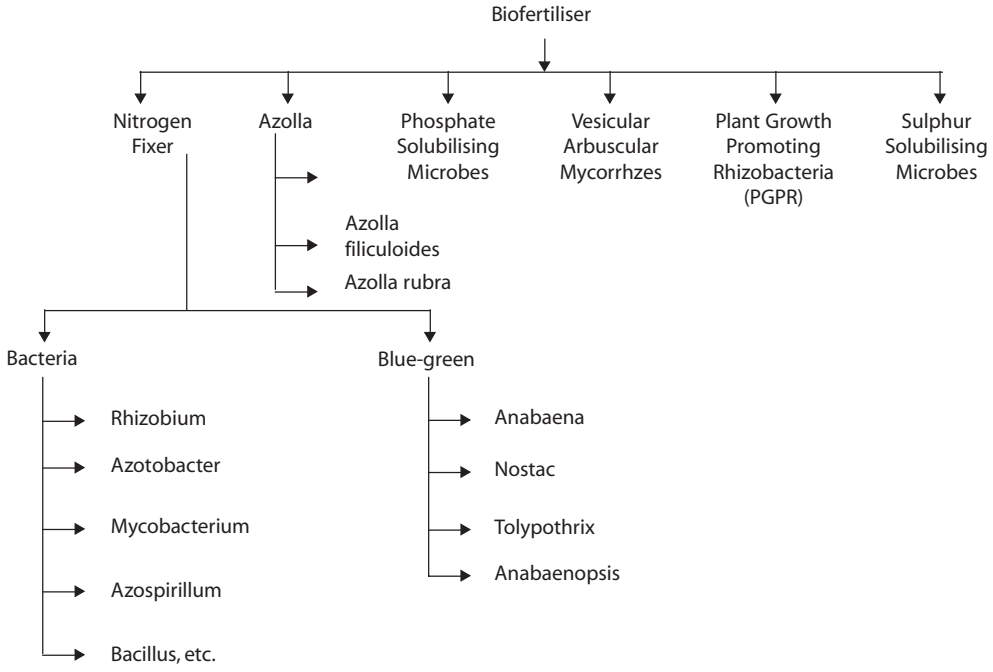
Field Crops Rotation:

	Cool Season	**Monsoon Season**
Year 1	Wheat	Corn
Year 2	Mustard	Pigeon Pea

DAY SIX

Session I

Biofertilisers
Biofertilisers are natural products including bacteria, algae, or fungi that provide plants with nutrients.



Benefits of biofertilisers:
- Enriches the soil with nitrogen or phosphorus;
- Stimulates microbial activity around the root, thus improving plant health;
- Reduces incidence of diseases;
- Improves soil aeration and moisture; and
- Does not pollute the soil or water.

DAY SIX

Session I

Economic arguments:
- Cheaper than chemical fertilisers; and
- Reduces the need for chemical fertilisers.

Major Biofertilisers

Biofertiliser	Target Crop	Effect
Rhizobium	Leguminous Crops (pulses, oilseeds, fodder)	Increases nitrogen uptake when associated with legumes
Azatobacter	Wheat, Rice, Vegetables	Increases nitrogen uptake
Azospirillum	Rice, Sugarcane	
Blue Green Algae (BGA)	Rice	
Azolla	Rice	
Phosphate Solubilising Micro-organisms (PSMs)	All	Increases phosphorus uptake

Biofertilisers in practice:
- Check the expiry date on the package before buying it;
- Check the storage conditions specified on the package;
- Buy biofertilisers from known manufacturers only, for instance, NAFED, Zuari Agro, Cadilla; and
- Biofertilisers do not replace chemical fertilisers, they only help to reduce their use.

Precautions:
Never mix biofertilisers with chemical fertilisers, as the beneficial bacteria, algae or fungi would be killed. Apply chemical fertilisers at least one week after applying biofertilisers.

DAY SIX

Session I

Total Time: 2 hours

Objective

At the end of the session, the participants' will be able to understand:

- The importance of chisel application; and
- How chisel helps in improving the physical health of the soil.

Chiselling
When the soil becomes too hard, root growth is slowed and water, air and soil organisms can no longer circulate, the result is slow-growing, weak and small-sized plants. Such soil conditions can be improved with chiselling.

Chiselling:
Deep tilling that breaks hardpan without disturbing organic matter and farm residues.

Benefits of chiselling:
- Improves water penetration;
- Aerates root zone;
- Reduces erosion;
- Increases product quality;
- Increases root zone depth; and
- Increases water retention capacity.

Economic arguments:
- Increases product yield; and
- Saves water as frequency of irrigation is reduced.

Chiselling in practice:
A field must be chiselled twice. Although a chisel theoretically ploughs the soil 12 inches deep, in practice, it often goes no deeper than 9 or 10 inches.

Cost:
Rs. 600 to hire the tractor and chisel machine to chisel twice on one acre.

Timing:
- Chisel every three years, once the hardpan has formed.

DAY SIX

Session II

Wrap-up Session

At the end of the day, the trainer should explain in brief what they have discussed during the day and summarise the days' work into bullet points. The trainer should also ask the participants if some topic is not clear, that can be discussed again.

At the end of the day, the trainer should explain in brief what they have discussed during the day and summarise the day's work into bullet points.

Trainer should take about one hour to recap the subjects that have been taught in the last five days. The trainer should advise the participants to make use of the knowledge and skill they have gained from here and apply that in their respective fields. Handouts should be read regularly to update their knowledge.

All the participants should be requested to fill up the feedback form without mentioning their name on the form. The trainer should also explain the objective of the feedback form so that each participant fills up the form without bias.

The trainer can see the chart where the expectations and worries of participants are listed and ask the participants whether their expectations have been met and their worries disappeared after this training.

Finally, the trainer should thank all the participants for giving their time and patience and say GOOD LUCK to all. The trainer can give his contact number to participants for future reference.

Back

IRRAD

Institute of Rural Research and Development

(An Initiative of S M Sehgal Foundation)
Plot No.- 34, Sector - 44
Gurgaon, Haryana - 122002, India.
Tel: +91-124-4744100
Fax: +91-124-4744123
Email: smsf@smsfoundation.org
http://www.smsafoundation.org

REGISTERED OFFICE
6346 Sector C6
Vasant Kunj
New Delhi - 110070, India.

SEHGAL FAMILY FOUNDATION
100 Court Ave # 211,
Des Moines, IA 50309-2256, U.S.A.
Tel: +1-515-288 0010
Fax: +1-515-288 4501