SOIL SAMPLING AND SOIL TESTING

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This developPPP project aims to strengthen the production of cardamom (Kerala), Cumin and Dill seed (Rajasthan) turmeric (Tamil Nadu and Karnataka), Celery (Punjab and Haryana) by increasing the capacities of spice farmers and making the production practices economically, socially and environmentally more sustainable.

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AVT McCormick Ingredients Pvt. Ltd, McCormick Switzerland GmbH' and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH are working together within the framework of the develoPPP funding programme, which GIZ implements on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

This manual is published under develoPPP project, Enhancement of Smallholder Spice Farmers' Capacities in Sustainable Farming. It aims to increase awareness about soil health and fertility to improve productivity.

CONTENTS

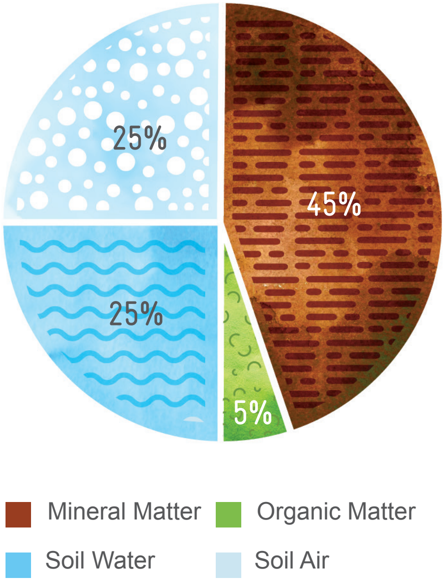
1. What is Soil

Soil is a dynamic natural body on the surface of the earth in which plants grow and is composed of mineral matter, organic matter and living forms. Soil is the medium for plant growth which supplies essential elements, water and soil air for the growth and development of plants.

1.1 Components of Soil

The soil consists of four major components i.e. mineral matter, organic matter, soil air and soil water.

Composition of Soil (percent)



Mineral Matter

The mineral matter in the soil is the primary source of essential nutrient elements for plants. Mineral matter consists of disintegrated and weather fragments of rock. Mineral matters are extremely variable in size. Some are as large as the smaller rock fragments, others, such as colloidal clay particles, are so small that they cannot be seen without the aid of an electron microscope.

Organic Matter

Soil organic matter represents partially decayed plant and animal residues. Such material is continually being broken down by the action of soil microorganisms. Organic matter plays an important role in the growth and development of the plant by supplying essential nutrients, water and air to the plant.

Soil Water

Soil water is the major component of the soil in relation to plant growth. The water is held within the capillary soil pores. If the moisture content of the soil is optimum for plant growth, plants can readily absorb water. Soil water dissolves salts and makes up the soil solution, which is important as a medium for supplying nutrients to growing plants. There is an exchange of nutrients between the soil solids and the soil solution and then between the soil solution and plant roots.

Soil Air

A part of the soil volume that is not occupied by soil particles, known as pore space, is filled partly with soil water and partly with soil air. As the pore space is occupied by both water and air, the volume of air varies inversely with water. As the moisture content of the soil increases, the air content decreases and vice-versa.

2. Why need for Soil Testing?

The use of chemical fertilisers has been increasing over the last few decades.

The lack of awareness among the farming community regarding when to apply fertiliser, how much to apply and what type of fertiliser to be applied are the major causes behind the indiscriminate use of chemical fertilisers. Farmers are using excess chemical fertiliser for maximum production which leads to increased cost of production, reduces fertiliser use efficiency and causes declining soil health. So, soil testing is an essential component to determine soil fertility levels and make balanced nutrient management recommendations based on the available nutrients in the soil. Balanced nutrient application based on soil testing helps to increase yields, reduce production costs, prevent surface and groundwater pollution and increase nutrient use efficiency. There are 20 elements essential required for the growth and development of plants, of which primary and secondary elements like N, P, K, Ca, Mg and S are involved in major metabolic functions of plants. The deficiency of any one of the essential elements in the plant causes a proportional decrease in crop yield. Secondly, soil testing will help to identify the soil reaction i.e. whether the soil is acidic or alkaline in reaction.

3. Soil Testing

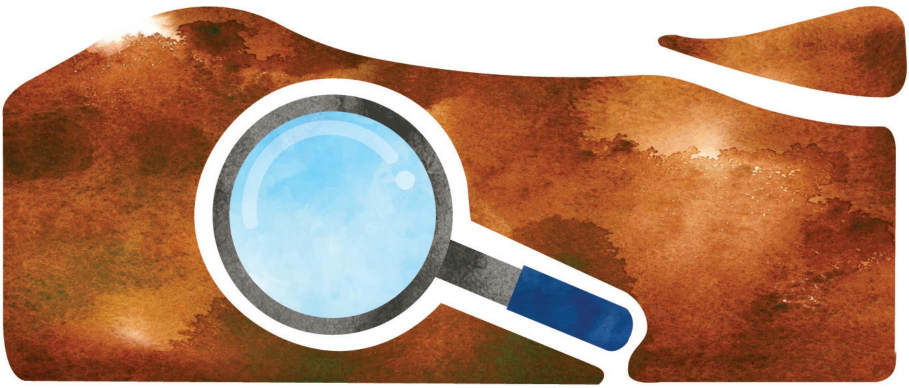
Soil testing is a rapid chemical analysis to assess the available nutrient status of the soil and includes interpretation, evaluation and fertiliser recommendation based on the result of chemical analysis of the soil.

3.1 Objectives of Soil Testing

1. Grouping of soil into classes relative to the soil fertility level.
2. Balanced use of nutrients based on the soil testing report.
3. Increase the nutrient use efficiency and reduce the cost of cultivation.
4. Help to identify the deficiency of the nutrients.

3.2 Soil Sampling

Soil testing is an essential component of soil resource management. Each sample collected must be a true representative of the area being sampled. The utility of the results obtained from the laboratory analysis depends on the sampling precision. Hence, the collection of a large number of samples is advisable so that samples of the desired size can be obtained by sub-sampling. In general, for large-scale soil survey purposes, sampling is done at the rate of one sample for every two-hectare area in irrigated land and one sample in 10 ha area for dryland area. At the individual level, farmers can take one sample for one or two ha area depending upon the slope, size and soil type of the farmland. For soil survey work, samples are collected from a soil profile representative of the soil of the surrounding area. Soil testing should be done at least once in three years to know the fertility status of the farm. This will help for better nutrient management to get optimum production with maximum nutrient use efficiency and also for maintaining and improving the health of the soil.

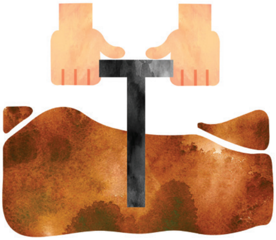


Materials Required

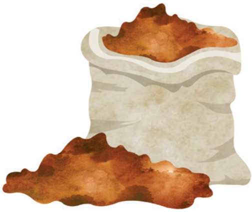
1. Spade or auger

2. Khurpi

3. Core sampler



4. Sampling bags

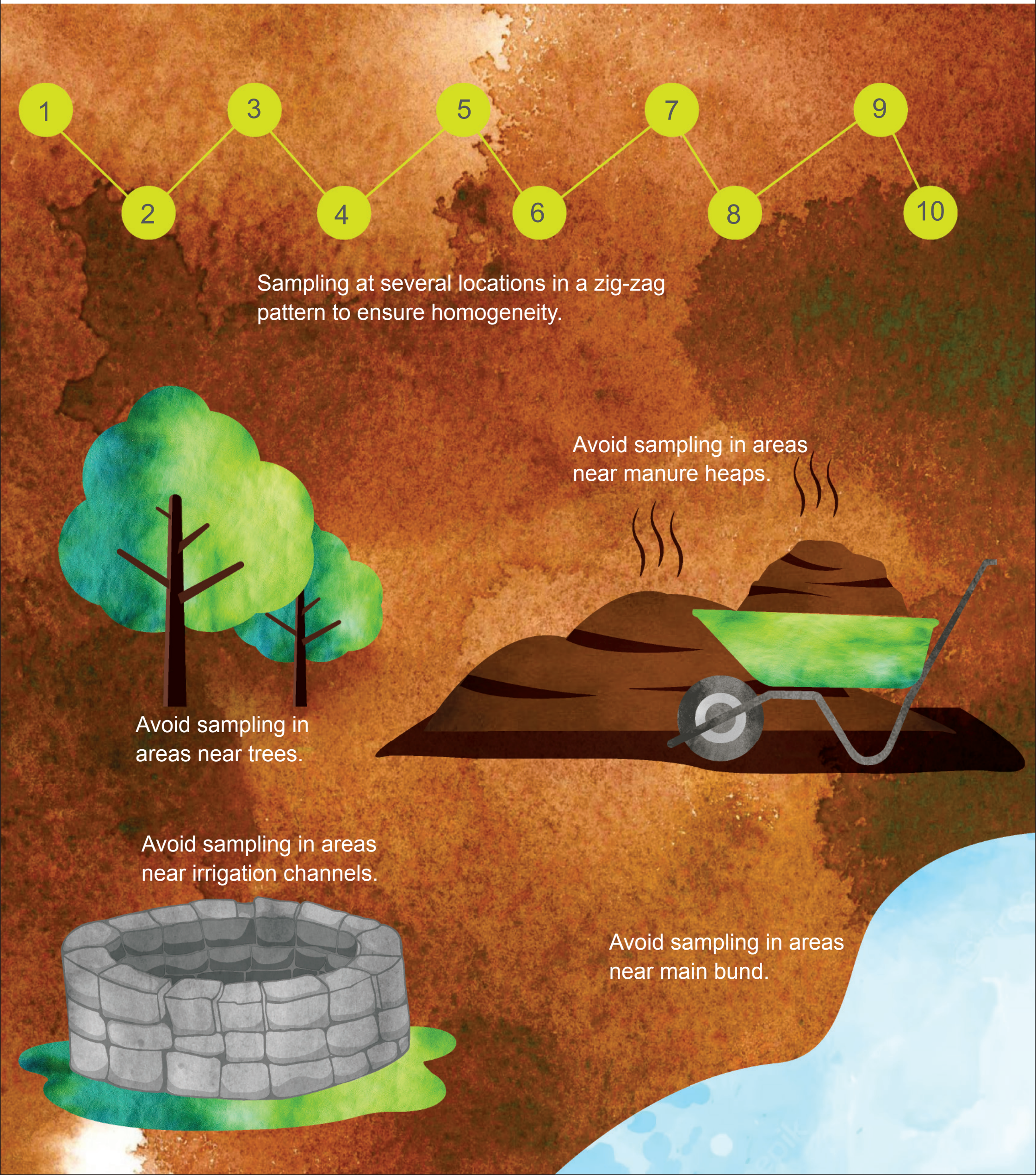


5. Plastic tray or bucket

General points to be considered at the time of soil sample collection

1. Collect the soil sample during the fallow period.
2. In the standing crop, samples should be collected between rows.
3. Sampling at several locations in a zig-zag pattern to ensure homogeneity.
4. Fields, which are similar in appearance can be grouped into a single sampling unit.
5. Collect separate samples from fields that differ in colour, slope, drainage, past management practices like liming, gypsum application, fertilization, cropping system etc.

6. Avoid sampling in dead furrows, wet spots, areas near main bund, trees, manure heaps and irrigation channels.
7. For shallow rooted crops, collect samples up to 15 cm in depth. For deep rooted crops, collect samples up to 30 cm in depth. For tree crops, collect profile samples.

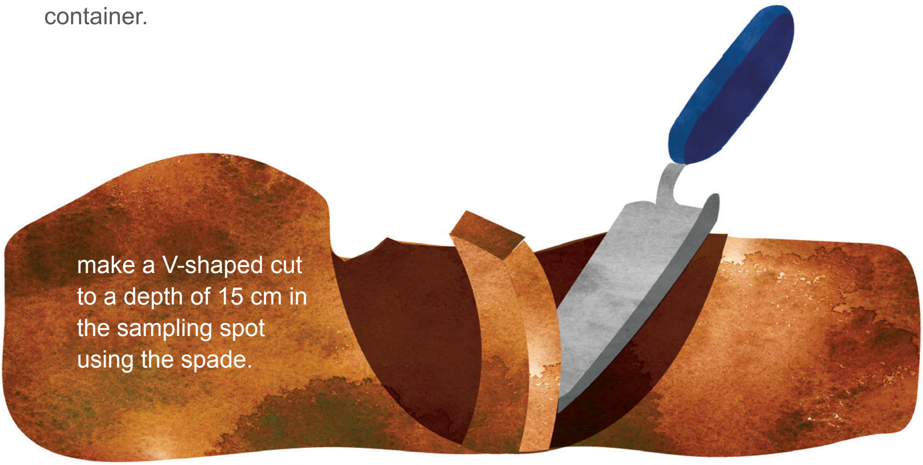


3.3 Procedure for Soil Sampling

1. Divide the field into different homogenous units based on the visual observation and the farmer's experience.
2. Remove the surface litter, crop residues, gravel, etc. at the sampling spot.
3. Drive the auger to a depth of 15 cm and draw the soil sample.
4. Collect at least 10 to 15 samples in a zig-zag shape from each sampling unit and place them in a bucket or tray.
5. If the auger is not available, make a 'V' shaped cut to a depth of 15 cm in the sampling spot using the spade.
6. Remove thick slices of soil from top to bottom of the exposed face of the V-shaped cut and place them in a clean container.

Processing of the sample before submission to the laboratory

1. Collected samples spread on a plastic sheet at a hard flat surface and mix the samples thoroughly and remove foreign materials like roots, stones, pebbles and gravels.
2. Reduce the bulk to about half to one kilogram by quartering.
3. Quartering is done by dividing the thoroughly mixed sample into four equal parts. Compartmentalization is done by uniformly spreading the soil over a clean hard surface.
4. Divide the samples into smaller compartments by drawing lines along and across the length and breadth.
5. The two opposite quarters are discarded

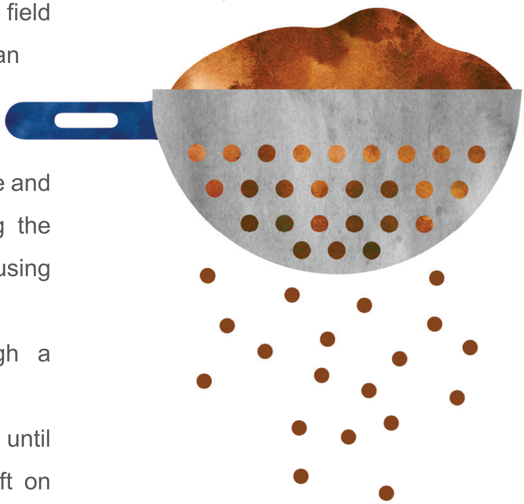


and the remaining two quarters are remixed. Repeat the process until the desired sample size i.e. half kg is obtained.

6. Collect the sample in a clean cotton bag.
7. Label the bag with information like the name of the farmer, village name, tehsil, district, location (GPS coordinates of the farm), survey number, previous crop grown, present crop, crop to be grown in the next season, date of soil sample collection, name of the sampler etc.

Storage and processing in the laboratory

1. Assign the sample number and enter it in the laboratory soil sample register.
2. Dry the sample collected from the field in shade by spreading it on a clean sheet of paper.
3. Spread the soil on a paper or polythene sheet on a hard surface and powder the sample by breaking the clods to its ultimate soil particle using a wooden mallet.
4. Sieve the soil material through a 2 mm sieve.
5. Repeat powdering and sieving until only materials of >2 mm are left on the sieve.
6. Collect the material passing through the sieve and store it in a clean glass or plastic container or polythene bag with proper labelling for laboratory analysis.
7. For the determination of organic matter, it is desirable to grind a representative sub sample and sieve it through a 0.2 mm sieve.
8. If the samples are meant for the analysis of micronutrients utmost care is needed in handling the sample to avoid contamination of iron, zinc and copper. Use stainless steel or polythene materials for the collection, processing and storage of samples.



3.4 Guidelines for Sampling Depth

Crops	Soil sampling depth (cm)
Grasses and grasslands	5
Rice, finger millet, groundnut, pearl millet, small millets etc. (shallow rooted crops)	15
Cotton, sugarcane, banana, tapioca, turmeric, vegetables etc. (deep rooted crops)	22
Perennial crops, plantations and orchard crops	Separate sample at 30, 60 and 90 cm

How can we use soil testing results?

Soil testing reports can be used for the balanced recommendation of nutrients based on the available nutrients in the soil. There are different approaches on nutrient recommendations based on soil testing i.e. 1. Soil test crop response equations (STCR). 2. Sufficiency level approach is based on the critical limits of the nutrients.

STCR Approach

In the STCR approach, a precise quantity of fertiliser application is recommended based on the nutrients available in the soil and target yield of the crops. These STCR equations are developed by the agricultural universities by doing long term research trials on various crops. These state wise developed equations can be used for the fertiliser recommendations. eg. Turmeric.

FN= "(6.45 * targetYield) - (0.88 * soilN) - (2.55 * fym)",

FP: "(4.03 * targetYield) - (6.48 * soilP) - (0.59 * fym)",

FK : "(4.52 * targetYield) - (0.45 * soilK) - (1.40 * fym)"

Soil NPK values in kg/ha and target yield q/ha

Sufficiency Level

The fertiliser recommendation is based on the critical limits of the nutrients and considers the standard recommended dose of the fertiliser. The critical limits rating of the nutrients are given in the table.

- If the deficiency of any nutrients in the soil then the recommended dose of that nutrient needs to be increased by 25%.
- If that nutrient is sufficient in the soil then standard dose remains the same.
- If that nutrient is very highly available in the soil then standard dose is reduced by 25%.

Table: 1. *Rating for classification of soil test values*

Sr. No.	Available Nutrient	Rating			Method Followed
		Low	Medium	High	
1.	Available N (Kg/ha)	Below <250	250-500	Above >500	Alkaline KMnO4 Method
2.	Organic Carbon (%)	0.50 below	0.50-0.75	Above 0.75	Walkley and Black Method
3.	Available phosphorus (Kg P2O5 /ha)	Below 28	28-56	56	Olsen's Method
4.	Available Potassium (Kg K2O/ha)	Below 140	140-280	Above 280	Neutral normal NH4OAC Extractant
5.	Available Sulphur (ppm)	Below 10	10-20	Above 20	Heat Soluble
6.	Available Iron (ppm)	Below 5.0	5-10	Above 10.0	DTPA (0.005 M) Extractant Method
7.	Available Manganese (ppm)	Below 5.0	5-10	Above 10.0	DTPA (0.005 M) Extractant Method
8.	Available Zinc (ppm)	Below o.5	0.5-1.0	Above 1.0	DTPA (0.005 M) Extractant Method
9.	Available Copper (ppm)	Below 0.2	0.2-0.4	Above 0.4	DTPA (0.005 M) Extractant Method
10.	Available Boron (ppm)	Below 0.1	0.1-0.5	Above 0.5	Hot water soluble
11.	Available Molybdenum (ppm)	Below 0.05	0.05-0.1	Above 0.1	Ammonium Oxalate Extractant

4. Problematic Soil

The problematic soil are generally classified into saline soil, alkali soil, acid soil and water logged soil. The phenomenon of accumulation of excess salt/acid in the root zone, results in a partial or complete loss of soil productivity and such soil is defined as 'Problem (alkali, saline & acid) Soil[1]. The major causes of the formation of problematic soil are due to the nature parent material of the soil, climate i.e. temperature, rainfall etc.; faulty agricultural management practices like excess use of irrigation, fertiliser and pesticides.

4.1 Saline Soils

Saline soil has electric conductivity of more than 4 dS/m at 25 oC, and the ESP is less than 15. The pH is less than 8.5. These soil are also known as white alkali soil and the Solonchaks. Saline soil is often recognized by the presence of white crusts of salts on the surface. Due to the presence of excess salts, saline soil is generally flocculated and as a result, the permeability of soil is equal to or higher than that of non saline soil.

1 https://agricoop.nic.in/sites/default/files/rps_guidelines%20%282%29.pdf

4.2 Saline-alkali (Sodic) Soil

Saline-alkali soil has electric conductivity greater than 4 dS/m at 25 oC and the exchangeable sodium percentage is greater than 15. This soil forms as a result of the combined process of salinization and alkalization. As long as excess salts are present, appearance and properties of these soil generally are similar to saline soil and the pH readings are seldom higher than 8.5. If the excess salts are leached downward, the properties of these soil change markedly and become similar to alkali soil.

4.3 Alkali Soil

Alkali soil is the soil for which the conductivity of the saturation extract is less than 4 dS/m at 25 oC and exchangeable sodium percentage is greater than 15. The pH readings range between 8.5 and 10. This soil is also known as ‘black alkali’ soil. The removal of excess salts in such soil tends to increase the rate of hydrolysis of the exch. The highly exchangeable sodium, the alkali soil develop characteristics of columnar or prismatic structure below the surface soil. The soil become highly dispersed, possess low permeability and are difficult to till.

4.4 Degraded Alkali Soil

This soil contains exchangeable sodium more than 15% and have the pH as low as 6.0. They occur only in absence of lime and the low pH reading is the result of exchangeable hydrogen. The physical properties are however dominated by the exch. sodium. This soil is formed due to intensive leaching of saline-alkali soil in absence of Ca or Mg in high rainfall areas.

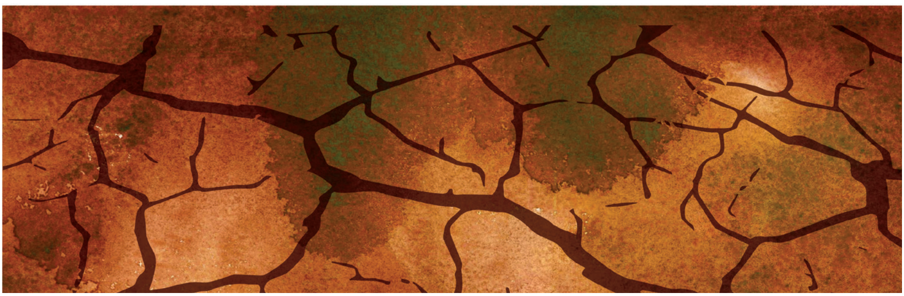


Table 2 : *Characteristics of problematic soils*

Sr. No.	Characteristic	Saline	Alkali	Saline-alkali	
1	Colour of soil	White	Black	-	Black lower layer
2	Presence of salts in the soil	Sodium chloride, sulphate etc.	Sodium carbonate	-	Sodium carbonate (lower level)
3	ESP	< 15%	> 15%	> 15%	> 15%
4	pH	< 8.5	8.5 to 10	8.5 or above	>8.5 (lower layer)
5	ECe dS/m	> 4	< 4	> 4	< 4
6	Physical condition of soil	Flocculated condition, permeable to water and air	Deflocculated condition, permeability to water and air is poor	May be flocculated deflocculated condition depends upon the presence of sodium salts and Na-Clay	Compact (deflocculated), low infiltration and permeability
8	Organic matter content	Slightly less than normal soil	Very less quantity	Variable	Low
9	Other name	White alkali, Brown alkali	Black alkali typical user, alkali soil, sodic soil		

5. Saline Soil Reclamation and Management

Mechanical Methods

1. Flooding and leaching down of the soluble salts

The leaching can be done by ponding water on the land and allowing it to stand there for a week. Most of the soluble salts would leach down below the root zone. After a week, standing water (dissolved with soluble salts) is allowed to escape. Such, 2-3 treatments are given to reclaim highly saline soil.

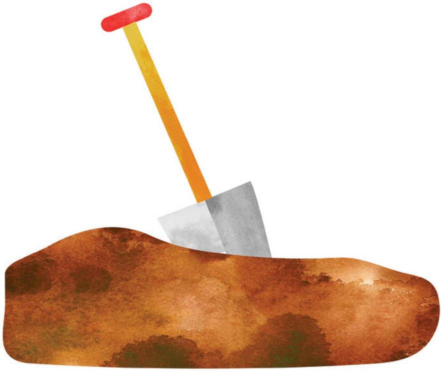
2. Scraping of the surface soil

When the soluble salts accumulate on the soil surface then scraping of the upper surface of the soil helps to remove salts. This is a temporary solution for the management of the saline soil.

Cultural Methods

- Provide proper drainage in the salt affected soil. If the soil is not free draining, artificial drains are opened or tile drains lay underground to help wash out the soluble salts.
- Use salt free good quality water to irrigate the crops.

- Seeds or seedlings should be planted inside the furrows to escape the zone of maximum salt concentrations, so it will reduce the effect of salt on germination and development of seedling during their early growth stage.
- Use of acidic nature of fertiliser in saline soil (e.g. Ammounium sulphate).
- Use sufficient amounts of organic manures in the soil so as to reduce the electric conductivity of the soil solution.



- Ploughing and leveling of the land increases the infiltration and percolation rate. Therefore, salts leach down to the lower level with the water.
- Mulching should be done with crop residues. Thus, salts may remain in the lower level with the water.

Growing of Salt Tolerant Crops

High salt tolerant crops	Barley, sugar beet, cotton, etc.
Moderately salt tolerant crops	Wheat, rice, sorghum, maize, etc
Low salt tolerant crops	Beans, radish, white clover etc.
Sensitive crops	Tomato, potato, onion, carrot etc.

6. Saline-alkaline and Alkali Soil Reclamation and Management

- Application of soil amendments (Gypsum/Pyrite) at the average rate of 5 tones per ha. Apply these amendments 15 days prior to sowing and mix well into the soil. (The application of gypsum should be done based on soil test report to get appropriate results).
- Green manuring should be done with Dhaicha, Sunhemp and leguminous crops to increase carbon content of the soil.
- Mulching should be done with crop residues.
- If the soil has low soluble salt then apply molysis, 5 ton per ha at the time of land preparation.
- Application of chemical fertilisers and micro-nutrients based on the soil test values.

- Judicious and balanced use of fertilisers.
- Surface and subsurface drainage systems should be install to drain out excess water from the field.
- Sowing should be done on the top side of the ridges.
- Use 10-20% higher seed rate to maintain optimum plant population.

Growing of Alkali Tolerant Crops

Tolerant	Semi tolerant	Sensitive
Rice	Wheat	Cow pea
Sugabeet	Barley	Gram
Rhodes grass	Oat	Groundnut
Para grass	Sugarcane	Maize
Karnal grass	Cotton	Pea
		Lentil
		Green gram

SCAN HERE

OTHER AVAILABLE RESOURCES ON THE WEBSITE:

- Handbooks on Concept and Methods of Integrated Pest Management in Sustainable Agriculture, Soil Sampling and Soil Testing, Integrated Nutrient Management and Low-Cost Organic Formulations (English, Hindi, Kannada and Malayalam).
- Farmers' Manuals on Sustainable Production Practices for Cardamom (English and Malayalam), Cumin (English and Hindi) and Turmeric (English, Kannada and Tamil).
- Farmers' Diaries on Cumin (Hindi), Turmeric (Tamil), Dill seed and Celery (Hindi).
- Animated Video Series on Practicing Sustainable Agriculture, Sustainable Food production, organic farming and more (English, Hindi, Kannada and Malayalam).

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