

# SOIL HEALTH MANAGEMENT

## PREREQUISITE FOR PEST AND DISEASE CONTROL

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## Soil as an ecosystem

- Soil is not just a growing medium for plant growth
- Consists of a dynamic complex of plant, animal, microbial communities and non-living environment.
- Function as a unit with close interaction between the components.
- Change in this balanced system impairs the soil's function as a medium for plant growth.
- It is a living, dynamic and ever changing environment, sustaining plant, animal productivity and diversity
- Enhances water and air quality and support human health and habitation

- Crop plant's ability to tolerate insect pests and diseases has direct links to optimum chemical and biological properties of soils
- High soil organic matter and active soil biological activity exhibit good soil fertility, complex food webs and beneficial organisms that reduce pest population and disease incidence
- Lower pest pressure in organic systems is due to greater use of crop rotation, bio pesticides, preservation of beneficial insects and no use of chemical pesticides
- Adequate earthworm population in the rhizosphere will reduce nematode infestation

## Disease Suppressive soils

- Suppressive soils provide the best examples of natural microbe-based plant defense, via rhizo deposition of plant roots which stimulate, enrich, and support soil microorganisms as the first line of defense against soil borne pathogens (Weller et al 2002,2007 )
- Some suppressive soils because of their microbial makeup and activity, a pathogen does not establish or persist, establishes but causes little or no disease, or establishes and causes disease at first but then the disease declines with successive cropping of a susceptible host even though the pathogens may still persist in the soil
- General suppression is a natural and preexisting characteristic of soil; is often effective against a broad spectrum of soil borne diseases; is not transferrable from field to field

## Soil Health Concept

- Soil health refers to the biological, chemical and physical features of a soil that are essential for long term sustainable agricultural production with minimal environmental impact
- No direct measurement, can be inferred by measuring specific properties like organic matter content, physical and chemical properties, microbial population and diversity

# Common Soil Health indicators

## Physical properties

- Soil texture, soil structure, porosity, water holding capacity, infiltration, permeability

## Chemical properties

- Organic matter status, cation exchange capacity, plant nutrient content

## Electrochemical properties

pH, Eh, EC

## Biological properties

Microbial activity as well as microbial diversity

## Attributes of a healthy agro ecosystem

- Agro ecosystem - Arbitrarily defined coherent unit, including living. nonliving components and their interactions within the unit, area where all agricultural activity takes place. Includes crop land, grassland, pastures etc
- Sustain plant and animal productivity and diversity
- Maintain or enhance water and air quality
- Support human health and habitation

## Maintenance of agro ecosystem health

- Habitat manipulation through agronomic practices
- Soil fertility enhancement through soil organic matter and plant nutrient management
- Conservation of below ground biodiversity
- Innovative ecologically based pest/disease management
- Plant constitutes a link of aboveground and belowground biodiversity

## Fertility constraints of Kerala soils

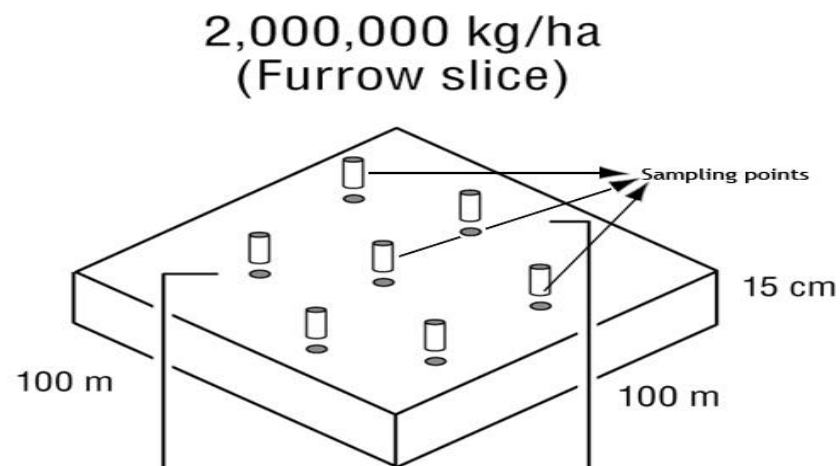
- ❖ The State of Kerala falls in the humid tropical belt with high rainfall and temperature conditions conducive to intense weathering processes
- ❖ In general, the soils are acidic, kaolinitic, gravelly with low cation exchange capacity, inherently poor in bases and plant nutrients, low water holding capacity and high phosphorus fixation



- ❖ Intensive agriculture and the use of high analysis fertilisers with greater purity resulted in depletion of secondary and micronutrients
- ❖ Soil test based nutrient management is crucial for maintaining soil health and thereby plant health and finally health of the community

## SOIL TESTING

- Soil testing is a proven diagnostic tool to evaluate the available nutrient status of a soil and evolve a balanced fertiliser recommendation for crops
- Deficiency was further compounded by nutrient imbalances which upset the uptake of various nutrients



5 kg soil in Bucket, mixed well

Reduced by cone and quartering to 500 gm

Air dried soil, ground and passed through 2mm sieve



Mixed and stored in glass bottle

mixed sub sample for analysis

## Collection of representative soil samples

**Hectare furrow slice (HFS)** is the volume or weight of the surface 15 cm (approximate plough depth) of soil in one hectare of land

**One hectare = 100 m x 100 m = 10,000 cm x 10,000 cm = 10,00,00,000 cm<sup>2</sup>**

**Volume of soil up to a depth of 15 cm = 10,00,00,000 x 15 cm<sup>3</sup>**

**Bulk density of soil = 1.33 g/cm<sup>3</sup> (approximately)**

**Weight of HFS = 10,00,00,000 x 15 x 1.33 g = 20,00,000 kg (rounded) = 2 x 10<sup>6</sup> kg**

## Soil test advisories for lime and fertilizers

- Soil samples are tested for pH, EC, OC, P, K, Ca, Mg, S, Cu, Zn and B
- Soil pH is classified into 11 pH classes for recommendation of lime
- Soil test values of OC, P and K are classified into 10 fertility classes and NPK fertilizers prescribed
- Soil test data of secondary and micro nutrients are classified as adequate / deficient and recommendations offered

# Soil reaction (pH) classes and Lime recommendation

	<u>Classes</u>	<u>pH range</u>	<u>Lime (kg/ha)</u>
1.	Ultra acid	<3.5	1000
2.	Extremely acid	3.5 -4.4	850
3.	Very strongly acid	4.5- 5.0	600
4.	Strongly acid	5.1-5.5	350
5.	Moderately acid	5.6-6.0	250
6.	Slightly acid	6.1-6.5	100
7.	Neutral	6.6-7.3	-
8.	Slightly alkaline	7.4-7.8	-
9.	Moderately alkaline	7.9-8.4	-
10.	Strongly alkaline	8.5 -9.0	-
11.	Very strongly alkaline	>9.0	-

## pH and Plant Nutrient Availability

<b>Nutrient</b>	<b>pH below 6</b>	<b>pH 6 -7.5</b>	<b>pH above 7.5</b>
<b>N</b>	<b>Falls gradually</b>	<b>Steady</b>	<b>Falls slightly</b>
<b>P</b>	<b>Falls rapidly</b>	<b>Steady</b>	<b>Falls slightly</b>
<b>K</b>	<b>Falls slightly</b>	<b>Steady</b>	<b>Steady</b>
<b>Ca, Mg &amp; S</b>	<b>Falls steadily</b>	<b>Steady</b>	<b>Steady</b>
<b>Fe, Mn &amp; Al</b>	<b>Rises rapidly</b>	<b>Falls rapidly</b>	<b>Falls rapidly</b>
<b>Cu, Zn &amp; B</b>	<b>Steady</b>	<b>Falls slightly</b>	<b>Falls gradually</b>
<b>Mo</b>	<b>Falls steadily</b>	<b>Increases as pH rises</b>	<b>Steady</b>

## Soil fertility classes for OC, P and K (KAU)

Soil fertility class	% of organic carbon		N as % of general recommendation	Available P (kg ha <sup>-1</sup> )	Available K (kg ha <sup>-1</sup> )	P and K as % of general recommendation
	Sandy	Clayey/loamy				
0	0.00 – 0.10	0.00-0.16	128	0.0 – 3.0	0 - 35	128
1	0.11 – 0.20	0.17-0.33	117	3.1 – 6.5	36 -75	117
2	0.21 - 0.30	0.34-0.50	106	6.6 – 10.0	76 -115	106
3	0.31 - 0.45	0.51-0.75	97	10.1- 13.5	116-155	94
4	0.45 - 0.60	0.76-1.00	91	13.6 -17.0	156-195	83
5	0.61 - 0.75	1.01-1.25	84	17.1 -20.5	196 -235	71
6	0.76 - 0.90	1.26-1.50	78	20.6- 24.0	236 -275	60
7	0.91 - 1.10	1.51-1.83	71	24.1- 27.5	276 -315	48
8	1.11 - 1.30	1.84-2.16	63	27.6 – 31.0	316 -355	37
9	1.31 - 1.50	2.17-2.50	54	31.1- 34.5	356- 395	25

## Secondary nutrients (Ca, Mg & S)

Soil analysis data of secondary nutrients were grouped as adequate / deficient based on the critical levels given below (KAU, 2012)

Nutrients	Deficiency	Adequate
Calcium	$\leq 300 \text{ mg kg}^{-1}$	$> 300 \text{ mg kg}^{-1}$
Magnesium	$\leq 120 \text{ mg kg}^{-1}$	$> 120 \text{ mg kg}^{-1}$
Sulphur	$< 5 \text{ mg kg}^{-1}$	$\geq 5 \text{ mg kg}^{-1}$



## Micro nutrients (Cu, Zn & B)

Soil analysis data of micro nutrients were grouped as adequate / deficient based on the critical levels given below (KAU, 2012)

Nutrients	Deficiency	Adequate
Copper	$< 1.0 \text{ mg kg}^{-1}$	$\geq 1.0 \text{ mg kg}^{-1}$
Zinc	$< 1.0 \text{ mg kg}^{-1}$	$\geq 1.0 \text{ mg kg}^{-1}$
Boron	$< 0.5 \text{ mg kg}^{-1}$	$\geq 0.5 \text{ mg kg}^{-1}$

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# Project on Soil Based Plant Nutrient Management Plan (NMP)

- ❖ Analysis of 2 lakhs soil samples for 13 parameters (macro, secondary, micro nutrients, EC and pH)
- ❖ Issue of soil fertility and nutrient advisory cards for 2 lakhs farmers of the State
- ❖ Nutrient management plan for all local bodies (1043)
- ❖ Block level NMP (152)
- ❖ District level NMP (14)

## Project on Soil Based Plant Nutrient Management Plan (contd.)

### COMPONENTS OF NMP

- Amounts of nutrients present in the soil
- Amounts of nutrients and lime needed for the crop
- Application of manures and fertilizers to meet the nutrient needs of crop
- Recommendation for nutrients, forms, time and method of application

## NMP- Booklet (12 pages)

**SOIL BASED PLANT NUTRIENT MANAGEMENT PLAN FOR SULTHAN BATTERY GRAMA PANCHAYAT**

Block - Sulthan Battery District - Wayanad

**Management of potassium fertilizers**

- Rock phosphates can be used advantageously in rice, grown in acid soils during the virippu season. Powdered rock phosphate may be applied and mixed thoroughly with soil by ploughing. After two or three weeks, the field may be flooded, worked up and planted with rice. Under this situation, phosphorus in rock phosphate gets converted to iron phosphate, which on subsequent waterlogging becomes available to the rice crop.
- Rock phosphate can be used successfully as a phosphatic source for leguminous crop since its root system can extract phosphorous from rock phosphate.
- In case of rice-legume cropping sequence in acid soils, application of rock phosphate to the pulse crop helps to skip phosphatic fertilizers in the succeeding rice crop.
- Since phosphorus requirement of seasonal crops is confined to the early stages, phosphatic fertilizers are to be applied at the time of seeding or planting. Top dressing of phosphatic fertilizer leads to wastage of the fertilizer nutrient. Further, excessive phosphates may lead to deficiency of micronutrients such as zinc, boron etc.

**Management of potassium fertilizers**

- Potassium fertilizers should be applied in as many splits as possible, to reduce loss of potassium.
- In acid soils, potassium fertilizers should be applied only after lime application to prevent loss of potassium by leaching.

A multi-institutional project of Kerala State Department of Agriculture involving DST laboratories, CSIR, ICAR Institutes (IBSS&LUP, Bengaluru, CTCRI, Thiruvananthapuram, CPCRI, Kayamkulam, IFRI, Kozhikode), Kerala Agricultural University (COA-Y, COA-P, OARS-K, RRS-V, RRS-M, RARS-K, RTL, RARS-P, KVK-W, PHS-P), KFRS-Peechi, ICRI (Spices Board), IITM-Kerala and CESS-Thiruvananthapuram and Co-ordinated by Kerala State Planning Board.

Soil Nutrient Management Information System  
Developed by IITM-K  
[www.keralasoilfertility.net](http://www.keralasoilfertility.net)

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## NMP- Poster (120 x 90 cm)

**Block - Sulthan Battery District - Wayanad**

**DEPARTMENT OF AGRICULTURE, GOVERNMENT OF KERALA**

**SOIL BASED PLANT NUTRIENT MANAGEMENT PLAN FOR SULTHAN BATTERY GRAMA PANCHAYAT**

**NUTRIENT MANAGEMENT PLAN**

Nutrient management plan (NMP) is prepared based on the soil test data. It assists the farmers to make best use of fertilizers and organic manures. There is potential cost savings in inputs, balanced supply of nutrients and improved crop performances. Enhanced crop yields and quality, with lesser environmental hazards due to excess of nutrients and improvement in soil health are added benefits. NMP also helps to plan fertilizer management strategies and compute fertilizer needs of the panchayat.

In order to develop the NMP, composite surface soil samples (0-20 cm) were collected from 291 farmer's fields, well distributed in the panchayat and representing the major land use systems.

**Soil reaction (pH)**  
Soil pH was grouped as per the 11 classes and frequency distribution diagram prepared.

Class	Frequency	Percentage
1.0-1.5	1	0.34
1.5-2.0	1	0.34
2.0-2.5	1	0.34
2.5-3.0	1	0.34
3.0-3.5	1	0.34
3.5-4.0	1	0.34
4.0-4.5	1	0.34
4.5-5.0	1	0.34
5.0-5.5	1	0.34
5.5-6.0	1	0.34

**Status of organic carbon, available P and N**  
Soil analysis data was grouped as low, medium or high as per the soil fertility rating and frequency distribution diagrams prepared.

Parameter	Low	Medium	High
Organic carbon (%)	0.0-0.5	0.5-1.0	1.0-1.5
Available phosphorus (ppm)	0-10	10-20	20-30
Available nitrogen (ppm)	0-10	10-20	20-30

**Nutrient Index Value**  
Nutrient index value (NIV) is calculated giving weightage to the number of samples falling in the low, medium and high fertility classes as suggested by Parker et al., 1951. An index value less than 1.5 is low, between 1.5 and 2.5 is medium and greater than 2.5 is high.

**NIV of the Panchayat**

Index	Organic carbon	Available P	Available N
NIV Rating	2.2	3.0	3.8
	Medium	High	Medium

**Secondary and micronutrient status**  
Soil analysis data of secondary and micronutrients were grouped as adequate or deficient based on the critical levels and frequency diagrams prepared.

**Soil test based fertilizer Recommendation**

Parameter	Low	Medium	High
Organic carbon (%)	0.0-0.5	0.5-1.0	1.0-1.5
Available phosphorus (ppm)	0-10	10-20	20-30
Available nitrogen (ppm)	0-10	10-20	20-30

**Soil Nutrient Management Information System, Developed by IITM-K, [www.keralasoilfertility.net](http://www.keralasoilfertility.net)**

**Soil samples were tested at Krishi Vigyan Kendra, Wayanad**

A Project on Soil Based Plant Nutrient Management Plan for Agro-Ecosystems of Kerala implemented by the Department of Agriculture, Government of Kerala, involving DST laboratories, CSIR, ICAR Institutes (IBSS&LUP, Bengaluru, CTCRI, Thiruvananthapuram, CPCRI, Kayamkulam, IFRI, Kozhikode), Kerala Agricultural University (COA-Y, COA-P, OARS-K, RRS-V, RRS-M, RARS-K, RTL, RARS-P, KVK-W, PHS-P), KFRS-Peechi, ICRI (Spices Board), IITM-Kerala and CESS-Thiruvananthapuram and Co-ordinated by Kerala State Planning Board.

2014

# Soil Health Management Strategies- Soil Acidity amelioration

## Problems in acid soils

- Toxicity of Fe, Al and Mn
- Deficiency of Ca and Mg
- Decreased availability of P by fixation
- Retards N fixation by legumes and mineralisation of organic matter
- Poor structural development in soils
- Harmful to bio-fertilizers and bio control agents

## BENEFITS DERIVED FROM LIMING

- Reduces toxicity of Fe, Al and Mn
- Increases availability of soil P
- Alleviates deficiency of Ca and Mg if dolomite is used as the liming material
- Improves structural development and thereby air and water movement
- Stimulates microbial activity
- Improves N fixation and organic matter decomposition
- Stimulates growth, improves efficiency of bio-fertilizers and bio-control agents

## LIMING MATERIALS

- Most common is shell lime from backwaters
- Availability of shell lime fast depleting
- Collection very much restricted due to environmental issues
- Prohibitive cost of shell lime restricts use
- Dolomite, an alternate cheap source is available which also supplies Mg



## Neutralizing value (calcium carbonate equivalent ) of liming materials

- Ability of liming materials to neutralize acidity
- Pure calcium carbonate has standard value of 100 %
- Neutralizing value depends on purity of materials
- Calcium oxide has highest value and superior to other liming materials

## Neutralizing value of pure forms of liming materials

Liming materials	Neutralizing value
Calcium Oxide	179
Calcium hydroxide	136
Magnesium carbonate	109
Dolomite ( Calcium magnesium carbonate)	109
Calcium carbonate	100
Calcium Silicate	86

## Selection of liming material

- Neutralizing value decides efficiency
- Purity of the material – greater the purity more the efficiency
- Degree of fineness- finer the material greater the reactivity

# Method of lime application

- Best applied at the time of land preparation and at right moisture regime
- Allow maximum contact with the soil
- Uniform distribution and turning over will increase reactivity
- In areas with subsoil acidity, deep placement is more effective for perennial crops

# Strategies to address soil health

- Organic manures and recycling of biomass to be promoted
- Encourage mixed/intercrops of pulses in all major cropping systems
- Encourage N-fixing and other useful trees/bushes as hedges on bunds for *in-situ* production of biomass
- Wherever possible, green manure crops to be promoted
- Liming for soil acidity management and fertilizer application only based on soil test

## Strategies to address soil health (contd.)

- Encourage integration of livestock in farming system
- Bio fertilisers like VAM to be promoted on massive scale for improving nutrient use efficiency and better root health
- Improve earthworm population in soils with enough organics
- Need based balanced fertilization in conjunction with organics and bio fertilizers

## Strategies to address soil health (contd.)

- Encourage integration of livestock in farming system
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- Need based balanced fertilization in conjunction with organics and bio fertilizers

# Root Health – the key to improving yield

## Main functions of roots

- Anchor the plant to the soil
- Provide a large surface area through the presence of root hairs
- Facilitate the uptake and absorption of water and nutrients
- Structure and growth habits of roots have pronounced effect on the size and vigor of the plants
- Around 80% of all plant health problems start with soil/root problems
- Roots of most plants are prone to attack by pathogenic fungi and nematodes
- Effects of such organisms are noticed only when the attack is sufficiently severe to cause crop failure



## Effect of AMF inoculation on root activity



## Summing up

**The superimposition of all sources of plant nutrients on a cropping system basis as an integrated plant nutrient system will provide balance of nutrients, increase in nutrient use efficiency and enhanced productivity with least damage to the environment**

### References

**Miguel A Altieri, Luigui Ponti, Ana Clara I Nicholls, 2005, Enhanced pest management through soil health: towards a belowground habitat management strategy, [www.researchgate.net](http://www.researchgate.net) 253:33-40**

**Department of Agriculture & Farmer's Welfare, 2019, Soil Health Management for Sustainable Crop Production in Kerala. (eds.) V.K. Venugopal, K.M. Nair, P. Rajasekharan, A.N. Sasidharan Nair, Kerala State Planning Board, Thiruvananthapuram, P 1-426**

*Essentially, all life depends upon the soil. There can be no life without soil and no soil without life; they have evolved together*

Charles E. Kellog





**Thank You**