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

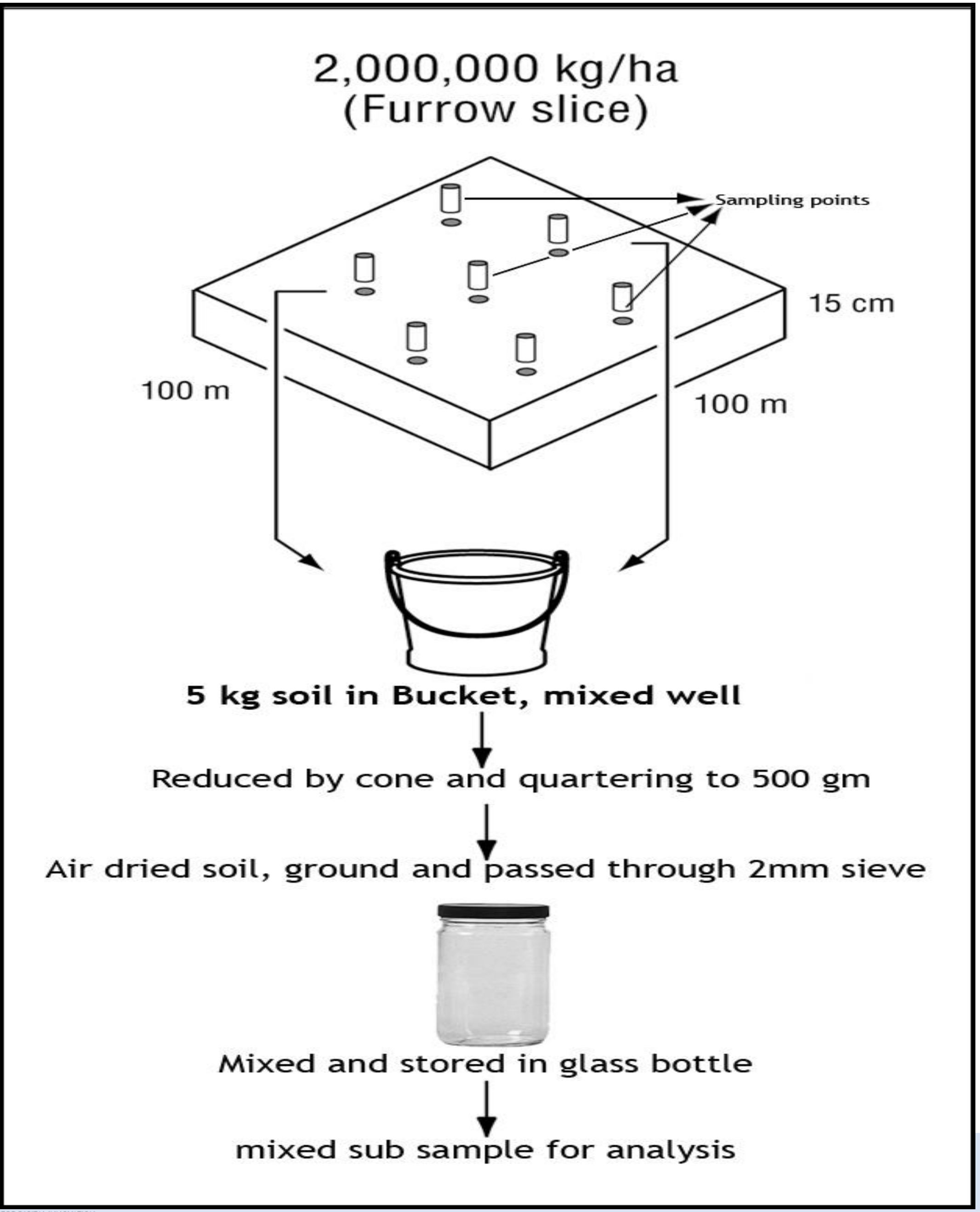
- Intensive agriculture and the use of high analysis fertilisers with greater purity resulted in depletion of secondary and micronutrients

- 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



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^2

Volume of soil up to a depth of 15 cm = 10,00,00,000 x 15 cm^3

Bulk density of soil = 1.33 g/cm^3 (approximately)

Weight of HFS= 10,00,00,000 x 15 x 1.33 g = 20,00,000 kg (rounded) = 2 x10^6 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

	Classes	pH range	Lime (kg/ha)
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

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

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

Soil fertility class	% of organic carbon		N as % of general recommendation	Available P (kg ha^{-1})	Available K (kg ha^{-1})	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	**≤ 300 mg kg^{-1}**	**> 300 mg kg^{-1}**
Magnesium	**≤ 120 mg kg^{-1}**	**> 120 mg kg^{-1}**
Sulphur	**< 5 mg kg^{-1}**	**≥ 5 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 mg kg^{-1}	≥ 1.0 mg kg^{-1}
Zinc	< 1.0 mg kg^{-1}	≥ 1.0 mg kg^{-1}
Boron	< 0.5 mg kg^{-1}	≥ 0.5 mg kg^{-1}

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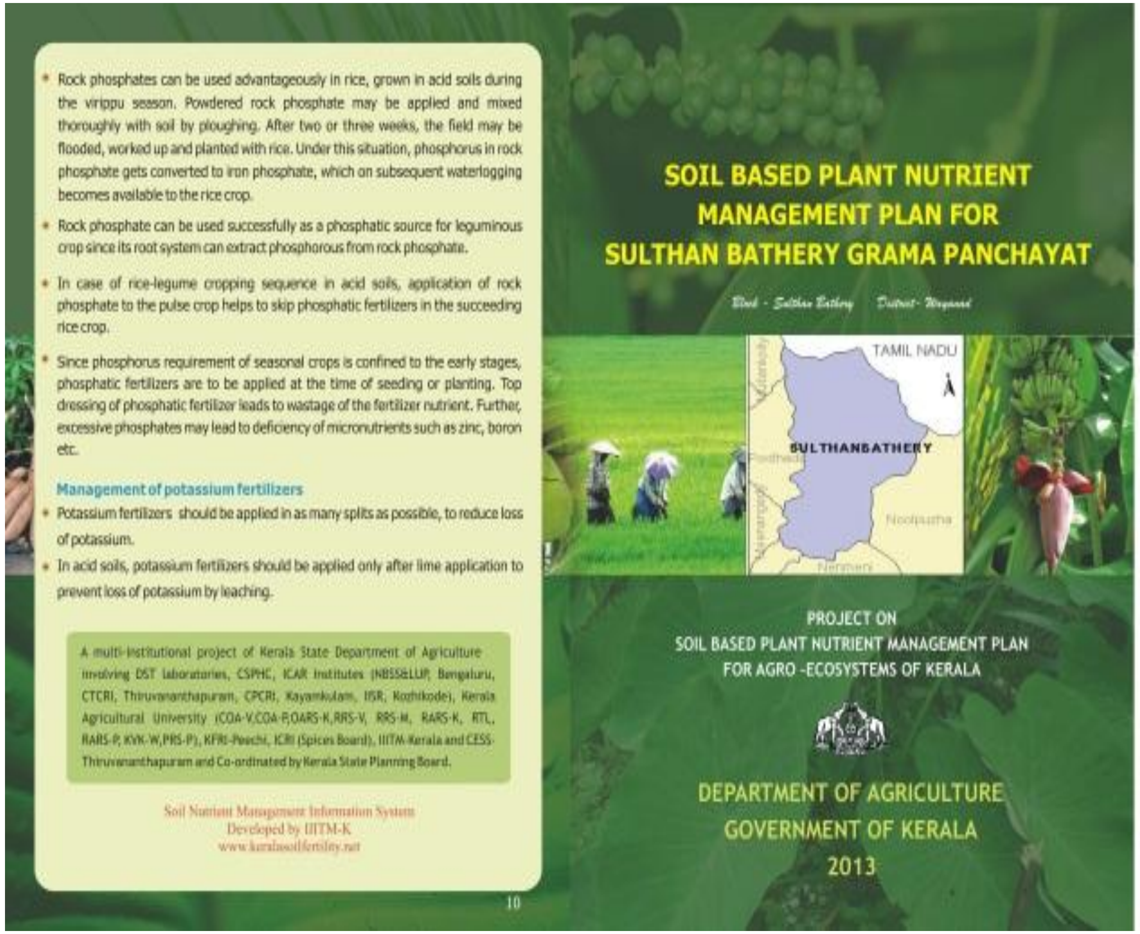
Project on Soil Based Plant Nutrient Management Plan (NMP)

- 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)

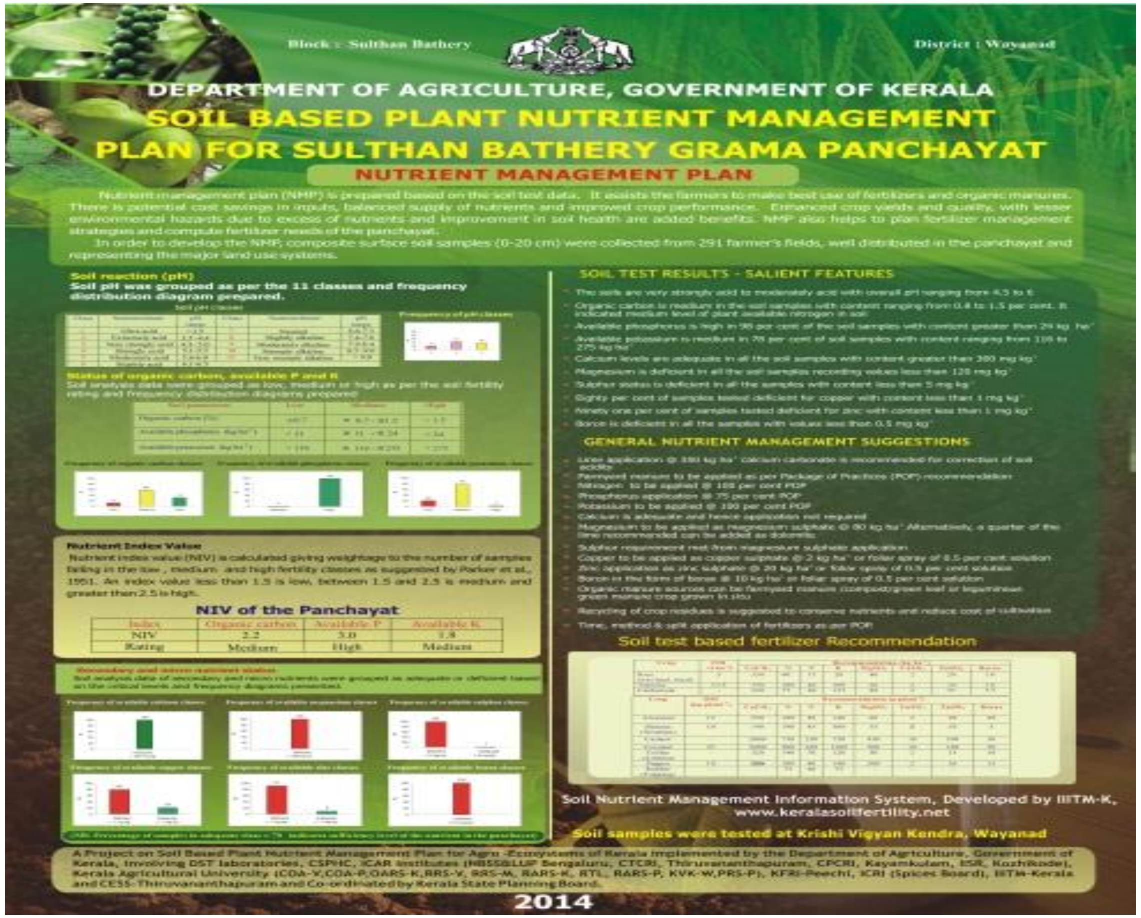
COMPONENTS OF NMP

- 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)



NMP- Poster (120 x 90 cm)



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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

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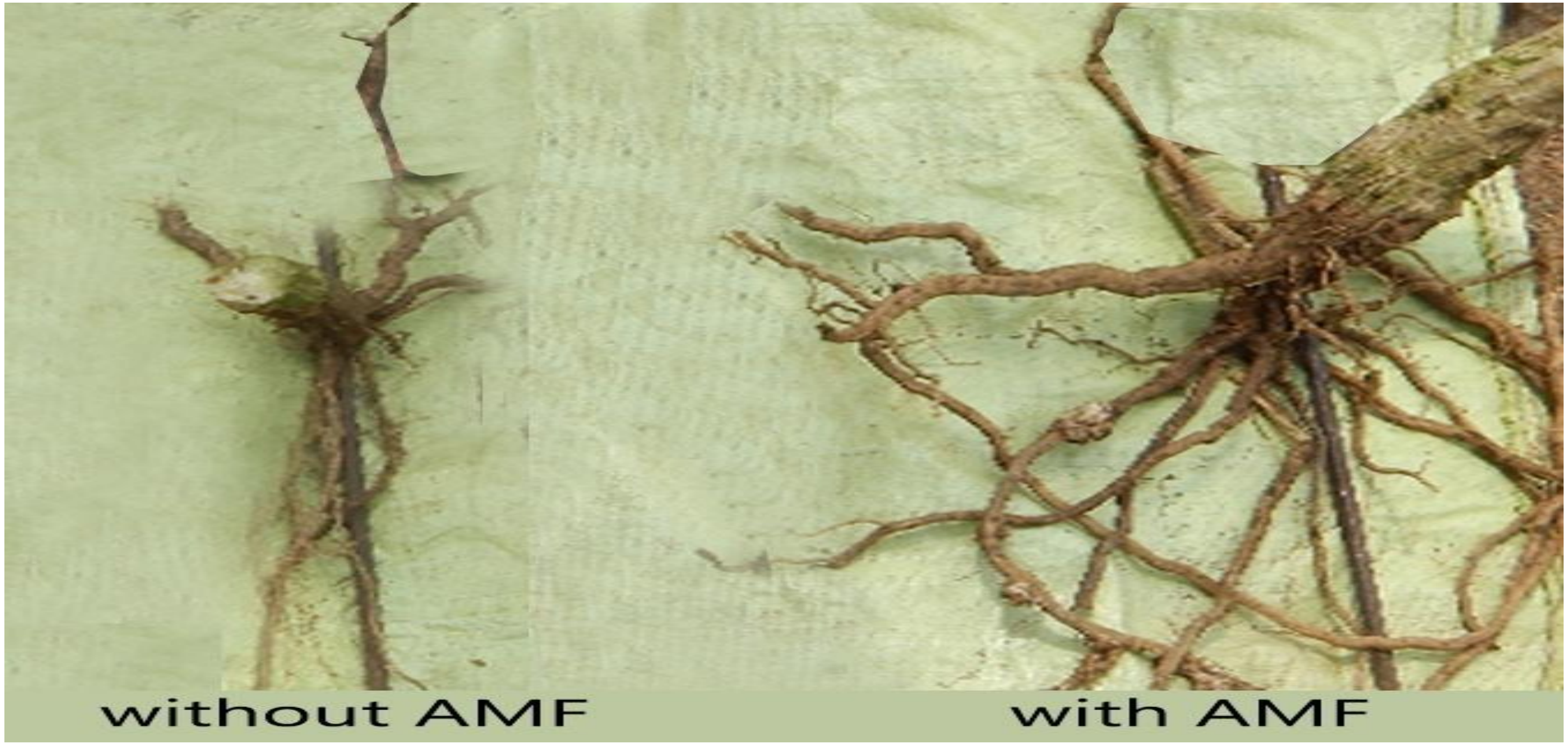
Root Health – the key to improving yield
Main functions of roots

- 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

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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