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## SAVE

# SOIL

## SAVE FUTURE





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Page in the magazine: 60

# SOIL - THE SOURCE OF LIFE

Soil holds different meanings for different people. For some, it is a medium for growth, for others it forms the foundation of buildings, it is source of minerals and for others it is source of food and clothing. However, most of them on planet earth treat them as dirt, abusing them, exploiting them and ignoring them.

The equivalent of one soccer pitch of soil is eroded every five seconds. 33% of the Earth's soils are already degraded and over 90% could become degraded by 2050. India is far up ahead in the game. As of 2017, the country saw an average soil erosion rate of 16.35 tonnes per hectare per year, a rate significantly higher than the 2020 global average of just 2.4 tonnes per hectare per year. Soil is a finite resource considering the fact that it can take up to 1000 years to produce just 2-3 cm of soil. The loss is happening in terms of quality as well. Most alarming of which is the reduction in Soil Organic Carbon Content. The Soil Organic Carbon (SOC) content in India has come down to 0.3 per cent from 1 per cent in the past 70 years.

The estimates and analysis are disconcerting. Saving the soil has to be assigned top priority as the existence of all the living things on earth is dependent on soil. Application of chemical fertilizers, compaction of soil by operating machinery, water logging, lack of cover crops, mulching and most importantly excluding organic matter from the crop care regime have made the soils lifeless and formless. Soil should be tested and only the most needed nutrients in the required quantity should be incorporated. We have to make sure the balance of soil in terms of water, nutrients, microorganism and organic matter are restored and maintained. There is more than enough carbon in the atmosphere and the countries around the world are trying to bring it down. Carbon farming can not only offset emissions and restore degraded soils; they can also help farmers in improving their incomes.

The December issue is a tribute to our soils that have endured abuse and neglect from humans. We have been fortunate enough to curate an entire edition that showcases the opinions of veterans on soil health management, stories of soil restoration, methods to offset land degradation and most importantly create a concerted effort to nurture soil health. Healthy soils create a healthy world.

Wishing you a Happy World Soil Day!






From The Group Editor's Desk	03
<b>TÊTE-À-TÊTE WITH ANJANA</b>	
SOIL: Shelter Of Invisible Life	12
<b>ANALYSIS</b>	
Biologicals: Future of sustainable agriculture	20
<b>MICROLIFE</b>	
Beneficial Microbes for Soil Rejuvenation	22
<b>CASE STUDY</b>	
Nurturing the Earth	25
<b>CHANGE MAKERS</b>	
Carbon Projects for Soil Regeneration and Farmer Prosperity	26
Soil Microbiome: The Driver for a Greener Agricultural Revolution	28
<b>VIEWPOINT</b>	
Soil: The essence of life	32
<b>IN FOCUS</b>	
Crop Residue Management in India An Important Step towards Sustainable Agriculture	34
<b>SMART AGRICULTURE</b>	
Smart Soil System Solutions: Krishi-Rastaa	36
<b>CROP NUTRITION</b>	
Managing Soil Health through Balanced Crop Nutrition	38
<b>TALES FROM FARM</b>	
Parappiamma: The Plant Genome Saviour	40
<b>DIFFERENT TAKE</b>	
Why We Should Take Soil More Seriously	42
<b>DIGITAL AGRICULTURE</b>	
From Seeds to Success	44
<b>BASICS</b>	
Why Does the Adoption of Soil Testing Remain Low?	46
<b>FARM MECHANIZATION</b>	
Mini Tractors in India	48
<b>DIFFERENT STROKE</b>	
Carbon Farming Should be India's Gift to the World	50
<b>FINANCIAL INCLUSION</b>	
Exploring Financial Solutions for Small Holders	52
<b>REMEDICATION</b>	
Promising Amendments for Degraded Soils	54
<b>SOIL CHECK</b>	
The Key to Food Security	56
<b>CREATIVE SPARK</b>	
Sustainable Palm 2023	58

06

PERSPECTIVE

RATTAN LAL



10

REGENERATION

DR RS PARODA



14

SUSTAINABILITY

DR KRK REDDY



16

IN CONVERSATION

HARSHVARDHAN BHAGCHANDKA

18

CONSERVATION

DEEPAK PAREEK



30

MECH TALK

DR V N KALE



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# Announcement

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# THE SOIL-CENTRIC AGRICULTURE IN INDIA: CELEBRATION OF THE 2023 WORLD SOIL DAY

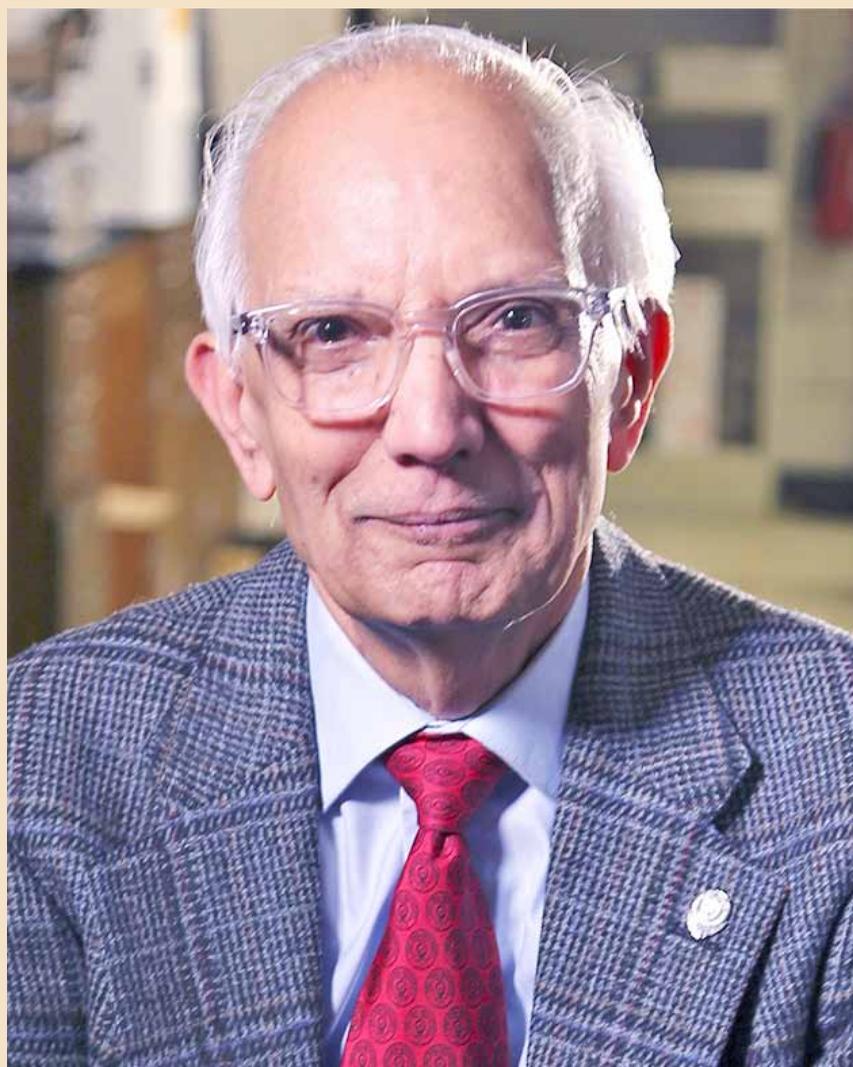
## Space-Age in India

The moon landing of Chandrayaan-3 on 23rd August, 2023 at 18:03 IST made India the 4th country to successfully land on the lunar soil. This success raises India's stature in science, engineering, innovation, and modernization. In addition to understanding soils of the moon, it is equally important to usher-in an era of soil-centric agriculture in India. The modernization of agriculture, by restoring soil health and its functions, will build upon the uniquely iconic historic success in agriculture. Between 1947 and 2023, the population of India increased by a factor of 4.25 from 330 million (M) to 1440 M. However, the food grain production in India increased by a factor of 6.55 from 50 M ton in 1947 to 328 M ton in 2023. Yet, the potential of food grain production in India is 550 M ton/yr. This historic success would have even a broader impact if the soil resources are protected and restored so that numerous ecosystem services are also strengthened. Notable among these ecosystem services, dependent on soil health and its sustainable management are:

- Sequestration of atmospheric carbon (C) in soil as Soil Organic C (SOC) as humus and Soil Inorganic C (SIC) as secondary carbonates for adaptation and mitigation of anthropogenic climate change,
- Improvement of water quality and renewability and recharge of aquifers,
- Increase in above and below-ground biodiversity,
- Enhancement of air quality by elimination of in-field burning of crop residues and use of biomass as traditional fuel, and
- Restoration of degraded/desertified landscapes which can enhance its aesthetical and environmental attributes.

## Launch of the Soil-Centric Agriculture on 2023 World Soil Day

The United Nations World Soil Day (WSD) is celebrated on 5th December on the birthday



### About the AUTHOR

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of the late King of Thailand (His Majesty King Bhumibol Adulyadej) who was a strong protector of soil. He launched a program of establishing contour hedges of vetiver grass (*Chrysopogon zizanioides*) to conserve soil and water on steep lands. Thus, launching a soil-centric agriculture on 2023-WSD is an auspicious occasion. This initiative will reinforce the mission of King Bhumibol Adulyadej to protect and restore soils of agro-ecosystems so that the precious and finite resource can thrive and flourish and so

will the 1.44B people of India dependent on it. People are the mirror-image of soil they live on. Thus, restoration of soil health will enhance prosperity and well-being of India's vast and growing population.

### Restoring Degraded Soils of India

The extent and severity of soil degradation in India, the serious problem that is undermining the roots of our food and environmental security, must be addressed urgently and decisively. Land area affected by a wide range of soil degradation processes is estimated at 114 to 147 Mha out of the total land area of 329 Mha (34.7 to 44.7% of total area). India also has wasteland of 94 Mha, of which 54 Mha (57.4%) is in arid/semi-arid regions and is challenging to restore because of harsh environments. Land area affected by different degradation processes include 63.8 Mha by water erosion (19.4%), 8.9 Mha by wind erosion (2.7%), 14.3 Mha by water logging (4.3%), 6.7 Mha by salinity/alkalinity (2.0%), 16.0 Mha by soil acidity (4.9%), and 7.4 Mha by other processes (2.2%). These estimates do not include the serious problem of depletion of SOC stocks, and the land area scalped by brick making. Urban encroachment on prime agricultural soil is another issue that needs an urgent attention.

The problem of soil degradation, over and above the adverse effects on environment (quality of soil, water, air, biodiversity), also undermines food and nutrition security. In December, 2022, 194.4 million (14.37% of the total population) were prone to under nutrition. More than one third of the world's malnourished children live in India. The problem of malnutrition, deficiency of protein and several of the 17 micro-nutrients, is aggravated by the extent and severity of soil degradation. Indeed, soil health has direct and indirect effects on human health.

### Transformation of Food Systems in India by Soil-Centric Approach

Rather than seed or variety-centric approach adopted since 1960s, the time is right for enthusiastic adoption of a soil-centric farming. The strategy is to adopt land use and soil/crop/livestock/tree management systems which restore soil health through

**Table 1. Timetable for soil-centric low-input agriculture (a hypothetical scenario)**

Input	Units	Year			
		2020	2030	2050	2100
Pesticides	103 Mg	56	40	20	10
Fertilizers	106 Mg	30	25	20	15
In-Field Burning of Residues	106 Mg	200	0	0	0
Irrigated Land Area	106 ha	70	75	80	100
Water Use	Km <sup>3</sup> /yr	200	150	100	75
Post-Harvest Losses	%	34-40	20	10	5
Organic Manure Use	106 Mg/yr	200	300	400	500
National Cereal Yield	Mg/ha	2.1	2.5	3.5	4.0

Nature-positive soil-centric agriculture encompasses the following:

- Adopt system-based conservation agriculture (involving no-till, residue mulch, complex rotations, integration of crops with trees and livestock),
- Create a positive soil-carbon budget by adding the biomass-C at rate more than the losses of SOC via erosion and decomposition,
- Promote practices of soil/crop/water management which also enhance sequestration of SIC as secondary carbonates and leaching of bicarbonates,
- Eliminate in-field burning of crop residues,
- Replace puddled and flooded rice paddies by direct-seeded and aerobic rice,
- Reduce input of chemicals and enhance use-efficiency by improving soil health,
- Adopt practices and operations which lead to negative emission farming,
- Promote bio-circular economy,
- Use precision agriculture, digital innovations, robotics, and artificial intelligence, and
- Practice carbon-farming.



**The extent and severity of soil degradation in India, the serious problem that is undermining the roots of our food and environmental security, must be addressed urgently and decisively.**

re-carbonization of depleted and degraded/desertified soils, recharge the groundwater, and enhance activity and species diversity of soil biota.

### Carbon Farming

Carbon, grown in soil (as SOC and SIC) and in trees (above-ground and below-ground biomass), is a new crop which can create another income stream for farmers. In addition to sequestration of C in soil and trees, emission avoided (especially those of N<sub>2</sub>O and CH<sub>4</sub>) must also be an integral component of carbon farming. Farmers should be rewarded through payments for ecosystem services equivalent to the societal value of C estimated at Rs 5000/acre or Rs 5000/credit (1 ton of CO<sub>2</sub> eq). Therefore, C grown in soil/vegetation and that by emission-avoided through adoption of best management practices,



### Soil Health Act

There is a strong need for agricultural policies which are pro-nature, pro-agriculture, and pro-farmer. There is a need for Soil Health Act which can incentivize farmers to protect and restore soil health so that agriculture is a part of the solution to restore the environment. Through implementation of Soil Health Act, farmers can be rewarded only if they adopt environment-friendly practices such as follows:

1. Sequester C in soil and restore soil health
2. Avoid infield-burning of crop residues
3. Adopt conservation agriculture with mulch and complex rotation
4. Use micro-irrigation (drip sub-fertigation) and eliminate food irrigation
5. Grow aerobic and direct seeded rice
6. Apply balanced nutrients based on soil test and expected yield, and adopt CNPK concept
7. Recycle biowaste
8. Practice controlled grazing
9. Diversity farming systems
10. Adopt nutrition-sensitive agriculture

mixing of fertilizers in the surface soil, also lead to emission of  $N_2O$ . Cultivation of rice paddies with puddling and flood irrigation (causing anaerobiosis) lead to emission of  $CH_4$ , the same process that occurs in the enteric fermentation in the rumen of cattle. These GHGs have a high global warming potential of 310 for  $N_2O$  and 21 for  $CH_4$ .

Restoring soil health, by increasing SOC content in the root zone from 0.1-0.2% at present to 0.8-1.1% over a generational scale (20-25 yr.), can increase use efficiency of fertilizers and irrigation (Table 1). The goal is to produce more from less, restore soil health in agroecosystem, and return some marginal soil (steep and rocky) back to nature. A proposed timeline for reducing use of inputs in soils of India is outlined in Table 1.

Farmers must be encouraged to adopt agricultural practices which achieve food and nutritional security for all while also restoring soil health, recharging aquifers, improving biodiversity, and adapting to and mitigating the anthropogenic climate change. The soil-centric approach to agriculture is a win-win-win option: make agriculture a part of the solution, put Sustainable Development Goals on track for accomplishment by 2030, and reward farmers for being the greatest steward of "Dharti Mata".

would bring income to the farm household as a commodity with inherent value.

### Making Soil-Centric Agriculture a Solution to Environmental Issue

Agricultural intensification since 1960s, through seed-centric package with heavy use of agrochemicals and energy-based inputs along with flood-type irrigation, has aggravated degradation of soil and en-

vironments in India. Fertilizer is often broadcasted in standing water of rice paddies. Consequently, the use efficiency of fertilizer is low, and a large proportion is leaked into the environment. With 30% use efficiency of nitrogenous fertilizer, a large proportion is leached into the ground water and another part emitted into the atmosphere as  $N_2O$ . The process of nitrification and denitrification in upland, plough-based tillage methods and



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# SOIL HEALTH FOR OUR FUTURE SUSTAINABILITY

**W**e all know that healthy soils are critical for plants, animals and human health. Hence, since COVID-19 pandemic, concept of 'One Health' has assumed great importance. Mother earth nurtures all the living beings through air to breathe, water to drink, food to eat and shelter to live. Unfortunately, the demographic pressure had doubled in 19th century due to the Industrial Revolution, which further tripled in 20th century resulting in a total of eight billion people. Although India has attained self-sufficiency in food grain production, there still remains SDG challenges of achieving zero hunger, and no poverty. Despite six and half fold increase in food grain production (330 million tons), about 15 per cent people are still below poverty and around 40 per cent of children below 5 years of age suffer from chronic and hidden hunger caused by nutritional deficiency. One of the key reasons of malnutrition is the soil nutrient deficiency that occurred over the years due to overexploitation of natural resources (soil, water, biodiversity, etc.). Infact, the inadequate and imbalanced nutrition in the soil is limiting crop productivity and affecting adversely the nutritional quality of our food. The 2021 food crisis in Sri Lanka as a result of ban on import of inorganic fertilizers is a glaring example as to how soil health can affect national economy.

## India Needs Regenerative Agricultural Practices

The gradual decline in soil organic matter (SOM) specially in the Green Revolution region is already affecting soil health as well as agricultural sustainability. Soils act as carbon (C) sinks, and play an important role towards mitigation of greenhouse gas (GHG) emissions. Also, we need to recognize that lack of attention and policy support to soil health would adversely affect our agri-food security. Meeting future food demand would be a great challenge in the face of rapidly depleting natural resources, especially the soil health. The very realization that farmers are to be associated with soil health initiatives such as: soil health cards (SHC) and public-private partnership like Bhoochetna, would enable us to regenerate soils in north-western region. The UN Food Systems Summit (2021) and G-20 held recently in India also recognized an urgent need for regenerative agricultural practices aiming at improved soil, plant, animal and human health (one health).

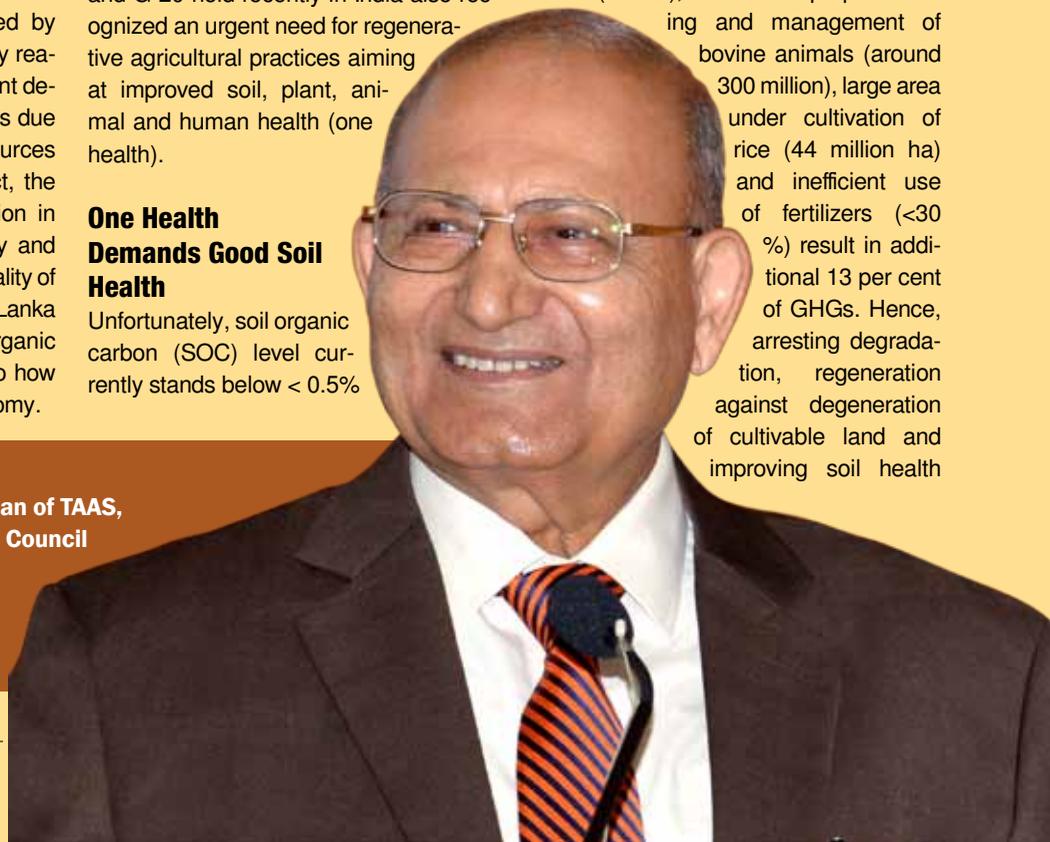
## One Health Demands Good Soil Health

Unfortunately, soil organic carbon (SOC) level currently stands below < 0.5%

nearly 55 per cent of the Green Revolution belt (Punjab, Haryana and Western U.P.) due to existing exploitative agricultural practices that are unsustainable. Already, the factor productivity has declined, and the imbalanced use of nutrients with increasing deficiency of micronutrients is affecting the productivity of plants, animals and humans. Earlier, farmers could harvest 32 kg foodgrain from one kg of nitrogen applied, but now they get around 12 kg only. Existing fertilizer subsidy provisions also favour more use of nitrogenous fertilizers, resulting in imbalanced use of macro-, and micro-nutrients. The low nitrogen use efficiency (NUE), around 30 per cent only, is further affecting both production and income of farmers. India accounts for 10 percent of global 1.0 billion ha degraded land. Land degradation alone causes 11 per cent of greenhouse gases (GHGs), whereas improper housing and management of bovine animals (around 300 million), large area under cultivation of rice (44 million ha) and inefficient use of fertilizers (<30%) result in additional 13 per cent of GHGs. Hence, arresting degradation, regeneration against degeneration of cultivable land and improving soil health

### About the AUTHOR

**Dr RS Paroda, Founding Chairman of TAAS, Former Director General, Indian Council of Agricultural Research (ICAR) & Secretary, Department of Agricultural Research and Education (DARE)**





become critical for human survival. Hence, one health demands first good soil health. Sooner we act better it would be for our future survival. Also, increase in soil acidity in eastern India due to increased fertilizer use is an additional concern. Groundwater depletion is another challenge in Punjab, Haryana and Rajasthan. The challenges are further compounded due to increased greenhouse gases (GHGs), rapidly declining soil health and drying aquifers. Hence, long-term sustainability of varying ecosystems is drawing attention worldwide with greater focus on 'one health' concept.

### Soil Health Restoration Plan

For restoring soil health, urgent efforts and enabling policy environment are needed to scale innovations around Regenerative Agriculture (RA), which includes practices like conservation agriculture (CA), also known as "no till" agriculture, organic farming; use of fertilizers only as per soil test; diversification of cropping systems; reclaiming saline, alkaline and acidic soils; need based use of micronutrients (Zn, Fe, Mn, etc.), biofertilizers, etc. The

### Soils act as carbon (C) sinks, and play an important role towards mitigation of greenhouse gas (GHG) emissions.

4Rs (right source, right rate, right time, and right place) approach for application of balanced fertilizers also needs to be promoted for sustainable agriculture. Also, there is an urgent need to link the 4Rs approach with soil health cards (SHC) and "PM-PRANAM" schemes. Mechanization for deep placement of fertilizers is another option for fertilizer use efficiency. The integrated nutrient management (using organic manures like cattle dung, vermicompost, and poultry manure in combination with mineral fertilizers) could considerably improve soil health as well as crop yields. Use of happy turbo seeder in rice-wheat system also ensures in situ conservation of straw resulting in increased soil organic

carbon. The age old practice of broadcasting fertilizers also needs to be discouraged by promoting use of ferti-cum-seed drill. Also, division support systems such as leaf colour chart, green seeker and now use of artificial intelligence (AI) would enable fertilizer use efficiency so critical in national as well as farmers' interest.

Hence, to conclude, there is an urgent need for an enabling policy environment that is pro-nature, pro-agriculture and pro-farmer. Towards this, needed incentives for eco-system services, including mission mode approach of doubling NUE (from current 30 to 60 %) by 2030 would save use of inorganic fertilizers as well as huge subsidy. Currently, fertilizer subsidy is about 2.2 lakh crores. We can convert this subsidy into incentives to an extent of Rs 10,000 per ha using fertilizers on the basis of soil analysis and by adoption of good agronomic practices (GAP) by the majority of smallholder farmers (around 80 %). Such a policy decision will make all the difference in soil health as well as national food and agricultural sustainability.

# S.O.I.L

## SHELTER OF INVISIBLE LIFE

“Soil is a living entity. Will you pour something artificial or synthetic on a living entity? No. But we do that to our soils. We take away a lot from soil but never replenish them. Today our soils are hungry and naked. They are craving for organic matter. They are not asking for much. We have to just put back 5-10% of what they produce (residues). Carbon, the key index is missing in soils. Soil doesn't want to be naked. It needs to be covered by leaf, litter, and plants. Soil is a Shelter of Invisible life. Soil loss is not a farmers' issue. It is the issue of everyone. Soil is generous, kind and reservoirs of water. But we are abusing them.”

Narsanna Koppula is agitated and gets emotional when the discussion centers on soil. He has spent the last 35 years propagating the concept of Permaculture.

### Destiny Unravels

Narsanna's tryst with Permaculture happened quite accidentally in the late eighties. He was visiting Central University of Hyderabad and was intrigued to find a white person standing amidst a crowd and interacting with them. He went there and found out that the discussion was on permaculture. A month passed by and destiny had him meet the same person once



“Permaculture is not just about agriculture. It is a way of life.”

again. The white man was invited by KL Gopal of Deccan Development Society to conduct a workshop on permaculture.

“I interacted with them and their concept of Permaculture attracted me and inspired me. I came to know that it was Bill

Mollison, the Co Founder of Permaculture. I also met Dr Venkat, who remained my lifelong mentor and guide. I wanted to know more. My first Training was with Mr. Mollison in 1987. I also attended another course with Robin Francis. I went to Australia, where Mr Mollison lived and came back with many ideas and concepts. My biggest challenge was how to apply those designs in Indian conditions. It has been 35 years and I am still struggling how to apply those concepts in Indian context. I am still working on how to increase productivity of land and life of people. In 2013, I started taking courses on Permaculture.”

Narsanna doesn't want to define Permaculture and limit its contours. He likes to view permaculture as response. “It is an alternate way of life based on natural systems and how to build a relationship with nature in a cooperative way rather than an exploitative way. You have

The word 'permaculture' is derived from Permanent Agriculture or Permanent Culture. It stands for responsible and wise use of natural resources in a way that will sustain life for the present as well as future generations. It is a philosophy and practice that enables people to design and establish productive systems to provide for their food, energy, shelter, and other material and non-material needs, in harmony with natural systems. Narsanna was among the pioneers of Permaculture in India.

to closely work with nature. It strongly works on ethics. There are three ethics to permaculture- Care of Earth, Care of People and Fair Share. These are the Foundation of Permaculture. Any surplus in our life system in terms of food, knowledge, earnings resources etc., should be shared with others. Permaculture is not just about agriculture. It is a way of life.”

### Early Life

Narsanna is a post graduate in Philosophy and a graduate in Law. He hailed from a family of farmers in Adilabad, Telangana. “I used to help my family in the agricultural operations. Taking animals out, cutting grass, ploughing, cleaning cattle shed was something we all did - me, my three brothers and two sisters. My father also used to do masonry work. In the summer season, when there was nothing to do on the farm, he used to go for construction work”.

### Different Thoughts

Having seen agriculture and practiced it since childhood, he has come to realize that farming is not just agriculture. It should

*tête-à-tête with Anjana*



**“We always address farmers as men only. I have found women to be receptive and closer to nature.”**

mean more. “Today agriculture means just growing crops involving operations from sowing seeds to marketing. There are other life forms in nature. Like us they are also hungry. In our pursuit for more, we are depriving nourishment for all of them. That

is wrong. Farming is just not agriculture. It should be about community.”

He has found women farmers to be more receptive to new ideas. “We always address farmers as men only. I have found women to be receptive and closer to nature. They are trust worthy, open and practical people. I have associated with many women’s groups.”

He believes that food that we eat should be produced by us. “If there is no land, will look for resource from the government. Revenue department has the right to give land to landless.” He is also against rice and wheat based farming systems and the importance given to it.

### More Join Permaculture

“Many people are coming forward to know about permaculture. These are not farmers. The mindset of farmers is fixed, as they have been taught not to think of any other system. For them farming is their source of revenue and they need money for their survival. The target group is changing. The people who are coming to us for training are those who have other sources of income and who have a piece of land. They come to us for training and go back. They practice these concepts on their own farm or work for other companies. They are also into teaching. Since 2014, we have trained almost 3000 students. Every month we organize courses.

Narsanna, a permaculture activist who has devoted his life for protecting earth, soil and water. He has been educating and assisting villagers in transforming their lands into food self sufficient permaculture farms.



### Aranya Agricultural Alternatives

Narsanna wanted to put all the concepts into practice. This marked the birth of Aranya Agricultural Alternatives, an environmental and developmental NGO, in Hyderabad in March 1999. ‘Aranya’ in Sanskrit means forest and forests were considered as the home for all life forms by ancient Indian mythology. The organisation has been working towards promoting alternative and permanent agriculture practices with a focus on sustainable natural resource management, along with strengthening the rural and farming communities to achieve food security.

# SOIL, LIFE AND SUSTAINABILITY

**S**oil plays a fundamental role in supporting and sustaining various forms of life and often referred to as “skin of the earth”. The relationship between soil and life is multifaceted and encompasses a range of ecological, biological, and environmental interactions. Soil is a complex and dynamic ecosystem that provides a habitat for an incredible diversity of microorganisms, including bacteria, fungi, protozoa, and nematodes. These microorganisms contribute to nutrient cycling, decomposition of organic matter, and various other soil processes that are essential for the functioning of ecosystems. The ideal soils contribute to nutrient recycling that ensures continuous supply for the plant growth and development apart from acting as medium to anchor roots and extract water. The arable soil play crucial role in water regulation and carbon storage apart from the two other major components like water storage and climate stability.

**According to the Indian government's Soil Health Survey (2019-20), 55% of India's soil is deficient in nitrogen, 42% in phosphorus, and 44% in organic carbon.**

## Healthy Soil Healthy Life

The health of the soil is closely linked to the well-being of life on Earth. A healthy soil ecosystem provides numerous benefits that contribute to the overall health and sustainability of our planet. Healthy soils are rich in nutrients that support plant growth. Plants, in turn, form the basis of the food chain, providing nutrition for animals and humans. Adequate nutrient cycling in the soil is essential for the production of nutritious crops. Healthy soils have a good structure and organic matter content, which helps prevent soil erosion. Erosion control is essential for maintaining fertile topsoil, preventing loss of agricultural productivity, and safeguarding ecosystems. Healthy soils help maintain water quality by preventing pollutants from reaching groundwater and surface water, ensuring a clean and safe water supply. Organic rich soils host a diverse community of microorganisms, plants, and animals. A healthy soil ecosystem supports a rich biodiversity, contributing to the resilience and stability of ecosystems. This biodiversity is crucial for various ecological functions and services.

## Soil and Food

The health and fertility of soil directly influence crop growth, and consequently, the quality and quantity of the food that is harvested. Soil is a reservoir of essential nutrients such as nitrogen, phosphorus, potassium, and various micronutrients. Plants absorb these nutrients from the soil to fuel their growth and development. Adequate nutrient levels in the soil are crucial for producing healthy and nutritious crops. Given the critical role of soil in food production, sustainable soil management practices are essential.

## Soil Degradation is Threatening Nutrition

Soil degradation refers to the decline in soil quality, fertility and overall health, often resulting in the loss of ecosystem services and productivity. Chemical and intensive agriculture, characterized by the heavy use of synthetic fertilizers, pesticides, and herbicides, have significantly impacted soil health and quality. While these chemicals are often employed to enhance crop yields and control pests, their misuse or overuse have led to various negative consequences for the soil ecosystem.

Soil nutrient loss is a significant concern in the context of soil degradation, and it poses a threat to agricultural productivity, ecosystem health, and human nutrition. Intensive agriculture practices coupled with environmental factors have resulted in erosion of top soil which has negatively impacted soil fertility. Nutrient leaching due to irrigation and excessive rainfall, vegetation loss due to deforestation and monoculture leading to loss of biodiversity remind us urgent action on implementing soil conservation practices. Poor land management practices, such as monoculture and continuous cultivation without proper soil conservation measures have resulted in depletion of soil nutrients over the time. These practices often lead to imbalances in soil



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nutrient levels and increase the risk of nutrient loss.

### Soil Conservation Practices

To address soil nutrient loss and promote sustainable soil management, it's essential to implement conservation practices such as cover cropping, crop rotation, agroforestry, and terracing. These practices help prevent erosion, improve soil structure, enhance organic matter content, and reduce the need for excessive chemical inputs. Apart from this, adopting precision agriculture techniques, optimizing fertilizer application, and promoting integrated nutrient management are critical steps toward mitigating soil nutrient loss and ensuring the long-term health and productivity of soils. Sustainable agricultural practices play a pivotal role in maintaining the delicate balance of nutrients within ecosystems while meeting the food demands of a growing global population.

### Soil Restoration and Regeneration

Practices like regenerative agriculture, precision nutrient management, agroforestry techniques, application of soil amendments like biochar, fermented organic manures, microorganisms etc., coupled with adopting new technologies like soil metagenomics, soil microbiome engineering, artificial intelligence, machine learning, blockchain, precision farming, bioremediation and nano technologies address several soil problems. Research and collaboration between scientists, farmers, and policymakers are crucial for advancing these techniques and promoting sustainable soil management practices.

### Soil Status-Indian Scenario

According to the Indian government's 2019-20 Soil Health Survey, 55% of India's soil is deficient in nitrogen, 42% in phosphorus, and 44% in organic carbon. Indian soils traditionally have low nitrogen and phosphorus content, but high potassium. Over 70% of soils suffer from either soil acidity or soil alkalinity and about 29% of the total geographical area



**To restore soils, a combination of awareness, education, policy development, and on-the-ground practices is required.**

is under the process of land degradation. Over 35% of soils are estimated to be deficient in zinc and about 11% of soils are estimated to be deficient in iron. India's Soil Health Card Scheme is a significant initiative aimed at providing farmers with information about the health of their soil and recommendations for appropriate nutrient management (Annual Report SLUSI 2019-2020). In addition to the soil diagnostic parameters of the current Soil Health Card, soil biology component also must have been there to assess soil health/life.

### Societal Response and Public Policies of Soil Restoration

Restoring soils is a complex task and societal response that requires coordinated efforts at various levels, including individuals, communities, governments, and international organizations. To restore

soils, a combination of awareness, education, policy development, and on-the-ground practices is required. It all starts from education and awareness conducting public campaigns informing the public about the importance of soil health, the consequences of soil degradation, and the benefits of soil restoration is crucial. Public awareness campaigns can be conducted through various media channels, schools, and community events. Providing farmers, landowners, and communities with training on sustainable land management practices, soil conservation techniques, and principles of regenerative agriculture is very essential.'

Policy development on land use and enforcing land use policies that prioritize sustainable practices, such as protecting natural habitats, promoting agroecology, and minimizing urban sprawl, contribute to soil conservation. Government may provide incentives to the farmers who adopt sustainable practices, and implement and enforce regulations on the use of chemical inputs, including fertilizers and pesticides. This will help in preventing soil contamination and degradation. Involvement of Non-governmental organizations (NGOs), environmental groups, and advocacy organizations can play a role in raising awareness about soil degradation and advocating for policies that promote sustainable land management.

# GETTING IT RIGHT WITH BIOLOGICALS

Established in 1994, it took few years for IPL Biologicals to develop new products and get the necessary regulatory approvals. They entered Punjab in 2000. With all their products designed in house, the company today sells its products in 23 states in India and exports to more than 10 countries. “We do have a plan for global expansion by the next year. We plan to register our products in markets like USA, Europe and Brazil. Since corona, there has been a very big push worldwide for biologicals specifically bio pesticides,” says Harshvardhan Bhagchandka, President, IPL Biologicals in an interview with Agriculture Today.



It takes around 2-4 years to create the new product and make it market ready.

## How was the market in 2000, when agrochemicals commanded the lions share in the market?

Yes., it was quite difficult, because we were advocating biologicals at a time when universities, farmers, conventional chemical companies and government regulators did not believe that these products worked. Presence of spurious products added to our misery. It was challenging time. But over the last few years, things have changed. Today government and bureaucrats are promoting biologicals. Many reports confirm the efficacy of the product. Early 2000 was a difficult year for the in-

dustry but now everyone agrees that biologicals are the way forward for sustainable agriculture.

## Established companies like Bayer, Syngenta etc. are now coming into biologicals. Do you consider them as a challenge?

We don't consider this as a challenge. It is imperative that they will come. Their entry will expand the market for us. We are a growing company that focuses on biologicals and does not have any chemical products. We have limited resources to reach every farmer in the country. In India,

as we know that there are millions of farmers, unlike the West, where a farmer will have 200-1000 hectares of land. So the conversion would be easier and this has prompted big companies to enter into the sector. Ultimately, if the industry grows, it is beneficial for the farmers and the Industry as well.

## What is the current market share of biologicals in India?

Roughly it would be around <5%. There are multiple reports, and all are contradictory, so if we take government bodies like CIB, NCOF, it will be around < 5% of the total agriculture market.

## Have you ever approached the government, to create awareness among the consumer and farmers and create some specific policies to promote the products and enhance soil health?

We have been invited by many forums that NITI Ayog organizes with Ministry of Agriculture and Farmers' Welfare. The government is acknowledging their concerns

seriously. They have shown concern for subsidy bill. They have active plans like PM Pranam, which was recently introduced. Soil fertility is declining with the excessive use of fertilizers. Government have taken cognizance of the fact and are taking steps to address the issue. IPL is also actively involved with government, giving input wherever and in whichever manner required. Without the intervention of biologicals and biocontrol products, it is very hard to reach the MRL prescribed by the Western world.

### What are the policy interventions that you would like to see?

Overall government is getting aware that there is a need for intervention. The government is giving production linked incentives, which will be good for the companies to gear up and promote the products. Secondly, the government should regulate the GST on biologicals, since they are safe and natural products.

### There are subsidies on fertilizer, and whereas nothing of that sort for biologicals. What is your take on this?

Discussions are happening in the Ministry of Fertilizer to come with a plan to give 5% of the subsidy, for the biologicals. Hopefully, we should expect something very soon. It will be a big push.

### You are planning to expand to US as well, which is a different scenario in terms of market and farming. What are your plans there?

The biggest challenge for now is to get the product registered, and the distribution of products. The registration would take around 18-34 months. Simultaneously the team is working on distribution. We are going to work with some local partners, who have the capabilities and interest in the biologicals segment.

### Any plan to expand to North East India?

We are there in Assam. Despite having challenges we are focusing on Tea, which



Without the intervention of biologicals and biocontrol products, it is very hard to reach the MRL prescribed by the Western world.

is giving good results. Last 2-3 years have been good, since there was a very big shift. The biggest challenge is scaling up of the product, and conversion rate of farmers is very small.

### What is the R&D facility at your end? How much budget roughly, would you allocate for R&D Team?

We practice several steps like comparing different strains with strong properties, identifying very strong strain with best efficacy, and adaptability. Multiplication and mass



production then follows. It takes around 2-4 years to create the new product and make it market ready. 7-9% of the generated revenue, is invested in Research.

### Regulations and Registration process of biologicals in India is quite difficult and time consuming. What is your take on this?

It is the responsibility of CIB mandated by GOI, to show that the safe products are used by the farmers. Government should review if there is some additional studies to be added, or if there is a need to increase the regulation. Companies and entrepreneurs have to wait until the product is market ready. So, I go in favor of CIB.

### How many farmers have IPL worked with? Is there any CSR activity that IPL is working on?

IPL used to take project funded by government. We were involved in projects in states like Haryana, Bihar, Jammu & Kashmir and Sikkim, where IPL was paid to convert and train the farmers. Around 80,000 acres of land have been converted into organic farming. We are 100% CSR compliant. We work with third party foundations, usually which works for farmers, education, women education etc. When IPL becomes big we would have our own CSR team and foundation.

# CELEBRATING WORLD SOIL DAY

## NURTURING THE GROUND BENEATH OUR FEET

**B**eneath our feet lies a vital resource that often goes unnoticed – soil. This seemingly ordinary substance is the foundation of life on Earth, supporting the growth of plants and trees, filtering water, and storing vast amounts of carbon. Yet, despite its immense importance, soil is facing increasing threats from human activities, putting our food security, ecosystem health and climate resilience at risk.

World Soil Day, observed annually on December 5th, is a day dedicated to raising awareness about the importance of soil and advocating for the sustainable

**Healthy soils are not only essential for our present but also for the well-being of future generations.**

management of soil resources. As the foundation of life on Earth, soil plays a crucial role in supporting agriculture, biodiversity, and overall ecosystem health. This day serves as a platform to highlight the significance of soil conservation and sustainable land management practices

to ensure a healthy and prosperous future for our planet.

### **The Significance of Soil: A Cornerstone of Life**

Soil is vital for sustaining humanity. It is a dynamic, living ecosystem that sustains a myriad of life forms. From microscopic bacteria to complex plant roots, the health of soil directly influences the well-being of the entire planet. Soil is so vital for various reasons most important amongst them being:

**Agriculture and Food Security:** Soil is the backbone of agriculture, providing essential nutrients and a medium for plant growth. Healthy soil is a prerequisite for robust crop yields, and therefore, it plays a crucial role in ensuring global food security.

**Biodiversity:** Soil is home to a diverse range of organisms, including insects, fungi, and microorganisms. This biodiversity is essential for the proper functioning of ecosystems and contributes to the overall health of the planet.

**Water Filtration:** Soil acts as a natural filter for water, removing impurities and pollutants as water percolates through it. This process helps in maintaining clean and sustainable water resources.

**Climate Regulation:** Soil plays a key role in climate regulation through processes such as carbon sequestration. Healthy soils help mitigate climate change by storing carbon and regulating greenhouse gas emissions.

### **Threats to Soil Health: A Wake-Up Call for Sustainable Practices**

Despite its crucial role, soil health is facing numerous challenges that threaten its sustainability

Soil erosion, caused by factors like deforestation and improper land use, poses a significant threat to soil health.



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It can lead to the loss of fertile topsoil, reducing the land's productivity. An estimated 10 to 12 billion tonnes of fertile soil are lost annually due to erosion, threatening food security and ecosystem health.

Agricultural runoff, industrial activities, and improper waste disposal contribute to soil pollution. Contaminants in the soil can have detrimental effects on plant and human health. An estimated more than 100,000 new chemicals are introduced each year, many of which find their way into the soil, posing risks to human health and ecosystems.

Intensive agricultural practices, including monoculture and excessive use of chemical fertilizers and pesticides, can lead to soil degradation and loss of fertility. Global soil organic matter content has declined by an average of 50% since the pre-industrial era, diminishing soil fertility and water retention capacity.

The impacts of climate change, such as extreme weather events and shifts in precipitation patterns, can exacerbate soil degradation and pose additional challenges to sustainable land management.

### Sustainable Soil Management Practices: A Roadmap to Soil Conservation

World Soil Day encourages individuals, communities, and governments to take action and adopt sustainable soil management practices. Here are some key strategies to promote soil health:

**Conservation Agriculture:** Implementing conservation agriculture practices, such as minimal tillage and cover cropping, helps reduce soil erosion and improve water retention.

**Agroforestry:** Integrating trees and shrubs into agricultural landscapes promotes biodiversity, enhances soil structure, and provides additional benefits such as shade and windbreaks.

**Improving Organic Matter:** Transitioning to farming methods that increase organic matter and reduce the reliance on synthetic chemicals and foster healthier soils, free from harmful residues.



Let World Soil Day be a catalyst for action, inspiring us to become stewards of the soil, the foundation of our food, our ecosystems, and our future.

**Stop Contamination:** Proper waste disposal practices, including the use of treatment facilities, can prevent the contamination of soil with hazardous substances.

**Education and Awareness:** Increasing awareness about the importance of soil health through education campaigns and outreach programs is essential for fostering a global understanding of the need for sustainable soil management.

### Soil Testing: The First Step to Save The Soil

Soil testing stands as a crucial step in the ongoing efforts to maintain soil health and optimize crop production. This analytical process provides valuable insights into essential soil attributes, including nutrient content, pH levels, and overall soil condition. Armed with this information, farmers and gardeners can make well-informed decisions regarding fertilization, irrigation, and other crucial management practices.

The significance of soil testing is underscored by its various benefits. Firstly,

it facilitates accurate nutrient management by identifying deficiencies or excesses in the soil. This precision ensures the appropriate application of fertilizers, preventing overuse and potential harm to the environment. Moreover, soil testing contributes to improved crop yields by promoting optimal nutrient levels that foster healthy plant growth and development, resulting in higher productivity and superior-quality produce.

Beyond nutrient management, soil testing plays a vital role in enhancing overall soil health. Identifying potential issues such as compaction, acidity, or salinity, allows for timely corrective measures. This proactive approach not only addresses immediate concerns but also contributes to the long-term productivity and sustainability of the soil.

A particularly crucial aspect of soil testing is its role in environmental protection. The risk of nutrient runoff, which can contaminate water sources and harm aquatic ecosystems, is mitigated through the optimization of fertilizer use guided by soil test results. In this way, soil testing serves as a preventive measure, aligning agricultural practices with environmental sustainability.

The importance of soil testing cannot be overstated. It empowers land stewards with the knowledge needed to make informed decisions, promote sustainable agriculture, safeguard the environment, and ensure the long-term health and productivity of our vital soil resources.

### A Collective Responsibility for Soil Stewardship

World Soil Day serves as a poignant reminder of the vital role that soil plays in sustaining life on Earth. As we face global challenges such as climate change and food security, the health of our soil becomes even more critical. By adopting sustainable land management practices, promoting biodiversity, and raising awareness, we can work towards preserving and restoring the health of the ground beneath our feet, ensuring a prosperous and sustainable future for generations to come.

# BIOLOGICALS: FUTURE OF SUSTAINABLE AGRICULTURE

Crop protection has been playing an instrumental role in safeguarding agricultural crops from pests, diseases, and weeds. This fortification, extending across decades, has become synonymous with augmented yields and a better quality of harvested produce. However, the sustained and at times prodigious deployment of pesticides over these years, has led to sustainability-related challenges in agriculture. Today, 33% of the world's farmland is moderately to highly degraded, a consequence, in part, of intensive pesticide use alongside other contributing factors. Despite the diminishing arable land, the imperative to double global food production looms large, compelled by the impending surge in the global population, projected to approach 10 billion by the year 2050. And meeting that demand will need to happen more sustainably, urging a paradigm shift towards environmentally friendly farming solutions.

## Changing Consumers

Even the new age consumers are increasingly conscientious, demanding that their food be produced in a sustainable manner. A recent survey underscores this shift, revealing that 60% of millennials are aware of the implications their food choices have on the environment. Notably, 85% of customers exhibit a willingness to pay a premium for products that offer transparency concerning suppliers, sustainable practices, and product origins. This consumer sentiment reflects through the entire value chain, prompting action from major players in the packaged food and agribusiness sectors:

- General Mills is stepping up to curtail the use of synthetic pesticides on

**Notably, 85% of customers exhibit a willingness to pay a premium for products that offer transparency concerning suppliers, sustainable practices, and product origins.**

supplier farms.

- Pepsi is targeting to sustainably source 100% of its key ingredients and crops by 2030.
- Cargill aims to bring 10 million acres of North American farms under regenerative agriculture by 2030.

Industry is also witnessing disruption due to policy mandates that are driving sustainable agriculture. The EU is at the forefront as they aim to reduce chemical pesticide use by 50% and fertilizer use by at least 20% by 2030. Concurrently, the US intends to reduce the environmental footprint of agriculture by 50% till 2050. Even the major Asian nations such as India and China are actively promoting soil health enhancements through efficient nutrient management and adoption of bio crop inputs.

## Demand for Biologicals

All these drivers are collectively fuelling the demand for biologicals — plant protection products derived from naturally occurring

microorganisms, plant extracts, beneficial insects or other organic matter. The intrinsic advantages of biologicals over synthetic pesticides are manifold; they are inherently less toxic, leave lower residues and run-offs, and predominantly impact only the targeted pests. Moreover, biologicals boast a nearly 2x faster time-to-market and a 95% lower development cost compared to the synthetic chemistries, rendering them increasingly appealing for crop input companies. With these advantages, it is no surprise that the biologicals market is poised to outpace the overall crop protection industry, with an anticipated CAGR of 13.5%, reaching approximately \$28 billion by 2030, surpassing the latter's CAGR of around 3%.

Though the top five players account



### About the AUTHOR

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for nearly three quarters of the global crop protection market, their share in the biologicals is a mere 11%, making it a highly fragmented market. Therefore, major corporations have been actively externalizing their endeavors to secure market share and boost their innovation in the field of biologicals. The big players are strategically focusing on acquisitions to gain market share and expand their biologicals portfolio. Noteworthy transactions include Corteva's acquisitions of Stoller and Symborg, Syngenta's purchases of Valagro and select bioinsecticides from Bionema, and FMC's acquisition of BioPhero. Similarly, larger players are also pursuing partnerships and investing in start-ups to accelerate innovation in biologicals. Bayer, for instance, has recently forged partnerships with Kimitec and Ginkgo Bioworks, aimed at accelerating the discovery and development of biological products.

### A Marked Decline in both Innovation Share And Patent Impact

In the ever-evolving landscape of innovations in biologicals, industry leaders have been focusing on external partnerships for driving development. However, a discernible shift is underway as these top players observe a marked decline in both innovation share and patent impact for biologicals. A comparative analysis between 2016 and

**Though the top five players account for nearly three quarters of the global crop protection market, their share in the biologicals is a mere 11%, making it a highly fragmented market.**

2021 reveals a diminishing footprint in the western markets and global patent landscape, respectively. This decline serves as a noteworthy signal of intensifying competition within the sector. Consequently, the imperative for incumbents becomes clear. "There is a fundamental need to bolster internal R&D capabilities alongside their ongoing external collaborations. This joint approach is paramount for sustaining competitiveness in the high-growth biologicals market," says Naveen Singla, Managing Director, Chemicals Practice at Accenture.

### Challenges Persists

Though the biologicals market is expected to outstrip overall crop protection growth, it must navigate its unique set of challenges. Lack of awareness of benefits and applications of biologicals for the farmers is perhaps one of the biggest challenges for adoption of biologicals. As cited in one of the surveys at the 2023 Biologicals Sum-

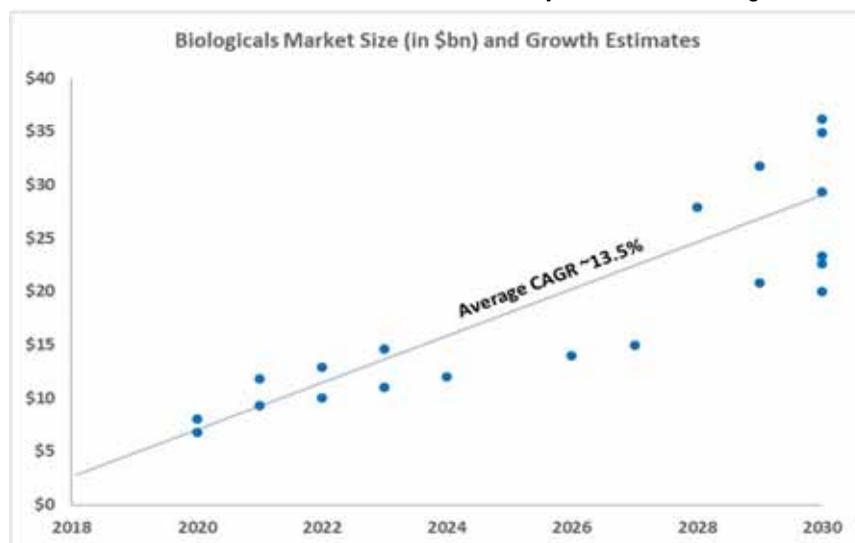
mit in the US, 51% of the growers have never ventured into biologicals due to a limited understanding of these products. The adoption of biologicals is further impeded by many intricate challenges. The formulation's shelf life, stability, and efficacy emerge as critical considerations, demanding meticulous attention to ensure product integrity. Additionally, supply chain and manufacturing complexities contribute to the barriers inhibiting the widespread acceptance of biologicals. Navigating these challenges will be pivotal for stakeholders, as they strive to carve a sustainable niche in the realm of crop protection.

### Actions for Incumbents for Growing Biologicals Business

The crop protection players must accelerate their in-house R&D for biologicals, transitioning towards digital R&D and processes driven by generative artificial intelligence (AI). Adapting supply chain and manufacturing capabilities to navigate the increased complexities inherent in an expanded crop protection portfolio is equally paramount. As stewards of sustainable agriculture, these industry players must actively champion regenerative and low-carbon farming practices, simultaneously enhancing trace and track capabilities to ensure the application of sustainable crop inputs. Moreover, a concerted effort to educate and empower farmers is essential, shedding light on the benefits of biologicals and optimal integration of biologicals with synthetic pesticides through Integrated Pest Management (IPM) strategies. Here, digital agronomists can play a vital role in bridging the knowledge gap for the farmers. Through the implementation of the aforementioned measures, the industry can foster a harmonious amalgamation of cutting-edge technology and agricultural best practices for a resilient and sustainable future.

*Special thanks to*

*Dr. Karin Walczyk, Prince Choudhary, Rashmi Yadawad, Sruthi Vempati, Prerna Raviraj and Farkhanda Anjum Ansari for their contributions on this research study.*



\*Dots show various available market size estimates for biologicals

# BENEFICIAL MICROBES FOR SOIL REJUVENATION

**S**oils are at the extreme outer part of the mother Earth's crust and take millions of years to develop under the influence of chemical, physical and biological processes. The process of soil formation is complex and many events can interrupt the life cycle of soils. Their loss and degradation is not recoverable within a human life span.

The environmental conditions that drive soil formation are physical, chemical and biological processes that are commonly known as the five soil forming factors: climate, organisms (flora and fauna, including human activity), relief or terrain, parent material and time.

## Role of Soil

Soil is our sole support system for life. Soils supports roots, hold water and store nutrients. Soils are reservoirs to earthworms, termites and a myriad of micro-organisms that fix nitrogen and decompose organic matter. Soil plays a vital role in the Earth's ecosystem and without soil, human life would be very difficult.

Soil is large store house of organic carbon. It is the biggest terrestrial store of carbon. On an average, the soil contains almost three times more organic carbon than the vegetation and about twice as much carbon than is present in the atmosphere. This is of particular



**The use of microbial inoculants while developing sustainable agriculture techniques in chemical-based farming is one of the most promising alternatives these days.**



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importance in efforts to mitigate climate change. Carbon that comes out of the atmosphere can be stored in the soil, helping to re-balance the global carbon budget.

## Soil - A Threatened Natural Resource

It can take up to 1000 years to produce just 2-3 cm of soil. 33% of the Earth's soils are already degraded and over 90% could become degraded by 2050 (FAO and ITPS, 2015; IPBES, 2018). The equivalent of one soccer pitch of soil is eroded every five seconds. This is happening although we are aware of land management, ways to improve soil fertility, and protection of soil nutrition. Intensive chemical based agriculture eventually leads to soil erosion, depletion of organic matter and soil nutrition, which results in permanent degradation of soil and leads to significant productivity losses. To maintain optimal yields and avoid soil degradation, it is very much essential to protect soil from organic carbon and biodiversity losses, micronutrient imbalance, acidity, and salinity. The use of microbial inoculants

To potentially exploit the benefits of bio fertilizers based on the consistency of their performance, it very much essential to have right knowledge with respect to type of microbial inoculant required for an ecosystem, method and dosage of application, proper placement of these microbial products in the crop cycle etc.

while developing sustainable agriculture techniques in chemical-based farming is one of the most promising alternatives these days. Input of exogenous organic matter, such as farm yard manure or animal manure, can enrich soil with the necessary elements and prevent soil organic matter (SOM) decomposition.

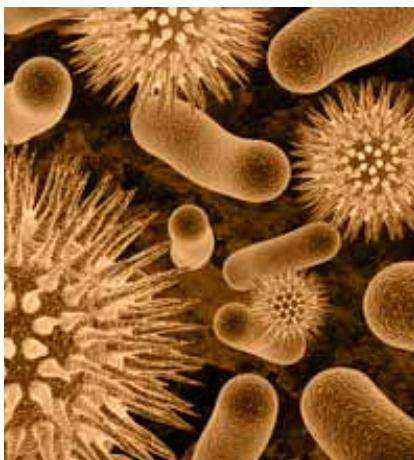
### Microbes and Soil

Role of microbes in improving soil fertility is as below

- Microbes improves soil fertility by incorporating air, minerals, and nitrogenous compounds.
- Microbes increase plant growth by providing essential elements, and minerals that plants cannot utilize on their own. Many times these nutrients remain in chelated forms and not available to plants
- Microorganisms decompose organic matter into a simpler form that can be absorbed by plants.
- Microbes improve soil fertility through nutrient recycling such as carbon, nitrogen, sulphur, and phosphorus.

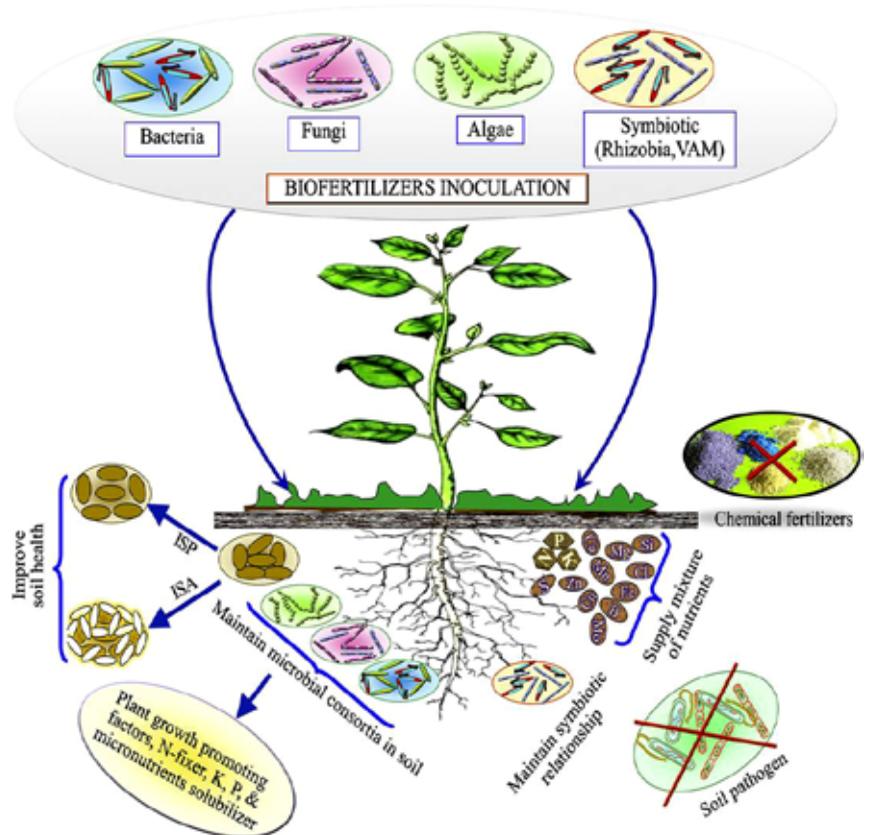
### Benefits of Beneficial Microorganisms

The biological activity of beneficial



### Bio fertilizer

Biofertilizer is the microbial inoculants that contain the culture of dormant or live cells of the effective strains of N fixers, phosphate solubilizers and potash mobilizers at their cellular level which is often applied to seeds, soils, or compost material to accelerate the microbial activities by such potent microbes through their multiplication and enhance the nutrient's availability, which can be easily accessible by the plants.



Schematic representation; Influence of bio fertilizers on plant growth-performance and soil health. [VAM = Vesicular-arbuscular mycorrhiza, ISP=Increase soil porosity, ISA = Increase soil aggregation].

Fig Source: Mahmud et.al,2021, Bio fertilizers: A Nexus between soil fertility and crop productivity under abiotic stress; Current Research in Environmental Sustainability, 2021

microbes helps in mobilizing the availability of nutrients and recovery of nutrients, thereby improving the soil quality in general. Bio fertilizers have the potential to impede the nitrification process for a long period while improving

the fertility status of the soil .They are one of the important constituents of Integrated nutrient management (INM) strategies for meeting both the soil's productivity and sustainability and at the same time they are environmental friendly. Being



pollution-free, economic and source of renewable nutrients to the plants to augment synthetic fertilizers in the sustainable production system supports the fact that the impact of bio-fertilizers for yield improvement ranges between 35% to 65%. However, to potentially exploit the benefits of bio fertilizers based on the consistency of their performance, it is very much essential to have right knowledge with respect to type of microbial inoculant required for an ecosystem, method and dosage of application, proper placement of these microbial products in the crop cycle etc.

### Challenges in Utilising Microbes in Agriculture

Following are some of the main challenges faced in exploiting beneficial activities of soil microorganisms for improving soil fertility and productivity:

- Absence of technical knowledge in exploring these microbes for soil restoration.

Various beneficial microbes which play a major role in soil nutrition are

- Nitrogen fixers like *Azotobacter spp*, *Azopsirillum spp*, *Rhizobium spp*, *Beijerinckia spp*, *Pseudomonas spp*, *Paenibacillus azotofixans etc*
- Phosphate solubilisers like *Bacillus spp*, *Pseudomonas spp*, *Enterobacter spp*, *Aspergillus spp*, *Burkholderia spp etc*
- *Acidothiobacillus ferrooxidans*, *Paenibacillus spp.*, *Bacillus mucilaginosus*, *B. edaphicus*, and *B. circulans* have capacity to solubilize K minerals (e.g., biotite, feldspar, illite, muscovite, orthoclase, and mica).

- Limited usage of these microbes as product by farmers
- Poorly developed marketing channels and infrastructure and limited involvement of the private sector in the distribution of bioinoculants.
- Limited farmer awareness and access to bioinoculants.

Actually microbes are the first inhabitants of the soil and they have been living in the soil ecosystem for the last so many billions of years. They are strong powerful factories which does the process of nutrient restoration. Disturbances caused to the microbial

ecosystem due to the recent intensive and modern agriculture has led to shift in their ecosystem and eventually leading to soil degradation. Hence to bring back the soil fertility and nutrition back, it is imperative to go back to nature and harness the potential of tiny microbes in the process of sustainable agriculture and making them the important concept or part of the system.

With this would like to conclude that Microbes are going to be the integral part of the sustainable agriculture and as per words of Louis Pasteur “**The role of the infinitely small is infinitely large.**”

**-Louis Pasteur (1869)**

# NURTURING THE EARTH

## VARAHA'S INDO-GANGETIC PLAINS REGENERATIVE AGRICULTURE PROJECT

**A**s we confront the climate crisis, agriculture is both a contributor and a potential saviour. Agriculture accounts for 22% of global greenhouse gas emissions. In 2018, India ranked as the third-largest emitter; conventional farming practices are contributing to high emissions and soil degradation. However, amidst these challenges, Varaha's Indo-Gangetic Plains Regenerative Agriculture Project stands out as a pivotal effort, advocating sustainability and resilience.

### Indo-Gangetic Plains Regenerative Agriculture Project

The project, initiated in 2019, aims to implement regenerative agricultural practices in the Indo-Gangetic plains, with a specific focus on smallholder farmers. Covering states such as Haryana, Punjab, Uttar Pradesh, Odisha, Uttarakhand, West Bengal, and Bihar, the project targets over 80% of the cropping area, encompassing 63.9 million hectares.

The project introduces a holistic approach to farming, moving away from conventional practices that include flooding, transplanting, residue burning, and monocropping. Instead, smallholder farmers are encouraged and incentivized to embrace regenerative practices that benefit the environment and promise increased income, revenue from carbon credit sales, and reduced production costs. Practices such as zero/reduced tillage and direct-seeded rice (DSR) are pivotal in sequestering carbon and reducing emissions. These practices



Madhur Jain, CEO & Co-Founder and Shubham Deshmukh, Carbon Projects Marketing Manager, Varaha

enhance soil, water, and air quality while mitigating soil erosion, ensuring a sustainable agricultural ecosystem.

### Ripple Effect

Efficient nutrient management and crop residue incorporation further contribute to sequestration and emission reduction. The positive ripple effect extends to water quality improvement and substantial savings in expenses, time, and labor for farmers. The project's emphasis on crop diversity through rotations and cover crops not only aids in carbon sequestration but also reduces erosion and water requirements.

Varaha's MRV (Monitoring, Reporting, and Verification) technology plays a crucial role in this transformation, employing a user-friendly design app for data collection. The introduction of ground truth data into Varaha's biogeochemical models allows for precise calibration tailored to local climatic conditions, incorporating details such as soil samples and gaseous emission data. Utilizing machine-learned models for various farming practices

ensures a high level of scientific rigor, enabling accurate quantification of carbon sequestration and emission reduction.

### Driving Transformation

One of the unique aspects of Varaha's project lies in its collaboration with various entities, each playing a crucial role in driving transformative change. Implementation partners actively educate farmers about regenerative practices and provide support during the transition. Varaha takes on registering the project, identifying partners, monitoring farmlands, quantifying emission reductions, and validating the process through accredited auditors.

As we celebrate World Soil Day on December 5th, Varaha's Indo-Gangetic Plains Regenerative Agriculture Project serves as a model of what can be achieved through a combination of innovative practices and advanced technology, to not only mitigate greenhouse gas emissions but also reverse land degradation and uplift the livelihoods of smallholder farmers. The project's success prompts broader conversations on the future of sustainable agriculture and the public and private sector's roles in addressing climate change, including by enabling farmers to earn carbon credits.

Varaha's Indo-Gangetic Plains Regenerative Agriculture Project showcases collective action's power and its positive impact on the environment and those reliant on the land. This World Soil Day, let's celebrate and commit to nurturing the soil for future generations through sustainable practices.

# CARBON PROJECTS FOR SOIL REGENERATION AND FARMER PROSPERITY

**R**estoring soil health is not just a necessity; it is a matter of urgency. Half of the world's agricultural land is degraded. The recent decline in soil health has led to a weak and unstable food system, all the while releasing 133 billion tonnes of soil carbon into the atmosphere. In India, specifically, soil organic carbon (SOC) content has diminished from 1 percent to 0.3 percent over the past 70 years, raising significant concerns within the agricultural sector. Boomitra is at the forefront of leveraging technology and regenerative agricultural practices to combat climate change, restore

By converting increased soil carbon into Verified Emission Removals (VERs), Boomitra creates carbon credits, which are sold to corporations and governments to achieve sustainability targets.

## About the **AUTHOR**

**Aadith Moorthy,**  
CEO,  
Boomitra



soil health, and simultaneously provide economic benefits to farmers in India and across the globe.

### Understanding Soil Carbon Projects

Soil carbon projects remove carbon dioxide (CO<sub>2</sub>) from the atmosphere and store it in the soil. When farmers and ranchers improve their agricultural practices, they are taking part in a movement that can capture and store 3-5 gigatons of CO<sub>2</sub> equivalent each year, approximately 10% of annual global emissions (IPCC). This process, called carbon sequestration, is crucial for mitigating climate change.

Beyond its impact on climate, soil carbon sequestration yields many other benefits. When farmers and ranchers switch to regenerative practices, such as cover crops and rotational grazing, they improve soil fertility, enhance water retention, increase nutrient availability, support microbial activity, and build biodiversity. The result is higher crop yields and enhanced resilience against climate variability.

### Boomitra's Transformative Model

Boomitra is unlocking carbon removal at scale. As a leading international soil carbon marketplace, Boomitra leverages AI and remote sensing technology to measure, report, and verify soil's carbon content, nutrients, and moisture levels. Through our network of global partners, we help farmers and ranchers adopt agricultural practices that increase carbon sequestration. Boomitra then quantifies the additional carbon captured. By converting increased soil carbon into Verified Emission Removals (VERs), Boomitra creates carbon credits, which are sold to corporations and governments to achieve sustainability targets. One tonne of carbon removed from the atmosphere and stored in the soil equals one carbon credit. The proceeds from these sales are predominantly directed back to the farmers, enabling them to reinvest in their land and communities.

### Amplifying Local Solutions

Across the world, conventional farming,



Aadith Moorthy is the winner of Earthshot Prize, founded by Britain's Prince William and referred to as the 'Eco Oscars.' The awards recognize 15 global innovators, entrepreneurs, community leaders and activists working to find cutting-edge solutions to climate change. In the "Fix Our Planet" category, Aadith Moorthy's Boomitra emerged as the winner for its work with struggling farmers the world over.

## Boomitra is already operating at scale: 150,000 farmers and ranchers enrolled, 5 million acres under regenerative management, and millions of credits sold to date

practices have depleted soil carbon levels by 30% to 75%. To counter this, Boomitra's global projects uplift local, indigenous, and scientific knowledge to regenerate soil carbon. Participating farmers and ranchers select the practices best suited for their regional, ecological, and cultural context.

Our team works with local implementation partners, like Pronatura Noreste in Northern Mexico and the Farm to Market Alliance in Kenya, to provide expert support and capacity building to help farmers and ranchers adopt each new practice. In India, our partnerships with organizations such as CSA, DCM Shriram, SHARSID, and Subhiksha are central to promoting sustainable practices, including organic farming and the elimination of stubble burning. Through carbon farming,

we are scaling these efforts. Our projects in India contribute to Prime Minister Narendra Modi's goal of restoring 26 million hectares of degraded land by 2030.

### A Vision for the Future

As an Earthshot Prize Winner, we're on a mission to recarbonize the soil and protect the planet. We aim to make carbon finance accessible to all farmers and ranchers, from half-acre smallholder farms to large ranches, particularly in the Global South. Our goal? A gigaton of CO<sub>2</sub> sequestered in the soil by 2030. Boomitra is already operating at scale: 150,000 farmers and ranchers enrolled, 5 million acres under regenerative management, and millions of credits sold to date. This World Soil Day, and every day, we are working to restore soil health.

### A Path to Resilience and Prosperity

Soil carbon projects represent a harmonious blend of ecological stewardship and economic prosperity, paving the way for a resilient and equitable future in agriculture. Together, we can support farmers and ranchers to put carbon back where it belongs – underground – while mitigating a significant portion of greenhouse gas emissions.

# SOIL MICROBIOME

## THE DRIVER FOR A GREENER AGRICULTURAL REVOLUTION

*"In the past, great civilizations have fallen because they failed to prevent the degradation of the soils on which they were founded..."* Scholes and Scholes, Science, 2013

Recently, India bagged the title of being the world's most populous country, surpassing China. However, unlike the Chinese, the Indian population keeps on growing. In the Indian context, one of the issues aggravating the increasing number of mouths to feed, is the rapid land degradation. Approximately 30% of India's geographical area is degraded, and the impact of climate change worsens the situation. Further, there has been a steep decline in the arable land (currently ~0.11 hectares per person) in India. All these emphasize the need to turn towards more sustainable agriculture, increasing crop productivity within the constraint of a decreasing area of arable land.

### Significance of Holobiont

The concept of "holobiont" has gained popularity in the current scenario. While the term was coined way back in 1990 by Margulis, its significance has been realised in the recent past. Holobiont considers a higher organism and its associated microorganisms as a single entity, co-adapting and co-evolving. The rapidly dividing and evolving component of the holobiont, the microbiome (the summation of all microorganisms and their interactions) is an indispensable part of the higher organism, facilitating the latter's fitness and adaptability. For example, a human being devoid of its microbiome is only hypothetical, with crucial processes like development and maintenance strongly dependent on the "invisible but mighty" microbiome. Any dysbiosis in the microbial composition re-

ffects upon the health of the system/higher organism. Conversely, replenishing the diversity of microbiomes associated with higher organisms and the environment is an excellent strategy to transform a non-optimized / poorly performing holobiont to an optimised one.

### Soil Microbiome

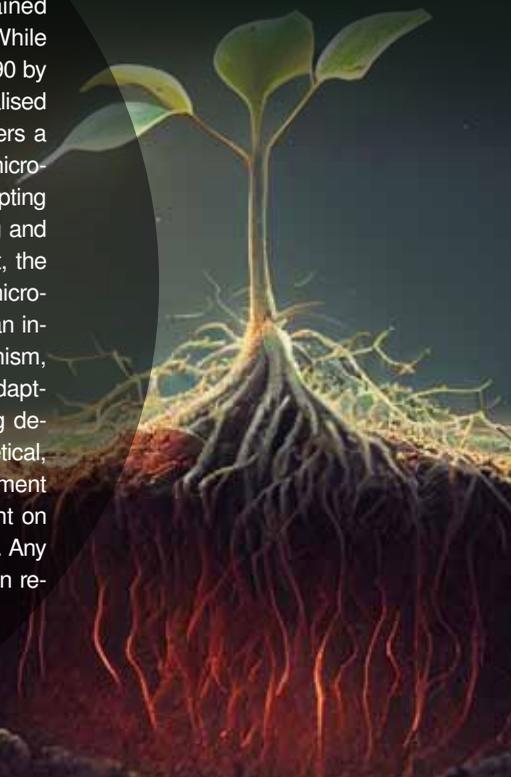
Soil microbiome serves as a major bank for the recruitment of beneficial microorganisms by plants. It drives nutrient cycling and maintains soil fertility. Strong links have also been established between the human gut microbiome and soil. The microbial "old friends" hypothesis suggests the relatedness of microbial exposure to human inflammatory responses. The soil

microbiome also serves as an excellent indicator for anthropogenic effects. Due to the tight association of soil microbiome with humans and plants, it is proposed to be explicitly included in the One Health concept, instead of being a subtle part of it through the environmental component.

Over the years, agricultural intensification, combined with climate change, has led to a compromised soil microbiome, which has eventually impacted the soil functioning and health. Soil microbiome being a unifying factor, such a dysbiosis has adversely affected the other components of the One Health concept. Infact, agriculture is believed to be the largest threat to biodiversity.



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 Delhi



Due to an ardent need for agricultural sustainability, researchers are working towards developing sustainable means of enhancing crop productivity by replenishing the soil of its microbial diversity.

### Rhizosphere Engineering

It has been established that the plant-associated microbiome plays a crucial role in determining the plant health. Of special interest is the rich zone of soil surrounding the roots, called the rhizosphere. It serves as an excellent choice of system for eco-friendly manipulation for enhancement of plant attributes. The rhizosphere is a rich region in terms of the array of metabolites released by plant roots, attracting specific microorganisms from the bulk soil. It is also rich in terms of the microbial diversity it harbours. The rhizosphere microbiome benefits the plants by several mechanisms, including sequestration of nutrients, secretion of metabolites directly promoting plant growth, helping the plants evade abiotic stresses, and competing with the deleterious microbes in the plant's vicinity. Hence, engineering the rhizosphere microbiome is a promising approach to attain a desired function, including enhanced crop productivity, reduced disease incidence, etc.

There are three modes of engineering the rhizosphere. Agricultural practices like organic amendments, crop rotation, and others, have been reported to replenish the lost microbial diversity in soil, thereby positively affecting soil health. Such strategies consider the holobiont and do not specifically focus on a particular component. The rhizosphere microbiome can also be manipulated via the plant, viz., the choice of cultivars or genetically engineered plants with altered root exudation profile, which results in attracting a specific microbiome beneficial for the plant. This comes with its own set of challenges and ethical concerns. A "simpler" approach is to engineer the microbiome component of the holobiont directly. While still in its infancy, in terms of large-scale application, microbiome-based engineering of the rhizosphere, and soil in general, holds immense potential.

### Microbiome-Based Engineering in

**Prof. Shilpi Sharma is the winner of the Tata Transformation Prize – the award instituted to recognize and support visionary scientists in India who are developing innovative solutions to critical societal challenges. She was selected by the jury for her work in the engineering of the soil microbiome using synthetic microbial communities, called microBIOME-based soil TRANSFORMAtion (BIOTRANSFORM).**

**While still in its infancy, in terms of large-scale application, microbiome-based engineering of the rhizosphere, and soil in general, holds immense potential.**

### Agriculture

In agriculture, microbiome-based engineering has been attempted primarily by two strategies. The first strategy, which is an advancement of the amendment of bioinoculants, is the generation of Synthetic microbial communities (SynComs / SMCs), which are simplified versions of the natural microbiome, but offer advantages over the conventional means. While applying bioinoculants faces challenges, including competence in the field, designing SynComs holds promise. This is because SynComs are developed with a prior understanding of the core microbiota of the systems, and after identifying the keystone members in the community. Such background informa-

**Due to the tight association of soil microbiome with humans and plants, it is proposed to be explicitly included in the One Health concept, instead of being a subtle part of it through the environmental component.**

tion helps come up with robust SynComs. One can understand it as bringing together the best soldiers shortlisted from a battalion, for the success of a mission.

Another approach is to acclimatise the microbiome to repeated cycles of stresses (abiotic or biotic), such that a stress-tolerant microbiome evolves in the process. The microbiome thus generated has a strong potential to offer enhanced services under stressed conditions. This can be viewed as the rigorous training of a battalion to prepare for combat in hostile conditions.

While the first approach is relatively straightforward in terms of its large scale application, taking the acclimatisation strategy to field application is cumbersome.

### Bottlenecks in Soil Microbiome Engineering

There are limited efforts to apply engineering of soil microbiomes to a large scale. Several logistic issues have served as bottlenecks. One prime challenge is the universality of the microbiome engineering approaches. "One Method-Fits all" or "One microbiome-Fits all" is not practical. Further, extensive studies must be performed to catalogue the microbiome diversity of different crops in various agroclimatic zones etc. For microbiomes established as superior over others for a desired function, the major issue is its preservation for later use. Initiatives around the world are working towards the storage, cataloguing, and propagation of soil microbiome, and generating Soil Microbiome banks. But this is a Herculean task. Nonetheless, with increasing interest in harnessing the potential of the soil microbiome for environmental sustainability, by scientists from multiple disciplines, the day is not far when a sprinkling of soil will do the magic.

# 'The aim is to enhance farm power availability and improve agricultural efficiency'

Farm Mechanisation in India still remains a distant dream due to a plethora of factors. With a significant push from the government to promote mechanisation in agriculture, things are changing. In an interview with Agriculture Today, Dr. V N Kale, Additional Commissioner (Mechanization & Technology), Govt. Of India, Ministry Of Agriculture and Farmers' Welfare, discusses the current status of farm mechanisation in India, the challenges and way forward.

Excerpts from the interview:

## What is the status of farm mechanization in our country?

Agricultural mechanization in India is a complex subject due to significant regional variations and requirements. Policy frameworks have been tailored to suit the needs of individual states and their unique agricultural landscapes. Despite efforts, the overall level of farm mechanization in India remains relatively low, with about 2.5 kilowatt per hectare of farm power availability during 2018-19, which is insufficient for the country's mechanization goals. In contrast, advanced countries like the USA and European nations boast much higher farm power availability, often exceeding 8-9 kilowatt per hectare, with significantly lower labor engagement in agriculture. India faces the challenge of a large agricultural workforce with relatively small landholdings, making high-tech and costly machinery less accessible. To address this issue, the government has introduced custom hiring centers, allowing entrepreneurs or farmers to provide machinery on a rental basis to others, creating a win-win situation that benefits both the farmers and those providing the equipment. The aim is to enhance farm power availability and

improve agricultural efficiency while catering to the diverse regional needs of Indian agriculture.

## Despite efforts, the overall level of farm mechanization in India remains relatively low, with about 2.5 kilowatt per hectare of farm power availability during 2018-19, which is insufficient for the country's mechanization goals.



improve agricultural efficiency while catering to the diverse regional needs of Indian agriculture.

## Is mechanization still inaccessible to small farmers?

While India is the world's largest tractor manufacturer, it's essential to recognize that farm mechanization isn't accessible to everyone. In India, the prevailing perception of farm mechanization often equates to tractorization, but this approach doesn't cater to the diverse needs of small and marginal farmers. To achieve a balanced and inclusive approach, promoting small machineries like power tillers, sometimes referred to as walk-behind tractors, is crucial. These self-propelled, affordable machines, costing approximately 1.5 to 2 lakh rupees, can bring small-scale farmers into the realm of farm mechanization. However, the success of this endeavour largely depends on proactive measures taken by state governments to meet the needs of small and marginal farmers and expand the accessibility of mechanization beyond just tractors.

## How can we improve the



### situation?

Addressing the need for agricultural expertise, particularly within state governments, is a critical step in advancing farm mechanization. Many regions, such as Tamil Nadu, Madhya Pradesh, and Odisha, have made significant progress in farm mechanization by establishing separate directorates of agricultural engineering. These directorates actively recruit agricultural engineers, ensuring a specialized workforce capable of improving and innovating in the field of farm mechanization. This approach has the potential to drive advancements and efficiencies in agricultural practices, benefiting both farmers and the agricultural sector as a whole.

### The general automobile segment is progressing towards electric and hybrid variants. So how long will it take for agri-machinery segment to migrate to the same?

In the agricultural sector, electric vehicles (EVs) have already made their entrance. Manufacturers are producing electric tractors. However, the widespread adoption of these EVs faces a significant hurdle in the form of high initial costs compared to their diesel-engine counterparts. Despite the numerous benefits that EVs offer, such as reduced pollution and lower maintenance

### The government's commitment to agricultural mechanization is underscored by its efforts to distribute drones to self-help groups, with plans to distribute 15,000 drones in the coming years.

and operating costs, their popularity hinges on the reduction of this high initial cost. As these costs become more competitive, the agricultural industry can embrace EVs on a larger scale, reaping the advantages they bring to the sector and the environment.

### Can farm mechanization lure youngsters to agriculture?

In the contemporary agricultural landscape, attracting youth to engage in farming is a pressing challenge, given the strenuous efforts and challenges associated with the sector. The introduction of advanced agricultural machinery serves as a key strat-

egy to entice the younger generation and present agriculture as a viable employment opportunity. Recognizing this, the Government of India has integrated cutting-edge technologies into the agricultural sector, including the significant introduction of drone technology. The government is actively facilitating the procurement of drones, aimed at optimizing the utilization of agricultural inputs, such as fertilizers, seeds, and pesticides. This approach enhances precision in planting, germination, and ultimately reduces cultivation costs and timelines, which is particularly crucial given the limited time between successive crops. Furthermore, to address concerns like stubble burning, the government has launched a Crop Residue Management Scheme, offering support for both in-situ and ex-situ management of crop residue. The scheme encompasses the entire value chain, from collection to utilization, involving power generation plants and pellet manufacturers. The government's commitment to agricultural mechanization is underscored by its efforts to distribute drones to self-help groups, with plans to distribute 15,000 drones in the coming years. These initiatives aim to promote modernization in agriculture and create opportunities for the youth while addressing pressing environmental and agricultural challenges.



# Soil

## THE ESSENCE OF LIFE

**T**he cycle of life is directly dependent on healthy soil. With no soil, there will hardly be any vegetation and certainly no crops to feed our growing hunger.

Herbivorous animals are dependent on plants for their sustenance. They will be negatively impacted. There is empirical evidence showing that land degradation negatively affects the incomes of agricultural producers.

### Soil ,Water and Life

Soil plays a key role in water cycle. Its absence would disrupt natural water filtration processes, affecting both water quality and availability. Soil also acts as a natural barrier to flooding by absorbing excess water. Without it, there would be more frequent and severe floods. Water is essential to life as well. Absence of soil will severely impact water availability, leading to disastrous consequences.

Soil is home to billions of microorganisms and other life forms that contribute to ecosystem health. Many of the microorganisms found in soil are used in the field of medicine like penicillin and also to develop various biotech products including antibiotics. Their loss will hamper medical services permanently. Soil microbes help regulate our emotions and immune response. And they also play a key role in determining the nutrient content of our food.

Forests and plantations rely on soil

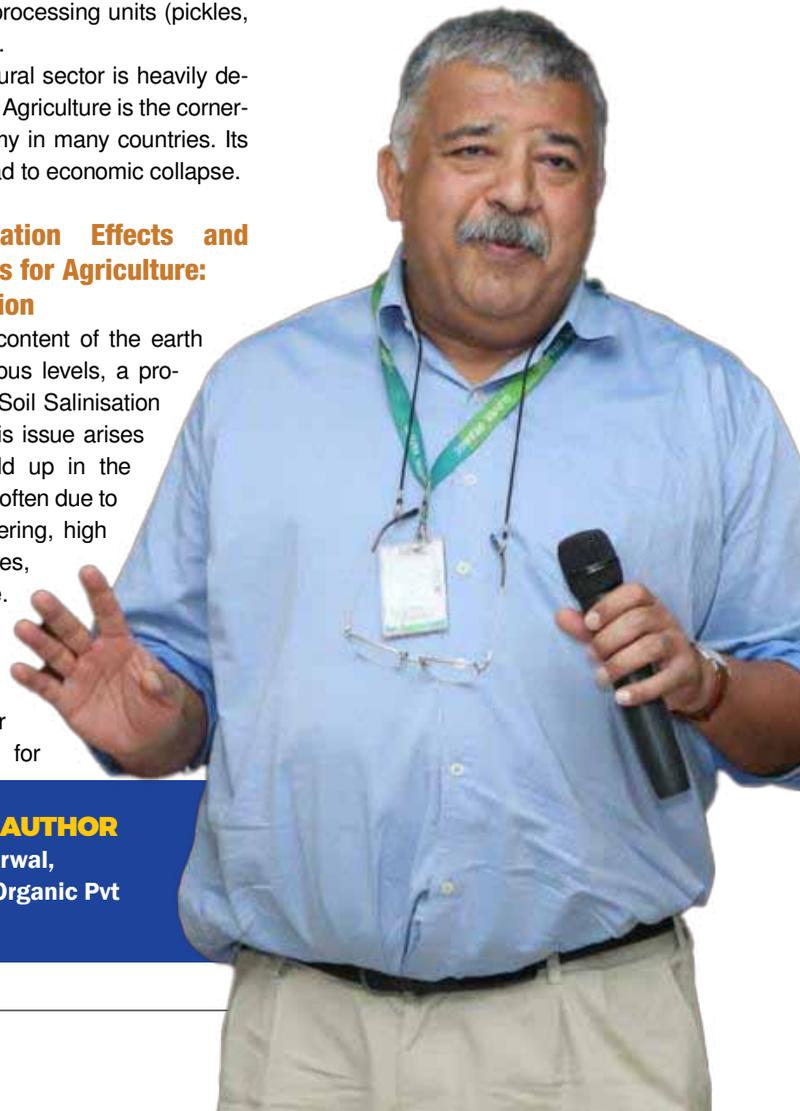
and are our sources for timber and natural fibre like cotton and flax. Their absence would severely impact multiple industries. All agriculture based Industry will perish that include dairy, poultry, sugarcane, leather, rubber, biofuel, rice mills, jute, paper, textile, vegetable tea & coffee& fruit processing units (pickles, jam, chips, etc.).

The agricultural sector is heavily dependent on soil. Agriculture is the cornerstone of economy in many countries. Its failure would lead to economic collapse.

### Soil Degradation Effects and Consequences for Agriculture: Soil Salinisation

When the salt content of the earth rises to dangerous levels, a process known as Soil Salinisation takes place. This issue arises when salts build up in the plant root zone, often due to inadequate watering, high evaporation rates, or bad drainage. Soil salinisation slows crop growth and can even render land unsuitable for

**Soil is home to billions of microorganisms and other life forms that contribute to ecosystem health**



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**Ltd.**

cultivation.

### Soil Acidification

Decreases in soil pH leads to increased acidity, a phenomenon known as “acidification.” Inappropriate crop or fertilizer selection is usually to blame for this. Acidification can affect the microorganism population, which in turn affects land ecosystem productivity and the rate of nutrient cycling. Acidity further worsens land degradation by breaking down aggregates in the earth and weakening the earth’s structural integrity.

### Organic Matter Loss

Organic matter loss, also known as dehumification, occurs as a result of land degradation and other long-term processes. Organic matter acts as glue and binds particles together, making the ground structure more stable. Land erosion and fertility loss due to natural or man-made causes become more likely when the earth contains a lower percentage of humus.

### Soil Compaction

Most soils perform best at a density of around 1.2 t/m<sup>3</sup>. However, as a result of repeated runs by heavy agricultural machines over the same areas, nowadays densities of 1.4–1.5 t/m<sup>3</sup> are not uncommon. As plant roots can’t sprout through such a thick mass, compaction has a devastating effect on agricultural crop growth and development.

### Possible Solutions to Arrest Soil Erosion

Soil degradation due to natural causes cannot be controlled in anyway. However, loss of soil quality due to human activity can be controlled and is in our hands. Human greed must be controlled. Everyone needs to do their bit to conserve this precious resource. It should not be left to farmers or policy makers. We have one planet and we must do everything in our power to ensure that life continues to eternity.

Practising organic farming in its pure form, or at least implementing important



**Practising organic farming in its pure form, or at least implementing important ecological practices, while using minimal synthetics, could turn around the tide.**

ecological practices, while using minimal synthetics, could turn around the tide. These practices will include:

**Change of focus:** Conventional farming looks at crops rather than soil, while organic farming mainly focus on soil health with the assumption that if soil health is good, it would lead to higher productivity for the farmers.

**Change of mindset:** Compost is not a fertiliser in the true sense. It is a substrate or food for soil borne microorganisms. These microorganisms in turn produce all the nutrients needed by plants and make the soil more fertile and porous. Hence it takes time for plant growth to be witnessed by farmers as compared to the use of chemical fertilisers. Farmers need to understand this fundamental difference and change their mindset accordingly. Compost must be applied irrespective of whether one is practising organic farming or not.

**Mulching:** Soil likes to cover itself just like we want to cover our body with clothes. It has several benefits for the farmers and the soil. There is an almost 100% eradication of weeds, irrigation requirements get reduced by more than 60%, soil organic carbon increases and top soil does not easily get dislodged by nature.

**Green manuring:** Green manuring is a simple practice of growing leguminous crops like lentils, peas, sun flowers etc., along with main crop. This enhances soil productivity and also minimises economic risk for the farmers by providing him with alternative crops.

**Crop rotation:** Practicing crop rotation allows different plants to grow in an area of soil every year. This allows the soil to replenish itself of nutrients that are lacking after the growth of one type of plant.

Agroforestry should be practiced widely. It involves growing crops around trees and other plants such as hedges. Trees create their own microclimate, which is favourable for crops. They also act as a form of protection against wind and water damage and encourage biodiversity, which keeps ecosystems strong and healthy.

Education should be widespread for everyone to make a more informed decision on their role in curbing soil erosion. All human activities, which lead to degradation must be curtailed. Deforestation, industrial agriculture (use of farmlands to highest yields to fulfil human food needs), overgrazing, and rapid urbanisation needs to be arrested or slowed down considerably.

# CROP RESIDUE MANAGEMENT IN INDIA AN IMPORTANT STEP TOWARDS SUSTAINABLE AGRICULTURE



**A**griculture plays an important role in India, accounting for 18.3% of the country's GVA and employing approximately 62% of its population. Such large-scale farming activity across the nation generates vast amounts of waste in the form of stubble, chaff etc. that must be disposed of between crop cycles. Due to a variety of reasons, some of which include lack of incentives to dispose of this waste responsibly, many farmers resort to the burning of this agricultural waste to clear it off their fields.

Today, crop residue management has become a key area of focus as the nation works to strike a balance between agricultural productivity and environmental sustainability. The government has also introduced a bevy of initiatives aimed towards achieving this goal.

## The Burning Problem

In India, stubble burning—the deliberate setting on fire of crop residues that have



**The cycle of stubble burning degrades the environment, in addition to reducing the sustainability and long-term viability of agriculture.**

been left in the fields after harvest—has become a significant issue. In states like Punjab, Haryana and Uttar Pradesh, where rice and wheat are the staple crops, this practice is common.

Additionally, burning crop residues also results in the loss of important nutrients and organic matter. To maintain agricultural productivity, this depletion weakens soil

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health, reduces the soil's ability to retain water and necessitates a greater use of synthetic fertilizers. As a result, the cycle of stubble burning degrades the environment, in addition to reducing the sustainability and long-term viability of agriculture.

### Central and State Government Initiatives

Acknowledging the dire need to address the issue of stubble burning, the Indian government has launched several initiatives to encourage sustainable crop residue management. The Ministry of Agriculture and Farmers' Welfare's "Promotion of Agricultural Mechanization for In-Situ Management of Crop Residue" scheme is one of the noteworthy initiatives that have been introduced. This program aims to give farmers financial support for the acquisition of tools and machinery that make it easier to manage crop residue in the field itself, thereby reducing the man-hours to clear the field and obviating the need for burning as well.

Furthermore, the government has launched extensive awareness campaigns to educate farmers about the advantages of sustainable crop residue management, in addition to introducing an assortment of financial incentives. These campaigns stress the value of implementing substitute behaviors such as mulching, composting and using crop residues as animal feed. Additionally, the government has collaborated with agricultural research organisations and university institutions to create cutting-edge technologies and make them accessible to farmers so as to enable efficient crop residue management.

### Promotion of Agricultural By-Products

Promoting the use of agricultural byproducts and crop residues is a promising strategy for ending stubble burning. The establishment of biomass-based power plants that use crop residues as a feedstock for energy production has been encouraged by the government. This not only offers a green way to dispose of waste, but also helps to increase the energy security of these places and creates entrepreneurial

Adopting sustainable crop residue management techniques also improves the fertility and health of the soil.

and employment opportunities in rural parts of the country.

Additionally, the use of crop residues in a variety of industries, including paper, cardboard, and packaging, presents a chance for economic development and environmentally responsible resource management. Farmers can generate additional income while lessening the environmental impact of stubble burning by turning crop residues into marketable goods.

### Benefits, advantages and Challenges

Switching from burning stubble to sustainable crop residue management offers numerous advantages and the improvement of air quality is the most important of these. By ceasing to burn this waste, harmful pollutants are released into the atmosphere in much lesser quantities, which results in cleaner air and better public health. Since fewer greenhouse gases are emitted, this step has a positive impact on reducing climate change and puts India closer to achieving its goal of becoming carbon neutral by 2070.

Adopting sustainable crop residue management techniques also improves the fertility and health of the soil. When crop residues are incorporated into the soil using methods like mulching and ploughing, they add organic matter and nutrients that improve the mud's structure and increases its ability to hold water. As a result, less fertilizer needs to be applied and agriculture is encouraged to become more sustainable.

However, the switch to sustainable crop residue management is not without its own set of challenges. Adopting mechanized solutions may be difficult for small and marginal farmers who comprise a sizable portion of India's agricultural fraternity. Additionally, concerted efforts in education and extension services are needed to raise awareness and alter traditional farming practices.

### Demand for Balers

Due to the short window between paddy harvesting and wheat sowing, there is a growing preference for larger Balers to collect the paddy residue quickly to collect straw and to optimize transportation, the farming community prefers large balers and the demand for the same is growing year on year. CLAAS with its range of Rectangular Balers (MARKANT 650), Round Balers (ROLLANT 520) & the most recently introduced Large Square Balers (QUADRANT 4000, 4200 and 5300) pioneers in the art of knotting technology, thereby providing an excellent solution to prevent stubble burning. Suitable Tractors (ARION & AXION series) to drive these large square and round balers are also offered by CLAAS in India. Government initiatives to prevent paddy residue burning and using the straw for economic use is a huge demand driver for professional baling equipment. This also is a win-win situation for the farmer, contractor and the power plant.

### Way forward

An essential step on India's path to environmentally friendly agriculture is the management of crop residues. A shift towards more responsible and effective resource use is signaled by government programmes to promote sustainable practices and agricultural byproducts. The potential benefits of reducing stubble burning in the country go beyond better air quality and include better soil health, increased agricultural productivity and economic growth in rural areas. The government, farmers and other stakeholders must work together to pave the way for a cleaner and healthier agricultural future in India.

# SMART SOIL SYSTEM SOLUTIONS KRISHI-RASTAA

*"Farming looks mighty easy when your plow is a pencil, and you're a thousand miles from the corn field." — President Dwight D. Eisenhower*

**T**he soil is the great connector of lives, the source and destination of all. High level of heterogeneity prevails in farm size, farm income and farm resources categories. The application of information technology supports farmers in making intelligent decisions based on concrete data. It also enables individuals to get specialised solutions, granular information of direct use. Though the knowledge production centres striving for technology transfer, there exists an information gap between clientele and knowledge centres. The work load of the farmers, experts availability, time constraints and information asymmetry leads to over or lesser dose of fertilizers, higher cost of cultivation and soil fertility deterioration in the long run. The integration of technologies enables planting to be adapted to a specific field, to ensure an efficient and transparent production process. Mobile technology has many more advantages such as personalized information sharing, instant delivery of message, mobility of devices and cheaper cost for deployment than any other ICT devices such as computers, Internet etc., Through mobiles, people in rural areas can connect with the local, regional and national knowledge centres and will be able to receive farm based services, access markets and avail banking/ financial services.

## Mobile Application for decision

### support

Application softwares popularly called as 'Apps' paves the way for individual to connect with networks. The Agro info apps ensures the direct participation of small holders in the decision making practices and integrates all the stakeholders in the crop value chain system.

ICAR-Indian Institute of Rice Research, Hyderabad and their partners institutions, AICRIP Centres spread across India, through a series of interventions have brought deep insights and advanced



ICAR-Indian Institute of Rice Research, Hyderabad and their partners institutions, AICRIP Centres spread across India, through a series of interventions have brought deep insights and advanced levels of understanding for farmers regarding the health and management of their soil.



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**Dr. K.C. Siva Balan - Founder and CEO, CREA, Trichy, TN**



A completely automated and portable soil testing solution, **Krishi RASTAA – Rapid Automated Soil Testing with Agronomy Advisory**, can determine the soil quality in most rapid and reliable manner, where the farmer can get his soil report instantly along with fertilizer recommendation on his mobile phone.

levels of understanding for farmers regarding the health and management of their soil. A decisive attribute in farming is soil. In characteristic foresight, where soil being the next impoverished resource hampering food production, food security, microbial diminution, ecological imbalance and climate resilience, we developed several cutting edge tools and technologies for soil system solutions.

### Soil Fertility Testing Solution- Krishi-Rastaa

(Rapid Automated Soil Testing & Agronomy Advisory)

To address the challenges in soil health, Krishitantra and ICAR-IIRR Jointly developed KrishiRASTAA.

A completely automated and portable soil testing solution, Krishi RASTAA – Rapid Automated Soil Testing with Agronomy

Advisory, can determine the soil quality in most rapid and reliable manner, where the farmer can get his soil report instantly along with fertilizer recommendation on his mobile phone.

#### KrishiRASTAA

The device is less than 2.5 cubic feet and weighs less than 12 kgs. It operates in the principle of spectrophotometry and uses 1/8th of the chemicals required in the regular soil testing lab. The device is provided with chemicals which can do 100 soil tests, later which must be refilled accordingly. The accuracy of the results obtained by the KrishiRASTAA are precise and accurate to 95% when compared with conventional lab test.

The device is completely automated, where the system can be easily operated by anyone with even a basic school educa-

tion and working knowledge on computers.

#### How this automation works

Krishitantra’s field Agent goes to farmer field and registers the farmer. Farmer registration will capture the details including the farmer name, phone number, address, latitude and longitude, previous fertilizer usage, previous crop and propose crop besides few other details.

The sample of soil is collected from field zone wise from predefined field as per the standard methodology. The prepared soil will be tested for 11 available parameters such as Nitrogen, Phosphorus, Potassium, pH, Electrical conductivity, Organic Carbon, Sulphur, Boron, Zinc, Iron and Copper. Report generated on the application will be sent as an SMS to the farmers mobile number and also printed ( Optional ) by Krishitantra operator and provided to the respective farmer. The data is automatically synchronized on dedicated secured server of Krishitantra hosted on Amazon Web Services. The data available on cloud will be integrated to cloud platform using the Krishitantra’s API service.

Unique Username and Password will be provided to login over Krishitantra’s portal. Multilingual ( English, Hindi and Telugu ) languages reports can be viewed and printed after secure successful login. Fertilizer recommendation can be customized and added as per the customer requirement for both macro and micro nutrients for specific crops and regions, from the front end. The total tests being done on each day can be viewed through the login.

#### KRISHI RASTAA - Salient Features

Automated	<ul style="list-style-type: none"> <li>• Easy to operate</li> <li>• Robust system</li> <li>• No professionals required. Can be operated by anyone with basic school education and working knowledge of computers</li> </ul>
Accessibility	<ul style="list-style-type: none"> <li>• Portable and can be made available at any location</li> <li>• Works with electricity and battery</li> </ul>
Time	<ul style="list-style-type: none"> <li>• Analysis of soil samples for 11 parameters within 45 minutes of simultaneous operations</li> </ul>
Accuracy	<ul style="list-style-type: none"> <li>• As the process is completely automated, there is little scope for human errors and hence, the test results are accurate</li> </ul>
Cloud services	<ul style="list-style-type: none"> <li>• The results are stored on the cloud and sent as an SMS to farmer in 6 regional languages</li> <li>• API integration with client’s platform, if required</li> </ul>

# MANAGING SOIL HEALTH THROUGH BALANCED CROP NUTRITION

Soil, as a finite and non-renewable resource, needs to be protected and managed responsibly for the benefit of current and future generations. It plays vital role in global sustainability and ensuring food, fodder, and fibre security to feed the rising population

## Soil Health Decline

There has been a long-term decline in the soil quality and productivity due to various factors which adversely affect its physical, chemical, and biological properties. Managing soil health through balanced crop nutrition by providing essential nutrients to crops using Right Source, in the Right Rate, at the Right Times and at Right Place can help in maintaining soil fertility and supporting plant growth, while

minimizing environmental impacts. However, in early days, fertilizer program was mostly dependent upon straight fertilizers like Urea, Super phosphate, and Muriate of Potash. The post green revolution era was ruled mainly by second-generation relatively more efficient granular complex fertilizers. Initially the crop response to all NPK fertilizers was very good as the soils were rich in secondary and micronutrients with favourable soil chemistry in terms of Soil Organic Carbon (SOC) to support the crop. But over the years, the soil – fertilizer – crop response equations changed rapidly and adversely. This has posed multilevel challenges to agriculture.

## Implications of Soil Health Decline

Excessive mining of nutrients without replenishing it back to soil has created negative nutrient balance in the soil. In recent times, the deficiencies of secondary and micronutrients like sulphur, magnesium, zinc, boron, iron, became common and are on the increasing trend.

Soil ecology and Soil microbiome plays key role in sustaining the soil health but due to several factors including decline in SOC to less than 0.5%, poor agronomic practices, intensive cropping system in certain regions, improper crop rotations and non-judicious and imbalanced use of agrochemicals and fertilizers in soil, this area has gained a lot of importance in recent times and requires us to improve our knowledge and understanding on them. This has led to lowered B:C ratio of the crops due to decline in nutrient response ratio.

Although nitrogen (N) being the most important crop nutrient, its use as fertilizer is associated with high losses. Such losses pollute the environment and increase greenhouse gas emissions that are leading to environmental events associated with climate change implications. They also cause soil nitrate leaching and run-off that pollute surface and underground waters, along with human health effects. Even by knowing the facts with evidence we are not able to dissuade farmers from using cheaper Urea.

## Balanced Crop Nutrition Is Key Solution in Sustainable Agriculture

The fundamental principle of balanced



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crop nutrition is to provide right proportion of essential nutrients needed for healthy growth and optimal yield. This typically includes combination of macro and micronutrients in appropriate amounts that ensures to receive without excess or in deficient nutrients to plants therefore maximizing utilization efficiency of available nutrients. In this context as a first step to maintain soil overall health inclusive of physical, chemical, and biological properties, balanced crop nutrition approach providing essential nutrients to crops in the right amounts and at the right times to maintain soil fertility and support plant growth while minimizing environmental impacts is essential. For sustained crop production, it requires precise nutritional inputs through important Sustainable Agriculture Practices (SAPs) such as

- Organic farming
- Integrated Nutrient Management (INM)
- Use of Enhanced Efficiency Fertilisers (EEFs) in the form of controlled or slow-release fertilisers
- Smart farming
- Precise and efficient use of inorganic fertilizers by adopting 4R principles of Right Source, Right Rate, Right Place and Right time of application

### Crop Nutritional Solutions

Farmers are not experts in fertilizer scheduling, finding the right mix of fertilizer at right time and calculating the right quantity based on scientific recommendation and the soil nutrient profile and on top of it, they are also not supported sufficiently with proper resources. Most of the farmers are mainly dependent on local input dealers for their farming solutions which may or may not be appropriate & cost effective for them. Under such circumstances, farmer should have a nutrition solution readily available at their disposal taking care of all their pain points and helping them to optimize the crop nutrition cost with an objective to maximize their returns through high yield and premium quality produce.

The newly developed grades by Ma-



**Managing soil health through balanced crop nutrition by providing essential nutrients to crops using Right Source, in the Right Rate, at the Right Times and at Right Place can help in maintaining soil fertility and supporting plant growth, while minimizing environmental impacts.**

hadhan Agritech Limited will solve the problem of inconsistent RDF and non-judicious use of fertilizer applications in different crops by farmers. While understanding the gravity of these problems, MAL has stepped into a value-added complex fertilizer called Mahadhan Croptek fortified with all required nutrients in required quantities and form to support the crop at its critical development phases. This is an innovative, advanced fertilizer, and value-added through Nutrient Unlock Technology (NUT) which brings with it a complete

crop nutrition solution in one and every fertilizer granule of Croptek.

In summary, the responsible management and conservation of soil are fundamental to addressing global challenges, including food security, environmental sustainability, and climate change mitigation. It is essential for governments, organizations, farmers, and individuals to prioritize soil health and adopt practices that protect and enhance this valuable resource for the benefit of current and future generations.

# PARAPPIAMMA

## THE PLANT GENOME SAVIOUR

**P**arappiamma cultivates chillies, colocasia, yam, tapioca, amaranthus and many crops in her farm. Once she even planted sugarcane, just because her grandsons fought over a small piece of sugarcane to munch. Her love for farming is evident by the diversity in her farm situated in the hills close to the reserve forests in Manithooki Adivasi hamlet in Vithura panchayath of Thiruvananthapuram, Kerala. All the crops grown in her farm are traditional varieties which she had procured from someone, somewhere decades ago. Among this collection, the one which shot her to fame was the 'Makkalvalarathi' variety of pineapple which she had procured three decades ago. The variety received her attention when she visited her sister in law in Chathankodu. She got a very small sucker. With care and dedication, Parappiamma attended to it. Three years later it bore fruit. That plant gave her two more suckers. Now it commands an area of one acre.

### National Recognition

The Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), operating under the Union Ministry of Agriculture selected her for the Plant Genome Saviour Farmers Award for the year 2020-21 in recognition of her conservation efforts. The Authority confers Award annually on the basis of shortlisting and site verification of the applications received from the community of farmers/farming community based organizations which have a long track record for conserving plant agro-biodiversity. The award carries a purse of Rs 1.5 lakh. Parappiamma received the award on



September 12, 2023 in New Delhi from the Honourable President, Smt Droupadi Murmu during the Global Symposium on Farmer's Rights.

### Proponent of Biodiversity and Organic Cultivation

Parappiamma, the child of the forest, very well understands the perils of chemical fertilizers and she has always steered clear of them. Her farm a repository of traditional varieties of a diverse array of crops, is maintained with organic manures. Mostly she uses the compost developed from the farm waste. At 78 too,

she is very active and takes care of her farm all by herself. With no formal education, her instinct guides her in the farm.

Apart from 'Makkal Valarathi' variety, she also cultivates other traditional pineapple varieties such as undachakka, mullan etc. She sells them in the nearby township at Vithura. Some marketing happens in her farm as well, who come in search of this unique variety. There is no fixed price. She sells it for Rs 100- 250 per fruit depending on the size.

In Colocasia, she mostly cultivates esthamarakannan, neelipaalchembu, paalchembu. Bittergourd, Brinjal, cowpea



etc are also residents of her farm.

### Getting Noticed

The term Makkalvalarthi means one who raises children. The peculiar name comes from the peculiar morphological features of the fruit. There is a main mother fruit which has got a tapering shape and it carries around it little fruits too - the children. The number of the children can be 2- 12 depending on the quantity of manure and the size of the basin taken around the plant. It looks like a chandelier and the unique appearance cannot be missed. So once when DFO, K I Pradeep Kumar came to their settlement for a function, she presented him with this variety. His wife, a veterinarian, was working with the Farm Information Bureau at the time, brought it to the notice of the others. The pineapple variety was then even presented to the Agriculture Minister of Kerala, P Prasad.

Under his instruction, she was nominated for the award.

### Wild Life Challenge

Situated adjacent to the reserve forests, her farm is routinely raided by wild boars



PICTURE CREDIT - ARUN MOHAN

and elephants. To protect her farm she stays in an open shack in the farm itself. The dog by her side alerts the presence of wild animals in the night, and she chases them away.

But things took a different turn while she was away in Delhi to receive her award. The wild boars that descended on the farm wreaked havoc and upturned the precious varieties. It took Parappiamma 31 years to multiply these plants. Each plant gives off only two suckers which take a considerable time to give new suckers. The sight which awaited her nearly destroyed her. "We cant blame them too. These animals need food and there are no fruit trees left in the forest," she finds it hard to blame the animals for her loss.

### Family

Her husband is no longer with her. She has two sons. MallanKani who is a retired soldier and Gangadharan Kani who is a forest official.

Parappiamma has been able to save a dying variety. However, she is anxious at the fate of her pineapples. She has, till now, worked as a one man army against the invading wild life. She may need help from authorities in helping her to find a suitable solution to keep away the wild life from her farm. Both her life and that of her varieties need protection.

# WHY WE SHOULD TAKE SOIL MORE SERIOUSLY

**W**hen it comes to the sustenance of life on Earth, we often regard water, air, and the sun as the primary pillars that support our existence on this beautiful planet. Yet, one crucial element continues to be overlooked, under appreciated, and understudied: the soil. That's largely due to the common assumption that the soil, just like sunshine, is infinite. While our attention gravitates towards perishable resources like breathable air and drinkable water, the common misconception about soil has led to the startling truth: we are rapidly depleting our liveable soil. What's more interesting is that recent studies have unveiled the profound impact healthy soil

**The depth of the earth's crust extends up to 70 km, but it's the top 5 to 10 inches that host the majority of life.**

can have on making the air purer and the water cleaner. To put things in perspective, it appears that great soil may be the silver bullet we've long been searching for.

## The Soil-Water Relationship

The depth of the earth's crust extends up to 70 km, but it's the top 5 to 10 inches that host the majority of life. This ultra-thin layer, known as topsoil, teems with organic matter and currently faces the highest risk of perishing. Healthy forest soil, for instance, boasts a remarkable 7–10% soil carbon content by weight, equivalent to more than 10 billion bacteria in a mere teaspoon (5g) of soil. But why should we care about this seemingly obscure fact? Because soil carbon directly influences the availability of freshwater. Microscopic organisms in the soil, like soil carbon alchemists, modify its structure at a granular level, aerating it and enhancing its capacity to retain water. In fact, certain studies indicate that a mere 1% increase in soil carbon can contribute to approximately 95,000 litres of water availability per acre. Let's break this down further.

## The Cauvery Example

Consider the contentious Cauvery River, spanning nearly 82,000 square kilometres across three Indian states. Over a 30-year period, the Cauvery basin receives an average annual rainfall of around 108 centimetres. While this might seem abundant, the challenge lies in the fact that most of this rain falls during the monsoon season, which lasts only three months per year. Mathematically, the river should flow for just a quarter of the year, flooding its basin before gradually drying up. Nature, however, has a more efficient design. The excess monsoon water is meant to be absorbed by the soil, which acts as a sponge, replenishing millions of aquifers and springs. It releases the water over time in the form of countless streams that ultimately feed the perennial Cauvery.

Unfortunately, in the last two decades, the soil carbon percentage has plummeted to an average of 0.3% (from roughly 3%), a staggering 90% decrease. This means that the 'sponge' can no longer retain the deluge, resulting in a vicious cycle of monsoon floods and summer water crises. The Cauvery today is more of a chain of stagnant reservoirs than a flowing river. Now, consider what could happen if we managed to restore the average carbon content to its previous 3% level. This would equate to approximately 280,000 litres of additional water per acre throughout the basin, totalling about 5.8 trillion litres of



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increased water availability. This is roughly the amount of water required annually for 100 million people to survive in urban India. The real scenario is more intricate, with variations across the entire Cauvery basin, but this successfully illustrates the profound impact healthy soil has on our access to water.

### **The Natural Air Purifier**

While global warming has captured our attention recently, the world has temporarily shifted its focus to other pressing concerns, like COVID-19. The passionate pleas of activists like Greta Thunberg have led to nations pledging to reduce their carbon emissions. However, experts argue that simply slowing down is not enough; we must change course entirely. The solution, in essence, is carbon sequestration, the act of removing carbon from the atmosphere and storing it in a safe place. It's not as complex as it sounds, as nature has provided us with a powerful, often ignored tool for this task: our forests.

### **Forest - The Carbon Fixers**

Plants are nature's remarkable carbon-sucking machines. They draw carbon dioxide from the air and convert it into living tissue, effectively sequestering carbon.

**It is estimated that a mere 1% increase in soil carbon content can offset all carbon emissions from the past four decades.**

When these plants eventually wither and fall, their stored carbon can remain safely trapped in the soil if it harbours the right microorganisms. Canopy trees, which live for centuries, offer vast potential for carbon sequestration as their tissue holds carbon for extended periods. Furthermore, not all trees in a forest perish at once, ensuring that the carbon emission, if any, into the atmosphere is gradual rather than abrupt. To maximise this process, three key factors must be consistently present: life in the soil, more plants growing than falling, and the ability of those plants to thrive for extended periods. Hence the emphasis is on cultivating perennial forest systems rather than annual crops.

However, when we speak of forests, we aren't referring solely to protected national parks. We are advocating for self-sustaining ecosystems that can provide for their basic needs like nutrition, water,

and air. Whether we harvest food from these ecosystems is inconsequential as long as they maintain a harmonious balance. In fact, if the entirety of the world's agricultural land shifted to food forests, we could potentially support five times more people while continuously increasing soil carbon content. It is estimated that a mere 1% increase in soil carbon content can offset all carbon emissions from the past four decades.

### **Afterword**

It's quite evident that the well-being of the soil and forest systems in one region profoundly affects distant areas. A person in Chennai must care about the soil and forests in Malenadu, South Karnataka, just as a Hyderabad resident should be concerned about the happenings in Adilabad and Nashik. We must abandon the fragmented approach to problem-solving and acknowledge the inter connectedness of nature. It's high time we grasp these interdependent relationships and move beyond mere agreement to take action. While we hurtle towards a point of no return, solutions remain within reach to steer us back to a stable equilibrium, and we must seize this opportunity. Anything less is just a conversation.

# FROM SEEDS TO SUCCESS

## How Data-Driven Farming is Educating Farmers for Higher Yields

The agricultural sector is on the cusp of a profound transformation, and at the core of this transformation, lays the power of data. Precision agriculture, often referred to as data-driven farming, has redefined the landscape of crop and resource management for farmers worldwide. By seamlessly integrating state-of-the-art technologies and data analytics, farmers now have access to a wealth of information. This information empowers them to make smarter decisions, optimize crop vitality, and ultimately, elevate yields.

### What is Precision Agriculture or Data-Driven Farming?

Data-driven farming relies on a range of technological tools to collect and analyze data, enabling farmers to optimize their practices. Here are some of the key components of precision agriculture:

**Sensor Technology:** One of the cornerstones of data-driven farming is the use of sensors. These sensors come in various forms, including GPS systems, drones, soil moisture sensors, and more. They collect real-time data on soil conditions, weather patterns, and crop health. This data is invaluable for making informed decisions.

**Weather Monitoring and Forecasting:** Accurate weather information is crucial for farmers. Data-driven farming incorporates advanced weather monitoring systems and forecasting models. Farmers can access up-to-date weather data, allowing them to plan irrigation and pest control measures more effectively.

**Satellite Imaging:** Satellite imagery provides a bird's-eye view of farmlands. This technology can be used to detect early signs of disease or pest infestations, enabling prompt intervention. Satellite imaging also helps in assessing crop health and growth.

**Law of Diminishing Returns:** Data-driven farming acknowledges

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the principle of the law of diminishing returns. It recognizes that beyond a certain point, adding additional resources such as water, fertilizers, or pesticides does not significantly increase crop yields. Instead, it can lead to increased production costs and potential harm to the environment. Data-driven insights help farmers strike the right balance between resource input and output.

### Benefits of Data-Driven Farming

The adoption of data-driven farming practices comes with a multitude of benefits for both farmers and the agricultural industry as a whole.

Access to real-time data empowers farmers to make informed decisions. They can adjust irrigation schedules, fine-tune fertilization plans, and implement pest control measures precisely as needed thereby boosting yields while reducing waste. A report by the World Economic Forum estimates that the adoption of data-driven farming practices could generate an additional \$2.3 trillion in agricultural output by 2030.

Early detection of diseases and nutrient deficiencies prevents losses by enabling swift corrective actions. By optimizing the use of resources such as water, fertilizers, and pesticides, farmers can reduce their production costs while maximizing profitability. Weather-related risks are a constant concern for farmers. Data-driven insights enable farmers to anticipate and prepare for adverse weather conditions, mitigating losses through timely adjustments.

### Challenges and Future Prospects

Despite the considerable promise it holds, data-driven farming does encounter its share of challenges.

The initial investment in technology and infrastructure for data-driven farming can be high, and these costs often deter many small-scale farmers from adopting data-driven farming practices, potentially creating a digital divide within the agricultural sector. To further complicate matters, data privacy and security concerns also need to be addressed to ensure farmers' trust in sharing sensitive agricultural data. Additionally, subsistence farmers, who form a significant portion of India's agricultural landscape, often



## The future of farming lies in harnessing the power of data to drive success from seeds to harvest.

lack the technical knowledge required for data-driven farming, making comprehensive training programs essential. India's diverse agro-climatic zones further complicate the adoption of data-driven farming, necessitating adaptable precision farming solutions and demanding ongoing monitoring and evaluation efforts. While the regulatory environment for data-driven agriculture is still in its nascent stages, government initiatives aim to address this issue and provide a framework for responsible data use. Finally, convincing farmers to embrace data-driven practices can be met with resistance, as many have deeply ingrained traditional farming methods that they may be reluctant to change.

### Industry Perspective: Sourcing and Linking Farmers with Markets

The challenges notwithstanding, certain industry stakeholders are taking proactive measures to empower farmers towards data-driven farming. Some new age players are undertaking initiatives that involve sharing long-term sowing and harvesting plans with farmers. These are crafted based on historical price and demand trends spanning the past three years. Such a strategic approach aids farmers in optimizing their returns by aligning their crop choices with prevailing market demands.

Additionally, these entities provide

farmers with insights into cultivating crop varieties that are in high demand, ultimately resulting in higher price realizations. For instance, the encouragement to grow distinctive crops, such as yellow watermelon, has demonstrated significant improvements in farmers' income.

Moreover, they advise farmers on cultivating off-seasonal crops, a recommendation rooted in price and demand data analysis. This not only ensures better market prices for agricultural products but also diversifies income sources, reducing dependency on seasonal fluctuations.

These industry players are dedicated to bridging the gap between farmers and consumer preferences. They facilitate the flow of daily-level complaints and customer feedback to farmers, enabling them to make real-time adjustments to their farming practices to better align with market needs. This direct feedback loop proves instrumental in enhancing both crop quality and market suitability.

### Future of Farming

Looking at the outlook, there is no doubt that data-driven farming, or precision agriculture, has the potential to transform the agricultural landscape by providing farmers with the tools and insights needed to optimize their practices. While challenges like cost barriers and data privacy concerns exist, industry players and governments are stepping in to bridge the gap and link farmers with market demands. The future of farming lies in harnessing the power of data to drive success from seeds to harvest. As technology continues to advance, the potential for higher yields and sustainable agriculture practices is within reach for farmers in India, and indeed, around the world.

# WHY DOES THE ADOPTION OF SOIL TESTING REMAIN LOW?

**S**oil testing is a science-based, time-tested tool for assessing soil fertility and nutrient status, offering an effective means for judicious fertilizer use through soil health-based recommendations. However, the adoption of soil testing and the implementation of soil test-based recommendations still remain low among end-farmer users. Adoption, in this context, refers to farmers initiating soil testing and following the recommendations provided post-testing. Several reasons contribute to this phenomenon, and to better understand them, let's explore a few anecdotal farmer stories.

## Lack of Empathy and Farmer-Centric Designs

Vaibhav Deshmukh from Wadegaon, Akola, was motivated to undergo soil testing due to the increasing cost of fertilizers and decreasing productivity. He collected his soil sample and sent it for testing to one of the leading agricultural universities in the region, located about 30 kms from his village. After waiting for about a month, he received his results. In the second-half of the report, the recommendations suggested using single-nutrient fertilizers, such as Urea, MOP, and SSP. However, Vaibhav was specifically looking for recommendations for multi-nutrient fertilizers like DAP or 15:15:15 for his short-duration Soybean crop. Disappointed, he did not bother to review the report again and reverted to his regular practices.

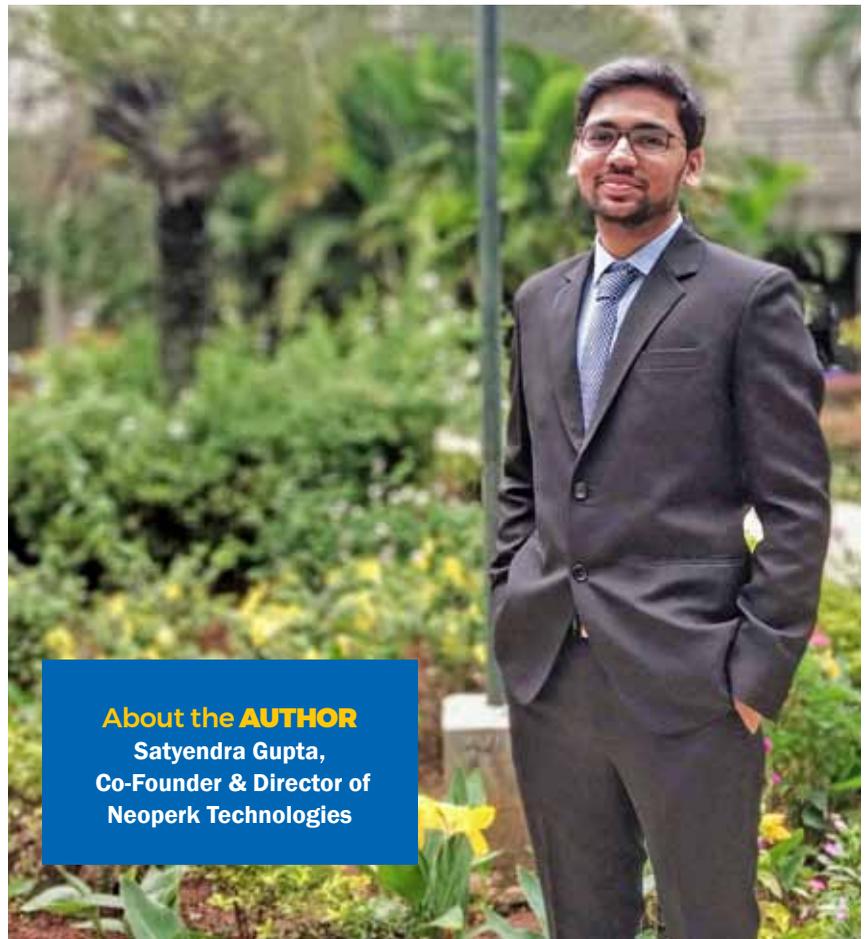
On the flip side, numerous farmers claim that marketing agents from certain companies or organizations collected their soil samples either for free or at a nominal charge but never delivered the reports. Even those who received the reports found

**Alongside alternate testing methods, it is essential to adopt a user-centric and holistic approach to ensure that the benefits of soil testing reach the end-farmer user, creating a positive feedback loop.**

them unhelpful as they recommended only a specific brand of inputs. The challenge with current soil testing services lies in the lack of empathy and farmer-centric designs and processes, leading farmers to believe that soil testing is not effective, resulting in low adoption.

## Different Story

The situation is very different in Nashik, where one of the oldest private, traditional chemical-based soil testing laboratories in the region charges up to Rs. 2000 for soil testing, sends a person for sampling to the



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farmers' fields, and delivers a multi-page report with comprehensive recommendations. They consistently have high demand for soil testing because farmers in Nashik, especially grape growers, have developed trust in soil testing and the benefits derived from their high-quality services. This demonstrates a potential path for replicating the adoption of soil testing and recommendations in other geographies across the country.

However, for nationwide testing for 10 Crore farmers, this may not be a scalable solution, as setting up such state-of-the-art soil testing laboratories can cost approximately Rs. 4-5 Crores with an operational running cost of Rs. 30-40 Lakhs per year for

**The challenge with current soil testing services lies in the lack of empathy and farmer-centric designs and processes, leading farmers to believe that soil testing is not effective, resulting in low adoption**

10,000 samples. Alternate testing solutions, such as chemical-based mini-kits, were developed to address the scalability issue, but they have their limitations. The chemical

reagents for kits are not readily available in the open market and take weeks or even months to get delivered, resulting in testing delays. Users such as FPOs, NGOs, and KVKs also complain about the lack of maintenance and servicing for kits, circling back to the same problem of inadequate service and low adoption among farmers.

Soil testing and soil data have the potential to revolutionize agriculture and address global problems such as climate change and food insecurity. Alongside alternate testing methods, it is essential to adopt a user-centric and holistic approach to ensure that the benefits of soil testing reach the end-farmer user, creating a positive feedback loop.



# MINI TRACTORS IN INDIA

## A Boon for Small-Scale Farmers

**T**ractors have long been used to boost agricultural productivity and efficiency in India, which is known for its wide agricultural terrain and different farming practices. Large tractors have traditionally dominated the market, fulfilling the demands of medium to large-scale farms. However, with the shifting agrarian environment and the changing dynamics of Indian farming, the introduction of mini tractors has resulted in a revolutionary change, particularly for small-scale farmers. Because of their low cost, ease of operation, and suitability for smaller land holdings, these compact and multifunctional machines have grown in favor in recent years.

### Evolution of Mini Tractors in India

The concept of mini tractors in India emerged to cater to the specific needs of small and marginal farmers. Unlike large tractors, mini tractors are designed to be compact, lightweight, and less expensive, making them more accessible to small farmers with limited financial resources. These machines can perform various agricultural tasks like ploughing, tilling, planting, harvesting, and transportation of goods, making them versatile

and suitable for a wide range of farming operations. As small-scale farmers face unique challenges due to smaller land holdings, mini tractors have become a game-changer, empowering them with mechanization and improving their agricultural practices.

### Advantages of Mini Tractors

Mini tractors offer several advantages that have contributed to their increasing popularity among small-scale farmers:

**Affordability:** One of the primary advantages of Mini tractors is their low cost. Because these machines are less expensive than their larger counterparts, small farmers can possess mechanized equipment without experiencing considerable financial obligations. The affordability aspect has been an important motivator of Mini tractor adoption, particularly among farmers with little financial resources.

**Versatility:** Mini tractors are very adaptable for their small size. They are capable of a wide range of agricultural tasks, allowing farmers to use them throughout the cropping cycle. Mini tractors expedite many agricultural activities, such as soil preparation, planting, tending, and harvesting, reducing reliance on manual labor and increas-



Rajesh Patel, Managing Director.  
Captain Tractors

As small-scale farmers face unique challenges due to smaller land holdings, mini tractors have become a game-changer, empowering them with mechanization and improving their agricultural practices.





ing overall efficiency.

**Maneuverability:** The compact design of mini tractors makes them highly maneuverable. They can navigate through narrow pathways and small fields with ease, enabling farmers to work efficiently even in challenging and restricted spaces. This maneuverability is particularly crucial in Indian farming, where many fields have irregular shapes and limited access points.

**Fuel Efficiency:** Because mini tractors typically have smaller engines, they are more fuel efficient than larger tractors. This not only lowers farmers' operational expenses, but it also helps to reduce greenhouse gas emissions, boosting sustainable farming practices.

**Lower Maintenance Costs:** The simplicity of design and the use of relatively basic components contribute to lower maintenance and repair costs for mini tractors. Small-scale farmers, who may not have access to advanced technical expertise or sophisticated service centers, find these machines more manageable in terms of maintenance.

### Impact on Indian Agriculture

The introduction of mini tractors has had a significant impact on Indian agriculture, particularly for small-scale farmers. By providing small-scale farmers with mechanized equipment, mini tractors have significantly increased the productivity of small farms. These machines allow farm-

**The affordability aspect has been an important motivator of Mini tractor adoption, particularly among farmers with little financial resources.**

ers to complete tasks faster and more efficiently, leading to higher crop yields and increased agricultural output.

Traditional labour-intensive processes like ploughing and tilling required a significant amount of time and effort. These chores may be accomplished quickly and efficiently with the help of mini tractors, saving farmers important time during critical agricultural activities.

Increased efficiency and reduced labor requirements have benefited small-scale farmers' livelihoods. Mini tractors save time and resources by automating multiple chores, allowing farmers to diversify their crops and engage in other income-generating activities.

The availability of Mini tractors, as well as the resulting increase in agricultural efficiency, has helped to limit rural-to-urban migration. As farming grows more productive and profitable, more young people seek employment in agriculture, contributing to the long-term viability of rural communities.

### Government Initiatives and Support

Recognizing Mini tractors' potential for increasing agricultural output and assisting small-scale farmers, the Indian government has introduced a number of measures and subsidies to encourage their use. Among these initiatives are:

The government has established the PMKTY (PradhanMantriKisan Tractor Yojana) to provide farmers with financial help and subsidies for the purchase of tractors, including Mini tractors. This scheme intends to improve mechanization in Indian agriculture and provide access to inexpensive tractors to small and marginal farmers. The government provides various subsidies and tax benefits to manufacturers, dealers, and farmers to promote the manufacturing, purchase, and use of mini tractors. These incentives reduce the overall cost of ownership and encourage farmers to invest in mini tractors.

The government has been encouraging domestic manufacturing of agricultural machinery, including mini tractors, by providing support to local manufacturers.

### Revolutionizing Indian Agriculture

Mini tractors have emerged as a boon for small-scale farmers in India, revolutionizing the way agriculture is practiced in the country. Their affordability, versatility, maneuverability, fuel efficiency, and lower maintenance costs have transformed traditional farming methods, leading to increased productivity, improved livelihoods, and reduced labor dependency.

The impact of mini tractors on Indian agriculture has been significant, curbing rural-to-urban migration and empowering farmers with access to mechanization. However, challenges like regional adaptability, access to finance, and after-sales service need to be addressed to ensure the widespread adoption of mini tractors. As these machines continue to gain popularity, collaborative efforts from manufacturers, stakeholders, and policymakers will be essential in realizing the full potential of mini tractors for the benefit of Indian farmers and the agricultural sector as a whole.

# CARBON FARMING SHOULD BE INDIA'S GIFT TO THE WORLD



**S**oil is an important food source for all living things on Earth because it provides important nutrients and helps plants grow, which in turn sets the base of the food chain. The role of soil in filtering pollutants and stopping erosion is also very important. When the soil is healthy, all living things, from the tiniest microbes to the biggest animals, can grow and stay alive.

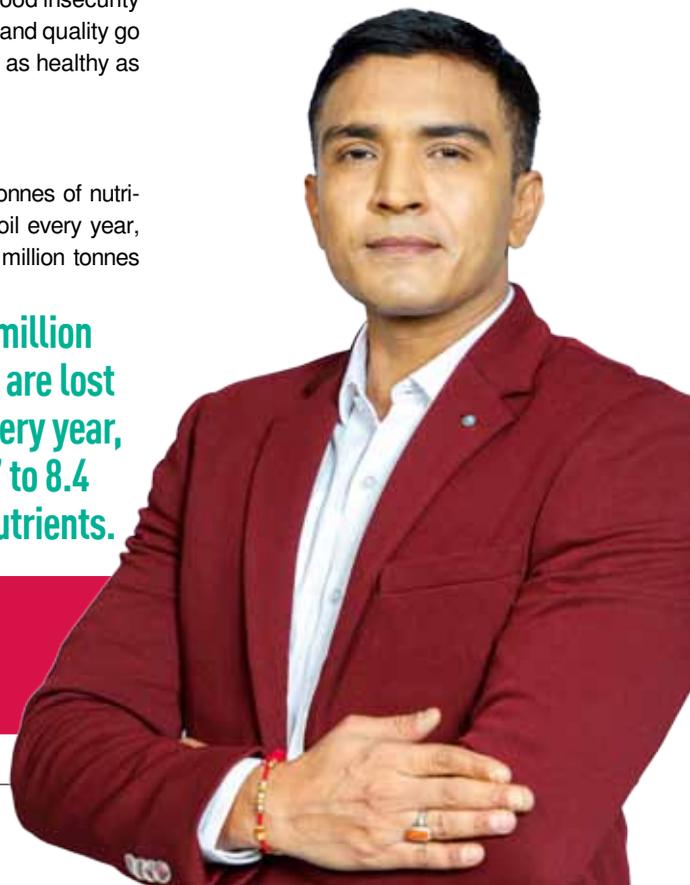
Loss of nutrients in the soil, also known as soil degradation, is a worldwide problem that threatens both food security and the long-term health of the environment. Not having enough of important nutrients like nitrogen, phosphorus, and potassium makes the soil less fertile and less able

to support farming. Higher food insecurity could happen if crop yields and quality go down because the soil isn't as healthy as it used to be.

## Land Degradation

An estimated 16.4 million tonnes of nutrients are lost from India's soil every year, which is about 5.37 to 8.4 million tonnes

**An estimated 16.4 million tonnes of nutrients are lost from India's soil every year, which is about 5.37 to 8.4 million tonnes of nutrients.**



## About the **AUTHOR**

**Shailendra Singh Rao,**  
Climateur and founder of Creduce India Pvt Ltd.

## Carbon Credits

It is possible for farmers to make more money through carbon farming by creating carbon credits. The ability to reduce the release of a certain amount of carbon dioxide into the atmosphere is shown by carbon credits. Farmers can sell these carbon credits to businesses that want to offset their carbon emissions. This gives farmers another way to make money.

of nutrients. Heavy tillage, monoculture farming, and using too many fertilizers and pesticides can deplete nutrients in the soil and damage its structure. Deforestation removes the protective layer of plants that keeps soil from washing away and nutrients from being lost. Overgrazing by livestock can lead to nutrient loss by compacting the soil, breaking down organic matter, and making erosion worse. Extreme weather, like floods and droughts, can mess up the cycling of nutrients and speed up soil degradation caused by climate change.

## Effects on Global Food Security

It gets harder to meet the growing demand for food because of the loss of soil nutrients, which lowers the amount of food produced per unit of land area. Also, crops grown in soil that doesn't have enough nutrients may be smaller, have less nutrition, and be more likely to get pests and diseases. It's possible that this will result in food that isn't good enough to meet its nutritional needs.

When soil nutrients are lost, agricultural productivity goes down. This can cause food prices to rise, which can be hard on families' budgets and make food insecurity worse, especially in developing countries.

## Carbon Farming

Carbon farming, which is another name for regenerative agriculture, is a set of methods used to improve the health of the soil and remove carbon from the air. It offers a possible way to lessen the bad effects of climate change, improve food security, and make soil healthier. In order to get farmers to switch to carbon farming, the Indian government has also started programs that recognize how important it is.

Carbon farming methods might make the soil more fertile, increase crop



production, and lessen the bad effects of climate change. Soil carbon sequestration can be greatly increased by using carbon farming methods such as cover crops, applying compost, and no-till farming. This helps with the fight against climate change. By storing carbon in the soil, these practices help lower greenhouse gas emissions, which play a big role in keeping the Earth's temperature stable.

Carbon farming also improves the structure of the soil, the cycling of nutrients, and the amount of organic matter in the soil, all of which improve soil health. This makes it easier for plants to get nutrients, lets more air into the soil, and keeps water in the soil better, all of which help crops grow and produce more.

## Government Interventions

As its main goals, the National Mission on Sustainable Agriculture (NMSA) wants to encourage environmentally friendly farming methods, make the soil healthier, and boost farm output.

Soil health cards distributed to farmers bear information on nutrient deficiencies in the soil. Farmers can use this information to make smart decisions about how to manage the nutrients in the soil.

Prakritik Krishi Protsahan Yojana (PPK) encourages organic farming methods, such as carbon farming, to improve the health

of the soil and cut down on the use of chemicals.

The Carbon Capture and Storage (CCS) program's goal is to speed up the creation of technologies that can store carbon dioxide from industrial sources underground. Carbon farming can be an extra part of this program because it stores carbon in the soil naturally.

## Problems can be Fixed

Many farmers don't fully understand the benefits and how to use carbon farming. There needs to be more education and awareness campaigns to get farmers to use these methods and get the word out. Farmers may need technical help and direction in order to use carbon farming techniques effectively. By giving farmers training and support, you can help them get past technical problems and get the most out of your carbon farming efforts.

It is important to create a stable market for carbon credits so that farmers have a good economic reason to use carbon farming methods. Setting up clear pricing systems and making sure everyone has equal access to carbon markets will be very important. For carbon farming to become more popular, financial help and government policies can make a big difference. Farmers may be more likely to use carbon-sequestration techniques if they are given money for research, subsidies, or tax breaks.

## Summing Up

India could improve food security, soil health, and efforts to fight climate change all at the same time by using carbon farming methods. This would lead to a better and more stable future for the country. To sum up, carbon farming could be a way to solve India's problems with soil degradation, food security, and climate change, all of which are connected. India could set an example for a profitable, resilient, and environmentally sustainable agricultural industry that protects food security, the environment, and the economic well-being of future generations by implementing carbon farming practices and resolving the problems that come with them.

# EXPLORING FINANCIAL SOLUTIONS FOR SMALL HOLDERS



**C**redit is used as an instrument to raise the capital required to increase farm productivity, income and welfare of farmers, particularly small and marginal farmers who lack the capital to buy necessary inputs in time for agricultural operation. Farmers with a larger farm size have shown a higher probability of accessing credit facilities, whereas small and marginal farmers have the least probability of credit access. Nevertheless, credit access, overall, has significant positive effects on farm investments, such as land-building, livestock and machinery. It also has a significant positive effect on the farm revenue expenditure, including the expenditure on seeds, machinery, labour, irrigation, plant protection chemicals and livestock inputs. As a result, credit access has an incremental effect on farm income per hectare, livestock income and monthly consumption expenditure.

## Agricultural Credit and Financial



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## Inclusion in Farming Sector

Agricultural credit becomes a strong force to enhance the production level, productivity and income of the farmers, which play important role to alleviate rural poverty. In the last 10 years, agriculture credit increased by 500% but has not reached sizeable population of small and marginal farmers. Despite an increase in agri-credit, even today, 95% of tractors and other agri-implements sold in the country are being financed by NBFCs.

## Microfinance

The credit needs of poorer households, in rural as well as urban areas are generally overlooked by mainstream banking and financial institutions due to their structural compulsions as well as nature of the needs. Microfinance sector is best placed to cater to such credit needs of this segment of the population as it provides small loans, without collaterals irrespective of the purpose at their doorstep services.

MFIs currently operate in 28 States, 5



small and marginal farmers by leveraging technology such as satellite imagery, soil testing and climate forecasting tools, warehouse-sourced loans among others. Some Ag-Fintech start-ups that provide financial products and services include Sagri, Samunnati, Arya, Jai Kisan, DeHaat, FarMart, Kissht and Bijak. The past five years have seen about 3,116 start-ups registered in the food and agriculture sector in the country, registering 25-30% growth on a year-on-year basis. Agri-fintech start-ups are plugging in the gaps to help small and marginal farmers in accessing financial products, aggregation of produces, marketing of commodities etc.

### Technology as a solution – Way Forward

With mobile phone penetration among agricultural households in India being as high as 89.1%, the prospects of aggressive efforts to improve institutional credit delivery through technology-driven solutions can reduce the extent of the financial exclusion of agricultural households.

Farmers have been able to avail loans themselves through mobile phone apps. These apps use satellite imagery reports which capture the extent of land owned by farmers in States where land records are digitised. Otherwise, farmers have to produce the certified land record copy from the revenue department, which is much time consuming.

Other steps are reforming the land leasing framework and creating a national-level agency to build consensus among States and the Centre concerning agriculture credit reforms to fill the gap and reach out to the most number of small and marginal farmers.

The way forward is to empower small and marginal farmers by 'giving them direct income support on a per hectare basis rather than hugely subsidising credit. Streamlining the agri-credit system to facilitate higher crop loans to FPOs of small farmers against commodity stocks can be a win-win model to spur agriculture growth.

*\*Views expressed are that of the author*

**With mobile phone penetration among agricultural households in India being as high as 89.1%, the prospects of aggressive efforts to improve institutional credit delivery through technology-driven solutions can reduce the extent of the financial exclusion of agricultural households.**

UTs and 602 plus districts in India. There are 213 MFIs with a branch network of 22,428. Ashirvad has the highest number of branches (1525) followed by Credit Access Grameen (1164) and Spandana (1049). Together they have reached nearly 450 lakh clients with a total loan outstanding of Rs.1,35,099 crore under micro credit. The loan outstanding per borrower stood at Rs.20,789/- and 96% of loans were used for income generation purposes.

MFIs generally have three kinds of delivery models under Gross Loan Portfolio (GLP). Of this, JLG model is the predominant one with 78% share, followed by SHG model (17%) and Individual lending (5%). An analysis of the loan portfolio held by reporting MFIs under different sub-sectors of income generation loans indicate that agriculture loans are predominant at 41% followed by animal husbandry loans at 19%, trading at 12% and Agro-based enterprises at 3%.

### Farmer Producer Organisations

FPOs play a crucial role in empowering small and marginal farmers by providing better market access, resources, and knowledge sharing. FPOs are organisations that make them more efficient buyers of agricultural inputs, and more effective sellers of their products to fresh food wholesalers, retailers and large corporates sourcing raw materials.

With typical holdings of less than one hectare, farmers (especially lower-income women farmers) cannot individually afford

to invest in mechanisation or technology to enhance productivity, procure key inputs at a low price, nor directly access buyers. Aggregation through FPOs is the only feasible option left for farmers to enhance their bargaining power and accrue more value. There are more than 8000 registered FPOs in India, formed by various agencies like SFAC (898), NABARD (3904), CSS (2257).

### Ag-FinTech Start-ups for financing Small holders

Complex policy patterns and lack of loan access, provide an opportunity for Ag-Fintech start-ups to provide credit to

# PROMISING AMENDMENTS FOR DEGRADED SOILS



**A**pproximately 60% of total agricultural land of India area is degraded. Poor agricultural practices, such as overgrazing, deforestation, pollution–contamination, irrigation–induced salinization, and desertification, have increased soil degradation since the beginning of time. Soil sodicity is an environmental issue that contributes to crop production loss and land degradation. Sodic and specific ions toxicity

(presence of excess  $\text{Na}^+$  and carbonate and bicarbonates) in the soil exchange and solution phases limit the agricultural output because they negatively affect soil

structure and nutrient dynamics. Therefore, the amount of soluble and exchangeable  $\text{Na}^+$  present in soil magnifies the sodicity induced damage in soil.

**Soil sodicity is an environmental issue that contributes to crop production loss and land degradation.**

## Reclamation of Soil Sodicity

Sodicity–affected soils require specific strategies for management and restoration in order to maintain their long–term productivity. Approximately 618 million hectares of land globally are affected by sodicity. Sodic soil usually contains a dis-

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**Sludge and city waste compost (CWC) produced from municipal waste can be used to meet the needs of plants for N and other important nutrients. Sole application of gypsum during sodicity reclamation slows down the availability of N and P.**

proportionately large amount of exchangeable Na and an excess of soluble electrolytes viz., Na<sup>+</sup>, CO<sub>3</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup>. For healing sodicity an external supply of Ca<sup>2+</sup> or mobilization of native calcite are the ways. Therefore, deteriorated sodic and saline-sodic soils might be put under cultivation after adoption of physical, chemical, biological, and cultural reclamation techniques. Approaches for sodicity management using different amendments are: conventional amendments; industrial wastes and futuristic amendments. Mineral gypsum, Phosphogypsum and Pyrite form the conventional amendments.

### Industrial waste

Fly-ash is the residue in thermal power plant furnaces and the low pH, nutritional content and Ca<sup>2+</sup> supplying liming ability helps for sodicity reclamation. However, presence of certain metal(oids) is a concern for large scale adoption for sodicity reclamation.

Distillery spent wash refers to the leftover liquid waste generated during the manufacturing of alcohol. The acidic nature of these by-product and presence of organic matter and nutrients like N, P, K, and Ca helps in reclaiming and boosting the fertility of sodic soil.

### Futuristic amendments

Extremely reactive, sulfuric acid, neutralizes soluble CO<sub>3</sub><sup>2-</sup> and HCO<sub>3</sub><sup>-</sup> and mobilises the calcium carbonate (CaCO<sub>3</sub>) present in sodic soil and release Ca<sup>2+</sup> insitu in soil. Marine and FGD gypsum are also useful.



**Approximately 618 million hectares of land globally are affected by sodicity.**

### Manures, city waste compost and sewage and sludge

Cattle dung and chicken litter are the readily available organic nutrient sources use as fertilizers supplement. Poultry manure

increases the cation exchange capacity and facilitates for adsorption of Ca<sup>2+</sup>/Mg<sup>2+</sup>/K<sup>+</sup> than Na<sup>+</sup>. Sludge and city waste compost (CWC) produced from municipal waste can be used to meet the needs of plants for N and other important nutrients. Sole application of gypsum during sodicity reclamation slows down the availability of N and P. Hence, a conjunctive application of gypsum and CWC compensates the N and P deficiency and meet the nutrition demand in sodic soil reclamation.

### Acidified biochar and nano-scale materials and polymers

Solid carbonaceous residue biochar enhance salt-adsorption, decreases soil pH, enhanced photosynthesis and reduces Na<sup>+</sup> uptake in crops under salt-stress conditions. Nanoscale and polymer-based compounds like polyacrylamide are also promising amendments.

### Microbial formulations

Arbuscular mycorrhizae fungi (AMF) generates organic acids and glomalin. These organic compounds chelate heavy metals, enhance carbon sequestration, prevent soil erosion, and stabilize soil macro-aggregation leads to improvement in soil health. AMF improves the structure of the soil as AMF mycelia hyphae facilitates formation of soil aggregations. AMF is essential for increasing the P availability in soil through synthesis of phosphatase enzymes. PSB also secretes organic acids siderophores, gluconic acid, and ketogluconic acid that help the mineralization of organic P in soil.

# THE KEY TO FOOD SECURITY

## *Soil Testing for Sustainable Agriculture*

In a world where the global population is expected to reach nearly 10 billion by 2050, the pressure on our agricultural systems to produce enough food is greater than ever. Achieving food security, the state in which all people have consistent access to enough safe and nutritious food to maintain a healthy and active life, is a pressing concern. However, this goal is intrinsically tied to the health of our soils, and the solution to this challenge lies in soil testing for sustainable agriculture. Soil testing is not merely a technicality but a vital practice that ensures both nutrition for the crops and food security for the people.

### **Understanding the Importance of Soil**

Soil is a precious resource that is often overlooked. It's not just dirt beneath our feet; it is the foundation of our food system. Healthy soil is a living ecosystem, teeming with microorganisms, minerals, and organic matter. It serves as a home for plants, a reservoir for water, and a

source of essential nutrients. These nutrients are absorbed by plants and, in turn, consumed by humans and animals. Hence, the quality of soil directly affects the quality of the food we grow.

### **Challenges to Food Security**

Several factors contribute to the challenges of food security:

**Rapid Population Growth:** As the global population increases, so does the demand for food. To meet this demand, agriculture must produce more, but without harming the environment.

**Climate Change:** Climate change is causing unpredictable weather patterns, which can disrupt agricultural practices and reduce yields.

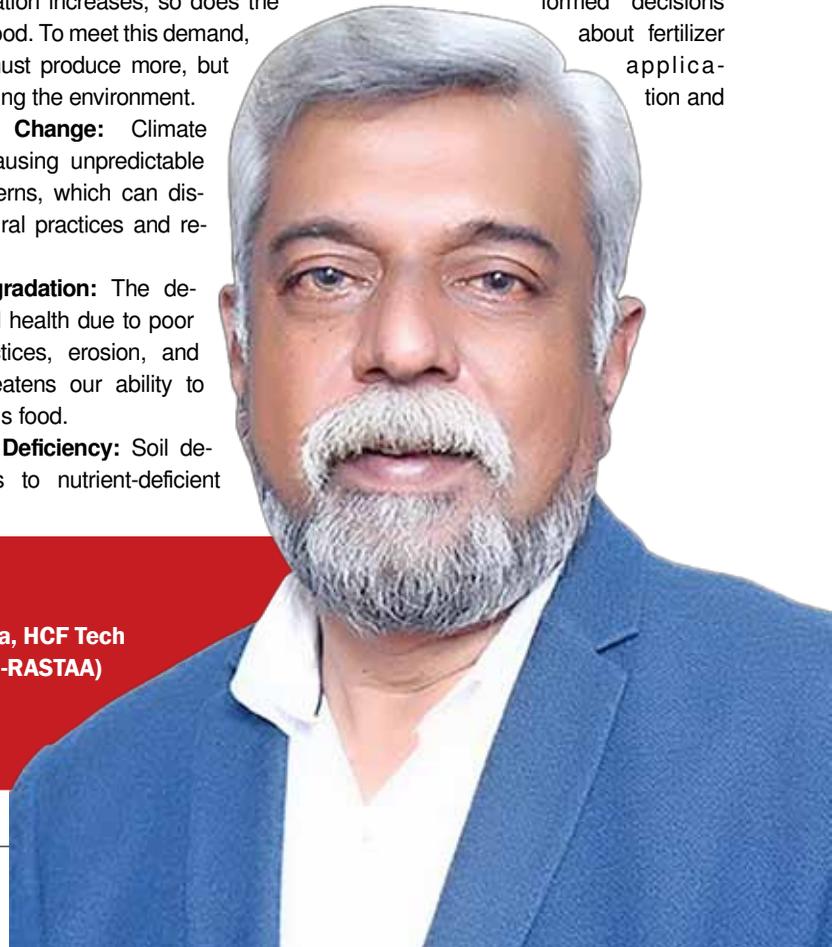
**Soil Degradation:** The depletion of soil health due to poor farming practices, erosion, and pollution threatens our ability to grow nutritious food.

**Nutrient Deficiency:** Soil depletion leads to nutrient-deficient

crops, which can result in health issues for those who rely on these foods.

### **The Role of Soil Testing**

Soil testing is a fundamental practice that can address many of these challenges. It involves analyzing soil samples to determine their nutrient content, pH level, and overall health. This information is critical for farmers, as it helps them make informed decisions about fertilizer application and



### **About the AUTHOR**

Melind Deshpande, Founder and CEO of BhoomiSeva, HCF Tech Private Limited and distributor for Bhu-Vision (Krishi-RASTAA) which is an IOT based automated soil testing and agronomy advisory platform



crop selection.

**Optimising Fertilizer Use:** By knowing the nutrient content of the soil, farmers can apply the right type and amount of fertilizers, reducing waste and environmental impact.

**Preventing Overuse of Chemicals:** Unnecessary or excessive fertilizer application can lead to soil degradation and water pollution. Soil testing prevents these harmful practices.

**Crop Selection:** Soil tests guide farmers in selecting the most suitable crop varieties for their specific soil conditions, enhancing crop productivity.

**Early Detection of Problems:** Soil tests can identify issues like nutrient deficiencies or high soil acidity before they severely impact crop health.

### Promoting Sustainable Agriculture

Sustainable agriculture is the key to ensuring long-term food security while preserving our environment. By promoting

**Healthy soil is a living ecosystem, teeming with microorganisms, minerals, and organic matter. It serves as a home for plants, a reservoir for water, and a source of essential nutrients**

sustainable agricultural practices, we can maintain and improve soil health, ensuring that it continues to provide us with nutritious food for generations to come. Here's how soil testing contributes to sustainable agriculture:

**Reducing Environmental Impact:** Proper soil testing and nutrient management minimize nutrient runoff and soil erosion, which can harm nearby water bodies and ecosystems.

**Preserving Biodiversity:** Sustainable

agriculture, driven by soil health, supports a rich and diverse ecosystem that benefits not only crops but also the environment as a whole.

**Economic Viability:** By optimizing resources and crop selection through soil testing, farmers can enhance their long-term economic sustainability.

The importance of soil testing for sustainable agriculture in the context of nutrition and food security cannot be overstated. As we face the challenges of a growing global population, climate change, and soil degradation, it is crucial that we prioritize the health of our soils. Soil testing empowers farmers to make informed decisions, reduce environmental impact, and promote sustainable agriculture. By investing in our soils, we invest in our future, ensuring that we can continue to feed the world in a way that is environmentally responsible and nutritionally sound. Food security is a complex challenge, but it starts with the very ground beneath our feet – the soil.

# SUSTAINABLE PALM 2023

The Oil Palm is very tropical  
And no one thought it topical  
To grow it in higher latitudes.  
But we have changed attitudes.  
Oil Palm requires constant rain.  
In India this was cause for pain.

Some months are cold, some months  
are dry,  
So many thought this would not fly.  
But the secret is good irrigation.  
The yields now meet expectation.  
The seasonal swing is very wide.  
And this for us is the downside.  
But then the higher insolation  
Is a partial consolation.

More male flowers are also found.  
Fruit bunch development is very sound.  
The summer yields are very high  
And so Oil Palm is worth a try.  
In fact compared to global yields  
We reach one third in Soya fields.

But in Oil Palm, I must mention  
That with the help of good extension  
On small holdings our yields are fair  
And with other lands they can compare.  
And so Oil Palm can entice  
Land from Mango, Coconut and Rice,  
Which the farmers choose to spurn  
For Oil Palm's good, sustained return.  
In India we switch from crop to crop.  
So forest area doesn't drop.

We do not choose to slash and burn.  
And if we cut we plant in turn.  
With Oil Palm too we'll ensure  
Good practices will endure.  
It's the policy in our nation  
To avoid peat lands and deforestation.  
We'll practice water conservation  
By using drip irrigation.  
And controlling GHG emission  
Will be our abiding mission.

As the Oil Palm steadily grows  
In the early years everyone knows  
Much carbon is captured in the wood.

In later years it's understood  
The carbon capture would be less.  
But some there would be, I'd like to  
stress.

We will always closely work  
With our farmers and never shirk  
In new knowledge acquisition.  
Helping our farmers is our mission.

Our farmer practices we can assess  
Thanks to our useful FMS.  
The Farmer Management System's nice  
It helps provide good advice.  
Yields increase, the costs decline  
The farmer practices are fine.  
Both soil and leaf are analysed.  
Good insights are realised.  
Our farmers are then made aware.  
As all these insights we carefully share.  
Another benefit of course  
Is traceability to source.

On this much effort has been spent.  
We have achieved 100 percent.  
Of course to implement this scheme  
We have our extension team.  
150 is now their strength  
And they will go to any length  
To help the farmers in every way.  
The yields improve day by day.  
Good advice is always sought.



**Nadir Godrej,**  
Chairperson of Godrej Agrovet

Sustainable practices are taught.  
We always like to stay in touch

After all there is so much  
That we can share through our app.  
We can quickly fill a gap.  
The users are clearly identified.  
Tailor made solutions are supplied.  
High yielding seedlings will be supplied  
Many experiments will be tried.  
At GAVL, I should mention  
Sustainability covers every dimension.  
And indeed it is our goal  
To have robust internal control.  
On geomapping we are bent.

We have achieved 90%.  
Oil Palm indeed, can be sustainable  
The goal for us is attainable.  
After studying RSPO  
As well as ISPO, MSPO  
For India IPOS was conceived  
The Standard has been well received.  
It is the standard that we use.  
Last year's assessment made good  
news.  
The many criteria that they fix  
Amount to as many as 76!  
Our rating we were told  
Was 94% level gold!  
But we of course will aspire  
To go higher and higher!

Now Indian output's bound to grow  
With the new policies we can show  
Progress of a substantial kind  
Till then of course you will find  
Immense imports from SE Asia  
From Indonesia and Malaysia.  
But we should have no fears  
In about 20 years  
As our farmers get efficient  
India will be self sufficient.  
Thanks to innovation and constant toil  
We won't need to import oil.

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