Trust for Advancement of Agricultural Sciences (TAAS)

Brainstorming Session on 'Regenerative Agriculture for Soil Health and Environmental Security'

chnology Landscape for Enhancing S Health in Regenerating Agriculture

Ashok K. Patra

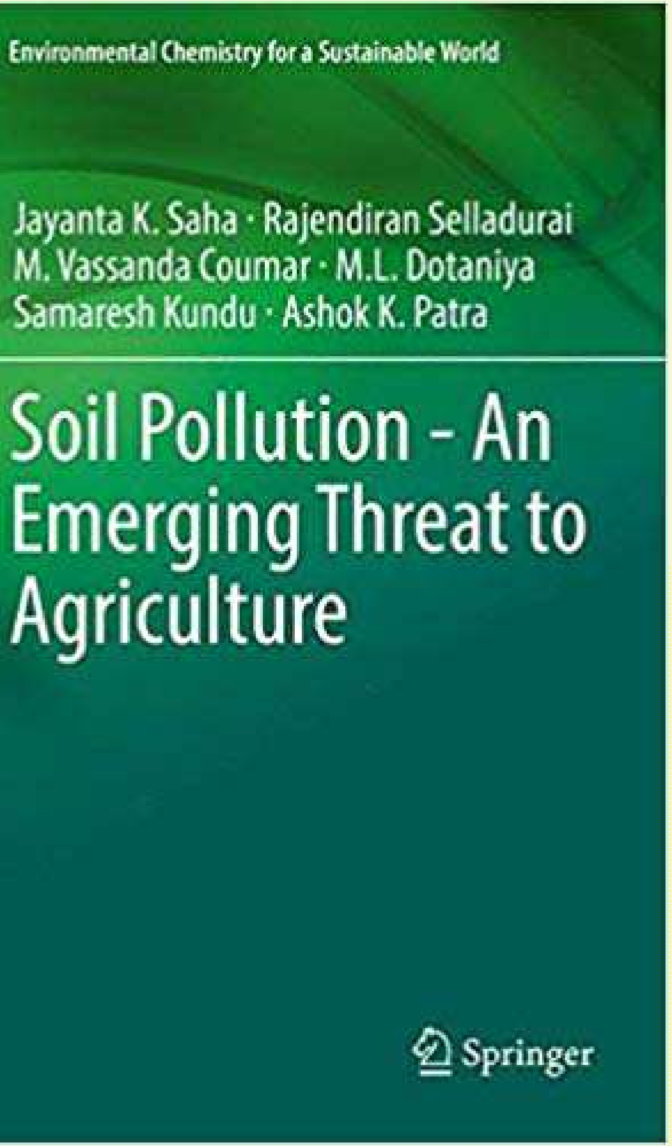
ICAR-Indian Institute of Soil Science
Bhopal

Soil under severe threats !!!

Only 60 years of far
left if current rate of
degradation conti
(FAO)

We are sleepwalking
a crisis of agriculture

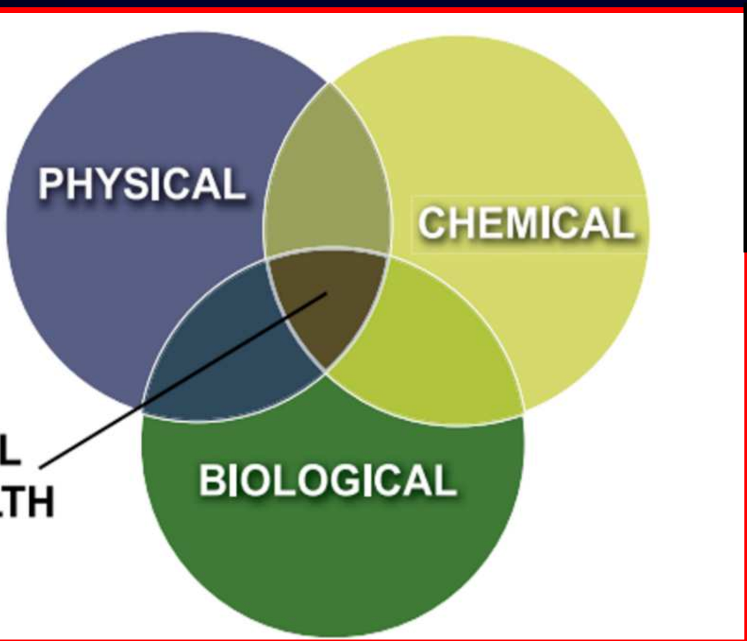
Increasing Soil Pollution



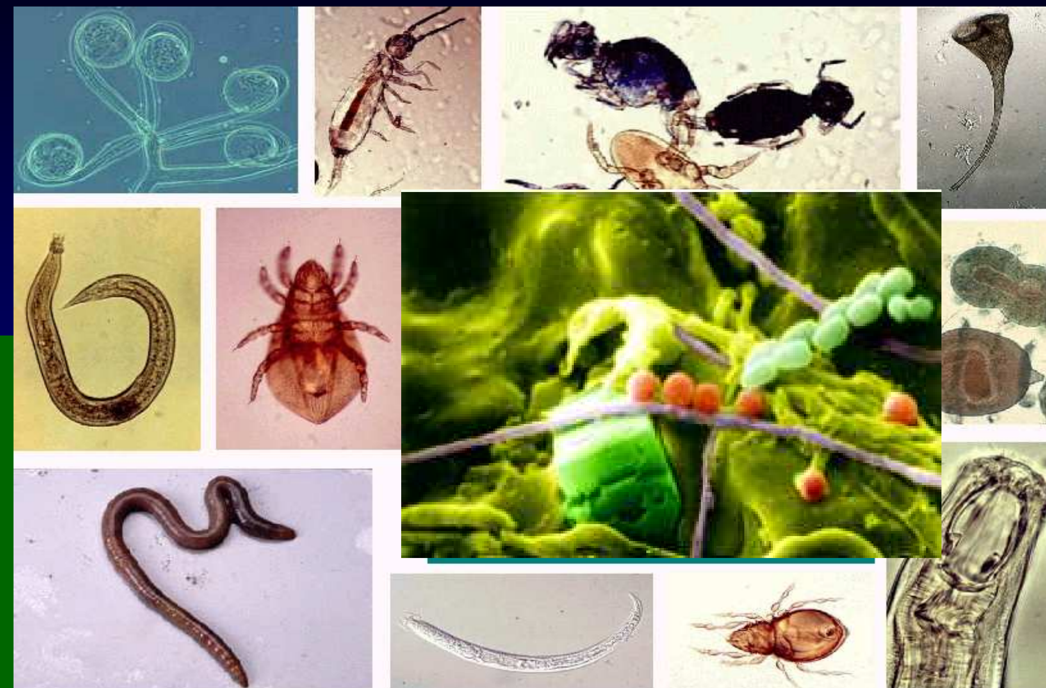
- Solid and liquid wastes contaminating land with salts, heavy metals and organic pollutants.
- India generates >2 mt e-wastes/yr.
- >10 mt of plastic wastes/yr.
- COVID-19: Experts raise alarm about soil and water contamination (*Mid Day, 17 Dec. 2020*).

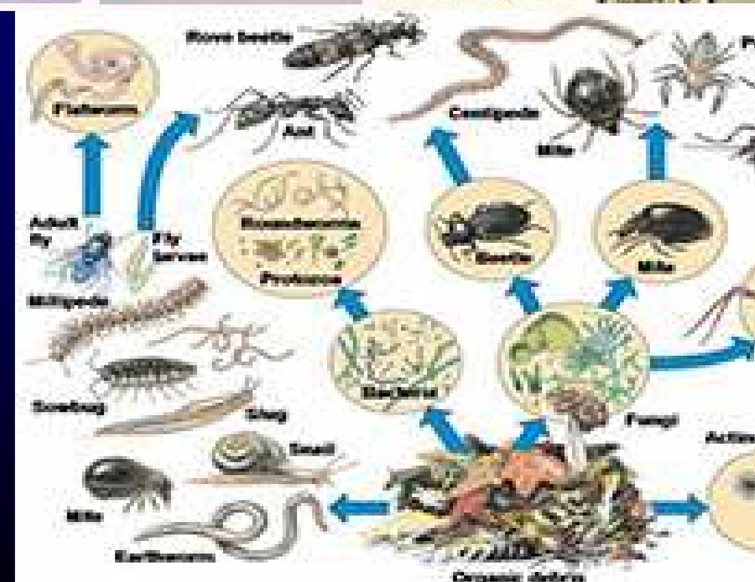
Pollution of Water Bodies

Declining soil health & biodiversity



1 teaspoon healthy soil may contain 10^4 species of bacteria. 100 m bacteria.





health: "The continued capacity of soil to function as a vital system, within ecosystem and land-use boundaries, to sustain gical productivity, maintain the quality of air and water onments, and promote plant, animal, and human health." (Doran 1996: Adv. Agron. 56).

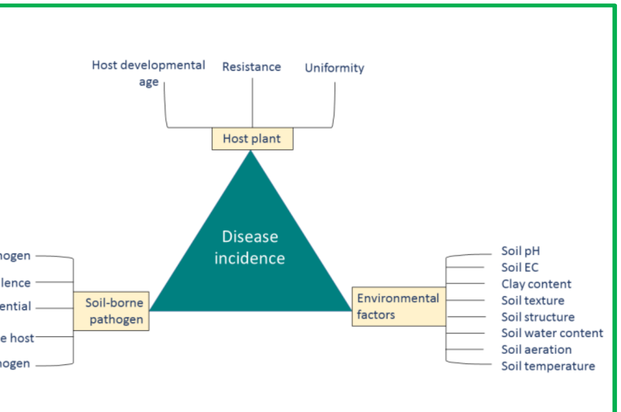
good soil health is key to sustainability of roduction, farmers' profits, and entire ecosystem hain covering animal and human health

Disease-Suppressive Soils—Beyond Food Production

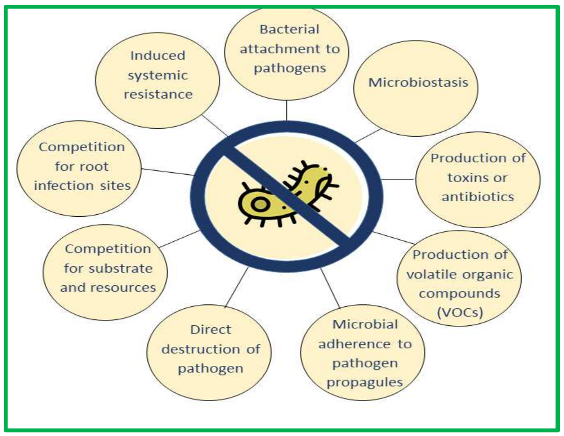
Soil disease suppression is the reduction in the incidence of soil-borne diseases even in the presence of a host plant and inoculum in the soil.

The beneficial microorganisms employ some specific functions such as antibiosis, parasitism, competition for resources, and predation.

The current trend of “ecological intensification” of farms demands a promising crop protection/production with environmentally friendly practices such as maintaining and promoting disease-suppressive soils

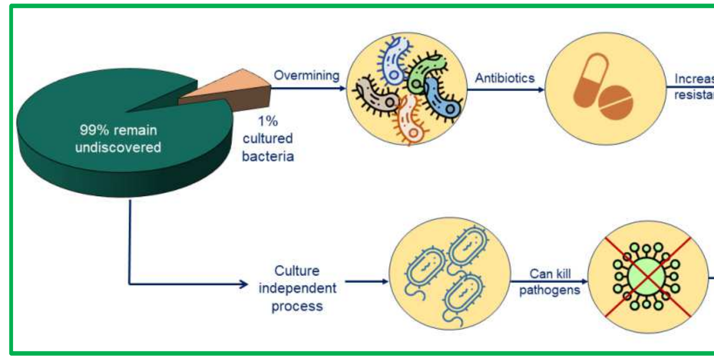


ept of soil disease triangle with main ponents and their respective factors

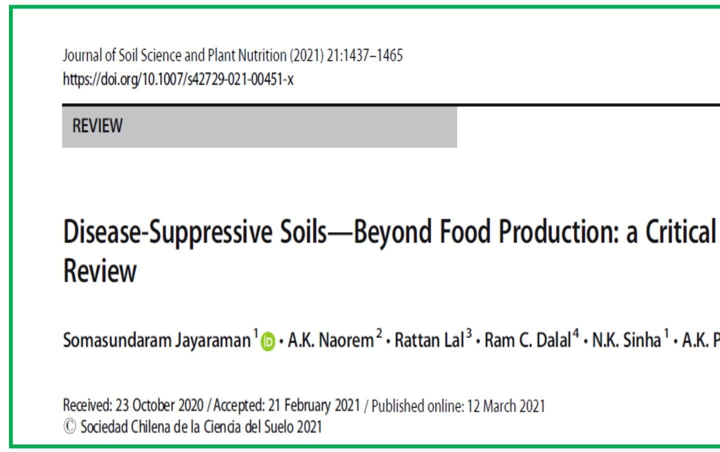


Possible mechanisms of disease-suppressive soils—a close view

Unraveling soil microbes for new antibiotics



The need for the discovery of new antibiotics uncultured portion of soil microbes


Journal of Soil Science and Plant Nutrition (2021) 21:1437–1465
https://doi.org/10.1007/s42729-021-00451-x

REVIEW

Disease-Suppressive Soils—Beyond Food Production: a Critical Review

Somasundaram Jayaraman[1] · A.K. Naorem[2] · Rattan Lal[3] · Ram C. Dalal[4] · N.K. Sinha[1] · A.K. P

Received: 23 October 2020 / Accepted: 21 February 2021 / Published online: 12 March 2021
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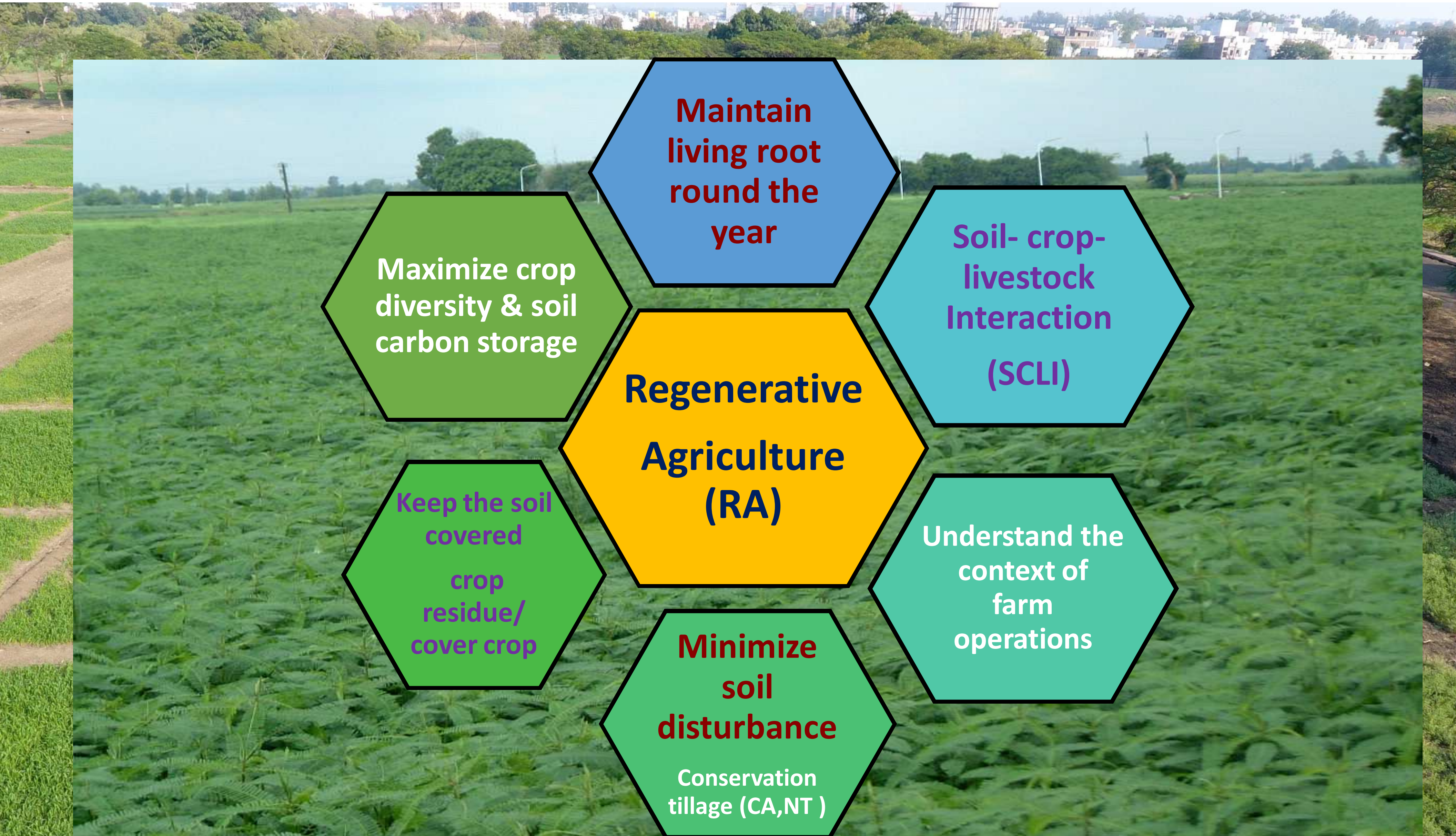
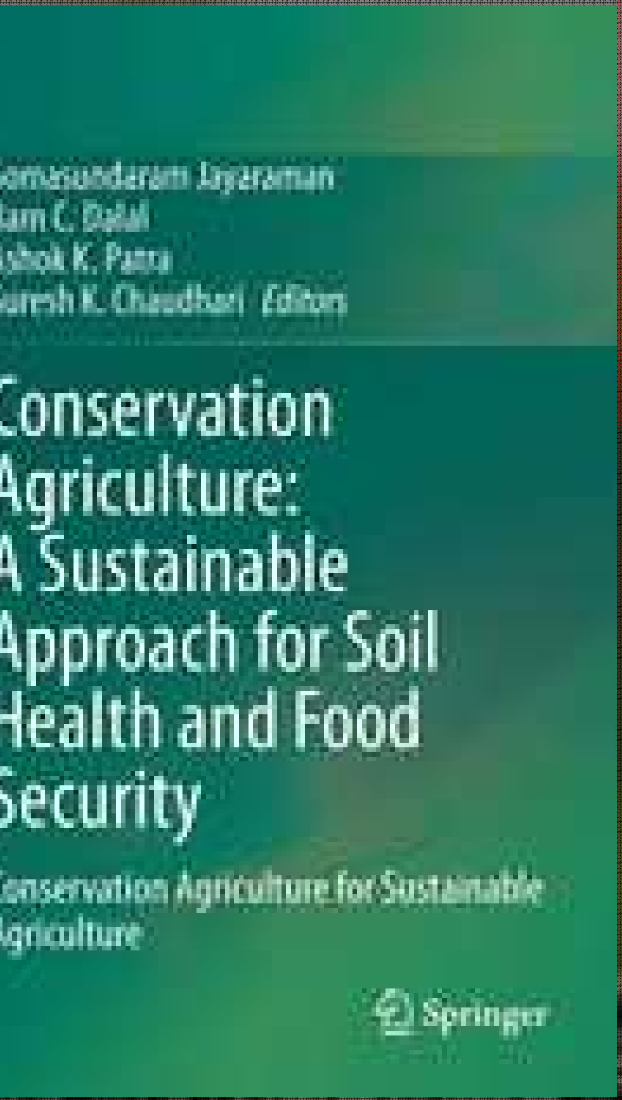


To revert land degradation (soil protection); to maximize crop productivity per unit area; to enhance carbon storage – soil biodiversity, soil health; and to increase ecosystem services.

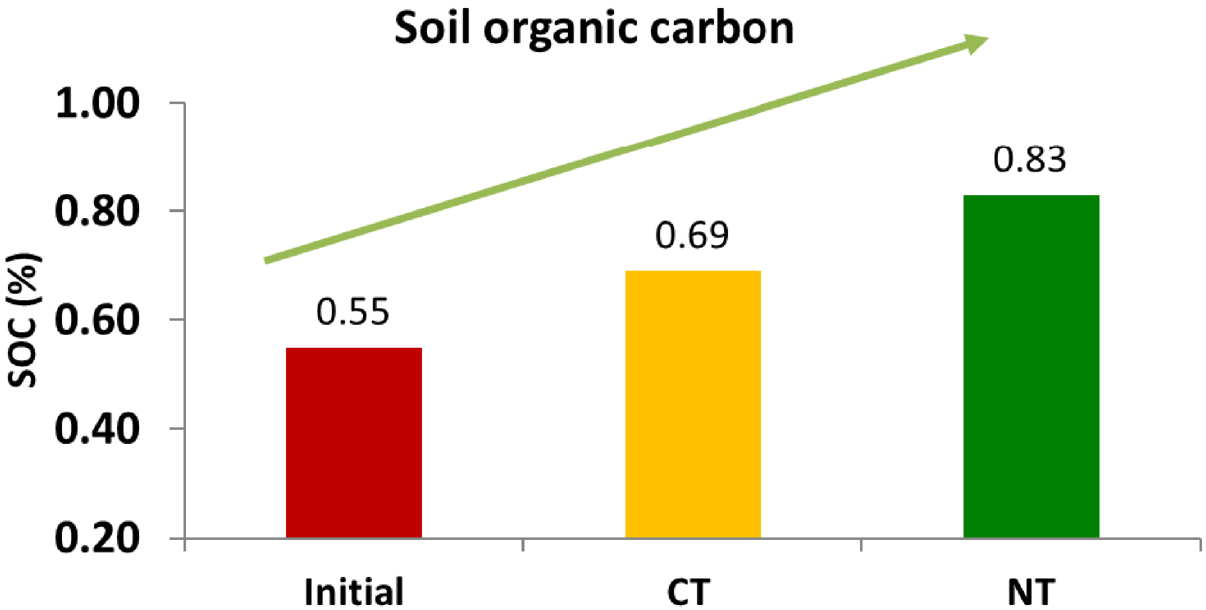
Technology Landscape

Conservation Agriculture



- Energy saving by up to 60 % compared to conventional farming.
- Water use efficiency increased by 15-30%.
- Soil and water run-off losses were almost 25-30% lower in ZT as co RT and CT. There were 5-15 and 15-30% improvement in soi retention and aggregate stability, respectively,
- and 10-30 and 20-40% improvement in soil carbon and n mineralization, respectively.

Conservation Agriculture (CA): Soil Health & Biodiversity



er SOC recorded under NT and RT with residue retention than CT after 8 crop s (2019).

offers better physical protection of C through aggregation

her SOC stock concentration observed under RT (3.58 to 4.14 t C/ha) and NT to 4.48 t C/ha) than CT (3.54 to 3.76 t C/ha,) at surface layer, respectively.

practices have been found to add 2.30 tonnes/ha wheat residues (0.90 tonnes) in Vertisols compared to 0.70 tonnes/ha (0.30 tonnes C/ha) in farmers' ices under soybean-wheat system indicating more C addition in soil.

nstreaming CA technologies/capacity building; non-availability of location fic farm machinery for Vertisols/Custom hiring;

d for strong-linkage between ICAR and SAUs and KVK for better dissemination ; Need for Policy decisions and incentives


Taylor & Francis Online

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Critical Reviews in Plant Sciences ›
Volume 39, 2020 - Issue 3

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1,625 Views
5 CrossRef citations to date
0 Altmetric

Articles

No-Till Farming and Conservation Agriculture i – Issues, Challenges, Prospects and Benefits

J. Somasundaram, N. K. Sinha, Ram C. Dalal, Rattan Lal, M. Mohanty, A. K. Naorem, ...show all

Pages 236-279 | Published online: 14 Jul 2020

Download citation | https://doi.org/10.1080/07352689.2020.1782069 | Check for updates

Biofertilizer Technology: Microbial consortia

ertilizer Technology

Rhizobium inoculation of pulses gives 15-30% yield increase with residual benefits of 30-40 kg N/ha. Co-inoculation with Plant growth promoting rhizobacteria (PGPR)- Azospirillum, Pseudomonas and Bacillus, saves 20-25% nutrients (N and P).

Mixed Consortium Biofertilizers :

Mixed biofertilizers (BIOMIX) containing a consortium of N solubilizers and Plant Growth Promoting Rhizhobacteria (P developed through the AINBB. Field trials showed the saving o and P fertilizers. Field trials of BIOMIX in various states show increase of 9% - 14%.

Family net vessel compost technology recycl kitchen waste

Rapid recycling of organic wastes

Microbial Enriched Compost Production

erent composting techniques developed depending
n the availability of raw materials

hospho Compost
hospho-Sulpho-Nitro Compost
pent Wash amended Compost
nriched Organo - Mineral Compost
licrobial enriched Municipal Solid Waste Compost

Phospho-sulpho-nitro compost for imp
nutrient enrichment, productivity and sc

tu decomposition of crop residues using microbial
sortia to combat residue burning

Bioreactor with microbial consortia to recycle food waste using rapid-composting technology

eloped "Ekcel-CompostR" and **"Ekcel-ShrdR"** for rapid decomposition of
Applying this technology compost can be prepared in **20 days (for kitchen and**
ble waste), 35 days (for horticulture waste) and 45 days for farm waste
ophilic fungi and thermophillic ligno-cellulolytic bacteria, actinomycetes
eveloped"Accel microbial consortia".


आई.सी.ए.आर. भारतीय मृदा विज्ञान संस्थान, भोपाल
डॉ. राजेन्द्र प्रसाद केन्द्रीय कृषि विश्वविद्यालय, समस्तीपु
एवं
कृषि विज्ञान केन्द सुजानी, देवघ
के तत्वावधान में
2 सितम्बर 2019


जैविक खाद

Apply manures to soil

Green manu

Quick growing nitrogen fixing leguminous plants - addition of organic matter along with nitrogen

Minimum Fertilizers in Regenerative Agriculture

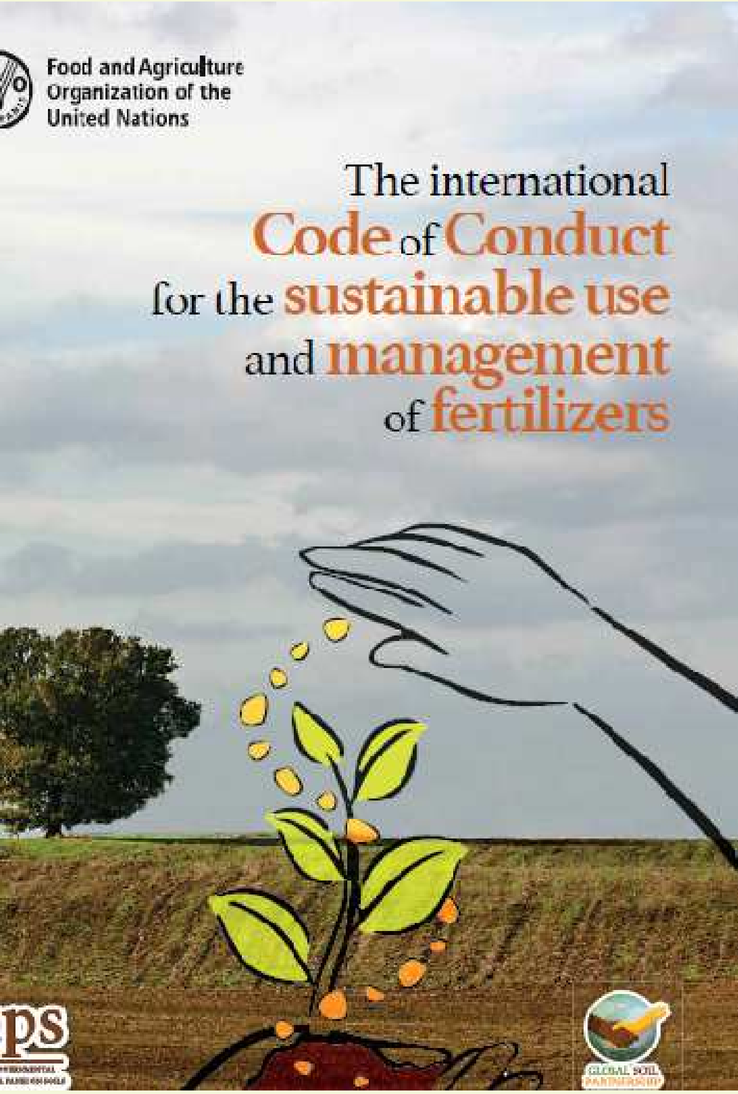
Manures and fertilizers are key for <u>sustainable intensification</u> of griculture

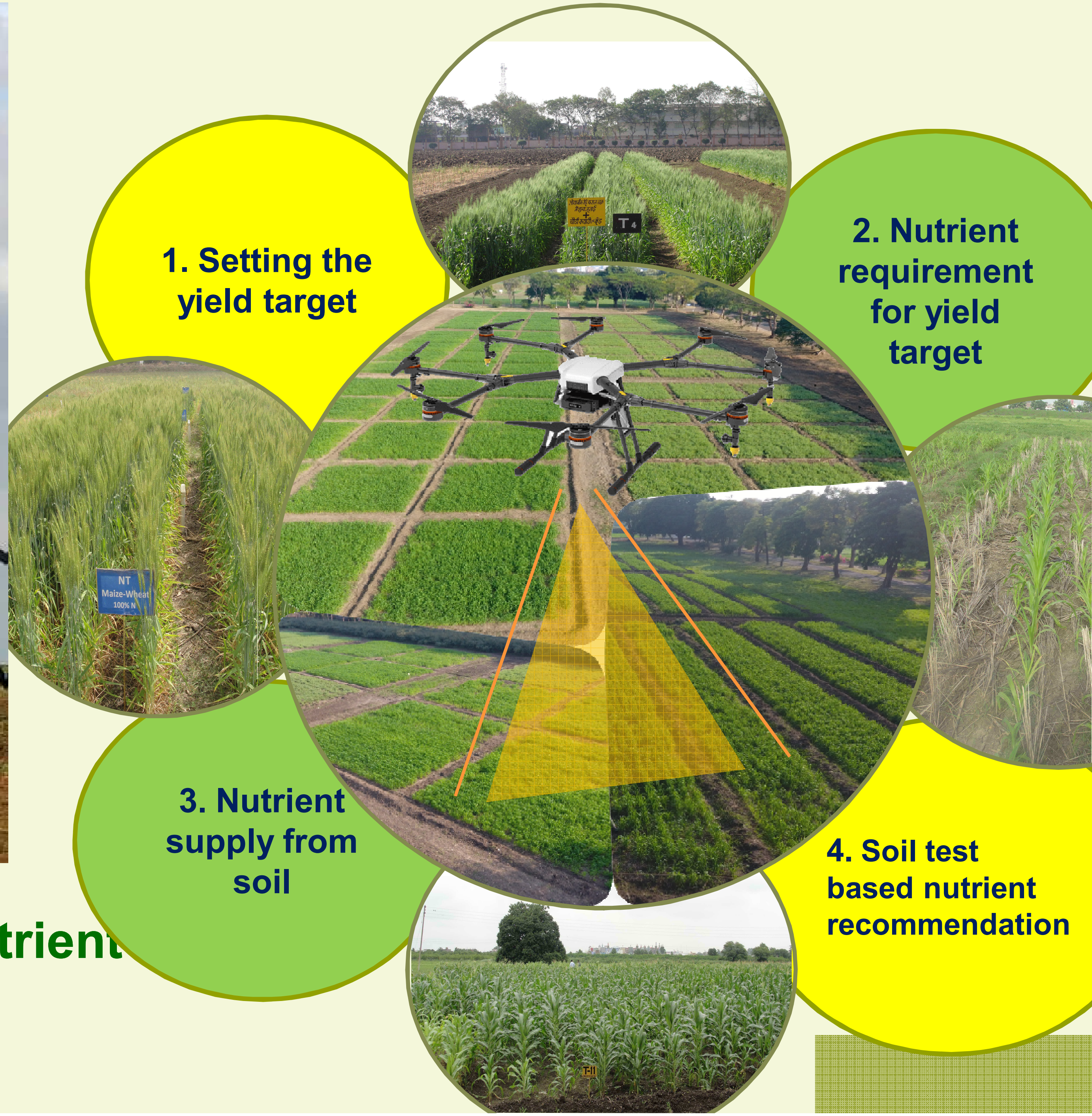
Demand for organic produce is set to increase exponentially in both lomestic and export markets, especially due to the COVID pandemic vhen more and more people are looking for safe and nutritious food.

ntegrated use of organics and inorganics improves the nutrient use fficiencies, soil health and resilience towards climate change

udicious management of chemical fertilizers is necessary to prevent nd reverse soil degradation and enrich biodiversity

For strengthening organic farming/integrated nutrient nanagement, concerted effort for supply of quality bio and organic ertilizers within reach of the farmers is imperative



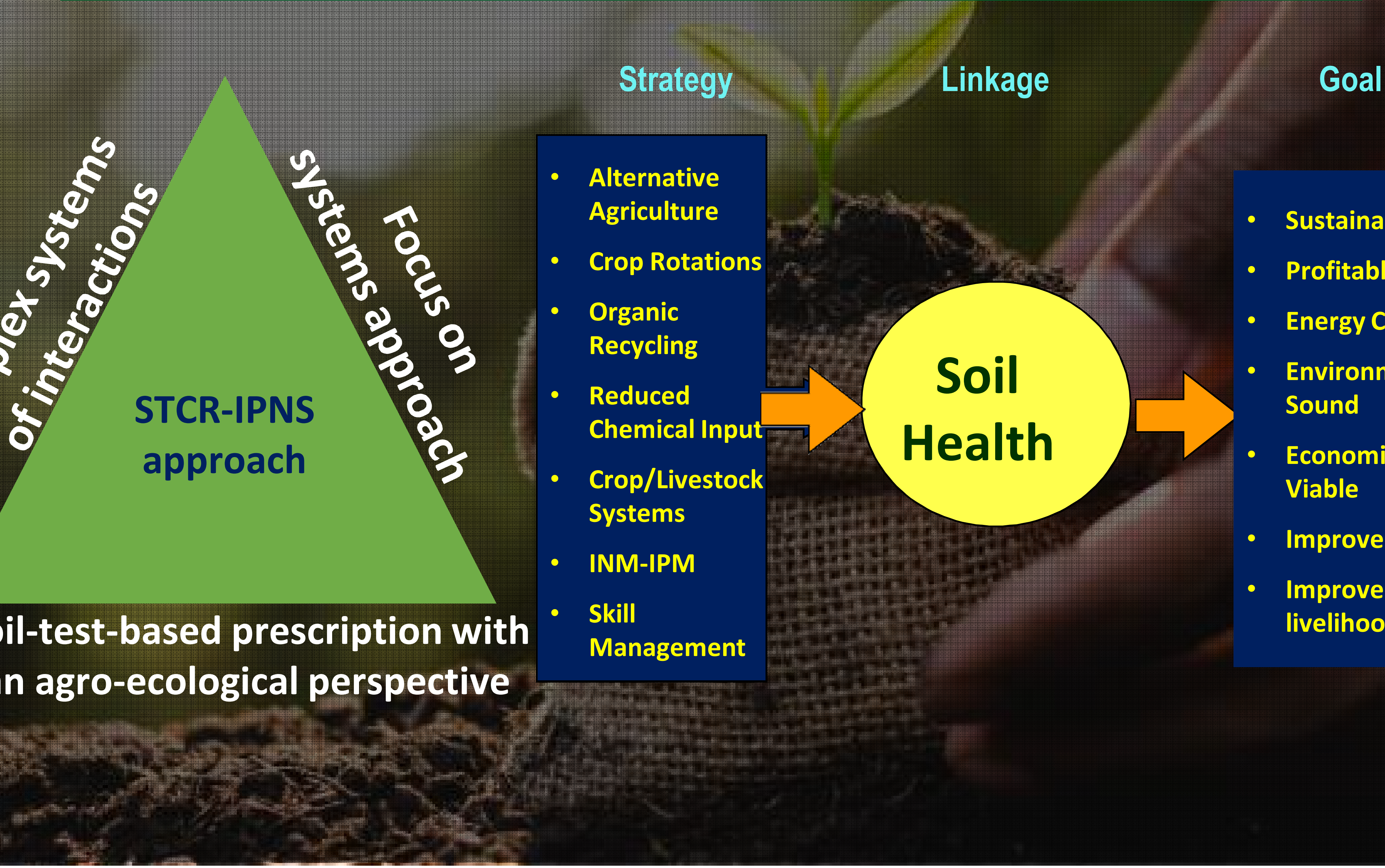


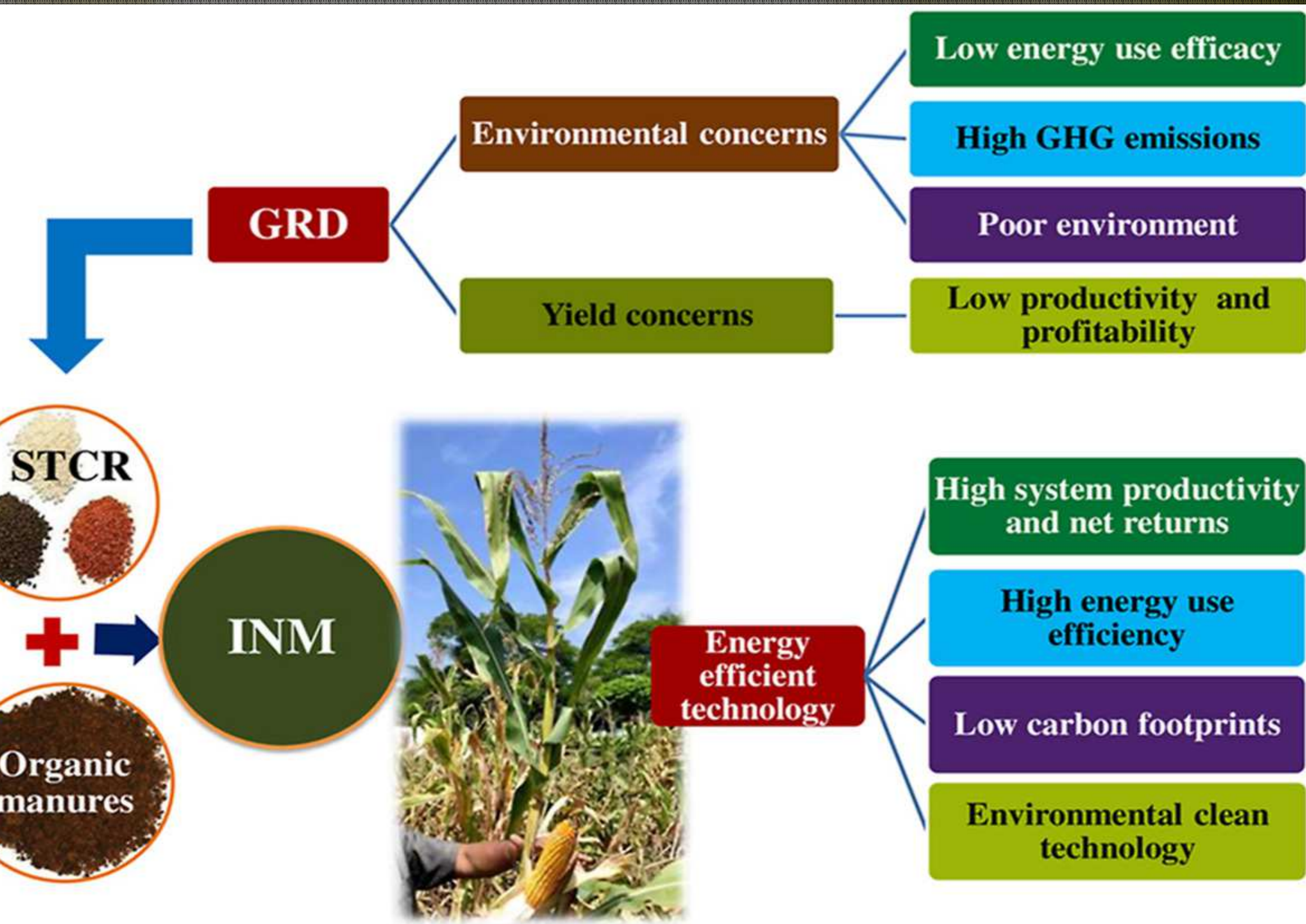
e Specific Integrated Nutrient
nagement, 4R Driven.

Enhancing Nutrient Use Efficiency – LTFE Studies

Soil Type	Location	Crop	Nitrogen use efficiency (%)			
			100% N	100% NP	100% NPK	100% NPK+FYM
Inceptisol	Ludhiana	Maize	16.7	23.5	36.4	40.2
Alfisol	Palampur	Maize	6.4	34.7	52.6	63.7
Mollisol	Pantnagar	Rice	37.5	40.7	44.4	61.7
Inceptisol	Ludhiana	Wheat	32.0	50.6	63.1	67.8
Alfisol	Palampur	Wheat	1.9	35.6	50.6	72.6
Mollisol	Pantnagar	Wheat	42.4	46.1	48.4	47.9

STCR-IPNS approach of plant nutrition is the key





Energy budgeting and carbon footpri term integrated nutrient management r a cereal-legume (*Zea mays–Cicer* cropping system

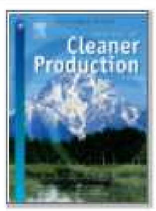
- INM module (FYM+75%NPK of increased system productivity 17.0%, carbon efficiency (CE) b and carbon sustainability index by 21% than GRD.
- Also reduced the energy requi by 14%, cost of cultivation by 6 besides that CF on a spatial sc 17% lower than GRD.

LSEVIER

Journal of Cleaner Production

Available online 15 June 2021, 127900

In Press, Journal Pre-proof



Recommended articles

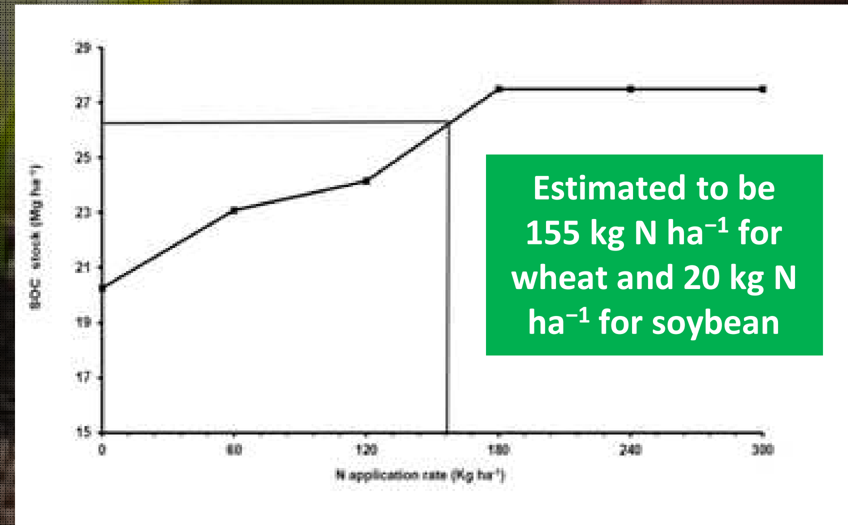
(Meena et al. 2021)

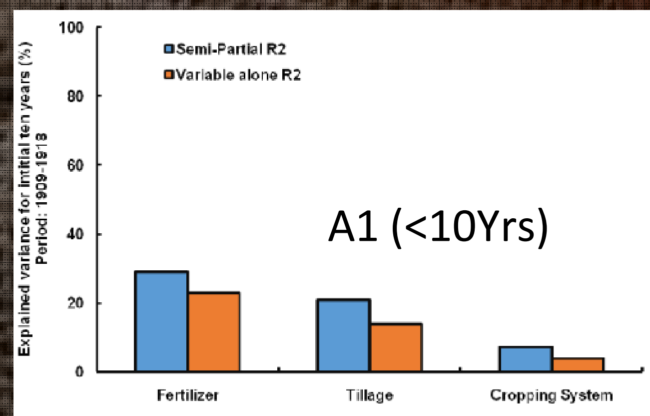
Integrated/ Optimum N application rate for higher soil C sequestration in Vertis
Central India

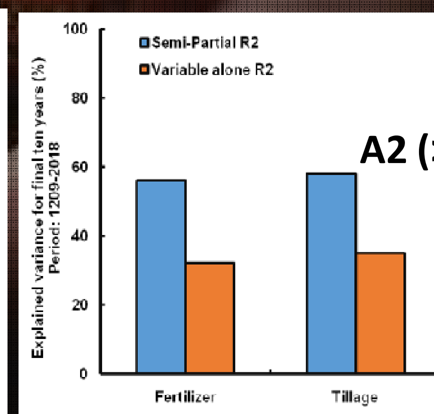
lated soil organic C (SOC) equilibrium values and time to
the saturation level under different treatments as
lated by the APSIM model in the Vertisol. maximum

ment	SOC equilibrium values/saturation values (t ha^{-1}) at top 30 cm depth	Steady state (year)##	SOC sequestered (Mg ha^{-1} yr^{-1})
ol (No	20.26	37	0.061
PK	23.53	73	0.075
NPK	24.53	77	0.084
NPK	27.34	78	0.119
NPK (INM)	48.65	104	0.294

tial SOC stock.i.e 18 Mg ha-1 was deduced from SOC
orium value; After 43 years: Control :-15.75 kg ha^{-1},
NPK: 155.9 kg ha^{-1}; 100% NPK +FYM: 578 kg ha^{-1}



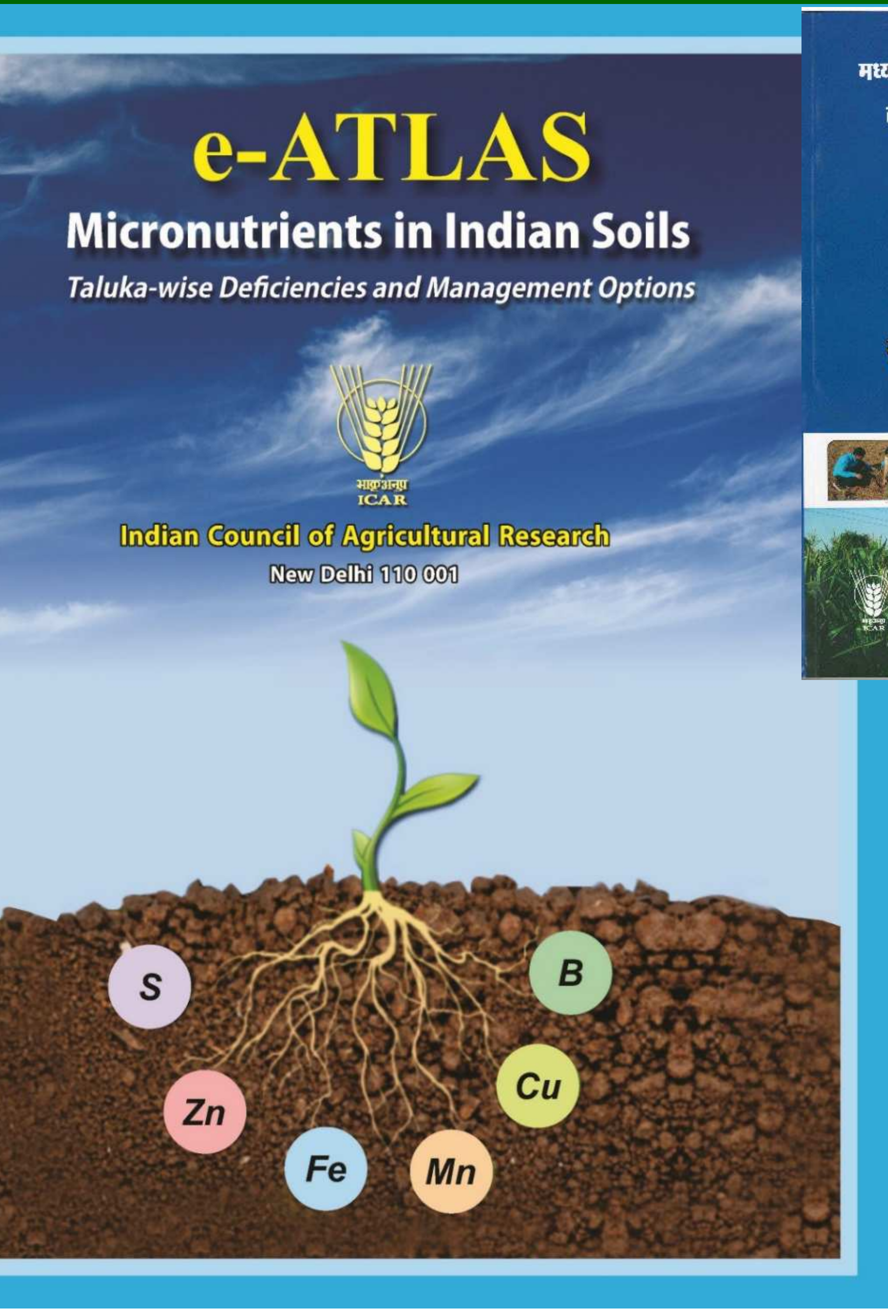


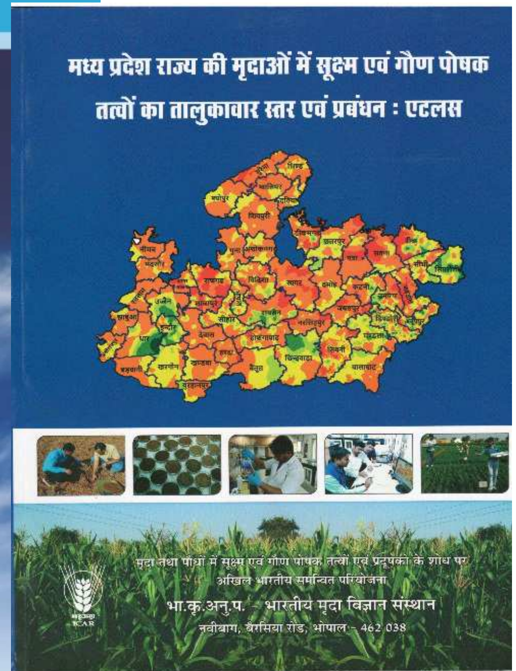


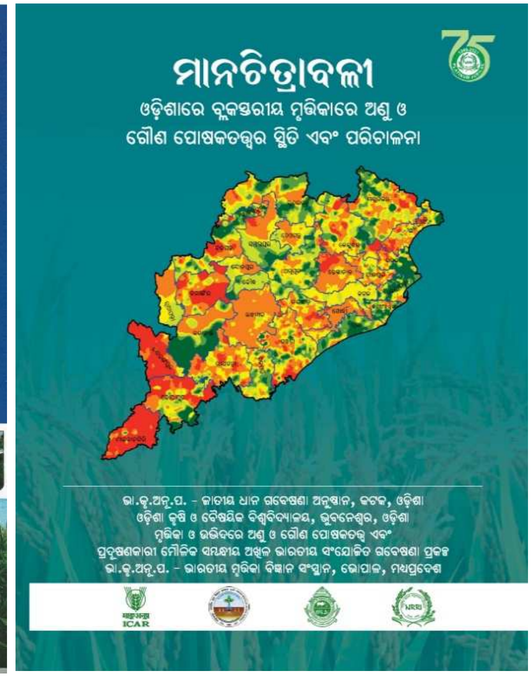
Contribution of different farming management practice
variations: (A1) represents the initial years of farming pr
surface soils and (A2) for long-term years

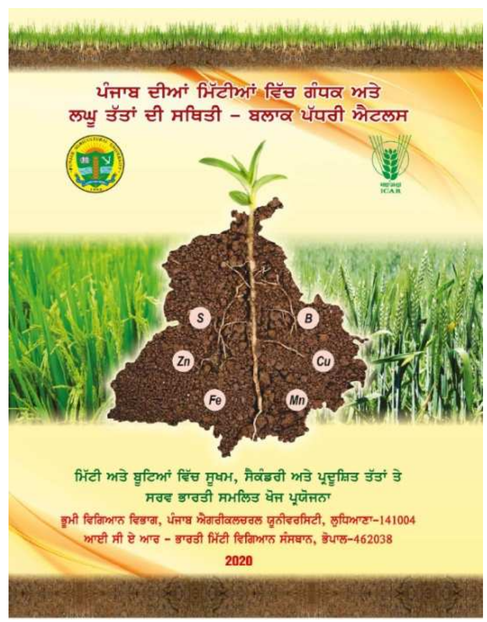
Mohanty et al. 20

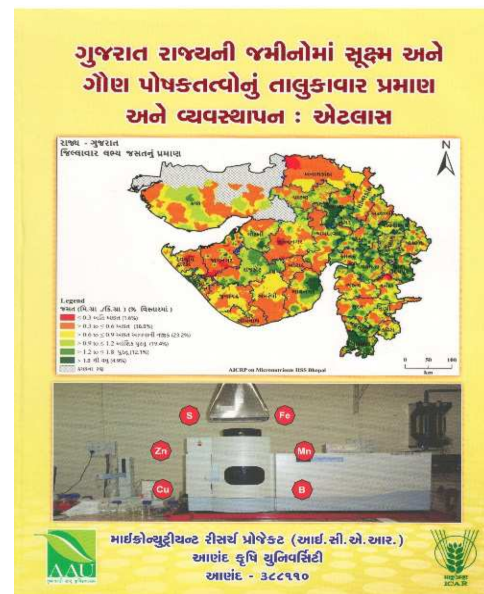
Atlases containing *taluka* wise S and micronutrients status



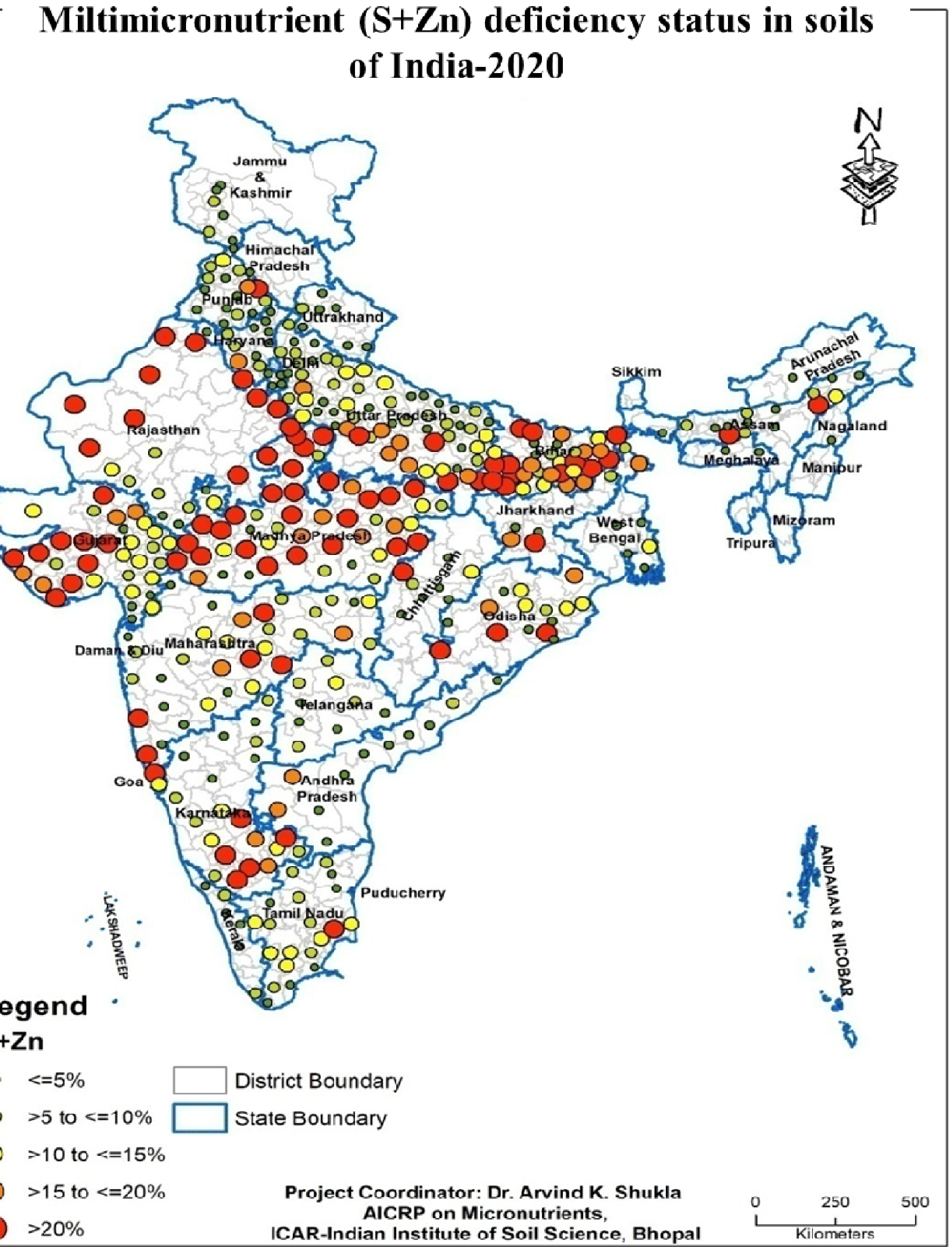


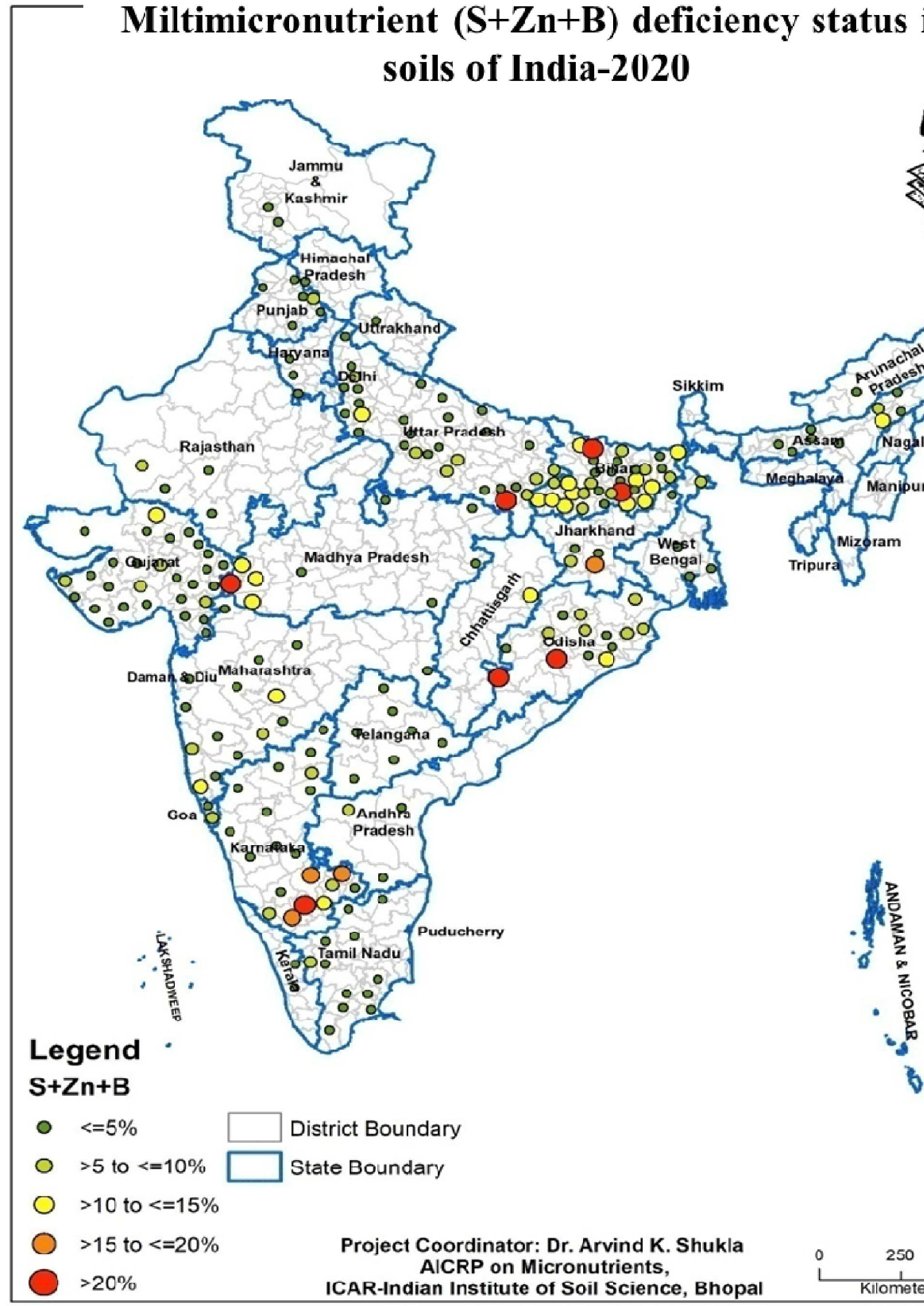






AICR


Miltimicronutrient (S+Zn) deficiency status in soils of India-2020
N
Jammu & Kashmir
Himachal Pradesh
Punjab
Haryana
Uttrakhand
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Nagaland
Meghalaya
Manipur
Mizoram
Tripura
Jharkhand
West Bengal
Gujarat
Madhya Pradesh
Chhattisgarh
Odisha
Daman & Diu
Maharashtra
Telangana
Goa
Andhra Pradesh
Karnataka
Puducherry
Tamil Nadu
Kerala
LAKSHADWEEP
ANDAMAN & NICOBAR
Legend
+Zn
<=5%
>5 to <=10%
>10 to <=15%
>15 to <=20%
>20%
District Boundary
State Boundary
Project Coordinator: Dr. Arvind K. Shukla
AICRP on Micronutrients,
ICAR-Indian Institute of Soil Science, Bhopal
0 250 500
Kilometers


Miltimicronutrient (S+Zn+B) deficiency status i soils of India-2020
Jammu & Kashmir
Himachal Pradesh
Punjab
Haryana
Uttrakhand
Delhi
Rajasthan
Uttar Pradesh
Bihar
Sikkim
Arunachal Pradesh
Assam
Nagal
Meghalaya
Manipur
Mizoram
Tripura
Jharkhand
West Bengal
Gujarat
Madhya Pradesh
Chhattisgarh
Odisha
Daman & Diu
Maharashtra
Telangana
Goa
Andhra Pradesh
Karnataka
Puducherry
Tamil Nadu
Kerala
LAKSHADWEEP
ANDAMAN & NICOBAR
Legend
S+Zn+B
<=5%
>5 to <=10%
>10 to <=15%
>15 to <=20%
>20%
District Boundary
State Boundary
Project Coordinator: Dr. Arvind K. Shukla
AICRP on Micronutrients,
ICAR-Indian Institute of Soil Science, Bhopal
0 250
Kilomete

Generalized transition zone of critical limits for micronutrients in soil

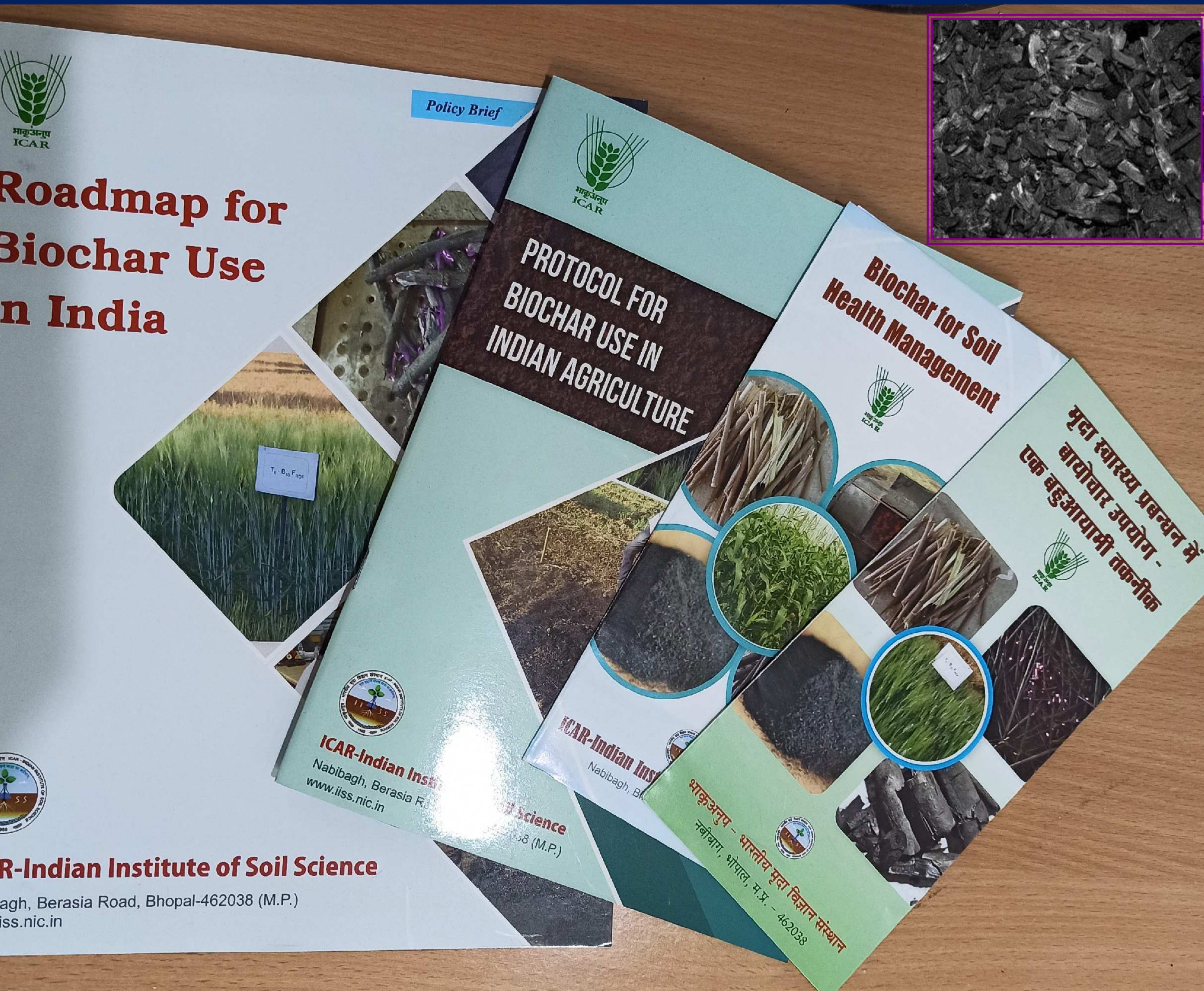
tical limit nsition zones	HWS-B	DTPA-Zn	DTPA-Fe	DTPA-Mn	DTP
ute deficient	≤ 0.2	≤ 0.3	≤ 2.5	≤ 1.0	
icient	0.2–0.5	0.3–0.6	2.5 – 4.5	1.0-3.0	
ent deficient	0.5–0.7	0.6–0.9	4.5 – 6.5	3.0-5.0	
rginally sufficient	0.7–0.9	0.9–1.2	6.5 – 8.5	5.0-7.0	
equate	0.9-1.10	1.2-1.8	8.5-10.5	7.0-9.0	
gh	> 1.10	>1.8	> 10.5	> 9.0	

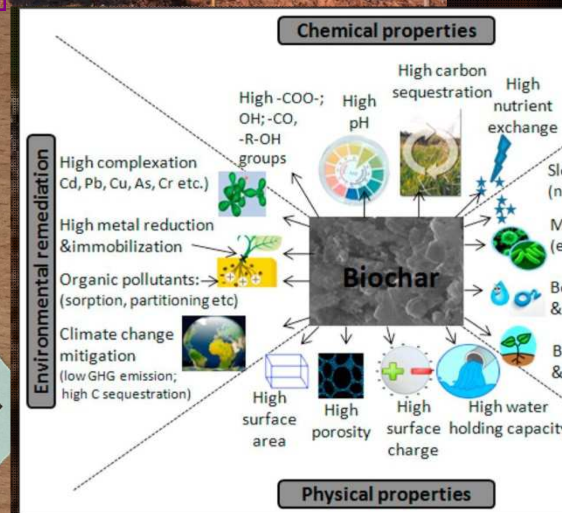
imits are inclusive

ased on >1465 experiments conducted at cultivators' field to derive critical limits ansition zones

Shukla and Behera, 202

Biochar for C-sequestration and soil health





Soil structure, soil water, soil aggregate stability

Soil GHG

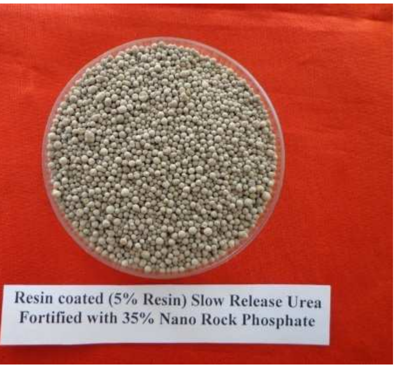
Soil nutrient dynamics

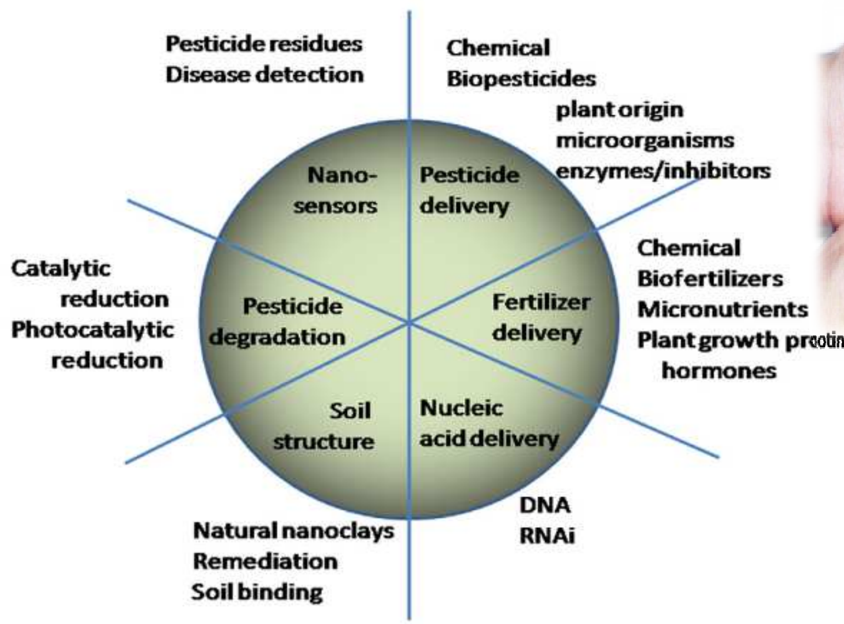
Soil fungal diversity

Soil microbial population


Climate proof
• Integrated Farming Systems
• Integrated Nutrient and Pest Mana
For sustainability and inco

notechnology: Possible Areas of Innovations for Futu Regenerative Agriculture



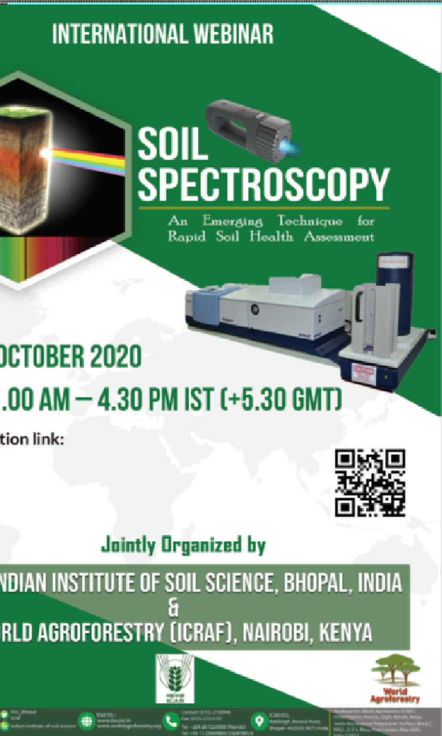


LTILOCATION TRIAL OF NANO ROCK OSPHATE BY ICAR-IISS, Bhopal

Nano-rock phosphate - A Potential phosphorus fertilizer derived from rock phosphate using nano-technology.

Nano-Rock Phosphate (NRP) is equally good as DAP on soybean yields

ICAR-IISS – ICRAF Collaboration on Soil Spectroscop

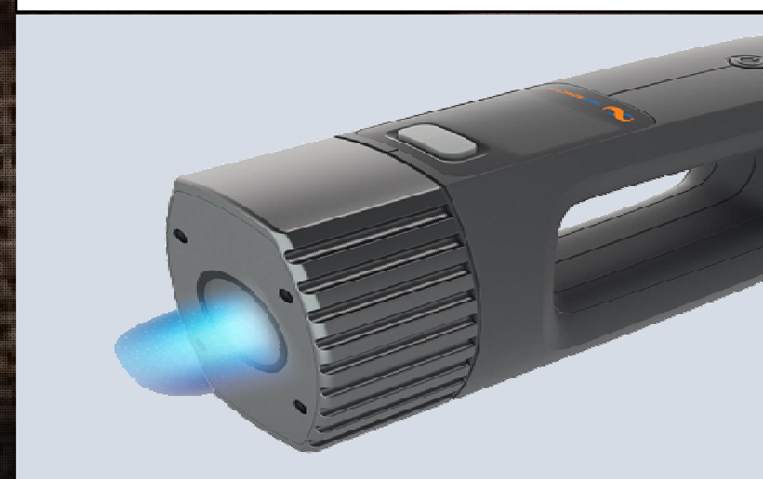


- The Mid-infrared technology has been validated for the estimation of the soil organic carbon, pH, clay, silt and sand in Alfisols, Inceptisols and Vertisols of India. It may be used for rapid analysis of such parameters in these soil types.

Alpha-FT MIR Spectrometer

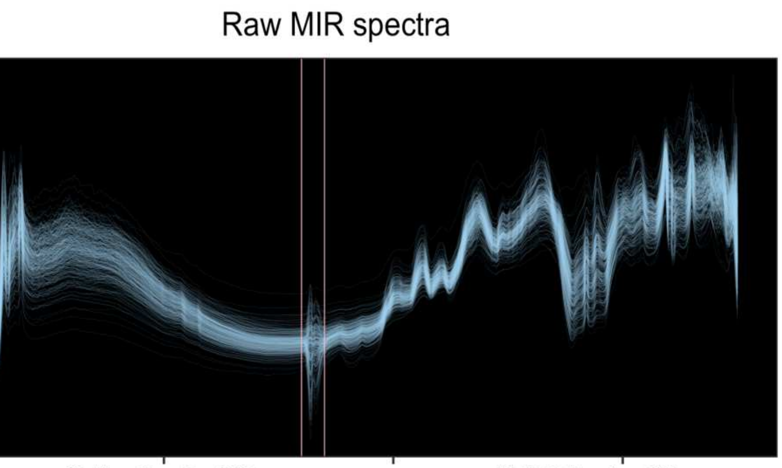
Capacity building

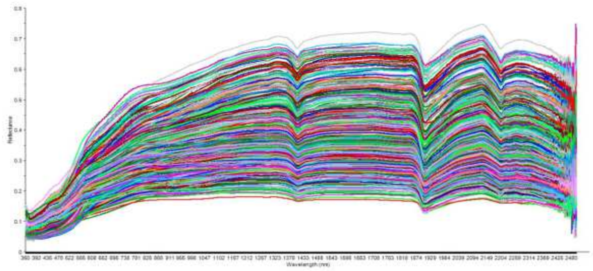
Portable XRF



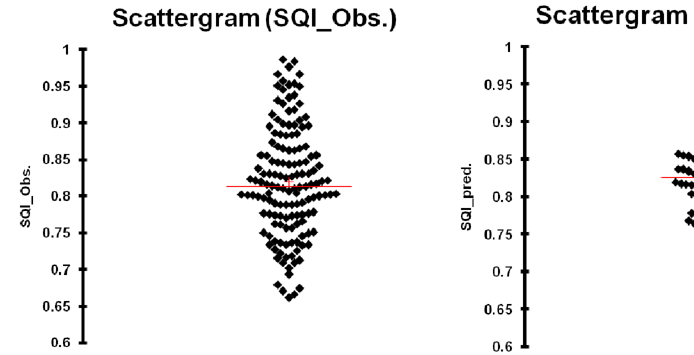
Neo-spectra Soil NIR scanner

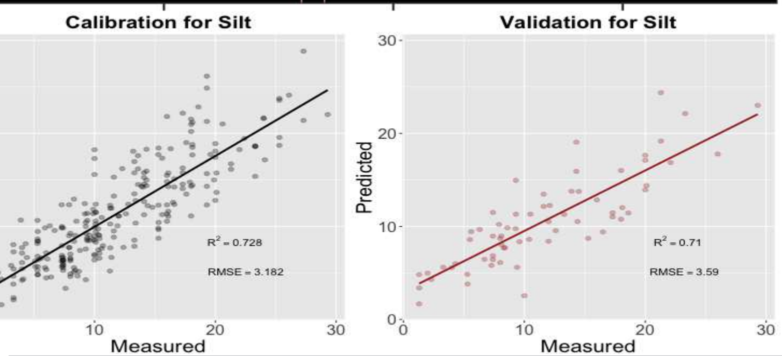
Spectral analysis of soil properties (NIR and MIR) and Library

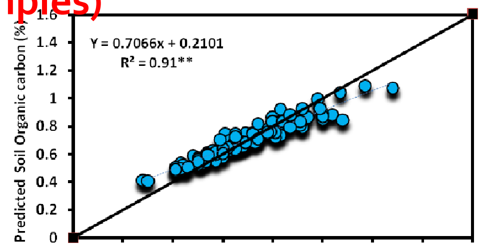


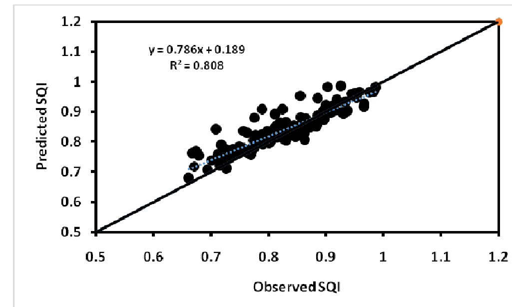


Spectral Signatures from soils collected from central Indian Vertisols (1200 samples)

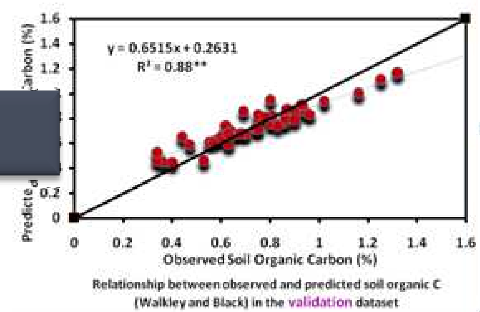




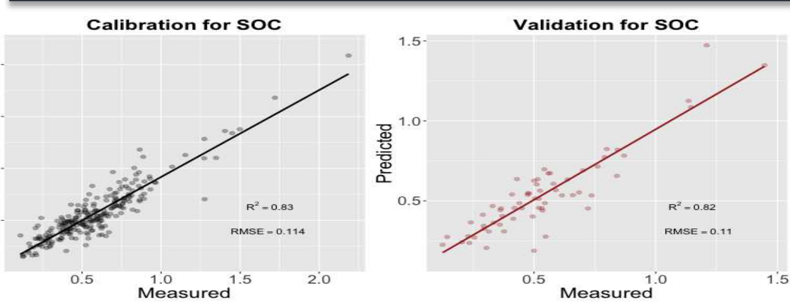


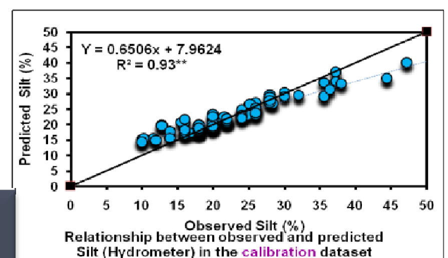


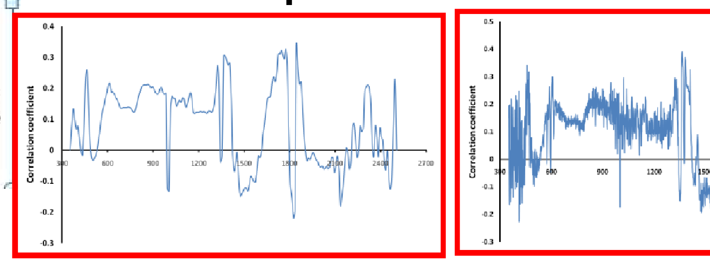
Clay content (%)



Relationships between laborat
SQI and spectral based SQI



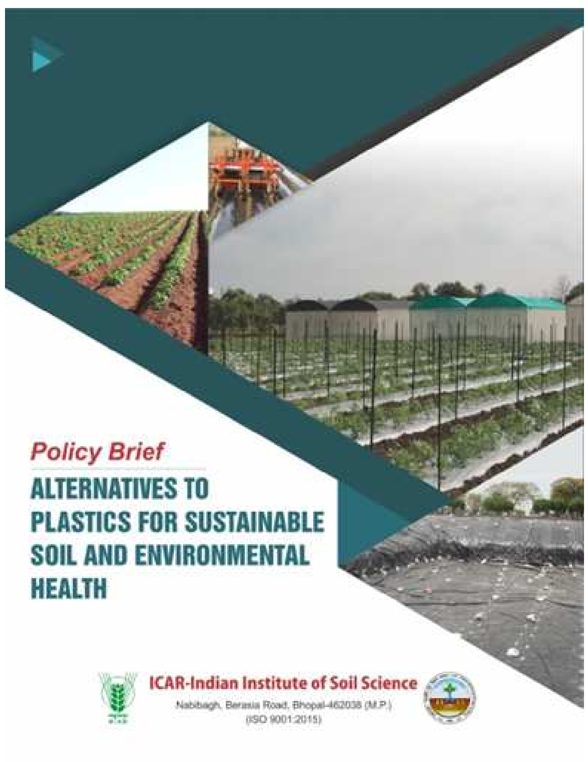




Individual band vs SQI correlation

il Organic Carbon concentration (%)

Alternatives to Plastic Mulches: Potential options



Primary use of plastics in agriculture as mulch, shade nets, lining, micro-irrigation, etc. and also indicated the associat with the use of conventional plastic materials

Organic mulch materials are in use since before the inventi plastics, yet stand as a viable options for alternatives to pla

Road map and actionable points:

- Organic fibre materials and crop residues
- Mulching with paper sheets or vegetable oil stained pap cellulose fibre and wool fibre can be other good options
- Poly acrylic acids (PLAs) based bio-polymers because of biodegradable nature.
- In-depth study is essential under different mulches on s properties/hydrothermal properties.
- In-depth study is required on the key mechanisms involv biodegradation, active plastic degrading organisms, and of resultant micro-particles in the soil.
- Urgent need to identify efficient microorganisms that co immediately biodegrade plastic film mulch (PFM) after u paramount in developing biodegradable films and biore of pollution problem.
- Soil protection law or legislation is essential to safeguar resources and environment from serious threat of plasti

Drip irrigation and fertigation: More crop per drop

Comparative efficiency of different irrigation methods

Conventional	30-40 % (Flood and Furrow)
Sprinkler	40 - 60 %
Drip	90-95 %
N use efficiency	85-90%

- Drip irrigation – 2.5 to 3.0 times more area than conventional.
- Sprinkler irrigation – 1.5 to 2.0 times more area than conventional.

- **Water Resources Management**

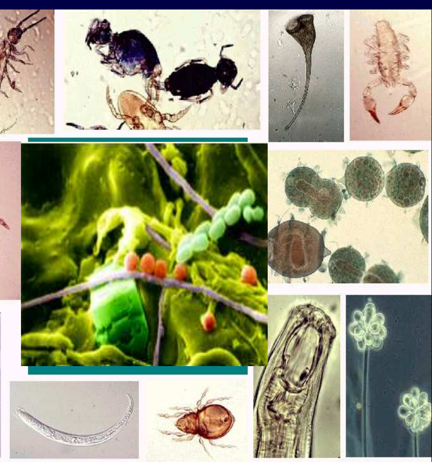
  - ***Reduce, Recycle, Reuse, Recharge (4R)***

- **Increase in yield 12-84%**
- **WUE 17-65%**
- **Fert saving 20-25%**
- **Net return 10-130%**

Increase SOM, population & diversity of soil biota

Fertilization (INM, 4R)
No tillage
Higher plant diversity
Irrigation (MI esp. dry areas)
IPM

Organic amendments
Green manure (cover crops)
Crop rotation
Liming



Regeneration of Soil Health

Uncovered soil
Burning (fire)
Heavy machinery
Erosion

Acidification
Monoculture
Intensive tillage
Pesticides, soil contaminants

Decrease SOM, population & diversity of soil biota

Conclusion & way forward

- ✓ Future agriculture is in crisis in the face of rapid soil degradation, colla soil health and extinction of biodiversity.
- ✓ For managed soils, it should be managed mimicking nature's way to pr and enhance soil biodiversity, health and sustainability and to pro degradation following the tenet of regenerative agriculture.
- ✓ For healthy soils in natural ecosystems, protect them from conversion degradation
- ✓ For degraded soils, mitigate soil threats, restore and improve soil health
- ✓ Mechanisms to develop regenerative soil utilization – site specific mode
- ✓ Promote best agricultural practices and mass awareness for RA.
- ✓ Policy implementation for incentives and rewards for regener agriculture and creation of ecosystem services. Differentiate farmers protects soils from others.

FAO CONFERRED KING BHUMIBOL WORLD SO DAY AWARD 2020 TO ICAR-IISS

The Institute has received the prestigious "King Bhumibol World Soil Day Award 2020" from FAO Rome for outstanding role for Mass Awareness Campaign on soil health enhancement in India on 5 Dec 2020.

UN Decade on Ecosystem Restoration (2021-2

THANK YOU