Major integrated nutrient management strategies for rice-wheat cropping, and their impact on nutrient cycling, use efficiency and climate resilience of the system

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SOILS: WHERE FOOD BEGINS

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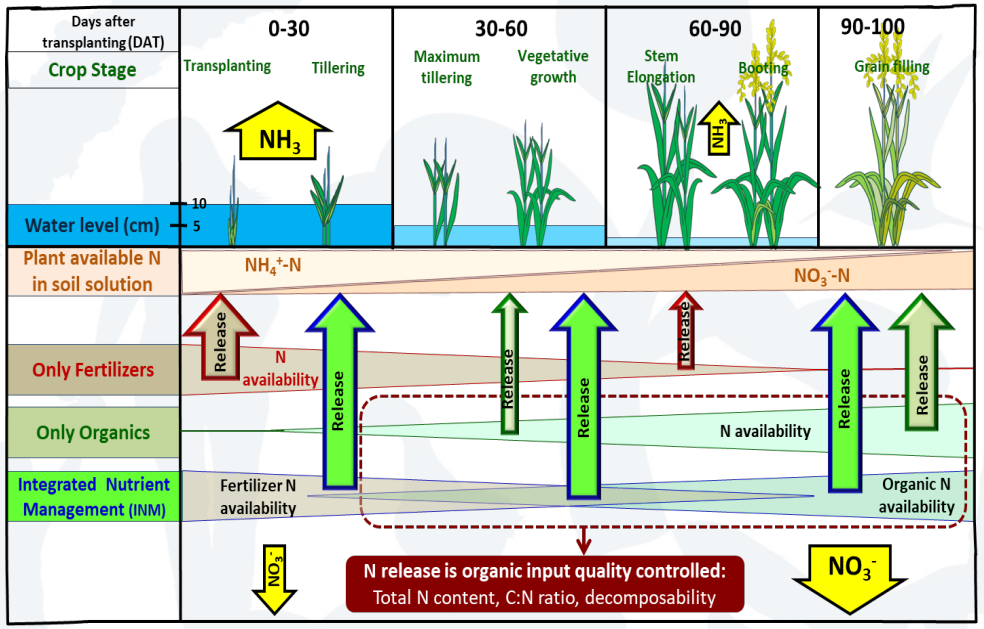
GLOBAL SOIL PARTNERSHIP

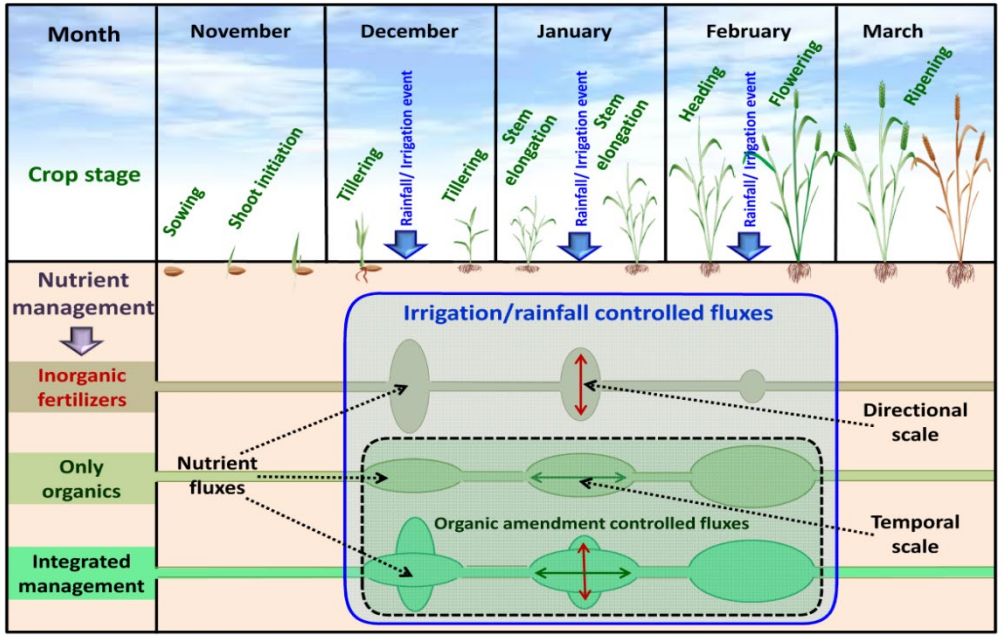
Introduction

- **Major cropping system** in the South Asian region
- **Highly intensive** management, especially tillage and fertilizer application
- **High fertilizer use**; IGP=180 kg ha^{-1}, Western IGP >200 kg ha^{-1}
- **Low resource use efficiency**; 30-40% NUE
- **Land degradation and environmental issues** revealed
- **Newly emerged challenges**; residue burning

Rice-wheat: Contrasting management conditions



RICE - WHEAT

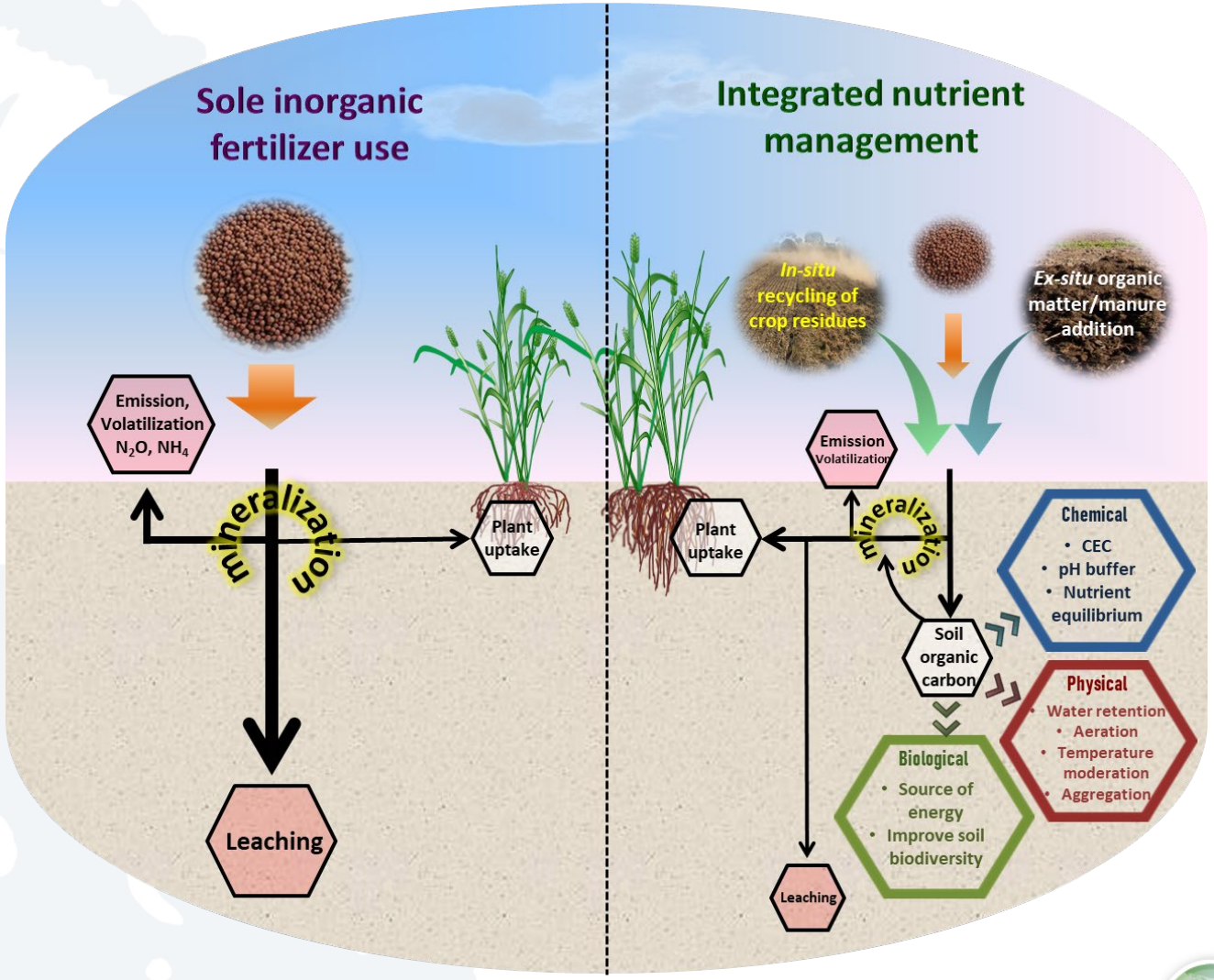


- **Puddled, waterlogged** soils
- **Anaerobic** decomposition & mineralization
- **Water-excess driven fluxes** (e.g. CH_4 emission, NH_4 volatilization)

- **Dry-tilled** soils
- **Aerobic** decomposition & mineralization
- **Water-deficit driven fluxes** (e.g. CO_2 emission, NO_3 losses)

INM: Balancing Crop nutrition & Soil health

- **Integrated nutrient management (INM)** enhanced nutrient use efficiency and soil health via:
- Increased soil **carbon**
- Improved soil **biological activity**
- Improved **electrochemistry**



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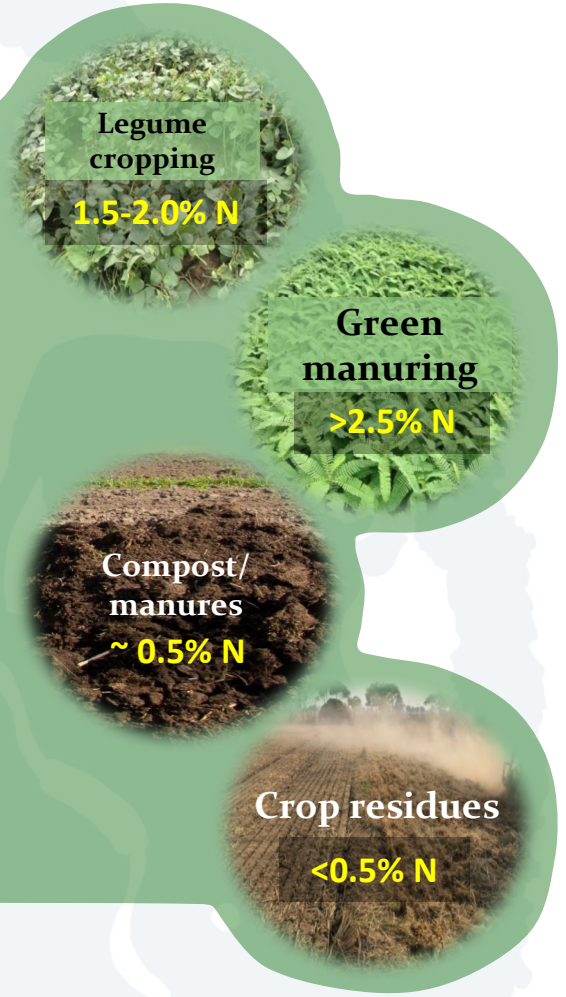
Key components of INM Strategies

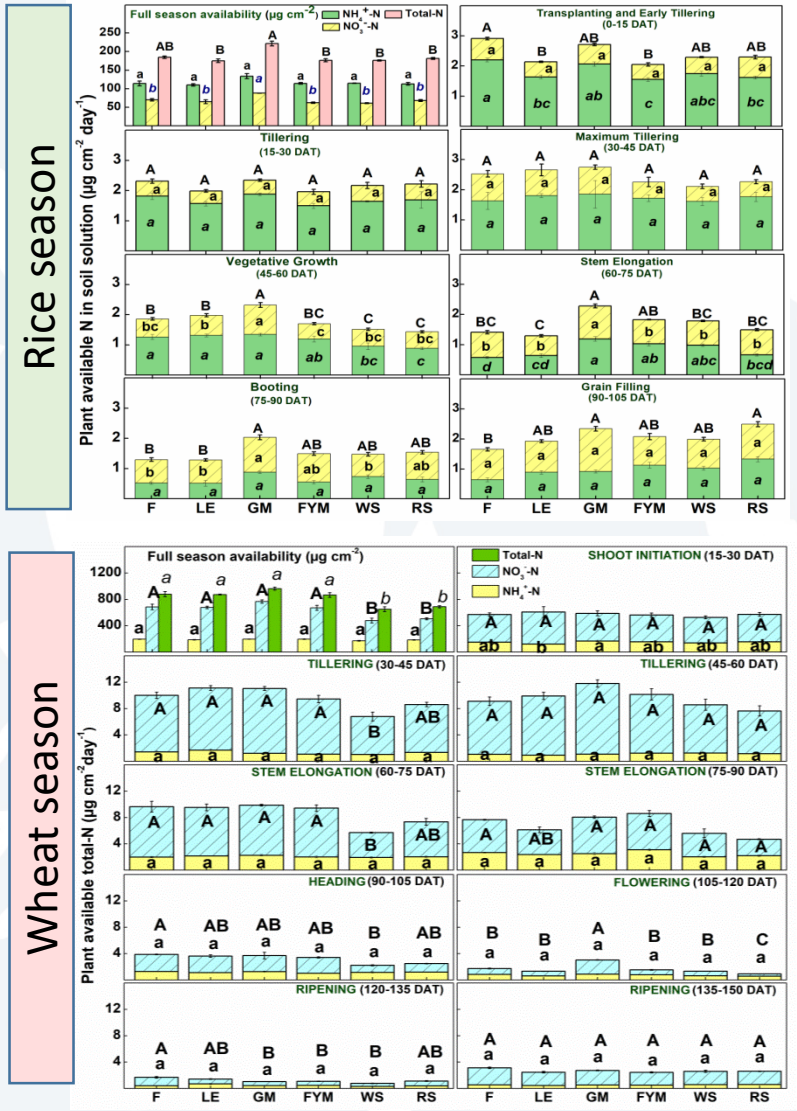
F	100% inorganic fertilizers only
LE	Legume-*Vigna radiata* in lean period between wheat and rice + 55% inorganic fertilizers
GM	Green manure crop-*Sesbania aculeata* in lean period between wheat and rice + 55% inorganic fertilizers
FYM	Farmyard manure (FYM) @ 10 t ha^{-1} + 55% inorganic fertilizers
WS	Wheat standing stubble (30 cm) retained and incorporated + 55% inorganic fertilizers
RS	Rice straw (30 cm standing stubble) retained and incorporated+ 55% inorganic fertilizers

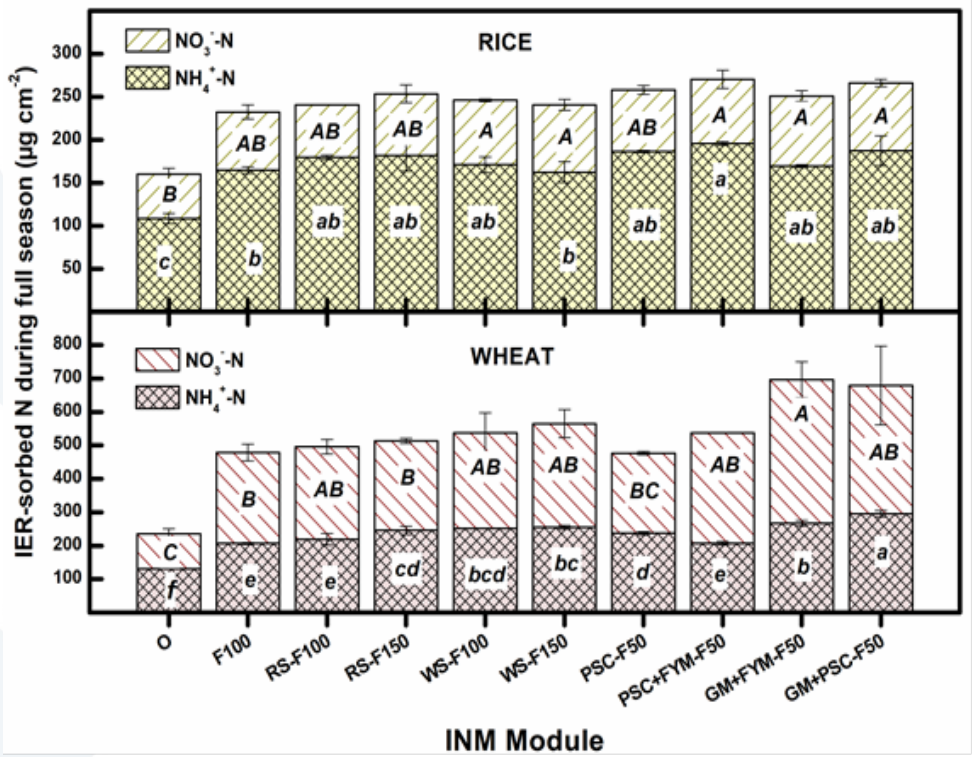


Treatment	Details
O	Absolute Control
F	100 % recommended fertilizer
RS 100	Rice stubble (RS) retention with 100 % of recommended fertilizers application
RS 150	Rice stubble (RS) retention with 150 % of recommended fertilizers application
WS 100	Wheat stubble (WS) retention with 100 % of recommended fertilizers application
WS 150	Wheat stubble (WS) retention with 150 % of recommended fertilizers application
PSC 50	Paddy straw compost @ 5 Mg ha^{-1} with 50 % of recommended chemical fertilizers
PSC+FYM 50	Combination of Paddy straw compost @ 5 Mg ha^{-1} and Farmyard manure @ 5 Mg ha^{-1} with 50 % of recommended chemical fertilizers
GM-FYM 50	Combination of Green manuring with Sesbania aculeata and Farmyard manure @ 5 Mg ha^{-1} with 50 % of recommended chemical fertilizers
GM-PSC 50	Combination of Green manuring with Sesbania aculeata and Paddy straw compost @ 5 Mg ha^{-1} with 50 % of recommended chemical fertilizers

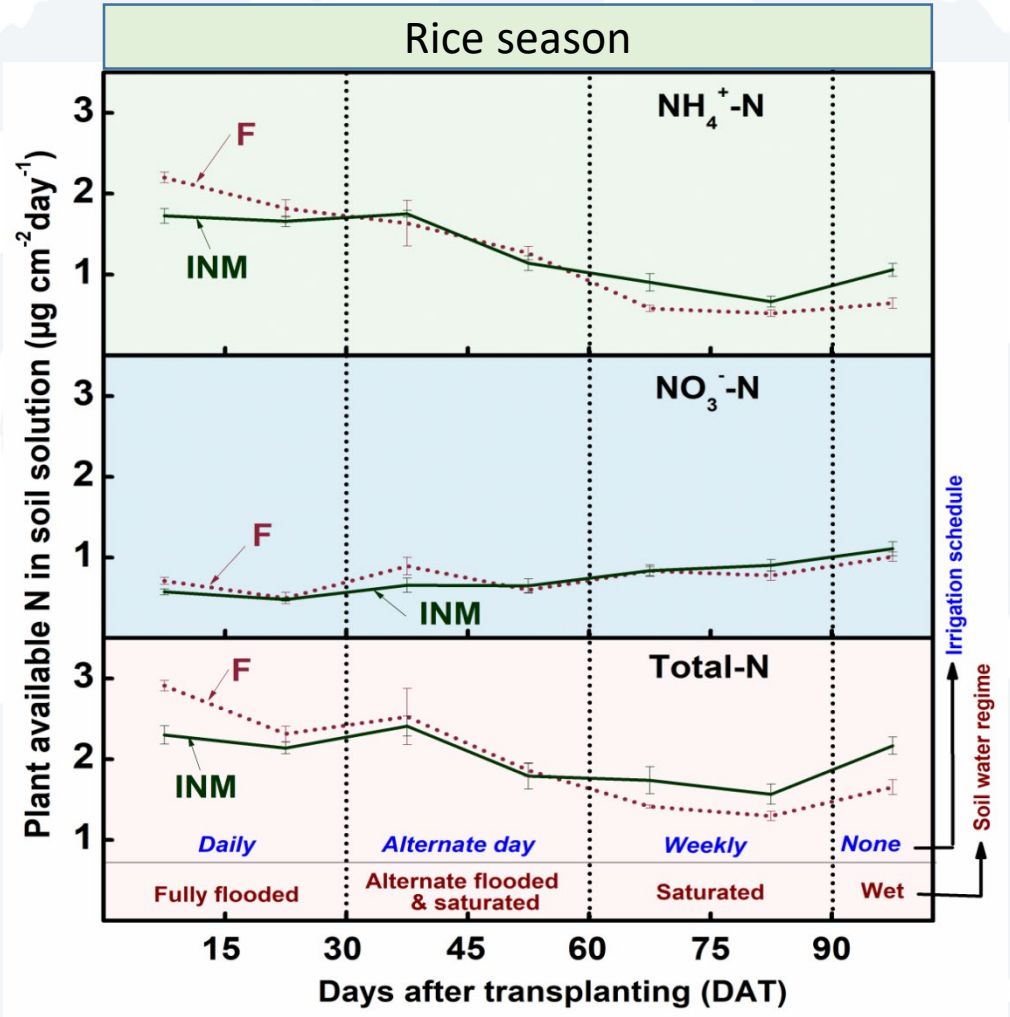
Nitrogen Mineralization

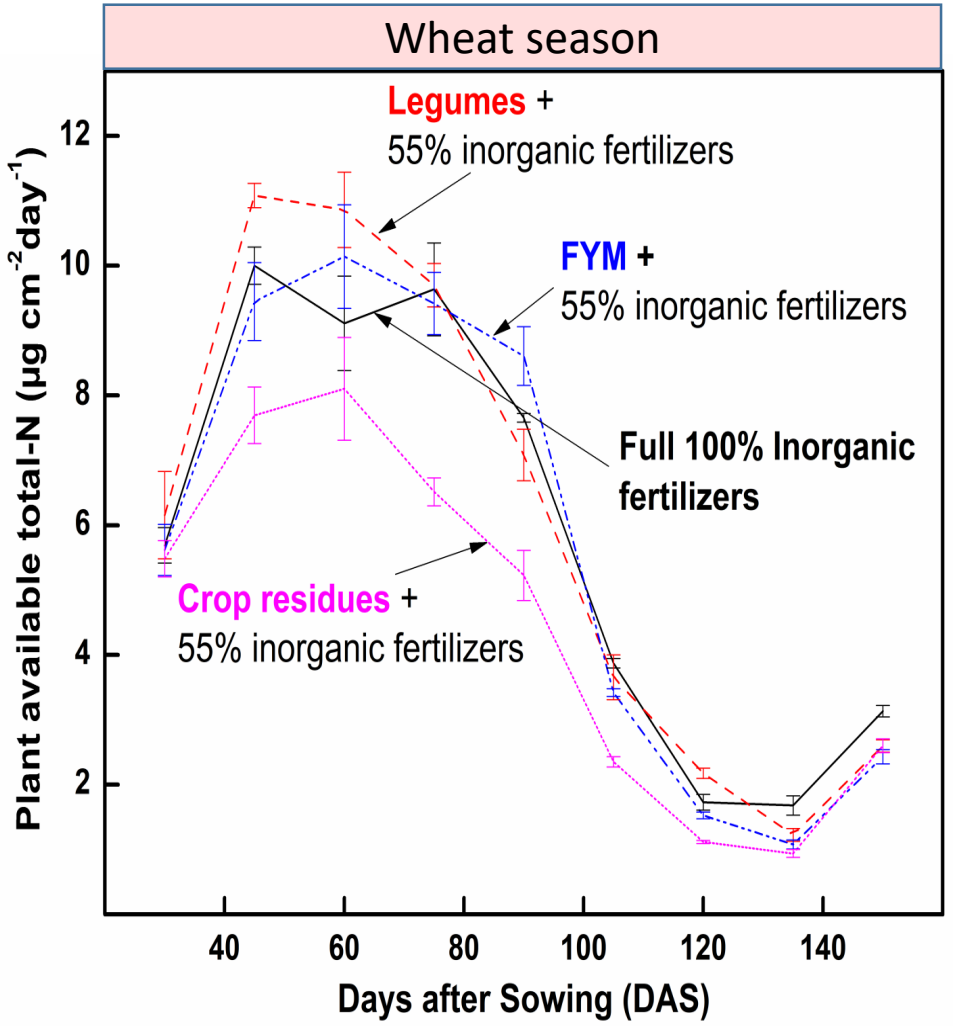
- **Legume** based management had significant release of N during **peak vegetative growth & grain filling**
- **Rice, wheat residue** based management had significant releases during **grain filling** and **maturity stage**
- **Rice, wheat residue** based management had significantly lower availability of nitrogen during most of the growth period





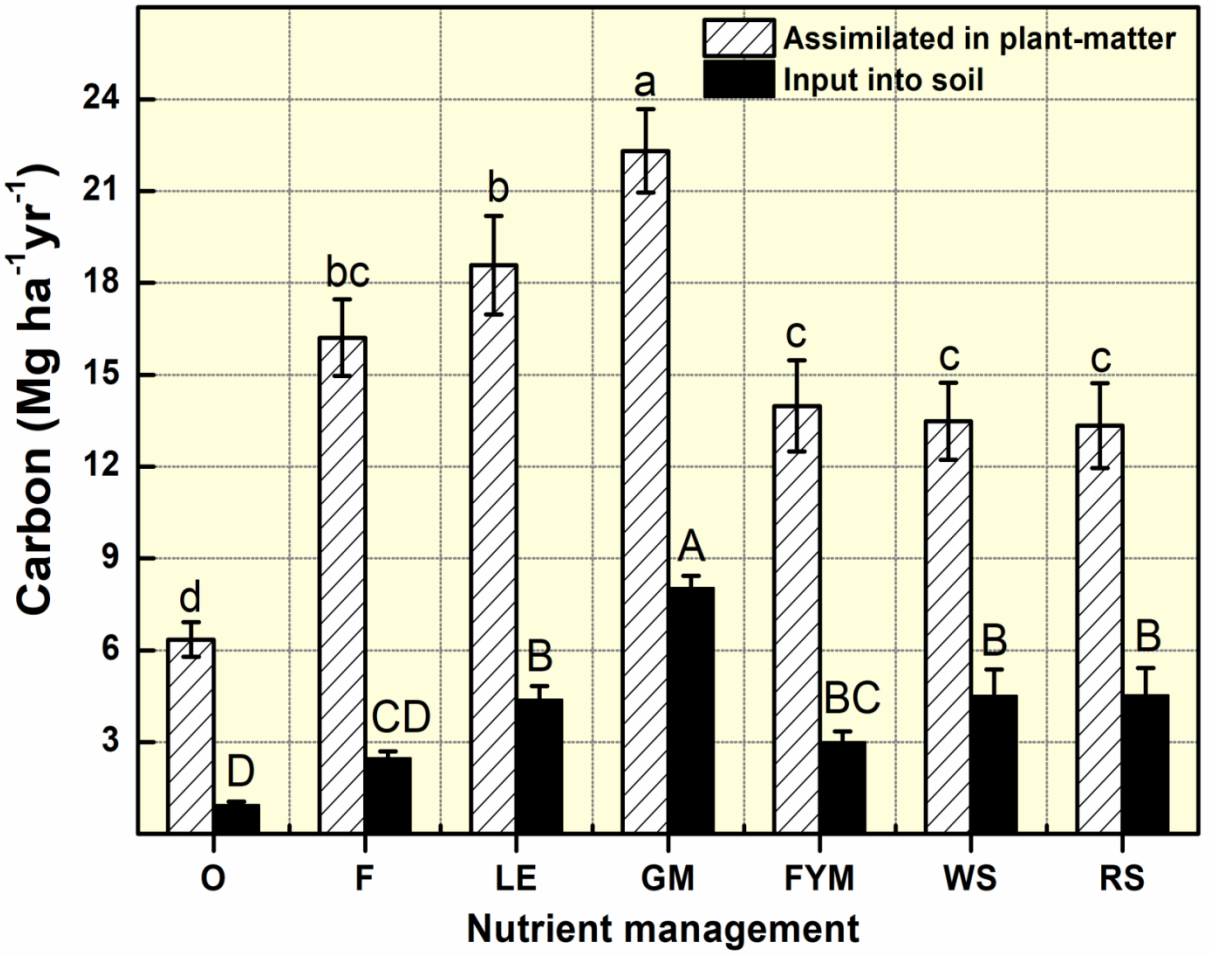
Plant available Nitrogen





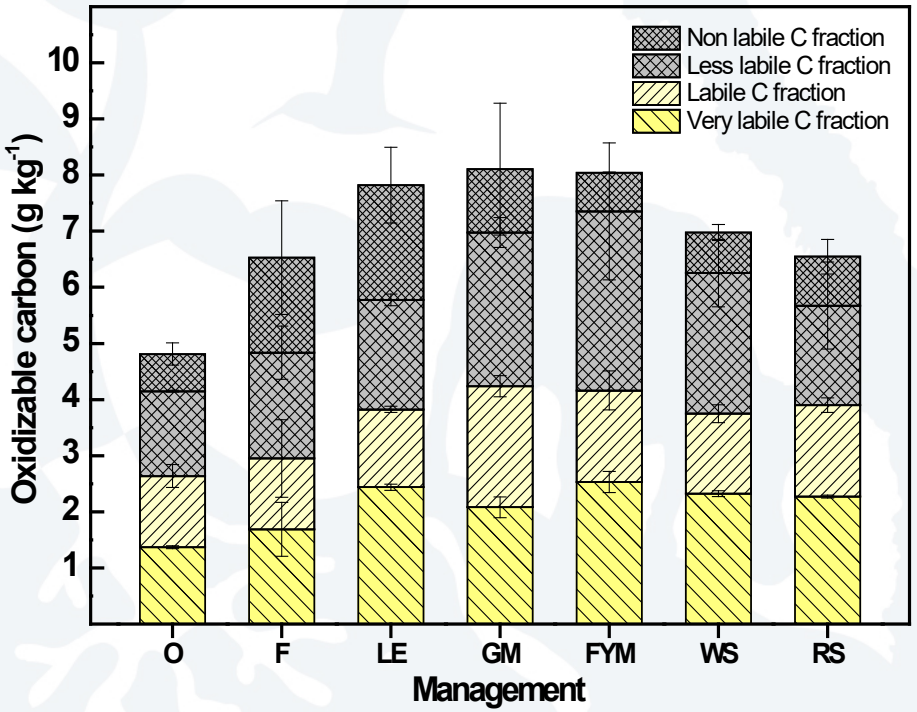
Carbon assimilated and sequestration

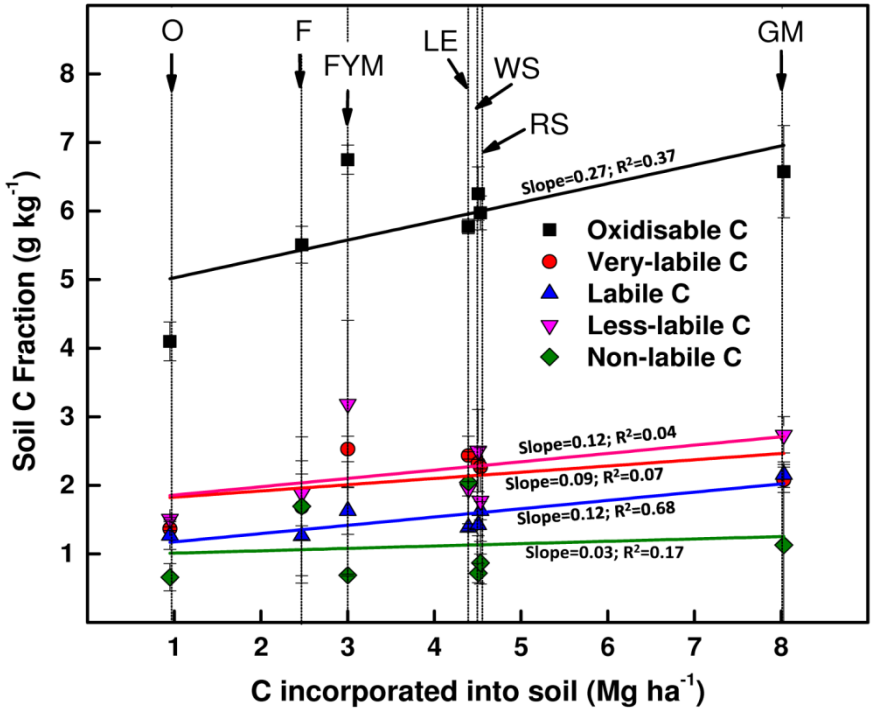
- Legume residue based and cereal residue based management had maximum **biomass C inputs into the soil**.



Soil carbon sequestration %fractionation

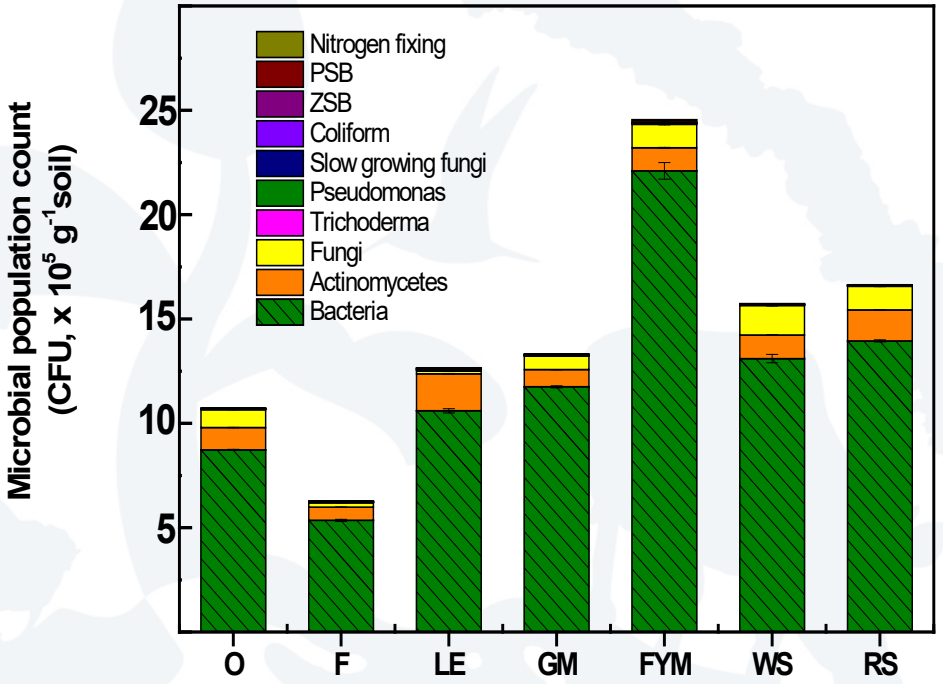
- Legume-based biomass inputs accrued most benefits for soil **carbon sequestration**
- **Labile fractions** most benefitted

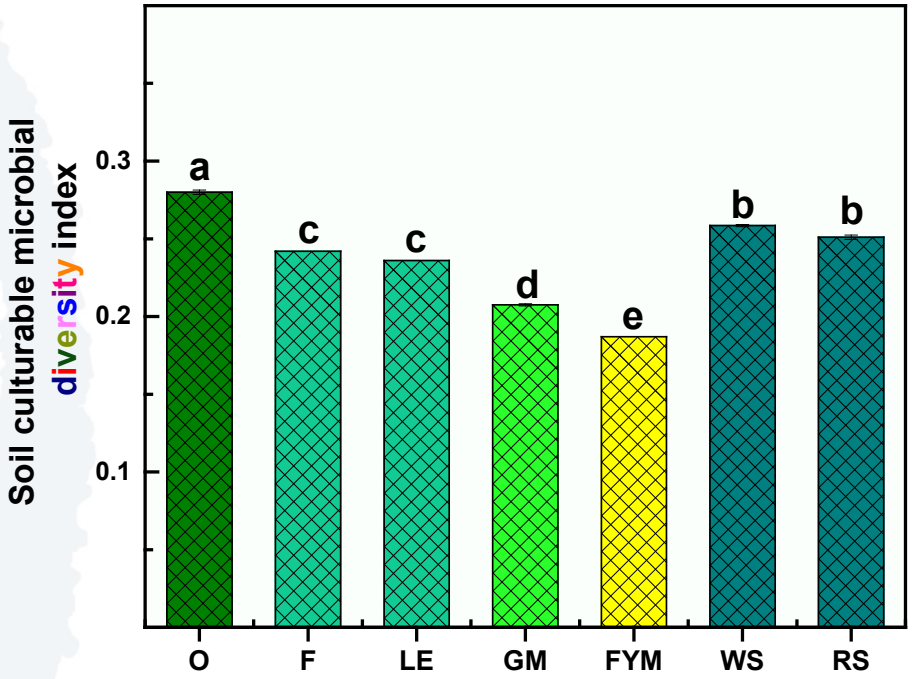




Biological activity & diversity in soil

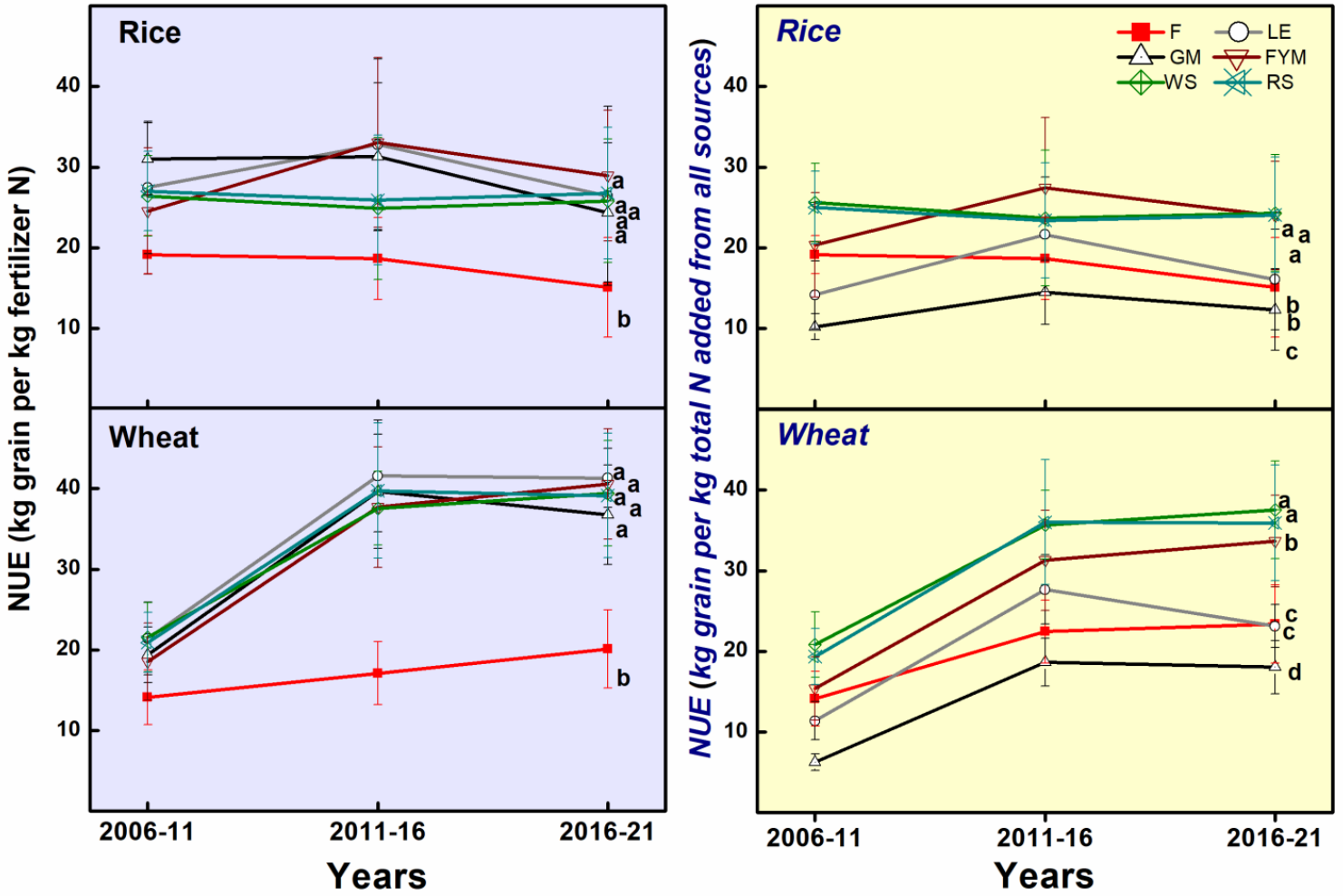
- Better **biological activity**
- Improved **microbial diversity**





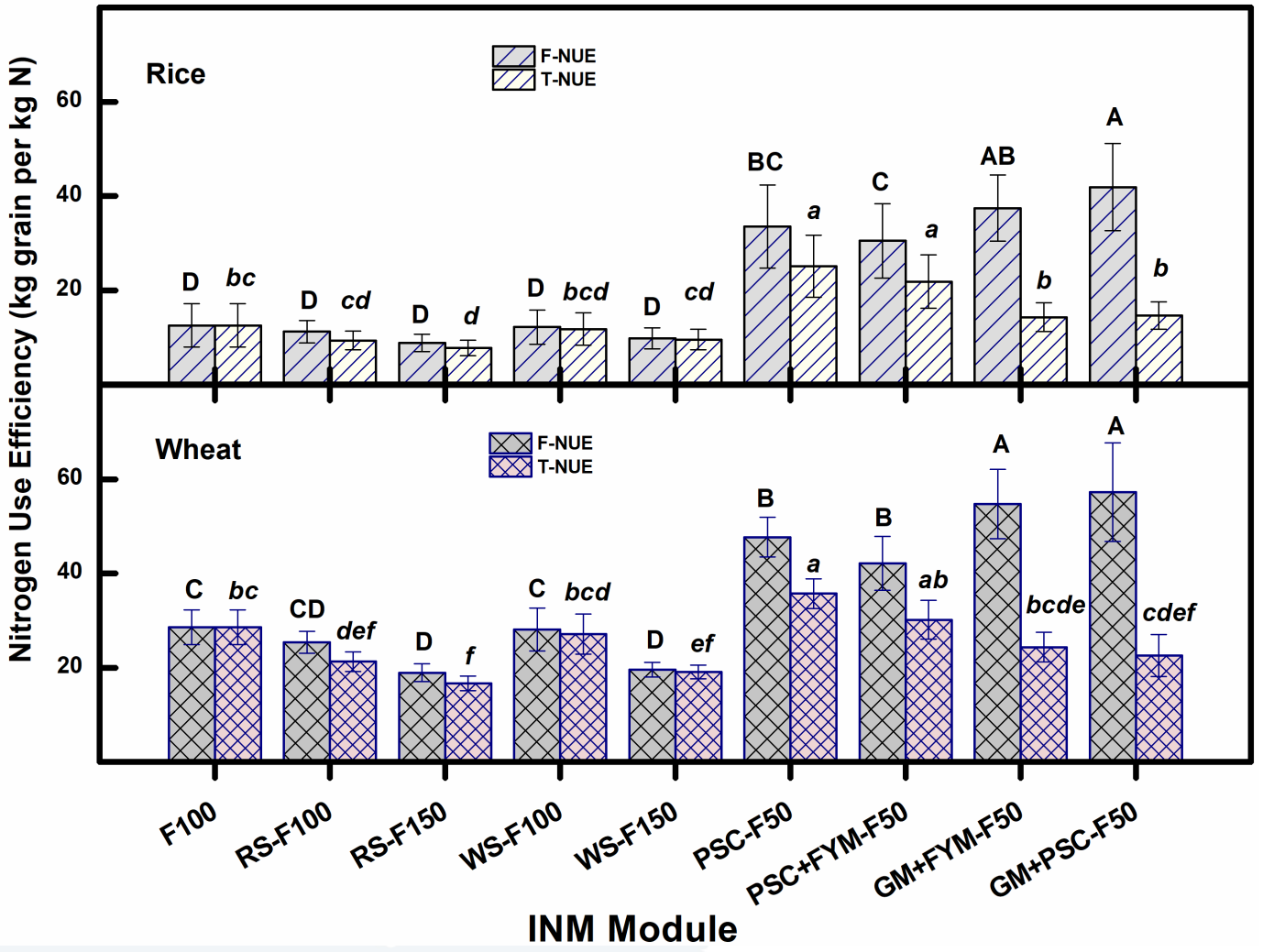
Nitrogen use efficiency

- **INM** improved fertilizer use efficiency
- **Cereal residue and compost** based INM provided most efficient N use



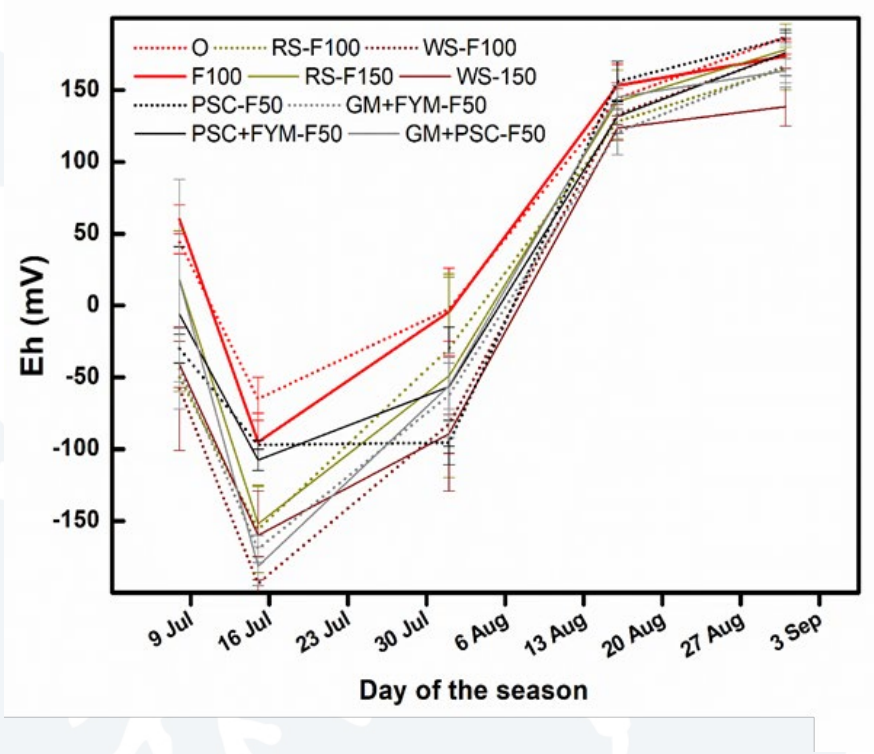
Nitrogen Use Efficiency

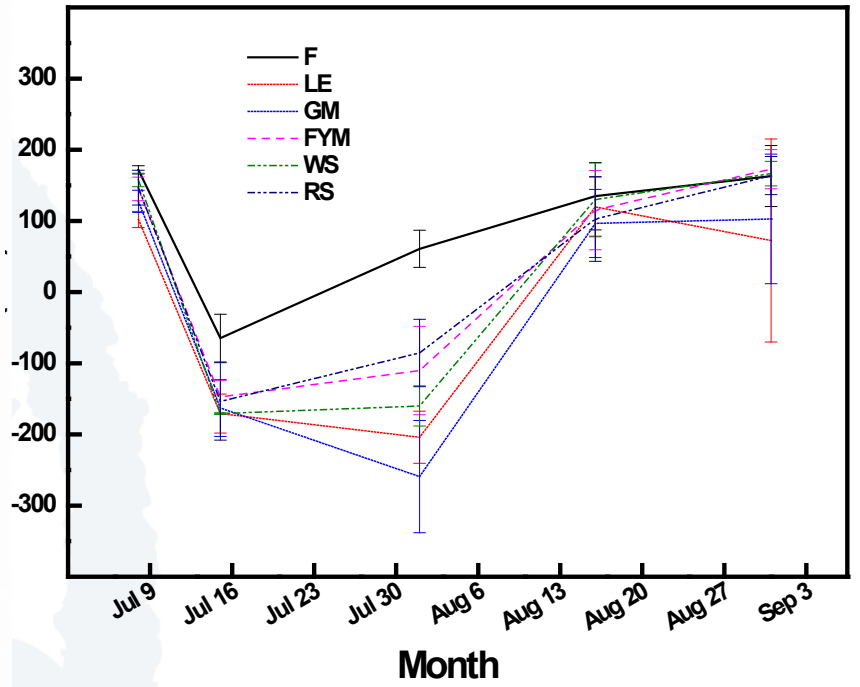
- Integration of **paddy straw compost (PSC)** and **green manuring** provided best NUE



NUE linkages to Redox potential [rice crop]

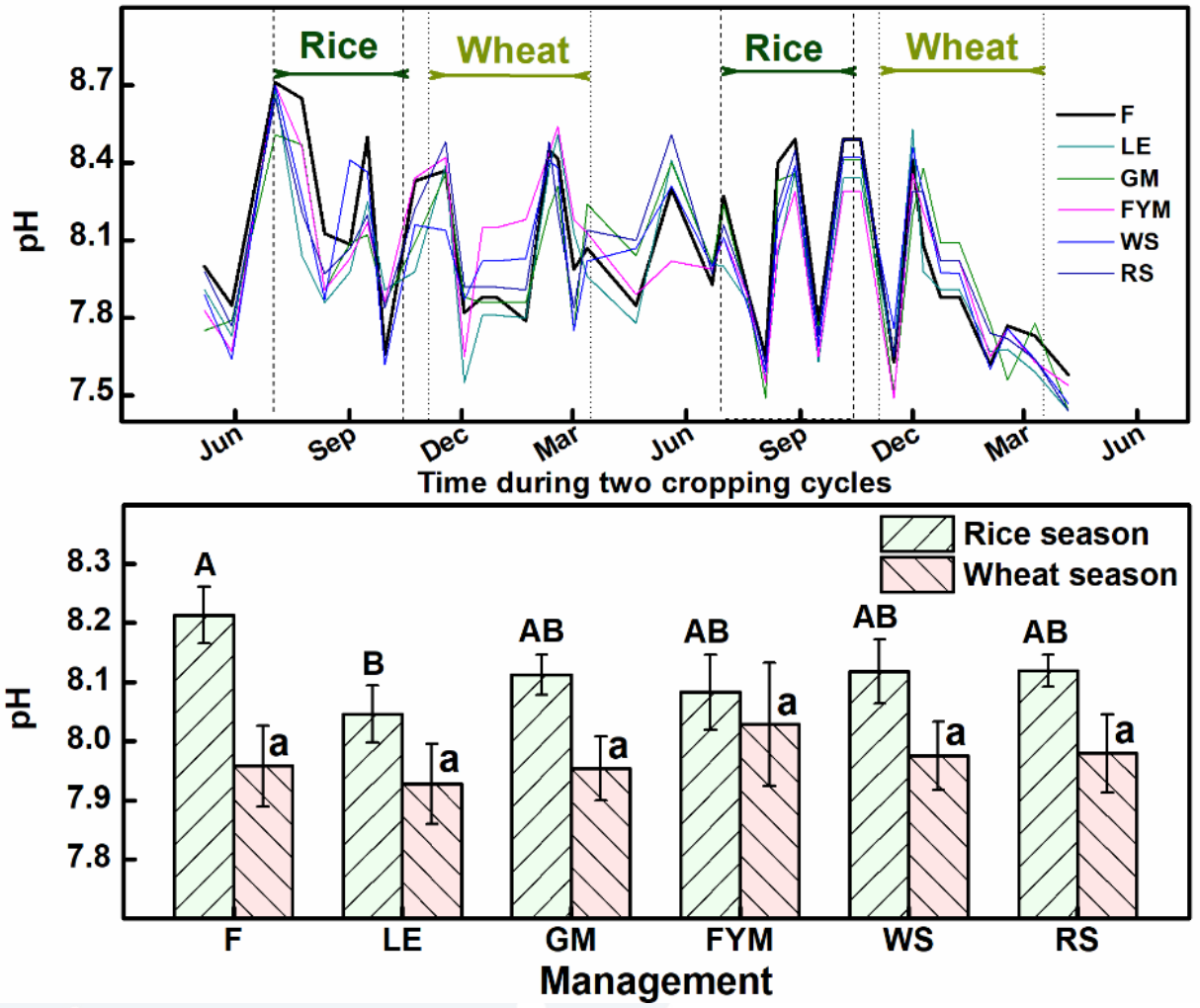
- Significant drop in the **redox potential** help **improve nutrient availability in INM**





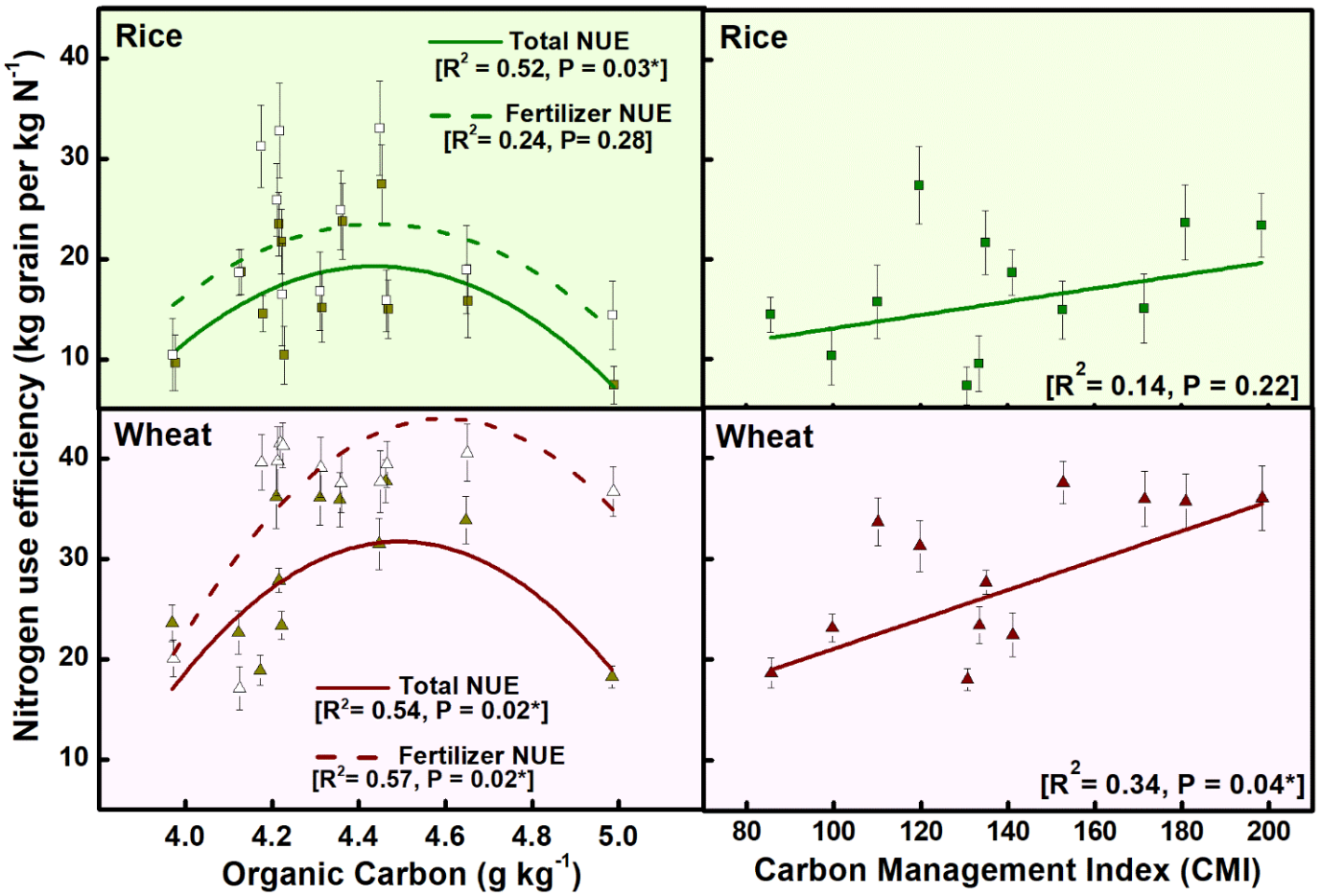
NUE linkages to Soil pH [rice crop]

- **Drop in pH** of soils with integration of organic, in **rice season**
- **Increase availability of nutrients** for alkaline soils



NUE linkage to soil C [wheat crop]

- For **wheat** crop, changes in labile soil carbon correlated best to the improved NUE
- Increased CMI-increased NUE



***Carbon management index (CMI)** is derived from the total soil organic C pool and C lability

Conclusion

- Cereal crop residue integration needed augmenting with 100% fertilizer
- Legume residue integration afforded cutting down fertilizers to 50%
- **BEST OPTION-Integration of green manuring with residue compost (PSC)/manure improved productivity, nutrient availability with 50% fertilizer cut down**
- Changes in electrochemistry favoured improved productivity & NUE with INM in **rice crop**
- Management promoting soil carbon accrual favoured increased NUE and productivity for **wheat crop**

Thank you !

FOR DETAILS REFER:

- Bhardwaj AK, Rajwar D, Mandal UK, Ahamad S, Kaphaliya B, Minhas PS, Prabhakar M, Banyal R, Singh R, Chaudhari SK, Sharma PC (2019) Impact of carbon inputs on soil carbon fractionation, sequestration and biological responses under major nutrient management practices for rice-wheat cropping systems. Scientific Reports 9(1):1-10. https://doi.org/10.1038/s41598-019-45534-z
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