Integrated management of nutrients from organic and inorganic sources increase productivity, soil health and climate resilience of sodic soils

Ajay Kumar Bhardwaj*, Bhaskar Narjary, Priyanka Chandra
Central Soil Salinity Research Institute, Karnal 132001, Haryana, India

INTRODUCTION

Sodic soils are inherently low in organic carbon (C), which is lifeline of a fertile soil. Organic carbon controls many functions which play vital role in plant nutrition by controlling cation exchange, aeration, water holding, leaching of salts, and nutrient mineralization etc. Nutrient availability to plants in the sodic soils is also low, and therefore higher than normal nutrient application is advocated for crop production in these soils. Soil pH range is unfavorable for micronutrient availability. Increased levels of sodium (Na) salts in soil adversely affect microbial and enzymatic activity which plays role in nutrient transformations. Not only presence of Na salts and pH play important part but physical conditions may also assert significant negative impact, indirectly. Sodic conditions result in clay dispersion and compaction of soil, and this restricts plant-root growth to explore more soil volume for nutrients and water. Overall, the poor soil conditions, chemically and physical makes sodic soils poor in crop productivity. The effects of climatic variability and change can also be worse in sodic conditions than normal soils as both wetter and drier conditions (two predicted extremes under climate change scenarios) generate conditions for high plant stress in sodic soils.

Use of organic manures is advocated yet it is minimal in practice because of non-availability, low nutrient loads, uncertainty in nutrient release characteristics, and increased labor and cost of transportation and spreading. An integrated approach is desirable yet the long term effects on nutrient availability and productivity are not well known.

RESULTS

Integration of organics in nutrient management improved nitrogen availability and use efficiency (Fig 1), enhanced enzymatic activity (Fig 2), enhanced C sequestration (Fig 3), and increased system resilience (Fig 4).

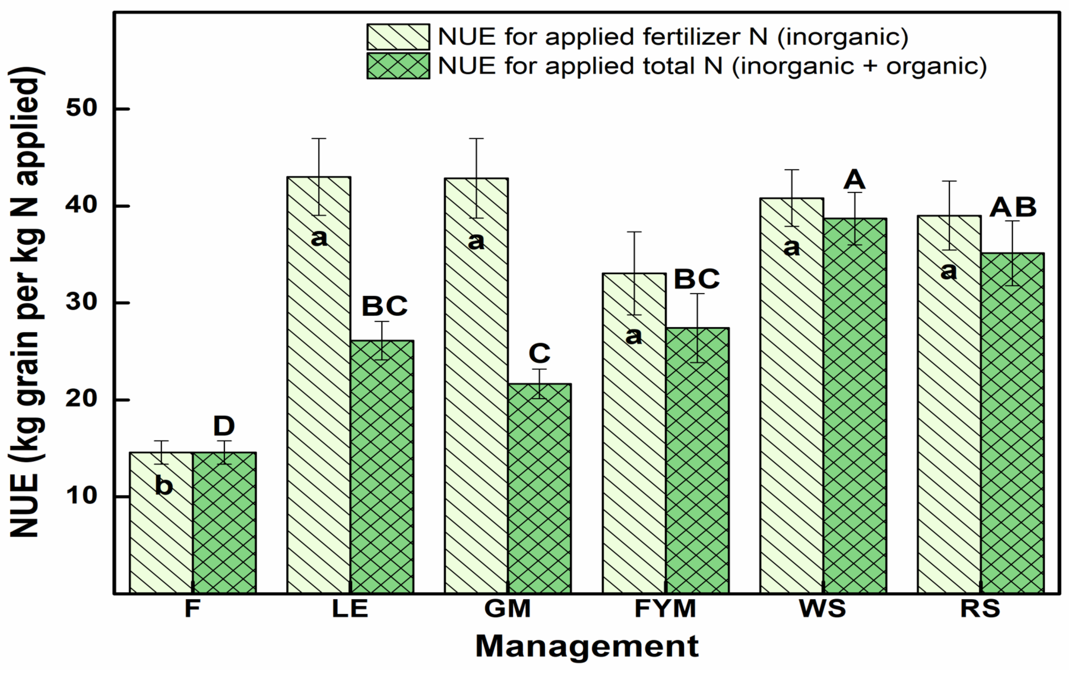

Fig 1. Nitrogen use efficiency (NUE) of the wheat crop in response to different management (averaged for 2 cropping cycles)

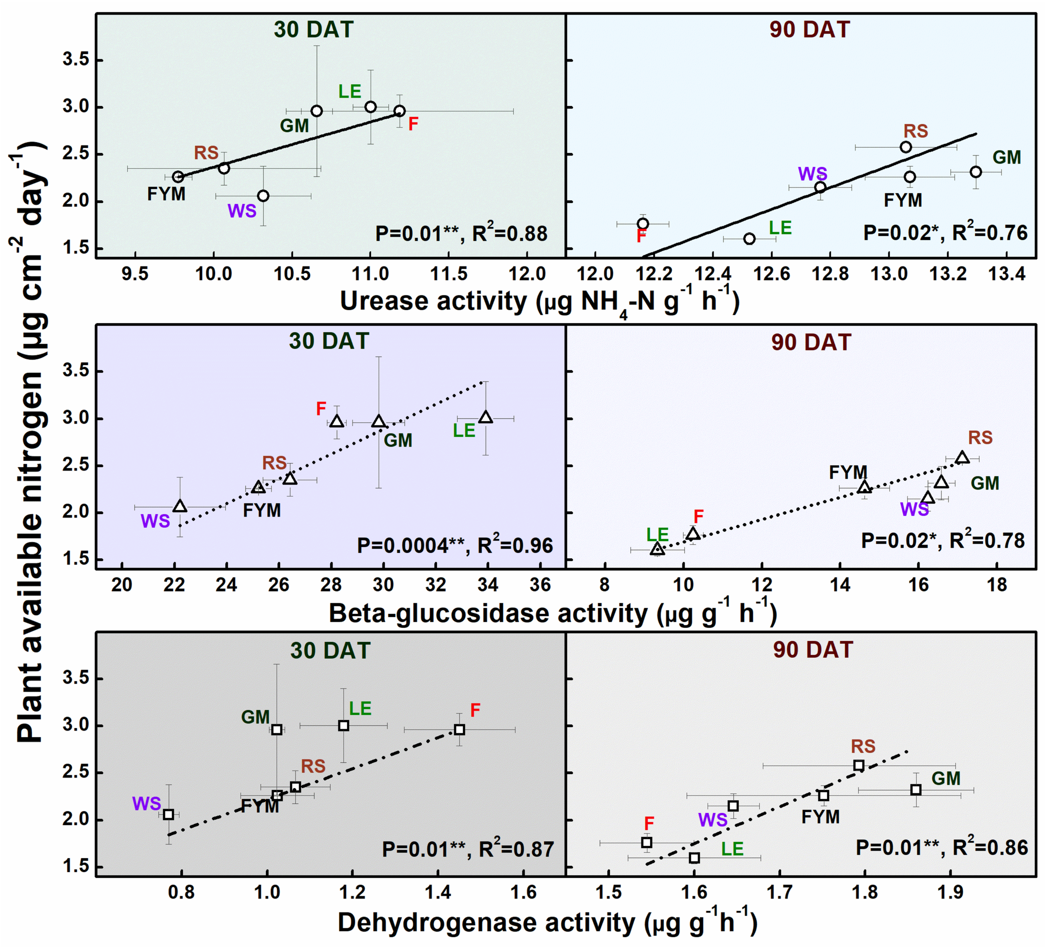

Fig 2. Relation between enzymatic activity and plant available nitrogen at 30 and 90 days after rice transplanting (DAT)(averaged for two cropping cycles)

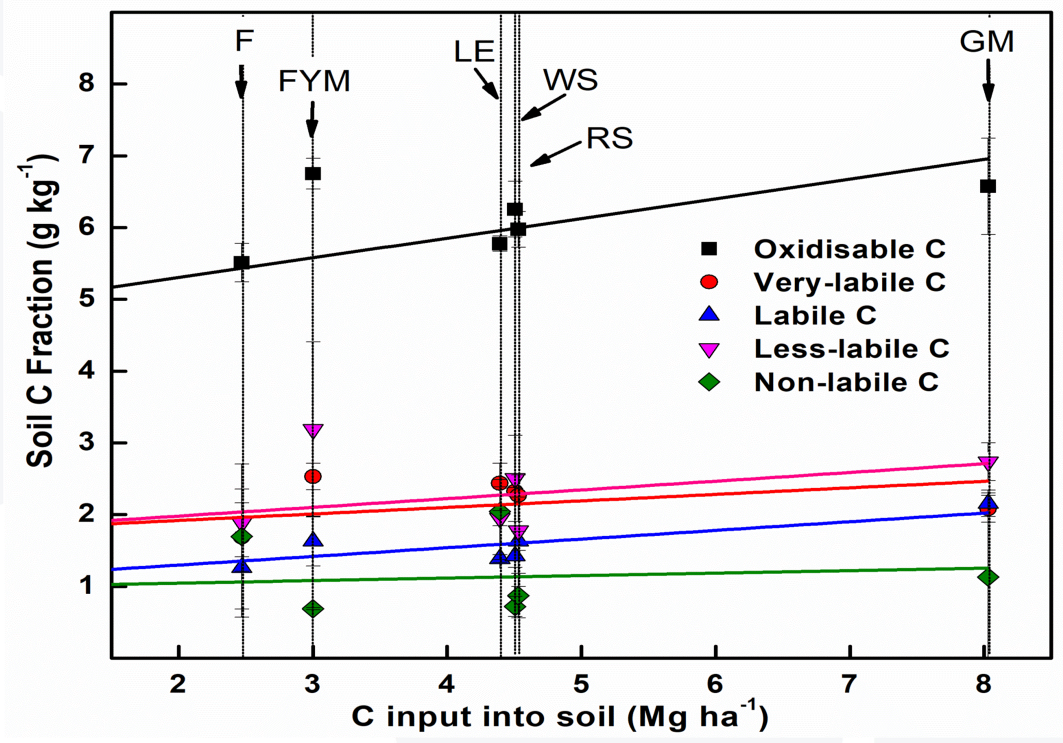

Fig 3. Relationship between carbon (C) input into the soil and soil C fractions under different management

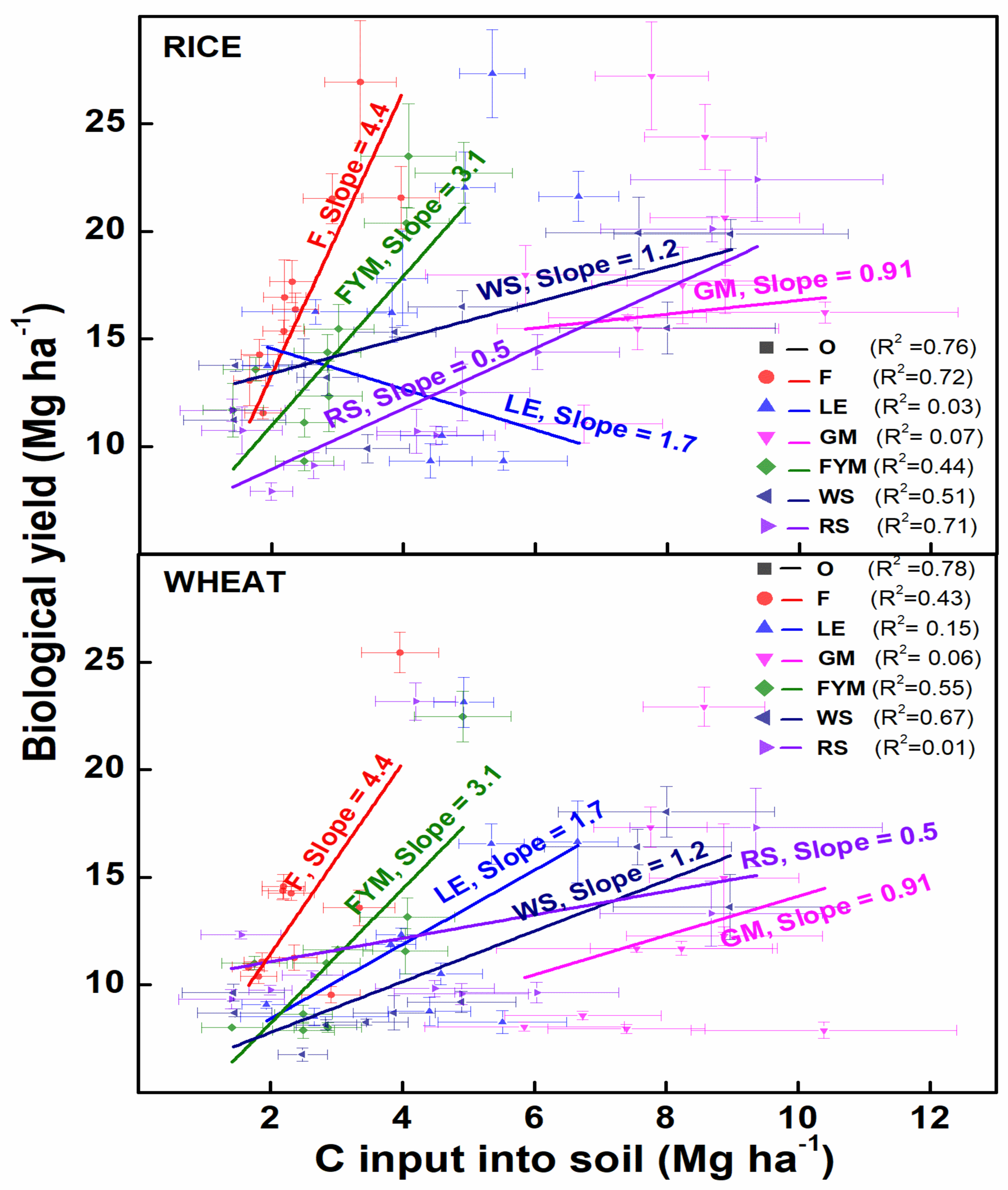

Fig 4. Response of carbon (C) input into the soil in terms of above ground biomass yield (grain+ straw), under different management

METHODOLOGY

15 year long (2005-21) experiments on nutrient management for rice-wheat systems on a soil with sandy loam texture at CSSRI, Karnal, India, were used to study nutrient mineralization, soil carbon dynamics and productivity. At the initiation of experiment the soils recorded a pH of 8.6, soil organic carbon equal to 2.1 g kg^{-1}, and bulk density equal to 1.43 Mg m^{-3} initially. Integrated nutrient management treatments as described in the table below were imposed. Soil carbon fractions were determined using the Modified Walkley Black Method (Bhardwaj et al., 2019; Scientific Reports), enzymatic activities were determined with the colorimetric analysis (Bhardwaj et al., 2020, Journal of Soil Science and Plant Nutrition), and nitrogen use efficiency was calculated using standard method (Bhardwaj et al., 2021, Frontiers in Plant Science).

F	Rice followed by wheat was grown with full recommended inorganic fertilizer input (N:P:K=180:26:42). No organic inputs were provided.
LE	Legume (LE), *Vigna radiata*, was grown in the summer lean period between wheat and rice as an "opportunity crop". The Vigna seeds were sown in the first week of April, immediately after wheat harvest. In the first week of July (after ~ 60 days of sowing) pods were harvested and the remaining plant biomass was incorporated into the soil, just before rice transplanting. Inorganic fertilizer (N,P, K) application was cut to half.
GM	A green manure crop, Sesbania aculeata, was grown in the lean period between wheat and rice. The green manure crop was sown on or around 20th of May every year after wheat harvest. After 35-40 days of sowing, the crop was incorporated into the soil, just before rice transplanting. Inorganic fertilizer (N,P, K) application was cut to half.
FYM	Farmyard manure (FYM) at the rate of 10 Mg ha^{-1} was incorporated in the soil just before transplanting of rice. Inorganic fertilizer (N,P, K) application was cut to half.
WS	30 cm standing stubble was retained at the time of harvesting of wheat; dry-plowed into the soil before rice transplanting in the 1st week of July. Inorganic fertilizer (N,P, K) application was cut to half.
RS	30 cm standing stubble was retained at the time of harvesting of rice; dry-plowed into soil at the time of wheat sowing in 2nd week of November. Inorganic fertilizer (N,P, K) application was cut to half.

CONCLUSIONS

- Three integrated nutrient management systems for sodic soils provide benefits in terms of improved nutrient availability with improved soil biological activity, increased productivity, improved soil health and resilience.
- The integrated practices include:
  - Green manuring with *Sesbania aculeata*
  - Integration of a legume crop (*Vigna radiata*) in the main cropping systems and soil incorporation of its residues
  - Partial retention and soil incorporation of cereal crop residues
- Reduced application of inorganic fertilizers (as low as 50%) can be afforded with these practices.
- These practices provide long term benefits in checking sodification and increasing productivity.

GLOBAL SYMPOSIUM ON
SALT-AFFECTED SOILS
20 - 22 October, 2021