

Original Research Article

Restoration of Soil Health through Soil Organic Carbon Management: A Case Study of N-Carb and Fertilisil in Drylands of Adoni, Andhra Pradesh

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Abstract

The present study was undertaken to evaluate the potential of N-Carb, fermented organic manure (FOM), for improving soil health through soil organic carbon (SOC) management in dryland chilli-growing areas of Adoni, Kurnool district, Andhra Pradesh. The study focused on soils characterized by low organic carbon, nutrient deficiencies and localized salinity problems, which can adversely affect crop productivity and nutrient-use efficiency. N-Carb contains fermented organic extracts along with organic matter and plant nutrients, including nitrogen, phosphorus, potassium and micronutrients. Its application was evaluated for its potential to improve soil organic matter, soil structure, moisture retention and nutrient availability in the root zone. A field-based assessment was conducted in selected chilli-growing areas of Adoni. A total of 32 surface soil samples (0–15 cm depth) were collected from the experimental plots and analyzed using rapid soil-testing kits and the Krishitantra soil-testing system developed by ICAR–IIRR, Rajendranagar, Hyderabad. The study examined the soil conditions associated with low SOC and nutrient stress and assessed the response to the application of N-Carb and Fertilisil under farmer-managed conditions. The observations indicated that SOC management through organic inputs has potential to improve soil physical conditions, nutrient availability and crop growth under dryland conditions. Improved soil moisture retention, aeration and root-zone conditions may contribute to better nutrient uptake and improved crop tolerance to abiotic stresses such as drought and salinity. The findings suggest that the integration of fermented organic manure with balanced fertilizer management may be a useful approach for improving soil health and promoting sustainable and regenerative agricultural practices in degraded and nutrient-stressed soils.

Keywords: Soil organic carbon, soil health, N-Carb, Fertilisil, fermented organic manure, nutrient management, soil moisture, salinity, nutrient-use efficiency, dryland agriculture, microorganisms

Introduction

Terrestrial soil organic carbon is having more influence on climate change and global warming than atmospheric carbon. Soil has the potential to capture and store both organic and inorganic forms of carbon and act as a sink as well as a source.

Restoration of soil health through soil organic carbon (SOC) management is a crucial aspect of sustainable agriculture and land management. Soil organic carbon is the carbon contained in organic matter within the soil, such as plant and animal residues, microorganisms, and decomposed organic material. Managing SOC levels in the soil is essential for several reasons:

Improving Soil Fertility: Organic carbon is a fundamental component of soil organic matter, and it plays a vital role in nutrient cycling. Soil microorganisms break down organic matter, releasing essential nutrients like nitrogen, phosphorus, and sulphur, which are then available for plant uptake. Increased SOC levels can lead to enhanced soil fertility.

Enhancing Soil Structure: Organic matter helps bind soil particles together, improving soil structure and reducing erosion. This can prevent soil erosion, improve water infiltration, and increase soil water-holding capacity. As a result, soil with higher SOC content is generally more resistant to drought and erosion.

Carbon Sequestration: Managing SOC can also contribute to climate change mitigation by sequestering carbon in the soil. This means that carbon is stored in the soil, reducing its presence in the atmosphere as carbon dioxide, which is a greenhouse gas. Healthy soils act as a carbon sink, helping to offset carbon emissions.

Increased Water Retention: Soils with higher organic carbon content can retain more water, reducing the risk of water stress for crops during dry periods. This is especially important in regions with limited water resources.

How N-Carb Restores Soil Health through SOC Management

N-Carb is fermented organic manure; it adds organic matter to the soil, which can increase SOC levels over a period of time. These materials provide a source of carbon and nutrients for soil microorganisms. Application of N-Carb to the soil is one among the holistic management practices of Regenerative Agriculture.

N-Carb helps pH Buffering: Organic matter can help buffer soil pH, making it more stable and resistant to drastic changes. This is particularly important for

maintaining optimal conditions for nutrient uptake by plants.

N-Carb Enhances Biological Diversity: Organic compounds support a diverse and healthy soil ecosystem, including beneficial insects, earthworms, and microorganisms. This biodiversity contributes to pest control, nutrient cycling, and overall soil health.



Figure 1. N-Carb promotes microbial activity and gives life to the soil.

N-Carb Reduces Dependency on Synthetic Inputs: By incorporating organic matter and compounds, farming reduces the need for synthetic fertilizers, which can have negative environmental impacts when overused.

Trail Details

CROP & VARIETY	CHILLIES , Ryal Delux
FARMER NAME	VENKATESH
VILLAGE	CHINAPENDEKAL
MANDAL	ADONI
STATE	ANDHRAPRADESH
PLANTING DISTANCE	60 CM x 30 CM
AREA OF TREATMENT	1 Acre = 0.4 ha
SOIL	SANDY LOAM
IRRIGATION METHOD	FLOOD - ROWS
DATE OF SOWING	12-08-2021
ASSESSMENT	From 35 DAT to Harvest
AREA OF ASSESSMENT	1 sqm

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Figure 2. N-Carb product overview and the soil functions it is intended to promote.

N-Carb Typical Analysis

Materials and Methods

PROGRAMME:

- Control : F1
- Regular Farmer Practice (F1)
- Advance Practice: F2
- Third Party Product Practice: F3
- Regular Farmer Practice + 19:19:19

Nutrition schedule with 0:40:40+TE and N-Carb(Organic matter enhancer) + Reduced Quantity of Chemical fertilizers.

Table 1. N-Carb typical analysis compared with the general range for farmyard manure (FYM). Test method: Fertilizers (Control) Order 1985 – IS 7219.

Characteristics	Range of FYM	N-Carb
pH (in Water)	7.3–8.6	6–7.1
Carbon Content (%)	6.63–7.2%	52.63%
Total Protein	0	40.17%
Total Nitrogen (%), Kjeldahl	1.4–5.8%	6.42%
Total Phosphorus (%)	0.4–1.4%	0.44%
Total Potassium (%)	0.12–0.52%	0.03%
Total Zinc (%)	0.01–3.0%	0.04%
Total Calcium (%)	1.5–3.0%	0.22%
Total Magnesium (%)	0.5–1.1%	0.24%
Iron	0	0.04%
Boron	0	0.001%
Carbon:Nitrogen Ratio	7.7–8.03	8.24
Total Organic Matter	83.21 (Fresh Cow Dung)	89.87%

Site Selection and Experimental Approach

Geographical areas with major soil constraints, including low soil organic carbon, salinity and nutrient deficiencies, were identified for conducting field experiments with N-Carb. The objective was to evaluate the potential of N-Carb for improving soil health and crop performance in chilli-growing areas of Adoni division, Kurnool district, Andhra Pradesh.

The selected areas are important chilli-growing regions where soils are characterized by low organic carbon content, ranging from 0.35 to 0.65%, with an average of approximately 0.50%, along with localized salinity problems and nutrient deficiencies. These soil constraints were associated with relatively low chilli productivity. The observed yield was generally 15–18 quintals per acre, compared with a potential yield of approximately 25–30 quintals per acre under improved soil and crop management conditions.

Considering the existing fertilizer practices and the economics of chilli cultivation, N-Carb was incorporated into the farmer's existing nutrient-management schedule. The product was applied during final land preparation before transplanting so that its use could be integrated into the farmer's normal cultivation practices without major changes in the production system.

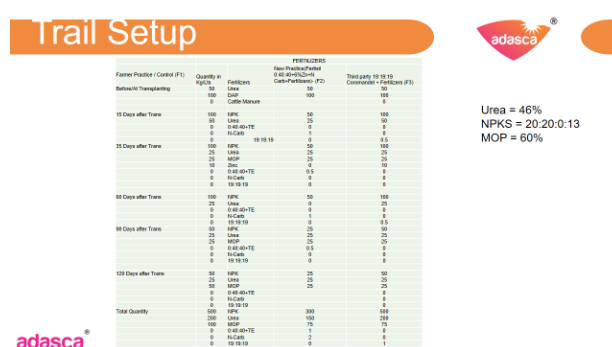
Description and Application of N-Carb

N-Carb is fermented organic manure (FOM) in liquid form containing organic extracts and is described as a proprietary product of Adasca. The product is reported to be FCO-certified by the Government of India. It is intended for use in regenerative agricultural practices and contains organic matter along with nitrogen, phosphorus, potassium and micronutrients. Its application is intended to improve soil organic matter and soil organic carbon, thereby contributing to better soil structure and overall soil health.

Soils with a high sand content generally have weak aggregation and low organic matter, which can adversely affect water and nutrient retention. The application of organic materials can improve soil aggregation and structural stability. N-Carb was therefore used with the objective of improving soil structure and organic matter content in the selected fields.

Improvement in soil structure and aggregation may enhance soil porosity and aeration, reduce the risk of soil degradation and erosion, and improve moisture retention in the root zone. These improvements may subsequently help the crop tolerate periods of moisture stress and other adverse soil conditions. The field observations were therefore focused on changes in soil condition, root development and crop growth following N-Carb application.

Trial Details

**Figure 3.** Trial details for the field demonstration.

The programme compared three treatments: Control (F1, regular farmer practice); Advance Practice (F2, nutrition schedule with 0:40:40+TE and N-Carb (organic matter enhancer) plus reduced quantity of chemical fertilizers); and Third-Party Product Practice (F3, regular farmer practice plus 19:19:19).

Trial Setup

Trial Design Particulars					
Sr. No.	Treatment on Days	Purpose	Method of Application	Product	Dosage
1	15 DAT	Organic matter enhancer (SOM)	Soil Application	N-Carb	1 Ltr for 1 Acre
2	35 DAT	Flowering	Spray	Fertisil 0:40:40+TE	500 ml for 1 Acre
3	60 DAT	Organic matter enhancer (SOM)	Soil Application	N-Carb	1 Ltr for 1 Acre
4	90 DAT	Flowering & Fruit development	Spray	Fertisil 0:40:40+TE	500 ml for 1 Acre
DAT = Days after Transplanting					
Third Party Product 19:19:19					
	135 DAT	Flowering	Spray	19:19:19	500 ml for 1 Acre
	290 DAT	Flowering & Fruit development	Spray	19:19:19	500 ml for 1 Acre

Figure 4. Trial setup: fertilizer quantities (kg/L) applied under each practice at successive stages after transplanting. Urea = 46%, NPKS = 20:20:0:13, MOP = 60%.

Trial Design Particulars

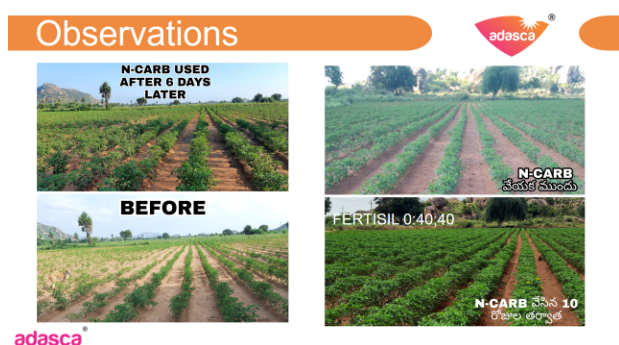


Figure 5. Trial design particulars: treatment schedule, purpose, method of application, product and dosage. DAT = Days after Transplanting.

Results and Discussion

Field Demonstration of N-Carb in Chilli

The field demonstration was conducted in Chinapendekal village of Adoni mandal, Kurnool district, Andhra Pradesh, in a farmer's chilli field. The farmer, Sri K. Venkatesh, was cultivating chilli under conditions of low soil organic carbon, with patches affected by salinity. Based on the initial assessment, the soil was neutral to alkaline in reaction and characterized by very low organic carbon content. The low soil organic carbon and associated salinity were considered important factors contributing to reduced crop productivity. An area of 1 acre out of the farmer's 2-acre chilli field was selected for demonstration. N-Carb, fermented organic manure (FOM), was applied along with the farmer's normal agronomic practices and recommended fertilizer schedule. The product was applied in two equal doses, at 15 and 60 days after transplanting (DAT), by broadcasting after mixing 1 L N-Carb per acre with the fertilizer at each application [2,3,10].

The chilli variety cultivated was Royal Delux, and transplanting was carried out on 12 August 2021. Two nutrient management practices were compared. Under

farmer practice (F1), the fertilizer application consisted of 500 kg NPK complex fertilizer, 200 kg urea, 100 kg MOP and 10 kg ZnSO₄ per acre. Under the advanced practice (F2), 300 kg NPK complex fertilizer, 150 kg urea, 75 kg MOP and 2 L N-Carb per acre were applied along with fertilizers. In addition, FERTISIL (0:40:40 + 6% Zn) was applied at 2 mL L⁻¹ at 40 DAT as a foliar spray. The field was monitored at 15-day intervals from transplanting until harvest. Visual observations indicated that the N-Carb-treated plot developed a comparatively loose soil structure and a lighter brown colour of the surface soil. Plants in the treated plot exhibited vigorous vegetative growth, greater branching and a comparatively larger canopy than those under farmer practice [4,5,6].



Figure 6. Field observations before N-Carb application and 6 days after N-Carb application, alongside a comparison of N-Carb and Fertisil-treated rows.

The N-Carb-treated plants also showed better performance with respect to plant height, number of branches per plant, number of chilli pods per plant and pod length. More extensive root hair development was observed in the treated plot, suggesting improved rhizosphere development and root proliferation. The

greater root development may have contributed to improved exploration of soil nutrients and water. Improvement was also observed in several soil and crop attributes, including soil porosity, permeability, and moisture retention in the root zone, vegetative biomass, branching, flowering and pod setting. The treated plants appeared better able to withstand short periods of delayed irrigation and adverse soil conditions. These observations indicate the potential of N-Carb as a soil-conditioning organic input under low-organic-carbon and salinity-affected conditions [6,7,8].



Figure 7. Root system comparison of chilli plants treated with N-Carb versus untreated plants, showing more extensive root and root-hair development in the treated plant.



Figure 8. Root hair and biomass observations recorded at 35 DAT: more root hairs and biomass compared with the control plot, increased soil porosity, earthworm movement observed 15 days after application, and more branching and healthier vegetative growth compared with the control plot.

The improved soil physical condition observed in the N-Carb-treated plot may have facilitated greater root spread and better access to soil moisture and nutrients. Improved aeration and moisture conditions in the rhizosphere can also support the activity of beneficial soil microorganisms, including bacteria and fungi, which play important roles in nutrient cycling and soil organic matter transformation. Overall, the field observations suggest that incorporation of a carbon-rich fermented organic input such as N-Carb may contribute

to improvement in soil physical condition and crop growth. However, quantitative soil analyses, yield measurements and statistical validation are required to establish the magnitude and significance of these effects [9,10,11].

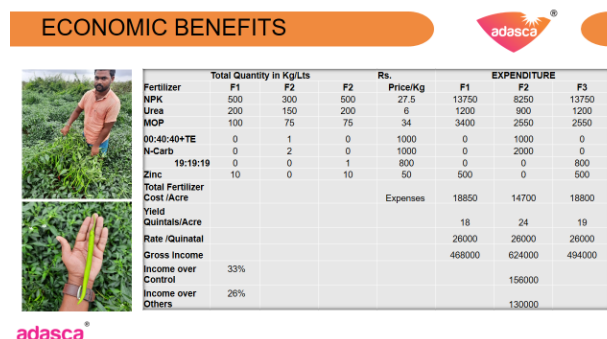


Figure 9. Observations taken at 60 days until harvest: 1. Rhizosphere development. 2. Soil porosity and water holding capacity. 3. Biomass development. 4. Improvement in branching and vegetative growth. 5. Flowering and pod setting / flower dropping. 6. Effect of pest and diseases. 7. Fertilizer use efficiency. 8. Yield parameters and economic benefit to farmer.



Figure 10. Economic benefits: fertilizer quantities, expenditure, yield and income across the three treatments (F1 = Control, F2 = Advance Practice, F3 = Third-Party Product).



Figure 11. Yield (quintals per acre) under Control (F1), Advance Practice with N-Carb (F2), and Third-Party Product Practice (F3). The Advance Practice (F2) recorded a 33% yield increase over Control.

Conclusions			
Parameter	F1 (Control)	F2 (Advance)	F3 (Third Party)
Rhizosphere Root development	Low /Normal 8 cm	Good root growth 15 cm	Normal 10 cm
Soil Porosity and Water holding	Low/Normal(Hard and compact)	Better (soil become loose and better water holding capacity)	Normal (Hard and compact)
Biomass Development	Normal and No earth worms	Well developed and Earthworms movement observed	Normal and No earth worms
Absorption of Nutrients through roots and Leaves		> 50% better absorption rate observed, Better crop and Yield	
Branching and Vegetative Growth	Comparatively low	More branches and Vegetative growth	Comparatively low
Flowering and fruit setting	Low	Good and less flower dropping	Normal
Pest and Diseases	More Affected	Less affected	More affected
Fertilizer use efficiency		Comparatively >70%	
Yield Parameters	18 Quintal/Acre	24 Qty with better quality fruits	19 less quality
Economic Benefit		33% more benefit than the Control and 26% more over others	

Figure 12. Summary comparison of soil and crop parameters across the three treatments.

Conclusion

The field demonstration indicated that application of N-Carb, a fermented organic manure (FOM), had a positive effect on soil condition and chilli crop growth under low-organic-carbon and salinity-affected soil conditions. The N-Carb-treated plot showed improved soil looseness, porosity and moisture-retention characteristics, together with better root development, vegetative growth, branching, flowering and pod formation compared with farmer practice. The improved rhizosphere condition and greater root development may have enhanced the availability and uptake of nutrients and water by the crop. The observations also indicated better crop establishment and tolerance to short periods of moisture stress and adverse soil conditions. The carbon-rich organic material in N-Carb may support beneficial microbial activity and contribute to the improvement of soil organic matter. Thus, N-Carb has potential as an organic soil-conditioning input for improving soil health and crop performance, particularly in soils characterized by low organic carbon and salinity-related constraints. Its use may be integrated with balanced fertilizer management as part of regenerative and sustainable agricultural practices. However, further multi-location and multi-season studies involving quantitative soil properties, nutrient uptake, yield, soil organic carbon and economic returns are recommended to scientifically validate its long-term effectiveness.

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