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Comparative effects of organic and inorganic fertilizers on soil organic carbon under sub-humid southern plain and Aravalli hills of Rajasthan

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Abstract— *A field experiment was conducted during rabi 2023–24 and 2024–25 at the Instructional Farm, Rajasthan College of Agriculture, Udaipur, to evaluate the comparative effects of long-term organic and inorganic fertilization on soil organic carbon (SOC) under a maize–wheat cropping sequence. The experiment was laid out in a randomized block design with 12 nutrient management treatments, comprising sole chemical fertilizers, organic manures and their integrated combinations. The results revealed that SOC content was significantly enhanced under organic and integrated nutrient management practices compared to sole chemical fertilization and unfertilized control. Application of FYM @ 20 t ha^{-1} (T_8) recorded the highest SOC values (0.985–0.987%), showing nearly an 86% increase over control (0.530%), followed by NPK + FYM 10 t ha^{-1} (T_7: 0.942%) and FYM 10 t + 100% NPK (T_6: 0.921%). Balanced fertilization with micronutrients and biofertilizers resulted in moderate improvements in SOC, whereas imbalanced fertilization treatments such as 100% N and 100% NP showed limited effectiveness. Pooled analysis across years confirmed that continuous application of FYM, either alone or in combination with NPK, was most effective in sustaining and building soil organic carbon. The study highlights the critical role of organic and integrated nutrient management in enhancing soil carbon stocks, thereby improving soil health and sustainability of wheat-based cropping systems in the sub-humid southern plain and Aravalli hills of Rajasthan.*

Keywords— ***Soil organic carbon, integrated nutrient management, farmyard manure, soil health, sustainable agriculture***

I. INTRODUCTION

Soil organic carbon (SOC) is a fundamental indicator of soil health and plays a pivotal role in regulating nutrient availability, soil structure, water retention and biological activity, thereby directly influencing crop productivity and long-term sustainability of agro-ecosystems. The dynamics of SOC are highly sensitive to nutrient management practices, cropping systems and residue management, particularly under intensive agriculture. Long-term fertilizer inputs, whether organic or inorganic, significantly modify the quantity and quality of soil organic matter, influencing carbon sequestration, aggregate stability and nutrient cycling (Lal, 2004; Bronick and Lal, 2005). Continuous reliance on chemical fertilizers without organic amendments has often been associated with a gradual decline in SOC, leading to soil degradation and reduced system resilience, especially in cereal-based cropping systems. Agricultural intensification in semi-arid and sub-humid regions, such as the sub-humid southern plain and Aravalli hills of Rajasthan, has increased pressure on soil carbon stocks due to high cropping intensity, limited residue returns and accelerated organic matter mineralization. Several studies have reported that long-term imbalanced fertilization or sole application of nitrogenous fertilizers results in depletion of SOC, deterioration of soil structure and reduced nutrient-use efficiency (Pagliai *et al.,* 2004; Kodešová *et al.,* 2008, 2011). In contrast, the incorporation of organic manures such as farmyard manure (FYM), either alone or in combination with balanced mineral fertilizers, has been shown to enhance SOC by supplying external carbon inputs, stimulating microbial activity and promoting physical protection of organic matter within soil aggregates (Regelink *et al.,* 2015; Basche and DeLonge, 2019). Integrated nutrient management practices are particularly effective in sustaining SOC under long-term cropping systems because they synchronize nutrient supply with crop demand while simultaneously replenishing soil carbon pools. Organic amendments improve soil aggregation and reduce carbon losses by decreasing erosion and mineralization rates, while balanced inorganic fertilization enhances biomass production and root turnover, indirectly contributing to SOC build-up. Long-term experiments have demonstrated that FYM-based and integrated fertilization systems consistently maintain higher SOC levels compared to sole chemical fertilizer treatments or unfertilized control (Singh *et al.,* 2018; Panagos *et al.,* 2014). In wheat-based cropping systems, SOC status after harvest is especially critical, as soils are exposed to erosion and rapid organic matter oxidation. Variations in fertilization practices create distinct differences in residue input, root biomass and microbial activity, which ultimately govern SOC accumulation or depletion. Understanding the comparative effects of organic and inorganic fertilizers on SOC under long-term maize–wheat rotations is therefore essential for designing sustainable nutrient management strategies. In this context, the present study was undertaken to evaluate the comparative effects of long-term application of organic and inorganic fertilizers on soil organic carbon under the maize–wheat cropping sequence in the sub-humid southern plain and Aravalli hills of Rajasthan. The study aims to identify nutrient management practices that enhance SOC sequestration and improve soil health for sustainable agricultural production in the region.

II. MATERIAL AND METHODS

Field Location and Experimental Site

The experiment was conducted under the aegis of the All India Coordinated Research Project (AICRP) on Long-Term Fertilizer Experiment at a fixed site (B_2 block) of the Instructional Farm, Rajasthan College of Agriculture, Udaipur. The present investigation represents the 26th and 27th maize–wheat cropping sequence of the long-term fertilizer experiment, which was initiated during kharif 1997. The experimental site is located in the south-eastern part of Rajasthan at an altitude of 582.2 m above mean sea level, with geographical coordinates of 24°35′ N latitude and 73°42′ E longitude. The region falls under Agro-climatic Zone IVa (Sub-humid Southern Plain and Aravalli Hills) of Rajasthan.

Experimental Details

The field experiment was conducted during the rabi seasons of 2023–24 and 2024–25 using wheat (*Triticum aestivum* L.) variety Raj 4037 as the test crop under a maize–wheat cropping system. A uniform seed rate of 100 kg ha^{-1} was maintained across all treatments. The experiment was laid out in a Randomized Block Design (RBD) comprising 12 treatments with four replications, resulting in a total of 48 experimental plots. Each gross plot measured 20.0 m × 9.0 m (180 m^2), while the net plot size was 19.0 m × 8.0 m (152 m^2). Sowing was carried out with a row-to-row spacing of 22.5 cm. All agronomic practices, including irrigation, weed control and plant protection measures, were carried out uniformly for all treatments following the recommended package of practices for wheat cultivation in the region.

Treatment Details

The experiment consisted of twelve long-term nutrient management treatments, involving combinations of organic and inorganic fertilizers, applied continuously on the same plots since 1997. The treatments were as follows:

T_1: NPK,
T_2: NPK + Zn,
T_3: NPK + Zn + S,
T_4: NPK + S,
T_5: NPK + Bio,
T_6: FYM 10 t ha^{-1} + 100% NPK (– NPK supplied through FYM),
T_7: NPK + FYM 10 t ha^{-1},
T_8: FYM 20 t ha^{-1},
T_9: 150% NPK,
T_{10}: 100% NP,
T_{11}: 100% N,
T_{12}: Control (no fertilizer).

III. ANALYSIS OF SOIL PARAMETERS

Soil Organic Carbon (SOC)

Soil samples were collected from the surface soil layer (0–15 cm depth) after the harvest of wheat during both years of investigation. The collected soil samples were air-dried, gently crushed and passed through a 2-mm sieve for laboratory analysis. Soil organic carbon content was determined using the Walkley and Black (1934) wet oxidation method, which involves oxidation of organic matter by potassium dichromate in the presence of concentrated sulfuric acid, followed by titration with ferrous ammonium sulfate. SOC content was expressed as percentage (%) of soil organic carbon, and pooled analysis was carried out by averaging the values of both years to assess the long-term influence of organic, inorganic and integrated nutrient management practices on soil carbon dynamics.

IV. Result and Discussion

It was explicit from the data (Table 1 and Figure 1) that soil organic carbon (SOC) was significantly influenced by long-term application of organic and inorganic fertilizers under the maize–wheat cropping sequence. During 2023–24, the lowest SOC content was recorded in the control (0.529%), whereas the highest SOC content was observed under FYM @ 20 t ha^{-1} (T_8: 0.985%), indicating an increase of about 86% over control. Integrated nutrient management treatments also resulted in substantial SOC build-up, with NPK + FYM 10 t ha^{-1} (T_7: 0.941%) and FYM 10 t ha^{-1} + 100% NPK (T_6: 0.920%) recording significantly higher SOC and remaining statistically at par with T_8. Sole application of chemical fertilizers showed comparatively lower SOC accumulation; recommended NPK (0.760%) and balanced fertilization with micronutrients or biofertilizers resulted in only moderate improvements, while imbalanced fertilization treatments such as 100% NP (0.693%) and 100% N (0.658%) were least effective. A similar trend was maintained during 2024–25, with SOC ranging from 0.531% in control to 0.987% in FYM 20 t ha^{-1}, and integrated treatments again performing superior to sole chemical fertilization. The pooled mean confirmed that continuous application of FYM, either alone or in combination with balanced NPK fertilization, consistently enhanced SOC by 73–86% over control, emphasizing the cumulative benefits of long-term organic inputs. The pronounced increase in SOC under FYM and integrated treatments can be attributed to direct addition of organic carbon through manure, greater crop biomass and root residue return, enhanced microbial activity and improved aggregate stability, which collectively reduce organic matter mineralization and promote carbon stabilization within soil aggregates. In contrast, sole and imbalanced chemical fertilization supply nutrients without sufficient carbon inputs, leading to limited SOC build-up under intensive cropping. These findings are in close agreement with earlier studies, which reported that long-term organic and integrated nutrient management practices are more effective than sole chemical fertilization in sustaining and enhancing SOC and overall soil health (Lal, 2004; Bronick and Lal, 2005; Regelink *et al.,* 2015; Singh *et al.,* 2018).

V. CONCLUSION

The present study clearly demonstrated that long-term application of organic and integrated nutrient management practices significantly enhanced soil organic carbon (SOC) compared to sole chemical fertilization and unfertilized control under the maize–wheat cropping system. Continuous application of FYM @ 20 t ha^{-1} (T_8) resulted in the highest SOC content, followed closely by its integration with balanced inorganic fertilization **(**T_6 and T_7**)**, indicating the strong potential of organic inputs in building and sustaining soil carbon stocks. Organic and integrated treatments increased SOC by 73–86% over control, highlighting the critical role of farmyard manure in replenishing soil carbon through direct organic matter addition and improved biomass recycling. Integrated nutrient management involving FYM and balanced NPK fertilization proved superior to sole chemical fertilization in maintaining higher SOC levels, reflecting improved carbon stabilization and reduced organic matter losses. In contrast, imbalanced fertilization treatments and sole application of nitrogen or NP were less effective in sustaining SOC, underscoring the limitations of chemical fertilizers when applied without organic amendments. The enhancement of SOC under FYM-based treatments can be attributed to improved soil aggregation, increased microbial activity and greater retention of crop residues, which collectively promote long-term carbon sequestration.

Table 1: Effect of organic and inorganic fertilization on organic carbon of soil after harvest of wheat under wheat maize cropping sequence

Treatment	**OC (%)**		
	2023-24	**2024-25**	**Pooled**
T_1: NPK	0.760	0.762	0.761
T_2: NPK + Zn	0.769	0.770	0.770
T_3: NPK + Zn + S	0.772	0.774	0.773

T_4: NPK + S	0.763	0.765	0.764
T_5: NPK + Bio	0.782	0.783	0.783
T_6: FYM 10 t + 100% NPK (- NPK of FYM)	0.920	0.921	0.921
T_7: NPK + FYM 10 t ha^{-1}	0.941	0.943	0.942
T_8: FYM 20 t ha^{-1}	0.985	0.987	0.986
T_9: 150% NPK	0.814	0.816	0.815
T_{10}: 100% NP	0.693	0.695	0.694
T_{11}: 100% N	0.658	0.659	0.658
T_{12}: Control	0.529	0.531	0.530
S.Em. ±	0.069	0.071	0.046
C.D. (P= 0.05)	0.199	0.206	0.131

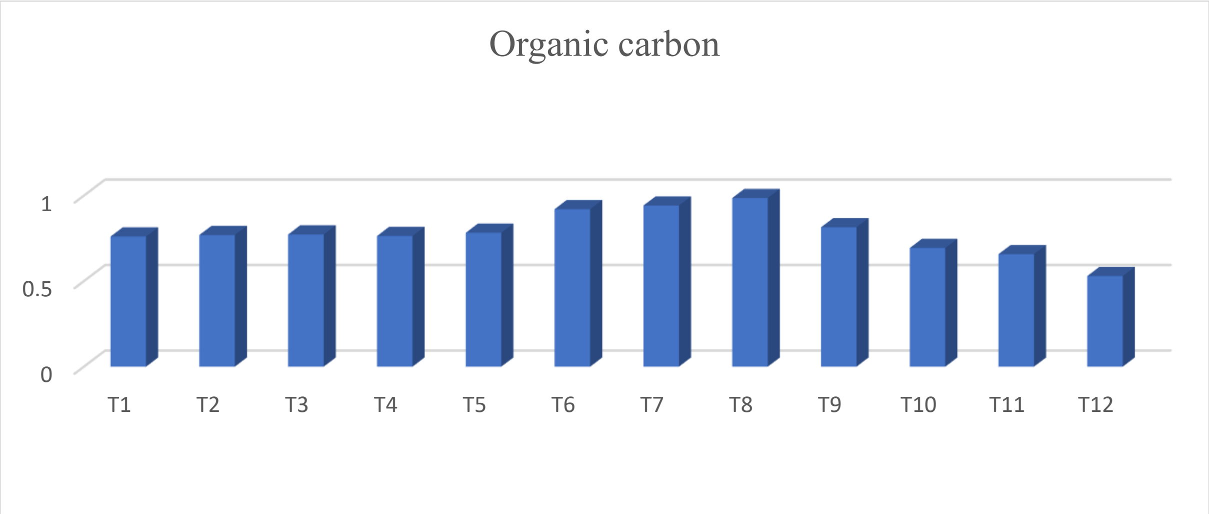

Fig.1: Effect of organic and inorganic fertilization on organic carbon of soil after harvest of wheat under wheat maize cropping sequence

REFERENCES

[1] Basche, A.D. and DeLonge, M.S., 2019. Comparing infiltration rates in soils managed with conventional and alternative farming methods: A meta-analysis. *PLoS ONE*, **14**(9): e0215702.

[2] Bronick, C.J. and Lal, R., 2005. Soil structure and management: A review. *Geoderma*, **124**: 3–22.

[3] Davin, E.L., Seneviratne, S.I., Ciais, P., Olioso, A. and Wang, T., 2014. Preferential cooling of hot extremes from cropland albedo management. *Proceedings of the National Academy of Sciences*, **111**(27): 9757–9761.

[4] Jin, Y., Randerson, J.T., Goulden, M.L. and Goetz, S.J., 2017. Postfire changes in albedo and vegetation in boreal forests of North America. *Environmental Research Letters*, **7**: 024015.

[5] Kodešová, R., Kodeš, V., Žigová, A. and Žigová, M., 2008. Impact of tillage practices on soil properties and preferential flow pathways. *Soil and Tillage Research*, **99**: 65–73.

[6] Kodešová, R., Nikodem, A., Žigová, M., Žigová, A. and Neuberger, P., 2011. Long-term tillage impact on properties of haplic Luvisol used as arable land. *Soil and Tillage Research*, **113**: 37–46.

[7] Lal, R., 2004. Soil carbon sequestration to mitigate climate change. *Geoderma*, **123**: 1–22.

[8] Pagliai, M., Vignozzi, N. and Pellegrini, S., 2004. Soil structure and the effect of management practices. *Soil and Tillage Research*, **79**: 131–143.

[9] Panagos, P., Borrelli, P., Poesen, J., Ballabio, C., Lugato, E., Meusburger, K., Montanarella, L. and Alewell, C., 2014. The new assessment of soil loss by water erosion in Europe. *Environmental Science & Policy*, **54**: 438–447.

[10] Regelink, I.C., Stoof, C.R., Rousseva, S., Weng, L. and Lair, G.J., 2015. Linkages between aggregate formation, porosity and soil chemical properties. *Geoderma*, **247–248**: 24–37.

[11] Singh, V., Dwivedi, B.S., Shukla, A.K. and Meena, M.C., 2018. Effect of long-term fertilization on soil physical properties and crop productivity in a rice–wheat cropping system. *Journal of Plant Nutrition and Soil Science*, **181**: 836–847.