

EFFECTS OF DIFFERENT INTEGRATED NUTRIENT MANAGEMENT PRACTICES ON HYDRAULIC CONDUCTIVITY OF UPLAND AND LOWLAND PADDY FIELDS

Tejaswini A. Umbarkar¹, G.S. Mhasal^{2*}, Dr. J.R.Katore³, Dr. S.M.Mule⁴, Dr. Savita G.Pawar⁵, K.P.Solanke⁶, Dr. Ankita G.Angaitkar⁷, T.S.Kamdi⁸, Dr. S. S. Balpande⁹

¹PG Scholar, Dept. SSAC, COA, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

^{2*}Programme Assistant (Lab. Technician), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

³Senior Scientist-cum-Head, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. ORCID iD:-0000-0003-0655-3063

⁴Subject Matter Specialist (AHDS), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

⁵Subject Matter Specialist (Agril.Engg.), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India.

⁶Farm Manager, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

⁷Subject Matter Specialist (Extension Education), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India, ankita.angaitkar@gmail.com

⁸Junior Research Assistant, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India. tusharkmd@gmail.com

⁹Associate Professor, Dept. SSAC, COA, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India

*Corresponding Author: G.S. Mhasal, ORCID ID:-0000-0002-5685-0472

ABSTRACT

A field study was carried out during kharif season of 2018 - 19 at different paddy growing practices such as certified organic farmer's lowland, conventional lowland and upland, INM lowland and upland practice in Parseoni Tahsil of Nagpur district to assess the soil properties like physical, chemical, biological properties and carbon pools (fractions) and yield under paddy cultivation on farmers field influenced by different organic inputs such as, manures, sowing, fertilizer, fertilizer spray, residue addition, Biofertilizers used in various paddy growing practices. Thirty Soil samples taken from paddy growing practices (5 Treatments and 6 Replications) of 0-20 cm depth were collected randomly at maturity stage of paddy crop from different locations viz., Nayakund, Chargaon, Aawleghat, Parseoni of Nagpur district were selected for recording various observations about Hydraulic conductivity of rice field was noted from farmer's field of above locations. Hydraulic conductivity varied among the different paddy-growing practices, with values ranging from 0.57 to 0.80 cm hr⁻¹. The highest hydraulic conductivity was recorded under organic lowland practice (0.80 cm hr⁻¹), followed by INM upland (0.76 cm hr⁻¹), conventional lowland (0.75 cm hr⁻¹) and INM lowland (0.68 cm hr⁻¹). The lowest hydraulic conductivity was recorded under conventional upland practice (0.57 cm hr⁻¹). This study reported 18.6–40% improvement in hydraulic conductivity with organic amendments compared with no-manure treatments.

KEYWORDS: Paddy cultivation, Hydraulic conductivity, Organic amendments, Soil properties, INM

INTRODUCTION

Rice (*Oryza sativa* L.) is cultivated under diverse water and soil-management conditions, particularly in lowland and upland production systems, where differences in soil moisture, aeration, aggregation and pore continuity can influence water transmission through the soil. Hydraulic conductivity is an important indicator of soil physical quality because it reflects the capacity of soil to transmit water and is affected by soil structure, porosity, bulk density, organic matter and continuity of soil pores. Integrated nutrient management (INM), involving the combined application of inorganic fertilizers with organic nutrient sources such as farmyard manure, green manure and crop residues, can improve soil fertility as well as soil physical, chemical and biological properties. Recent research in a rice–wheat system demonstrated that organic amendments increased hydraulic conductivity by 18.6–40%, together with improvements in porosity, infiltration rate and available water content, compared with soils without organic amendments (Rajni et al., 2025). Long-term evidence also indicates that INM can improve soil carbon sequestration and overall soil health; a 38-year rice–wheat experiment reported 58% greater soil carbon sequestration under INM than under chemical fertilization alone (Bhatet al., 2026). In addition, recent research has emphasized the role of INM in improving soil microbial activity and physical, chemical and biological soil functions in sustainable rice production. However, the response of hydraulic conductivity to nutrient management may vary between upland and lowland rice systems because of their contrasting moisture regimes and soil physical conditions (Kamboj et al., 2024). Therefore, evaluating hydraulic conductivity under integrated nutrient management in upland and lowland paddy fields is important for understanding the effects of nutrient management on soil water movement and for developing sustainable nutrient and water-management practices for rice production.

MATERIAL AND METHODS

The four locations of Nagpur districts were selected Locations: Villages of Parseoni taluka of Nagpur District with 30 farmers field are selected and the farmers followed five different paddy-growing practices, namely conventional lowland, organic lowland, INM lowland, conventional upland and INM upland practices. In conventional lowland paddy, manure use was rare and low (2–3 t ha⁻¹), with transplanting, low-dose fertilizer application, fertilizer spray and low residue addition in the form of root stubbles, while no biofertilizer was used. Organic lowland paddy received regular and higher manure application (10 t ha⁻¹), transplanting, no chemical fertilizer, application of manurial liquid (500 L ha⁻¹), straw

incorporation at 5 t ha⁻¹ and use of Azolla as a biofertilizer. INM lowland paddy involved regular manure application (5 t ha⁻¹), transplanting, optimum fertilizer application, spraying of 2% urea solution, addition of 2–3 t ha⁻¹ straw and use of blue-green algae. In conventional upland paddy, manure use was rare and low (2–3 t ha⁻¹), drilling was followed for sowing, low-dose fertilizer was applied, 2% urea solution was sprayed, and only low amounts of root stubbles were retained, with no biofertilizer use. In INM upland paddy, regular manure application (5 t ha⁻¹), drilling, optimum fertilizer application, spraying of 2% urea solution, low residue addition in the form of root stubbles and use of Azotobacter were followed. In this study Saturated hydraulic conductivity (cm hr⁻¹) was determined by following procedure, the 200 g of air dried <2mm soil of each site was dumped in one motion in permeater that was fitted with a screen and filter paper. The permeater was then tapped 100 times to attain uniform bulk density. After saturating the soil with distilled water the saturated hydraulic conductivity was measured using constant head method of Richards (1954).

CALCULATIONS

QL

Hydraulic conductivity, $K_{sat}(\text{cm min}^{-1}) = \frac{Q}{A(h+L)t}$

Q=Volume of water collected, cm³

L= Length of soil column, cm

A=Cross sectional area of the permeameter= πr^2 , cm²

r= inner radius of the core, cm

t=Time interval of collection, min

h=Depth of the water above the soil, cm

Inference table for K_{sat} (cm hr⁻¹)

Classes	Hydraulic conductivity (cm hr ⁻¹)	Hydraulic conductivity (in hr ⁻¹)
Very slow	<0.125	0.05
Slow	0.125-0.5	0.05-0.2
Moderate slow	0.5-2.0	0.2-0.8
Moderate	2.0-6.25	0.8-2.5
Moderately rapid	6.25-12.5	2.5-5.0
Rapid	12.5-25.0	5.0-10.0
Very rapid	>25.0	>10.0

(Source: Bandyopadhyay et al., 2012)

RESULT AND DISCUSSION

Hydraulic conductivity varied among the different paddy-growing practices (Table 1; Figure 1), with values ranging from 0.57 to 0.80 cm hr⁻¹. The highest hydraulic conductivity was recorded under organic lowland practice (0.80 cm hr⁻¹), followed by INM upland (0.76 cm hr⁻¹), conventional lowland (0.75 cm hr⁻¹) and INM lowland (0.68 cm hr⁻¹). The lowest hydraulic conductivity was recorded under conventional upland practice (0.57 cm hr⁻¹). Thus, the treatments were ranked as organic lowland > INM upland > conventional lowland > INM lowland > conventional upland with respect to hydraulic conductivity. The relatively higher hydraulic conductivity under organic lowland practice may be attributed to the differences in management practices and organic inputs followed under the respective paddy-growing systems. The study included variations in the use of manures, crop residues, fertilizers, fertilizer sprays and biofertilizers among the paddy-growing practices, which could influence soil physical conditions and water transmission (Bwire et al., 2024). The maximum value of 0.80 cm hr⁻¹ under organic lowland was 40.35% higher than the minimum value of 0.57 cm hr⁻¹ under conventional upland practice. This represents the largest numerical difference between the highest and lowest hydraulic conductivity values among the practices. In contrast, the hydraulic conductivity under INM upland (0.76 cm hr⁻¹) was only 5.26% lower than organic lowland (0.80 cm hr⁻¹), indicating that these two practices recorded comparatively similar values. Similarly, conventional lowland (0.75 cm hr⁻¹) was 6.67% lower than organic lowland, while INM lowland (0.68 cm hr⁻¹) was 17.65% lower than organic lowland. Overall, the results indicate that organic lowland practice recorded the highest numerical hydraulic conductivity, whereas conventional upland practice recorded the lowest, with a 40.35% difference between the two extreme values. However, the reported critical difference at 5% was non-significant (NS), indicating that the numerical differences among the paddy-growing practices were not statistically significant at the 5%

probability level. Integrated nutrient management where organic matter is used generally improves hydraulic conductivity of paddy soils by increasing soil organic matter, aggregate stability, porosity and continuity of water-conducting pores. Treatments combining organic manures such as FYM, green manure or compost with inorganic fertilizers are therefore expected to show higher hydraulic conductivity than control and sole inorganic fertilizer treatments. This study reported 18.6–40% improvement in hydraulic conductivity with organic amendments compared with no-manure treatments, mainly due to improved soil structure and reduced bulk density (Rajni et al., 2025). Long-term studies have also shown that INM with FYM improves soil organic carbon and overall soil physical health compared with chemical fertilizers alone (Krishna et al., 2025). Thus, INM can improve water movement and soil physical quality in both upland and lowland paddy fields, although the response in lowland soils may be moderated by puddling and the formation of a compacted layer.

Table- 1 Effects of different integrated nutrient management practices on saturated hydraulic conductivity of upland and lowland paddy fields

Paddy Practices	Growing	Hydraulic conductivity (cm hr ⁻¹)
T1: Conventional Lowland		0.75
T2: Organic Lowland		0.80
T3: INM Lowland		0.68
T4: Conventional Upland		0.57
T5: INM Upland		0.76
SE (m)+-		0.06
CD at 5%		NS

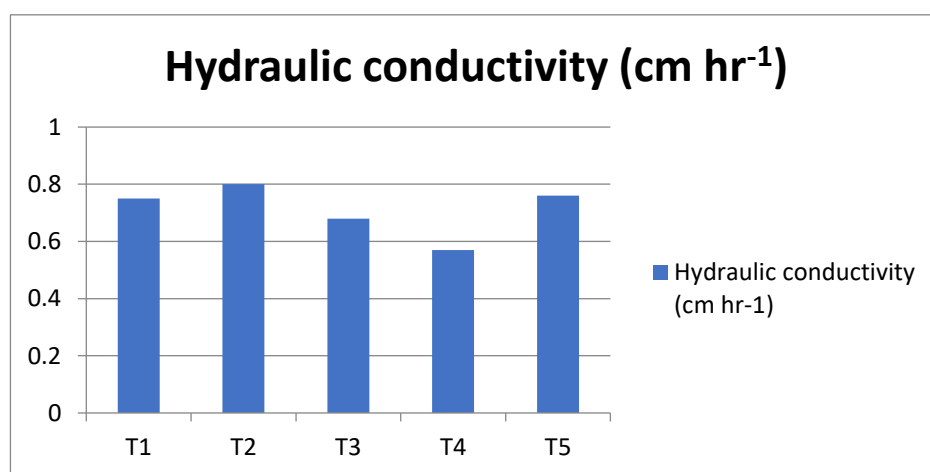


Figure- 1 Effects of different integrated nutrient management practices on saturated hydraulic conductivity of upland and lowland paddy fields

CONCLUSION

The study revealed that hydraulic conductivity is moderate slow and varied among the different paddy-growing practices, ranging from 0.57 to 0.80 cm hr⁻¹. The highest value was recorded under organic lowland (0.80 cm hr⁻¹), followed by INM upland (0.76 cm hr⁻¹), while the lowest was observed under conventional upland (0.57 cm hr⁻¹). Although the organic lowland and INM practices showed comparatively higher hydraulic conductivity, the differences among treatments were statistically non-significant at the 5% level. Overall, the results indicate that the use of organic inputs and integrated nutrient management can help maintain favourable soil physical conditions and water movement in paddy soils.

REFERENCE

- GoBandyopadhyay, K., Agarwal, P., Chakraborty, D., Pradhan, S., Garg, R., Singh, S. (2012). Practical manual on measurement of soil physical properties, Div. of Soil Physics, IARI.
- Bhat, M.A., Singh, M.J., Yousuf, A., Khokhar, A., Sandhu, P.S., Singh, K.B., Dhillon, B.S., Singh, R., Gurav, P.P., Kundu, S. and Ravindra, C.G. (2026). Long-term integrated nitrogen management: effects on crop productivity, soil properties, and carbon sequestration potential of a rainfed maize-wheat cropping system in Punjab, India. *Environmental Sustainability*, 1-18.
- Bwire, D., Saito, H., Sidle, R. C., & Nishiwaki, J. (2024). Water management and hydrological characteristics of paddy-rice fields under alternate wetting and drying irrigation practice as climate smart practice: a review. *Agronomy*, 14(7), 1421.
- Kamboj, D., Choudhary, R., Diwakar, A. K., & Maurya, S. (2024). Integrated nutrient management for improving the soil sustainability and crop productivity: a review. *Journal of Advances in Biology & Biotechnology*, 27(11), 1053-1062.

5. Krishna, K.M., Choudhary, M., Bana, R.S., Paramesha, V., Mandal, A., Kakraliya, M., Jamakhandi, H., Rajpoot, S., Palsaniya, D.R. and Jat, S.L. (2025). Integrated nutrient management strategies: Enhancing soil health, productivity, and climate resilience. *Indian Journal of Fertilisers*, 21(11), 1128-1141.
6. Rajni, Gupta, N., Sharma, S. and Saini, K.S. (2025). Integrated effect of organic amendments and inorganic fertilizers on crop productivity and drivers of soil quality under rice-wheat cropping system in the Indo-Gangetic plains of India. *Discover Soil*, 2(1), 126.
7. Richards, L. A. (Ed.). (1954). *Diagnosis and improvement of saline and alkali soils* (No. 60). US Government Printing Office.
8. Walia, S. S., Dhaliwal, S. S., Gill, R. S., Kaur, T., Kaur, K., Randhawa, M. K., ... & Hossain, A. (2024). Improvement of soil health and nutrient transformations under balanced fertilization with integrated nutrient management in a rice-wheat system in Indo-Gangetic Plains—A 34-year Research outcomes. *Heliyon*, 10(4).