



Impact of Long-term Manuring and Fertilization on Micronutrient Status under Sorghum-wheat Cropping Sequence in Vertisols

Sindhu R. Rathod ^{a*}, S.D. Jadhao ^a, S.M. Bhojar ^a,
V.V. Gabhane ^a, B.A. Sonune ^a, Snehal D. Wakchaure ^a
and Manish R. Pandao ^a

^a Department of Soil Science, PGI, Dr. PDKV, Akola-444104, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A long-term fertilizer experiment has been under progress since 1988-89 at LTFE field department of soil science PGI, Dr. PDKV, Akola with sorghum wheat cropping sequence consisting of twelve treatments and replicated four times in a randomized block design. The present study was conducted to assess the influence of continuous fertilizer and manure application on micronutrient availability in long term fertilizer experiment during 2023-24. Long term application of organic and inorganic fertilizers in combination (100 % NPK+ FYM @ 5 t ha⁻¹, FYM @ 10 t ha⁻¹ and 75% NPK

*Corresponding author: E-mail: sindhurrathod9@gmail.com;

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+ 25 % N through FYM) or balanced fertilization (100% NPK, 150% NPK and 100 % NPK + Zn@ 2.5 kg ha⁻¹) for about 36th cropping cycles lead to marked increase in soil micronutrient availability. All four micronutrient cations were significantly higher under INM treatments. On an average, the INM treatments (T₃) had 53.29, 22.86, 69.56 and 34.44 % higher content of available Fe, Mn, Zn and Cu respectively, over the balance fertilizer (T₂). However, continuous cultivation of crops without or imbalanced nutrient supply (50% NPK, 100 %NPK (-S), 100 % NP, 100 % N and Control) lead to decline in soil micronutrient status. Balanced fertilization and organic matter addition has played an important role in improving micronutrient status in soil after 36 years of cropping cycles.

Keywords: LTFE; organic and inorganic fertilizers; soil micronutrients.

1. INTRODUCTION

“Long-term field experiments provide one of the means of measuring sustainable management systems in agriculture (Rasmussen et al., 1998) as they contribute to better understanding of the effects of soil fertilization on nutrient availability and crop yields. Long-term fertilization using either organic manure or mineral fertilizer has significant effects on improving crop yields” (Lin et al., 2015). Bischoff (1995) showed that “combined mineral and organic fertilization increased crop yields more than mineral treatments only. Integrated nutrient management practice is seen as a viable option in restoring the soil physical structure and chemical fertility, improving soil organic C and therefore, sustaining the system productivity”.

Micro nutrient the availability plays essential role in “plant growth and development, influencing various physiological and biochemical processes”. The availability of essential micronutrient such as manganese (Mn), iron (Fe), copper (Cu) and zinc (Zn) is vital for optimizing crop yield and quality. These nutrients are often present in trace amount in soil, and their deficiency can lead to poor crop performance, reduce productivity, and imbalance nutrient cycling. Therefore, managing the micronutrient status of soils is critical for sustainable crop production, especially in soils like vertisols, which are known for their unique properties and varying nutrient availability.

Vertisols, characterized by high clay content and swelling and shrinking behaviour, present challenge in nutrient management. The fertility of this soil often depends on the balance of macro and micro nutrients, and their response to fertilization practices can vary over time. Understanding how different level of fertilization influence the availability of micronutrients is essential for optimizing nutrient management strategies. When used, the sorghum-wheat

cropping method severely depletes nutrients and results in a negative nutritional balance through careless fertilization. Using a sorghum (*Sorghum bicolor* L.)–wheat (*Triticum aestivum* L.) sequence in a Vertisol, the current experiment was started in 1988–1989 to investigate the impact of manures and fertilizers on micronutrient availability status.

2. MATERIALS AND METHODS

A field experiment was conducted during rabi season of 2023-24 at the Research Farm, Department of Soil Science, Akola, Maharashtra Under the auspices of the All India Coordinated Research Project on Long-term Fertilizer Experiments (AICRP-LTFE), a long-term field experiment was started in 1988–1989, with the goal of examining how integrated nutrient management affects changes in crop productivity, sustainability, and soil quality under the sorghum–wheat crop sequence. The soil of experimental field is black cotton soil.

The nutrients were applied using mineral fertilizers such as diammonium phosphate, muriate of potash, urea, and single super phosphate.

T₄ and T₉. For sorghum, sulphur was applied annually using gypsum (T₉), and for wheat exclusively (T₅), zinc was applied every two years using zinc sulphate.

An annual application of farmyard manure was made one month prior to the sorghum being sown. The suggested fertilizer dosages for wheat and sorghum were 120:60:60-kilogram N, P₂O₅, and K₂O ha⁻¹, and 100:50:40, respectively. The plot wise soil samples (0-20cm) were collected after harvest of wheat. These samples were analysed for soil micronutrients by DTPA extract method using AAS (Atomic absorption Spectrophotometer) (Lindsay and Norvell 1978).

3. RESULTS AND DISCUSSION

3.1 DTPA-extractable Fe

The data presented in Table 1 demonstrate the DTPA-extractable Fe of soil, as influenced by long term manuring and fertilization under sorghum-wheat cropping sequence. The DTPA-extractable iron in soil was found significantly influenced due to the various treatments and it ranged from 5.17 to 11.39. Significantly highest DTPA-extractable iron was recorded with application of 100%NPK+ FYM @ 5 t ha⁻¹ (T₈) and statically on par with FYM @ 10 t ha⁻¹(T₁₀) while, lowest was noted in control (T₁₂).

The increases in DTPA-Fe under INM (T₈) treatment was 53.29% of higher compared to balanced fertilizer treatment (T₂), again signifying the role of FYM in enhancing soil chemical properties. The improvement in DTPA-Fe was consistent across the increments level of balanced nutrition. However, the higher DTPA-Fe was noted with the application of 100% NPK.

The imbalance fertilizer (100%NP and 100%N) application had deleterious effect on soil DTPA-Fe, indicating significance of balanced nutrition and INM. Continuous sorghum-wheat cropping without manure and fertilizer drastically decreased the DTPA-Fe of soil.

The improvement in DTPA-Fe with balanced fertilizer application along with FYM or organics was also reported by Hemalatha and Chellamuthu (2013), Reshmi et al. (2014) have reported similar findings. Additionally, studies by

Jadhav and Bharambe (2007) and Akbari et al. (2011) have also shown that the combined application of organic and inorganic fertilizers resulted in significantly higher DTPA-extractable Fe compared to using only inorganic fertilizers or no fertilizers at all.

3.2 DTPA- Extractable Mn

The data reveals in Table 1 that the application of different nutrient treatments significantly influenced the DTPA Mn levels in soil. The long-term application of manure and fertilizer, combined with different cropping systems, demonstrated a substantial impact on the DTPA Mn status of the soils. the DTPA Mn concentrations ranged from 8.82 to 13.11 mg kg⁻¹ in the sorghum wheat cropping systems.

The highest DTPA-Mn content was observed in the 100% NPK+FYM (T₈) treatment, while the control treatment exhibited the lowest DTPA Mn content. the highest amount of DTPA Mn, the combination of inorganic fertilizers and organic manure (100% NPK+FYM) resulted in the followed by the 75% NPK + FYM (T₁₁), FYM (T₁₀) treatments.

The increases in DTPA-extractable Mn under INM (T₈) treatment was 22.86% of higher compared to balanced fertilizer treatment (T₂), again signifying the role of FYM in enhancing soil chemical properties. The improvement in DTPA-extractable Mn was consistent across the increments level of balanced nutrition. However, the higher DTPA-extractable Mn was noted with the application of 100% NPK.

Table 1. Effect of long-term manuring and fertilization on DTPA-micronutrients under sorghum wheat cropping sequence in vertisol

Tr.	Treatments	DTPA Fe (mg Kg ⁻¹)	DTPA Mn	DTPA Cu
T ₁	50% NPK	7.01	10.08	3.03
T ₂	100% NPK	7.43	10.67	3.60
T ₃	150% NPK	9.78	11.31	3.99
T ₄	100 %NPK (-S)	7.31	10.55	3.38
T ₅	100 % NPK + Zn@ 2.5 kg ha ⁻¹	7.42	10.08	3.67
T ₆	100 % NP	6.68	9.68	3.19
T ₇	100 % N	6.59	9.51	2.87
T ₈	100 % NPK+ FYM @ 5 t ha ⁻¹	11.39	13.11	4.84
T ₉	100 % NPK + S @ 37.5 kg ha ⁻¹	8.19	10.53	3.69
T ₁₀	FYM @ 10 t ha ⁻¹	10.35	12.58	3.93
T ₁₁	75% NPK + 25 % N through FYM	10.12	12.81	4.05
T ₁₂	Control	5.17	8.82	1.96
SE(m) ±		0.009	0.08	0.009
CD @ 5%		0.028	0.24	0.027

The imbalance fertilizer (100%NP and 100%N) application had deleterious effect on soil DTPA-extractable Mn, indicating significance of balanced nutrition and INM. Continuous sorghum-wheat cropping without manure and fertilizer drastically decreased the DTPA-extractable Mn of soil.

The improvement in DTPA-extractable Mn with balanced fertilizer application along with FYM or organics was also reported by Jadhav and Bharambe (2007), who found that the application of organic manure, iron (Fe), sulphur (S₂), phosphomolybdate (PMC), and sulphur significantly increased the availability of Mn in saline-sodic swell shrink soil compared to the control. Moreover, adding organic materials might have enhanced the soils microbial activity and consequently released complex organic substances like chelating agents that could have prevented micronutrients from precipitation, fixation, oxidation and leaching and thus increased the availability (Shahid et al. 2016). Similar result was also reported by Randhawa et al. (2021).

Similar findings were reported by Jagadeesh (2000), further supporting the notion that the addition of organic materials can enhance the availability of DTPA-Mn in the soil. It is worth noting that the decrease in DTPA-Mn content observed in some cases could be attributed to

the uptake and removal of Mn by the crops themselves.

3.3 DTPA -extractable Zn

The DTPA -extractable Zn of soil, the DTPA Zn levels ranged from 0.26 mg kg⁻¹ to 0.83 mg kg⁻¹. The highest DTPA Zn level was observed in 100 % NPK + Zn@ 2.5 kg ha⁻¹ (T₅) (0.81 mg kg⁻¹), followed by (T₈) and T₁₀. The addition of FYM (Farm Yard Manure) to 100% NPK (T₈) significantly increased the DTPA Zn level to 0.78 mg kg⁻¹ (Fig. 1).

The study clearly demonstrates that long-term manuring and fertilization significantly affect the DTPA Zn levels in vertisols under a sorghum-wheat cropping sequence. The highest DTPA Zn levels were achieved with the combination of NPK and Zn, as seen in T₅, suggesting that Zn supplementation is important for maintaining adequate micronutrient levels in the soil.

The application of FYM either alone or in combination with NPK also showed promising results, highlighting the role of organic matter in enhancing soil nutrient availability. Treatments T₈ and T₁₀, which included FYM, resulted in high DTPA Zn levels, indicating that organic amendment can effectively improve soil micronutrient status.

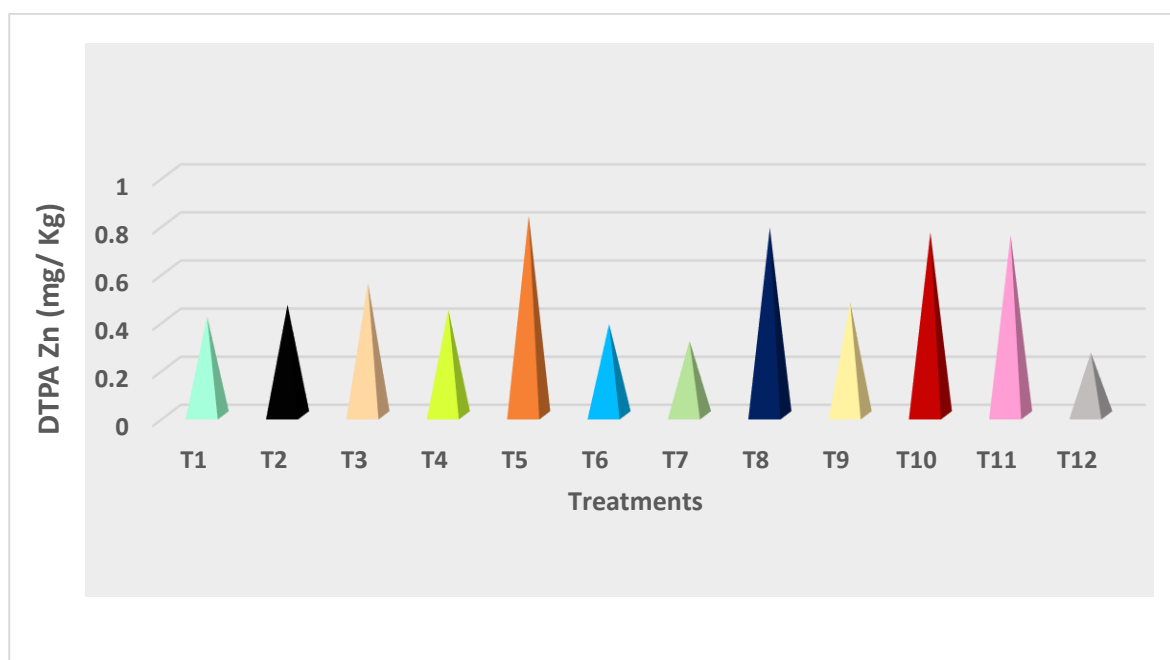


Fig. 1. effect of long-term manuring and fertilization on DTPA-Zn under sorghum wheat cropping sequence in vertisol

The improvement in DTPA Zn with balanced fertilizer application along with FYM or organics was also reported by Biswas et al., (2023) found that the available zinc (Zn) content was significantly higher in the 50% NPK + FYM treatment. The increasing the content of available micronutrients with INM treatments was mainly attributed to the fact that organic nutrient sources inherently contain sufficient amounts of micronutrients, which enrich the micronutrient pools of soil on decomposition (Sekhon et al. 2007). Bharadwaj and Omanwar (1994) studied the long-term effect of continuous rotational cropping and fertilization on the soil properties of an Alfisol. They observed that FYM when applied along with 100 percent dosage of NPK increased the DTPA extractable micronutrients to a significant extent. Parashuram (1998) observed that the use of FYM with recommended doses of inorganic fertilizers increased the DTPA extractable Zn content of the soil.

3.4 DTPA-extractable Cu

The DTPA-extractable Cu in soil were significantly affected by long-term manuring and fertilization (Table 1). After the 36th cropping cycle, the available Cu content ranged from 1.96 mg kg⁻¹ to 4.84 mg kg⁻¹ and being significantly lowest in control treatment (T₁₂). The application of balanced fertilizer combined with organic manure i.e. 100% NPK + FYM @5 t ha⁻¹ (T₈), 75% NPK + 25% N though FYM (T₁₁) and FYM @ 10 t ha⁻¹ (T₁₀) and 150% NPK (T₃) resulted significant improvement in DTPA Cu indicating role of organic manure in regulating soil chemical properties. On an average INM (T₈) treatment had 34.44% of higher Cu content over the balanced fertilizer treatment (T₂).

The imbalance fertilizer (100%NP and 100%N) application had deleterious effect on soil DTPA Cu, indicating significance of balanced nutrition and INM. Continuous sorghum-wheat cropping without manure and fertilizer drastically decreased the DTPA Cu of soil. Overall, the results emphasize the importance of comprehensive nutrient management strategies that combine chemical fertilizers with organic amendments to sustain soil health and ensure robust crop productivity in a sorghum-wheat cropping sequence.

The improvement in DTPA Cu with balanced fertilizer application along with FYM or organics was also reported by Akbari et al., (2011) found that the application of a combination of organic

and inorganic fertilizers significantly increased the DTPA extractable copper compared to using inorganic fertilizers alone. This suggests that the use of organic manure, such as FYM, in conjunction with inorganic fertilizers plays an essential role in maintaining the available micronutrient status of the soil over a long-term cropping period. Consistent with these findings, studies conducted by Bellakki and Badanur (1997) and Kharche et al. (2013) has also demonstrated the positive impact of organic-inorganic fertilizer combinations on soil micronutrient availability.

4. CONCLUSION

It can be concluded that the significant improvement in DTPA- micronutrient status (Fe, Mn, Zn and Cu) was observed where the integration of inorganic and organic fertilizer application. These nutrient management practices ensure improved micronutrient status of soil and better productivity of crop while advocating for sustainable agricultural practices.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declares that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) test-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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