**Impact of Long-Term Manuring and Fertilization on Micronutrient Status Under Sorghum-Wheat Cropping Sequence in Vertisol**

**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 + 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. 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 36years 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 iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) 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.MATERIAL AND METHOD**

 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, sulfur 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.RESULT 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 observed increase in iron (Fe) status in the INM treatment can be attributed to the release of organic acids during the mineralization of FYM, which may have contributed to the solubilization of iron minerals in the soil. It is key role to adopt integrated nutrient management (INM) practices to sustain the Fe status of soils, particularly in alkaline soils that tend to exhibit emerging deficiencies due to intensive cropping.

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.

However, it is noted in our study that, the application of INM (integrated nutrient management) and increasing levels of RDF (recommended dose of fertilizer) resulted in Fe content exceeding the critical limit in the soil. This indicates the importance of carefully managing nutrient application to avoid excessive Fe accumulation.

**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.

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. Similar results were also reported by Kharche *et al*. (2013), suggesting that the addition of organic manure enhances microbial activity in the soil, leading to the release of complex organic substances such as chelating agents. These substances help prevent the precipitation, fixation, oxidation, and leaching of micronutrients, thereby increasing their availability. The application of farmyard manure (FYM) specifically contributed to the increased availability of micronutrients, likely through its decomposition and subsequent release of micronutrients.

Similar findings were reported by Kabeerathumma *et al.* (1993) and 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.

Overall, these findings emphasize the importance of incorporating organic materials in fertilizer management practices to maintain and enhance the availability of DTPA Mn in the soil, ensuring an adequate supply of this essential micronutrient for optimal plant growth and development.

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

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tr.** | **Treatments** | **DTPA Fe** | **DTPA Mn** | **DTPA Cu** |
| **(mg Kg-1)** |
| T1 | 50% NPK | 7.01 | 10.08 | 3.03 |
| T2 | 100% NPK | 7.43 | 10.67 | 3.60 |
| T3 | 150% NPK | 9.78 | 11.31 | 3.99 |
| T4 | 100 %NPK (-S) | 7.31 | 10.55 | 3.38 |
| T5 | 100 % NPK + Zn@ 2.5 kg ha -1 | 7.42 | 10.08 | 3.67 |
| T6 | 100 % NP | 6.68 | 9.68 | 3.19 |
| T7 | 100 % N | 6.59 | 9.51 | 2.87 |
| T8 | 100 % NPK+ FYM @ 5 t ha -1 | 11.39 | 13.11 | 4.84 |
| T9 |  100 % NPK + S @ 37.5 kg ha -1 | 8.19 | 10.53 | 3.69 |
| T10 | FYM @ 10 t ha -1 | 10.35 | 12.58 | 3.93 |
| T11 | 75% NPK + 25 % N through FYM | 10.12 | 12.81 | 4.05 |
| T12 | Control  | 5.17 | 8.82 | 1.96 |
| SE(m) ± | 0.009 | 0.08 | 0.009 |
| CD @ 5% | 0.028 | 0.24 | 0.027 |

**3.3 DTPA -extractable Zn**

 The data presented in figure 1 demonstrate 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.

 The study clearly demonstrates that long-term manuring and fertilization significantly affect the DTPA Zn levels in vertisol 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. Sulphur application, as seen in T9, also contributed to higher DTPA Zn levels, reflecting the synergistic effect of Sulphur on Zinc availability in soil.

 Overall, the results suggest that a balanced fertilization strategy, including macro and micronutrients along with organic amendments, is essential for sustaining soil health and ensuring high crop productivity in a sorghum-wheat cropping system.

 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. Tandon (1989) reported the available Zn status in the NPK+Zn treated plot. Zn as against the usual critical level of 0.6 to 1.0 mg kg-1 increased up to 7.5 mg kg-1. Kabeerathumma *et al.*, (1993) found that Zn and Cu declined under continuous cropping with the addition of only chemical fertilizers. However, the addition of FYM increased the availability of Zn and Cu in the soil.

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.

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

**3.4 DTPA-extractable Cu**

The data presented in table 1 demonstrate the DTPA-extractable Cu of soil, as the effect of long-term manuring and fertilization on DTPA Cu levels under a sorghum-wheat cropping sequence in vertisol. The DTPA Cu levels varied significantly across treatments, ranging from 1.96 mg kg-1 to 4.84 mg kg-1.

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.

The increases in DTPA-extractable Cu under INM (T8) treatment was 34.44% of higher compared to balanced fertilizer treatment (T2), again signifying the role of FYM in enhancing soil chemical properties. The improvement in DTPA-extractable Cu was consistent across the increments level of balanced nutrition. However, the higher DTPA-extractable Cu was noted with the application of 100% NPK.

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.

The study highlights the significant impact of long-term manuring and fertilization on DTPA Cu levels in vertisol under a sorghum-wheat cropping system. Treatment T8, which combined 100% NPK with FYM, achieved the highest DTPA Cu levels, underscoring the effectiveness of integrating organic matter with chemical fertilization.

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.

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