Influence of zinc and iron application methods on available soil nutrient status and nutrient uptake by foxtail millet (*Setaria italic* L.) genotypes

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Abstract

A field experiment was conducted at Agricultural Research Station, Hagari, Karnataka in medium black soil during *rabi*-2017 to study the influence of zinc and iron application methods on available soil nutrients and nutrient uptake by foxtail millet genotypes at harvest. Research was carried out in split plot design consisting of three genotypes in the main plot and seven methods of micronutrients application in sub plot, it was replicated thrice. The experimental results revealed that, foxtail millet genotype Sia-2644 (G1) in main plot recorded significantly higher total zinc and iron uptake (0.206 kg ha\(^{-1}\) and 3.96 kg ha\(^{-1}\)) compared to other genotypes. In sub plot treatment, M3 (RDF + Soil application of ZnSO\(_4\) at 15 kg ha\(^{-1}\) and FeSO\(_4\) at 10 kg ha\(^{-1}\) + Foliar application of 0.5% ZnSO\(_4\) and FeSO\(_4\) each 30 DAS) recorded significantly higher total N, P, K, Zinc and iron uptake (136.07 kg ha\(^{-1}\), 25.47 kg ha\(^{-1}\) and 25.47 kg ha\(^{-1}\) and 3.595 kg ha\(^{-1}\), respectively). Whereas, significantly higher available soil N, P, K, zinc and iron (227 kg ha\(^{-1}\), 36.68 kg ha\(^{-1}\), 269 kg ha\(^{-1}\), 0.589 kg ha\(^{-1}\) and 3.959 kg ha\(^{-1}\), respectively) was recorded in RDF (M1; Control) at crop harvest. However, positive interaction effect between foxtail millet genotypes and methods of zinc and iron application on nutrient uptake was observed. But, no interaction effect on available soil nutrient status.

Keywords: Foxtail millet, genotypes, iron, nutrient uptake, soil nutrients, zinc

Introduction

Millets are important crops in the semiarid tropics of Africa and Asia, about 97% of millet is being produced by the developing counties. They have high drought tolerant capacity, suitable to extreme weather conditions and have a similar nutrient content to other major cereals. Foxtail millet is rich in calories that provide energy and strength to the body to perform activities. It is considered as the perfect substitute for the healthy diets. Foxtail millet contains significant levels of protein, fibre, mineral, and phytochemicals. Studies show that individuals on a millet based diet suffer less from degenerative diseases. Low glycemic index nutritious food products prepared from foxtail millet can be used as an effective support therapy in the treatment of *Diabetes mellitus* (Itagi et al., 2012 and Coulibaly et al., 2012) [9, 5]. In India, foxtail millet is still an important crop in its arid and semi-arid regions. In South India, it has been a staple diet among people for a long time from the Sangam period. Foxtail millet is a warm season crop, typically planted in late spring and due to its early maturity and efficient use of available water makes it suitable for growing in dry areas. It has a low water requirement, though it does not recover well from drought conditions because it has a shallow root system. Foxtail millet is adapted to well-drained soils, but remained as under-utilized food crop. Millets are the neglected crops, which are usually grown on poor and marginal soils. For the successful production of the crop we have to supply all the necessary elements in sufficient quantity in order to get the full potential yield of the crop. Along with the supply of the major nutrients supply of the micronutrients are most necessary. Deficiency even a micro nutrient also causes the yield reduction. Hence, in this present study we have investigated the effect of different methods of application of the micronutrients especially zinc and iron along with the recommended fertilizer dose on impact of uptake by the foxtail millet and to know the available nutrient status.
Materials and Methods
The experiment was conducted at Agricultural Research Station, Hagari which is situated between 15° 14’ N latitude and 77° 07’ E longitude with an altitude of 414 meters above the mean sea level and is located in Zone-3 of Karnataka. The experiment was laid out in split plot design and comprised of two factors for study viz., Main plot treatments: Genotypes (G) comprised viz., G1: HN-7 (Low in Fe and Zn), G2: HN-46 (Medium in Fe and high in Zn), G3: Sia-2644 (High in Fe and medium in Zn). Subplot treatments: Micronutrients application (M) comprised viz., M1: RDF (control), M2: RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each, M3: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹, M4: RDF + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS, M5: RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Soil application of ZnSO₄ @ 15 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹, M6: RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS. M7: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS. The gross plot size was 3.0 m × 3.0 m and net plot size was 1.8 m × 2.6 m. The soil of the experimental site belongs to medium deep black soil and clay texture, neutral in soil reaction (7.50) and low in electrical conductivity (0.25 dS m⁻¹). The organic carbon content was 0.72 per cent and low in available N (262.00 kg ha⁻¹), medium in available phosphorus (39.25 kg P₂O₅ ha⁻¹) and medium in available potassium (307.00 kg K₂O ha⁻¹). DTPA extractable zinc (0.67 ppm) and DTPA extractable iron (3.92 ppm). The data was statistically analysed as per the procedure given by Gomez and Gomez (1984) [9]. Nitrogen, phosphorous and potassium content in foxtail millet grain and stover was determined by modified micro kjeldhal method as prescribed by Jackson (1967) [10]. Vanadomolybdate phosphoric acid yellow color method and absorbance of the solution was recorded at 430 nm using spectrophotometer (Jackson, 1967) [10] and flame photometer method (Jackson, 1967) [10], respectively and expressed on percentage, and finally uptake of nutrient was calculated and expressed in kg ha⁻¹. Similarly the zinc and iron concentration (ppm) in plant sample was estimated by taking a known quantity of the digested samples by adopting atomic absorption spectrophotometer (AAS) method as described by Follett and Lindsay (1969) [7].

Results and Discussion
Grain and stover yield of foxtail millet genotypes
Significantly higher grain yield, stover yield and harvest index (2321 kg ha⁻¹, 9363 kg ha⁻¹ and 19.85%, respectively) recorded in genotype Sia-2644 with RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS and it was on par with genotype HN-46 with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS and it was on par with genotype HN-46 with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS, HN-46 with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS, HN-7 with RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS, HN-7 with M₂: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS, HN-7 with M₃: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS was applied (Table 1). The increase in the yield could be due to continuous supply of micronutrients (Zn and Fe) to the crop at different intervals through the soil application, seed treatment, foliar application and their combinations. Zn and Fe are part of the photosynthesis, assimilation and translocation of photosynthates from source (leaves) to sink (ear head) (Singh et al., 1995) [14].

NPK uptake by foxtail millet genotypes
Significantly higher N, P, K uptake by grain (51.57, 6.86, 9.00 kg ha⁻¹, respectively) and stover (89.57, 20.28, 27.68 kg ha⁻¹, respectively) was recorded in genotype Sia-2644 (G₁) with RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS (M₇) and it was at par with genotype HN-46 (G₂) with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS (M₆), genotype HN-7 (G₁) with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS (M₈), genotype HN-7 (G₁) with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS (M₉), genotype HN-7 (G₁) with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS (M₆). This may be due to better vegetative growth of the plant by the supply of zinc and iron through soil and foliar application at vegetative and grain filling stage which increases the photosynthetic pigments than sole application, which helps in continuous and better absorption of N, P, and K from soil. The absorbed nutrients ultimately stores in sink (grain). The better absorption of nutrients due to higher nutrient concentration of nutrients in soil. The results are similar to Zeidan et al. (2010) [17], Rathod et al. (2012) [13] and Arunkumar and Srinivasa (2018) [2]. The beneficial effect of soil and foliar application of ZnSO₄ and FeSO₄ in improving the absorption and enhancing the N, P and K availability and uptake has been reported by Latha et al. (2001) [11].

Zinc and Iron uptake by foxtail millet genotypes
Significantly higher zinc and iron uptake by grain (0.074 and 1.86 kg ha⁻¹) and stover (0.171 and 2.70 kg ha⁻¹) was recorded in genotype Sia-2644 (G₁) with RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS (M₇) and it was at par with genotype HN-46 (G₂) with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each + Foliar application of 0.5% ZnSO₄ and FeSO₄ each at 30 DAS (M₈), genotype HN-7 (G₁) with M₂: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS (M₉), genotype HN-7 (G₁) with M₃: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS (M₉) and genotype HN-46 (G₂) with M₇ treatment where, RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS applied (Table 1, 2 and 3). This may be due to increase in yield due to increase in availability of micronutrients (Zn and Fe), could be attributed to the formation of stable organometallic
complexes of micronutrients with soil organic matter, especially during the enrichment process to last for a longer time and release the nutrients slowly in the soil system in such a way that the nutrients are protected from fixation and made available to the plant root system during throughout the crop growth. Similar observations were recorded by Dhaliwala et al. (2010) [6]. Similarly Zn and Fe were directly absorbed by leaves due to foliar application of Zn and Fe as aqueous solution and finally accumulated into grain (Slaton et al., 2001) [13].

Available nutrients in soil after harvest of crop
Available nutrient status in soil helps to detect the efficiency of fertilizers applied and used by the crop. Significant difference in the availability of macro and micronutrients in soil influenced by soil and foliar application of Zn and Fe. The genotypes recorded non-significant difference. Among micronutrients application significantly higher availability of nitrogen, phosphorus and potassium in the soil was recorded with Control (RDF) (M1) (227 kg ha⁻¹, 36.68 kg ha⁻¹ and 269 kg ha⁻¹, respectively), which is on par with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each (M2) compared to other treatment (Table 5). The results are akin to (Latha et al., 2001) [11].

Data on soil available Zn and Fe after harvest of crop differed significantly due to soil and foliar application of Zn and Fe. Among micronutrients application, significantly higher availability of zinc and iron in the soil was recorded with Control (RDF) (0.589 mg kg⁻¹ and 3.595 mg kg⁻¹, respectively), which is on par with RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each (0.571 mg kg⁻¹ and 3.547 mg kg⁻¹, respectively) compared to other treatment (Table 6). This may be due to lower uptake of nutrients and lower grain and straw yield, which leads to lower utilization of nutrients present in soil and makes more availability to the next subsequent crop. The soil and foliar application of ZnSO₄ and FeSO₄ along with recommended chemical fertilizer and FYM may increases the utilization of nutrients mainly due to its beneficial effect in mobilizing the native nutrients to increases their uptake and ultimately leads to lower availability in soil after the harvest. Similar results were observed by Basavaraj et al. (1995) [3].

Table 1: Grain yield (kg ha⁻¹), stover yield (kg ha⁻¹) and harvest index (%) of foxtail millet as influenced by genotypes and methods of zinc and iron application

| Main plot | Grain yield (kg ha⁻¹) | Stover yield (kg ha⁻¹) | Harvest index (%) |
|-----------|-----------------------|------------------------|-------------------|
| G₁        | G₂                    | G₃                     | G₁                | G₂                | G₃                |
| Genotypes | Mean                  | Mean                   | Mean              | Mean              | Mean              |
| G₁:        |                       |                        |                   |                   |                   |
| HN-7 (low in Fe and Zn) | 1732 | 1724 | 1846 | 1767 | 8464 | 8549 | 8699 | 8571 | 16.97 | 16.79 | 17.49 | 17.08 |
| M₁        | 1835 | 1872 | 1896 | 1868 | 8867 | 8916 | 8886 | 8890 | 17.13 | 17.35 | 17.57 | 17.35 |
| M₂        | 1874 | 1935 | 2148 | 1986 | 8883 | 8837 | 9083 | 8934 | 17.41 | 17.96 | 19.12 | 18.16 |
| M₃        | 1953 | 1974 | 2150 | 2015 | 8980 | 8934 | 9109 | 9008 | 17.86 | 17.87 | 19.09 | 18.27 |
| M₄        | 2117 | 2134 | 2035 | 2095 | 9165 | 9196 | 9057 | 9139 | 18.76 | 18.83 | 18.34 | 18.64 |
| M₅        | 2285 | 2309 | 2076 | 2223 | 9313 | 9358 | 9149 | 9274 | 19.69 | 19.78 | 18.49 | 19.32 |
| M₆        | 2256 | 2239 | 2321 | 2327 | 9274 | 9255 | 9363 | 9298 | 19.56 | 19.47 | 19.85 | 19.63 |
| Mean      | 2007 | 2022 | 2067 | 2032 | 8993 | 9006 | 9049 | 9016 | 18.20 | 18.29 | 18.56 | 18.35 |
| S.Em±     | C D (P=0.05)          | S.Em±                  | C D (P=0.05)      | S.Em±             | C D (P=0.05)      |
| Main plot | 18                | NS                     | 28                  | NS                | 0.12              | NS                |
| Sub plot  | 38                | 108                    | 26                  | 76                | 0.29              | 0.84              |
| Interaction | 65              | 182                    | 46                  | 128              | 0.50              | NS                |

Table 2: Nitrogen uptake (kg ha⁻¹) by foxtail millet grain, stover and total nitrogen uptake as influenced by genotypes and methods of zinc and iron application

| Main plot | Grain (kg ha⁻¹) | Stover (kg ha⁻¹) | Total nitrogen uptake (kg ha⁻¹) |
|-----------|-----------------|-----------------|---------------------------------|
| G₁        | G₂              | G₃              | G₁                             | G₂              | G₃              | G₁                     |
| Genotypes | Mean            | Mean            | Mean                           | Mean            | Mean            | Mean                   |
| G₁:        |                  |                 |                                 |                 |                 |                        |
| HN-7 (low in Fe and Zn) | 33.02 | 33.43 | 34.95 | 57.28 | 59.53 | 64.09 | 60.30 | 90.30 | 92.96 | 102.50 | 95.25 |
| M₁        | 35.90 | 37.26 | 39.81 | 37.66 | 63.54 | 64.78 | 68.14 | 65.48 | 99.43 | 102.04 | 107.95 | 103.14 |
| M₂        | 38.52 | 39.69 | 46.84 | 41.68 | 66.31 | 67.74 | 79.64 | 71.23 | 104.17 | 107.43 | 126.48 | 112.69 |
| M₃        | 40.24 | 40.63 | 47.73 | 42.87 | 70.63 | 71.15 | 83.48 | 75.09 | 110.87 | 111.78 | 131.21 | 117.96 |
| M₄        | 45.11 | 46.23 | 43.18 | 44.86 | 81.27 | 82.44 | 72.16 | 78.62 | 126.38 | 128.72 | 151.34 | 123.48 |
| M₅        | 49.31 | 50.79 | 44.63 | 48.24 | 86.32 | 87.67 | 78.03 | 84.01 | 137.63 | 139.45 | 121.41 | 132.83 |
| M₆        | 48.49 | 47.95 | 51.57 | 49.34 | 85.96 | 84.82 | 89.57 | 86.78 | 135.44 | 133.76 | 139.00 | 136.07 |
| Mean      | 41.51 | 42.29 | 44.60 | 42.80 | 73.04 | 74.02 | 76.44 | 74.50 | 114.89 | 116.59 | 120.55 | 117.35 |
| S.Em±     | C D (P=0.05)    | S.Em±           | C D (P=0.05)                  | S.Em±           | C D (P=0.05)    |
| Main plot | 0.61             | NS              | 0.93                          | NS              | 1.49            | NS                |
| Sub plot  | 0.91             | 2.60            | 1.01                          | 2.91            | 1.09            | 3.14              |
| Interaction | 1.57           | 4.39            | 1.76                          | 4.91            | 1.90            | 5.30              |
Table 3: Phosphorus uptake (kg ha⁻¹) by foxtail millet grain, stover and total phosphorus uptake as influenced by genotypes and methods of zinc and iron application

| Grain (kg ha⁻¹) | Stover (kg ha⁻¹) | Total phosphorus uptake (kg ha⁻¹) |
|-----------------|------------------|----------------------------------|
| **G₁** | **G₂** | **G₃** | **Mean** | **G₁** | **G₂** | **G₃** | **Mean** | **G₁** | **G₂** | **G₃** | **Mean** |
| M₁ | 4.35 | 2.37 | 4.73 | 4.48 | 9.25 | 9.91 | 10.38 | 9.84 | 13.59 | 14.27 | 15.11 | 14.33 |
| M₂ | 4.71 | 4.84 | 4.95 | 4.83 | 11.35 | 12.24 | 10.95 | 11.51 | 16.06 | 17.08 | 15.90 | 16.35 |
| M₃ | 4.86 | 5.11 | 6.01 | 5.33 | 11.86 | 12.66 | 16.16 | 13.73 | 16.84 | 17.77 | 22.67 | 19.06 |
| M₄ | 5.26 | 5.28 | 6.11 | 5.55 | 12.58 | 13.71 | 15.73 | 13.94 | 17.84 | 18.99 | 21.64 | 19.49 |
| M₅ | 5.98 | 6.06 | 5.41 | 5.82 | 16.02 | 16.56 | 12.98 | 15.19 | 22.00 | 22.63 | 18.39 | 21.00 |
| M₆ | 6.62 | 6.76 | 5.70 | 6.36 | 18.95 | 19.96 | 14.94 | 17.95 | 25.57 | 26.72 | 20.64 | 24.31 |
| M₇ | 6.71 | 6.64 | 6.63 | 6.57 | 18.40 | 18.00 | 20.28 | 18.89 | 24.85 | 24.41 | 27.14 | 25.47 |
| **Mean** | 5.47 | 5.55 | 5.68 | 5.56 | 14.07 | 14.72 | 14.52 | 14.44 | 19.54 | 20.27 | 20.20 | 20.00 |

S. Err ± C.D (P=0.05) S. Err ± C.D (P=0.05) S. Err ± C.D (P=0.05)

Main plot: Genotypes (G) Sub plot: Micro nutrients application (M)

Table 4: Potassium uptake (kg ha⁻¹) by foxtail millet grain, stover and total potassium uptake as influenced by genotypes and methods of zinc and iron application

| Grain (kg ha⁻¹) | Stover (kg ha⁻¹) | Total potassium uptake (kg ha⁻¹) |
|-----------------|------------------|----------------------------------|
| **G₁** | **G₂** | **G₃** | **Mean** | **G₁** | **G₂** | **G₃** | **Mean** | **G₁** | **G₂** | **G₃** | **Mean** |
| M₁ | 6.07 | 6.08 | 6.57 | 6.24 | 22.73 | 22.54 | 23.11 | 22.79 | 29.47 | 28.95 | 29.68 | 29.36 |
| M₂ | 6.49 | 6.68 | 6.82 | 6.66 | 23.38 | 23.86 | 23.96 | 23.73 | 29.87 | 30.87 | 30.79 | 30.51 |
| M₃ | 6.76 | 7.02 | 8.13 | 7.30 | 23.96 | 24.01 | 25.95 | 24.64 | 30.72 | 31.03 | 34.08 | 31.94 |
| M₄ | 7.14 | 7.15 | 8.18 | 7.49 | 24.75 | 24.80 | 26.20 | 25.25 | 31.90 | 31.95 | 34.39 | 32.74 |
| M₅ | 8.02 | 8.12 | 7.42 | 7.85 | 26.46 | 26.27 | 24.88 | 25.87 | 34.47 | 34.39 | 32.30 | 33.72 |
| M₆ | 8.76 | 8.90 | 7.71 | 8.46 | 27.35 | 27.58 | 25.59 | 26.84 | 36.12 | 36.48 | 33.30 | 35.30 |
| M₇ | 8.66 | 8.57 | 9.00 | 8.74 | 27.05 | 26.90 | 27.68 | 27.21 | 35.71 | 35.48 | 36.68 | 35.96 |
| **Mean** | 7.41 | 7.50 | 7.69 | 7.84 | 25.10 | 25.14 | 25.34 | 25.19 | 32.69 | 32.73 | 33.03 | 32.79 |

S. Err ± C.D (P=0.05) S. Err ± C.D (P=0.05) S. Err ± C.D (P=0.05)

Main plot: Genotypes (G) Sub plot: Micro nutrients application (M)

Table 5: Zinc uptake by foxtail millet grain, stover and total zinc uptake as influenced by genotypes and methods of zinc and iron application

| Grain (kg ha⁻¹) | Stover (kg ha⁻¹) | Total zinc uptake (kg ha⁻¹) |
|-----------------|------------------|-----------------------------|
| **G₁** | **G₂** | **G₃** | **Mean** | **G₁** | **G₂** | **G₃** | **Mean** | **G₁** | **G₂** | **G₃** | **Mean** |
| M₁ | 0.011 | 0.037 | 0.030 | 0.026 | 0.118 | 0.122 | 0.127 | 0.122 | 0.129 | 0.159 | 0.157 | 0.148 |
| M₂ | 0.033 | 0.041 | 0.040 | 0.038 | 0.131 | 0.134 | 0.137 | 0.134 | 0.164 | 0.175 | 0.177 | 0.172 |
| M₃ | 0.039 | 0.044 | 0.062 | 0.048 | 0.140 | 0.141 | 0.156 | 0.146 | 0.179 | 0.185 | 0.218 | 0.194 |
| M₄ | 0.041 | 0.049 | 0.065 | 0.052 | 0.147 | 0.148 | 0.157 | 0.151 | 0.188 | 0.197 | 0.222 | 0.202 |
| M₅ | 0.058 | 0.060 | 0.051 | 0.057 | 0.157 | 0.158 | 0.149 | 0.155 | 0.215 | 0.218 | 0.206 | 0.213 |
| M₆ | 0.072 | 0.073 | 0.064 | 0.069 | 0.168 | 0.170 | 0.154 | 0.164 | 0.240 | 0.243 | 0.219 | 0.234 |
Table 6: Available nitrogen, phosphorus and potassium status (kg ha⁻¹) in soil after harvest of crop as influenced by genotypes and methods of zinc and iron application

| G1 | G2 | G3 | Mean | G1 | G2 | G3 | Mean | G1 | G2 | G3 | Mean |
|----|----|----|------|----|----|----|------|----|----|----|------|
| 0.071 | 0.070 | 0.074 | 0.071 | 0.166 | 0.166 | 0.171 | 0.168 | 0.236 | 0.236 | 0.245 | 0.239 |
| Mean | 0.046 | 0.053 | 0.055 | 0.052 | 0.147 | 0.148 | 0.150 | 0.148 | 0.193 | 0.202 | 0.206 | 0.200 |
| S.Em± C (P=0.05) | S.Em± C (P=0.05) | S.Em± C (P=0.05) |
| 0.000 | 0.002 | 0.001 | 0.000 | 0.001 | 0.005 |
| 0.001 | 0.002 | 0.002 | 0.005 | 0.002 | 0.005 |
| 0.001 | 0.004 | 0.003 | 0.008 | 0.003 | 0.009 |

Mean plot: Genotypes (G) Sub plot: Micro nutrients application (M)
G1: HN-7 (low in Fe and Zn) M1: RDF (control)
G2: HN-46 (medium in Fe and high in Zn) M2: RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each
G3: Sia-2644 (high in Fe and medium in Zn) M3: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹

Table 7: Available zinc and iron status (mg kg⁻¹) in soil after harvest of crop as influenced by genotypes and methods of zinc and iron application

| G1 | G2 | G3 | Mean | G1 | G2 | G3 | Mean | G1 | G2 | G3 | Mean |
|----|----|----|------|----|----|----|------|----|----|----|------|
| 0.580 | 0.581 | 0.606 | 0.589 | 3.529 | 3.579 | 3.679 | 3.595 |
| 0.559 | 0.571 | 0.583 | 0.571 | 3.481 | 3.531 | 3.631 | 3.547 |
| 0.543 | 0.555 | 0.570 | 0.556 | 3.342 | 3.392 | 3.492 | 3.408 |
| 0.537 | 0.549 | 0.564 | 0.550 | 3.394 | 3.444 | 3.560 | 3.466 |
| 0.529 | 0.541 | 0.556 | 0.542 | 3.333 | 3.383 | 3.483 | 3.399 |
| 0.512 | 0.524 | 0.539 | 0.525 | 3.288 | 3.338 | 3.438 | 3.354 |
| 0.504 | 0.516 | 0.531 | 0.517 | 3.240 | 3.290 | 3.390 | 3.306 |
| Mean | 0.538 | 0.548 | 0.564 | 0.550 | 3.372 | 3.422 | 3.524 | 3.440 |
| S.Em± C (P=0.05) | S.Em± C (P=0.05) |
| 0.01 | 0.04 | NS | 0.04 | NS |
| 0.00 | 0.01 | 0.05 | 0.13 |
| 0.01 | 0.08 | NS | 0.08 | NS |

Main plot: Genotypes (G) Sub plot: Micro nutrients application (M)
G1: HN-7 (low in Fe and Zn) M1: RDF (control)
G2: HN-46 (medium in Fe and high in Zn) M2: RDF + Seed treatment with 0.5% ZnSO₄ & FeSO₄ each
G3: Sia-2644 (high in Fe and medium in Zn) M3: RDF + Soil application of ZnSO₄ @ 15 kg ha⁻¹ and FeSO₄ @ 10 kg ha⁻¹

RDF: 30:15:15 kg N, P₂O₅ and K₂O ha⁻¹ + FYM @ 2.5 t ha⁻¹
Conclusion
The study revealed that genotype Sia-2644 (G3) with the application of Recommended dose of fertilizers + Soil application of ZnSO₄ @ 15 kg ha⁻¹ & FeSO₄ @ 10 kg ha⁻¹ + Foliar application of 0.5% ZnSO₄ and FeSO₄ each 30 DAS recorded better uptake of N, P, K, zinc and iron uptake due to better vegetative growth of the plant by the supply of zinc and iron through soil and foliar application at vegetative and grain filling stage than sole application. Where available soil N, P, K, zinc and iron content higher in the Control (Only Recommended dose of fertilizers) treatment.

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