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**Eppala Jeevana Lakshmi**
Assistant Professor, Department of Agronomy, Dr. YSR Horticultural University, Andhra Pradesh, India

**Dinesh Kumar M**
Professor, Department of Agronomy, UAHS, Shivamogga, Karnataka, India

**Kumar Naik AH**
Principal Investigator, ZBNF, ZAHRS, Hiriyur, Karnataka, India

**Sawargaonkar GL**
Senior Scientist, Department of Agronomy, ICRISAT, Hyderabad, Karnataka, India

**Veeranna HK**
Professor, Department of Agronomy, UAHS, Shivamogga, Karnataka, India

**Sarvajna Salimath**
Associate Professor, Department of Soil Science and Agricultural Chemistry, UAHS, Shivamogga, Karnataka, India

**Corresponding Author:**
**Eppala Jeevana Lakshmi**
Assistant Professor, Department of Agronomy, Dr. YSR Horticultural University, Andhra Pradesh, India

# Performance of pearl millet cultivars as influenced by different zinc and iron fertifortification strategies in semi-arid tropics

**Eppala Jeevana Lakshmi, Dinesh Kumar M, Kumar Naik AH, Sawargaonkar GL, Veeranna HK and Sarvajna Salimath**

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## Abstract
Two field experiments were conducted during *Kharif*, 2018 and 2019 on clay loam soils at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, Karnataka to evaluate the performance of pearl millet cultivars by different zinc and iron fertifortification methods in semi-arid tropics. Micronutrient (Zn and Fe) management strategies include application of NPK, deficit iron and zinc through soil and foliar application and FYM enriched with iron and zinc along with PGPR as main plot treatments and three pearl millet cultivars ICTP 8203 Fe (Dhanshakti) ICMH 1202 and WCC 75 (local cultivar) as sub plots laid in split plot design replicated thrice. The application of enriched FYM + PGPR achieved significantly higher grain yield of pearl millet (1919 kg ha$^{-1}$) accounting 13.95 per cent increase over without micronutrient application (1684 kg ha$^{-1}$). Among the pearl millet cultivars, ICMH 1202 reported significantly higher grain yield (2097 kg ha$^{-1}$) due to higher growth (16.51 leaves plant$^{-1}$, 18.28 dm$^2$ leaf area, 2.71 leaf area index at 60 DAS, 3.01 tillers plant$^{-1}$ and 30.09 g dry matter plant$^{-1}$ at harvest) and yield (1.31 effective tillers plant$^{-1}$, 20.92 cm ear head length and 16.69 g grain weight ear head$^{-1}$) parameters. This hybrid accounted for 43.82 per cent higher grain yield over WCC 75. The cultivars tested performed better in plots supplemented with iron and zinc enriched FYM along with PGPR.

**Key words:** Biofortified cultivars, fertifortification, growth, iron, pearl millet and zinc

## Introduction
Pearl millet is an indispensable dual purpose crop of arid and semi-arid climatic regions of the world. It is the hardiest warm season crop and one of the staple foods for a poor man in the country's dry tracts with an area of 7.11 m ha accounting for 8.66 m t production. In Karnataka, the average productivity (957 kg ha$^{-1}$) of pearl millet is low as compared to that of India (1219 kg ha$^{-1}$), occupying an area of 0.184 m ha producing 0.176 m t (Anon., 2019) [3].

Balanced crop nutrient management with all the essential nutrients is vital for healthy and vigorous crops to meet achievable yields. Even though crop demand for micronutrients is small in quantity, they play many vital physiological roles directly affecting crop growth and development. Of the micronutrients, iron is required in a more significant amount possessing a substantial role in the formation of chlorophyll, activation of metabolic pathways, a constituent of several enzymes and some pigments within the plant. On the other hand, zinc plays a vital role as a structural constituent or regulatory cofactor of a wide range of different enzymes and proteins in many critical biochemical pathways. These micronutrients *i.e.*, zinc and iron were found deficient in soils to the extent of 36.5 and 12.8 per cent, respectively from 2011-17 in different parts of growing areas of India (Shukla and Behera, 2019) [14]. Hence, their application decides the yield potential of crops in deficient soils with low organic carbon content.

Apart from widely adopted soil and foliar application methods, enrichment of organic manures is also an effective way in supplying the required nutrients to the crops. Organic manures and biofertilizers form ecological nutrient management components that contribute to the nutrient economy by reducing chemical fertilizers load.

They play a vital role in maintaining long term fertility and sustainability by improving soil health, nutrient use efficiency and soil productivity by limiting various soil system losses. They also result in a positive effect on soil health and improving its organic carbon content, quality and conversion of fixed forms of nutrients to simpler forms. A judicious combination of organic and inorganic fertilizers helps to maintain soil health and keep crop productivity in pace. The enrichment of organic manures with micronutrients facilitates high chelation and slow availability of nutrients by forming the organic complexes with the nutrients applied, thereby prevents fixation and precipitation losses leading to enhanced use efficiencies of applied fertilizers.

**Materials and Methods**

Field experiments were conducted during *Kharif*, 2018 and 2019 on clay loam soils at Zonal Agricultural and Horticultural Research Station, Babbur farm, Hiriyur, Chitradurga district, Karnataka. The geographical reference point of the experimental site was 13º 94' 38" North latitude and 76º 61'61" East longitude, with an altitude of 630 meters above mean sea level (MSL). It comes under the Agro-Climatic Region-10 and Central Dry Zone (Zone-IV) of Karnataka. The soil of the study was moderately alkaline in reaction (8.10 pH) with a normal electrical conductivity (0.86 $dSm^{-1}$) and low in organic carbon (1.92 g $kg^{-1}$). Further, the soil is low in available nitrogen status (259 kg $ha^{-1}$), medium status for available $P_2O_5$ (34 kg $ha^{-1}$) and available $K_2O$ (314 kg $ha^{-1}$). The experimental site was respectively deficient in Zn (0.31 ppm) and Fe (3.62 ppm).

The experiment was laid out in split plot design with four micronutrient (Zn and Fe) management strategies as main plots *viz.*, $F_1$: Control (Recommended dose of N, P and K), $F_2$: Recommended dose of FYM + N, P, K and management of deficit iron and zinc through soil application, $F_3$: Recommended dose of FYM + N, P, K and management of deficit iron and zinc through foliar application and $F_4$: Recommended dose of FYM enriched with deficit iron and zinc + recommended N, P, K + PGPR and three pearl millet cultivars, *viz.*, ICTP 8203 Fe (Dhanshakti), ICMH 1202 and WCC 75 (local cultivar) as sub plots. ICTP 8203 Fe and ICMH 1202 are biofortified variety and hybrid, respectively developed from ICRISAT. These twelve treatment combinations were replicated thrice in the experiment. The crop was established by spacing 45 cm X 15 cm, thereby accommodating 148148 plants $ha^{-1}$.

The recommended dose of FYM was applied @ 7.5 t $ha^{-1}$ two weeks before sowing for all the treatments as per the nutrient management practices planned across two years except for the plots with enriched FYM. FYM was enriched with the addition of $ZnSO_4$ (20 kg $ha^{-1}$) and $FeSO_4$ (10 kg $ha^{-1}$), cured for 15 days under a shade and applied to the prescribed treatments. The basal recommended dose of fertilizers (50:25:0 kg N, $P_2O_5$ and $K_2O$ $ha^{-1}$) in the form of urea (46 % N) and single super phosphate (16 % $P_2O_5$) were applied as per the treatments. In micronutrient management practices, soil application of $ZnSO_4$ (20 kg $ha^{-1}$) and $FeSO_4$ (10 kg $ha^{-1}$) was done two weeks after sowing the crop to avoid antagonism between phosphorus and zinc. The foliar application of both the micronutrients (Zn-0.2 % & Fe-0.5 %) was carried out at 35 and 55 DAS. The treatments involving PGPR and enriched FYM, seed treatment was carried out with microbial consortia (*Azospirillum*, PSB and KSB) and enriched FYM with zinc and iron was applied after curing before sowing of the crop.

Five plants were randomly selected and labelled in each net plot for recording observations on growth and yield parameters. The data on different parameters collected was subjected to analysis of variance. Duncan's multiple range test was performed for yield interactions. The pooled data is presented and explained in the following paragraphs.

**Results and Discussion**

**Growth parameters**

The results of the investigation revealed that the different growth parameters (plant height, number of leaves, leaf area, leaf area index, total number of tillers $plant^{-1}$ and dry matter) of pearl millet cultivars were significantly influenced by different micronutrient management strategies. The plant height and dry matter production of cultivars tested progressed with the advancement of crop stage, while the number of functional leaves, leaf area and leaf area index were peak at 60 DAS among the different treatments.

The pooled data indicated that among the different micronutrient management practices tested, significantly higher plant height at harvest (158.65 cm), number of leaves (16.01), leaf area (19.63 $dm^2$), leaf area index (2.91) at 60 DAS and total number of tillers $plant^{-1}$ (3.14) were obtained in the treatment $F_4$ that received recommended FYM enriched with deficit iron and zinc + recommended NPK + PGPR (Table 1 and 2) followed by the application of recommended FYM + NPK + soil application of deficit iron and zinc ($F_2$). As a result, treatment $F_4$ recorded higher dry matter production (28.30 g $plant^{-1}$) at harvest which was on par (27.36 g $plant^{-1}$) with recommended FYM + NPK + soil application of deficit iron and zinc ($F_2$).

Chosen cultivars differed in canopy spread and habitat. Accordingly, significantly higher plant height (176.59 cm) at harvest was recorded with local cultivar WCC 75 ($G_3$) while, ICMH 1202 ($G_2$) was significant in getting higher number of leaves $plant^{-1}$ (16.51), leaf area (18.28 $dm^2$), leaf area index (2.71) at 60 DAS and total number of tillers $plant^{-1}$ (3.01). Due to these variations, higher dry matter of 30.09 g $plant^{-1}$ was noticed in ICMH 1202 ($G_2$) at harvest, while ICTP 8203 Fe ($G_1$) was the next best variety (28.20 g $plant^{-1}$).

Balanced fertilization is one of the targeted ways to boost production in soils with low productivity. Application of FYM and recommended fertilizers along with deficit micronutrients through foliar or soil application improved these parameters. But, the application of FYM enriched with deficit micronutrients along with recommended fertilizers and PGPR supported the soil with sustained nutrient capacity reflecting crop growth at best. The result obtained corroborates the findings of Ananthi and Parasuraman (2019) [1], Durgude *et al*. (2019) [7], Chouhan *et al.* (2018) [5], Rekha *et al.* (2018) [13] and Anilkumar and Kubsad (2017) [2]. As a result of improved source among the pearl millet cultivars with different micronutrient strategies, dry matter production produced contributed in realizing higher crop yields as it showed a very high positive correlation (0.972**) with > 86 per cent of dependency towards yield (Table 5 and 6). The application of deficit micronutrients to the soil produced tailoring in the cultivars to its potentiality, in that supply of micronutrients through fortification and PGPR application recorded maximum.

Cultivars with different genetic makeup responded differently to management practices in recording the various parameters. Higher plant height of WCC 75 ($G_3$) at different growth stages was due to its inherent nature and slenderness that paved the way for less dry matter production. Further, hybrid ICMH 1202 at tested micronutrient practices performed better for the growth components (16.51 leaves plant$^{-1}$, 18.28 dm$^2$ leaf area, 2.71 leaf area index at 60 DAS and 3.01 tillers plant$^{-1}$). As a result, it performed maximum dry matter (30.09 g plant$^{-1}$) wherein other cultivars did not reach this level indicating its superiority. The higher growth parameters of biofortified cultivars were comparable with that of finding by Divya *et al.* (2017) [6].

## Yield attributes and yield

The pooled data indicated that the number of effective tillers plant$^{-1}$ (1.39), grain weight ear head$^{-1}$ (16.49 g) were significantly higher with the application of recommended FYM enriched with deficit iron and zinc + recommended NPK + PGPR ($F_4$) followed by $F_2$ treatment soil (1.29 and 15.12 g, respectively) application of deficit iron and zinc along with recommended FYM + NPK (Table 3). The micronutrient management practices were comparable with each other concerned to ear head length and test weight.

Variations accrued in growth and yield attributes due to the application of treatments essentially reflects in achieving final harvestable yield. Nutritional and cultural practices often stimulate source, thus making it more responsive. The data on leaf area obtained was subjected to correlation and regression analysis. It was found that a significant positive correlation was observed between grain yield and leaf area (0.607**) at peak period (Table 5). Further, the regressed yield by leaf area alone was to the extent of 40 per cent and above in the individual years and for combined years of data it enhanced to 46 per cent (Table 6). The plots treated with micronutrient supplementation improved the growth and yield components of the crop and resulted in enhanced yield levels. Treatments that received either soil ($F_2$) (1841 kg ha$^{-1}$) or foliar ($F_3$) (1797 kg ha$^{-1}$) application of deficit iron and zinc along with recommended FYM + NPK were comparable to each other for grain yield levels (Table 4). In that way, these modes of application of treatments gained 9.32 and 6.71 per cent higher than that of RDF application alone. Results envisaged the influence of micronutrients on crop growth and corroborate the findings of Ananthi and Parasuraman (2019) [1], Choudhary *et al.* (2017) [4] and Rani *et al.* (2017) [12]. Significantly higher grain yield (1919 kg ha$^{-1}$) of pearl millet was recorded with recommended FYM enriched with deficit iron and zinc + recommended NPK + PGPR ($F_4$) which was 13.95 per cent higher compared to that of only RDF application with straw and biological yield of 4202 and 6121 kg ha$^{-1}$, respectively and was statistically on par with that of recommended FYM + NPK + soil application of deficit iron and zinc ($F_2$) with 4062 and 5902 kg ha$^{-1}$, respectively. The more or less stable organometallic complexes were formed during the curing process of enrichment, making them less available for fixation and more accessible for the plant. The increased plant nutrient uptake capacitated the plant to manufacture a greater quantity of photosynthates and hence higher yields were obtained. The results are comparable to that of Durgude *et al.* (2019) [7], Yadav *et al.* (2019) [15], Fulpagare *et al.* (2018) [8], Jain *et al.* (2018) [9] and Kadivala *et al.* (2018) [11].

The yield is an outcome of attributing characters which varied with cultivars. The amount of photosynthates dictates to produce dry matter of different compositions due to their translocation and partitioning efficiency. Among the three different cultivars, ICMH 1202 ($G_2$) recorded significantly higher grain, straw and biological yields of 2097, 4468 and 6565 kg ha$^{-1}$, respectively, over the other two cultivars mainly due to higher growth and yield attributing parameters *i.e.*, higher number of effective tillers plant$^{-1}$ (1.31), ear head length (20.92 cm) and grain weight ear head$^{-1}$ (16.69 g) followed by ICTP 8203 Fe ($G_1$) with 1875, 4188 and 6063 kg ha$^{-1}$ grain, straw and biological yields, respectively (Table 4). The above statements were strengthened by noting a significant increase in yields with the treatment application of enriched FYM + PGPR in ICMH 1202 (Table 7). The grain yield of crop was positively correlated with higher degree by grain weight ear head$^{-1}$ (0.771**), test weight (0.794**) and effective tillers plant$^{-1}$ (0.601**) (Table 5). It is gleaned from the obtained equation that year wise the extent of contribution was to the tune of 71 and 66 per cent while combined over the years resulted 77 per cent thereby realized the importance of direct contribution (Table 6). Harvest index was comparable among the micronutrient management practices, while ICMH 1202 hybrid (31.90 %) achieved significantly higher harvest index over local cultivar. The higher translocation of assimilates to sink due to better source and sink channel reflected in superior yields in ICMH 1202 ($G_2$) and ICTP 8203 Fe ($G_1$) cultivars.

**Table 1:** Plant height (cm), dry matter production (g plant$^{-1}$) and number of tillers plant$^{-1}$ of pearl millet cultivars as influenced by different micronutrient management practices

| Treatments | Plant height | | | Dry matter production | | | Number of tillers plant$^{-1}$ | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| **Main plots (Micronutrient management practices)** | | | | | | | | | |
| $F_1$ (no Zn and Fe application) | 131.80 | 145.90 | 138.85 | 24.26 | 26.70 | 25.48 | 2.63 | 2.71 | 2.67 |
| $F_2$ (soil application of Zn and Fe) | 144.84 | 162.92 | 153.88 | 26.16 | 28.56 | 27.36 | 2.79 | 3.07 | 2.93 |
| $F_3$ (foliar application of Zn and Fe) | 141.75 | 154.41 | 148.08 | 24.47 | 28.04 | 26.26 | 2.68 | 2.82 | 2.75 |
| $F_4$ (EFYM with Zn and Fe + PGPR) | 151.21 | 166.10 | 158.65 | 26.51 | 30.08 | 28.30 | 2.95 | 3.32 | 3.14 |
| S. Em± | 4.08 | 3.45 | 1.94 | 0.53 | 0.52 | 0.41 | 0.06 | 0.11 | 0.07 |
| CD (P=0.05) | NS | 12.12 | 6.83 | 1.86 | 1.82 | 1.45 | 0.21 | 0.37 | 0.26 |
| **Sub plots (Cultivars)** | | | | | | | | | |
| $G_1$ (ICTP 8203 Fe) | 121.00 | 144.27 | 132.63 | 27.74 | 28.66 | 28.20 | 2.72 | 3.00 | 2.86 |
| $G_2$ (ICMH 1202) | 130.82 | 149.94 | 140.38 | 27.99 | 32.19 | 30.09 | 2.82 | 3.10 | 3.01 |
| $G_3$ (WCC 75) | 175.38 | 177.80 | 176.59 | 20.33 | 24.19 | 22.25 | 2.65 | 2.84 | 2.75 |
| S. Em± | 3.50 | 2.90 | 2.63 | 0.38 | 0.47 | 0.28 | 0.06 | 0.11 | 0.06 |
| CD (P=0.05) | 10.58 | 8.76 | 7.94 | 1.15 | 1.41 | 0.86 | 0.19 | NS | 0.20 |
| **Interaction (F × G)** | | | | | | | | | |
| S. Em± | 7.03 | 6.77 | 4.71 | 0.82 | 0.92 | 0.62 | 0.12 | 0.20 | 0.13 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 2:** Number of leaves, leaf area ($dm^2$ $plant^{-1}$) and leaf area index of pearl millet cultivars as influenced by different micronutrient management practices

| Treatments | Number of leaves | | | Leaf area | | | Leaf area index | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| **Main plots (Micronutrient management practices)** | | | | | | | | | |
| $F_1$ (no Zn and Fe application) | 14.66 | 15..14 | 14.90 | 13.11 | 15.42 | 14.26 | 1.94 | 2.28 | 2.11 |
| $F_2$ (soil application of Zn and Fe) | 15.20 | 16.07 | 15.64 | 15.47 | 19.23 | 17.38 | 2.29 | 2.86 | 2.58 |
| $F_3$ (foliar application of Zn and Fe) | 14.99 | 15.59 | 15.29 | 14.75 | 16.24 | 15.49 | 2.18 | 2.41 | 2.29 |
| $F_4$ (EFYM with Zn and Fe + PGPR) | 15.50 | 16.52 | 16.01 | 18.77 | 20.49 | 19.63 | 2.78 | 3.04 | 2.91 |
| S. EM± | 0.09 | 0.09 | 0.09 | 0.38 | 0.46 | 0.30 | 0.06 | 0.07 | 0.05 |
| CD (P=0.05) | 0.30 | 0.31 | 0.31 | 1.34 | 1.64 | 1.06 | 0.20 | 0.24 | 0.16 |
| **Sub plots (Cultivars)** | | | | | | | | | |
| $G_1$ (ICTP 8203 Fe) | 14.61 | 15.34 | 14.97 | 15.67 | 17.15 | 16.41 | 2.32 | 2.54 | 2.43 |
| $G_2$ (ICMH 1202) | 16.13 | 16.90 | 16.51 | 16.51 | 20.06 | 18.28 | 2.45 | 2.97 | 2.71 |
| $G_3$ (WCC 75) | 14.53 | 15.25 | 14.89 | 14.40 | 16.39 | 15.39 | 2.13 | 2.43 | 2.23 |
| S. EM± | 0.26 | 0.28 | 0.25 | 0.40 | 0.82 | 0.48 | 0.06 | 0.12 | 0.07 |
| CD (P=0.05) | 0.79 | 0.83 | 0.77 | 1.22 | 2.47 | 1.44 | 0.18 | 0.37 | 0.21 |
| **Interaction (F × G)** | | | | | | | | | |
| S. EM± | 0.44 | 0.46 | 0.42 | 0.76 | 1.41 | 0.84 | 0.11 | 0.21 | 0.12 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 3:** Yield parameters of pearl millet cultivars as influenced by different micronutrient management practices

| Treatments | Number of effective tillers $plant^{-1}$ | | | Ear head length (cm) | | | Grain weight ear $head^{-1}$ (g) | | | Test weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| **Main plots (micronutrient management practices)** | | | | | | | | | | | | |
| $F_1$ (no Zn and Fe application) | 1.08 | 1.10 | 1.09 | 19.31 | 19.05 | 19.18 | 12.71 | 13.16 | 13.10 | 9.88 | 10.17 | 10.03 |
| $F_2$ (soil application of Zn and Fe) | 1.25 | 1.32 | 1.29 | 19.59 | 20.58 | 20.08 | 14.34 | 15.88 | 15.12 | 10.34 | 10.62 | 10.48 |
| $F_3$ (foliar application of Zn and Fe) | 1.14 | 1.19 | 1.17 | 17.66 | 19.74 | 18.71 | 14.06 | 15.67 | 14.86 | 10.23 | 10.54 | 10.39 |
| $F_4$ (EFYM with Zn and Fe + PGPR) | 1.34 | 1.43 | 1.39 | 20.34 | 19.78 | 20.06 | 15.93 | 17.02 | 16.49 | 10.61 | 11.00 | 10.81 |
| S. EM± | 0.05 | 0.04 | 0.03 | 0.91 | 0.68 | 0.59 | 0.52 | 0.78 | 0.61 | 0.12 | 0.68 | 0.34 |
| CD (P=0.05) | 0.18 | 0.16 | 0.09 | NS | NS | NS | 1.84 | NS | 2.16 | 0.42 | NS | NS |
| **Sub plots (Cultivars)** | | | | | | | | | | | | |
| $G_1$ (ICTP 8203 Fe) | 1.22 | 1.28 | 1.25 | 17.25 | 18.05 | 17.65 | 15.29 | 16.07 | 15.80 | 11.16 | 11.64 | 11.40 |
| $G_2$ (ICMH 1202) | 1.31 | 1.31 | 1.31 | 20.62 | 21.23 | 20.92 | 16.02 | 17.11 | 16.69 | 10.94 | 11.63 | 11.29 |
| $G_3$ (WCC 75) | 1.08 | 1.19 | 1.14 | 19.81 | 20.08 | 19.95 | 11.24 | 13.12 | 12.18 | 8.69 | 8.48 | 8.58 |
| S. EM± | 0.06 | 0.03 | 0.04 | 0.61 | 0.34 | 0.37 | 0.98 | 0.67 | 0.55 | 0.23 | 0.43 | 0.23 |
| CD (P=0.05) | 0.18 | 0.08 | 0.11 | 1.84 | 1.03 | 1.12 | 2.95 | 2.02 | 1.65 | 0.68 | 1.30 | 0.69 |
| **Interaction (F × G)** | | | | | | | | | | | | |
| S. EM± | 0.11 | 0.06 | 0.07 | 1.35 | 0.88 | 0.84 | 1.68 | 1.34 | 1.08 | 0.39 | 0.98 | 0.50 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 4:** Yields and harvest index of pearl millet cultivars as influenced by different micronutrient management practices

| Treatments | Grain yield (kg $ha^{-1}$) | | | Straw yield (kg $ha^{-1}$) | | | Biological yield (kg $ha^{-1}$) | | | Harvest index (%) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| **Main plots (micronutrient management practices)** | | | | | | | | | | | | |
| $F_1$ (no Zn and Fe application) | 1575 | 1792 | 1684 | 3600 | 3965 | 3782 | 5175 | 5758 | 5466 | 30.26 | 31.11 | 30.68 |
| $F_2$ (soil application of Zn and Fe) | 1698 | 1983 | 1841 | 3885 | 4239 | 4062 | 5583 | 6221 | 5902 | 30.33 | 31.87 | 31.10 |
| $F_3$ (foliar application of Zn and Fe) | 1617 | 1977 | 1797 | 3630 | 4160 | 3895 | 5247 | 6136 | 5692 | 30.73 | 32.23 | 31.48 |
| $F_4$ (EFYM with Zn and Fe + PGPR) | 1748 | 2090 | 1919 | 3940 | 4463 | 4202 | 5688 | 6553 | 6121 | 30.66 | 31.83 | 31.24 |
| S. EM± | 28.3 | 24.2 | 18.6 | 77.6 | 76.3 | 60.3 | 103.6 | 93.7 | 75.0 | 0.20 | 0.29 | 0.22 |
| CD (P=0.05) | 99 | 86 | 66 | 274 | 269 | 213 | 365 | 331 | 265 | NS | NS | NS |
| **Sub plots (Cultivars)** | | | | | | | | | | | | |
| $G_1$ (ICTP 8203 Fe) | 1814 | 1936 | 1875 | 4121 | 4254 | 4188 | 5935 | 6191 | 6063 | 30.58 | 31.31 | 30.94 |
| $G_2$ (ICMH 1202) | 1906 | 2288 | 2097 | 4155 | 4780 | 4468 | 6060 | 7069 | 6565 | 31.44 | 32.35 | 31.90 |
| $G_3$ (WCC 75) | 1259 | 1656 | 1458 | 3015 | 3586 | 3301 | 4275 | 5242 | 4759 | 29.46 | 31.06 | 30.26 |
| S. EM± | 30.9 | 27.2 | 18.6 | 57.4 | 69.7 | 42.7 | 81.7 | 77.2 | 55.4 | 0.32 | 0.45 | 0.22 |
| CD (P=0.05) | 94 | 82 | 56 | 174 | 211 | 129 | 247 | 233 | 168 | 0.95 | NS | 0.66 |
| **Interaction (F × G)** | | | | | | | | | | | | |
| S. EM± | 57.9 | 50.6 | 35.6 | 121.8 | 137.0 | 92.1 | 168.9 | 157.1 | 117.6 | 0.55 | 0.79 | 0.42 |
| CD (P=0.05) | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |

**Table 5:** Correlation coefficient for dry matter, leaf area and yield attributes versus grain yield of pearl millet cultivars as influenced by different micronutrient management practices

| S. No | Parameters | Correlation coefficient (r) | | |
|---|---|---|---|---|
| | | 2018 | 2019 | Pooled |
| **Growth parameters** | | | | |
| 1. | Dry matter at 30 DAS | 0.579** | 0.596** | 0.608** |
| 2. | Dry matter at 60 DAS | 0.879** | 0.822** | 0.927** |
| 3. | Dry matter at harvest | 0.961** | 0.914** | 0.972** |
| 4. | Leaf area at 30 DAS | 0.600** | 0.518** | 0.632** |
| 5. | Leaf area at 60 DAS | 0.498** | 0.592** | 0.607** |
| 6. | Leaf area at harvest | 0.155 | 0.357* | 0.375* |
| **Yield attributes** | | | | |
| 1. | Effective tillers $plant^{-1}$ | 0.475** | 0.563** | 0.601** |
| 2. | Ear head length | -0.021 | 0.264 | 0.135 |
| 3. | Grain weight ear $head^{-1}$ | 0.564** | 0.740** | 0.771** |
| 4. | Test weight | 0.822** | 0.625** | 0.794** |

**Note:** Number of observations-36, Significance level at *P = 0.05 = 0.330 level, **P = 0.01 = 0.424 level.

**Table 6:** Regression equations for dry matter, leaf area and yield attributes versus grain yield of pearl millet cultivars as influenced by different micronutrient management practices

| S. No. | Parameter (X) | | Regression equations (Y) [grain yield (kg $ha^{-1}$)] | $R^2$ |
|---|---|---|---|---|
| **Grain yield versus dry matter production** | | | | |
| 1. | Dry matter production (2018) | $X_1$ = Dry matter at 30 DAS | Y = -416.326 + 28.456 $x_1$ + 7.402 $x_2$ + 65.737 $x_3$ | 0.930 |
| 2. | Dry matter production (2019) | $X_2$ = Dry matter at 60 DAS | Y = -179.732 + 14.346 $x_1$ + 19.349 $x_2$ + 51.931 $x_3$ | 0.864 |
| 3. | Dry matter production (pooled) | $X_3$ = Dry matter at harvest | Y = -230.025 – 0.297 $x_1$ + 15.264 $x_2$ + 61.363 $x_3$ | 0.950 |
| **Grain yield versus leaf area** | | | | |
| 1. | Leaf area (2018) | $X_1$ = Leaf area at 30 DAS<br>$X_2$ = Leaf area at 60 DAS | Y = 535.567 + 115.645 $x_1$ + 28.207 $x_2$ | 0.398 |
| 2. | Leaf area (2019) | | Y = 618.145 + 89.254 $x_1$ + 38.958 $x_2$ | 0.435 |
| 3. | Leaf area (Pooled) | | Y = 476.475 + 113.320 $x_1$ + 36.165 $x_2$ | 0.457 |
| **Grain yield versus dry matter production and leaf area** | | | | |
| 1. | Dry matter production and leaf area (2018) | $X_1$ = Dry matter at 30 DAS<br>$X_2$ = Dry matter at 60 DAS<br>$X_3$ = Dry matter at harvest<br>$X_4$ = Leaf area at 30 DAS<br>$X_5$ = Leaf area at 60 DAS | Y = -398.263 + 27.853 $x_1$ + 7.526 $x_2$ + 65.455 $x_3$ + 7.034 $x_4$ – 3.273 $x_5$ | 0.931 |
| 2. | Dry matter production and leaf area (2019) | | Y = - 261.899 + 6.452 $x_1$ + 18.416 $x_2$ + 49.884 $x_3$ + 30.137 $x_4$ + 1.342 $x_5$ | 0.873 |
| 3. | Dry matter production and leaf area (pooled) | | Y = -234.385 – 5.574 $x_1$ + 15.183 $x_2$ + 59.726 $x_3$ + 14.708 $x_4$ + 0.017 $x_5$ | 0.952 |
| **Grain yield versus yield attributes** | | | | |
| 1. | Yield attributes (2018) | $X_1$ = Effective tillers<br>$X_2$ = Grain weight ear $head^{-1}$<br>$X_3$ = Test weight | Y = - 492.45 + 263.442 $x_1$ + 4.666 $x_2$ + 172.312 $x_3$ | 0.708 |
| 2. | Yield attributes (2019) | | Y = 224.451 + 476.721 $x_1$ + 38.669 $x_2$ + 50.927 $x_3$ | 0.655 |
| 3. | Yield attributes (Pooled) | | Y = -69.686 + 301.574 $x_1$ + 33.594 $x_2$ + 96.971 $x_3$ | 0.765 |

**Note**: The independent variable X refers to the parameters listed in serial number, Y is dependent variable (grain yield in kg $ha^{-1}$).

**Table 7:** Duncan's multiple range test (DMRT) for treatment interactions of grain and straw yield of pearl millet

| Treatments interactions | | Grain yield (kg $ha^{-1}$) | | | Straw yield (kg $ha^{-1}$) | | |
|---|---|---|---|---|---|---|---|
| | | 2018 | 2019 | Pooled | 2018 | 2019 | Pooled |
| $F_1G_1$ | Control X ICTP 8203 Fe | $1729.65^{b}$ | $1794.38^{def}$ | $1762.02^{e}$ | $3956^{b}$ | $4040^{de}$ | $3998^{c}$ |
| $F_1G_2$ | Control X ICMH 1202 | $1852.66^{ab}$ | $2043.78^{bc}$ | $1948.22^{cd}$ | $4010^{b}$ | $4421^{bcd}$ | $4216^{bc}$ |
| $F_1G_3$ | Control X WCC 75 | $1143.20^{c}$ | $1538.67^{g}$ | $1341^{g}$ | $2832^{c}$ | $3435^{f}$ | $3133^{e}$ |
| $F_2G_1$ | Soil application X ICTP 8203 Fe | $1838^{ab}$ | $1927.33^{cd}$ | $1882.67^{d}$ | $4175^{ab}$ | $4212^{cde}$ | $4194^{bc}$ |
| $F_2G_2$ | Soil application X ICMH 1202 | $1919.66^{ab}$ | $2327.67^{a}$ | $2123.67^{ab}$ | $4259^{ab}$ | $4944^{a}$ | $4601^{a}$ |
| $F_2G_3$ | Soil application X WCC 75 | $1336^{c}$ | $1692.67^{fg}$ | $1514.33^{f}$ | $3221^{c}$ | $3560^{f}$ | $3390^{de}$ |
| $F_3G_1$ | Foliar application X ICTP 8203 Fe | $1785^{b}$ | $1892.67^{cde}$ | $1838.83^{de}$ | $3953^{b}$ | $4173^{cde}$ | $4063^{c}$ |
| $F_3G_2$ | Foliar application X ICMH 1202 | $1855.66^{ab}$ | $2371.54^{a}$ | $2113.6^{ab}$ | $4089^{ab}$ | $4812^{ab}$ | $4451^{ab}$ |
| $F_3G_3$ | Foliar application X WCC 75 | $1211.13^{c}$ | $1665.67^{fg}$ | $1438.5^{fg}$ | $2848^{c}$ | $3494^{f}$ | $3171^{e}$ |
| $F_4G_1$ | EFYM + PGPR X ICTP 8203 Fe | $1901.65^{ab}$ | $2131.36^{b}$ | $2016.51^{bc}$ | $4400^{a}$ | $4592^{abc}$ | $4496^{a}$ |
| $F_4G_2$ | EFYM + PGPR X ICMH 1202 | $1994.76^{a}$ | $2410.33^{a}$ | $2202.5^{a}$ | $4260^{ab}$ | $4944^{a}$ | $4602^{a}$ |
| $F_4G_3$ | EFYM + PGPR X WCC 75 | $1347^{c}$ | $1728.67^{ef}$ | $1537.83^{f}$ | $3160^{c}$ | $3854^{ef}$ | $3507^{d}$ |

## Conclusion

Micronutrient application through enriched FYM and PGPR application in ICMH 1202 (2203 kg $ha^{-1}$) and ICTP 8203 Fe (2017 kg $ha^{-1}$) performed better in the study.

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## References

1. Ananthi K, Parasuraman P. Response of micronutrients foliar spray on leaf area, leaf area index, TDMA and yield variation in Varagu under rainfed condition. J Pharmacogn Phytochem. 2019;2:32-34.
2. Anilkumar AH, Kubsad VS. Effect of fortification of organics with iron and zinc on growth, yield and

economics of Rabi sorghum [*Sorghum bicolor* (L.) Moench]. J Farm Sci. 2017;30(4):547-549.
3. Anonymous. Area, production and productivity of bajra in India [Internet], 2019. Available from: http://www.indiastat.com
4. Choudhary GL, Rana KS, Bana RS, Prajapat K. Impact of moisture management and zinc fertilization on performance of pearlmillet (*Pennisetum glaucum* L.) under rainfed conditions. Int J Curr Microbiol App Sci. 2017;6(4):1098-1107.
5. Chouhan S, Naga SR, Bhadru P, Koli DK, Kumar A, Jaiswal A. Effect of bio-organic and potassium on yield attributes of pearl millet *Pennisetum glaucum* (L.) R. Br. Emend Stuntz. Int J Chem Stud. 2018;6(2):2038-2041.
6. Divya G, Vani KP, Babu PS, Devi KBS. Impact of cultivars and integrated nutrient management on growth, yield and economics of summer pearl millet. Int J Appl Pure Sci Agric. 2017;3(7):64-68.
7. Durgude AG, Kadam SR, Bagwan IR, Kadlag AD, Pharande AL. Response of zinc and iron to rabi sorghum grown on an Inceptisol. Int J Chem Stud. 2019;7(3):90-94.
8. Fulpagare DD, Patil TD, Thakare RS. Effect of application of iron and zinc on nutrient availability and pearl millet yield in Vertisols. Int J Chem Stud. 2018;6(6):2647-2650.
9. Jain AK, Shrivastava S, Arya V. Response of organic manure, zinc and iron on soil properties, yield and nutrient uptake by pearl millet crop grown in Inceptisol. Int J Pure Appl Biosci. 2018;6(1):426-435.
10. Lakshmi JE, Kumar DM, Sawargaonkar GL, Naik AH, Dhananjaya BC. Zinc and iron biofortification in pearl millet cultivars as influenced by different fertifortification strategies in semi-arid tropics. J Plant Nutr. 2022;46(4):589-599.
11. Kadivala VH, Ramani VP, Patel PK. Effects of micronutrient on yield and uptake by summer pearl millet (*Pennisetum glaucum* L.). Int J Chem Stud. 2018;6(3):2026-2030.
12. Rani YS, Triveni U, Patro TSSK, Anuradha N. Effect of nutrient management on yield and quality of finger millet (*Eleusine coracana* (L.) Gaertn). Int J Chem Stud. 2017;5(6):1211-1216.
13. Rekha DLM, Lakshmipathy R, Gopal AV. Effect of microbial consortium and organic manure on growth and nutrients uptake in pearl millet (*Pennisetum glaucum* L.). Int J Curr Microbiol App Sci. 2018;7(6):2256-2261.
14. Shukla AK, Behera SK. All India Coordinated Research Project on micro- and secondary nutrients and pollutant elements in soils and plants: Research achievements and future thrusts. Indian J Fert. 2019;15(5):522-543.
15. Yadav SK, Dudwal BL, Sarita, Yadav JK. Yield and economics of pearl millet (*Pennisetum glaucum* (L.)) as influenced by moisture conservation practices and zinc fertilization under rainfed conditions. Int J Chem Stud. 2019;7(2):1755-1757.