International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(1): 2640-2645

Received: 25-11-2019
Accepted: 27-12-2019

Sathisha GS
Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Desai BK
Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Yogesh LN
Department of Genetics and Plant Breeding, Agricultural Research Station, Hagari, Ballari, Karnataka, India

Satyanarayana Rao
Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Latha HS
Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

Corresponding Author:
Sathisha GS
Department of Agronomy, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India

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

Sathisha GS, Desai BK, Yogesh LN, Satyanarayana Rao and Latha HS

DOI: https://doi.org/10.22271/chemi.2020.v8.i1an.8671

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 (G_3) in main plot recorded significantly higher total zinc and iron uptake (0.206 kg ha^{-1} and 3.96 kg ha^{-1}) compare to other genotypes. In sub plot treatment, M_7 (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}, 32.79 kg ha^{-1}, 0.239 kg ha^{-1} and 4.49 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 3.595 kg ha^{-1}, respectively) was recorded in RDF (M_1: 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 rising 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.*, G_1: HN-7 (Low in Fe and Zn), G_2: HN-46 (Medium in Fe and high in Zn), G_3: Sia-2644 (High in Fe and medium in Zn). Subplot treatments: Micronutrients application (M) comprised *viz.*, M_1: RDF (control), M_2: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each, M_3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}, M_4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS, M_5: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}, M_6: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS, M_7: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ 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 spacing given was 30 cm × 10 cm. 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 P_2O_5 ha^{-1}) and medium in available potassium (307.00 kg K_2O 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) [8]. 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 $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS and it was on par with genotype HN-46 with RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS, HN-7 with RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS, HN-7 with M_7: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS, HN-46 with RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 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 (G_3) with RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS (M_7) and it was at par with genotype HN-46 (G_2) with RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS (M_6), genotype HN-7 (G_1) with RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS (M_6), HN-7 (G_1) with M_7 (RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS), and genotype HN-46 (G_2) with M_7 treatment where, RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS applied (Table 1, 2 and 2). 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 $ZnSO_4$ and $FeSO_4$ 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 (G_3) with RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS (M_7) and it was at par with genotype HN-46 (G_2) with RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS (M_6), genotype HN-7 (G_1) with RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS (M_6), HN-7 (G_1) with M_7 (RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS), and genotype HN-46 (G_2) with M_7 treatment where, RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS applied (Table 3 and 4). The combined application of micronutrients enhances the concentration of the particular nutrient. As a result of increase in micronutrient concentration (Zn and Fe) in plant which enhances the growth and it will increases the uptake of nutrients from the soil. The results are in conformity with the findings of Yang *et al.* (2011) [16] and Bharti *et al.* (2013) [4]. Similar results were observed by Meena *et al.* (2008) [12], Adsul *et al.* (2011) [1] and Rathod *et al.* (2012) [13] 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) [15].

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) (M_1**)** (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% $ZnSO_4$ & $FeSO_4$ each (M_2**)** 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% $ZnSO_4$ & $FeSO_4$ 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 $ZnSO_4$ and $FeSO_4$ 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

	Grain yield (kg ha^{-1})				**Stover yield (kg ha^{-1})**				**Harvest index (%)**			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
M_1	1732	1724	1846	1767	8464	8549	8699	8571	16.97	16.79	17.49	17.08
M_2	1835	1872	1896	1868	8867	8916	8886	8890	17.13	17.35	17.57	17.35
M_3	1874	1935	2148	1986	8883	8837	9083	8934	17.41	17.96	19.12	18.16
M_4	1953	1944	2150	2015	8980	8934	9109	9008	17.86	17.87	19.09	18.27
M_5	2117	2134	2035	2095	9165	9196	9057	9139	18.76	18.83	18.34	18.64
M_6	2285	2309	2076	2223	9313	9358	9149	9274	19.69	19.78	18.49	19.32
M_7	2256	2239	2321	2272	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	
Main plot : Genotypes (G)					Sub plot : Micro nutrients application (M)							
G_1: HN-7 (low in Fe and Zn)					M_1: RDF (control)							
G_2: HN-46 (medium in Fe and high in Zn)					M_2: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each							
G_3: Sia-2644 (high in Fe and medium in Zn)					M_3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}							
					M_4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS							
					M_5: RDF + Seed treatment + Soil application ($M_2 + M_3$)							
					M_6: RDF + Seed treatment + Foliar application ($M_2 + M_4$)							
					M_7: RDF + Soil application + Foliar application ($M_3 + M_4$)							
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}												

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

	Grain (kg ha^{-1})				**Stover (kg ha^{-1})**				**Total nitrogen uptake (kg ha^{-1})**			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
M_1	33.02	33.43	38.41	34.95	57.28	59.53	64.09	60.30	90.30	92.96	102.50	95.25
M_2	35.90	37.26	39.81	37.66	63.54	64.78	68.14	65.48	99.43	102.04	107.95	103.14
M_3	38.52	39.69	46.84	41.68	66.31	67.74	79.64	71.23	104.17	107.43	126.48	112.69
M_4	40.24	40.63	47.73	42.87	70.63	71.15	83.48	75.09	110.87	111.78	131.21	117.96
M_5	45.11	46.28	43.18	44.86	81.27	82.44	72.16	78.62	126.38	128.72	115.34	123.48
M_6	49.31	50.79	44.63	48.24	86.32	87.67	78.03	84.01	137.63	139.45	121.41	132.83
M_7	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	
Main plot : Genotypes (G)					Sub plot : Micro nutrients application (M)							
G_1: HN-7 (low in Fe and Zn)					M_1: RDF (control)							
G_2: HN-46 (medium in Fe and high in Zn)					**M_2**: RDF **+** Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each							

G3: Sia-2644 (high in Fe and medium in Zn)	**M3**: RDF **+** Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}
	M4: RDF **+** Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS
	M5: RDF **+** Seed treatment + Soil application ($M_2 + M_3$)
	M6: RDF **+** Seed treatment + Foliar application ($M_2 + M_4$)
	M7: RDF + Soil application + Foliar application ($M_3 + M_4$)
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}	

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	4.37	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	4.88	5.11	6.01	5.33	11.96	12.66	16.56	13.73	16.84	17.77	22.57	19.06
M4	5.26	5.28	6.11	5.55	12.58	13.71	15.53	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	6.45	6.41	6.86	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. Em±		C D (P=0.05)		S. Em±		C D (P=0.05)		S. Em±		C D (P=0.05)	
Main plot	0.05		NS		0.77		NS		0.78		NS	
Sub plot	0.12		0.34		0.60		1.72		0.60		1.73	
Interaction	0.20		0.57		1.04		2.90		1.05		2.93	

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% $ZnSO_4$ & $FeSO_4$ each
G3: Sia-2644 (high in Fe and medium in Zn)	M3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}
	M4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS
	M5: RDF + Seed treatment + Soil application ($M_2 + M_3$)
	M6: RDF + Seed treatment + Foliar application ($M_2 + M_4$)
	M7: RDF + Soil application + Foliar application ($M_3 + M_4$)
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}	

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	7.54	25.10	25.14	25.34	25.19	32.61	32.73	33.03	32.79
	S.Em±		C D (P=0.05)		S.Em±		C D (P=0.05)		S.Em±		C D (P=0.05)	
Main plot	0.07		NS		0.05		NS		0.09		NS	
Sub plot	0.14		0.39		0.15		0.44		0.23		0.67	
Interaction	0.24		0.66		0.27		0.75		0.40		1.12	

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% $ZnSO_4$ & $FeSO_4$ each
G3: Sia-2644 (high in Fe and medium in Zn)	M3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}
	M4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS
	M5: RDF + Seed treatment + Soil application ($M_2 + M_3$)
	M6: RDF + Seed treatment + Foliar application ($M_2 + M_4$)
	M7: RDF + Soil application + Foliar application ($M_3 + M_4$)
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}	

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

M_7	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 D (P=0.05)		S.Em±		C D (P=0.05)		S.Em±		C D (P=0.05)	
Main plot	0.000		0.002		0.001		NS		0.001		0.005	
Sub plot	0.001		0.002		0.002		0.005		0.002		0.005	
Interaction	0.001		0.004		0.003		0.008		0.003		0.009	

Main plot : Genotypes (G)	Sub plot : Micro nutrients application (M)
G_1: HN-7 (low in Fe and Zn)	M_1: RDF (control)
G_2: HN-46 (medium in Fe and high in Zn)	M_2: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each
G_3: Sia-2644 (high in Fe and medium in Zn)	M_3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}
	M_4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS
	M_5: RDF + Seed treatment + Soil application ($M_2 + M_3$)
	M_6: RDF + Seed treatment + Foliar application ($M_2 + M_4$)
	M_7: RDF + Soil application + Foliar application ($M_3 + M_4$)
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}	

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

	Nitrogen (kg ha^{-1})				**Phosphorus (kg ha^{-1})**				**Potassium (kg ha^{-1})**			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
M_1	224	226	230	227	36.60	36.95	36.50	36.68	266	270	272	269
M_2	220	222	226	223	35.92	35.90	36.45	36.09	263	267	270	267
M_3	213	215	219	216	34.45	34.80	35.25	34.83	261	264	267	264
M_4	208	210	214	211	33.80	34.25	33.75	33.93	258	261	264	261
M_5	204	206	210	207	32.05	32.50	32.33	32.29	253	256	259	256
M_6	200	202	206	203	31.70	31.75	31.82	31.76	250	253	255	253
M_7	197	199	203	200	30.45	30.75	31.13	30.78	246	249	251	249
Mean	209	211	215	212	33.57	33.84	33.89	33.77	257	260	263	260
	S.Em±		C D (P=0.05)		S.Em±		C D (P=0.05)		S.Em±		C D (P=0.05)	
Main plot	1.25		NS		0.30		NS		1.45		NS	
Sub plot	1.22		3.51		0.21		0.62		1.47		4.23	
Interaction	2.12		NS		0.37		NS		2.55		NS	

Main plot : Genotypes (G)	Sub plot : Micro nutrients application (M)
G_1: HN-7 (low in Fe and Zn)	M_1: RDF (control)
G_2: HN-46 (medium in Fe and high in Zn)	M_2: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each
G_3: Sia-2644 (high in Fe and medium in Zn)	M_3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}
	M_4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS
	M_5: RDF + Seed treatment + Soil application ($M_2 + M_3$)
	M_6: RDF + Seed treatment + Foliar application ($M_2 + M_4$)
	M_7: RDF + Soil application + Foliar application ($M_3 + M_4$)
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t 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

	Zinc (mg kg^{-1})				**Iron (mg kg^{-1})**			
	G_1	**G_2**	**G_3**	**Mean**	**G_1**	**G_2**	**G_3**	**Mean**
M_1	0.580	0.581	0.606	0.589	3.529	3.579	3.679	3.595
M_2	0.559	0.571	0.583	0.571	3.481	3.531	3.631	3.547
M_3	0.543	0.555	0.570	0.556	3.342	3.392	3.492	3.408
M_4	0.537	0.549	0.564	0.550	3.394	3.444	3.560	3.466
M_5	0.529	0.541	0.556	0.542	3.333	3.383	3.483	3.399
M_6	0.512	0.524	0.539	0.525	3.288	3.338	3.438	3.354
M_7	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 D (P=0.05)		S.Em±		C D (P=0.05)	
Main plot	0.01		NS		0.04		NS	
Sub plot	0.00		0.01		0.05		0.13	
Interaction	0.01		NS		0.08		NS	

Main plot : Genotypes (G)	Sub plot : Micro nutrients application (M)
G_1: HN-7 (low in Fe and Zn)	M_1: RDF (control)
G_2: HN-46 (medium in Fe and high in Zn)	M_2: RDF + Seed treatment with 0.5% $ZnSO_4$ & $FeSO_4$ each
G_3: Sia-2644 (high in Fe and medium in Zn)	M_3: RDF + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}
	M_4: RDF + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each at 30 DAS
	M_5: RDF + Seed treatment + Soil application ($M_2 + M_3$)
	M_6: RDF + Seed treatment + Foliar application ($M_2 + M_4$)
	M_7: RDF + Soil application + Foliar application ($M_3 + M_4$)
RDF : 30:15:15 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}	

Conclusion

The study revealed that genotype Sia-2644 (G_3) with the application of Recommended dose of fertilizers + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ each 30 DAS recorded better uptake of N, P, K, zinc and iron uptake due the 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.

References

1. Adsul PB, Anuradha P, Ganesh G, Ajeet P, Shiekh SS. Uptake of N, P, K and yield of *kharif* sorghum as influence by soil and foliar application of micronutrients. Bioinfolet. 2011; 11(2):578-582.
2. Arunkumar BR, Srinivasa N. Effect of Gypsum and Borax Application on Yield, Nutrient Content and Uptake in Maize under Different Nutrient Management Practices. International Journal of Pure and Applied Biosciences. 2018; 6(4):181-189.
3. Basavaraj PK, Dasog R, Vijayakumar, Sarangamath PK. Effect of zinc and iron application on maize yield in an irrigation vertisol. Karnataka Journal of Agricultural Sciences. 1995; 8(1):34-39.
4. Bharti K, Pandey N, Shankhdhar D, Srivastava PC, Shankhdhar SC. Improving nutritional quality of wheat through soil and foliar zinc application. J of Plant Soil and Environment. 2013; 59(8):348-352.
5. Coulibaly A, Kouakou B, Chen J. Extruded adult breakfast based on millet and soybean: Nutritional and functional qualities, source of low glycemic food. Journal of Nutrition and Food Sciences. 2012; 2(7):2155-9600.
6. Dhaliwal SS, Sadana US, Khurana MPS, Dhandli HS, Manchand JS. Enrichment of rice grain with zinc and iron through ferti-fortification. Indian Journal of Fertilizers. 2010; 6(7):28-57.
7. Follett RH, Lindsay WL. Changes in DTPA. extractable zinc, iron, manganese and copper in soils following fertilization. Soil Science Society of American Proceedings. 1969; 35:600-602.
8. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd Edition A wiley International Sciences Publications. New York (USA), 1984.
9. Itagi S, Naik R, Bharati P, Sharma P. Readymade foxtail millet mix for diabetics. International Journal of Science Nutrition. 2012; 3(1):4750.
10. Jackson ML. Soil Chemical Analysis. Prentice Hall of India, Private. Limited. New Delhi, 1967.
11. Latha MR, Savithri P, Indirani R, Kamaraj S. Influence of zinc enriched organic manures on the availability of micronutrient in soil. Madras Agriculture Journal. 2001; 88:165-167.
12. Meena MC, Patel KP, Rathod DD. Effect of Zn and Fe enriched FYM on yield and removal of nutrients under mustard-sorghum (Fodder) Cropping sequence in semi-arid region of Gujarat. Indian Journal of Dryland Agriculture Research Development. 2008; 23(2):28-34.
13. Rathod DD, Meena MC, Patel KP. Effect of different Zn-enriched organics on yields and micronutrient uptake under wheat-maize (Fodder) cropping sequence in semi-arid region of Gujarat. Indian Journal of Dryland Agriculture Research Development. 2012; 27(1):37-42.
14. Singh D, Singh RN. Effect of potassium, zinc and sulphur on growth characters, yields attributes and yield of soybean (*Glycine max* L.). Indian Journal of Agronomy. 1995; 40(2):223-227.
15. Slaton NA, Charles E, Wilson J, Ntamatungiro S, Richard J. Norman, Boothe DL. Evaluation of zinc seed treatments for rice. Agronomy Journal. 2001; 93:152-157.
16. Yang XW, Tian XH, Gale WJ, Cao YX, Lu XC, Zhao AQ. Effect of soil and foliar zinc application on zinc concentration and bioavailability in wheat grain grown on potentially zinc deficient soils. Cereal Research Communication. 2011; 39:535-543.
17. Zeidan MS, Mohamad MS, Hamouda HA. Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soil fertility. World Journal of Agricultural Sciences. 2010; 6(6):696-699.