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Nutrient Content and Dry Matter Accumulation in Foxtail Millet (*Setaria Italica* L.) as Influenced by Agronomic Fortification

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A B S T R A C T

A field experiment was conducted at Agricultural Research Station, Hagari, Karnataka in medium black soil during *rabi*-2017 to study the effect of agronomic fortification on nutrient content and dry matter accumulation in Foxtail millet. 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 study results revealed that the genotype Sia-2644 in main plot recorded significantly higher zinc and iron content (26.21 and 721 ppm) over the other genotypes. In sub plot, the treatment 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 content (3.11%, 0.492%, 0.648 %, 49.15 ppm and 1079 ppm, respectively) and dry matter accumulation in leaf at 30, 60 DAS and at harvest (1.71, 3.82 and 6.59 g $plant^{-1}$, respectively), stem (0.84, 5.80 and 11.33 g $plant^{-1}$, respectively), reproductive part at 60 DAS and at harvest (1.39 and 11.76 g $plant^{-1}$). In interaction, the genotype Sia-2644 (G_3) with treatment 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 (3.18 %), P (0.512 %), K (0.683 %), Zinc (49.97 ppm) and Iron content (1090 ppm) and dry matter accumulation at 60 DAS and at harvest in leaf (3.91 and 6.85 g $plant^{-1}$), stem (5.87 and 11.61 g $plant^{-1}$) and reproductive part (1.50 and 12.06 g $plant^{-1}$).

Introduction

Zinc (Zn) and Iron (Fe) deficiency is recognised as a major problem of human nutrition world-wide. It has been estimated to affect up to one-third of the world's population. Inadequate dietary intake of bioavailable forms of Zn and Fe is considered the most frequent cause of Zn and Fe deficiency. The risk of insufficient dietary Zn and Fe intake is particularly high in populations depending on sources with low levels of absorbable Zn and Fe such as cereals and with no or only limited access to sources rich in bioavailable Zn and Fe such as meat. This situation is wide-spread in arid regions of developing countries. In the developing world; cereal grains provide nearly 50% of the daily calorie intake of the population, and up to 70% in rural areas.

Deficiency of Zinc and iron are well-documented public health issue and an important soil constraint in production of crops. Moreover, there is a close geographical overlap between soil deficiency and human deficiency of Zn and Fe, indicating high requirements for increasing concentrations of these nutrients in food crops.

Breeding of new genotypes having high Zn and Fe concentration (genetic bio fortification) is the most cost-effective strategy to address the problem; but, this strategy needs long time. A quick and alternative approach is therefore required for fortification of food crops with Zn and Fe in the short term. In this regard, a fertilizer strategy (agronomic fortification) gives an effective way for fortification of food crops including foxtail millet.

Agronomic fortification provides Zn and Fe to plants by seed treatment, soil and application of Zn and Fe to make sure success of breeding efforts for increasing Zn and Fe concentration in seeds. Important complementary approach to the on-going breeding programme is fertilizer strategy and it is a rapid solution to the problem.

Studies on fertilizer focusing specifically on increasing Zn and Fe levels of grain very rare. The most effective method for increasing Zn and Fe in grain will be the combined application of Zn and Fe through soil and foliar in association with the seed treatment. In major parts of cereal growing regions, soils have a variety of physico-chemical problems, which significantly decreases the availability of Zn and Fe to plant roots. Thus, the genetic capacity of fortified cultivars to absorb required amount of Zn and Fe from soil and accumulate it in the grain may not be expressed to the full extent. Hence, there is necessity to have a short-term approach to improve Zn and Fe levels in grains like foxtail millet.

Materials and Methods

The experiment was conducted at Agricultural Research Station, Hagari which is situated between 15^o 14' N latitude and 77^o 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 dSm^{-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).Nitrogen, phosphorous and potassium content in foxtail millet grain and stover was determined by modified micro kjeldhal method as prescribed by Jackson (1967), Vanadomolybdate phosphoric acid yellow color method and absorbance of the solution was recorded at 430 nm using spectrophotometer (Jackson, 1967) and flame photometer method (Jackson, 1967), respectively and expressed on percentage.

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).

Results and Discussion

N, P and K content in foxtail millet as influenced by the agronomic fortification

Micronutrients application exhibited significant effect on N, P and K content in grain, stover, total N, P and K content. The treatment 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 recorded significantly higher N content in grain, stover and total N content(2.18, 0.93 and 3.11% , respectively), P content in grain, stover and total P content(0.289, 0.203 and 0.492%, respectively) and K content in grain, stover and total K content(0.385, 0.293 and 0.677%, respectively) and it was on par 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.

Significantly higher nitrogen content in grain, stover and total nitrogen content(2.24, 0.96 and 3.18%, respectively), Phosphorus content in grain, stover and total Phosphorus content (0.295, 0.217 and 0.512%, respectively) and Potassium content in grain, stover and total Potassium content(0.388, 0.296 and 0.683%, respectively) among the interaction effect was 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 but it was at 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 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 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 (Table 1 ,2 and 3).

This may be due to better vegetative growth of the plant by the supply of zinc and iron throughsoil 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) and Rathod *et al.,* (2012). 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).

Zn and Fe content in foxtail millet as influenced by the agronomic fortification

Foxtail millet genotype Sia-2644 recorded significantly higher zinc and iron content in grain (26.21 and 721 ppm), total zinc and total iron content (42.77 and 990 ppm) but it was on par with HN-46 and lower zinc and iron content in grain and total zinc and total iron content found in HN-7.

Treatment, 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 recorded significantly higher zinc and iron content in foxtail millet grain (31.10 and 796 ppm), stover (18.05 and 283 ppm) and total zinc and total iron content (49.15 and 1079 ppm) among the micronutrients application and it was at par with the treatment 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. In these two treatments the micronutrients are applied through the foliar application along with the seed treatment and soil application.

Hence the application of micronutrients in combination at different intervals through seed treatment, soil application and foliar application gives a better absorption of micronutrients than sole application. Similar results recorded by Mosanna and Ebrahim (2015) and Arunkumar *et al.,* (2017).

In interaction effect significantly higher zinc and iron content in grain (31.70 and 802 ppm), stover (18.27 and 288 ppm) and total zinc and total iron content (49.97 and 1090 ppm)was found in 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 but it was on par with 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 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 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 (Table 4 and 5).

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) and Bharti *et al.,* (2013).

Similar results were observed by Meena *et al.,* (2008), Adsul *et al.,* (2011), Rathod *et al.,* (2012), 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). 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).

Table.1 Nitrogen content (%) in foxtail millet grain, stover and total nitrogen content as influenced by genotypes and agronomic fortification

	N content in grain (%)				N content in stover (%)				Total nitrogen content (%)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	1.91	1.94	2.08	**1.98**	0.68	0.70	0.74	**0.70**	2.59	2.64	2.82	**2.68**
M_2	1.96	1.99	2.10	**2.02**	0.72	0.73	0.77	**0.74**	2.68	2.72	2.87	**2.75**
M_3	2.02	2.05	2.10	**2.06**	0.75	0.77	0.88	**0.80**	2.77	2.82	2.99	**2.86**
M_4	2.06	2.09	2.13	**2.09**	0.79	0.80	0.92	**0.83**	2.85	2.89	3.04	**2.92**
M_5	2.13	2.15	2.02	**2.10**	0.89	0.90	0.80	**0.86**	3.02	3.05	2.92	**2.99**
M_6	2.16	2.20	2.10	**2.15**	0.93	0.94	0.82	**0.89**	3.09	3.14	2.97	**3.06**
M_7	2.15	2.14	2.24	**2.18**	0.93	0.92	0.96	**0.93**	3.08	3.07	3.18	**3.11**
Mean	**2.06**	**2.08**	**2.11**	**2.08**	**0.81**	**0.82**	**0.84**	**0.82**	**2.87**	**2.90**	**2.97**	**2.91**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	0.02		NS		0.01		NS		0.03		NS	
Sub plot	0.02		0.06		0.01		0.03		0.02		0.06	
Interaction	0.04		0.10		0.02		0.05		0.04		0.11	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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 Phosphorus content (%) in foxtail millet grain, stover and total phosphorus content as influenced by genotypes and agronomic fortification

	P content in grain (%)				P content in stover (%)				Total P content (%)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	0.251	0.253	0.256	**0.253**	0.109	0.116	0.119	**0.115**	0.360	0.369	0.375	**0.368**
M_2	0.257	0.259	0.261	**0.259**	0.128	0.137	0.123	**0.130**	0.385	0.396	0.384	**0.388**
M_3	0.261	0.264	0.280	**0.268**	0.135	0.143	0.182	**0.153**	0.395	0.407	0.462	**0.421**
M_4	0.270	0.272	0.284	**0.275**	0.140	0.153	0.170	**0.155**	0.410	0.425	0.454	**0.430**
M_5	0.282	0.284	0.266	**0.277**	0.175	0.180	0.143	**0.166**	0.457	0.464	0.409	**0.443**
M_6	0.290	0.293	0.275	**0.286**	0.203	0.213	0.163	**0.193**	0.493	0.506	0.438	**0.479**
M_7	0.286	0.286	0.295	**0.289**	0.198	0.194	0.217	**0.203**	0.484	0.481	0.512	**0.492**
Mean	**0.271**	**0.273**	**0.274**	**0.273**	**0.155**	**0.163**	**0.160**	**0.159**	**0.426**	**0.436**	**0.434**	**0.432**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	0.002		NS		0.009		NS		0.009		NS	
Sub plot	0.002		0.005		0.006		0.018		0.007		0.020	
Interaction	0.003		0.009		0.011		0.031		0.012		0.033	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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.3 Potassium content (%) in foxtail millet grain, stover and total potassium content as influenced by genotypes and agronomic fortification

	K content in grain (%)				K content in stover (%)				Total K content (%)			
	G_1	G_2	G_3	**Mean**	G_1	G_2	G_3	**Mean**	G_1	G_2	G_3	**Mean**
M_1	0.351	0.353	0.356	**0.353**	0.261	0.264	0.266	**0.263**	0.611	0.616	0.621	**0.616**
M_2	0.354	0.357	0.360	**0.357**	0.264	0.268	0.270	**0.267**	0.617	0.624	0.629	**0.624**
M_3	0.361	0.363	0.379	**0.367**	0.270	0.272	0.286	**0.276**	0.630	0.634	0.664	**0.643**
M_4	0.366	0.368	0.381	**0.371**	0.276	0.278	0.288	**0.280**	0.641	0.645	0.668	**0.652**
M_5	0.379	0.381	0.365	**0.375**	0.289	0.286	0.275	**0.283**	0.667	0.666	0.639	**0.658**
M_6	0.384	0.386	0.372	**0.380**	0.294	0.295	0.280	**0.289**	0.677	0.680	0.651	**0.670**
M_7	0.384	0.383	0.388	**0.385**	0.292	0.291	0.296	**0.293**	0.675	0.674	0.683	**0.677**
Mean	**0.368**	**0.370**	**0.371**	**0.370**	**0.278**	**0.279**	**0.280**	**0.279**	**0.646**	**0.649**	**0.651**	**0.648**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	0.001		NS		0.001		NS		0.002		NS	
Sub plot	0.001		0.003		0.001		0.004		0.002		0.005	
Interaction	0.002		0.005		0.002		0.006		0.003		0.009	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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.4 Zinc content (ppm) in foxtail millet grain, stover and total zinc content as influenced by genotypes and agronomic fortification

	Grain (ppm)				Stover (ppm)				Total zinc content(ppm)			
	G_1	G_2	G_3	**Mean**	G_1	G_2	G_3	**Mean**	G_1	G_2	G_3	**Mean**
M_1	6.49	21.71	16.20	**14.80**	13.97	14.27	14.57	**14.27**	20.45	35.98	30.77	**29.07**
M_2	18.17	22.10	21.20	**20.49**	14.77	15.00	15.37	**15.04**	32.94	37.10	36.57	**35.53**
M_3	20.60	22.70	28.70	**24.00**	15.77	16.00	17.17	**16.31**	36.37	38.70	45.87	**40.31**
M_4	21.10	25.20	30.20	**25.50**	16.37	16.57	17.27	**16.73**	37.47	41.77	47.47	**42.23**
M_5	27.60	28.20	25.20	**27.00**	17.09	17.17	16.40	**16.88**	44.69	45.37	42.17	**44.07**
M_6	31.32	31.58	28.90	**30.60**	18.07	18.17	16.87	**17.70**	49.39	49.74	45.77	**48.30**
M_7	30.90	30.70	31.70	**31.10**	17.95	17.93	18.27	**18.05**	48.85	48.63	49.97	**49.15**
Mean	**22.31**	**26.03**	**26.21**	**24.78**	**16.28**	**16.44**	**16.56**	**16.43**	**38.59**	**42.47**	**42.77**	**41.24**

	S.Em±	C D (P=0.05)	S.Em±	C D (P=0.05)	S.Em±	C D (P=0.05)
Main plot	0.21	0.82	0.16	NS	0.33	NS
Sub plot	0.23	0.66	0.16	0.47	0.35	0.99
Interaction	0.40	1.11	0.28	0.79	0.60	1.67

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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.5 Iron content (ppm) in foxtail millet grain, stover and total iron content as influenced by genotypes and agronomic fortification

	Grain (ppm)				Stover (ppm)				Total iron content (ppm)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	393	554	719	**555**	227	230	236	**231**	620	784	955	**786**
M_2	465	586	601	**551**	236	238	245	**240**	701	824	846	**790**
M_3	526	624	749	**633**	240	243	274	**253**	766	867	1023	**886**
M_4	544	655	769	**656**	252	254	277	**261**	796	909	1046	**917**
M_5	753	765	644	**721**	264	267	248	**260**	1017	1032	942	**997**
M_6	798	801	765	**788**	283	286	265	**278**	1081	1087	1030	**1066**
M_7	793	792	802	**796**	281	280	288	**283**	1074	1072	1090	**1079**
Mean	**610**	**682**	**721**	**671**	**255**	**257**	**262**	**258**	**865**	**940**	**990**	**932**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	1.29		5.05		1.52		NS		3.97		15.57	
Sub plot	2.47		7.10		2.21		6.34		4.17		11.97	
Interaction	4.29		11.98		3.83		10.70		7.23		20.20	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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 Dry matter accumulation (g $plant^{-1}$) in leaves of foxtail millet at different growth stages as influenced by genotypes and agronomic fortification

	30 DAS				60 DAS				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	1.29	1.32	1.24	**1.28**	1.68	1.62	1.92	**1.74**	4.31	4.84	5.93	**5.03**
M_2	1.48	1.34	1.59	**1.47**	2.24	2.36	2.41	**2.34**	5.13	5.05	5.23	**5.14**
M_3	1.61	1.58	1.81	**1.67**	2.76	2.67	3.02	**2.82**	5.47	5.33	5.95	**5.58**
M_4	1.40	1.34	1.42	**1.39**	2.88	2.86	3.12	**2.95**	5.78	5.75	6.05	**5.86**
M_5	1.71	1.74	1.61	**1.69**	3.49	3.62	3.03	**3.38**	5.83	5.95	5.62	**5.80**
M_6	1.53	1.61	1.68	**1.61**	3.82	3.85	3.43	**3.70**	6.58	6.74	5.80	**6.37**
M_7	1.69	1.66	1.77	**1.71**	3.81	3.75	3.91	**3.82**	6.48	6.45	6.85	**6.59**
Mean	**1.53**	**1.51**	**1.59**	**1.54**	**2.95**	**2.96**	**2.98**	**2.96**	**5.65**	**5.73**	**5.92**	**5.77**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	0.02		NS		0.03		NS		0.10		NS	
Sub plot	0.03		0.10		0.04		0.11		0.14		0.39	
Interaction	0.06		NS		0.07		0.18		0.24		0.66	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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 Dry matter accumulation (g plant^{-1}) in stem of foxtail millet at different growth stages as influenced by genotypes and agronomic fortification

	30 DAS				60 DAS				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	0.46	0.50	0.55	**0.50**	3.93	4.08	4.25	**4.08**	7.01	7.19	7.50	**7.23**
M_2	0.62	0.66	0.68	**0.65**	4.17	4.20	4.27	**4.21**	7.74	7.93	7.94	**7.87**
M_3	0.75	0.79	0.84	**0.79**	4.76	4.64	5.10	**4.83**	8.65	8.95	9.95	**9.18**
M_4	0.48	0.53	0.57	**0.53**	4.75	4.85	5.17	**4.92**	9.74	9.55	10.15	**9.81**
M_5	0.87	0.86	0.81	**0.84**	5.47	5.58	5.15	**5.40**	10.72	10.80	9.95	**10.49**
M_6	0.69	0.68	0.71	**0.69**	5.80	5.83	5.40	**5.68**	11.40	11.50	10.21	**11.04**
M_7	0.79	0.81	0.92	**0.84**	5.78	5.75	5.87	**5.80**	11.25	11.14	11.61	**11.33**
Mean	**0.66**	**0.69**	**0.72**	**0.69**	**4.95**	**4.99**	**5.03**	**4.99**	**9.50**	**9.58**	**9.61**	**9.57**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	0.01		NS		0.03		NS		0.04		NS	
Sub plot	0.03		0.09		0.05		0.14		0.15		0.44	
Interaction	0.05		NS		0.09		0.24		0.27		0.74	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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.8 Dry matter accumulation (g $plant^{-1}$) in reproductive parts of foxtail millet at different growth stages as influenced by genotypes and agronomic fortification

	60 DAS				At harvest			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1	0.52	0.50	0.73	**0.58**	6.30	6.59	6.96	**6.62**
M_2	0.72	0.76	0.85	**0.78**	7.86	7.40	7.84	**7.70**
M_3	0.92	0.97	1.03	**0.97**	8.05	8.11	9.41	**8.52**
M_4	1.06	1.01	1.18	**1.08**	9.05	9.15	9.56	**9.25**
M_5	1.18	1.19	0.95	**1.11**	10.29	10.42	9.57	**10.09**
M_6	1.41	1.45	1.06	**1.31**	11.72	11.86	10.26	**11.28**
M_7	1.29	1.37	1.50	**1.39**	11.64	11.58	12.06	**11.76**
Mean	**1.02**	**1.04**	**1.04**	**1.03**	**9.27**	**9.30**	**9.38**	**9.32**
	S.Em±		**C D (P=0.05)**		**S.Em±**		**C D (P=0.05)**	
Main plot	0.04		NS		0.10		NS	
Sub plot	0.06		0.17		0.22		0.62	
Interaction	0.11		0.29		0.37		1.05	

Main plot : Genotypes (G)	**Sub plot : Micro nutrients application (M)**
G1: HN-7 (low in Fe and Zn)	**M_1**: RDF (control)
G2: 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)	**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}

Dry matter accumulation in Foxtail millet as influenced by the agronomic fortification

Among the micronutrients application significantly higher dry matter accumulation at 60 DAS and at harvest (3.82 and 6.59 g $plant^{-1}$ in leaves, 5.80 and 11.33 g $plant^{-1}$ in stem, 1.39 and 11.76 g $plant^{-1}$ in ear head or reproductive part) recorded in 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 but it was on par 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.

Significantly higher dry matter accumulation at 60 DAS and at harvest (3.82 and 6.59 g $plant^{-1}$ in leaves, 5.80 and 11.33 g $plant^{-1}$ in stem, 1.39 and 11.76 g $plant^{-1}$ in ear head or reproductive part) was recorded in the interaction of 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 over the other interactions but it was on par with 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 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 (Table 6, 7 and 8).The above findings are in close agreement with reports of Dhaliwala *et al.*, (2010),this might be due to Zn and Fe involve in enhancement of photosynthetic activity and translocation of the photosynthates and this may due to adequate supply of Zn and Fe increases the chlorophyll content. The increase in total dry matter production in foxtail millet is due to increase in the plant height, leaf area index, and accumulation of photosynthates in different parts of the crop due to supply the micronutrients like Zinc and iron.

Zinc and iron are the promising micronutrients which are deficient in most of the Indian soils, hence the crops which are grown on the deficient soils also lack of the same nutrients. And the people who consume it are suffering from micronutrients malnutrition. Hence, agronomic fortification of crops enriches the micronutrients by the way of seed, soil and foliar application. The foxtail millet 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 gives the better enrichment of all primary nutrients, Zn and iron content in grain and also gives better accumulation of the dry matter in the leaves, stem and reproductive part (ear head). It is due to combined application of micronutrients the micronutrients than sole application at different growth stages of the foxtail millet.

References

Adsul, P. B., Anuradha, P., Ganesh, G., Ajeet, P. and Shiekh, S. S., 2011. Uptake of N, P, K and yield of *kharif* sorghum as influence by soil and foliar application of micronutrients. Bioinfolet.11(2): 578-582.

Arunkumar, B. R. Srinivasa, N. Prakash, S. S. Krishna Murthy, R. and Yogananda, S. B. 2017.Soil chemical properties and micronutrient (Zn & B) content in maize crop at different stage as influenced by gypsum and borax application under different nutrient management practices. Journal of Pharmacognosy and Phytochemistry.

6(5): 1689-1694.

Bharti, K., Pandey, N., Shankhdhar, D., Srivastava, P. C. and Shankhdhar, S. C., 2013. Improving nutritional quality of wheat through soil and foliar zinc application. Journal of Plant Soil and Environment. 59(8): 348-352.

Dhaliwal, S. S., Sadana, U. S., Khurana, M. P. S., Dhandli, H. S. and Manchand, J. S., 2010. Enrichment of rice grain with zinc and iron through ferti-fortification. Indian Journal of Fertilizers. 6(7): 28-57.

Follett, R. H. and Lindsay, W. L., 1969. Changes in DTPA. extractable zinc, iron, manganese and copper in soils following fertilization. Soil Science Society of AmericanProceedings.35: 600-602.

Gomez, K. A. and Gomez, A. A., 1984.Statistical Procedures for Agricultural Research.2nd Edition A wiley International Sciences Publications. New York (USA).

Jackson, M. L., 1967. Soil Chemical Analysis. Prentice Hall of India, Pvt. Ltd., New Delhi.

Latha, M. R., Savithri, P., Indirani, R. and Kamaraj, S., 2001. Influence of zinc enriched organic manures on the availability of micronutrient in soil. Madras Agriculture Journal.88: 165-167.

Meena, M. C., Patel, K. P. and Rathod, D. D., 2008. 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 Dry land Agriculture Research Development.23(2): 28-34.

Mosanna, R. and Ebrahim, K. B., 2015.Morpho- physiological response of maize (Zea mays L.) to zinc nano-chelate foliar and soil application at different growth stages. Journal of New Biology Reports. 4(1): 46-50.

Rathod, D. D., Meena, M. C. and Patel, K. P., 2012. 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 Dry land Agriculture Research Development.27(1): 37-42.

Slaton, N. A., Charles, E., Wilson, J., Ntamatungiro, S., Richard, J., Norman and Boothe, D. L., 2001. Evaluation of zinc seed treatments for rice. Agronomy journal. 93: 152-157.

Yang, X. W., Tian, X. H., Gale, W. J., Cao, Y. X., Lu, X. C. and Zhao, A. Q., 2011. Effect of soil and foliar zinc application on zinc concentration and bioavailability in wheat grain grown on potentially zinc deficient soils. Cereal Research Communications. 39: 535-543.

Zeidan, M. S., Mohamad, M. S. and Hamouda, H. A., 2010. Effect of foliar fertilization of Fe, Mn and Zn on wheat yield and quality in low sandy soil fertility.World Journal of Agricultural Sciences. 6(6): 696-699.

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