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Studies on agronomic bio-fortification with zinc and iron on nutrient availability, uptake and yield in pearlmillet [*Pennisetum glaucum* (L.)] genotypes

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Abstract
A field experiment was conducted at Agricultural College Farm, Raichur, Karnataka, during *Kharif* 2016-2017 to studies on agronomic biofortification with zinc and iron on nutrient availability, uptake and yield in pearlmillet [*Pennisetum glaucum* (L.)] genotypes, the experiment was laid out in split plot design and comprised of two factors for study *viz.*, Main plot and subplot treatments. Significantly higher availability of nitrogen, phosphorus and potassium (303.15, 30.58 and 286.91 kg ha^{-1}) was recorded in the plots grown with genotypes G_3: HFeZn-113 (high in Zn & Fe). Among micronutrient applications significantly higher availability of nitrogen, phosphorus and potassium in the soil the treatment with M_7: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (323.45, 35.50 and 318.12 kg ha^{-1}) and also similar trend was followed by availability of zinc and iron. Significantly higher zinc and iron total uptake was recorded with genotype G_3: HFeZn-113 (high in Zn & Fe) (172.12 and 1089.14 ppm, respectively). Similarly micronutrients application significantly higher zinc and iron total uptake was recorded with M_7: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (808.21 and 1143.19 ppm, respectively respectively). The genotype G_3: HFeZn-113 (high in Zn & Fe) recorded significantly higher grain and stover yield (1721 kg ha^{-1} and 4437 kg ha^{-1}, respectively). Among the micronutrient application significantly higher grain and stover yield was obtained in M_7: 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 (1904 kg ha^{-1} and 4611 kg ha^{-1}, respectively) as compared to control.

Keywords: Pearlmillet, nutrient availability in soil, nutrient uptake and yield attributes

Introduction
Pearlmillet [*Pennisetum glaucum* (L.)] is the fifth most important cereal crop and widely grown in India during *Kharif*. It is cultivated by economically poor farmers and provides staple food for the poor in short period in the relatively dry tracts of semi arid India. Now a days, in the context of changing climate, this crop is mostly identified as contingent crop in the country particularly in dry areas. Pearlmillet grain is the staple diet and nutritious source of vitamins, minerals, protein and carbohydrates, while its stover is a valuable livestock feed. In India, it is cultivated on an area of 7.30 m ha with the production of 8.73 m t, among which only 8.5 per cent cultivated area is under irrigation. Karnataka state stands 5th position in area (0.28 m ha) and production (0.29 m t) with the productivity of 1036 kg ha^{-1} (Anon, 2014) [1]. The major area is confined to dry regions of northern Karnataka and generally grown as a rainfed crop and fits well in various cropping systems.
Pearlmillet contains significant levels of protein, fibre, mineral, and phytochemicals. Anti-nutrients such as phytic acid and tannin present in this millet can be reduced to negligible levels by using suitable processing methods. The millet is also reported to possess hypolipidemic, low-glycemic index, and antioxidant characteristics. Nutritional composition of pearlmillet per 100 g edible portion is proteins (12.3 g), carbohydrates (60.9 g), fat (4.3 g), crude fibre (8.0 g), calcium (31 mg), minerals (3.3g) and thiamine (0.59 mg). 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* (Coulibaly *et al.*, 2012) [4]. Malnutrition is a condition that results from eating a diet in which nutrients are either not enough or too much such that the diet causes health problems.
Agronomic biofortification providing Zn and Fe to plants by seed treatment and applying Zn or Fe fertilizers to soil and foliar appears to be important to ensure success of breeding efforts

for increasing Zn and Fe concentration in grain. Fertilizer strategy could be a rapid solution to the problem and can be considered an important complementary approach to the on-going breeding programs. Fertilizer studies focusing specifically on increasing Zn and Fe concentration of grain are, however, very rare. The most effective method for increasing Zn and Fe in grain will be the combined application through soil and foliar method which results in an increase concentration of Zn and Fe in grain in addition to seed treatment. In most parts of the cereal growing areas, soils have, however, a variety of chemical and physical problems that significantly reduce availability of Zn and Fe to plant roots. Hence, the genetic capacity of the newly developed (biofortified) cultivars to absorb sufficient amount of Zn and Fe from soil and accumulate it in the grain may not be expressed to the full extent. It is, therefore, essential to have a short-term approach to improve Zn and Fe concentration in grains.

Material and methods

The field experiment was conducted at Agricultural College Farm, Raichur, which is situated between 16º 12' N latitude and 77º 20' E longitude with an altitude of 389 meters above the mean sea level and is located in zone II 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: HFeZn-102 (low in Zn & Fe), G_2: IP-17720 (medium in Zn & Fe) and G_3: HFeZn-113 (high in Zn & Fe). Subplots treatments: micronutrients application (M) comprised *viz.*, M_1: Control, M_2: Seed treatment with 1 % $ZnSO_4$ & $FeSO_4$ each, M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}, M_4: Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ each at 30 and 45 DAS, M_5: Seed treatment + Soil application (M_2 + M_3), M_6: Seed treatment + Foliar application (M_2 + M_4) and M_7: Soil application + Foliar application (M_3 + M_4). Treatments M_1 to M_7 includes, RDF: 50:25:00 kg N, P_2O_5 and K_2O ha^{-1} + FYM @ 2.5 t ha^{-1}). The soils of the experimental site belong to medium deep black soil and clay texture, neutral in soil reaction (8.15) and low in electrical conductivity (0.46 dSm^{-1}). The organic carbon content was 0.69 per cent and low in available N (192.00 kg ha^{-1}), medium in available phosphorus (22.90 kg P_2O_5 ha^{-1}) and high in available potassium (251.00 kg K_2O ha^{-1}). DTPA extractable zinc (0.55 ppm) and DTPA extractable iron (3.72 ppm). The mean monthly meteorological data of rainfall, temperature and relative humidity during the period of experimentation (2016-17) recorded at the meteorological observatory of the MARS, Raichur**.**

Results and discussion

In the present study, available nutrient status in soil helps to detect the efficiency of fertilizers applied and used by the crop. There was no significant difference in the availability of macro and micronutrients in soil as influenced by soil and foliar application of Zn and Fe. Significantly higher availability of nitrogen, phosphorus and potassium (303.15, 30.58 and 286.91 kg ha^{-1}) was recorded in the plots grown with genotypes G_3: HFeZn-113 (high in Zn & Fe) as compared to G_1: HFeZn-102 (low in Zn & Fe) (280.22, 25.53 and 287.14 kg ha^{-1}), However, which was found on far with G_2: IP-17720 (medium in Zn & Fe) (298.09, 27.60 and 296.26 kg ha^{-1}). Among micronutrient applications significantly influenced the availability of nitrogen, phosphorus and potassium in the soil the treatment with M_7: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (323.45, 35.50 and 318.12 kg ha^{-1}) compared to the other treatments, *viz.*, control (270.52, 21.88 and 274.91 kg ha^{-1}), M_2: Seed treatment with 1 % $ZnSO_4$ & $FeSO_4$ (281.21, 26.16 and 284.52 kg ha^{-1}), M_4: Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (260.56, 25.11 and 254.50 kg ha^{-1}). However, it was found on par with M_5: Seed treatment + Soil application (315.50, 31.84 and 309.91 kg ha^{-1}). The soil and foliar application of $ZnSO_4$ and $FeSO_4$ along with recommendation chemical fertilizer and FYM may increases the utilization of nutrients mainly due to its beneficial effect in mobilizing the native nutrients to increase their availability these might be the reason for more available N, P and K in the soil at harvest. (Latha *et al*., 2001) [7] and also it might be due to incorporation of organic manures to soil along with inorganic fertilizer enhanced the soil nitrogen content when compared to initial level of nutrients in the soil. This might be due to the inherent higher value of N in the applied green manure to the soil due to release of mineralizable nitrogen from the organic manures by the increased nitrification process (Kavitha and Subramanian, 2007 and Rathod *et al*., 2012) [6, 8]

Significantly higher availability of zinc and iron was recorded in the plots under G_3: HFeZn-113 (high in Zn & Fe) (2.00 and 7.74 mg kg^{-1}), compared to G_1: HFeZn-102 (low in Zn & Fe) (1.72 and 7.38 mg kg^{-1}), which was found on far with G_2: IP-17720 (medium in Zn & Fe) (1.85 and 7.63 mg kg^{-1}). Among micronutrients application significantly higher availability of zinc and iron in the soil was recorded with M_7: 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 (2.79 and 8.50 mg kg^{-1}) as compared to other treatments, *viz*., Control (1.11 and 6.78 mg kg^{-1}), M_2: Seed treatment with 1 % $ZnSO_4$ & $FeSO_4$ (1.31 and 7.20 mg kg^{-1}), M_4: Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (1.40 and 7.31 mg kg^{-1}) and M_6: Seed treatment + Foliar application (1.49 and 7.42 mg kg^{-1}). However, it was found on far with M_5: Seed treatment + Soil application (2.49 and 8.03 mg kg^{-1}). 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 noticed by Basavaraj *et al.* (1995) [3].

Significantly higher zinc uptake by grain, stover and total uptake of zinc was recorded with genotype G_3: HFeZn-113 (high in Zn & Fe) (47.85, 124.46 and 172.12 ppm, respectively), however, it was found on par with G_2: IP-17720 (medium in Zn & Fe) (44.85, 113.88 and 159.21 ppm, respectively) and G_1: HFeZn-102 (low in Zn & Fe) (42.20, 100.15 and 142.42 ppm, respectively). Among micronutrients application significantly higher zinc uptake by grain, stover and total uptake of zinc was recorded with M_7: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (57.65, 142.30 and 200.40 ppm, respectively) as compared to control. Which was mainly due to 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) [9].

Significantly higher iron uptake by grain, stover and total uptake of iron was recorded with G_3: HFeZn-113 (high in Zn & Fe) (302.04, 786.41 and 1089.14 ppm, respectively), however, it was found on par with G_2: IP-17720 (medium in Zn & Fe) (292.21, 742.10 and 1034.23 ppm, respectively). Among micronutrients application resulted in significantly higher iron uptake by grain, stover and total uptake of iron was recorded with M_7: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} and $FeSO_4$ @ 10 kg ha^{-1}+ Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (335.41, 808.21 and 1143.19 ppm, respectively) as compared to control (214.56, 578.24 and 791.32 ppm, respectively) this might 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 results were observed by Adsul *et al.* (2011) [1] and Rathod *et al.* (2012) [8].

Similarly grain and stover yield of pearlmillet differed significantly due to agronomic biofortification the genotype G_3: HFeZn-113 (high in Zn & Fe) recorded significantly higher grain and stover yield (1721 kg ha^{-1} and 4437 kg ha^{-1}, respectively) and it was on far with G_2: IP-17720 (medium in Zn & Fe) (1719 kg ha^{-1} and 4255 kg ha^{-1}, respectively) and G_1: HFeZn-102 (low in Zn & Fe) (1703kg ha^{-1} and 4081 kg ha^{-1}, respectively). Significantly higher grain and stover yield of pearlmillet was obtained in M_7: soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} + Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ (1904 kg ha^{-1} and 4611 kg ha^{-1}, respectively) which is on par with M_5: Seed treatment with 1 % $ZnSO_4$ & $FeSO_4$ + Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} (1859 kg ha^{-1} and 4492 kg ha^{-1}, respectively) followed by M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1} (1770 kg ha^{-1} and 4351 kg ha^{-1}, respectively). Significantly lower pearlmillet grain and stover yield was recorded with control (1479 kg ha^{-1} and 3827 kg ha^{-1}, respectively) after M_2: Seed treatment with 1% $ZnSO_4$ and $FeSO_4$ each (1582 kg ha^{-1} and 4132 kg ha^{-1}, respectively) and M_4: Foliar application of 0.5 % $ZnSO_4$ and $FeSO_4$ each (1657 kg ha^{-1} and 4163 kg ha^{-1}, respectively). The increase in the yield attributes could be due to continuous supply of micronutrients (Zn and Fe) to the crop. Zn and Fe are part of the photosynthesis, assimilation, absorption and translocation of photosynthates from source (leaves) to sink (ear head) Zeidan *et al.* (2010) [10] and Esfahani *et al.* (2012) [5]. Similar trend was noticed by Adsul *et al*. (2011) [1].

Table 1: Available nitrogen, phosphorus and potassium status in soil after harvest of crop as influenced by genotypes and agronomic bio-fortification

Micronutrients application (M)	Genotypes (G)											
	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: Control	268.22	270.54	273.20	270.52	20.15	21.30	24.20	21.88	275.10	273.21	276.80	274.91
M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ Each	280.15	279.25	284.23	281.21	25.77	26.34	26.37	26.16	278.32	289.62	285.61	284.52
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	303.09	305.74	309.08	307.25	24.63	27.33	31.47	28.48	285.63	304.50	309.75	301.64
M_4: Foliar application of 0.5 % $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	188.24	294.22	299.29	260.56	22.67	25.00	27.67	25.11	277.15	287.81	198.66	254.50
M_5: Seed treatment + Soil application	309.45	313.30	321.07	315.50	27.97	31.97	35.60	31.84	299.64	310.62	315.61	309.91
M_6: Seed treatment + Foliar application	294.12	304.18	304.51	301.18	23.30	25.67	29.07	26.01	281.31	292.18	303.16	292.23
M_7: Soil application + Foliar application	317.25	321.14	332.15	323.45	34.23	36.30	39.67	35.50	314.09	319.11	321.08	318.12
Mean	280.22	298.09	303.15	-	25.53	27.60	30.58	-	287.14	296.26	286.91	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	2.10		8.23		0.99		3.90		2.32		9.09	
Micronutrients application (M)	1.29		3.71		1.01		2.89		1.13		3.24	
M at the same level of G	2.24		NS		1.74		NS		1.96		NS	
G at the same or different levels of M	3.17		NS		2.47		NS		2.77		NS	

Note

1. G_1: HFeZn-102 (low in Zn & Fe), G_2: IP-17720 (medium in Zn & Fe) and G_3: HFeZn-113 (high in Zn & Fe). NS - Non Significant
2. RDF is common to all the treatment from M_1 and M_7

Table 2: Available micronutrients (Zinc and Iron) status in soil after harvest of crop as influenced by genotypes and agronomic bio-fortification

Micronutrients application (M)	Genotypes							
	Zn (mg kg^{-1})				Fe (mg kg^{-1})			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1: Control	1.05	1.11	1.18	1.11	6.15	7.02	7.18	6.78
M_2: Seed treatment with 1 % $ZnSO_4$ & $FeSO_4$ each	1.21	1.28	1.45	1.31	7.1	7.21	7.29	7.20
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	2.20	2.45	2.55	2.40	7.76	7.81	7.94	7.84
M_4: Foliar application of 0.5 % $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	1.25	1.39	1.57	1.40	7.14	7.37	7.41	7.31
M_5: Seed treatment + Soil application	2.3	2.51	2.67	2.49	7.95	7.99	8.15	8.03
M_6: Seed treatment + Foliar application	1.37	1.47	1.64	1.49	7.29	7.46	7.51	7.42
M_7: Soil application + Foliar application	2.67	2.75	2.95	2.79	8.25	8.57	8.68	8.50
Mean	1.72	1.85	2.00	-	7.38	7.63	7.74	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	0.12		0.39		0.14		0.45	
Micronutrients application (M)	0.05		0.18		0.10		0.35	
M at the same level of G	0.01		NS		0.01		NS	
G at the same or different levels of M	0.02		NS		0.01		NS	

Note:

1. G_1: HFeZn-102 (low in Zn & Fe), G_2: IP-17720 (medium in Zn & Fe) and G_3: HFeZn-113 (high in Zn & Fe). NS - Non Significant
2. RDF is common to all the treatment from M_1 and M_7

Table 3: Zinc uptake by pearlmillet grain, stover and total zinc uptake as influenced by genotypes and agronomic bio-fortification

Micronutrients application (M)	Genotypes (G)											
	Grain (ppm)				Stover (ppm)				Total zinc uptake (ppm)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1: Control	30.51	32.87	36.72	33.37	82.40	90.50	97.70	90.20	113.12	123.14	134.05	124.21
M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ Each	34.35	40.26	44.73	39.78	88.90	104.00	121.80	104.90	123.09	144.32	167.23	145.41
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	49.88	47.09	49.93	48.97	109.60	122.40	131.80	121.30	160.45	170.17	182.15	170.25
M_4: Foliar application of 0.5 % $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	37.18	37.69	38.53	37.80	84.20	95.60	103.70	94.50	121.41	133.21	142.25	132.09
M_5: Seed treatment + Soil application	50.65	52.71	55.08	52.81	118.70	126.80	137.60	128.40	168.15	180.14	193.20	181.15
M_6: Seed treatment + Foliar application	40.84	43.38	48.95	44.39	94.40	109.90	123.60	109.30	135.12	153.09	173.14	154.19
M_7: Soil application + Foliar application	52.01	59.96	60.97	57.65	123.80	148.10	154.80	142.30	176.19	208.13	216.32	200.40
Mean	42.20	44.85	47.85	-	100.15	113.88	124.46	-	142.42	159.21	172.12	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	1.09		4.29		3.50		15.10		5.50		21.00	
Micronutrients application (M)	1.07		3.06		2.91		8.33		3.82		10.96	
M at the same level of G	1.84		NS		5.03		NS		6.62		NS	
G at the same or different levels of M	2.61		NS		7.12		NS		9.36		NS	

Note:
1. G_1: HFeZn-102 (low in Zn & Fe), G_2: IP-17720 (medium in Zn & Fe) and G_3: HFeZn-113 (high in Zn & Fe). NS - Non Significant
2. RDF is common to all the treatment from M_1 and M_7

Table 4: Iron uptake by pearlmillet grain, stover and total iron uptake as influenced by genotypes and agronomic bio-fortification

Micronutrients application (M)	Genotypes (G)											
	Grain (ppm)				Stover (ppm)				Total iron uptake (ppm)			
	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean	G_1	G_2	G_3	Mean
M_1: Control	**210.19**	**214.10**	**217.51**	**214.56**	**567.12**	**589.61**	**577.12**	**578.24**	**777.51**	**803.21**	**794.54**	**791.32**
M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ each	255.05	268.05	271.21	265.18	659.23	692.23	737.20	696.41	914.12	959.12	1008.15	960.15
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	353.23	299.14	321.32	325.23	776.45	778.10	848.51	801.62	1129.04	1078.45	1170.04	1125.20
M_4: Foliar application of 0.5 % $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	274.12	289.21	298.0	287.14	621.25	733.20	801.08	718.25	895.31	1022.10	1099.32	1005.10
M_5: Seed treatment + Soil application	302.17	337.31	355.20	332.32	719.14	832.01	901.36	818.17	1021.12	1169.09	1257.12	1149.23
M_6: Seed treatment + Foliar application	309.51	302.18	302.12	304.12	711.16	765.12	762.25	746.15	1020.51	1067.41	1064.10	1051.14
M_7: Soil application + Foliar application	319.81	335.26	351.21	335.41	741.42	805.09	878.19	808.21	1060.15	1139.16	1229.02	1143.19
Mean	289.45	292.21	302.04	-	685.14	742.10	786.41	-	974.12	1034.23	1089.14	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	4.87		19.12		10.58		41.53		15.11		59.32	
Micronutrients application (M)	3.96		11.36		6.87		19.69		8.51		24.39	
M at the same level of G	6.86		NS		11.89		NS		14.73		NS	
G at the same or different levels of M	9.70		NS		16.82		NS		20.83		NS	

Note:
1. G_1: HFeZn-102 (low in Zn & Fe), G_2: IP-17720 (medium in Zn & Fe) and G_3: HFeZn-113 (high in Zn & Fe). NS - Non Significant
2. RDF is common to all the treatment from M_1 and M_7

Table 5: Grain yield, stover yield and harvest index of pearlmillet genotypes as influenced by genotypes and agronomic bio-fortification

Micronutrients application (M)	Genotypes (G)											
	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: Control	1477	1479	1483	1479	3707	3831	3943	3827	28.49	27.85	27.33	27.87
M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ each	1581	1581	1585	1582	3999	4112	4286	4132	28.33	27.77	27.00	27.69
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	1764	1772	1775	1770	4146	4374	4532	4351	29.85	28.83	28.14	28.92
M_4: Foliar application of 0.5% $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	1644	1650	1678	1657	4001	4125	4362	4163	29.12	28.57	27.78	28.47
M_5: Seed treatment + Soil application	1855	1870	1852	1859	4167	4494	4815	4492	30.80	29.38	27.78	29.27
M_6: Seed treatment + Foliar application	1741	1738	1765	1748	4167	4294	4224	4228	29.47	28.81	29.47	29.25
M_7: Soil application + Foliar application	1859	1940	1912	1904	4377	4557	4898	4611	29.81	29.86	28.08	29.22
Mean	1703	1719	1721	-	4081	4255	4437	-	29.44	28.77	27.95	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	25.92		101.78		38.78		152.26		0.00		0.01	
Micronutrients application (M)	21.53		61.75		39.74		113.97		0.00		0.01	
M at the same level of G	37.29		NS		68.83		NS		0.00		NS	
G at the same or different levels of M	52.74		NS		97.34		NS		0.01		NS	

Note:
1. G_1: HFeZn-102 (low in Zn & Fe), G_2: IP-17720 (medium in Zn & Fe) and G_3: HFeZn-113 (high in Zn & Fe). NS - Non Significant
2. RDF is common to all the treatment from M_1 and M_7

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