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Performance of agronomic biofortification of zinc and iron on growth, yield and nutrient uptake by 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 study the performance of agronomic biofortification with zinc and iron on yield and quality of pearlmillet [*Pennisetum glaucum* (L.)] genotypes. The plant height, leaf area index and total dry matter production recorded with genotype G_3: HFeZn-113 (184.16 cm 3.01 and 224.9 g plant^{-1} at harvest, respectively). Among the Micronutrients application (193.10 cm, 3.73 and 244.6 g plant^{-1} at harvest, respectively) 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 as compared to other treatments. 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). 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). 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). 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). 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 other treatment.

Keywords: Pearlmillet, growth and yield attributes, nutrient uptake

Introduction
Pearlmillet [*Pennisetum glaucum* (L.)] is the fifth most important cereal crop and widely grown in India during *kharif*. It is well adapted to growing areas characterized by drought, low soil fertility, and high temperature. It performs well in soils with high salinity or low pH. Because of its tolerance to difficult growing conditions, it can be grown in areas where other cereal crops, such as maize or wheat, would not survive. Pearl millet is a summer annual crop well-suited for double cropping and rotations. Pearlmillet grain is the staple diet and nutritious source of vitamins, minerals, protein and carbohydrates, while its stover is a valuable livestock feed. 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.

About half of the world's population suffers from micronutrient malnutrition a term used to refer any condition in which the body does not receive enough nutrients for proper function, including selenium (Se), zinc (Zn), iron (Fe) and iodine (I), which is mainly associated with low dietary intake of micronutrients in diets with less diversity of food. Zinc and iron deficiencies are well-documented public health issue and an important soil constraint to crop production. Generally, there is a close geographical overlap between soil deficiency and human deficiency of Zn and Fe, indicating a high requirement for increasing concentrations of these nutrients in food crops. Pearlmillet is a principle source of energy, protein, vitamins and minerals of millions of poorest people in region where it is cultivated. It general has 9 to13 per cent protein but large variation among genotype ranging from 6 to 21 per cent has been observed. Pearlmillet contains more calories than wheat, probably because of its higher oil content of 5 per cent of which 50 per cent are poly unsaturated fatty acid. It is rich in calcium, potassium, magnesium, iron, zinc, manganese, riboflavin, thiamine, niacin, lysine and tryptophan. Pearlmillet gluten is free and thus is the only grain that retains its alkaline properties after being cooked which is ideal for people with gluten allergies.

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 16° 12' N latitude and 77° 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 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.

Table 1: Plant height (cm) of pearlmillet genotypes at different growth stages as influenced by agronomic biofortification

Micronutrients application (M)	Genotypes (G)											
	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: Control	32.54	38.86	41.58	37.66	165.04	170.10	168.12	166.23	163.14	167.18	172.11	168.12
M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ each	46.68	47.96	48.73	47.79	173.21	174.20	181.23	176.01	172.52	178.21	187.12	179.10
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	52.22	52.63	52.76	52.54	186.32	186.25	186.20	186.12	182.25	186.09	179.21	182.15
M_4: Foliar application of 0.5% $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	48.68	49.05	50.00	49.24	173.09	174.24	184.02	177.15	171.32	184.21	188.02	181.32
M_5: Seed treatment + Soil application	52.73	52.95	53.16	52.95	187.14	187.01	187.45	187.20	192.12	192.08	193.25	192.21
M_6: Seed treatment + Foliar application	43.42	41.33	43.33	42.69	178.16	175.12	179.12	177.14	189.45	177.30	178.09	181.12
M_7: Soil application + Foliar application	53.18	53.65	53.75	53.53	188.03	188.31	189.20	188.21	194.14	193.15	194.12	193.10
Mean	47.07	48.06	49.05	-	179.21	179.08	182.14	-	180.14	182.18	184.16	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	2.56		10.05		1.78		7.01		2.74		10.75	
Micronutrients application (M)	0.79		2.25		0.85		2.44		1.61		4.62	
M at the same level of G	1.36		NS		1.47		NS		2.79		NS	
G at the same or different levels of M	1.92		NS		2.09		NS		3.94		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
Note: 2. RDF is common to all the treatment from M_1 and M_7

Table 2: Total dry matter production (g $plant^{-1}$) of pearlmillet genotypes at different growth stages as influenced by agronomic biofortification

Micronutrients application (M)	Genotypes (G)											
	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: Control	6.13	6.61	6.70	6.48	38.80	41.38	47.13	42.44	178.6	181.9	196.7	185.7
M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ each	11.29	10.77	9.88	10.65	53.77	53.47	53.71	53.65	204.5	205.4	213.8	207.9
M_3: Soil application of $ZnSO_4$ @ 15 kg ha^{-1} & $FeSO_4$ @ 10 kg ha^{-1}	10.85	10.27	12.64	11.25	58.07	63.68	69.72	63.82	222.4	225.7	235.9	228.0
M_4: Foliar application of 0.5% $ZnSO_4$ & $FeSO_4$ each at 30 and 45 DAS	10.98	10.46	11.45	10.96	50.54	52.83	55.29	52.89	205.8	208.4	213.3	209.2
M_5: Seed treatment + Soil application	13.64	14.94	14.25	14.28	69.78	70.87	72.14	70.93	241.6	243.3	242.9	242.6
M_6: Seed treatment + Foliar application	8.73	8.40	9.82	8.98	53.46	55.87	55.23	54.85	205.7	212.1	224.9	214.2
M_7: Soil application + Foliar application	13.51	15.19	16.59	15.10	71.82	72.23	74.59	72.88	243.3	243.9	246.7	244.6
Mean	10.73	10.95	11.62	-	56.61	58.62	61.12	-	214.6	217.2	224.9	-
For comparing means of	S.Em±		C.D. at 5%		S.Em±		C.D. at 5%		S.Em±		C.D. at 5%	
Genotypes (G)	0.91		3.57		1.22		4.80		2.34		9.19	
Micronutrients application (M)	0.42		1.21		0.92		2.63		1.80		5.15	

M at the same level of G	0.73	NS	1.59	NS	3.11	NS
G at the same or different levels of M	1.03	NS	2.24	NS	4.40	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
Note: 2. RDF is common to all the treatment from M_1 and M_7

Table 3: Grain yield, stover yield and harvest index of pearlmillet genotypes as influenced by genotypes and agronomic biofortification

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
Note: 2. RDF is common to all the treatment from M_1 and M_7

Table 4: Zinc uptake by pearlmillet grain, stover and total zinc uptake as influenced by genotypes and agronomic biofortification

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
Note: 2. RDF is common to all the treatment from M_1 and M_7

Table 5: Iron uptake by pearlmillet grain, stover and total iron uptake as influenced by genotypes and agronomic biofortification

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
Note: 2. RDF is common to all the treatment from M_1 and M_7

Results and discussion

In the present study, plant height, leaf area index and total dry matter production recorded with genotype G_3: HFeZn-113 (184.16 cm 3.01 and 224.9 g plant^{-1} at harvest, respectively). Among the Micronutrients application (193.10 cm, 3.73 and 244.6 g plant^{-1} at harvest, respectively) 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 as compared to other treatments. The genotype G_3: HFeZn-113 recorded significantly higher grain and stover yield (1721 kg ha^{-1} and 4437 kg ha^{-1}, respectively). 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 $FeSO_4$ (1904 kg ha^{-1} and 4611 kg ha^{-1}, respectively). And also 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). Similar result was observed by Zeidan *et al.* (2010) [13] and Esfahani *et al.* (2012) [4].

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 other treatments, *viz.*, Control (33.37, 90.20 and 124.21 ppm, respectively), M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ (39.78, 104.90 and 145.41 ppm, respectively) and M_4: Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ (37.80, 94.5 and 132.09 ppm, respectively). However, it was found on par with M_5: Seed treatment + Soil application (52.81, 128.40 and 181.15 ppm, respectively).

Similarly 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) and G_1: HFeZn-102 (low in Zn & Fe) (289.45, 685.14 and 974.12 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 other treatment *viz.*, control (214.56, 578.24 and 791.32 ppm, respectively), M_2: Seed treatment with 1% $ZnSO_4$ & $FeSO_4$ (265.18, 696.41 and 960.15 ppm, respectively) and M_4: Foliar application of 0.5% $ZnSO_4$ and $FeSO_4$ (287.14, 718.25 and 1005.10 ppm, respectively).

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