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EFFECT OF Zn APPLICATION ON DIFFERENT RICE GENOTYPES IN YIELD, ZN CONTENT AND Zn UPTAKE

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ABSTRACT

This experiment was carried out at the Instructional Farm, College of Agriculture, Indira Gandhi KrishiVishwavidhyalaya, Raipur, Chhattisgarh in during 2013-14.Grain and straw yields were found significantly higher under rice genotypes (G1) CB-07-701-252 (65.36q ha^{-1} and 76.93q ha^{-1}) than all other rice genotypes. Other genotypes were performed either sequentially decreased significantly or at par in the yield. The effect of application of $ZnSO_4$ on different genotypes for yield and Zn uptake were found to be significant and was maximum with the application of basal dose + foliar application of $ZnSO_4$ (M3) (Grain 49.90 kg ha^{-1} and straw 56.18 q ha^{-1}) which was at par with that of basal application of $ZnSO_4$ (M1) (Grain 49.30 q ha^{-1} and straw 55.98 kg ha^{-1})as compared to control (M0) (Grain 46.54 q ha^{-1} and straw 53.04 q ha^{-1}). Rice genotype (G13) CHIR-8 (34.33ppm)showed highest Zn content in grain with the application of basal dose + foliar application of $ZnSO_4$ (M3) (25.59ppm) which was at par with the foliar application of $ZnSO_4$ (M2) (24.86ppm)as compared to control (M0) (21.22ppm).

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INTRODUCTION

Zinc is one of the most important micronutrient essential for plant growth especially for rice grown under submerged condition. Zinc deficiency is prevalent worldwide in temperate and tropical climates (Fageria *et al*., 2003; Slaton *et al.,* 2005). Zinc is required in small but critical concentrations to allow several key plant physiological pathways to function normally. These pathways have important roles in photosynthesis and sugar formation, protein synthesis, fertility and seed production, growth regulation and defence against diseases. Where zinc is deficient, these physiological functions will be impaired and the health and productivity of the plants will be adversely affected, resulting in lower yields (or even crop failure) and frequently in poorer quality crop products. Zinc deficiency in the soils has been reported at various parts of the world. The universal deficiency of nitrogen and phosphorus is followed by Zn deficiency. (Keram *et al.,*2014). Although total soil Zn concentration may be high, deficiencies arise because Zn availability depends on the soil chemical forms of Zn. Hence, keeping this in view, the study was emanated to have a better understanding of the transformation of soil zinc fractions and contribution of individual zinc form.The outcome of this experiment can be used to choose germplasm which will cover well under a range of nutrient supply as well as farmer's field conditions. In view of this, it may be worthwhile to evaluate the Effect of Zn application on different rice genotypes in yield, Zn content and Zn uptake.with the objective to evaluate the rice genotypes for high Zn content as affected by application of Zn.

MATERIALS AND METHODS

In order to evaluate yield and yield attributes of different rice genotypes as influenced by Zn applicationan experiment was carried in during 2013-14. The Instructional Farm, Indira Gandhi KrishiVishwavidyalaya, Raipur is situated on National Highway No. 6 in Eastern part of Raipur city and situated in Mid-eastern part of Chhattisgarh state and lies at 21º16′ N latitude and 81º36′ E longitudes with an attitude of 298.56 meter above the mean sea level. Some physicochemical properties of experimental soil was clay loam as presented in Table No.1

This experiment was done as strip plot design based on three replications. Zinc fertilizer application was chosen as main plotsviz., Control (M0), $ZnSO_4$ 20 kg ha^{-1} as basal application (M1), $ZnSO_4$ 0.25% as foliar (5kg/ha) application at panicle initial stage (M2), $ZnSO_4$ 20 kg ha^{-1} as basal application + $ZnSO_4$ 0.25% as foliar (5kg ha^{-1}) application at panicle initial stage (M3). Twenty four subplots represented by rice genotypes viz., (G1) CB-07-701-252, (G2) CK-143, (G3) RHZ-(1) (CURE 1), (G4) RHZ-(2)(CURE 10), (G5) RHZ SM(1)-(21), (G6) RHZ SM(2)-(23), (G7) CHIR-1, (G8) CHIR-2, (G9) CHIR-3, (G10) CHIR-4, (G11) CHIR- 5, (G12) CHIR-6, (G13) CHIR-8, (G14) CHIR-10, (G15) CHIR-11, (G16) 1301, (G17) 1304, (G18) 3402, (G19) 3404, (G20) 3405, (G21) 3406, (G22) RP-Bio-226, (G23) Chandrahashini, (G24) IR-64.

Nitrogen, phosphorous and potassium fertilizers were used at the rates of N 100 kg ha^{-1} urea, P_2O_5 60 kg ha^{-1}triple superphosphate and K_2O 40 kg ha^{-1} potassium sulphate. Basal fertilizers were applied in all plots 1 day before transplanting.Nitrogen was applied three times (first at planting time, second at tillering time and third panicle imitation. Phosphate and potassium fertilizers weren't used during of growth stages. Zinc levels used were 0, 20 kg ha^{-1} basal, 0.25 % as foliar spray (5 kg ha^{-1}) and 0.25 % + 20 kg ha^{-1} applied as zinc sulphate. The grain and straw yields were recorded by cutting the net plot of 5 m^2 from each treatment.

Soil pH was determined in 1:2.5 soil - water suspension after stirring for 30 minutes, by glass electrode pH meter as suggested by Piper (1966).Electrical conductivity was determined by taking supernatant liquid of 1:2.5 soil water suspension prepared for pH determination by using solubridge as described by Black (1965).Organic carbon was determined by Walkley and Black's rapid titration method (1934) as described by Piper (1966).The CEC of the soil was determined by leaching the soil with neutral normal ammonium acetate as described by Black (1965).The mechanical analysis of soil was carried out by International Pipette method as described by Piper (1966).Soil available nitrogen was determined by alkaline permanganate method as described by Subbiah and Asija (1956).

Soil available phosphorus was extracted by $NaHCO_3$ (pH 8.5) as described by Olsen *et al*. (1954) and the amount was determined by ascorbic acid method using spectrophotometer (Watnabe and Olsen 1965).Soil potassium was extracted by neutral normal ammonium acetate and determined with the help of flame photometer as described by Muhr*et al*. (1965).The micronutrients Zn, Cu, Fe and Mn were extracted by using 0.005 M b diethylene triaminepenta acetic acid, 0.01 M calcium chloride dehydrate and 0.1 m triethanol amine buffered at pH 7.3 (Lindsay and Norvell, 1978) and concentrations were analyzed by atomic absorption spectrophotometer.

Digestion of plant material

One gram of grain and straw samples was taken in digestion tube along with 10 ml of di-acid mixture (concentrated HNO_3 and $HClO_4$ in the ratio of 9:4). The material was digested at 150 ^{0}C in KEL plus digestion block till the material become colorless. The digested material was transferred in to 100 ml volumetric flask by repeated washing of tube with distilled water and make up the volume up to the mark. The digested material was used for the estimation of micronutrients Zn contents.

Zn content

One gram oven dried plant sample (grain and straw) was digest with 10 ml of di-acid mixture (HNO_3 and $HClO_4$ in 9:4 ratio) and final volume was made up to 100 ml with de-ionized water. Total concentration of zinc, copper, iron and manganese was analyzed by atomic absorption spectroscopy (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Grain yield

The various treatments imposed in the experiment i.e. rice genotypes and effect of $ZnSO_4$ application significantly affected grain yield (Table 2 and fig 2. a). (G1) CB-07-701-252 produced the average highest yield (65.30 q ha^{-1}) followed (by G21) 3406 (63.56 q ha^{-1}), G18 3402 (58.85 q ha^{-1}) and the (G19) 3404 (57.50 q ha^{-1}. The lowest grain yield of 30.64 qha^{-1} was recorded with (G9) CHIR-3. However, difference between genotype G1 and G 21 was found to be non significant. Other genotypes were performed either sequentially decreased significantly or at par. Grain yield was directly dependent on yield components such as number of tillers, length of panicles, filled grains per panicles and test weight. These yield components are genetic character of rice genotype and differ to each other.Application of $ZnSO_4$ on grain yields of different genotypes differed significantly as shown in the ((Table 2 and Fig. 2. b). The highest grain yield (49.90 q ha^{-1}) was recorded with the application of basal dose and foliar application of $ZnSO_4$ (M3) followed by (49.30 q ha^{-1})basal application of $ZnSO_4$ (M1) and, (48.75 q ha^{-1})in foliar application of $ZnSO_4$ (M2) and the lowest (46.54 q ha^{-1})in control (M0). Similar result were reported by so many worker (Ram *et al*. (1995), Sharma *et al*. (1999), Khan *et al*. (2003) andChakeralhosseine*t al*. (2009).Interaction between rice genotypes and fertilizer application was found to be non-significant result.

Straw yield

The data on effect of rice genotypes and $ZnSO_4$ application on straw yield are presented in (Table 3and fig 3. a) and revealed that CB-07-701-252 (G1) accumulated significantly higher straw yield (76.93 q ha^{-1}) than (G21) 3406 (71.47 q ha^{-1}) followed by (G18) 3402 (66.76 q ha^{-1}). Straw yield of rice found under genotype (G18) 3402 (66.76 q ha^{-1}) was statistically at par with (G5) RHZ SM (1) -21 (63.62 q ha^{-1}) and (G19) 3404 (62.02 q ha^{-1}). Straw yield of rice found under genotype (G5) RHZ SM (1) -21 (63.62 q ha^{-1}) and (G19) 3404 (62.02 q ha^{-1}) were also statistically at par with (G20) 3405 (60.95 q ha^{-1}), (G16) 1301 (60.81 q ha^{-1}), (G17) 1304 (60.66 q ha^{-1}), (G23) Chandrahashini (60.01 q ha^{-1}), (G24) IR-64 (60.01 q ha^{-1}) and (G3) RHZ-1 CURE-1 (59.05 q ha^{-1}).The lowest straw yields were recorded under genotype (G13) CHIR-8 (37.06 q ha^{-1}) by which was statistically at par with those of genotypes G9, G6, and G8. Application of $ZnSO_4$ significantly increased straw yield as shown in the ((Table 3 and fig 3. b). The highest straw yield (56.18 q ha^{-1}) was recorded with the application of basal dose + foliar application of $ZnSO_4$ (M3) which is at par with treatment basal application of $ZnSO_4$ (M1) (55.98 q ha^{-1}) followed by 54.72 q ha^{-1} in foliar application of $ZnSO_4$ (M2)

Table 1: Physico-chemical properties of experimental soil

Properties	Value
pH (1:2.5)	7.34
EC (dSm^{-1})	0.26
CEC (Cmol/kg)	38.21
Organic carbon (%)	0.60
Available N (kg ha^{-1})	273
Available P (kg ha^{-1})	16.81
Available K (kg ha^{-1})	432
Available Zn (ppm)	0.61
Available Fe (ppm)	5.43
Mechanical analysis	
Sand (%)	20
Silt (%)	34
Clay (%)	46
Textural class	Clay

Table 2: Effect of rice genotypes and $ZnSO_4$ application on grain yield of rice genotypes

Symbol	Genotypes	Grain yield (q ha^{-1})				
		Control (M0)	$ZnSO_4$ 20 kg ha^{-1}Basal (M1)	$ZnSO_4$ 0.25% Foliar (M2)	$ZnSO_4$ 20 kg ha^{-1}Basal + 0.25% Foliar (M3)	Mean
G 1	CB-07-701-252	62.57	65.96	66.04	66.88	65.36 a
G 2	CK-143	46.79	50.43	50.75	52.61	50.14 ef
G 3	RHZ-1 CURE-1	51.73	53.80	53.83	54.35	53.43 de
G 4	RHZ-2 CURE-10	53.49	55.98	55.87	56.09	55.36 cd
G 5	RHZ SM (1)-21	54.69	57.40	57.44	57.68	56.80 cd
G 6	RHZ SM (2)-23	33.36	36.18	34.23	36.16	34.98 h
G 7	CHIR-1	43.08	46.52	45.67	46.54	45.45 g
G 8	CHIR-2	31.89	33.36	32.58	34.17	33.00 hi
G 9	CHIR-3	29.03	31.59	30.11	31.84	30.64 i
G 10	CHIR-4	42.33	44.64	44.69	44.88	44.14 gs
G 11	CHIR-5	35.67	37.79	36.67	36.56	36.67 h
G 12	CHIR-6	32.73	34.07	33.13	34.00	33.48 hi
G 13	CHIR-8	31.85	33.07	33.43	34.68	33.26 hi
G 14	CHIR-10	43.81	45.96	45.30	46.54	45.40 g
G 15	CHIR-11	34.65	36.60	35.46	37.28	36.00 h
G 16	1301	53.04	57.03	55.97	57.14	55.79 cd
G 17	1304	54.00	58.27	57.12	60.52	57.48 cd
G 18	3402	58.49	62.85	62.39	63.24	61.74 ab
G 19	3404	55.95	59.45	59.67	60.32	58.85 bc
G 20	3405	54.97	58.89	57.15	58.98	57.50 cd
G 21	3406	61.73	63.89	63.91	64.73	63.56 a
G22	RP-Bio-226	43.85	48.61	47.16	49.29	47.23 fg
G 23	Chandrahashini	55.23	57.28	57.80	58.13	57.11 cd
G 24	IR-64	51.89	53.60	53.68	54.93	53.53 de
	Mean	46.54d	49.30ab	48.75bc	49.90a	48.62

$CD_{\text{at 5\% level}}$ for G* – 3.85, F* – 0.78, G x F – NS

Table 3: Effect of rice genotypes and $ZnSO_4$ application on straw yield of rice genotypes

Symbol	Genotypes	Straw yield (q ha^{-1})				
		Control (M0)	$ZnSO_4$ 20 kg ha^{-1}Basal (M1)	$ZnSO_4$ 0.25% Foliar (M2)	$ZnSO_4$ 20 kg ha^{-1}Basal + 0.25% Foliar (M3)	Mean
G 1	CB-07-701-252	73.83	77.83	77.14	78.91	76.93 a
G 2	CK-143	52.40	57.60	56.84	58.93	56.44 efg
G 3	RHZ-1 CURE-1	56.91	60.28	59.22	59.78	59.05 def
G 4	RHZ-2 CURE-10	56.17	58.78	57.61	58.89	57.86 ef
G 5	RHZ SM (1)-21	61.25	64.29	64.33	64.60	63.62 cd
G 6	RHZ SM (2)-23	38.22	41.53	39.38	41.54	40.17 i
G 7	CHIR-1	51.70	55.82	54.01	55.45	54.24 fg
G 8	CHIR-2	38.91	40.70	39.75	41.68	40.26 i
G 9	CHIR-3	35.41	38.55	36.74	38.85	37.39 i
G 10	CHIR-4	62.36	55.80	55.87	52.35	56.59 efg
G 11	CHIR-5	44.59	47.23	45.83	45.70	45.84 h
G 12	CHIR-6	40.92	42.58	41.42	42.50	41.86 hi
G 13	CHIR-8	35.67	37.04	36.70	38.84	37.06 i
G 14	CHIR-10	54.77	57.45	56.63	58.18	56.76 efg
G 15	CHIR-11	39.70	42.02	40.77	42.83	41.33 hi
G 16	1301	57.82	62.16	61.00	62.28	60.81 de
G 17	1304	57.24	61.76	59.49	64.15	60.66 de
G 18	3402	63.76	68.51	65.82	68.93	66.76 bc
G 19	3404	59.30	63.02	61.83	63.94	62.02 cde
G 20	3405	58.27	62.43	60.57	62.52	60.95 de
G 21	3406	69.13	73.80	70.46	72.49	71.47 b
G22	RP-Bio-226	47.80	52.99	51.41	53.73	51.48 g
G 23	Chandrahashini	58.54	60.72	60.21	60.56	60.01 de
G 24	IR-64	58.54	60.72	60.21	60.56	60.01 de
	Mean	53.05 d	55.98 bc	54.72 cd	56.18 a	54.98

$CD_{\text{at 5\% level}}$ for G* -4.862, F*-1.61, G x F- NS

and the lowest (53.05 q ha^{-1})in control (M0). Similar results were obtained by (Ram *et al.* (1995), Sharma *et al.* (1999), Khan *et al.* (2003) andChakeralhosseinet *al.* (2009). Interaction between rice genotypes and fertilizer application was found

Table 4: Effect of rice genotypes and $ZnSO_4$ application on total uptake Zn on rice genotypes

Symbol	Genotypes	Total uptake Zn (gm ha^{-1}) Control (M0)	$ZnSO_4$ 20 kg ha^{-1}Basal (M1)	$ZnSO_4$ 0.25% Foliar (M2)	$ZnSO_4$ 20 kg ha^{-1}Basal + 0.25% Foliar (M3)	Mean
G 1	CB-07-701-252	299.51 a	399.68 a	435.25 a	533.73 a	417.04 a
G 2	CK-143	207.12 d-i	249.01 fgh	330.81 d-h	357.32 cde	286.07 fghi
G 3	RHZ-1 CURE-1	232.80 c-g	284.81 def	377.85 bc	383.82 bcd	319.82 cd
G 4	RHZ-2 CURE-10	246.85bcd	297.77 de	336.41 d-g	373.83 bcd	313.71 cde
G 5	RHZ SM (1)-21	257.21 bc	296.12 de	341.25 c-f	351.03 def	311.40 cde
G 6	RHZ SM (2)-23	184.65 hij	207.36 ij	205.52 lm	232.05 i	207.40 nop
G 7	CHIR-1	226.06 c-h	285.54 def	329.60 d-h	343.36 def	296.14 efgh
G 8	CHIR-2	158.09 jk	190.37 j	193.76 m	228.91 i	192.78 p
G 9	CHIR-3	136.19 k	191.62 j	198.60 m	237.19 i	190.90 p
G 10	CHIR-4	195.42 f-j	216.50 hij	242.12 kl	257.89 hi	227.98 mn
G 11	CHIR-5	168.17 ijk	197.11 j	214.92 lm	235.61 i	203.95 op
G 12	CHIR-6	137.08 k	187.86 j	193.49 m	221.46 i	184.97 p
G 13	CHIR-8	191.84 g-j	245.06 f-i	290.48 hij	315.45 fg	260.71 jkl
G 14	CHIR-10	201.49 e-i	238.61 ghi	260.34 jk	286.36 gh	246.70 klm
G 15	CHIR-11	179.51 ij	213.94 hij	223.65 klm	253.41 hi	217.63 no
G 16	1301	225.53 c-h	299.37 de	321.42 e-i	365.04 cd	302.84 defg
G 17	1304	236.78 c-f	268.97 efg	306.96 e-i	362.82 cd	293.88 efgh
G 18	3402	252.43 bc	301.35 de	365.30 bcd	393.56 bc	328.16 c
G 19	3404	266.86 abc	315.15 cd	311.23 e-i	344.63 def	309.47 cdef
G 20	3405	230.05 c-g	268.02 efg	301.23 f-i	320.49 efg	279.95 ghij
G 21	3406	286.36 ab	357.29 b	390.36 b	410.20 b	361.05 b
G22	RP-Bio-226	198.25 f-j	270.57 efg	280.09 ij	315.18 fg	266.03 ijk
G 23	Chandrahashini	241.09 cde	343.33 bc	348.11 cde	366.32 cd	324.71 cd
G 24	IR-64	232.57 c-g	268.77 efg	296.20 g-j	319.29 efg	279.21 hij
	Mean	216.33	266.42	295.62	325.37	275.94

$CD_{at\ 5\%\ level}$ for G* – 23.63, F* – 8.74, G x F* – 39.39

Table 5: Effect of rice genotypes and $ZnSO_4$application on Grain Zn content on rice genotypes

Symbol	Genotypes	Grain Zn content (ppm) Control (M0)	$ZnSO_4$20 kg ha^{-1}Basal (M1)	$ZnSO_4$ 0.25% Foliar (M2)	$ZnSO_4$20 kg ha^{-1} Basal + 0.25% Foliar (M3)	Mean
G 1	CB-07-701-252	21.60 cde	26.13 b	27.10 bcd	27.20 b-e	25.51b
G 2	CK-143	19.73 efg	21.40 e-h	27.50 bc	29.63 b	24.57 b
G 3	RHZ-1 CURE-1	20.03 efg	21.57 e-h	29.83 b	28.23 bc	24.92 b
G 4	RHZ-2 CURE-10	21.93 b-e	24.23 b-e	25.57 cde	26.73 b-e	24.62 c
G 5	RHZ SM (1)-21	22.37 b-e	23.47 b-e	23.47 e-h	24.17 efg	23.37 d
G 6	RHZ SM (2)-23	24.33 bc	24.93 bc	25.23 c-f	25.87 c-f	25.09 b
G 7	CHIR-1	23.33 bcd	26.00 b	27.20 bcd	27.00 b-e	25.88 b
G 8	CHIR-2	20.97 def	24.73 bcd	23.43 e-h	25.63 c-f	23.69 cd
G 9	CHIR-3	20.87 def	25.80 b	24.27 d-g	25.43 c-g	24.09 cd
G 10	CHIR-4	16.50 h	19.40 gh	19.17 i	20.80 h	18.97 g
G 11	CHIR-5	19.73 efg	20.17 fgh	20.57 hi	23.17 fgh	20.91 f
G 12	CHIR-6	17.23 gh	23.40 b-e	22.93 e-h	24.60 d-g	22.04 ef
G 13	CHIR-8	28.37 a	33.20 a	37.27 a	38.47 a	34.33 a
G 14	CHIR-10	20.17 efg	21.40 e-h	21.73 ghi	22.33 gh	21.41 f
G 15	CHIR-11	24.87 b	26.07 b	26.60 cd	27.50 bcd	26.26 b
G 16	1301	19.77 efg	23.57 b-e	22.77 e-h	23.03 fgh	22.28 e
G 17	1304	21.13 def	21.67 d-h	23.30 e-h	23.30 fgh	22.35 e
G 18	3402	19.67 efg	22.57 c-f	24.77 c-g	24.67 d-g	22.92 de
G 19	3404	23.27 bcd	23.63 b-e	23.10 e-h	23.43 fgh	23.36 d
G 20	3405	18.33 fgh	19.17 h	22.47 e-h	22.73 fgh	20.68 f
G 21	3406	21.50 cde	23.87 b-e	23.37 e-h	23.57 fgh	23.08 d
G22	RP-Bio-226	21.60 cde	26.13 b	27.10 bcd	27.20 b-e	25.51 b
G 23	Chandrahashini	20.30 d-g	26.40 b	25.60 cde	27.07 b-e	24.84 bc
G 24	IR-64	21.60 cde	22.40 c-g	22.50 fgh	22.68gh	22.20 e
	Mean	21.22 c	23.80 bc	24.86 ab	25.59 a	23.87

$CD_{at\ 5\%\ level}$ for G* – 1.21, F* – 0.88, G x F* – 3.38

to be non-significant result.

Total Zn uptake

The effects of rice genotypes and $ZnSO_4$ application on total Zn uptake were found significant (Table 4and fig 4. a). Total

Table 6: Effected of rice genotypes and $ZnSO_4$ application on total Zn uptake, grain yield and straw yield andZn content in grain.

Genotypes	Grain yield (q ha^{-1})	Straw yield(q ha^{-1})	Total Zn uptake (gm ha^{-1})	Zn content in grain (ppm)
G 1	65.36 a	76.93 a	417.04 a	25.51b
G 2	50.14 ef	56.44 efg	286.07 fghi	24.57 b
G 3	53.43 de	59.05 def	319.82 cd	24.92 b
G 4	55.36 cd	57.86 ef	313.71 cde	24.62 c
G 5	56.80 cd	63.62 cd	311.40 cde	23.37 d
G 6	34.98 h	40.17 i	207.40 nop	25.09 b
G 7	45.45 g	54.24 fg	296.14 efgh	25.88 b
G 8	33.00 hi	40.26 i	192.78 p	23.69 cd
G 9	30.64 i	37.39 i	190.90 p	24.09 cd
G 10	44.14 gs	56.59 efg	227.98 mn	18.97 g
G 11	36.67 h	45.84 h	203.95 op	20.91 f
G 12	33.48 hi	41.86 hi	184.97 p	22.04 ef
G 13	33.26 hi	37.06 i	260.71 jkl	34.33 a
G 14	45.40 g	56.76 efg	246.70 klm	21.41 f
G 15	36.00 h	41.33 hi	217.63 no	26.26 b
G 16	55.79 cd	60.81 de	302.84 defg	22.28 e
G 17	57.48 cd	60.66 de	293.88 efgh	22.35 e
G 18	61.74 ab	66.76 bc	328.16 c	22.92 de
G 19	58.85 bc	62.02 cde	309.47 cdef	23.36 d
G 20	57.50 cd	60.95 de	279.95 ghij	20.68 f
G 21	63.56 a	71.47 b	361.05 b	23.08 d
G22	47.23 fg	51.48 g	266.03 ijk	25.51 b
G 23	57.11 cd	60.01 de	324.71 cd	24.84 bc
G 24	53.53 de	60.01 de	279.21 hij	22.20 e
CD (P= 0.05)	3.85	4.862	23.63	1.21
Zn application				
M 0	46.54 d	53.05 d	216.33 d	21.22 c
M 1	49.30 ab	55.98 bc	266.42 c	23.80 bc
M 2	48.75 bc	54.72 cd	295.62 bc	24.86 ab
M 3	49.90 a	56.18 a	325.37 a	25.59 a
CD (p= 0.05)	0.78	1.61	8.74	0.88
Interaction (GxF)	NS	NS	39.39	3.38

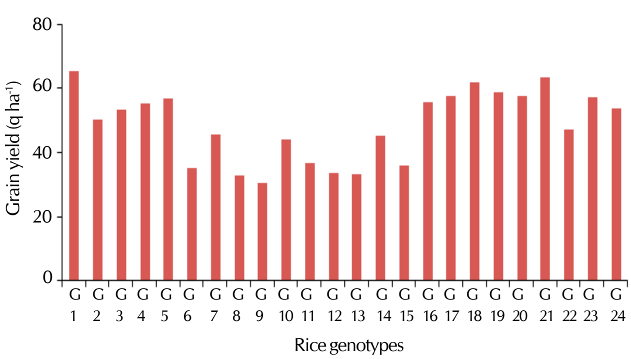

Figure 2.a Effect of rice genotypes on grain yield of rice genotypes

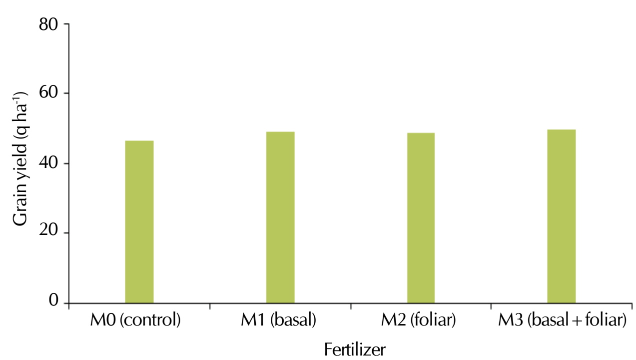

Figure 2.b Effect of $ZnSO_4$ application on grain yield of rice genotypes

Zn uptake under (G1) CB-07-701-252 (417.04 gm ha^{-1})and (G21) 3406(361.05 gm ha^{-1})was significantly higher than other rice genotype and these two genotypes were also significantly differed. Third highest Zn uptake was found under (G18) 3402 (328.16 gm ha^{-1}) followed by (G23) Chandrahashini(324.71 gm ha^{-1}), (G3) RHZ-1 CURE-1(319.82 gm ha^{-1}), (G4) RHZ-2 CURE-10(313.71 gm ha^{-1}), (G5) RHZ SM (1)-21(205.40 gm ha^{-1}) and (G19) 3404(309.47 gm ha^{-1}), which were statistically at par. Lowest Zn uptake value was found in (G12) CHIR-6(184.97 gm ha^{-1}). Other genotypes were performed either sequentially decreased significantly or at par. Since interaction effect was also found to be significant however, the trends of the order of genotypes performance at each level of ZnSO4 application were recorded almost in the same manner as discussed earlier with main effects. The $ZnSO_4$ application also increased total Zn uptake significantly as shown in the (Table 4and fig 4. b). All methods of $ZnSO_4$ application were significantly superior to over control. Total Zn uptake (325.37 gm ha^{-1}) recorded under treatment basal dose + foliar application of $ZnSO_4$ (M3) was significantly higher than Zn uptake (295.62 gm ha^{-1})in foliar application of $ZnSO_4$ (M2), which was also significantly higher than (266.42 gm ha^{-1}) in basal application of $ZnSO_4$ (M1) and the lowest 216.33 gm ha^{-1} in control (M0). *Yadiet. al.* (2012), Jadhazet

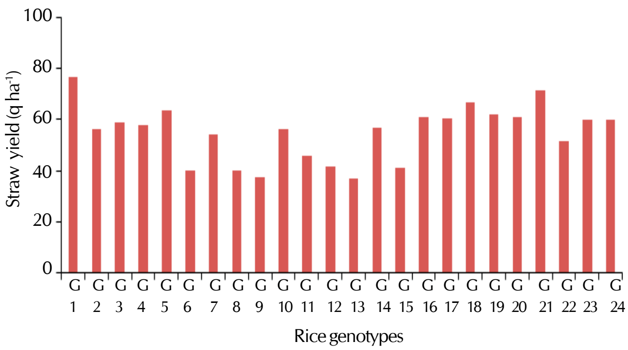

Figure 3a: Effect of rice genotypes on straw yield of rice genotypes

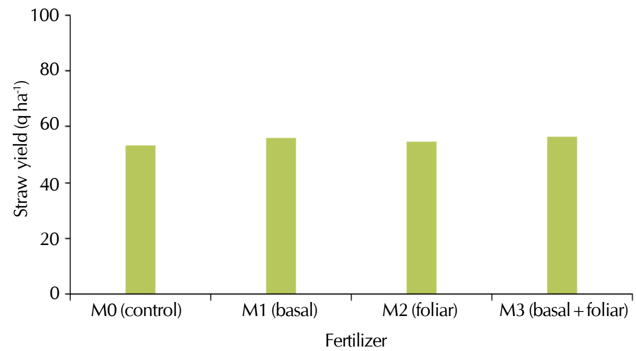

Figure 3b: Effect of $ZnSO_4$ application on straw yield of rice genotypes

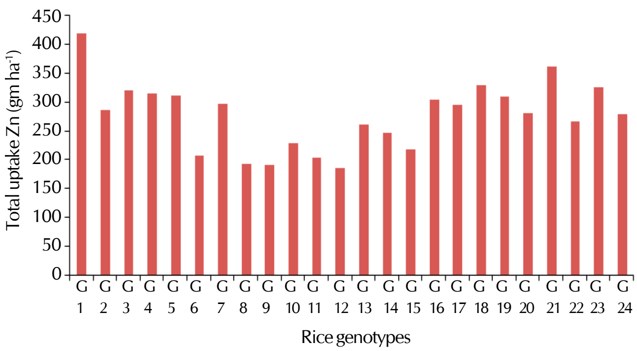

Figure 4a: Effect of rice genotypes ontotal uptake Zn on rice genotypes

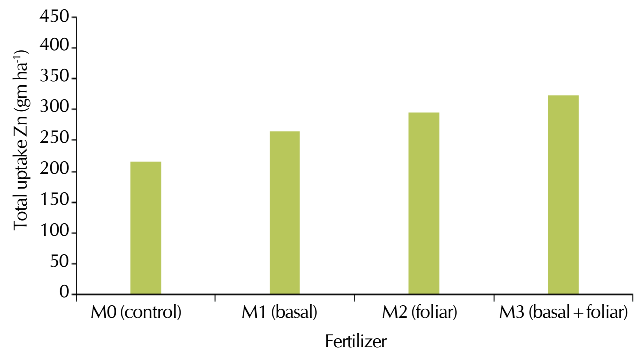

Figure 4b: Effect of $ZnSO_4$ application ontotal uptake Zn on rice genotypes

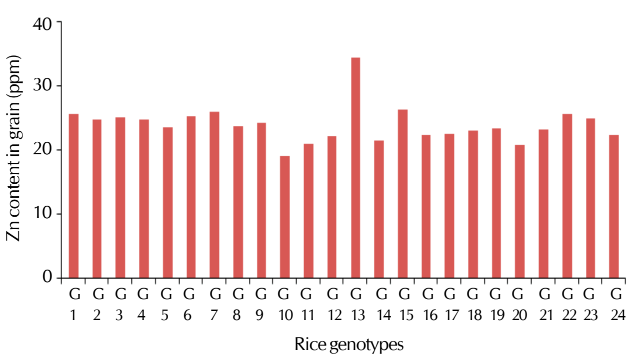

Figure 5: a Effect of rice genotypes on grain Zn content on rice genotypes

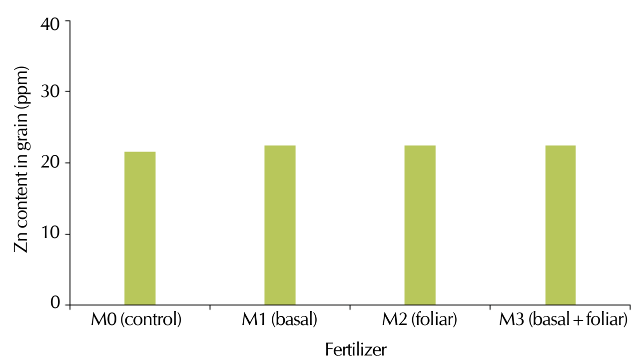

Figure 5: b Effect of $ZnSO_4$ application on grain Zn content on rice genotype

al.(1983) Mumba *et al.* (2013) and Chaabet *al.* (2011) were reported similar finding.

Grain Zn content

The effects of rice genotypes and $ZnSO_4$ application on Zn content in grain were found significant (Table 5 and fig 5 a). Total Zn content in grain under (G13) CHIR-8 (34.33 ppm) was significantly higher than other rice genotype. Second highest Zn content in grain was found under (G15) CHIR-11(26.26 ppm) followed by (G7) CHIR-1(25.88 ppm), (G1) CB-07-701-252(25.51 ppm), (G22) RP-Bio-226(25.51 ppm), (G6)RHZ SM (2)-23(25.09 ppm), (G3) RHZ-1 CURE-1and(24.92ppm) and(G23)Chandrahashini(24.84 ppm), which were statistically at par. Lowest Zn content value was found in (G10) CHIR-4(18.97 ppm). Other genotypes were performed either sequentially decreased significantly or at par. Since interaction effect was also found to be significant however, genotypes (G13) CHIR-8(34.33 ppm) was significantly higher in all $ZnSO_4$ application method including control. The genotypes (G19) 3404(23.08 ppm) performance at each level of $ZnSO_4$ application including control was recorded almost in the same value of Zn content. The $ZnSO_4$ application also increased Zn content significantly as shown in the (Table 5 and fig 5 b). Zn content recorded under treatment basal dose + foliar application of Zn (M3) (25.59 ppm) and Zn content in foliar application of $ZnSO_4$ (M2) (24.86 ppm) were significantly superior over to control (No Zn applied). Zn content in foliar application of $ZnSO_4$ (M2) was statistically at par with Zn content found in basal application of $ZnSO_4$ (M1) (23.8 ppm), which was significantly higher than control (M0) (21.22 ppm). *Akay et. al.* (2011), Khan *et al.* (2012) and Guo*et al.*(2014) were reported similar finding.

REFERENCES

Akay, A. 2011. Effect of zinc fertilizer applications on yield and element contents of some registered chickpeas varieties. *African J. Biotechnology*. **10(60):** 12890-12896.

Black, C. A. 1965. Methods of soil analysis. Amer. Soc. Agro. Inc. Publ. Madison, Wisconsin, USA. Brussels, Belgium and Paris, France.

Chaab, A., Avaghebigh, R. S and Motesharezadeh, B. 2011. Differences in the zinc efficiency among and within maize cultivars in a calcareous soil. *Asian J. Agricultural Sciences* **3(1):** 26-31.

Chakeralhossein, M. R., Mohtashami, R. and Owliaie, H. R. 2009. Effects of rate, source, and method of zinc fertilizer application on quantitative and qualitative characteristics of rice (choram 1). [Persian]. *J. Research in Agricultural Science*. **5(1):** 33-43.

Fageria, N. K., Slaton, N. A. and Baligar, V. C. 2003. Nutrient management for improving lowland rice productivity and sustainability. *Adv. Agron*. **80:** 63-152.

Guo, J. X., Liao, W. Q., Sun, Y. M., Guo, J. J., Kong ,Y. L., Shi, Y. H., Xu, A. Q., Zhang, J. C. and Guo ,S. W. (2014). Effects of Zn fertilizer application methods on yield and contents of N and Zn in grains of rice.[Chinese].*Chinese J. Rice Science*. **28(2):**185-192.

Jadhaz, B. B. Pati, V. H. and Kadrekar, S. B. 1983. Effect of soil and foliar application of zinc on rice. *J. Maharashtra Agricultural University*. **8(3):** 227-28.

Keram, K. S., Sharma, B. L., Sharma, G. D. and Thakur, R. K. 2014. Impact of zinc application on its translocation into plant parts of wheat in a vertisol. *The Bioscan*. **9(2):** 491-495.

Khan P., Memon M. Y., Muhammad I., Depar N., Muhammad A., Memon M. S., and Shah J. A. 2012. Determining the zinc requirements of rice genotype. *Sarhad J. Agric*. **28(1).**

Khan, M. U., Qasim, M., Subhan, M., Jamil, M. and Ahmad, R. D. 2003.Response of rice to different methods of zinc application in calcareous soil.*Pakistan-J.-Applied-Sciences*. **3(7):** 524-529.

Lindsay, W. L. and Norvell, W. A. 1978. Development of a DTPA soil test for zinc, iron, manganese and copper. *Soil Sci. Soc Amer. J.* **42:** 421-428.

Muamba, J. K. and Ambara G. S. 2013. Effect of different levels of zinc on growth and uptake ability in rice zinc contrast lines (*Oryza Sativa* L.*) Asian J. Plant Science and Research*. **3(3):**112-116.

Muhr, G. R., Datta, N. P., Subramoney, H., Leley, V. K. and Donahue, R. L. (1965).Soil testing in India.*United States Agency for International development mission on India,* New Delhi.

Olsen, S. R., Cole, C. V., Watnable, F. S. and Dean, L. A. 1954. Estimation of available phosphorous in soils by extraction with sodium carbonate. *U.S.D.A., Cir.* No. **933**: 1-10.

Piper, C. S. 1966. Soil and Plant Analysis. *Hans Publisher, Bombay*. pp. 85-102.

Ram, S., Chauhan R. P. S. and Singh, B. B. 1995. Response of rice (Oryzasativa L.) to zinc application in sodic soil of Uttar Pradesh. *Indian J. Agricultural Scieces*. **65(7)**: 525-527.

Saviour, M. N. and Stalin, P. 2014. Release behavior of zinc fractions for varying levels of addedzn in sandy loam soils. *The Bioscan*. **8(3&4):** 235-240.

Sharma, S. K., Bhunia S. R. and Pathan A. R. K. 1999. Effect of zinc fertilizer on transplanted rice in Ghagger Flood pb 3344lains of north west Rajsthan. *Annuls of Agrcultural Research*. **20:** 245-247.

Slaton, N. A., Normon, R. J. and Wilson, Jr. C. E. 2005. Effect of Zn source and application time on Zn uptake and grain yield of flood-irrigated rice. *Agron. J.* **92:** 272-278.

Subbiah, B. V. and Asija, G. L. 1956. A rapid procedure for estimation of available nitrogen in soils.*Curr. Sci*. **25:** 259-260.

Yadi, R. and Dastan, S. 2012. Role of zinc fertilizer on grain yield and some qualities parameters in Iranian rice genotypes. *Annals of Biological Research*. **3(9):** 4519-4527.