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Nitrogen use efficiency of high zinc rice genotypes in vertisols under varying levels of fertility

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Abstract
Nitrogen is one of the most important mineral nutrients required for intensive crop production and the enhancement of nutrient use efficiency (NUE) is an important economic and global goal. Rice crop is very important not only because it is the most staple food in the world but also because of its lowest Nutrient Use Efficiency (NUE) among the cereals. A field experiment was conducted at research cum instructional farm, IGKV, Raipur. The overall objective of present study was to identify the Nitrogen Use Efficiency of high zinc containing rice genotypes in *Vertisols* of Chhattisgarh during kharif season of 2013. The experiment was carried out in split-plot design with three replications having four fertility levels in main plots and twelve varieties in sub plots. Nitrogen use efficiencies of different rice genotype ranged from 22.30 to 49.40 per cent with overall average value of 38.70 per cent. The highest NUE was recorded by R-1033-968-1(ABL) that yielded maximum grain produce. Low fertility level exhibited higher efficiency than that of medium and high fertility level.

Keywords: Nitrogen use efficiency, NPK, *Oryza sativa* l., vertisols, zinc rice

Introduction
Rice (*Oryza sativa* L.) Is a C3 plant belong to the family Poaceae. Rice (*Oryza sativa* L.) is one of the most important staple food crops for approximately half of the global population, total rice crop area was 42.56 million hectares and production was 115.60 million tonnes (Anonymous, 2018-19a) [3]. Nitrogen is one of the major plant nutrient required for plant growth for maximizing the yield and encourages vegetative growth of plants. Nutrient use efficiency (NUE) is a critically important concept in the evaluation of crop production systems. Increasing nutrient levels of N increased plant height, sterility, normal kernels and 1000 grain weight (Amin *et al*., 2004) [2]. Application of higher levels of nitrogen produced higher plant height, higher effective tiller per hill, panicle length, filled grains per panicle and 1000 grain weight (Ahmed *et al*., 2005) [1]. The objective of experiment was to investigate response of high zinc containing rice genotype under different nitrogen fertilizers levels and to quantify high zinc rice nitrogen use efficiency.

Materials and Methods
Twelves rice genotypes of *Oryza sativa* L. used to study NUE, the experiment was conducted at Indira Gandhi Agricultural University, during *kharif* 2013 Raipur, Chhattisgarh. The soil of the experimental field comes under the order of *Vertisols* and identified as Arang II series. It is clayey in texture, dark brown to black in color, neutral to alkaline in reaction due to presence of lime concretion in lower horizon. The experiment was carried out in split-plot design with three replications having four fertility levels (00, 50, 80 and 110 kg N ha^{-1}) in main plots and twelve varieties R-RF-31 (ABL) (G-1), R-1033-968-1 (ABL) (G-2), SWARNA× MOROBRAKEN-23 (G-3), SWARNA×MOROBRAKEN-21 (G-4), Bas 1×IR681444 (G-5), IR 681444×HMT (G-6), IR 94297 (G-7), IR 94033 (G-8), IR 681444-2B-2-2-3-1-127 (G-9), IR 83286-22-1-2-7-1(G-10), Improve Chitimutalya (G-11) and Chandrahasini (G-12), in sub plots. $1/3^{rd}$ dose of N as basal and remaining $2/3^{rd}$ N was applied in two equal splits at early tillering and PI stage. Data was recorded at maturity *viz*., number of effective tillers per meter square, grain test weight and straw yield quintals per ha. Nitrogen, use efficiency was calculated by using the following formula.

$$\text{NUE (\%)} = \frac{\text{Uptake from treated plot (kg ha}^{-1}) - \text{Uptake from control plot (kg ha}^{-1})}{\text{Total nutrient applied}} \times 100$$

The data was analyzed using OPSTAT

Table 1: Some chemical properties of the soil used for the study.

Parameter	Rating/value	Parameter	Rating/value
EC (dSm^{-1})	0.18	Available Zn (ppm)	1.89
Soil pH	8.03	Available Fe (ppm)	6.56
Organic Matter %	0.58	Available Mn (ppm)	6.33
CEC (c mol (p+) Kg^{-1})	36.32	Available Cu (ppm)	2.51
Available nitrogen (Kg ha^{-1})	238.3	Texture	Clay
Available Phosphorous (Kg ha^{-1})	14.2		
Available Potash (Kg ha^{-1})	459.2		

Result and Discussion

Yield attributes

The Number of effective tillers (Table 2), test weight (Table 3), grain yield (Table 4) and straw yield (Table 5) were significantly varied under different genotypes and fertility levels. The average effective tillers were significantly higher with R-1033-968-1(ABL) followed by R-RF-31(ABL), IR 94297. The mean effective tillers of 156 /m^2 were recorded by Improved Chitimutalya, which was significantly lower than all other genotypes. The average test weight was significantly higher in R-RF-31(ABL) followed by R-1033-968-1(ABL), IR 94297. The test weight of 18.13 gram was recorded by Improve Chitimutalya, which was significantly lower than all other genotypes except IR 681444×HMT. The average grain yield was significantly higher in R-1033-968-1(ABL) followed by R-RF-31(ABL), followed by IR 94297. The grain yield of 30.09 q ha^{-1} was recorded by Improve Chitimutalya, which was significantly lower than all other genotypes, except (SWARNA×MOROBRAKEN-23). The average straw yield was accumulated significantly higher in R-RF-31(ABL) followed by R-1033-968-1(ABL), IR 94033. The straw yield of 43.33 q ha^{-1} was recorded by BAS 1×IR681444 which was significantly lower than all other genotypes, except SWARNA×MOROBRAKEN-21, IR 681444-2B-2-2-3-1-127 and Improve Chitimutalya. Fertility levels were also significantly influenced the effective tillers, test weight, grain and straw yield of different rice genotypes as shown in the Table 2, Table 3, Table 4 and Table 5 respectively. Significantly highest effective tillers, test weight, grain and straw yield of 230 m^2, 25.26 gram, 53.89 q ha^{-1} and 61.87 q ha^{-1} were recorded under high soil fertility level (F3) followed by medium soil fertility level (F2) with 222 m^2, 24.19 gram. While in case of grain and straw yields were at par with medium fertility level (51.11 q ha^{-1}) and (57.91 q ha^{-1}) (F2). Control soil fertility level (F0) recorded significantly lowest effective tillers, test weight, grain and straw yield of rice respectively, 165 m^2, 22.32 gram, 31.38 q ha^{-1} and 34.54 q ha^{-1}. Different rice genotypes have responded to the graded dose of fertilizer application created from low to high fertility level. Similar findings were also reported by Tabar *et al.* (2012) [8]. Test weight of rice genotypes increased with increasing levels of fertilizer application was also reported by Tabar *et al.* (2012) [8] and Ahmad *et al.* (2005) [1]. Similar results for grain yield also reported by Uddin *et al.* (2013) [9], Fageria *et al.* (2011) [5], Metwally *et al.* (2011) [6] and Awan *et al.* (2011) [4], who reported increase in paddy yield of rice as the rates of N increased. Genotypes had significant effect on the growth and yield attributes and among them, R-1033-968-1(ABL) recorded the higher growth and yield attributes i.e. total tiller, effective tiller and their combined effect resulted the maximum rice yield. Superiority of R-1033-968-1(ABL) over other varieties may also seems to be on account of higher root and shoot growth, leaf area index and efficient translocation of metabolites towards grain formation. The findings of increased paddy straw yields by the different fertility levels are also in consonance with the results of Fageria *et al.* (2011) [5], who reported increase in paddy yield of rice as the rates of N increased.

Table 2: Effective tillers m^2

S.N.	Rice genotype	Fertility levels				Mean
		00	50	80	110	
1	R-RF-31(ABL)	184	240	245	265	236
2	R-1033-968-1(ABL)	224	254	263	275	251
3	SWARNA×MOROBRAKEN-23	140	175	210	217	185
4	SWARNA×MOROBRAKEN-21	142	187	208	214	188
5	Bas 1×IR681444	182	226	235	240	221
6	IR 681444×HMT	163	182	200	210	189
7	IR 94297	170	218	245	266	225
8	IR 94033	154	182	210	208	188
9	IR 681444-2B-2-2-3-1-120	161	196	224	232	203
10	IR 83286-22-1-2-7-1	170	184	219	233	201
11	Improved Chitimutalya	142	149	163	170	156
12	Chandrahasini	152	189	240	233	204
	MEAN	165^D	198^C	222^B	230^A	204

CD $_{at}$ 5% for, F**= 5.02, G**=6.66

Table 3: Test weight (1000 grain weight (g).

S.N.	Rice genotype	Fertility levels				Mean
		00	50	80	110	
1	R-RF-31(ABL)	26.24	27.61	28.43	29.40	27.92
2	R-1033-968-1(ABL)	26.53	27.00	27.57	28.97	27.51
3	SWARNA×MOROBRAKEN-23	21.51	23.65	23.60	24.50	23.31
4	SWARNA×MOROBRAKEN-21	22.94	23.12	23.46	24.08	23.40
5	Bas 1×IR681444	22.08	24.06	25.32	25.87	24.33
6	IR 681444×HMT	17.98	18.98	19.67	19.76	19.09
7	IR 94297	23.57	24.59	26.35	27.83	25.58
8	IR 94033	22.71	24.28	24.08	25.53	24.15
9	IR 681444-2B-2-2-3-1-120	22.16	23.83	24.93	25.40	24.08
10	IR 83286-22-1-2-7-1	22.87	23.05	24.38	26.18	24.11
11	Improve Chitimutalya	16.39	17.48	18.84	19.82	18.13
12	Chandrahasini	22.91	22.61	23.63	25.71	23.71
	MEAN	22.32^{D}	23.35^{C}	24.19^{B}	25.26^{A}	23.78

CD $_{at}$ 5% for, F**= 0.55, G**=0.93

Table 4: Grain yield q ha[1]

S.N.	Rice genotype	Fertility levels				Mean
		00	50	80	110	
1.	R-RF-31(ABL)	33.87	49.46	62.80	64.04	52.54
2.	R-1033-968-1(ABL)	38.49	56.71	64.58	68.36	57.03
3.	SWARNA×MOROBRAKEN-23	21.82	30.09	36.05	38.67	31.66
4.	SWARNA×MOROBRAKEN-21	29.55	42.22	48.31	50.67	42.69
5.	Bas 1×IR681444	32.98	45.60	57.07	57.60	48.3
6.	IR 681444×HMT	32.22	43.56	50.13	50.58	44.12
7.	IR 94297	36.18	50.22	56.93	58.36	50.42
8.	IR 94033	27.11	41.87	45.95	45.29	40.05
9.	IR 681444-2B-2-2-3-1-127	29.29	45.95	55.91	59.87	47.75
10.	IR 83286-22-1-2-7-1	32.80	43.78	50.22	61.65	47.11
11.	Improve Chitimutalya	23.78	30.14	32.40	34.04	30.09
12.	Chandrahasini	38.49	43.02	53.02	57.60	48.03
	MEAN	31.38^{D}	43.55^{C}	51.11^{AB}	53.89^{A}	44.98

CD $_{at}$ 5% for, F**= 4.86, G**=3.42

Table 5: Straw yield q ha[1]

S.N.	Rice genotype	Fertility levels				Mean
		00	50	80	110	
1	R-RF-31(ABL)	43.52	65.75	84.79	84.93	69.75
2	R-1033-968-1(ABL)	46.50	68.37	77.71	81.05	68.41
3	SWARNA×MOROBRAKEN-23	35.46	48.93	55.72	63.68	50.95
4	SWARNA×MOROBRAKEN-21	29.76	42.48	49.65	52.40	43.57
5	Bas 1×IR681444	28.85	40.68	51.62	52.17	43.33
6	IR 681444×HMT	32.53	47.96	55.92	56.76	48.29
7	IR 94297	34.14	47.81	55.54	59.88	49.34
8	IR 94033	34.24	55.57	57.07	60.78	51.92
9	IR 681444-2B-2-2-3-1-127	26.40	42.47	50.46	57.67	44.25
10	IR 83286-22-1-2-7-1	31.51	44.55	51.24	62.71	47.50
11	Improve Chitimutalya	35.38	46.19	49.58	52.72	45.97
12	Chandrahasini	36.24	44.66	55.65	57.73	48.57
	MEAN	34.54^{D}	49.62^{C}	57.91^{AB}	61.87^{A}	50.99

CD $_{at}$ 5% for, F**= 4.92, G**=3.56

Table 6: Nitrogen use efficiency

S.N.	Rice genotype	Symbol	Fertility levels			
			Low	Medium	High	Mean
1	R-RF-31(ABL)	G-1	0.514	0.509	0.458	0.494^{a}
2	R-1033-968-1(ABL)	G-2	0.533	0.509	0.444	0.495^{a}
3	SWARNA×MOROBRAKEN-23	G-3	0.317	0.315	0.288	0.307^{e}
4	SWARNA×MOROBRAKEN-21	G-4	0.403	0.393	0.337	0.378^{bcd}
5	Bas 1×IR681444	G-5	0.375	0.439	0.365	0.393^{bc}
6	IR 681444×HMT	G-6	0.371	0.342	0.336	0.350^{cde}
7	IR 94297	G-7	0.460	0.456	0.388	0.435^{ab}
8	IR 94033	G-8	0.425	0.379	0.344	0.383^{bcd}
9	IR 681444-2B-2-2-3-1-127	G-9	0.508	0.477	0.442	0.476^{a}
10	IR 83286-22-1-2-7-1	G-10	0.329	0.343	0.310	0.327^{de}

11	Improve Chitimutalya	G-11	0.270	0.224	0.176	0.223^{f}
12	Chandrahasini	G-12	0.354	0.359	0.312	0.342^{cde}
	MEAN		0.409^{A}	0.398^{B}	0.353^{C}	0.383

CD $_{at\ 5\%}$ for, F**= 0.080, G**=0.079, Interaction (FG**)-NS

Nitrogen use efficiency as influenced by rice genotypes and fertility levels

The data presented that nitrogen use efficiencies of different rice genotype ranged from 22.30 to 49.40 per cent with overall average value of 38.70 per cent. The highest average NUE was recorded by R-1033-968-1(ABL) (G2) followed by R-RF-31(ABL), followed by IR 681444-2B-2-2-3-1-127, followed by IR 94297 and the lowest NUE was recorded by Improve Chitimutalya. Low fertility level exhibited higher nitrogen use efficiency (0.409 per cent) than that of medium (0.398 per cent) and high fertility level (0.353 per cent). Under low fertility level the genotype R-1033-968-1(ABL) recorded higher nitrogen use efficiency and the lowest was recorded by Improve Chitimutalya. Similar results on nitrogen use efficiency as influence by N, P and K levels were also reported by Zhang *et al*. (2009) [10] and Swain *et al*. (2006) [7].

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