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EFFECT OF DIFFERENT FERTILITY LEVELS AND NUTRIENT UPTAKE BY DROUGHT TOLERANT RICE GENOTYPES UNDER RAINFED CONDITION

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ABSTRACT

An ongoing field experiment was conducted to study the effect of different fertility levels on N, P, K and micro nutrient uptake by drought tolerant rice genotypes under rain fed condition at IGKV, Raipur.The Soil of experimental field's soil exhibited neutral reaction (pH 7.34), EC 0.26 (dSm^{-1}), medium status of organic C (0.58%), low in available N (273 kg ha^{-1}), medium in P (14.78 kg ha^{-1}), high in K status (616 kg ha^{-1}) and sufficient level in micronutrients (Fe, Mn, Cu, & Zn).Result showed that the overall average nutrients use efficiencies for N, P and K were recorded as 35.69, 18.41 and 112.75 per cent, respectively. Rice genotype R-RF-65 registered the nutrients use efficiencies for N, P and K ranged as 43.55-35.65, 23.65-20.15 and 165.60-92.50, respectively. Nutrient use efficiencies were observed higher at low fertility level and vice versa. Potassium use efficiency showed very high values which was due to less crop response to the applied K fertilizer. Most of the genotypes tested for their nutrient use efficiencies performed better than local check. The crop season was favorable and no water stress occurred during entire period which favored the genotypes to perform their potential level.

INTRODUCTION

Rice stands first among all food grain crops of the world and is the staple food of more than half of world's population. In India also rice is the major crop in terms of area, production and consumption. Rice is growing in diversified environments even with low inputs. It occupies the enviable prime place among the food crops cultivated around the world and is grown in 147 MH with a production of 525 MT. About 90 per cent of rice grown in the world is produced and consumed in Asian countries. India has the largest area among rice growing countries and enjoys the second rank in production. India produces 73.8 m. tones of rice from an area of 43.0 m. ha with the productivity of 2915 kg ha-1 (Anonymous, 2006).This level is considerably below expectations earlier in the year, largely reflecting the impact of severe droughts in Europe and Asia. Water and nutrition are two of the major components of environmental variations and together provide limitations to successful crop production. Mineral nutrients are essential for plant growth and development through their fundamental roles in plant metabolism, while drought is prominent among the most important ecological factors that impact crop growth and productivity (Bagci *et al.,* 2007).

Selection and evaluation of drought tolerant rice genotypes for rain fed environments is usually conducted under high input (i.e. fertilizer) conditions. The fertilizer rates used by the breeders are far beyond the rates used by the farmers, because one of breeder's most important selection targets is a high yield potential. Although yield under high and low input use is often related, the correlation is not always very strong. Thus farmer's adoption for new variety becomes different as the performance of new variety under suboptimal nutrient conditions is least as important as their performance under optimal nutrient supplies. Long term cropping

system along with fertilizer application can influence important soil properties such as soil structure, density, pH, quantity and quality of organic matter and nutrient cycle within soil profile. (Divya *et al.,* 2012). Zinc, B and Mn are involved in a wide range of physiological process within the plant cell, and several of these are also associated with tolerance to drought stress. These nutrients also play a key role in the maintenance of photosynthetic activity (Karim *et al.,* 2012), pollen viability (Karim et al., 2012), the preservation of membrane integrity (Bettger and O'Dell, 1981, Cakmak and Marschner, 1988) and the continuance of enzyme activity (Cakmak and Marschner, 1988), as well as being an important factor in a plant×s defense against reactive oxygen species, which proliferate under various stress conditions, including drought stress (Cakmak, 2000). This suggests that adequate nutrition may be important for maintaining high plant productivity in drought stress under arid and semiarid environment. This information concerning the relationship between nutrition and drought stress available in the literature, and interaction does not appear to have been studied before in Asian LDCs cereals to any depth. Therefore, the present study is designed to investigate the possible roles of nutrients in improving drought tolerance of cereals crops to nutrient supply and drought stress during early vegetative growth, flowering to grain filling stages, and the effects of these two stresses on grain yield and quality are also examined.This review describes current knowledge of the independent effects of drought stress and NPK along with Zn, B and Mn nutrition on the growth, grain yield and grain quality of cereals crops. The physiological responses of plants to drought stress are discussed, together with genetic variation in these responses that exists between cereal genotypes. genotypes. Consideration is given to the various roles of these micro- and macro-nutrients as an essential plant nutrients, and some of the better-understood mechanisms responsible for genotypic variations in their efficiency are described. Particular attention is given to the effects of drought on grain yield. Finally, the possible role of NPK along with Zn, B and Mn in the provision of drought tolerance of plants under drought stress is discussed.Considering the future demand of rice and fertilizer use, relatively low use of nutrients, and growing cost of rice production, fertilizer subsidies and environmental sustainability, it is important to develop non-monitory input technologies to optimum nutrient use and improve its use efficiency. Identifying superior genotypes for different environments based on their differential responses and efficiency of utilizing of soil and applied nutrients is one such area which is less explored. There fore the present study has been undertaken to study the effect of different fertility levels on N, P, K, and micro nutrient uptake by drought tolerant rice genotypes under rainfed condition.

MATERIALS AND METHODS

The experiment was carried out during *Kharif* season, at the Instructional Farm, Indira Gandhi Krishi Vishwa vidhyalaya, Raipur . In order to investigate the effect of nitrogen, phosphorus and potassium fertilizer on growth and yield in rice cultivar, The experiment was laid out in split plot design having three fertility levels as main plots and twelve rice genotypes as sub plot and replicated rice (Table 1). The fertility levels were taken as no fertility level (00:00:00 kg ha^{-1} N:P:K), medium fertility level (45:30:20 $kgha^{-1}$N:P:K) and high fertility level (90:60:40 kg ha^{-1} N:P:K)and treatments under sub plots as rice genotypes . Twelve rice genotypes having drought tolerance character were selected and taken as treatments as per the details given below (Table 1).

Plant chemical analysis

Grain and straw samples were taken at harvest and allowed to sun dry for a week, then grinded and used for chemical analysis for different parameters as under, Then the nitrogen in digested material was distilled by automatic KEL plus system (Amma, 1989).

Phosphorus content was determined by vanadomolybdo-phosphoric acid yellow color complex method as described by Jackson (1973),Potassium content was determined by flame photometer as described by Chapman and Pratt (1961). Analyzed for Micronutrient (Fe, Mn Cu and Zn) content by atomic absorption spectroscopy (Lindsay and Norvell, 1978).

RESULTS AND DISCUSSION

Effect of rice genotypes and fertility levels on total nitrogen uptake (kg/ha)

Total nitrogen uptake was significantly affected by different rice genotypes and fertility levels (Table 3). Among the genotypes, highest N uptake was observed in IR-64 (V11) which was similar to those of two other genotypes i.e. R-RF-65(V5), IR-83383-B-141-2 (V8). Total N uptake in these three genotypes had significantly higher values as compared to those of others like IR-83383-B-B-129-4 (V4),R-RF-85 (Local entry) (V10), IR-83388-B-B-129-3(V2), IR-83377-B-B-93-3 (V6), IR-83388-B-B-108-3 (V1), MTU-1010 (V12), IBD-I-85 (Local entry) (V9) ,R-RF-69 (V7) and IR-82589-B-B-84-3 (V3).Total nitrogen uptake was significantly increased with application of increasing doses of fertilizers from low to high and application of high fertilizer accumulated significantly higher nitrogen (72.574 kg ha^{-1}) followed by medium (66.66 kg ha^{-1}) and low (46.33 kg ha^{-1}) in without fertilizer treatment.Interaction between rice genotypes and fertility levels found as significant. Similar result was also reported by Tayefe *et al*. (2011), Fageria *et al*. (2011) and Singh *et al*. (2010).

Effect of rice genotypes and fertility levels on total phosphorus uptake (kg/ha)

The effects of rice genotypes and fertility levels on total phosphorus uptake was found to be significant (Table 4), The

Table1: Treatment details

Main plot: Fertilizer treatment (three)	
F_0	Low (00:00:00 NPK $kgha^{-1}$)
F_1	Medium (45:30:20 NPK $kgha^{-1}$)
F_2	High (90:60:40 NPK $kgha^{-1}$)
Sub plot: Rice genotype (Twelve)	
V-1	IR-83388-B-B-108-3
V-2	IR-83388-B-B-129-3
V-3	IR-82589-B-B-84-3
V-4	IR-83383-B-B-129-4
V- 5	R-RF-65
V-6	IR-83377-B-B-93-3
V-7	R-RF-69
V-8	IR-83383-B-B-141-2
V-9	IBD-I (Local entry)
V-10	R-RF-85 (Local entry)
V-11	IR-64
V-12	MTU-1010

Table 2: Physico-chemical properties of experimental soil

Properties	Rating/value
pH (1:2.5)	7.34
EC (dSm^{-1})	0.26
CEC (c mol (p^+) kg^{-1})	38.21
Organic C (g kg^{-1})	0.58
Available N (kg ha^{-1})	273
Available P (kg ha^{-1})	14.78
Available K (kg ha^{-1})	616
Available Zn (ppm)	2.70
Available Fe (ppm)	5.97
Available Mn (ppm)	6.38
Available Cu (ppm)	1.37
Mechanical analysis	
Sand (%)	20
Silt (%)	36
Clay (%)	44
Textural class	Clay

Table 3: Effect of rice genotypes and fertility levels on total nitrogen uptake (kg/ha).

Rice genotype	Symbol	Fertility levels			Mean
		Control	Medium	High	
IR-83388-B-B-108-3	V1	44.428 $^{b-e}$	63.578 ^{c}	73.343 ^{bc}	60.449 $^{d-h}$
IR-83388-B-B-129-3	V2	47.143 ^{abc}	66.408 ^{bc}	76.468 ^{abc}	63.339 $^{b-f}$
IR-82589-B-B-84-3	V3	35.860 ^{e}	49.985 ^{d}	71.443 ^{bcd}	52.429 ^{jkl}
IR-83383-B-B-129-4	V4	53.343 ^{ab}	65.580 ^{bc}	74.893 ^{bc}	64.605 ^{bcd}
R-RF-65	V5	52.213 ^{abc}	64.738 ^{bc}	85.033 ^{a}	67.328 ^{ab}
IR-83377-B-B-93-3	V6	49.240 ^{abc}	65.610 ^{bc}	71.820 ^{bcd}	62.223 $^{c-g}$
R-RF-69	V7	44.020 $^{b-e}$	61.283 ^{c}	63.483 ^{de}	56.262 $^{h-k}$
IR-83383-B-141-2	V8	55.823 ^{a}	74.357 ^{ab}	68.500 ^{cde}	66.227 ^{abc}
IBD-I-85 (Local entry)	V9	43.033 ^{cde}	65.450 ^{bc}	60.348 ^{e}	56.277 ^{hij}
R-RF-85 (Local entry)	V10	36.635 ^{de}	78.658 ^{a}	75.885 ^{abc}	63.726 ^{bcde}
IR-64	V11	48.173 ^{abc}	81.010 ^{a}	80.838 ^{ab}	70.007 ^{a}
MTU-1010	V12	46.023 $^{a-d}$	63.233 ^{c}	68.833 ^{cde}	59.362 $^{e-i}$
F-MEAN		46.327	66.657	72.574	61.853

$CD_{at\ 5\%}$ for T** = 4.925 F** = 6.776 FxT** = 10.561; *Same superscript shows the non-significant difference at 5%.

Table 4: Effect of rice genotypes and fertility levels on total phosphorus uptake (kg/ha)

Rice genotype	Symbol	Fertility levels	Mean		
		Control	Medium	High	
IR-83388-B-B-108-3	V1	8.953 ^{bc}	12.090 ^{abc}	13.068 ^{bcd}	11.370 ^{ef}
IR-83388-B-B-129-3	V2	9.503 ^{abc}	12.108 ^{abc}	13.918 ^{abc}	11.843 ^{cde}
IR-82589-B-B-84-3	V3	7.172 ^{d}	10.065 ^{d}	11.643 ^{d}	9.627 ^{h}
IR-83383-B-B-129-4	V4	10.885 ^{a}	13.488 ^{ab}	14.983 ^{a}	13.118 ^{ab}
R-RF-65	V5	9.967 ^{abc}	13.070 ^{ab}	15.255 ^{a}	12.764 ^{abc}
IR-83377-B-B-93-3	V6	10.018 ^{abc}	12.758 ^{ab}	14.560 ^{ab}	12.445 ^{bcd}
R-RF-69	V7	10.260 ^{ab}	13.203 ^{ab}	13.980 ^{abc}	12.481 ^{bc}
IR-83383-B-141-2	V8	11.178 ^{a}	13.763 ^{a}	15.515 ^{a}	13.485 ^{a}
IBD-I-85 (Local entry)	V9	9.655 ^{abc}	11.778 ^{bc}	13.045 ^{bcd}	11.493 ^{def}
R-RF-85 (Local entry)	V10	8.432 ^{cd}	10.868 ^{cd}	11.498 ^{d}	10.266 ^{gh}
IR-64	V11	9.552 ^{abc}	12.523 ^{abc}	14.408 ^{abc}	12.161 $^{b-e}$
MTU-1010	V12	8.280 ^{cd}	10.850 ^{cd}	12.800 ^{cd}	10.643 ^{fg}
F-MEAN		9.488	12.213	13.723	11.808

Table 5: Effect of rice genotypes and fertility levels on total Potassium uptake (kg/ha).

Rice genotype	Symbol	Fertility levels			Mean
		Control	Medium	High	
IR-83388-B-B-108-3	V1	8.953 ^{bc}	12.090 ^{abc}	13.068 ^{bcd}	11.370 ^{ef}
IR-83388-B-B-129-3	V2	9.503 ^{abc}	12.108 ^{abc}	13.918 ^{abc}	11.843 ^{cde}
IR-82589-B-B-84-3	V3	7.172 ^{d}	10.065 ^{d}	11.643 ^{d}	9.627 ^{h}
IR-83383-B-B-129-4	V4	10.885 ^{a}	13.488 ^{ab}	14.983 ^{a}	13.118 ^{ab}
R-RF-65	V5	9.967 ^{abc}	13.070 ^{ab}	15.255 ^{a}	12.764 ^{abc}
IR-83377-B-B-93-3	V6	10.018 ^{abc}	12.758 ^{ab}	14.560 ^{ab}	12.445 ^{bcd}
R-RF-69	V7	10.260 ^{ab}	13.203 ^{ab}	13.980 ^{abc}	12.481 ^{bc}
IR-83383-B-141-2	V8	11.178 ^{a}	13.763 ^{a}	15.515 ^{a}	13.485 ^{a}
IBD-I-85 (Local entry)	V9	9.655 ^{abc}	11.778 ^{bc}	13.045 ^{bcd}	11.493 ^{def}
R-RF-85 (Local entry)	V10	8.432 ^{cd}	10.868 ^{cd}	11.498 ^{d}	10.266 ^{gh}
IR-64	V11	9.552 ^{abc}	12.523 ^{abc}	14.408 ^{abc}	12.161 $^{b-e}$
MTU-1010	V12	8.280 ^{cd}	10.850 ^{cd}	12.800 ^{cd}	10.643 ^{fg}
F-MEAN		9.488	12.213	13.723	11.808

$CD_{at\ 5\%}$ for T** = 6.120 F** = 6.050 FxT = NS *Same superscript shows the non-significant difference at 5%.

genotypes IR-83383-B-141-2(V8), IR-83383-B-B-129-4 (V4) and R-RF-65 (V5) were statistically at par and significantly higher than IR-64 (V11) , IR-83388-B-B-129-3 (V2) , IBD-I-85 (Local entry) (V9) , IR-83388-B-B-108-3 (V1) , MTU-1010 (V12), R-RF-85 (Local entry) (V10) and IR-82589-B-B-84-3 (V3).The varieties IR-83383- B-B-129-4 (V4) was also statistically at par with R-RF-65 (V5) followed by R-RF-69 (V7) and IR-83377-B-B-93-3 (V6). P uptake increased with increasing fertilizer application from low to high fertility level. Application of high fertility level produced higher phosphorus uptake (13.723 kg ha^{-1}) followed by medium fertility level (12.213 kg ha^{-1}) and lowest in low fertility level (9.488 kg ha^{-1}).Plants absorb proportionately more nitrogen and phosphorus from the pool of available with higher dose of application. Patel *et al*., 1997 and Bharde *et al*. (2003) also reported the synergistic effect of N in availability of P and K. Interaction between rice genotypes and fertility levels was found to be non-significant. Similar findings were also reported by Sudhakar *et al*. (2009) and

Table 6: Fe Concentration (mg kg^{-1}) in grain and straw of different rice genotypes as influence by three fertility levels.

Rice genotype	Symbol	Fe content in Grain (mg kg^{-1})	in Straw (mg kg^{-1})			Fe content			
		Control	Medium	High	Mean	Control	Medium	High	Mean
IR-83388-B-B-108-3	V1	118 ^{b}	111 ^{d}	109 ^{c}	113 ^{e}	258 ^{a}	247 ^{ab}	236 ^{abc}	247 ^{ab}
IR-83388-B-B-129-3	V2	130 ^{ab}	122 $^{a-d}$	114 ^{bc}	122 ^{cd}	251 ^{ab}	255 ^{a}	252 ^{a}	253 ^{a}
IR-82589-B-B-84-3	V3	119 ^{b}	116^{cd}	114 ^{bc}	116 ^{de}	196 ^{d}	191 ^{d}	193 ^{d}	193 ^{e}
IR-83383-B-B-129-4	V4	136 ^{a}	131^{abc}	130 ^{ab}	132^{ab}	165 ^{f}	164 ^{e}	159 ^{e}	163 ^{g}
R-RF-65	V5	137 ^{a}	126 $^{a-d}$	122 ^{abc}	128 ^{abc}	225 ^{c}	213 ^{c}	196 ^{d}	212 ^{d}
IR-83377-B-B-93-3	V6	138 ^{a}	134 ^{ab}	132 ^{a}	135 ^{ab}	177 ^{ef}	173 ^{e}	162 ^{e}	171 ^{fg}
R-RF-69	V7	134 ^{ab}	132 ^{abc}	127 ^{ab}	131 ^{abc}	237 ^{bc}	231 ^{b}	227 ^{c}	231 ^{c}
IR-83383-B-141-2	V8	141 ^{a}	137 ^{a}	132 ^{a}	137 ^{a}	250 ^{ab}	247 ^{ab}	238 ^{abc}	245 ^{ab}
IBD-I-85 (Local entry)	V9	131 ^{ab}	128 ^{abc}	124 ^{abc}	127 ^{abc}	248 ^{ab}	241 ^{ab}	235 ^{bc}	241 ^{b}
R-RF-85 (Local entry)	V10	133 ^{ab}	129 ^{abc}	126 ^{ab}	129 ^{abc}	251 ^{ab}	247 ^{ab}	244 ^{ab}	247 ^{ab}
IR-64	V11	128^{ab}	126 $^{a-d}$	121 ^{abc}	125 ^{bc}	182 ^{de}	177 ^{de}	173 ^{e}	177 ^{f}
MTU-1010	V12	119 ^{b}	117 ^{bcd}	113 ^{bc}	116 ^{de}	181 ^{def}	177 ^{de}	174 ^{e}	177 ^{f}
F-MEAN		130	126	122	126	218	213	207	213
	CD $_{at\ 5\%}$ for T** = 8.316 F** = 3.769 FT = NS					CD $_{at\ 5\%}$ for T** = 8.603 F** = 5.210 FxT = NS;			

*Same superscript shows the non-significant difference at 5%.

Table 7: Mn Concentration (mg kg^{-1}) in grain and straw of different rice genotypes as influence by three fertility levels

Rice genotype	Symbol	Mn content in Grain (mg kg^{-1})		in Straw (mg kg^{-1})		Mn content			
		Control	Medium	High	Mean	Control	Medium	High	Mean
IR-83388-B-B-108-3	V1	68 ^{ab}	66 ^{ab}	62 ^{ab}	66 ^{ab}	315 ^{bcd}	304 ^{bc}	282 ^{abc}	300 ^{c}
IR-83388-B-B-129-3	V2	50 ^{bc}	49 ^{bc}	49 ^{b}	49 ^{f}	324 ^{abc}	307 ^{bc}	277 ^{bcd}	303 ^{c}
IR-82589-B-B-84-3	V3	68 ^{abc}	65 ^{ab}	63 ^{ab}	65 ^{ab}	289 $^{c-f}$	274 ^{d}	273 ^{cd}	261 ^{cde}
IR-83383-B-B-129-4	V4	54 ^{abc}	55 ^{abc}	52 ^{ab}	54 ^{def}	290 ^{cde}	256 ^{d}	234 ^{ef}	260 ^{def}
R-RF-65	V5	62 ^{abc}	60 ^{abc}	57 ^{ab}	60 $^{a-e}$	335 ^{ab}	309 ^{b}	306 ^{ab}	316^{bc}
IR-83377-B-B-93-3	V6	57 ^{abc}	55 ^{abc}	54 ^{ab}	55 $^{c-f}$	358 ^{a}	348 ^{a}	318 ^{a}	341 ^{a}
R-RF-69	V7	49 ^{c}	47 ^{c}	46 ^{b}	48 ^{f}	283 ^{def}	273 ^{cd}	250 $^{c-f}$	268 ^{de}
IR-83383-B-141-2	V8	66 ^{abc}	63 ^{abc}	62 ^{ab}	64 ^{abc}	335 ^{ab}	326 ^{ab}	314 ^{a}	325 ^{ab}
IBD-I-85 (Local entry)	V9	71 ^{a}	68 ^{a}	67 ^{a}	69 ^{a}	258 ^{ef}	250 ^{d}	225 ^{f}	244 ^{f}
R-RF-85 (Local entry)	V10	53 ^{abc}	52 ^{abc}	49 ^{ab}	51 ^{ef}	321 ^{bc}	310 ^{b}	302 ^{ab}	311 ^{bc}
IR-64	V11	58 ^{abc}	57 ^{abc}	54 ^{ab}	56 $^{b-f}$	254 ^{f}	252 ^{d}	243 ^{def}	250 ^{ef}
MTU-1010	V12	65 ^{abc}	63 ^{abc}	61 ^{ab}	63 $^{a-d}$	308 ^{bcd}	298 ^{bc}	298 ^{ab}	301 ^{c}
F-MEAN		60	58	56	58	306	292	276	291
	CD $_{at\ 5\%}$ for T** = 8.793 F = NS FxT = NS					CD $_{at\ 5\%}$ for T** = 18.63 F** = 8.88 FxT = NS;			

*Same superscript shows the non-significant difference at 5%.

Singh *et al*. (2010).

Effect of rice genotypes and fertility levels on total potassium uptake (kg/ha)

The effect of rice genotypes and fertility levels on total potassium uptake was observed to be significant (Table 5). The genotype IR-83377-B-B-93-3 (V6) absorbed highest potassium over other rice genotypes and lowest uptake was exhibited by MTU-1010 (V12). Variable amount of K accumulation by different genoty pesshowed their different genotypicc haracters and displayed variable test of significance, statistically. Total potassium uptake (Table 3) was significantly increased with successive increase in fertility levels. Application of high fertility level recorded significantly higher potassium uptake (85.255 kg ha^{-1}) followed by medium fertility level (83.910 kg ha^{-1}) and low fertility level (59.441 kg ha^{-1}) Interaction between rice genotypes and fertility levels did not affect significantly.Bahmaniar and Rajbar (2007) elucidated that K uptake in shoot and grain was significantly affected by cultivar and K interaction. The absorption by grain with the increase of K level was also reported by Dobermann *et al*. (1996), Fageria *et al*. (2010), Singh *et al*. (2010) also observed increased K uptake through increasing fertility levels

Micro Nutrient (Fe, Mn, Cu, Zn) Concentration (mg kg^{-1}) in grain and straw of different rice genotypes as influence by three fertility levels.

The average Fe content (mg kg^{-1}) in grain and straw of different rice genotypes in relation to three fertility levels (Table 6). Fe content significantly influenced by rice genotypes and fertility levels in grain and straw. Average Fe content in grain and straw part of different rice genotypes ranged from 113 to 131 and 171 to 253 mg kg^{-1}, respectively. Rice genotype IR-83383-B-141-2 in grain part absorbed highest Fe content and that in IR-83388-B-B-108-3 geno type hadlowest Fe content. In general, Fe was accumulated more in strawpart than that in grainpart. Fe content was significant higher in low fertility level (control) and decreased in high fertility level in grain and Straw. High content of Fe in lowfer tiltylevel may be due to less dry matter and content decreased in high fertility level due to increase in biomass production resulting dilution effect. Interaction effect between genotypes and fertility levels did not show any statistically significant results in grain and straw. Highest yielder of the genotypes did not show the high content of Fe in grain as well as in straw. Variations in Fe concentration in different genotypesmay be due to their genotypic characters.

Table 8: Cu content (mg kg^{-1}) in grain and straw of different rice genotypes in relation to three fertility levels

Rice genotype	Symbol	Cu content in Grain (mg kg^{-1})		in Straw (mg kg^{-1})		Cu content			
		Control	Medium	High	Mean	Control	Medium	High	Mean
IR-83388-B-B-108-3	V1	6^{a}	6^{a}	6^{a}	6^{abc}	30^{ab}	29^{b}	28^{ab}	29^{b}
IR-83388-B-B-129-3	V2	7^{a}	6^{a}	6^{a}	6^{abc}	29^{b}	28^{b}	28^{ab}	28^{b}
IR-82589-B-B-84-3	V3	6^{a}	6^{a}	5^{a}	6^{abc}	31^{ab}	29^{ab}	26^{b}	29^{b}
IR-83383-B-B-129-4	V4	7^{a}	7^{a}	6^{a}	7^{ab}	30^{ab}	29^{b}	28^{ab}	29^{b}
R-RF-65	V5	6^{a}	5^{a}	5^{a}	5^{c}	30^{ab}	29^{b}	27^{ab}	29^{b}
IR-83377-B-B-93-3	V6	6^{a}	6^{a}	5^{a}	6^{bc}	33^{a}	33^{a}	31^{a}	32^{a}
R-RF-69	V7	7^{a}	6^{a}	7^{a}	6^{abc}	30^{ab}	29^{b}	28^{ab}	29^{b}
IR-83383-B-141-2	V8	7^{a}	7^{a}	7^{a}	7^{a}	30^{ab}	29^{b}	28^{ab}	29^{b}
IBD-I-85 (Local entry)	V9	6^{a}	6^{a}	6^{a}	6.11^{abc}	30^{ab}	29^{b}	28^{ab}	29^{b}
R-RF-85 (Local entry)	V10	7^{a}	7^{a}	6^{a}	6^{abc}	29^{b}	28^{b}	27^{b}	28^{b}
IR-64	V11	7^{a}	6^{a}	6^{a}	6^{abc}	30^{ab}	29^{b}	28^{ab}	29^{b}
MTU-1010	V12	7^{a}	7^{a}	7^{a}	7^{ab}	30^{ab}	28^{b}	27^{b}	28^{b}
F-MEAN		6	6	6	6	30	29	28	29
	$CD_{at\ 5\%}$ for T=NS F= NS FxT= NS					$CD_{at\ 5\%}$ for T**=1.741 F**=0.983 FxT=NS;			

*Same superscript shows the non-significant difference at 5%.

Table 9: Zn Concentration (mg kg^{-1}) in grain and straw of different rice genotypes as influence by three fertility levels

Rice genotype	Symbol	Zn content in Grain (mg kg^{-1})		in Straw (mg kg^{-1})		Zn content			
		Control	Medium	High	Mean	Control	Medium	High	Mean
IR-83388-B-B-108-3	V1	58^{ab}	55^{ab}	54^{ab}	55^{ab}	110^{a}	105^{a}	102^{a}	106^{ab}
IR-83388-B-B-129-3	V2	53^{ab}	50^{ab}	45^{ab}	49^{bcd}	99^{a}	98^{a}	95^{a}	98^{b}
IR-82589-B-B-84-3	V3	60^{a}	60^{a}	59^{a}	60^{a}	98^{a}	96^{a}	91^{a}	95^{b}
IR-83383-B-B-129-4	V4	46^{ab}	43^{b}	42^{b}	44^{d}	103^{a}	98^{a}	90^{a}	97^{b}
R-RF-65	V5	53^{ab}	50^{ab}	47^{ab}	50^{bcd}	99^{a}	94^{a}	87^{a}	93^{b}
IR-83377-B-B-93-3	V6	57^{ab}	55^{ab}	51^{ab}	54^{ab}	114^{a}	111^{a}	105^{a}	110^{a}
R-RF-69	V7	50^{ab}	49^{ab}	48^{ab}	49^{bcd}	98^{a}	95^{a}	93^{a}	95^{b}
IR-83383-B-141-2	V8	52^{ab}	51^{ab}	47^{ab}	50^{bcd}	109^{a}	103^{a}	98^{a}	104^{ab}
IBD-I-85 (Local entry)	V9	44^{b}	43^{b}	41^{b}	43^{d}	107^{a}	99^{a}	94^{a}	100^{ab}
R-RF-85 (Local entry)	V10	46^{ab}	45^{b}	44^{ab}	45^{cd}	110^{a}	106^{a}	101^{a}	106^{ab}
IR-64	V11	50^{ab}	49^{ab}	45^{ab}	48^{bcd}	101^{a}	96^{a}	93^{a}	97^{b}
MTU-1010	V12	54^{ab}	52^{ab}	52^{ab}	53^{abc}	104^{a}	101^{a}	96^{a}	101^{ab}
F-MEAN		52	50	48	50	104	100	96	100
	$CD_{at\ 5\%}$ for T**=7.184 F=NS FxT= NS					$CD_{at\ 5\%}$ for T**= 10.606 F=NS FxT= NS			

*Same superscript shows the non-significant difference at 5%.

The Mn concentration in grain and straw part of different genotypes in relation to three fertility levels (Table 7). There was a significant effect of Mn content in grain and straw part of the different rice genotypes coupled with fertility levels accept in grain part. Average Mn content in grain part was 4 to 5 time less than that of straw part indicating major role of Mn in vegetative part. Mn contents in grain and straw were ranged from 48-69 and 244-341 mg kg^{-1}, respectively. Mn content was higher in low fertilty level then progressively decreased to high fertility level due to increase in grain and straw yields resulting dilution effect.

The Cu concentration in different rice genotypes as influenced by three fertility status (Table 8). There was no significant difference in Cu content in grain with respect to different genotypes, fertility levels and their interaction. However, in rice straw, Cu content affected significantly with rice genotypes and fertility levels. Like other micro nutrients as discussed previously, Cu content in grain part was four times less than that in straw part. In low fertility level, Cu content was recorded higher than medium to high fertility levels.

The average Zn content in rice grain and straw in relation to different genotypes and three fertility levels (Table 9). There was significant effect of Zn content in grain and straw of different rice genotypes. However, fertility levels and interaction effects on Zn content in grain and straw did not show any significant variation. Zn content in straw part was double of what in grain part of the genotypes. Zn content varies according to the genotypic variations. Concluded that the yield of different rice genotypes significantly increased with increasing level of fertility from low to high. Rice genotypes, R-RF-65, IR-83383-B-141-2, IR-83377-B-B-93-3,IR-83383-B-B-129-4, IR-83388-B-B-129-3, IR-83388-B-B-108-3, R-RF-69, MTU-1010,IR-64 and IR-82589-B-B-84-3 were recorded higher growth and yield attributes for grain and straw yields, nutrients uptake and higher nutrient use efficiencies.

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