ISSN 1023-1072

Pak. J. Agri., Agril. Engg., Vet. Sci., 2011, 27 (2): 134-142

MINERAL NUTRIENT DENSITIES IN SOME DOMESTIC AND EXOTIC RICE GENOTYPES

N. Depar[1], I. Rajpar[2], M. Y. Memon[1], M. Imtiaz[1] and Zia-ul-hassan[2]

[1]Soil Science Division, Nuclear Institute of Agriculture Tandojam, Pakistan
[2]Department of Soil Science, Sindh Agriculture University, Tandojam, Pakistan

ABSTRACT

Micronutrient deficiencies have been recognized in human which cause stunting in children, lower resistance to disease in both children and adults, and increase risks for both mothers and infants during childbirth. Micronutrients deficiency especially of Zn, Fe and Cu is also termed as hidden hunger. Their daily diet consists mostly of a few inexpensive staple foods, such as rice and wheat, which have traces of micronutrients. This study was carried out to explore information regarding mineral nutrient reserves in rice genotypes of different organizations. Rice grains of 60 genotypes were analyzed for these nutrients. The analytical results revealed that Zn ranged 12.5 to 26.3 mg kg^{-1} and 0.12 to 0.59 μg $rice^{-1}$. Significant variation in Fe, Cu and Mn concentrations were also observed in rice grains of different genotypes. Iron, Cu and Mn concentrations ranged from 31.6 to 65.0, 5.90 to 14.3 and 34.8 to 64.2 μg g^{-1}, respectively.

Keywords: Genotypes, micronutrient, mineral, rice, zinc

INTRODUCTION

Micronutrient mineral elements like zinc (Zn), iron (Fe) and copper (Cu) are very important for human health as of carbohydrates, fats, proteins and vitamins. Balanced human nutrition consists of proper diet in terms of carbohydrates, lipids, proteins and vitamins. Additionallly, ample amounts of inorganic nutrients must also be part of human diet. The deficiencies of these inorganic nutrients (Fe, Zn and Cu) can affect brain and immune functions (FAO, 1992; Imtiaz *et al.*, 2005). Globally, about two billion people in more than hundred countries are victim of multiple micronutrient deficiencies (FAO, 1992). More than 90% of the pregnant women and pre-school children in developing countries show signs of Fe deficiency, anaemia and other related nutrient disorders. Iron, Zn and K are also required at maximum level during adolescent stage. Micronutrient especially Zn, Fe and Cu deficiency is also termed as hidden hunger. The daily dietary requirement of a young adult ranges from 15 mg Zn, 10-60 mg Fe and 2-3 mg

Corresponding author: ndepar@gmail.com

day^{-1} for Cu. At the same time Na and K are also very crucial for human health and play a key role in various biochemical and physiological processes (Imtiaz *et al.*, 2005). The accumulation of micronutrient elements in seed and grains is controlled by a number of vital processes including root-cell uptake, root-shoot transfer, and the ability of leaf tissues to load these nutrients into the vascular phloem elements which are ultimately responsible for delivering these nutrients to developing seeds and grains via the phloem sap (Welch, 1986). Many agriculture strategies have been devised for accumulation of higher reserves of micronutrients in edible plant foods for making these foods richer sources of micronutrients for humans. These approaches would be fruitful when the micronutrient food reserves are available to human. Plant food can contain substances (i.e., antinutrients) that interfere with the absorption or utilization of these nutrients in human (Welch and Graham, 1999).

Zinc deficiency in human in general is a serious global issue and particularly in the developing nations (Hotz and Brown, 2004). In Pakistan, Zn deficiency has also been reported in children < 5 years of age and in adult women (Bhutta *et al.*, 2007). In Khyber Pakhtunkhuwah (former NWFP) 54.2% pre-school children were reported to be zinc deficient. About 54% women in urban and rural Sindh have also been observed to be zinc deficient (Bhutta *et al.*, 1999). Zinc deficiency affects many systems because of its essential roles in many aspects of metabolism including the activity of more than 300 enzymes, structure of many proteins and control of genetic expressions. Clinical signs of zinc deficiency include acrodermatitis, low immunity, diarrhea, poor healing, stunting, hypogonadism, fetal growth failure, teratology and other abnormalities of pregnancy, liver failure in alcoholic cirrhosis and neuropsychological abnormalities (Prasad, 1984). The recommended dietary allowances for Zn are 5 mg day^{-1} for infants, 10 mg day^{-1} for children less than 10 yrs, 15 mg day^{-1} for males more than 10 yrs, 12 mg day^{-1} for females more than 10 yrs and 15 mg day^{-1} for women during pregnancy; however, these intake limits are seldom met (Singh *et al.*, 2005). There are also a large number of enzymes in which zinc is an integral component of the enzyme structure (zinc enzymes). Activity of these enzymes has been correlated with zinc availability to the plants. Differences in internal utilization or mobility of Zn have been shown to be involved in expression of Zn efficiency (Gokhan *et al.*, 2003).

Considerable genetic variation in rice genotypes has been demonstrated in different rice genotypes, where 53% of the observed variability was associated with Zn uptake and translocation from roots, shoots and seed content. The observed variability described the possibility of identifying specific donor genotypes with high Zn efficiency and high Zn content. The concentration of leaf Zn is related with Zn accumulation of seed Zn levels. It means that Zn acquisition and transport revealed the two independent traits. (Nagarathna *et al.*, 2010; Wissuwa *et al.*, 2006). Cropping systems can be designed to maximize micronutrient output to meet human needs. Designing of cropping systems for maximum nutrient output to improve nutrition and health should become an integral part of agriculture's goal and government policies. Additionally, ways must be found to increase diet diversity among food-insecure people. This would substantially reduce the risk of micronutrient malnutrition to the most at-risk people. Furthermore, any increase in the production of more micronutrient-rich foods (micronutrient-dense food crops, livestock and dairy or fish) could contribute greatly to find sustainable solutions to micronutrient malnutrition (McIntyre *et al.*, 2001). Selection of cropping systems not only for their production potential, but also for their ability to supply needed dietary sources of bioavailable nutrients and health promoting factors should become a goal of all nations if we are to meet the laudable objectives of better health and prosperity for all.

Rice (*Oryza sativa*) is the main staple food of around half of the world's population (>2.7billion). However, it has been estimated that sufficient rice will be needed to feed 4 billion people by 2015. It has been suggested that rice yields would need to increase by around 50% to maintain current nutritional standards (which are still not adequate for many people). In order to provide an adequate level of nutrition for all the population and increase of production of 70% would be necessary. On a global basis, rice provides 21% and 15% *per capita* of dietary energy and protein, respectively. Rice is cultivated in more than 100 countries on every continent except for Antarctica, but 91% of the world's rice is grown and consumed in Asia.

In view of this, a study was carried to examine the micronutrient reserves in rice grains of different genotypes.

MATERIALS AND METHODS

The seed of 60 rice genotypes was collected from different agricultural organizations i.e. Nuclear Institute of Agriculture (NIA), Tandojam; Rice Research Institute (RRI), Dokri and National Agriculture Research Centre (NARC), Islamabad. The seed was cleaned from any of unwanted foreign materials, like stone, dust, weed seed, etc. stored at 4 °C in a refrigerator before further processing. Prior to chemical analysis, the seed of each genotype was dried in forced draft oven at 80 ^{0}C and then milled, polished and ground in IKA FM-10 grinding mill to pass through 0.5 mesh sieve.

Samples of ground seed material (0.500 ± 0.01 g) were weighed and transferred into an acid washed 100 ml Kjeldahl digestion tube. Ten milli litre of concentrated Analar nitric acid (69 %) was added to each tube and thoroughly mixed and lids were placed on each tube and the samples were left overnight in the fume hood. By the next day, the tubes were placed in digestion block and heated continuously for 1 hour at 60^{0}C. The temperature was gradually increased and digested for further 6 hours at 110^{0}C. The tubes were removed from the block, allowed to cool and then filtered in acid washed 100 ml volumetric flasks through a filter paper (Whatman 40). Successive rinsing of tubes was ensured with deionised water and thus the volume of the flask was made upto mark. The concentrations of Zn, Fe, Cu and Mn were determined by Atomic Absorption spectrophotometer (AAS), Novaa 400, Germany, following the method of single acid digestion as described by Westerman (1990).

Statistical analysis

Co-efficient of variation (CV) and Tukey Honesty Significant Difference (HSD) were computed by using STATISTIX® VERSION 8.1, Analytical Software, Inc., Tallahassee, FL, USA. $HSD_{0.05}$ was calculated only when the F value was significant at $p<0.05$

RESULTS AND DISCUSSION

Mineral elements like Zn, Cu, Fe and Mn are very crucial for human health and play a key role in various biochemical processes. The results of nutrient concentrations and contents of grains of different rice genotypes are presented in Table 1 and 2.

Zinc

Zinc concentration determined in the seeds of various rice genotypes ranged from 12.7 to 26.4 µg g^{-1}, when determined on oven dry weight basis (Table 1). The genotype Shua-92 showed highest concentration of Zn (26.4 µg g^{-1}), whereas the lowest Zn concentration was recorded in DR-64 (12.50 µg g^{-1}). It was further observed that out of 60 genotypes under investigation 06 contained Zn concentrations between 20.4 to 26.37 µg g^{-1}, rest of genotypes had between 12.5 to 20.0 µg g^{-1}. The data related to Zn contents (on single rice grain basis) of rice grains is presented in Table 2. The results revealed that there was a significant variation among genotypes for Zn contents of rice grains. The Zn contents of rice grain ranged from 0.12 to 0.59 µg $rice^{-1}$. The maximum Zn content of 0.59 µg $rice^{-1}$ was recorded from genotype Shua-92 and the lowest (0.12 µg $rice^{-1}$) in RG-119. The rice grains obtained from genotypes Sarshar and IR-36 were found to be rich in Zn (Table 2). All the genotypes were categorized as poor (1.5 µg Zn rice $grain^{-1}$) in Zn accumulation.

Copper

Copper concentrations also varied significantly among cultivars. Compared to Fe, Mn and Zn, the concentration of Cu was quite low and ranged from 4.70 to 14.30 µg g^{-1} (Table 1). The rice genotype Mahsoori had the higher Cu concentration (14.3 µg g^{-1}), which was significantly different from rest of the genotypes. The genotype RG-123 was found to be poorest in Cu concentration as it had 5.90 µg g^{-1} Cu. The results revealed that Cu contents in all the genotypes under study ranged between 0.07 to 0.33 µg $rice^{-1}$. Genotype DR-62 accumulated more Cu (0.33 µg $rice^{-1}$), whereas the Cu reserves of the RG-121 were only 0.08 µg $rice^{-1}$ (Table 2).

Iron

Similar to Zn concentration, Fe concentration in the seed of different genotypes varied considerably. Maximum Fe concentration of 65.1 µg g^{-1} was observed in genotype IR-6 where as minimum concentration (31.6 µg g^{-1}) was recorded in

Table 1. Mineral concentrations (μg g^{-1}) in rice grains of different genotypes.

Genotype	Zn	Cu	Fe	Mn	Genotype	Zn	Cu	Fe	Mn
	μg g^{-1}					μg g^{-1}			
DR-92	15.5±1.77	9.1±1.51	47.2±2.99	43.3±0.37	RG-106	19.1±0.32	9.0±2.85	49.4±3.44	44.2±1.75
Shandar	19.0±0.49	9.9±1.46	46.6±5.72	47.6±5.14	RG-108	16.1±1.00	8.6±2.55	41.6±2.92	40.7±2.87
Lateefi	15.1±1.47	7.3±0.67	40.7±1.38	42.3±0.64	RG-109	12.5±0.64	9.3±1.82	38.0±3.60	37.1±3.47
Shua-92	26.4±1.1	6.3±0.95	43.8±2.39	41.0±1.77	Mehak	18.7±0.47	8.0±1.51	47.6±1.23	44. 7±0.59
DR-60	14.3±0.97	13.4±0.52	42.3±2.27	42.3±2.27	RG-110	20.5±1.10	14.0±1.07	43.8±1.11	42. 9±1.66
DR-61	18.3±0.94	10.7±2.28	52.6±4.15	49.2±4.49	RG-114	14.4±0.88	8.3±2.32	41.4±0.90	40.5±1.68
DR-62	14.3±0.34	10.1±3.04	64.0±0.65	57.7±9.81	RG-115	17.4±1.35	11.3±1.76	45.4±1.41	44.6±2.24
DR-64	12.5±0.64	7.0±0.61	54.7±0.92	46.7±4.21	RG-116	14.7±0.91	7.4±0.70	42.6±1.88	41.7 ±2.65
DR-67	18.3±0.81	12.7±0.98	60.6±1.46	48.0±5.00	RG-117	19.1±0.32	10.7±2.03	40.6±1.31	39.7±2.15
DR-82	16.5±1.78	13.2±0.38	43.7±1.09	43.7±1.09	RG-118	16.1±1.00	10.2±2.73	44.4±1.85	43.6±2.03
Sarshar	20.4±0.43	10.7±2.28	41.0±0.90	41.0±0.90	RG119	13.5±0.64	10.6±2.28	45.4±1.41	44.6±2.24
DR-83	14.8±2.11	11.7±2.96	42.3±2.80	42.3±2.80	RG-120	18.7±0.47	11.6±1.84	53.1±3.69	52.2±3.55
Mahsoori	18.5±0.40	14.3±0.96	46.0±0.90	46.0±0.90	RG-121	19.6±0.66	9.0±1.98	55.7±1.54	46.1±2.18
S. Subdasi	16.0±0.58	13.0±1.16	49.0±4.70	49.0±4.70	RG-122	15.0±0.58	12.5±2.17	41.6±7.24	36.8±3.97
Kanwal-95	18.1±1.10	9.0±1.00	59.8±3.24	59.8±3.24	RG-123	17.4±1.35	5.9±1.05	31.6±2.36	36.7±3.48
Sada Hayat	16.1±1.00	13.4±1.37	61.6±2.96	61.6±2.96	RG-124	14.7±0.91	12.7±0.98	39.9±4.54	39.7±3.73
Shahkar	13.6±1.71	8.0±1.15	56.6±2.36	56.6±2.36	1-07f	19.1±0.32	11.3±1.55	42.6±1.88	38.1±2.26
Sada Gulab	17.9±1.16	12.5±1.01	54.9±4.60	54.9±4.60	2-07f	16.1±1.00	9.2±1.99	40.6±1.31	39.7±2.15
JJ-77	19.6±0.66	12.7±0.88	43.7±1.09	42.9±1.66	3-07f	12.5±0.64	9.0±3.59	44.4±1.85	43.6±0.03
IR-36	21.5±1.78	10.2±2.10	41.0±0.90	40.2±1.72	4-07f	18.7±0.47	14.3±0.96	45.4±1.41	44.6±2.24
IR-8	18.2±0.66	7.2±1.60	42.3±2.80	41.4±3.49	5-07f	19.6±0.66	13.0±1.16	53.1±3.69	52.2±3.55
IR-9	21.0±1.15	6.6±0.98	40.8±2.17	40.0±1.51	6-07f	13.8±1.13	8.4±1.43	51.3±3.27	50.4±3.18
Shadab	18.1±0.64	10.3±1.71	41.6±2.92	40.7±2.87	7-07f	17.4±1.35	13.4±1.37	37.2±2.92	36.4±3.61
Khushboo-95	19.8±0.33	12.9±0.06	48.1±8.60	47.2±8.28	8-07f	14.7±0.91	7.3±1.35	38.0±8.60	37.1±9.13
IR-6	15.0±3.03	8.3±2.28	65.1±9.63	64.2±9.30	9-07f	19.1±0.32	11.9±0.52	47.2±2.99	46.3±3.67
RG-101	20.0±1.03	12.7±2.43	50.5±4.08	49.6±3.91	10-07f	16.1±1.00	12.6±0.88	38.3±2.83	37.4±2.79
RG-102	17.4±2.83	6.6±0.68	53.4±6.15	52.5±5.88	11-07f	13.9±0.64	10.7±2.57	35.7±4.02	34.9±3.85
RG-103	13.8±1.13	10.1±2.43	45.4±1.41	44.6±2.24	12-07f	18.7±0.47	11.7±2.36	45.0±1.41	44.1±1.77
RG-104	17.4±1.35	10.4±1.14	42.6±1.88	41.7±2.65	13-07f	15.6±1.45	10.0±2.03	42.7±1.88	43.4±1.68
RG-105	14.7±0.91	11.2±1.56	45.8±6.25	40.6±2.76	16-07f	13.8±0.43	11.1±1.85	41.7±2.00	40.8±2.13

	Zn (μg g^{-1})	Cu (μg g^{-1})	Fe (μg g^{-1})	Mn (μg g^{-1})
Minimum	12.5	5.9	31.6	34.8
Maximum	26.3	14.3	65.1	64.2
HSD 0.05	6.5	10.4	22.1	21.8

Table 2. Mineral reserves (µg rice^{-1}) in rice grain of different genotypes.

Genotype	Zn	Cu	Fe	Mn	Genotype	Zn	Cu	Fe	Mn
	µg rice^{-1}					µg rice^{-1}			
DR-92	0.28±0.10	0.13±0.01	0.85±0.05	0.78±0.01	RG-106	0.37±0.02	0.20±0.05	0.95±0.07	0.85±0.03
Shandar	0.35±0.03	0.21±0.02	0.85±0.10	0.87±0.09	RG-108	0.30±0.06	0.15±0.04	0.77±0.05	0.76±0.05
Lateefi	0.19±0.05	0.12±0.02	0.50±0.02	0.52±0.01	RG-109	0.22±0.03	0.25±0.02	0.66±0.06	0.65±0.06
Shua-92	0.59±0.07	0.11±0.02	0.99±0.05	0.92±0.04	Mehak	0.28±0.02	0.09±0.00	0.71±0.02	0.67±0.01
DR-60	0.28±0.06	0.24±0.04	0.82±0.04	0.82±0.04	RG-110	0.30±0.05	0.20±0.03	0.64±0.02	0.63±0.02
DR-61	0.33±0.05	0.11±0.00	0.96±0.08	0.90±0.08	RG-114	0.21±0.04	0.12±0.02	0.61±0.01	0.60±0.02
DR-62	0.25±0.02	0.33±0.03	1.12±0.19	1.01±0.17	RG-115	0.28±0.07	0.17±0.02	0.73±0.02	0.71±0.04
DR-64	0.22±0.03	0.12±0.01	0.96±0.02	0.82±0.07	RG-116	0.24±0.04	0.11±0.02	0.70±0.03	0.69±0.04
DR-67	0.31±0.04	0.17±0.02	1.03±0.02	0.82±0.09	RG-117	0.31±0.02	0.19±0.02	0.65±0.02	0.64±0.03
DR-82	0.30±0.10	0.14±0.00	0.79±0.02	0.79±0.02	RG-118	0.25±0.05	0.13±0.04	0.70±0.03	0.68±0.03
Sarshar	0.49±0.03	0.15±0.02	0.99±0.02	0.99±0.02	RG119	0.12±0.02	0.10±0.02	0.45±0.01	0.44±0.02
DR-83	0.36±0.15	0.26±0.05	1.02±0.07	.02±0.07	RG-120	0.17±0.01	0.13±0.01	0.49±0.03	0.48±0.03
Mahsoori	0.24±0.02	0.12±0.03	0.60±0.01	0.60±0.01	RG-121	0.23±0.02	0.07±0.00	0.64±0.02	0.53±0.03
S. Subdasi	0.21±0.02	0.13±0.04	0.63±0.06	0.63±0.06	RG-122	0.20±0.02	0.15±0.02	0.57±0.10	0.50±0.05
Kanwal-95	0.25±0.05	0.10±0.01	0.84±0.05	0.84±0.05	RG-123	0.23±0.05	0.08±0.01	0.41±0.03	0.48±0.05
Sada Hayat	0.23±0.04	0.18±0.02	0.89±0.04	0.89±0.04	RG-124	0.16±0.03	0.15±0.01	0.45±0.05	0.44±0.04
Shahkar	0.25±0.09	0.21±0.03	1.02±0.04	1.02±0.04	1-07f	0.38±0.02	0.17±0.05	0.85±0.04	0.76±0.05
Sada Gulab	0.29±0.06	0.18±0.04	0.88±0.07	0.88±0.07	2-07f	0.31±0.06	0.18±0.04	0.78±0.03	0.77±0.04
JJ-77	0.31±0.03	0.18±0.02	0.69±0.02	0.68±0.03	3-07f	0.23±0.03	0.19±0.05	0.81±0.03	0.79±0.04
IR-36	0.34±0.13	0.24±0.07	0.96±0.02	0.94±0.04	4-07f	0.27±0.02	0.13±0.03	0.65±0.02	0.63±0.03
IR-8	0.41±0.04	0.27±0.04	0.95±0.06	0.93±0.08	5-07f	0.37±0.04	0.23±0.05	1.01±0.07	0.99±0.07
IR-9	0.41±0.07	0.15±0.04	0.79±0.04	0.77±0.03	6-07f	0.27±0.07	0.14±0.02	0.99±0.06	0.97±0.06
Shadab	0.33±0.03	0.25±0.02	0.76±0.05	0.74±0.05	7-07f	0.32±0.07	0.23±0.02	0.68±0.05	0.66±0.07
Khushboo-95	0.28±0.01	0.15±0.02	0.68±0.12	0.67±0.12	8-07f	0.26±0.05	0.16±0.03	0.67±0.15	0.65±0.16
IR-6	0.34±0.20	0.24±0.05	1.46±0.22	1.44±0.21	9-07f	0.40±0.02	0.15±0.02	0.99±0.06	0.97±0.08
RG-101	0.39±0.06	0.26±0.03	0.97±0.08	0.96±0.08	10-07f	0.36±0.07	0.22±0.08	0.86±0.06	0.84±0.06
RG-102	0.32±0.15	0.13±0.01	0.97±0.11	0.96±0.11	11-07f	0.23±0.03	0.20±0.04	0.64±0.07	0.63±0.07
RG-103	0.24±0.06	0.19±0.03	0.80±0.02	0.78±0.04	12-07f	0.34±0.03	0.26±0.01	0.82±0.03	0.80±0.03
RG-104	0.39±0.09	0.15±0.02	0.95±0.04	0.93±0.06	13-07f	0.24±0.07	0.12±0.03	0.65±0.03	0.66±0.03
RG-105	0.34±0.06	0.25±0.03	1.05±0.14	0.93±0.06	16-07f	0.29±0.03	0.22±0.07	0.91±0.05	0.86±0.08
	Zn (µg g-1)		Cu (µg g-1)			Fe (µg g-1)		Mn (µg g-1)	
Minimum	0.12		0.07			0.41		0.44	
Maximum	0.59		0.33			1.46		1.44	
HSD 0.05	0.12		0.19			0.40		0.09	

RG-123 (Table 1). The results revealed that average Fe contents (1.46 µg rice^{-1}) of genotype IR-6 was significantly higher as compared with the content of other genotypes (Table 2). The lowest Fe contents of 0.41 µg rice^{-1} were recorded in genotype RG-123.

Manganese

The Mn concentration of all the under study genotypes ranged from 34.86 to 64.2 µg g^{-1}. Maximum values (64.2 µg g^{-1}) of Mn concentration were observed in genotype IR-6 where as minimum Mn concentration (34.86 µg g^{-1}) was recorded in line 11-07f (Table 1). Similar to Zn and Fe concentrations, the Mn contents of genotypes varied considerably from 0.44 to 1.44 µg rice^{-1}. Rice genotype IR-6 was found to be the best accumulator of Mn; whereas, the RG-119 was found to be the poorest Mn accumulator (Table 2).

Seed size and quality are important determinant of dietary nutrition, seedling vigour and growth of cereals (Imtiaz *et al*., 2005). Healthy and large seed grains produce improved crop stand, increase crop yield while small seeds gather bigger reserves of food (Grieve and Francois, 1992). Seed quality expressed as higher content results in better human nutrition (Ahmad *et al.,* 2001), vegetative growth and grain yield (Rengel and Grahm, 1995a). The present study also showed a large variation in acquisition of these mineral elements, which substantiate the earlier findings of those reported by Imtiaz *et al*. (2005, 2010). Variation in acquisition attributed to genetic make up (Gram and Rengel, 1998), agro-climatic conditions in which cereals are grown and the fertility of soil, which is more important (Takkar and Walker, 1993). In general heavier seeds of genotypes contained more minerals like Zn, Cu and Fe, however, dilution in concentration was noticed in certain genotypes (Ortiz-Monasterio *et al.*, 2007). Mineral elements of malnutrition in much of human population have been dealt by fortifying the cereals with a plant and animal product, which increases the cost of production of these commodities. Due to wide availability of staples, their share in malnourished food is always higher. Zinc deficiency in crop plants reduces not only grain yield, but also the nutritional quality of grains. High consumption of cereal-based foods with low levels and poor bioavailability of Zn is thought to be a major factor for the widespread occurrence of Zn deficiency in human being (Welch, 1993; 2003).

In this study concentration of different micronutrients was assessed in 60 rice genotypes to disseminate information about their mineral reserves. The rice genotypes like Shua-92, IR-9, IR-36 and Shandar which had higher concentration of these mineral elements can be included in breeding program to enhance the amount of elements for human consumption to overcome the problem of deficiencies of these elements in human. There was also a great variation for the concentration of Fe, Zn, Cu and Mn in different rice genotypes (Table 1), this sugests that within the same, species can vary greatly in grain-Fe and grain-Zn concentrations. Thus, it seems feasible for rice breeders to select for high-Fe and high-Zn density traits in breeding programs.

CONCLUSION

It is concluded from this study that the rice genotype Shua-92 and Shandar accumulate more amount of mineral elements. The results further revealed that the edible portions of high-Fe and high-Zn dense rice still retain enriched levels of Fe and Zn after milling and processing, and that enriched levels of Fe and Zn in rice are bio-available to target human populations.

REFERENCES

Ahmad, M., M. Hussain and M. Shafhique. 2001. Important macro and micro elements of wheat and rice. The Nucleus, 38 (3-4): 311-315,

Bhutta, Z. A., A. Jiwani, A. Feroze, N. Kissana and I. Ortiz-Monasterio. 2007. Assessment of human zinc deficiency and determinants in Pakistan: Implications for interventions. Zinc Crops 2007: Improving Crop Production and Human Health. May 24-25, Istanbul, Turkey.

Bhutta, Z. A., S. Q. Nizami and Z. Isani. 1999. Zinc supplementation in malnourished children with persistent diarrhea in Pakistan. Pediatrics, 103 (4): 1-9.

FAO. 1992. Theme paper No. 06. International Conference on Nutrition, Rome, December, 5-11.

Gokhan, H., J. J. Hart, W. Yi-Hong, I. Cakmak, and L. V. Kochian. 2003. Zinc efficiency is correlated with enhanced expression and activity of zinc-requiring enzymes in wheat. Plant Physiol., 131: 595–602.

Graham, R. D. and Z. Rengel. 1998. Genotypic variation in zinc uptake and utilization by plants. pp. 107-118. *In:* A. D. Robson (Ed.), Zinc in Soils and Plants. Kluwer Academic Publishers: Dordrecht, Netherlands.

Grieve, C. M. and L. E. Francois. 1992. The importance of initial seed size in wheat plant response to salinity. Plant and Soil, 147: 197-205.

Hotz, C. and K. H. Brown. 2004. Assessment of the risk of zinc deficiency in populations and options for its control. Food Nutr. Bull., 25 (1): 291–204.

Imtiaz, M., A. Rasheed, P. Khan, M. Y. Memon and M. Aslam. 2010. The role of micronutrients in crop production and human health. Pak. J. Bot., 42 (4): 2565-2578.

Imtiaz, M., P. Khan, H. Babar, N. Depar, S. H. Siddiqui, M. Y. Memon, M. Aslam, K. H. Shah and M. H. Naqvi. 2005. Mineral dietary status of existing domestic wheat genotypes. The Nucleus, 42 (3-4): 213.

McIntyre, B. D., D. R. Bouldin, G. H. Urey, and F. Kizito. 2001. Modelling cropping strategies to improve human nutrition in Uganda. Agricultural Systems, 67: 105-120.

Nagarathna, T. K., A. G. Shankar and M. Udayakumar. 2010. Assessment of genetic variation in zinc acquisition and transport to seed in diversified germplasm lines of rice (*Oryza sativa* L.). J. Agri. Tech., 6 (1): 171-178.

Ortiz-Monasterio, J. I., N. Palacios-Rojas, E. Meng, K. Pixley, R. Trethowan and R. J. Peña. 2007. Enhancing the mineral and vitamin content of wheat and maize through plant breeding. J. Cereal Sci., 46 (3): 293-307.

Prasad, A. S. 1984. Discovery and importance of zinc in human nutrition. Annual Meeting of the Federation of Am. Soc. for Exp. Bio. 67, Chicago (1983) 43 (13): 2829-2834.

Rengel, Z. and Graham, R. D. 1995a. Wheat genotypes differ in Zn deficiency when grown in chelate buffered nutrient solution, I: Growth Plant and Soil, 176: 307-316.

Singh, B., S. Kumar, A. Natesan, B. K. Singh and K. Usha. 2005. Improving zinc efficiency of cereals under zinc deficiency. Review Articles. Current Sci., 88(1): 37.

Takkar, P. N. and C. D. Walker. 1993. Soil and plants. Ed. A. D. Robson. Kluwer Academic Publishers, Dordrecht, 151-165.

Welch, R. M. 1986. Effects of nutrient deficiencies on seed production and quality. Adv. Plant Nutr., 2: 205-247.

Welch, R. M. 1993. Zinc concentrations and forms in plants for humans and animals. pp. 183-195. *In:* Zinc in Soils and Plants. Kluwer Dordrecht, Netherlands.

Welch, R. M. 2003. Farming for nutritious foods: Agricultural technologies for improved human health. IFA-FAO Agriculture Conference "Global Food Security and the Role of Sustainable Fertilization" Rome, Italy, 26-28 March.

Welch, R. M. and R. D. Graham. 1999. A new paradigm for world agriculture: Meeting human needs - productive, sustainable, nutritious. Field Crops Res., 60: 1-10.

Westerman, R. L. 1990. Soil testing and plant analysis, eds. Soil Science Society of America Incorporation. Madison, Wisconsin, USA.

Wissuwa, M., A. M. Ismail and S.Yanagihara. 2006. Effects of zinc deficiency on rice growth and genetic factors contributing to tolerance. Plant Physio., 142: 731-741.

(Received 30 October, 2011; Revised 31 December, 2011)