Variability for Fe and Zn in Selected Germplasm Growing on Stressed Lands

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Abstract: Wheat germplasm comprising commercial varieties, advanced genotypes, land races, intergeneric hybrids and some synthetic hexaploids obtained from CIMMYT were analyzed for variability of Fe and Zn in the seeds. Plants were grown under normal and saline plots having electrical conductivity of EC6-10 dS^{-m}, soil pH between 7–7.6 and saturation percentage (SP) between 34.9 and 41.8. Seeds were digested according to AOAC official method of analysis. The digested samples in appropriate dilutions were analyzed using Atomic Absorption Spectrophotometer preset at wavelengths of 248.3 nm for Fe and 213.8 nm for Zn. Both the elements showed significant variation under control which ranges between 1.0–3.9 μg/g dry seeds for Fe and between 1.5–3.5 μg/g dry seeds for Zn. These values appeared significantly lower than the minimum (24 and 8 μg/g dry seeds) and maximum (51–61 μg/g dry seeds) values reported of Fe and Zn, respectively in wheat germplasm growing under normal soils. One of the reasons for low contents is the high pH of the soils in which the test material was grown. Salinity further reduced the values for both Fe and Zn (to 0.37–2.53 and 1.5–3.5 μg/g dry seeds, respectively) reported for both chemicals. It is inferred that salinity not only reduces the productivity but the nutritional value of the cereals is also affected. It is therefore, imperative for breeding programmes on salinity tolerance to start with germplasm having a initial high range of both the essential elements in order to get quality cereals on saline lands.

Keywords: iron; zinc; minerals deficiency; micronutrient salinity

Zinc and iron deficiencies are the most prevalent micronutrient deficiencies in soils and plants, resulting in large decrease in crop production and quality (White & Zasoski 1999). Iron deficiency is the most widespread nutritional disorder in the world. It affects more than 3.5 billion people and well over two out of every three people in the developing world (Bouis 2002). Zinc deficiency is also a common micronutrient deficiency in wheat and other cereals. It is estimated that about 50% soils used for cereal production in the world have low levels of plants available Zn (Graham & Welch 1996). In high tech wheat cultivars, variation in zinc and iron concentration in seed is relatively small. The environmental management factors exert a greater effect on the variation of micronutrient in wheat than genetic factors (Paterson *et al*. 1989; Rengel *et al*. 1999).

In the present study, we have tried to evaluate the Zn and Fe status of existing wheat cultivars, breeding lines being produced using these cultivars, and material produced through transferring gene(s) form wild wheat species. The objectives were to see the variability of both the elements in the prevalent wheat cultivar, and a possible effect on both the elements of salinity and high pH prevailing in the fields where wheat is being cultivated in the country.

MATERIAL AND METHODS

Material. Material used in this study comprised local cultivar, varieties, breeding lines, germplams originated through wide hybridization at CIMMYT and NIAB. Details description of the material is given in Table 1.

Table 1. Description of material

No.	Cultivar/Breeding Line/variety/Pedigree	Origin
1	Lilin/3croc-1/*Ae. tauschi* (205)//KAUZ/4/F	CIMMYT
2	Ures/PRL//BAV-92	CIMMYT
3	Parus/Pastor	CIMMYT
4	DOY1/*Ae. tauschii* (458)//Opata	CIMMYT
5	WEEB/l	CIMMYT
6	Darwar Dry Checks	CIMMYT
7	Postar/3/Aktar.84/*Ae. tauschi*//opata	CIMMYT
8	Sitta	CIMMYT
9	VEE/MJ1//^{2}TUL/^{3}/^{2} Pastor	CIMMYT
10	Pastor/BAV 92	CIMMYT
11	Filin/Irena/^{5}/CNDO/R143//ENTE/MEXi0.	CIMMYT
12	Irena/Baba//Pastor	CIMMYT
13	WL-1073: LU-26/*Ae. cylindrica*//LU-26	NIAB, PK
14	Ratti (land race)	Baluchistan, PK
15	886: (S-A): LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
16	880: LU-26/*Ae. cylindrica*//LU-26	NIAB, PK
17	41 (S-I): LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
18	41 (S-II): LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
19	41 (S-III): LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
20	Inqlab	CIMMYT/AARI
21	Iqbal	AARI, PK
22	Chakwal	Barani, PK
23	Pasban	CIMMYT/AARI
24	N-90683: 1073/Pasban	NIAB,PK
25	359: LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
26	751: LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
27	879: LU-26/*Ae. cylindrica*//LU-26	NIAB, PK
28	880: LU-26/*Ae. cylindrica*//LU-26	NIAB, PK
29	883: Durum/*Ae. cylindrica*//Pak-81	NIAB, PK
30	885: LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK
31	886: (S-B) LU-26/*Ae. cylindrica*//Pak-81	NIAB, PK

Method. One gram dry seeds were digested in a mixture of nitric acid: perchloric acid (2:1) and analyzed on Hitachi Model 180-80 Polarized Zeeman Atomic Absorption Spectrophotometer using air acetylene flame and wavelengths of 589, 766.5, 243.3 and 213.8 for Na, K, Fe and Zn, respectively. All the samples were analyzed in three replications and data was analyzed using mean and standard deviation.

RESULTS

Variability Fe for plants growing under non-saline conditions is significantly less (1.0–3.9 μg/g dry seeds) than the reported values of both the elements in wheat. Salinity induced reduction was highly significant ($P < 0.01$) in all the germplasm that ranged between 0.37–1.85 μg/g dry seeds (Figure 1).

Under controlled conditions, Zn concentration ranged between 1.5–3.5 μg/g dry seeds, and like Fe, Zn also reduced drastically and significantly in all the germplasm under the influence of salinlity (Figure 2).

Germplasm with higher Na^+ concentration in seeds generally exhibited lower vales of Zn and Fe but correlation was neither negative nor significant except in two lines (19, 22) where Na^+ and

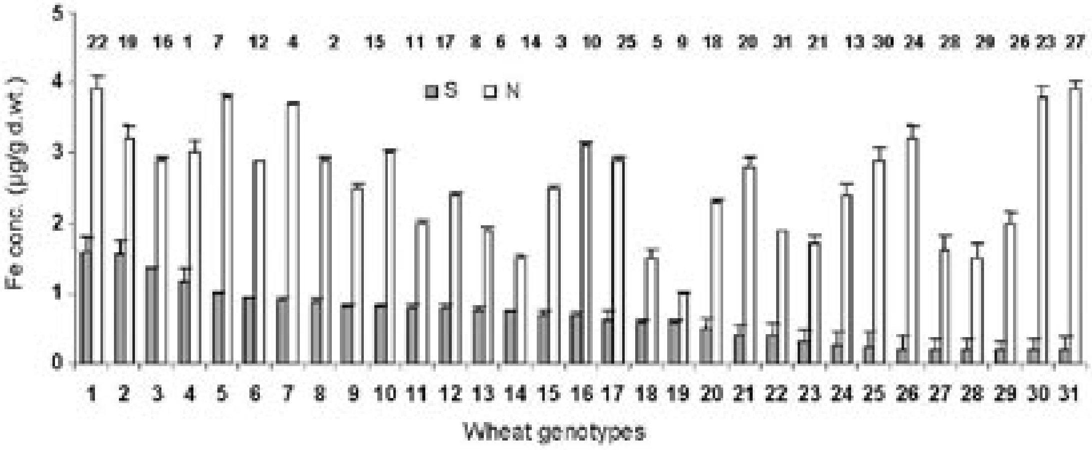

Figure1. Fe concentrations in different genotypes of wheat growing in saline (S) and non-saline (N) conditions. Number given above the bars indicate actual number as given in Table 1

Fe concentration are not significantly different (Figure 3) however, Fe/Zn concentration increased under salinity (Figure 4).

DISCUSSION

Micronutrient malnutrition currently affects over 2 billion people worldwide especially in developing countries. Wheat and wheat based products are mostly consumed as the major stable food in these countries. If they contain low level of micronutrients like Zn the Fe their consumption will result in poor dietary value and consequently poor health. In the present study we have tested a range of genetically diverse wheat genotypes under saline and non-saline soils. We have observed variation for Fe and Zn concentrations in the range of 1.0–3.9 and 1.5–3.5 µg/g dry seed respectively under normal soils which is significantly lower compared to the values reported in wheat for these two vital elements by different groups. For example, Gregorio (2002) reported higher values (28.8–56.5µg/g dry seed) for Fe and (25.2 to 53.3 µg/g dry seed) for Zn and believed that there is a significant component of genotype × environment interaction in studies of Fe and Zn nevertheless, the genetic component of accumulation of Fe and Zn is stronger than the environment and can be exploited for improvement of micronutrient ceiling of wheat varieties. The lower values observed in the present study could possibly be due to strong genotype × environment interaction, evident from the value Fe and Zn observed in the material from CIMMYT. We are not sure whether this particular material was studied by Gregorio (2002), but all the CIMMYT germplasmshowed values in the range of 24–61 and

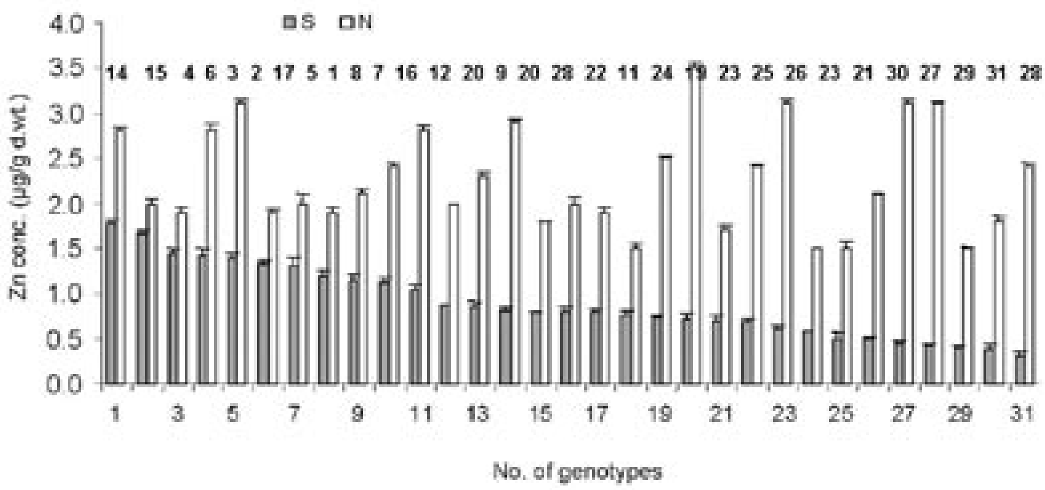

Figure 2. Zn concentrations in different genotypes of wheat growing in saline (S) and non-saline (N) conditions (Number given above the bars indicate actual numbers as given in Table 1)

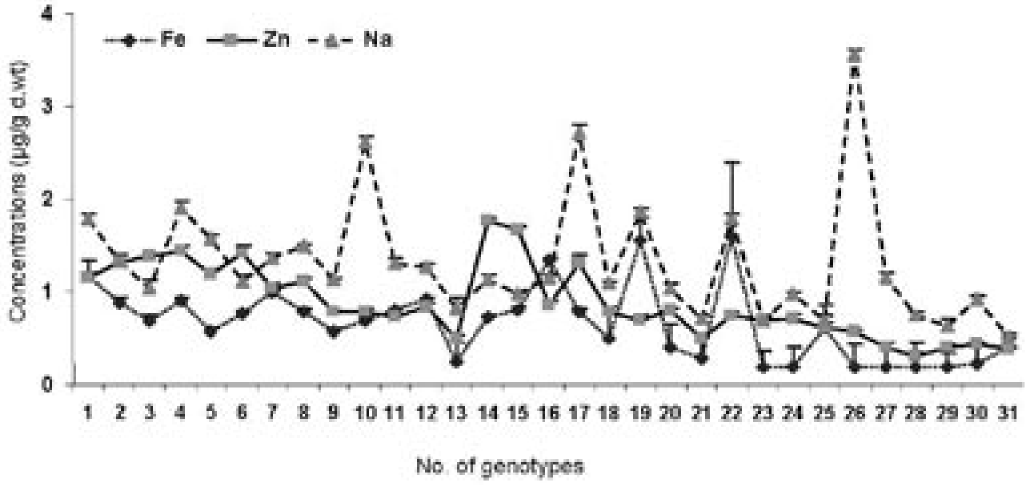

Figure 3. Comparative values of Fe, Zn and Na in different genotypes of wheat growing under saline condition

13–68 µg/g dry seed for Fe and Zn, respectively, the observed lower values can only be due to strong G × E interaction which also believe to be stronger than the genetic component (Cakmak *et al.* 2000). Secondly it could be due to sandy loam texture with low organic matter in our soils (< 2%), which may have affected the availability of micronutrient as reported by McKenzie (2001).

Salinity further reduces Fe and Zn concentration to 0.37–1.85 and 0.25–1.76 µg/g dry, respectively in all the germplasm possibly due to high pH (6.5–9) of saline soils on which the material was planted because the mobility of Zn is particularly restricted in alkaline soil (Grimme 1968) with severe retardation of Zn in wheat growing under alkaline soil being already reported (Chaudhary & Loneragan 1970). Similarly, Fe availability decreases in soil with high pH (O'Conner *et al*. 1971). Despite this Fe concentration under saline conditions was observed in the range of 0.37–1.85 µg/g dry seeds which mean that some of the material possesses the ability to secrete phyto-sidero-phore. Since this secretion and its ability to mobilize Fe is independent of pH in the range of 4–8 (Takagi 1976), hence some of the genotypes can take up Fe from the soil, which is indicated at various concentrations in the germplasm studied presently.

CONCLUSION

Genetically diverse wheat material tested in the present study under normal and saline conditions clearly indicated reduction in two most vital elements in the wheat grains obtained from saline

Figure4. Fe/Zn ratio in different wheat types growing under saline (S) and non-saline (N) conditions

or saline sodic soils. The consumption of such grains as staple diet, will eventually affect the nutritional status of the population dependent on such crop and will increase malnutrition. In the world of 800 million undernourished people, Pakistan is sharing 26.3 million people that are 19% of her population especially those residing in the rural areas (where poor people can not afford any supplementary diet) and the trend is on the rising side. This rising trend can be stabilized or reduced further if attention is paid to the wheat harvest that we obtained form the saline areas: 60% of which is under wheat cultivation.

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