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EVALUATION OF ZN DISTRIBUTION AMONG GRAIN AND STRAW OF TWELVE INDIGENOUS WHEAT (*TRITICUM AESTIVUM* L.) GENOTYPES

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Abstract

Zinc (Zn) deficiency is widespread in wheat grown on alkaline calcareous soils. A large population of the world as result of this also lacks adequate Zn nutrition. A pot study was conducted on Pindorian series *(Udic Haplustalf*) to evaluate the distribution of Zn in grain and straw of 12 indigenous wheat genotypes. Zinc was applied @ 6mg Zn kg^{-1} soil as $ZnSO_4.7H_2O$. Various fertilizer doses were imposed in triplicate according to complete randomized design. All 72 pots received uniform dose of 60 mg N kg^{-1} soil as urea, 60 mg P kg^{-1} as monoammonium phosphate and 30 mg K kg^{-1} soil as K_2SO_4. Plant tops were harvested 30 days after sowing. There was a significant ($P<0.05$) main and interactive effect of wheat genotypes and zinc application on grain and straw yield, Zn concentration and total uptake of Zn by wheat plants. Sehar-06 produced maximum grain and straw yield whereas Iqbal-2000 produced minimum grain and straw yield. The genotypes Sehar-06, Shafaq-06 and SARC-1 were able to retain more Zn in grain compared to straw. However, further verification of the results is warranted under field conditions.

Introduction

Wheat is an important staple food crop of the entire world as well as Pakistan. But the average yield of wheat is low due to many factors. Nutrient deficiency is one of the important factors. The universal deficiency of nitrogen and phosphorus is followed by Zn deficiency. Almost 50% of the world soils used for cereal production are Zn deficient (Gibbson, 2006). As a result, approximately 2 billion people suffer from Zn deficiency all over the world. Bhutta *et al*., (1999) have reported Zn deficiency in Pakistan in children less than five years of age and women of reproductive age. Low soil Zn is attributed to a number of soil and environmental factors including low soil organic matter, high soil pH, calcareousness, water logging and arid climate (Cakmak, 1998; Tandon, 1995; Mortvedt, 1991). Several approaches have been investigated to overcome the common problem of Zn deficiency. These include Zn supplementation, food diversification as well as food fortification. Increasing the Zn content of food crops can be a good strategy to overcome its deficiency in people of developing countries. The Zn content of crops can be increased *via* Zn fertilization but the resource poor farmers are unable to bear the relatively high cost of Zn fertilizers.

Like many other crop species, wheat genotypes possess great variation in their Zn acquisition and utilization (Oikeh *et al.*, 2003; Banziger & Long, 2000). Most studies emphasize on the effect of Zn application on vegetative growth and grain production and not on the Zn status in grain. The objective of the present study was to compare the response of 12 indigenous wheat genotypes to Zn deficiency on a calcareous soil and to estimate the Zn status in grain.

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Materials and Methods

Soil: Bulk surface soil sample (0-15 cm) was collected for Pindorian series (*Udic Haplustalf*). The sample was air-dried and ground to pass through a 2 mm sieve. A portion of the prepared soil sample was analyzed for various physico-chemical properties. Soil had pH 7.36 which was measured in 1: 1 soil: water suspension by calomel glass electrode assembly by using a Beckman pH meter. Soil texture determined by hydrometer method was sandy loam (Gee & Bauder, 1982). Organic matter content in the soil sample was 1.66 % according to Walkley-Black method (Nelson & Sommer, 1982). Free lime was 1.5% which was estimated by acid dissolution (Allison & Moodie, 1965). Plant available Zn in the soil was 0.75 mg kg^{-1} which was extracted with 0.005 M DTPA (Lindsay & Norvell, 1978) and determined by atomic absorption spectrophotometer.

Pot study: Five kilogram of thoroughly mixed soil was filled each in 72 polyethylene lined plastic pots. Thirty mg N kg^{-1} soil as urea, 45 mg P kg^{-1} soil as monoammonium phosphate (MAP) and 30 mg K kg^{-1} soil as K_2SO_4 was applied uniformly to all pots in solution form. Two rates of Zn (0, 6 mg Zn kg^{-1} soil) were applied as $ZnSO_4.7H_2O$ in solution form. Before planting, soil in all the pots was moistened with distilled water, dried and thoroughly mixed for equilibration. The pots were arranged according to a completely randomized design in the green house (Steel & Torrie, 1980). During the experimental period, the average temperatures in the green house were 20±5˚C at different times of the day and 12± 3 ˚C during the night. Light intensity varied from 300 to 1400 µmol photon m^{-2} s^{-1} and relative humidity varied from 35% (midday) to 85 % (midnight). Eight seeds of each of the 12 wheat genotypes were sown per pot. After germination two plants per pot were allowed to grow. Distilled water was used to maintain moisture contents at field capacity in all the pots during the experimental period. Two weeks after sowing, a second dose of 30 mg N kg^{-1} soil as urea and 15 mg P kg^{-1} soil as MAP were applied uniformly to all pots in solution form. Plant were harvested at maturity, washed with distilled water and blotted dried with tissue paper. The grains were separated from the straw. The straw samples were air-dried and then oven-dried at 70 ˚C to a constant weight for dry matter yield in a forced air oven. The straw and grain samples were then finely ground with a Wiley mill fitted with a stainless steel chamber and blades. A portion of finely ground plant and grain samples was digested in a diacid (HNO_3:$HClO_4$) mixture. The Zn concentration in the digest was estimated by atomic absorption spectrophotometer.

The data obtained for straw yield, grain yield, Zn concentration and its uptake by wheat plants were statistically analyzed using Microsoft Excel and MSTAT-C computer software (Russell & Eisensmith, 1983).

Results

The wheat genotypes produced significantly (P<0.01) different grain yield. The sandy loam soil had marginally available DTPA extractable Zn up to 0.75 mg kg^{-1}. The application of Zn therefore had a significant (P<0.05) effect on grain yield (Table 1). Maximum grain yield was produced by Sehar-06 and minimum by Iqbal-2000 by Zn application and also under control treatment. Overall there was a 9.5% increase in grain production when Zn was applied. There was a significant effect (P<0.05) of zinc application on straw production of wheat genotypes over control (Table 1). Under adequate Zn supply maximum straw was produced by Sehar-06 (15.83g) and minimum was produced by Iqbal-2000 (11.23 g).

There was a significant effect ($P<0.05$) of wheat genotypes and Zn application on the grain to straw ratio. Grain to straw ratio ranged between 1.4 to 0.78. Yaqora, Sehar-06 and Auqab-2000 had a higher grain to straw ratio compared to other genotypes.

Zinc concentration and uptake: There was a significant ($P<0.05$) main and interactive effect of different wheat genotypes and Zn application on concentration and uptake of Zn in wheat grain and straw (Table 2). Zinc concentration in wheat straw ranged from 29.80 to 51.22 µg g^{-1}. An 18.1% increase in straw Zn concentration was observed by Zn application. Both under control and adequate Zn supply, Zn uptake was maximum in Sehar-6 and minimum in Iqbal-2000. There was a significant ($P<0.05$) main and interactive effect of wheat genotypes and Zn application on the grain Zn concentration and uptake (Table 2). Zinc concentration in wheat grain ranged from 34.9 to 69.93 µg g^{-1}. Maximum grain Zn uptake was observed by Shafaq-06 under adequate Zn supply and by Sehar-06 under deficient Zn supply.

Discussion

The genotypes exhibited wide variation for straw as well as grain biomass production. Aycicek & Yildirim, 2006 also reported differences in grain yield and yield components in different wheat genotypes. Cakmak *et al*., (1998) and Hoffland *et al*., (2006) reported that by Zn addition to the root medium, straw production in different crops increases. They correlated genotypic variation of crop plants to their tolerance to low Zn availability in soil. The genotypes Shafaq-06, Sehar-06 and SARC-1 showed an overall increase in grain production by Zn application over control compared to increase in straw production (Fig. 1). This attribute is an important parameter in improving nutrient content of the edible parts of plants. Total Zn uptake both in grain and straw ranged from 975.23 to 351.24 µg $plant^{-1}$. Wheat grains are mostly used for human consumption. A 48.3 to 62.2% of Zn was stored in grains.

Zinc contents in straw and grain is an important parameter indicating the relative acquisition efficiencies of these genotypes from a Zn deficient soil. Efficient genotypes such as Sehar-06, Shafaq-06 and Inqalab-91 accumulated more Zn even under deficient soil Zn conditions. Zinc use efficiency is the amount of dry matter produced per unit of Zn absorbed (Siddiqui & Glass, 1981). Present results also indicated significant differences in wheat genotypes for Zn utilization efficiency. Zinc use efficiency was positively correlated with dry matter production (Fig. 2). Differences in Zn use efficiency have been reported in various crops such as wheat, rye, barley, oats (Cakmak *et al*., 1998) and cotton (Shukla & Raj, 1987).

Relative reduction in shoot dry matter (SDM) or Zn stress factor (ZnSF) is a useful parameter in assessing relative tolerance of crop genotypes to Zn deficiency (Babikar, 1986; Yaseen, *et al*., 2000; Irshad *et al*., 2004). Significant differences for ZnSF (Fig. 3) were exhibited among wheat genotypes. The maximum relative reduction in SDM (%) due to Zn deficiency was exhibited by Inqalab-91 (16.5 %) while As-2002 and Bhakar-2000 showed negligible reduction in SDM.

Conclusion

Useful genetic variations existed among wheat genotypes for Zn acquisition and its utilization to produce biomass. Cultivars efficient in Zn acquisition and utilization (Sehar-06, Shafaq-06 and Inqalab-91) showed more growth than inefficient cultivars. Efficient cultivars also translocated more Zn from the straw to the grains. Nevertheless verification of the results is needed under field conditions.

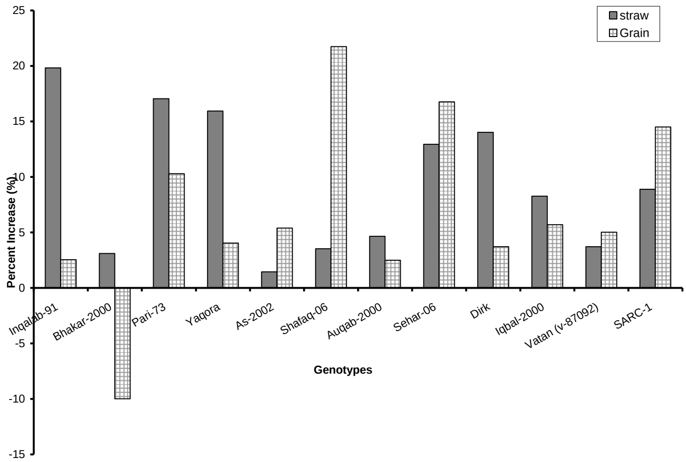

Fig. 1. Percent increase (%) over control by Zn application in straw and grain yield of 12 wheat genotype.

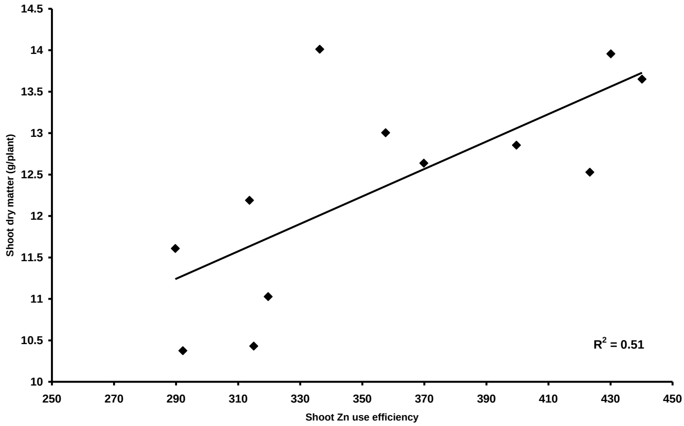

Fig. 2. Correlation between shoot dry matter and Zn use efficiency of wheat genotypes.

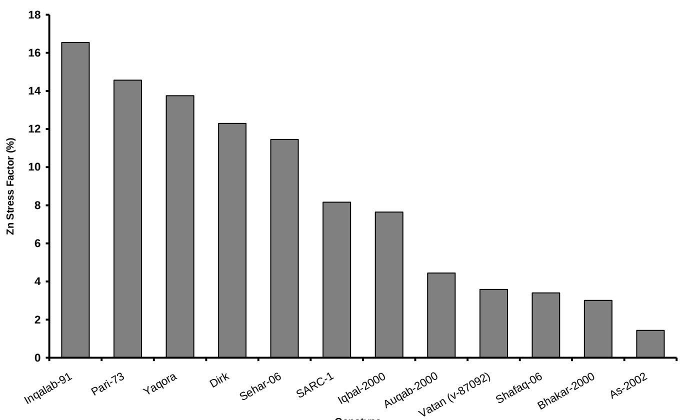

Fig. 3. Relative reduction in shoot dry matter (ZnSF%) in 12 wheat genotypes due to Zn deficiency.

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