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SHORT COMMUNICATION

EFFECT OF HEAVY METAL FERTILIZATION ON GROWTH, YIELD AND METAL DISTRIBUTION IN WHEAT

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In the present study the effect of different heavy metal salts on the growth, yield and metal accumulaton pattern of wheat (*T. aestivum*) cv. HD 2285 was examined. The studies revealed that application of heavy metals in soil before sowing caused varying extent of reduction in yields of wheat. Mercury caused maximum reduction in biological as well as economic yields followed by copper, lead and cadmium, while zinc did not affect the growth and grain yield of wheat markedly. The number of spikes/pot and grains/spike were reduced, while 1000 grain weight increased significantly by the application of copper, lead and cadmium in soil. The heavy metal stress, however did not affect the harvest index of wheat plants. The content of all the tested metals increased both in straw and grain by their application in soil, but their accumulation was much higher in vegetative shoots (straw) than in reproductive shoot (grain). However, zinc registered higher content in grain than in straw of wheat plants. The content of metals in wheat shoots was in the order of Zn > Cu > Cd .> Pb. The larger proportion of both essential (Cu) and toxic metals (Pb and Cd) absorbed by wheat plants thus remained in straw and a small proportion of the same only transported to edible part (grains).

Key words: **Biological yield, economic yield, harvest index, translocation.**

Heavy metal contamination of different crops following their cultivation on metal contaminated soil of peri-urban lands have become a major concern today, as these crops are said to be the major source of heavy metal contamination of human beings through various food chains. Several industrial, vehicular and agricultural activities contribute to heavy metal contamination of agricultural lands in peri-urban areas (Allinson and Dzialo 1981, Barman *et al.* 2000, Rattan *et al*. 2002). When these toxic metals (lead, cadmium nickel, mercury) are present in soil at very high levels and absorbed by the food and fodder crops, they not only hamper their growth, productivity and quality, but also cause health hazards in human beings through their consumption (Hall 1972, Aery and Sarkar 1991, Cheng 2003). Various crop species showed differential growth, yield and metal distribution response to heavy metal stress (Allinson and Dzialo 1981, Aery and Jagetiya 1997, Barman *et al*. 2000). Since wheat is a very important crop and occupies large area of peri-urban lands, which are generally contaminated with heavy metals (Rattan *et al*. 2002, Kumar 2004), it is necessary to examine the effect of heavy metals on productivity and their distribution in edible and non-edible parts of wheat plants. The present study attempts to examine the effect of different heavy metals application in soil on growth, yield and metal accumulation pattern in straw and grain of wheat plants.

Wheat cv. HD 2285 was grown in pots amended with different heavy metals separately. Earthen pots of 30x30x30 cm size were filled with 8 kg of soil thoroughly mixed with different heavy metals viz., Cu, Zn, Pb, Cd and Hg @ 100 mg/kg soil separately in the form of $CuSO_4$, $ZnSO_4$, $PbNO_3$, $CdNO_3$ and $HgSO_4$

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respectively. Control pots were maintained without adding any metal salt. All the treatments including control had four replications. All the metal treated pots including control ones received equal dose of NPK nutrients at their recommended schedules of application to maintain normal growth and development of wheat plants. After watering and soil preparation, equal number of seeds of wheat cv., HD 2285 were sown in each pot including control ones. The soil used under the experiment was neutral in pH (6.8) and poor in organic carbon content (0.3 %). Normal agronomic practices were followed throughout the growing period of wheat. Plants were harvested at maturity and yield parameters were recorded. After harvesting, grains and straw were ground to fine powder in grinder for their metal analysis. The dry powder of straw and grain of all the treatments were digested in nitric and perchloric acid mixture (9:4) following Singh *et al.* (1999). After digestion, filtration and makeup of final volume, the concentration of Cu, Zn, Pb and Cd were determined by atomic absorption spectrophotometer.

In general, amendment of soil with heavy metals (Cu, Pb, Cd, Hg) caused varying extent of reduction in grain yield (9-22%) owing to marked reduction in the number of spike/pot (6-16 %), grains/spike (4-24 %) and biological yield (2-20%) without affecting the harvest index. Thousand grain weight, however, increased (5-10%) by metal application in soil. Among the metals, Hg and Cu caused maximum degree of reduction both in economic and biological yields followed by Pb and Cd. Application of Zn, an essential plant micronutrient, however did not show any detrimental effect on economic as well as biological yields of wheat plants, although it reduced the number of spikes/pot but enhanced the number of grains/spike and 1000 grain weight over control plants. Cu, despite being an essential element of plant, showed detrimental effect on growth and yield of wheat, which may perhaps be due to its negative effect on growth of wheat plants at higher dose of application. Among the non-essential toxic metals, Hg showed more deleterious effect on grain yield compared to Pb and Cd mainly through marked reduction in the number spikes/pot (13 %) and grains/spike (16 %) (Fig.1). However, none of the metal applied in soil affected the harvest index of the wheat plants markedly. Significant reduction

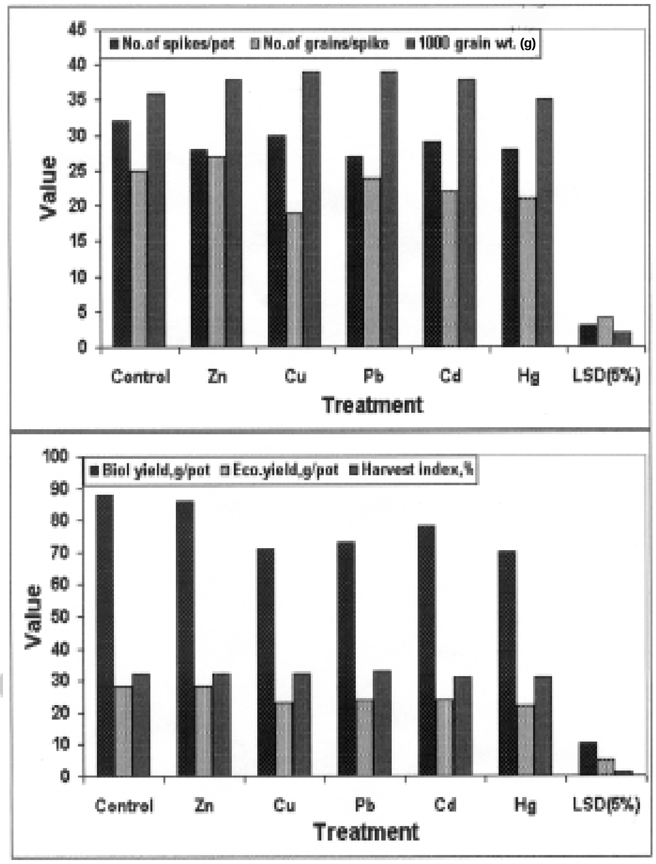

Fig. 1. Effect of heavy metal stress on growth and yield components of wheat.

in ryegrass and oat seed yield by the application of Cd and marked increase in the same following the application of Pb at 250 ppm in soil was reported by Allension and Dzialo (1981). An increase in dry matter production by low level of Pb and Zn, and marked decrease in the same by high level of these metals in barley have been reported by Arey and Jagatiya (1997). The deleterious effect of heavy metals especially non-essential ones (Pb, Cd and Hg) on wheat growth and yield under present study might be due to metallic suppression of metabolism at cellular and sub-cellular levels in wheat plants at their excessive level. These elements, however failed to show any metal toxicity symptoms in wheat plants, as most of the non-essential heavy metals are absorbed by the plants but are generally dumped into vacuoles or in cell wall in order to make them physiologically inactive or non-functional (Ernst 1976). Greater stability in harvest index under metal fertilized soil indicates that metallic effect was almost similar on vegetative and reproductive shoots growth.

Application of heavy metals (Cu, Zn, Pb and Cd) in soil enhanced their level both in vegetative shoots (straw) and grain of wheat plants markedly. The level of metals both in straw and grain was found in the order of Zn> Cu> Cd> Pb. However, the extent of increase in the content of metals in wheat plants under metals treated soil was recorded to be highest for Cd followed by Pb, Cu and Zn. The concentration of metals was invariably higher in straw than in grain except Zn, which manifested its higher level in grain than in straw (Fig. 2). The level of Zn and Cd in straw as well as grain exceeded their safe limits when applied in soil, but Cu and Pb levels did not exceed their safe limits following their soil amendment. Although the biological yield of wheat plant reduced drastically by the application of metals in the soil, but their uptake in straw and grain was apparently higher in metal applied soil than in control (Fig. 3). It is interesting to note that large proportion (85-90 %) of Cu, Pb and Cd absorbed by the wheat plants remained in the vegetative shoots (straw), and only a small proportion of Cu (10%), Pb (13 %) and Cd (15 %) translocated to the wheat grains (Fig. 4). However, 33% of Zn absorbed by the wheat plants was transported to grain and 67 % remained in the straw (Fig. 4). Although the accumulation of Zn and Cd in plant tissues above their permissible limits did not show any metal toxicity symptoms in wheat plants throughout their growing period, but their accumulation in wheat shoots (stem and leaves) at varying levels caused marked reduction in their growth and yield.

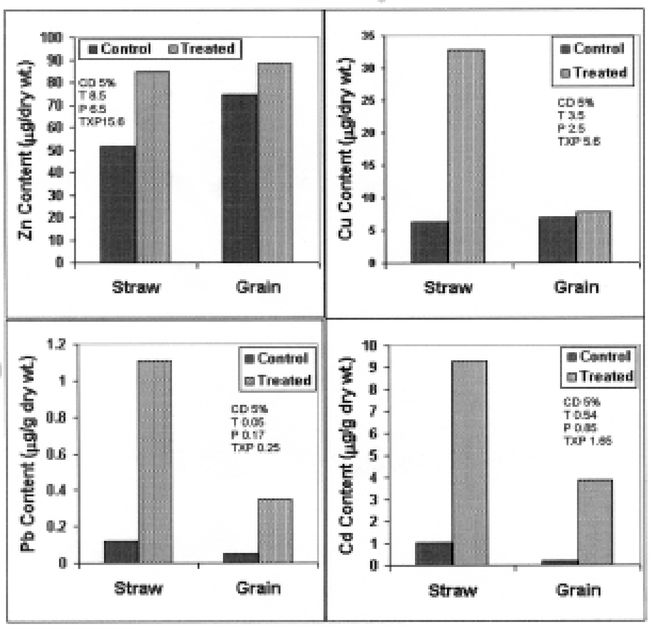

Fig. 2. Heavy metal content in straw and grain of control and treated wheat plant
Safe limit: Cu (30 µg/g dry wt.); Zn (50 µg/g dry wt.); Pb (2.5 µg/g dry wt.); Cd (1.5 µg/g dry wt.)

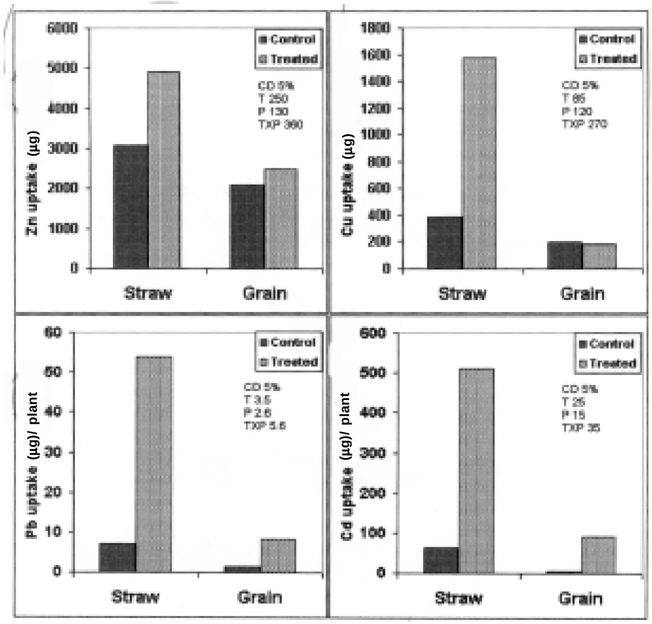

Fig. 3. Heavy metal uptake by straw and grain of wheat plant

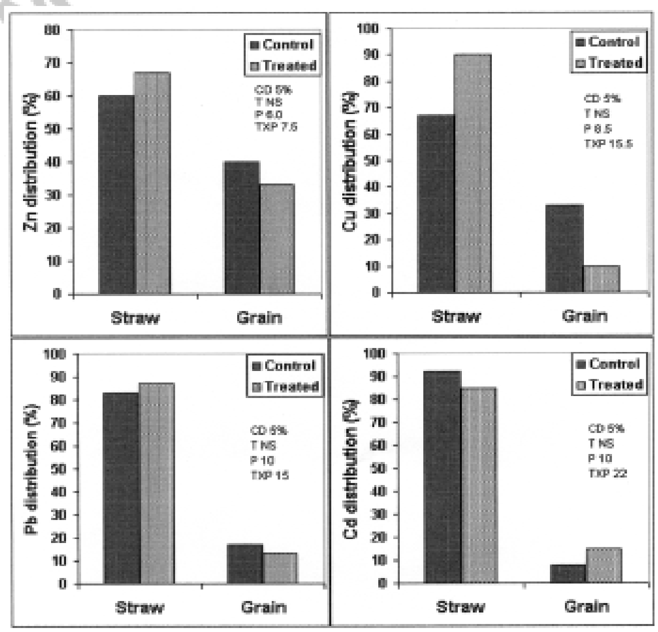

Fig. 4. Metal distribution pattern in straw and grain of wheat plant

Increased tissue concentration of Cd, Pb and Ni in ryegrass and oat by their soil application was reported by Allinson and Dzialo (1981). Several researchers (Barman *et al*. 2000, Hooda and Alloway 1996, Rattan *et al*. 2002, Wang *et al*. 2003) reported heavy metal accumulation in different parts of various crop species when grown on metal contaminated soils in peri-urban areas. Very low concentration of copper and lead in wheat grains under the present study was also reported by Allinson and Dzialo (1981) in oat grain and Iretskaya and Chien (1998) in some fruit vegetables and this may possibly be due to their poor mobility compared to zinc and cadmium in the plants. The greater accumulation of zinc in wheat grain than in straw under present study is in agreement with the similar findings of Ernst (1976) and Barman *et al.* (2000). Greater proportion of translocation of zinc from vegetative shoots to grains in wheat might be due to its metabolic requirement for the synthesis of auxin (IAA) in the apical meristem (spike) for grain growth and development.

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