Zinc is one of the most important nutrients amongst the trace elements. As early as in 1903 it was felt that green plants are benefited by Zinc and later on it was established that Zinc is absolutely essential for the growth and development of green plants. (Adriano, 1986).

Singh (1967) reported that number of physiological diseases of plants have been listed due to deficiency of Zinc. The most important of these are "mottle leaf", "Little Leaf", "Yellows" or "Rosette" in fruit trees; formation of many abnormally small rosettes, mottled leaves with small size, malformed fruit on branches which show die back. Zinc is also involved in the
uptake of nutrient from the growth medium and thus helps in nitrogen metabolism like protein synthesis (Singh, 1967).

Tripathi and Gaur (2004) suggested that Zinc with Copper helps in various enzymatic activity. However, at higher concentrations, essential trace metals like Zinc become toxic. Metals usually considered to be toxic at "Physiological dose" may be stimulatory or essential in very minute doses depending upon the environment and state of the organism. (Marschner, 1993).

Zinc is produced and consumed in five major forms; metal, chloride, dust, oxide and sulphate. The electrochemistry of Zinc is such that it corrodes sacrificially to steel; in the galvanizing process, steel is coated with a thin layer of Zinc, which corrodes instead of the steel and is itself lost into irrecoverable chemicals in the process. Galvanizing is applied to sheet and strip, wire and wire rope, tube and pipe, tanks and containers, structural components, nails, bolts, fencing and netting and vehicle undercoating. The same chemical properties make zinc suitable for use as anodes to protect ships' hulls, oil rigs, pylons and all forms of submerged or buried steel work. Other important applications include dye casting of items ranging from automotive components to toys and models in alloys containing around 96% Zinc.

Zinc dust is essentially finely divided zinc metal whose appearance, typically bluish grey, depends on particle size and on the state of surface
oxidation. Zinc dust is produced by distillation from high grade scarp or galvanizers' dross, evaporated and condensed in large vessels. It contains 98.5% to 99.5% Zinc, 0.05% to 0.15% lead (In some cases upto 0.25%) and 0.02% to 0.10% cadmium. It is used in chemical reduction processes, where its high surface area/volume ratio increases reaction rates.

Zinc oxide is used in products, such as rubber and paints. Other dissipative uses are dyes and inks, paint pigments, wood preservatives, fungicides, pharmaceuticals, electronics. Oil additives and welding fluxes. Zinc chloride is used as a tinning and soldering flux, in dry battery cells and as wood preservative. Zinc sulphate is used in textiles, in chemical manufacture as plant micronutrient and in mineral processing.

Zinc is also an essential micronutrient and is generally regarded as one of the less hazardous elements, though its toxicity may be enhanced by the presence of arsenic, lead, cadmium and antimony, as impurities. Toxic effects have been observed from the inhalation of fumes from galvanizing baths. The 'zinc fever' is characterized by chills, fever, nausea, vomiting and diarrhea. Removal of the subjects from the fumes leads to complete recovery. Zinc chloride fumes have sometimes caused fatal oedema of the lungs. Zinc or galvanized containers are not recommended for food storage but are acceptable for storing drinking water. This is because acidic foods can dissolve enough zinc from the container to cause poisoning. A factor which serves to minimize the risk of zinc poisoning is that it appears to be lost along food chains, unlike methyl mercury or cadmium. Long term
exposure to high zinc intakes substantially in excess of requirements has been shown to result in interference with the metabolism of other trace elements. Copper utilization is especially sensitive to an excess of zinc. This copper/zinc interaction has been responsible for the inadvertent induction of copper deficiency.

Zinc, is a divalent heavy metal with saturated and orbitals favours tetrahedral coordination for stable metals enzyme complexes and thereby regulate the various processes of cell metabolism. Being an integral part of 200 DNA binding proteins, it plays a crucial role in gene expression and is an attraction for the genetic engineers as well as environmental biotechnologists (Vallee, 1992; Meenakshi and Singh, 2007).

Thus, present investigations done on three cereals belonging to the largest monocot family Poaceae (Gramineae).

Rice (*Oryza sativa*) is the premier food crop, contributing to 73% of total calories intake of world’s population. Likewise wheat (*Triticum aestivum*) considered as the “King of Cereals” and is a major cereal crop of India. India is the second largest wheat growing country in the world after China. In the same manner maize (*Zea mays*) accounts 18% of the world cereal heatarage and around 25% of the world cereal production. Thus, wheat, rice and maize are one of the three most important cereal crops in the world.
Therefore, it was of the interest to work on these plants and observe the effect of zinc.

Thus, on the basis of available literature as given earlier and previous work done by various workers. The present work done on the following lines with Rice, Wheat and Maize plants.

1. Effects of different concentrations of Zinc on seed germination, seedling growth and dry matter transfer in certain cereals in dark as well as in light.

2. Effects of different concentrations of Zinc on adult plant growth and yield of above three cereals.

3. Effect of Zinc on the uptake and distribution of total N, total p during seedling growth & also during further adult growth in above 3 cereals.

4. Effects of Zinc on the uptake and distribution of total heavy metal in adult plant growth (with emphasis on edible plant parts) in materials and soil samples selected from above studies in three cereals.

Above studies have resulted the following conclusions:

1. There is general retardation at higher concentration of Zinc on seed germination and seedling growth of certain cereals. Similar inhibition in seed germination and seedling growth was also observed by Pundir, 1995; Ward Neil et al., 1977 and Jenny, 1962. Thus, in lower concentration of Zinc, the dry matter increase in seedling parts is induced with simultaneous increase in dry matter.
transfers/loss from cotyledons. Further, in higher concentration of Zinc, the dry weight increase in seedling parts is suppressed with simultaneous decrease in dry matter transfer/loss from the cotyledon to different parts studied (Hompkins and Blinn, 1976; Tandon, 1982 and waly, 1987).

2. Result shows that cereal crop responds to 50 mg/kg Zinc amended soil. Result shows less growth and yield at higher concentration (50 mg/kg Zn amendment soil). However, organ specific and crop based difference in response to Zinc concentration are well marked (Akeson and Munns, 1990; Bhargava, 1987, 1989; Azad et al. 1984; Banerji and Kumar, 1979; Vara and Donneberg, 1979; Bowen, 1969; Broyer, 1961 and Burstrom, 1961).

3. Total N, Total P uptake and distribution in seedling parts and also in adult plant is nearly similar to dry weight changes in plants studied. Observation shows that total N, total P levels on per organ basis are inhibited in higher concentration of Zinc soaked sets and promoted in lower concentration of Zinc soaked seeds.

4. The data on total N, total P on unit weight basis show increased level in Zinc treated sets as compared to control sets. Thus, the promotion and inhibition of total N, total P levels of the seedling part as shown by data on per organ basis is a consequence of promoted and inhibited growth rather than its cause.

5. Total heavy metal uptake and distribution during adult growth of above three cereals, showed heavy metal uptake rates are increased in plant in presence of Zinc amended soil. Thus, uptake being more
at higher concentration i.e. 50 mg/kg Zinc soil amendment. Further, the plant containing soil of the pots with zinc in general were found to contain more amount of total heavy metal than the soils of the pots without zinc, this indicates uptake of total heavy metals from the Zinc treated soil by crop plants. Thus, it is possible that out of several factors, responsible for the reduced growth in the presence of higher concentration of Zinc it might be an increased uptake of heavy metals which probably interfere with the growth mechanism (Ravindran et al., 1986; Arora, 1985; Wong et al., 1982; William et al., 1979 and Parik, et al., 1977).

Above findings are discussed in the following sections:

Observation in response to different concentration of Zinc in our experiments are comparable with the finding of several workers. Pundir, 1995; Agarwal, 1989; Bhargava and Singh, 1982; Banerji and Kumar, 1979.

Our observations of promotion and inhibition of seed germination and seedling growth in cereals are also in agreement with the finding of Kunmar, 1981; Sahai et al., 1983; Singh and Bhargava, 1984; Singh, 1986; Verma, 1993; Pundir, 1995 and Suman, 1999. Similar finding of promotion and inhibition of seed germination and seedling growth of certain plants in presence of Zinc is also comparable with the result of Anderson and Nilson, 1976; Bhargava, 1987, 1989 and Poonam, 2001. Further, seedling growth is also in agreement with the finding of Kanwar, 1976; Juwarkar, et al. 1990. Results of our finding of promotion and inhibition at lower and higher
concentration of Zinc is also comparable with studies on several other industrial effluents; Andreson and Nilson, 1976; Azad et al., 1984; and Goel, 1992. Thus, present observations indicate that seedling growth is accelerated in lower Zinc concentration and is suppressed in higher concentration of Zinc.

Our findings of some differences on seed germination and seedling growth in light and dark could be due to different rate in certain metabolic activities. Palmiana and Juliano (1972) have shown in rice grains that when grain were germinated in dark, the breakdown of protein was not accompanied by immediate rise in soluble N level. Pickiring and Puia (1969) and Pinkertoin and Simpson (1977) also did nearly similar studies.

Similarly our findings of metabolic activities with these concentrations of Zinc can further be correlated with the work of Agarwal (1989); Bhargava (1983); Banerji and Kumar (1979). Excess supply of heavy metal decrease the enzymatic activity, thus lower the mobilization of reserve material from the cotyledon to the developing embryonic axis. Further, findings on the effects of higher concentration of Zinc on growth and yield indicate that higher concentration is inhibitory. Our findings, of plant growth parameters at higher concentration of Zinc are comparable with other studies made with industrial effluent (Goel, 1992; Gipps and Collar, 1980; Jain, 1980; Giordano and Mays, 1977). Our findings also matches with Kumar, 2000; Ruhina, 2000. Similarly, decrease in the yield of certain plants as observed in the present study at higher concentration of Zinc are in
accordance with the findings of several workers Smarrelli and Campbell, 1983; Bahrgava, 12987, 1989 and Bhargava, 1997.

The inhibitions of growth parameters and yield of plant as observed in the presence of higher concentration of Zinc are correlated with the work of Hirsch, 1992; Pohill et al., 1981; Patterson, 1976. Further, our observation of decreased growth of higher concentration of Zinc is also comparable with the finding of Bhargava, 1983 and Jawtarkar, et al., 1990. Porter and Sheridan (1987) reported that high concentration of heavy metal show statistically significant inhibition of nitrogen fixation in Medicago sativa. Thus, possible explanation to inhibition of growth may be that these metals like Zinc might be interfering with nitrogen metabolism or protein synthesis.

Our observations further reveal that dry weight of crop plant at yield stage in presence of higher concentration of Zinc is inhibition. These inhibition of dry of dry weight at yield stage matches with the work of Chahal et al (1979); Davis and Jekson (1975).

Present finding also shows that organ specific differences in response to Zinc correlated with the work of Foy, 1995; Foy and Weil, 1996. They stated that various plant species response differentially to concentration of metals in soil. Thus, the physiology of metal toxicity begins with increased metal supply through effluents to root and proceeds to a failure of a clearly defined essentially to life plant process.
Our observations on promotion and inhibition of total N and P levels during seedling growth and also in later adult plant growth in presence of zinc concentrations are also similar to several such findings (John, 1973; Johnson and Krutt, 1975; Coombs, 1980; Flanagan et al., 1980; Greszta, 1983; Jain, 1980; Singh, 1983; Bobby et al., 1986; Agarwal 1989; and Bhargava, 1987, 1989; Borovik, 1990; Hundal and Sandu, 1990; Kabatta and Brummer, 1994, Johnson, 1997 and pearce, 1999).

Similar inhibition of total N and P uptake also reported by several workers (Borovik, 1990; Sharma and Sobti, 1989; Bhargava, 1989; Goel, 1992; Shashi Kant, 1982; Sharma and Sharma, 1976 and Selwood, 1959.

Present finding also shows that total heavy metal contents, on unit weight basis of plant grown on soil with zinc concentrations, in all the crops studied are more than those grown on control soils. These findings reflect the differential accumulation pattern of total heavy metal and are in accordance with the work of Kabata and Brummer, (1994). Kim et al., 1978 also showed that with the increase in supply of total heavy metal concentration in nutrient solution and also in soil irrigation, the concentration of heavy metal in plant part also increases. Greszta (1983) reported differential accumulation rate in the tissue of maize. They found that maize generally show higher metal concentration in soil and also in plant part (Garty and Halgemeyer, 1988; Krishnan et al., 1988; Khummung Kol, 1987; Garty, 1987; Koepppe and Miler, 1977; Lutyrick et al., 1976 and Hagihiri, 1973).
Observations also reveal that total heavy metal contents per bag of soil does not decline much in blank set i.e. soil without plant and with Zinc. However, increase do not seems to be in proportion with added amount of Zinc and may be due to some leaching of heavy metal from the soil of blank sets. Ritter and Eastburn (1978) and Rasico (1977) demonstrated that hazardous amount of heavy metal generally get leached to the ground water. Further, studies of several workers have indicated three possible mechanism for heavy metal uptake; exchange adsorption, irreversible binding and diffusion. However, more work is needed to understand the uptake, translocation and distribution of heavy metals in plants (Rico, et al., 1989; Lag and Elskkory, 1978; Lager Werff and Milberg, 1978; Little and Martin, 1972; Osmond, 1968 and Page and Dainy, 1964.

Results obtained in our analysis of total N, P and heavy metal in presence of Zinc and its experimental concentration used in experiments are in accordance with the findings of several workers (Agarwal, et al., 1976; Antonov cs et al. 1971; Burmer et al., 1976; Fredman, 1972; Garcia et al., 1979; Goverdhana, 1989; Green, 1987, Hidefumi and Timura, 1979; Huckabee et al., 1983; Hundal et al., 1990; Jackman, 1965; Kardos et al., 1977 and Khan and Dandracea, 1989.

Heavy metals can inhibit a number of enzyme (Vallee and Ulmer, 1972). The action of heavy metals in protein hydrolysis appear to be two folds. Firstly, the proteins present in cotyledons may be denatured due to complexing of heavy metal with various groups of the proteins, thus making
them unsuitable for enzyme action. Secondly, the enzyme themselves may get affected. As mentioned earlier, the endopeptidases which have been shown to be responsible for protein hydrolysis during germination have - SH group in their active sites (Chrispees and Boulter, 1975). Heavy metals inhibit such enzymes with - SH groups, by complexing with these sulpha hydryl groups (Vimla, 1983). Thus, effects growth of plant.

The present work has clearly established the nutrient as well as hazardous nature of metal Zinc. Control of metal pollution seems to be a nearly difficult job. If somehow we are able to check all the industrial sources of metal pollution, it would not mean the problem has been solved. Metals which have already reached the environment will damage the ecosystem. These pollutant being non degradable with continue to be accumulated through food chain and thus in due course of time, will attain lethal concentrations. So, it is suggested that first of all some methods be devised to control further release of these pollutants from industries.

Trivedi and Gudekar (1983) used water hyacinth to purify and clear the digested industrial waste and also enhance the biological oxidation of the wastes. Apart from this, it increases the oxidation reduction potential, coagulate and remove turbidity and odour. Thus, possible approaches of control are –

(a) Checks be installed at the source in the from of effluent/emission filter
(b) Polluted areas be ‘cleaned’ through bioaccumulators;
(c) Heavy metals in effluents be recycled by recovering them from the ash of such bioaccumulators, thus, partly substituting for the ores.
PHOTO – 1  
Oryza sativa plant

PHOTO – 2  
Triticum aestivum plant
PHOTO – 3

Zea mays plant

PHOTO – 4

Wheat plants in Polythene begs.
PHOTO – 5  Rice plants in Polythene begs.

PHOTO – 6  Maize plants in Polythene begs.
PHOTO – 7  Germinating wheat seeds at 3rd day.

PHOTO – 8  Germinating wheat seeds at 5th day.
PHOTO – 9  Germinating wheat seeds at 7th day.

PHOTO – 10  Wheat crop in field irrigated with polluted water.
Distillation apparatus.

B.O.D. incubator.
PHOTO - 13  Oven used for drying material.

PHOTO - 14  Digestion process.