5. Conclusions

1) Cadmium at 10 μM concentration clearly exhibited toxicity to the plants assessed as oxidative stress to all the cellular components.

Zn showed an antagonistic interaction with Cd and alleviated Cd toxicity as:

2) Zinc inhibited Cd uptake directly by competition and indirectly by controlling \( \text{H}^+\text{ATPase} \) leading to a reduced intracellular concentration of Cd.

3) Zinc reduced Cd-increased peroxidation, membrane leakage and lipolysis, formation of reactive oxygen species triggered by Cd-influenced NADPH dependent oxidation.

4) Zn substantially increased the antioxidant enzymes activity SOD, CAT, POD, APX to a great extent effectively combating ROS.

5) Zinc exerted its influence considerably on the maintenance and cycling of the redox pool (AsA, GSH and -SH) of the cells through modulation of the ascorbate-glutathione cycle involving APX, MDHAR, DHAR and GR, enhanced GSH-PX and GST activity indicating enhanced detoxification of ROS.

6) The restoration and enhanced functioning of CA in Zn supplemented Cd treatments by competitive substitution of Cd by Zn in the impaired enzyme and the protection of enzyme conformation and properties by Zn conclusively prove the antagonistic nature of Zn towards Cd toxicity and the active role of Zn as a stabilizer of protein structure.

7) The studies on photochemical functions provide a clear picture of the protective role of Zn against structural and functional damage to plant chloroplasts.

8) Zinc supplements effectively prevented the oxidative damage to the DNA.

9) Amino acids as well as organic acids efficiently protected the plant from Cd toxicity adopting different routes of toxicity alleviation, amino acids being GSH-mediated and organic acids by chelation mechanism. Zn supplements in addition to amino and organic acids were influential in enhancing amino acid detoxification system but not organic acids.