SUMMARY

1. A review of literature pertaining to heavy metal stress in plants has been presented.
2. The materials used and procedures followed to carry out the experiments are discussed in details in materials and methods.
3. Okra [*Abelmoschus esculentus* (L.) Moench] seedlings of different cultivars (Arka Anamika, Deepti, Najuka-F1, Paras Soumya, PB-57 and Parbhani Kranti) were selected for the present study.
4. The four heavy metals cadmium nitrate 4-hydrate [$Cd(NO_3)_2\ 4H_20$], copper(II) sulphate-5-hydrate [$CuSO_45H_2O$], mercury(II) chloride [$HgCl_2$] and lead(II) nitrate [$Pb(NO_3)_2$] used in the present study were applied in the form of their respective salts at 100 and 1000 $\mu g\ ml^{-1}$ concentration.
5. In most of the cultivars 1000 $\mu g\ ml^{-1}$ treatments with the heavy metal salts inhibited germination significantly. After 72 h different cultivars exhibited germination between 77% (Parbhani Kranti) and 100% (Arka Anamika) in control.
6. The tolerance index of the different heavy metal treated okra plants showed a decreasing trend. Hg had the most deleterious effect in all the cultivars.
7. There was a marked decrease in the leaf area of the heavy metal treated plants. There was a general decline in most of the growth parameters after heavy metal treatment.
8. Relative growth rate decreased with heavy metal application in most of the cases.
9. The heavy metal treatments showed an inhibitory effect on the specific leaf area. The inhibition was maximum with Hg treatment in Deepti, Paras Soumya and Parbhani Kranti.

10. Highly significant decrease in yield was observed in all the treatments and cultivars after the heavy metal treatments.

11. The results of quantification of reducing sugar at different stages following heavy metal treatments revealed that in all stages there was an increase of reducing sugar, although there was a decrease in the total soluble sugar content. Starch contents in roots, stems and leaves of okra plants following heavy metal treatments also showed a decreasing trend.

12. Proline content of leaves of all six cultivars was determined after heavy metal treatments at seedling, vegetative and reproductive stages. In all treatments heavy metal induced accumulation of proline. However, 100 $\mu g\ ml^{-1}$ treatments induced comparatively higher accumulation than 1000 $\mu g\ ml^{-1}$.

13. Total chlorophyll content of the leaves showed a general decline following heavy metal treatments. Among all the heavy metals Hg reduced total chlorophyll content to the greatest degree in all the six cultivars. Decreases in almost all the treatments were statistically significant.

14. Heavy metal treatments significantly reduced the carotenoid contents in all the cultivars.

15. Protein contents of the leaves and roots of okra cultivars at seedling, vegetative and reproductive stages were determined for all treatments. Leaves of both seedling and vegetative stage had slightly higher protein content than reproductive stage. In the leaves heavy metal treatments mostly increased the protein content though not very significantly.

16. SDS-PAGE analysis of the heavy metal treated seed proteins revealed accumulation of few new proteins which again varied with the cultivar. Similarly, no significant changes were observed in leaves.

17. Activities of antioxidative enzymes in leaves of different cultivars of okra subjected to heavy metal treatments at 1000 $\mu g\ ml^{-1}$ of the salts were assayed. Catalase activities in all the cultivars subjected to heavy metal stresses

showed a decline.POX activity in all the cultivars was enhanced by the heavy metal treatments, though the degree of increase varied.All the heavy metal stresses enhanced activities of APOX and SOD in the different cultivars.

18. A significant increase in lipid peroxidation of leaves from treated plants in relation to control was observed. Cd induced maximum lipid peroxidation in three cultivars (Arka Anamika, Parbhani Kranti and PB-57) and Pb in two (Deepti and Najuka F1).

19. Influence of heavy metals on flavonoid accumulation in three cultivars (Arka Anamika, Deepti and Najuka-F1) of okra were analysed by HPLC. In case of Arka Anamika all treatments had 3 peaks whereas Pb had only 2 peaks. The second peak in control, Cd and Cu treatments were more or less similar but there was a decrease in the peak height in Hg and Pb treatments. The peak height decreased in relation to control in all the treatments except Hg. Peak height in Hg treatment was greater than that of control. Peaks obtained following Cd treatment were almost similar to that of control. Control had 4 peaks, Cd, Cu and Hg showed 3 peaks and only a single peak was observed in Pb treatment.

20. Accumulation of heavy metals in roots and fruits was determined. Traces of heavy metals were found in untreated control in all cases. Maximum deposition was observed in Cu and minimum in Cd treatments.

21. The microscopic studies of cross section of radicles of seedlings revealed some deposition in the intercellular spaces of cortical tissue. Changes in the shape of the cortical cells were also noticed.

22. In case of fruits, sections from both basal and middle portions revealed changes in accumulation as well as in the cellular structure.

23. Treatment with $CaCl_2$ and KNO_3 along with the heavy metals increased the germination to some extent which was however still lower than control.

24. It was observed that in seedling protein content increased to some extent following heavy metal stress. Treatment with $CaCl_2$ and KNO_3 in combination with heavy metals also increased the protein content.

25. Treatment with $CaCl_2$ and KNO_3 increased the antioxidant responses elicited by the heavy metal treatments.