Preface

Field studies were conducted from seed to seed to investigate the responses of Cowpea (*Vigna unguiculata* (L.) Walp.) and Bhindi (*Abelmoschus esculentus* (L.) Moench.) to sole application of different levels of Cd (100µM, 250µM, 500µM, 750µM and 1mM), Pb (100µM, 500µM, 1mM, 5mM and 10mM) and Mn (100µM, 500µM, 1mM, 5mM and 10mM). The plants were analyzed for morphological characters of root, stem, leaves, flowering and yield; growth parameters (growth coefficient, tolerance Indices, relative growth rate, total phytomass and net productivity); anatomical characters of root and stem; physiological features (leaf area and stomata); biochemical parameters (total protein and carbohydrate) and bioaccumulation of Mg, Fe, Cu, Zn, Mn, Cd and Pb in root, stem, leaves and fruits.

From the results obtained, it is evident that different morphological aspects of root, stem, leaves, flowers and fruits of cowpea and bhindi were positively affected by lower concentrations up to 100µM or 500µM in the case of Cd and Pb and up to 1mM in the case of Mn. Various levels of Cd sighted a steady retardation in growth of root and stem, they slowly adjust to overcome the stress condition at certain extent in both plants. Growth coefficient of stem in cowpea and root in bhindi was found to be more in lower concentrations of Pb. As the maturation proceeded, rate of growth per day was hindered in all treatments of Pb in these plants. Tolerance Indices (TI) were found to be decreasing with increasing concentrations of Cd, Pb and Mn in bhindi and Cd in cowpea. But TI displayed linear positive relationship with lower levels of Pb and Mn and negative relationship in their higher levels in cowpea. Relative Growth Rate (RGR) of root and stem was suppressed by Cd, Pb and Mn in cowpea. However, bhindi plants treated with Cd and Pb, the RGR decreased proportionately with the increase of the metal. The total phytomass was linearly diminishing in all Mn treated bhindi and Cd treated cowpea plants. In

the remaining studies, total phytomass increased in lower concentrations and decreased in higher concentrations of the metal. The anatomical parameters like breadth of secondary xylem core, number of secondary xylem vessels, width of secondary xylem vessel, number of secondary xylem groups and breadth of secondary phloem core of root and stem were significantly diminished by different treatments of Cd. Major differences were noticed in 1mM of Cd. Concentrations up to 1mM or 5mM of Pb and Mn promoted the studied anatomical parameters. Above these concentrations, both these metals considerably hampered all these parameters. Concomitant toxicity was seen in 10mM. An inhibitory effect in all Cd treatments was observed in the number of stomata, length and width of stomata and stomatal index. However a stimulatory effect at lower concentrations of Pb and Mn (it may be up to 1mM or 5mM in certain cases) was noticed in stomatal features, but it was inhibitory at10mM in both cases. Cadmium adversely affected the leaf area and total carbohydrate content. Total content of protein and carbohydrate increased due to Pb up to 500μM and Mn up to 100μM; in contrast inhibition was noted in 1, 5 and 10mM. Applications of Cd, Pb and Mn caused an increase in its concentration in root, stem, leaves and fruit. The highest storage of these metals was seen in fruits in both plants. The highest dose of Cadmium (1mM), Pb (10mM) and Mn (10mM) markedly blocked the uptake and translocation of Mg, Fe, Cu, Zn and Mn in root, stem and leaves. The relative toxicity of these studied metals are in the order of Cd> Pb >Mn.

Key Words: *Vigna unguiculata, Abelmoschus esculentus, growth coefficient, tolerance Indices, relative growth rate, phytomass, net productivity and bioaccumulation.*