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RESEARCH ARTICLE

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EFFECT OF MERCURY ON TOMATO GROWTH AND YIELD ATTRIBUTES

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ABSTRACT

In the present investigation, the seeds of (*Lycopersicon esculentum* Mill.) variety Pusa Ruby were used to evaluate as to what effect this heavy metal mercury would create on the vegetable crop plant at different stages of its growth and development. The heavy metal mercury does and duration of treatment at optimal and suitable level was finalized after trial experiments conducted by considering present germination and seedling growth. At lower concentration treatment showed enhanced percentage of germination, survival percentage, plant height, root length, early flowering more pollen viability, increase in total chlorophyll content. Apart from this metal analysis was also studied. Different yield components such as number of fruits / plant, fruit weight and fruit girth were under taken. The higher concentration of heavy metal mercury treatments showed inhibitory effect in general. The results were discussed in relation to treatment and concentration of heavy metal mercury.

KEYWORDS

Lycopersicon esculentum, Mercury, Seed germination and Metal analysis.

INTRODUCTION

Heavy metals are important environmental pollutants. Their presence in the atmosphere, soil and water even in trace concentrations can cause serious problems to all living beings. Heavy metals are integral components of ecosystem. The characteristics feature of heavy metal is poisoning and resulting in the inactivation of enzyme systems. All heavy metals are potentially toxic at elevated concentrations[1]. Although heavy metals form an essential part of human and plant nutrition, but their higher levels of plants uptake cause carcinogenic and mutagenic effects[2]. The ions present in the soil and atmosphere may enter plant either by their root system[3-4] or through foliar up take[5]. Bioaccumulation of heavy metals in the food chain can be highly dangerous. Heavy metals have been shown to effect chlorophyll content and biosynthesis[6], germination and seedling growth[7]. Heavy metals in growth media can function as stressors, causing physiological constrains that decrease plant vigour and inhibit plant growth[8].

Mercury is an important non-degradable toxic heavy metal pollution and increasing rapidly in our biosphere and is accumulated by plants in polluted areas. Human activities are estimated to account of $2x10^4$ to $7x10^4$ tones of mercury per year being released into the atmosphere and water supply[9]. It is a potential inhibitor of the algal growth[10]. Early studies on organic mercury revealed the chromosome fragmentation, somatic mutations and pollen sterility[11-15]. Some workers observed toxic effects of mercury on germinating rich seeds[16] and on physiological aspects of the several legumes[17].

MATERIAL AND METHODS

A series of pots were filled with equal amount of soil (3:1 garden soil: cow dung manure). The inner surface of pots was lined with polythene sheet. Soil was dried and then different concentrations of Mercuric chloride i.e., 1, 5, 10, 15 and 20 mg/kg is added per kg of soil and mixed thoroughly. Pots without the addition of metals were constituted as the controls. Healthy and uniform seeds of *Lycopersicon esculentum* Mill were selected. Seeds were first sterilized with 0.1% $HgCl_2$ and then rinse with water to remove traces of $HgCl_2$. Equal number of seeds were sown in each pot and irrigated with water for every alternate day to enough the soil moistened plants were allowed to grow till maturity. The plants control and treated were compared on the basis of height of the plant, number of flowers, number of sepals and petals, number of fruits and size, weight of the fruit chlorophyll content and phytoremediation. To estimate the pollen viability, fresh anthers of each treatment as well as control were collected and their stainability represented index for viability. Pollen grains were placed in equal quantity of acetocarmine 1% on a slide and gently warmed and observed under microscope. The filled and stained grains were regarded sterile. The data represented average of the three replicates have been analysed statistically along with correlation wherever necessary.

The estimation of total chlorophyll, was done in the matured leaf by spectrocalorimeter following the method described by Arnon (1949) of both control as well as treated. Care was taken to select the leaves at same position and age of the plant for the determination of their chlorophyll content in different treated and control samples. The data was the average of three replicates and was represented in figures. The amount of metal absorbed in a plant can be estimated by the following procedure: The plants were uprooted at the time of harvest, then washed with deionised water and dried in oven at 60^0C for 48h. The samples were then finely powdered and digested in concentrated nitric acid and perchloric acid (5:1) until a clear solution was obtained (Barman and Lal, 1994). It was then filtered reconstituted to the desired volume with double distilled water and analysed in Atomic Absorption spectrometer (Nebul son, 680). The analysis of heavy metal mercury was done for root, stem, leaf and fruit of *Lycopersion esculentum* at low and higher concentrations.

RESULTS AND DISCUSSION

The interaction of heavy metal Hg in tomato plant has been presented in table-I. In general, the amendment of soil with heavy metal Hg causing varying extent of reduction in germination, survival percentage, plant height, root length, number of flowers, number of sepals and petals, pollen viability, average number of fruit, fruit girth and fruit weight. The germination percentage of seeds decreased significantly with increasing leaves of Mercury (Table-1). The control samples showed a germination of 95%. There was a gradual decrease in percentage of germination with increasing concentration. It was 90, 84, 71, 52 and 40% respectively in 1, 5, 10, 15 and 20mg/kg treated samples. Mercury treated sample showed delayed germination as compared to that of controls. The filed survival percentage of seedlings in the control samples was 89%. The survival percentage of seedlings decreased gradually in all the Hg treated samples (Table-1). In 1mg/kg it was 80 percentage. 75, 69, 57, and 50% respectively in 5, 10, 15 and 20 mg/kg treated samples.

TABLE – 1

EFFECT OF MERCURY ON TOMATO GROWTH AND YIELD ATTRIBUTES

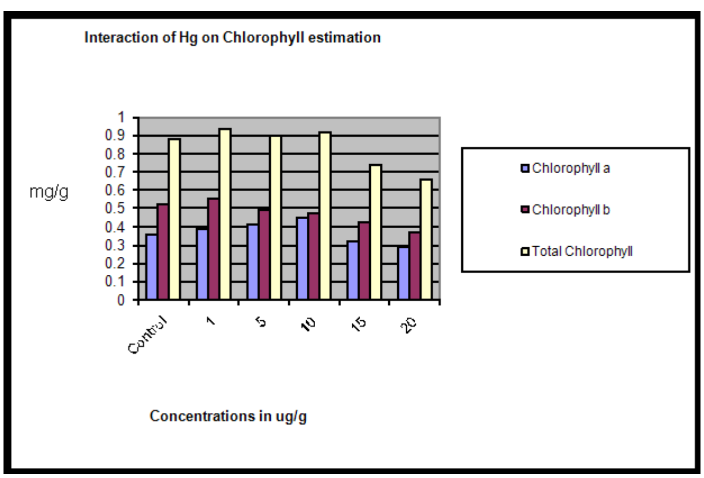
Concentration in mg/kg	% of germination	Survival percentage	Plant height (cm)	Root length (cm)	Number of flowers/plant	Number of petals/sepals	Pollen viability %	Average number of fruits	Fruit girth (cm)	Fruit weight (g)
Control	95	89	61.5±0.580	10.2±0.129	7.0±0.261	5.5	81.2	6±0.216	11.0±0.216	51±0.8
1	90	80	61.5±0.580	9.5±0.191	5±0.173	6.5	83.1	4±0.129	10.0±0.191	47.5±0.258
5	84	75	56.5±0.316	8.2±0.208	4±0.129	5.5	70.0	3±0.258	8.9±2.4221	40.3±0.58
10	71	69	50.2±0.374	7.4±0.129	2±0.216	5.5	65.0	2±0.216	7.3±0.129	35.7±0.428
15	52	57	42.8±0.507	6.7±0.191	1.0±0.00	5.5	52.0	1.0±0.00	7.0±0.261	33±0.92
20	40	50	35.5±0.493	10.4±0.374	-	-	-	-	-	-

Above ground level plant height was measured in field at the time of flowering and fruiting. In the control samples, the average plant height was 61.5cm. There was no change in plant height in mercury 1mg/kg treated sample (Table-1). In 5, 10, 15 and 20 mg/kg treated samples, the average height of plant were 56.5, 50.2, 42.8 and 35.5cm respectively. Plant with more branching and early ripening was observed in Hg 5mg/kg treated soil. In the control samples the average root length was 10.2cm. The tendency of decrease in the root length was seen in all Hg treated samples as increasing the concentration (Table-1). However increasing in the root length with less number of lateral roots was observed in Hg 20mg/kg treated samples compared to controls (Plate –I, Fig-d). In control samples, root system with elongated more number of lateral roots (Plate –I, Fig-c) were seen.

Decrease in the number of flowers was seen in all Hg treated samples as increasing in their level of metal, when compared to control (Table-1). No initiation of flowering at the concentration (20mg/kg) of Hg i.e., sterile plants were observed. However, these sterile plants could not survive. In the control flowers number of petals was 5.0 (Plate-I, Fig-e). There was no change in all Hg treated samples, except in Hg 1mg/kg, where the number of petals induced was 6 (Plate-I, Fig-f). In the control samples, the percentage of pollen viability was 81.2%. The pollen viability was increased in the 1mg/kg, Hg treatment and it was decreased from 5-15mg/kg Hg treated samples (Table-1). It was 70, 65 & 52% in 5, 10 & 15mg//kg treated samples respectively. In controls number of fruits formed were 6.0. Number of fruits 4.0 were formed in Hg 1mg/kg. The number of fruits were 3, 2 & 1 recorded in Hg 5.0, 10 & 15mg/kg treated samples respectively (Table-1). In control samples, fruit formation was early when compared to metal treated samples. Interestingly, early ripening of fruits were seen in Hg 5mg/kg treated samples. (Plate-I, Fig-b) In control samples, the average fruit weight was 51.0g and fruit girth was 11.0cm. In all Hg treatments, fruit weight and girth decreased as increasing concentration (Table-1).

Chlorophyll content was calculated at the time of flowering stage. Control samples showed the amount of chlorophyll a and b as 0.36 and 0.52 mg/kg respectively. The amount of chlorophyll "a" increased in some lower concentrations of Hg up to 10mg/kg than there was a decrease still in rest of remaining concentrations when compared to control samples (Fig-1). The amount of chlorophyll "b" increased only 1mg/kg and in remaining all treated samples there was decreased as increasing of Hg concentrations (Fig-1). The accumulation of mercury was insignificant in all the plant parts tested and it was below detectable (Table-2).

Fig – 1



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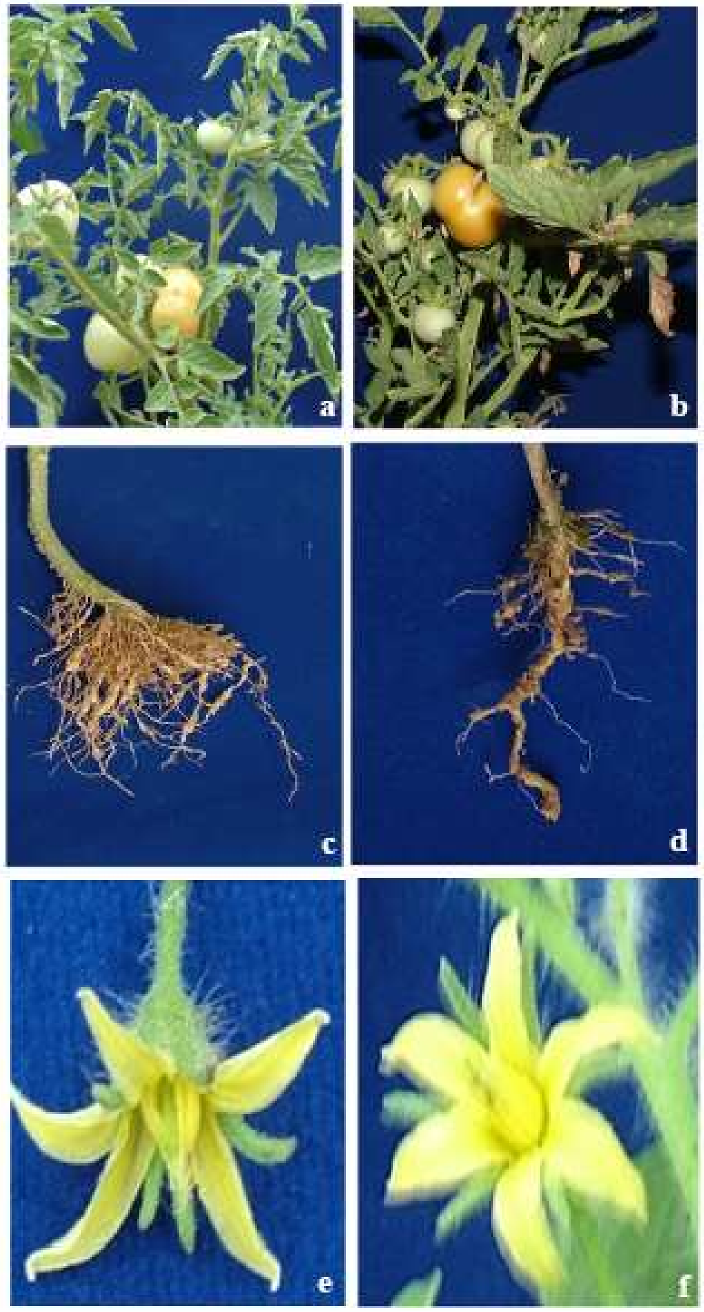

Fig.a: Control plant with fruting

Fig.b: Plant with more branching and early ripening was observed in Hg 5mg/kg

Fig.c: Control root

Fig.d: Increasing in the root length with less number of lateral roots was observed in Hg 20mg/kg

Fig.e: Control flower with five petals

Fig.f: Six petals at Hg 1mg/kg

TABLE – 2

Accumulation of mercury when added at lower & higher concentrations

Metal	Root	Stem	Leaf	Fruit
Lower				
Hg	BDL	BDL	BDL	BDL
Higher				
Hg	BDL	BDL	BDL	BDL

BDL = Below detectable limit

Earlier heavy metals inhibition on germination of seed and growth of the seedling has been reported in *Phaseolus aureus*[18], *Sorghum*, Finger millet and green gram[19] whose work was coincided with our results. Decrease in the seed germination percentage with increasing the concentration has been observed in all mercury treated samples. Inhibition of seed germination and seedling growth by mercury might be due to the fact that mercury has a strong affinity with SH- groups in living cells and is likely to form S-Hg-S bridges and thus affect the growth of seedlings[20]. Numerous studies have revealed the detrimental effects of heavy metal pollution on plants under natural and laboratory conditions.

REFERENCES

1. Gadd, G. M. and C. White. Heavy metal and radionuclide accumulation and toxicity in fungi and yeasts. In: Metal Microbe Interactions (eds) R. K. Poole and G. M. IRL press, 19-38 (1989).
2. Goyer, R.A. and Mehlman, M.A. Toxicology of toxic elements. In; Advances in Modern Toxicology, John Wiley and sons, Newyork, 65-73 (1977).
3. Lagerwerff, J. V. and A. W. Specht. Contamination of road side soil and vegetation with cadmium, nickel, lead and zinc. Environ sci. Technol., 7: 583-586 (1970).
4. Page, A. L., F. T. Bingham and C. Nelson. Cadmium absorption and growth of various plant species and influenced by solution and cadmium concentration. J. Environ. Qual., 1: 288-291 (1972).
5. Buchever, M. J. Contamination of soil and vegetation near a zinc, smelters by zinc, cadmium, copper and lead. Environ. Sci. Technol., 7:131-135 (1973).
6. Somashekaraiah, B V., K. Padmaja and A. R. K. Prasad. Phytotoxicity of cadmium ions on germinating seedlings of mungbean (*Phaseolus vulgaris*). Involvement of lipid peroxides in chlorophyll degradation. Physiol. Planturm, 85:85-89 (1992).
7. Hsu, F. H. and H. C. Chang. Inhibitory effects of the heavy metals on seed germination and seedling growth of *Miscanthus* species. Bot. Bull. Acad., 33:335-342 (1992).
8. Wu. L. and S. L. Lin. Copper tolerance and copper uptake of *Lotus purshianus* (Benth.) Clem. and Clem. and its symbiotic Rhizobiumloti derived from a copper mine waste pollution. New phytol., 116:531-539(1990).
9. Robinson, J.B and O.H. Tuovinen. Mechanism of microbial resistance and detoxification of mercury and organomercury compound. Physiology, Biochemical, and Genetic Analysis Microbiological Reviews. 48:95-124 (1984).
10. Rao, J. C. S. Toxicity of heavy metals on algae. Ph. D. Thesis, Andhra University, Waltair (1982).

11. Macfarlane, E. W. E. Effects of water source on toxicity of mercurial poisons. II. Reactions of *Allium* root tip cells as indicators of penetrations, Growth, 15:241-245 (1950).
12. Macfarlane, E. W. E. Somatic mutations produced by organic mercurials in flowering plants. Genetics., 35:122-123 (1951).
13. Macfarlane, E. W. E. and Mering, A. M. S. R. Shoot chimeras after exposure to mercurial compounds. Bot. Gaz., 115:66 (1953).
14. Ramel, C. Genetic effects of organic mercury compound. I. Cytological investigations on *Allium* roots. Hereditas, 61:200-233 (1969).
15. Levan, A. Cytogenetic effects of hexyl mercuri bromide in the *Allium* test. J. Ind. Bot. Soc., 50 A:340-349 (1971).
16. Mukherji, S. and G. Ganguly. Toxic effects of mercury in germinating rice (*Oryza sativa* L.) seeds and their reversal. Ind. J. Exp. Biol., 12:432-434 (1974).
17. Sharma, S. S. Effect of mercury on germination and seedling growth of different varieties of *Phaseolus aureus*. Ind. J. Ecol., 9:79-81 (1982).
18. Sneh Lata. Effects of cadmium treatment of seeds on growth, yield, level of chlorophyll and hill activity of chloroplasts isolated from *Phaseolus aureus* cv. PS-16. Ad. Plant Sci., 2(2):286-290 (1989).
19. Kumudha, P. and K. Janardhanan. Studies on the effect of some heavy metals on seed germination and early seedling growth in *Sorghum*, fingermillet and green gram. J. Swamy Bot. Cl., 3:125-131 (1986).
20. Thimann, K. V. and W.D. Bonner. Effects of mercury in germinating crop plants. Amer. J. Bot., 36:214-217 (1949).