BIOLOGICAL PERSISTENCE OF ARSENIC AND THEIR EFFECT ON GERMINATION, GROWTH & DEVELOPMENT OF SELECTED PLANTS

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Abstract -

Arsenic toxicity is reported in the Indo Gangetic plain of Bihar and severe health hazards have been reported in many villages. The uptake of arsenic on *Lycopersicum escluetnumL.* growing under pot condition confirms phyto availability and phyto toxicity in the plant. At all stages, growth and development of tomato i.e. on seed germination to maturity stages, as the concentration of arsenic increases significantly with increasing arsenic concentration in different treatments at growing condition effects the germination, growth and development of plant. Higher concentrations of arsenic showed significant reduction in germination and plant growth (i.e. root, shoot, stem, leaves, flower and fruit yield). The results of this study confirm the adverse effect of arsenic on tomato growth and development. This aspect has practical importance for the arsenic contaminated agricultural system where adequate and appropriate production techniques are required to be formulated to avoid stunted growth of the food plants (especially tomato) and severe yield and quality loss.

***Key Words*:**agricultural system, phyto toxicity, arsenic,Indo Gangetic plain

1.INTRODUCTION

Long term exposure to arsenic creates large number of health problems. It is carcinogenic and reported to cause cancer in skin, lung, bladder and kidney. Abnormal skin changes such as hyperkeratosis and pigmentation changes are reported. The evidence is that it is also causing hypertension, cardiovascular diseases, diabetes, reproductive ill effect, cerebrovascular diseases and neurological ill effect on human as well as life stock.

Arsenic is non-essential and generally toxic to plants. Roots are usually the first tissue to be exposed to As, where the metalloid inhibits root extension and proliferation. Upon translocation to the shoot, As can severely inhibit plant growth by slowing or arresting expansion and biomass accumulation, as well as compromising plant reproductive capacity through losses in fertility, yield, and fruit production (Garg and Singla, 2011). At sufficiently high concentrations, As interferes with critical metabolic processes, which can lead to death. Most plants possess mechanisms to retain much of their As burden in the root. However, a genotype-dependent proportion of the Arsenic is translocated to the shoot and other tissues of the plant. Arsenic present in salt marsh soil is taken up by plants and subsequently transferred to other parts of the ecosystem. The reduced state of the bulk soil of salt marshes favours the mobility of arsenic. In the rhizosphere of plants however, arsenic may be immobilized owing to oxidation of arsenic (III) to less mobile arsenic (V) and adsorption to iron (hydroxides). In a greenhouse experiment accumulation of arsenic and iron in the rhizosphere occurred, which could be due to the oxidizing activity of plant roots and microorganisms. Arsenic accumulates in the different tissues in different parts of the plant and adversely effects the growth and productivity of the plants. It is a threat for millions of population in terms of health and food security.

Arsenic (As) is an environmental and food chain contaminant. Excessive accumulation of As, particularly inorganic arsenic (As (i)), in different crops poses a potential health risk to populations with its regular consumption.

Arsenic also contaminates standing food crops if it is present in the soil and soil water. As the Bihar plains are highly fertile and its crops are marketed to many distant places, apart from being locally consumed, it becomes imperative to test the levels of arsenic in the food chain too. What is worrisome is that arsenic contaminated ground water tables have abrupt occurrences both over time and space. Also arsenic manifestation exists at different levels in different areas. In north-west Maner, it is reported that arsenic contaminated hand pumps have a shallow depth of between 60 to 80 feet in the diara (land along the river belt) belt. In Bhojpur, the depth of contaminated aquifers goes down to 150 feet away from new diara land, while by a study in Vaishali, arsenic is found in the shallow and middle aquifers at an average distance of five km away from the river bank. Regular monitoring of drinking water from hand pumps is immediately required as a part of the mitigation strategy. Patna, the first district to be covered, revealed pockets of high arsenic contamination, above the acceptable limit of 10 ppb in 171 villages in Maner, Danapur, Sampatchak, Barh, Bakhtiarpur, Fatuha, Khusrupur, Phulwari, Mokama, Pandarak and Patna City. The highest AAS reading of arsenic level in government hand pump water is reported as 724 ppb in village Naikatola in Maner, 450 ppb. in Kasimchak village in Danapur, 553 ppb in Ghiaspur Mahazi and 538 ppb in Kala Diara, Bakhtiarpur,, and 484 ppb in Malahi Banda village in Barh. Sampatchak Block has reported low contamination levels of below 50 ppb over a larger area in most of the villages. In Bhojpur, the highest AAS test readings are 1861 ppb and 1064 ppb in Pandey tola, Barhara block, a situation far more serious than the one represented by the much-touted village Ojhapatti of Shahpur block. In a research work it was reported that as per government report, out of the 6,292 hand pumps tested, 47.7 percent were arsenic contaminated. In Barhara, 62.84 percent, in Udwantnagar 59.39 percent, in Shahpur 40.41 percent, in Behea 37.17 percent, in Koilwar, 29.20 percent, and in Ara 25.88 percent of block level hand pumps were arsenic contaminated. In Vaishali, all the blocks covered within 10 km along the Ganga banks, have low level arsenic contamination at present. In Bhagalpur district, most affected areas are Kahalgaon, Pirpainti, Sabaur and Sultanganj. A detailed study has been presented on groundwater metal contents of Sahebgunj district in Jharkhand, with special reference to arsenic. Both tubewell and well waters have been studied separately with greater emphasis on tubewell waters. Rivers flowing through the coal fields of Jharkhand have been reported to carry arsenic responsible for arsenic poisoning in downstream areas of West Bengal. The coal fields of Bachara and Piprawar areas of Jharkhand have contaminated the waters of the Damodar and its tributary, the Safi. Arsenic contamination arises mainly due to the dumping of waste from the coal mines along the river bed. The coal of the area mentioned contains sufficient amount of arsenic.

Arsenic is highly carcinogenic metalloid which is present in nature. It is widely distributed into Indo Gangetic plains of Bihar. A large number of populations are severely affected by its toxicity. It has been reported that traces of arsenic have been found in crops grown into arsenic contaminated soil.

The source of the problem is geological in origin, which has been aggravated due to excessive withdrawal of groundwater in agricultural areas. The real truth is that people of the area are ignorant about this toxicity.

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2. Body of Paper

The present investigation on biological persistence of arsenic and their effect on germination, growth & development of selected plants were carried out during the year 2010 to

2012 in the laboratory of the P.G Deptt of Biotechnology, A.N. College, Patna. The details of the experiments conducted for the present study are described in the chapter of materials and methods. The study was undertaken at P.G Deptt of Biotechnology, A.N. College, Patna located between 24.57" N latitude 84.44"-86.4"E longitude at an elevation of 129 meter above the mean sea level. In the national physiography its main land is sandwiched between the high Himalayan range in the far north and the hilly track of Chotanagpur plateau in the south. Seeds of tomato of popular variety (Pahuja 508) were purchased from the reputed dealer and experimentation was conducted in earthen pot in randomised block design with five treatments and three replications.

Lot of research work have been done and published in local, national and international journals on arsenic contamination and its effect on environment, livestock and human health. Thorough literature survey on related topic of this research work was done from research journal, periodicals, government and non-government report and websites. Over 200 national research papers, 50 international research papers and 35 net downloaded research papers were seen and read under the chapter **"Review of literature."**The work related to arsenic and their adverse effects have been presented exhaustively and reported by references appended in the last.

Meteorological observation of the three complete years2010, 2011 and 2012 were collected from the IMD, civil aerodrome Patna during the period of study. The monsoon appears almost in time in mid-June and the good rain spread throughout the rainy month. The minimum temperature recorded was 5^0 C and maximum 41^0 C. during the rainy month the relative humidity touched upto 90%. The soil and the water used in the experiments were analysed for their physico-chemical properties. The representative soil of Patna was found to be fertile containing sufficient quantity of NO_2,K_2O, P_2O_5 and other micro elements which are supposed to be essential for the healthy growth of the tomato plant. Similarly, good quality of experimentation water used although the experiment as per the recommended package of practice for growing tomato plant.

The observation recorded for the study of influence of arsenic concentration on germination of tomato revealed that although the lower concentration of arsenic upto 2ppm do not affect much to the germination but higher concentration above 4ppm significantly affect the germination.

The fresh root weight at lower concentration of arsenic i.e. up to 2 ppm is not adversely affected by the treatment but at higher concentration (more than 4 ppm),fresh root weight was significantly affected.

Arsenic at low concentrations, do not affect the dry root weight but at higher concentration (above 4 ppm) significantly affect the dry root weight.

The fresh shoot weight in lower concentration of arsenic i.e. up to 2 ppm is not adversely affectedby the treatment but in higher concentration of more than 4 ppm fresh shoot

weight was significantly decreased by increasing level of arsenic concentration.The lower concentrations of arsenic treatment do not affect the dry shoot weight but in higher concentration above 4ppm of arsenic concentration significantly decrease the shoot weight.

The numbers of branches per plant of tomato as influenced by different levels of arsenic was affected by its number. A clear decline was seen in number of branches per plant in more than 4 ppm of concentration, established the fact that arsenic effects the growth and development of the tomato plants.

The observations made after transplanting showed adverse effect of arsenic treatment on various growth parameters especially number of leaves/plant. The total number of leaves decreased significantly at higher arsenic concentration (>4ppm).

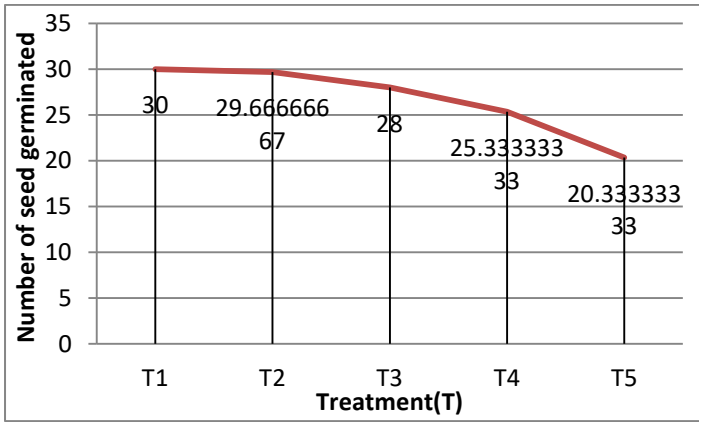
Similarly, after 8 weeks of transplantation, the number of flowers/ plant of tomato treatment showed a decreasing trend in the number of flowers/plants. The number of flowers was also affected by the presence of arsenic concentration of 4 ppm and above.

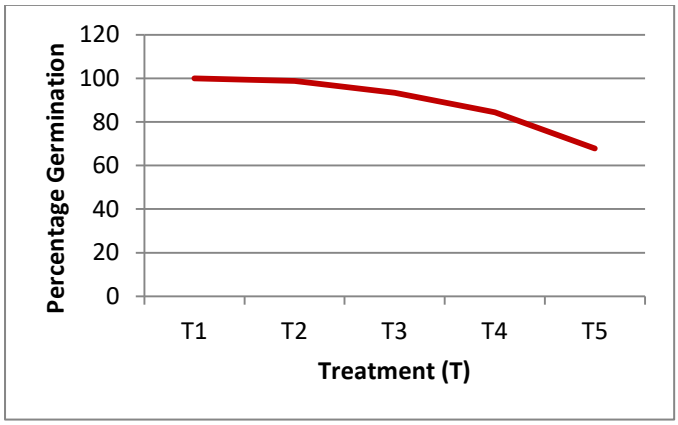
Similar, decreasing trend in harvested fruit/plant was also observed. Fresh fruit weight of tomato decreases with increasing concentration of arsenic. In higher concentration of As treatment (T5), the fresh fruit weight was less than the half of the treatment T1 (control) harvest. With the application of arsenic at different concentrations showed significant lowering in fruit dry weight. Clear adverse effect of arsenic was evident in the dry fruit weight of tomato as found in fresh fruit weight.

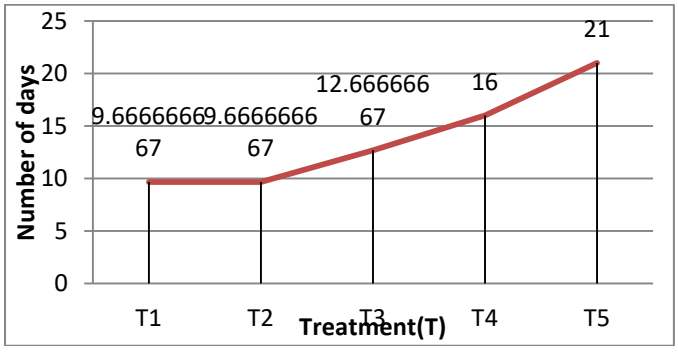
The uptake of arsenic on *Lycopersicum escluetnum*L. growing under pot condition confirms phyto availability and phytotoxicity in the plant.At all stages,growth and developmentof tomato i.e. on seed germination to maturity stages, as the concentration of arsenic increases significantly with increasing arsenic concentration in different treatmentsat growing condition effects the germination, growth and development of plant. Higher concentrations of arsenic showed significant reduction in germination and plant growth (i.e. root, shoot, stem, leaves, flower and fruit yield). The results of this study confirm the important role of arsenic on tomato growth and development. This aspect has practical importance for the arsenic contaminated agricultural system where adequate and appropriate production techniques are required to be formulated to avoid stunted growth of the food plants (especially tomato) and severe yield and quality loss.

Fig -1: Arsenic concentration testing

Charts







3. CONCLUSIONS

Observations and results from germination experiments on *Lycopersicum esculentum*L.withdifferent concentrations of Arsenic treatments

Germination is very important factor which controls the lifecycle and determines the chances of its survival. The behavior pattern of the tomato in term of growth, development, flowering, fruiting and yield content all depend on good germination percentage rate. Therefore the experimentations with different concentration of arsenic were conducted to know the effect of arsenic on germination ability of tomato.

Experiments were conducted in random block design in the earthen pot and petri dishes for two consecutive years (2010-2012) for studying the effect of different concentrations of arsenic solution on germination rate in tomato. Seeds of ***Lycopersicum esculentum*L.** procured from local traders of the popular variety of certified F1 Hybrid Tomato Pahuja -508 were purchased for experimentation. Total of 30 numbers of apparently healthy seeds were soaked in each set, Petri dishes containing cotton wool and filter paper bed in three replications. To study the germination percentage five treatments were studied as per lay out plan with different concentrations of arsenic to find out effect of arsenic on germination percentage. The treatments given were as per following lay out plan with a control set as T1:

Different treatment of Arsenic used during research work

Serial No.	Treatments	Concentration level
1	T1	Nil
2	T2	2 ppm
3	T3	4 ppm
4	T4	6 ppm
5	T5	8 ppm

The data of germination percentage was shown in table no.17 and graph 15 showing 100% germination in T1 (control) i.e. all the thirty (30) seeds were germinated within 5 days of treatment. The result indicates that in treatment T2 (2ppm) the germination percentage was found to be 98.8%i.e. almost all seeds were germinated except one (1) which could not germinate due to the 2ppm concentration of arsenic. It was observed that the increasing dose of arsenic hamper the germination percentage and gradually germination percentage were decreased with increasing concentration of arsenic. The result of treatment T3 (4ppm) showed 93.33% germination i.e. 28 out of 30 seed germinated. The result of treatment T4 (6ppm) showed that 84.44% seeds germinated i.e. out of 30 only 25 could germinate. Similarly in treatment T5 8 ppm the germination rate was lowest i.e. only 67%, out of 30 seeds only 20seeds germinated in replicate R2 of treatment T5.

The result obtained clearly indicates that the presence of arsenic(**As)** in water regime adversely affect the germination rate of the tomato seeds. Even the lowest dose of arsenic concentration of 2ppm made significant effect on the germination. As the dose increased the germination percentage drastically decreased thereby meaning that tomato (*Lycopersicum esculentum*L.) seeds are highly sensitive to arsenictoxicity in irrigation water.

With the beginning of germination, the embryo starts growing and comes out of the seed coat. The whole structure together is juvenile plant or seedling. Radicle emerges firstly out of the seed and has the role of establishing contact between soil and seedling. Further, it is also the radicle which comes in contact with the environment first and develops as root. Initially, the growth rate of the root of a seedling is higher than that of shoot but in due course, the later grows faster than the former. Since, root and shoot have to perform different sets of functions, therefore, it will not be illogical to assume the presence of different "genetic programming" in the two structures because of this difference the reactions of root and shoot to environmental diversities may be diverse. Further, the response shall also depend upon age of seedlings and the composition of soil.

Root adsorbs nutrients from soil and control the growth and development of plant. The elongation and spreading of root help in the development of plant. It is an established fact that availability of water affected the fresh root weight of the tomato

plant. Fresh weight of root depends upon the sum total of the amount of water absorbed and the amount of stored dry matter consumed by root. A significance deviation in its value from control sets was indicative of distortion in the balance between fresh and dry root weight of tomato plant.The fresh weight and dry weight of tomato plants grown in soil amended with different concentration of arsenic were studied to know the effect of arsenic during this research work (2010-2012) in randomised block design pot experiments. The results were indicated in graph.

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ACKNOWLEDGEMENT

It is the result of my three years research work for acquiring in depth knowledge and self-actualization. I have not travelled in a vacuum in this journey. This research has been kept on track and been seen through to completion with the support and encouragement of numerous people including my well-wishers, friends and colleagues' would like to express my thanks to all those who contributed in many ways to the success of this study and made it an unforgettable experience for me.

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