International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Impact Factor (2012): 3.358

Persistence of Arsenic and its Effect on Germination on *Lycopersicum esculentum* L. (Tomato's) Seeds

Amrita Singh[1], Dr. Chandrawati Jee[2]

[1]Research Scholar, Post Graduate Department of Environmental Sciences, A. N. College, Patna, Magadh University, India

[2]Head, Post Graduate Department of Biotechnology, A. N. College, Patna, Magadh University, India

Abstract: ***The uptake of arsenic on tomato (Lycopersicum escluetnumL.) growing under pot condition confirms phyto toxicity in the plant even at the seed germination as the concentration of arsenic increases significantly with increasing arsenic concentration in different treatments at growing condition effects the germination of seeds. Higher concentrations of arsenic showed significant reduction in germination. The results of this study confirm the adverse effect of arsenic on the germination tomato seeds. 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 rate of germination (especially tomato) and severe yield and quality loss.***

Keywords: Agricultural system, Bihar, arsenic, Indo Gangetic plain

1. Introduction

Arsenic contamination: a serious concern

The four major problems threatening the existence of life on our globe are population explosion, food shortage, fuel scarcity and environmental degradation. During the last two decades, the area of maximum concern is the environmental pollution which is manifested. One significant contributor to environmental degradation has been identified as arsenic. It is difficult to clean such a huge area having several types of pollutant in which heavy metals are one. Thus problems are dramatically severe due to food chain contamination and the only solution is to localize the metalloid in non-edible parts of the crops and seedlings (Sahu *et al.*, 2007).Environmental contamination by arsenic especially of water and soil has become a subject of prime interest due to its direct effect on human health. It is found everywhere and creating unmanageable health related problem.

In the research work examined the potential of tomato's seeds are hyper accumulating the **As** from soil and water. According to previous reports the potential of tomato crop was examined hyperaccumulation of Arsenic from soil and water. The two forms of inorganic arsenic, arsenate (As V) and arsenite (As III), are easily taken up by the cells of the plant root.

Arsenic & its biological persistence

Indo Gangetic plain of Bihar has an agricultural based economy where, arsenic is already been detected in hand tube wells used for irrigation. Due to high cost involved in supplying arsenic free water for irrigation purposes, communities were forced to use arsenic contaminated hand tube wells or borings for irrigating crops and vegetables. Recently, it has been recognised that arsenic contaminated ground water used for irrigation possess a serious health hazard to people who feed from the crops irrigated, and that arsenic also accumulated in irrigated soils poses a serious threat to sustainable agriculture in affected areas. Little is yet known about the extent and severity of this threat to food production, human health and for livelihoods as well as for paddy production, the staple food of the country. Therefore, a rigorous field and laboratory studies are being done to know the biological persistence of arsenic & its impact.

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 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. 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.

Licensed Under Creative Commons Attribution CC BY

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.

Objective of the study

The present research was aim to study the problems of biological persistence of arsenic and scientifically study on its effect on germination (*Lycopersicum esculentum*L.) (Hindi- Tamatar).

The objectives of this study are to focus on the effect of Arsenic on the plants and their impact on germination. The elevated level of Arsenic in Plant may be a threat to life. This help to know the effect of arsenic on plants which enter into the food chain and create health problems. The data reveals that Arsenic problems will create a serious threat and arsenic toxicity creates problems of carcinoma, therefore it may be essential to know the mobilization of arsenic in environment, plants and animals through food chain.

2. Literature Survey

Arsenic in Environment

The present review of literature is the result of in depth and extensive, scanning of published research papers, literatures, books, journals, souvenirs, bulletins, periodicals of R&D and newspaper reports published in India and abroad. Efforts has been made to collect relevant information on literature available in respect of hazards and exposure of arsenic in environment, soil, water, livestock in general and agriculture & plant in particular to know the biological persistence of Arsenic in Indo Gangetic plain of Bihar. Arsenic toxicity has been reported in several districts of Bihar and created severe health problems in rural as well as in urban area.

General description of Arsenic

Arsenic (As) and its compounds are ubiquitous in nature and exhibit both metallic and non-metallic properties. The trivalent and pentavalent forms are the most common oxidation states. From both the biological and the toxicological points of view, arsenic compounds can be classifies into three major groups: inorganic arsenic compounds; organic arsenic compounds: and arsine gas.

Routes of exposure of Arsenic

Arsenic in Food

Food also contains many organic arsenic compounds, which are generally considered to have low toxicity, although toxicity does vary among the individual compounds. Developing analytical methods to identify these compounds has been important for distinguishing these compounds from the more toxic inorganic forms. The key organic arsenic compounds that can be routinely found in food (depending on food type) include monomethylarsonic acid ($MMAs^V$), $DMAs^V$, arsenobetaine, arsenocholine, arsenosugars, and arsenolipids. $DMAs^V$ or $MMAs^V$ can be found in various types of fin fish, crabs, and mollusks, but often at very low levels (Borak and Hosgood, 2007). Arsenobetaine is the major form of arsenic in marine animals, and, by all accounts, it is considered a compound that is nontoxic under conditions of human consumption (ATSDR, 2007b; EFSA, 2009). Although arsenobetaine is little studied, available information indicates it is not mutagenic, immunotoxic, or embryotoxic (Borak and Hosgood, 2007). Arsenocholine, which is mainly found in shrimp, is chemically similar to arsenobetaine, and is considered to be "essentially nontoxic" (ATSDR, 2007b).

3. Problem Definition

Arsenic in agriculture

Arsenic poisoning is the sword of poisoning agricultural produce of northern (Indo-Gangetic) plain of Bihar. Its stress is increasing at an alarming rate in agricultural soils throughout the Indo-Gangetic plains of our state where agriculture is backbone of economics. The Arsenic, in general, can cause several health hazards, including dermatological, respiratory, gastrointestinal, cardiovascular, hepatic, neurological, haematological, renal, mutagenesis, reproductive and mental health disorders. Arsenic is also referred to as slow poison. The effect of arsenic is noticeable after its continuous intake for five to seven years. There is no cure for arsenic once its effects become visible on human body. The initial symptoms include skin lesions developing into keratosis and pigmentation and it can even lead to cancer in acute cases. The entry of arsenic in food chain is a serious issue, as it leads to increase in disease burden being already present in ground water.

Low levels of **As** are naturally present in the soil. The background levels are around 5mg/kg worldwide with substantial variation depending on the origin of the soil (Mandal and Suzuki, 2002) The behaviour of As is distinctly different under flooded (anaerobic) and non-flooded (aerobic) soil conditions, with flooded conditions being likely the most hazardous in terms of uptake by plants and toxicity, as will be explained in this chapter. Taking into consideration that rice is the staple crop in Asia, that its largely takes place under flooded conditions, and that its high demand for irrigation water, often from groundwater resources, understanding the behaviour of As under flooded soil conditions is of particular importance

Effect of Arsenic on plants

Increased arsenic levels in soils causes considerable concern with respect to plant uptake and subsequent entry into wildlife and human food chains. Arsenic speciation in the environment is complex; existing in both inorganic and organic forms, with inter conversion between species regulated by biotic and abiotic processes. Recent reports emphasize on arsenic uptake, metabolism and toxicity for arsenic resistant and non-resistant plants, including the recently discovered phenomenon of arsenic hyper accumulation in certain fern species. The reasons why plants accumulate and metabolize arsenic are considered in an evolutionary context. Shaibur et al (2006) reported physiological and mineralogy properties of arsenic induced chlorosis in rice seedlings grown hydroponically.

Guideline value of maximum arsenic contamination in soil, plant and animal systems are not available which is a serious concerned.

Licensed Under Creative Commons Attribution CC BY

4. Methods / Approach

Regular observation on various factors viz. minimum and maximum temperature, relative humidity, wind speed and average rainfall have been recorded for the experimentation site of Patna. Average maximum and minimum temperature at Patna ranged 31.4^{0}Cto 19.36^{0}C. Average Relative humidity (%) ranged between7.56 to 61.14 at Patna. Wind speed(km per hour) at 8 am was between 1 to 2.8 during the year of study and mean rainfall during various month of the year ranged between 75.25 mm to 163.68 mm.

The tomato crop in the study area extended from November to February in the first year and November to March in the second year and was characterized by cooler nights (around 11^0 C) and short days (about 8 hours of bright sunshine) known to be appropriate for the growth of the crop. The temperature ranged from 31.4^{0}C to 19.36^{0}C in experimentation year i.e. first and second year. It was considerably low during first fortnight of January and was high between the February to March. Relative humidity recorded ranged from7.56% to 61.1%.The trend of fluctuation during crop season was almost similar for both the years except the period of the first fortnight. Relative humidity in the first fortnight of January was less and in the fourth week of February was more during the second year of study.

Water Sample Characteristics

The water used for irrigation was taken and analysed for various physico chemical parameters, Arsenic Standard methods were used for estimation of water and waste water was used for analysing the irrigation water as suggested by APHA. The pH of the water was 7 and COD, TSS & TDS was 21.2,222 and 10 mg/litre respectively. Total hardness was recorded 148 mg/litre. Similarly the values recorded for other analyser factors viz Ca (38); Mg (7.73), Chloride (26.03), Ammonical Nitrogen (13.30), Phosphate (1.00), Sulphate (7.5), Fluoride (0.01), Nitrate (0.96), Arsenic (BDL) and available N(39.00), K (8.00) and Silica (2.50)mg/litre. Water used in irrigation was also examined for Arsenic concentration and result was found below determination limit. The water used for irrigation was of same standard or and was kept unchanged in all the treatments.

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

Germination is very important factor which controls the lifecycle and determines the chances of its survival. The behaviour 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 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	Picture
1	T1	Nil(Control)	
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 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

Licensed Under Creative Commons Attribution CC BY

only 25 could germinate. Similarly in treatment T5 8 ppm the germination rate was lowest i.e. only 67%, out of 30 seeds only 20 seeds 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.

The observations were also recorded for the first appearance of plumule and radical growth in terms of number of days taken. The data presented in table 18 and graph 16 revealed that the number of days taken for plumule and radical growth in T1 and T2 were at par i.e. mean 9.6 days whereas as the concentration increased the number of days taken for plumule and radicle growth increased to 12.6, 16 and 21 respectively for treatment T3, T4 and T5. The result confirmed that although the lower concentration of arsenic i.e. 2ppm do not affect the plumule and radical growth in the earlier stage but in higher concentration significantly delayed the appearance of plumule and radicle growth.

The observation recorded for length of the radicle at periodical interval i.e. from day 1 to day 15 of the germination in petri plates showed the similar trend of the adverse effect of arsenic concentration in moisture regime. There was normal length growth in control but as the concentration of arsenic increases the length of seedlings were found to be stunted, apparently weak, yellowish with brown tip. The control seed elongation resulted in the average growth of 17.33 cm in 15 days were as intreatmentT2, T3, T4 and T5 it was measured only 16.33,13.2, 8.5 and 6.6 cm respectively showing drastic change in radicle elongation. Similarly, the observation recorded for length of the plumule at periodical interval i.e. from day 1 to day 15 of the germination in petri plates showed the similar trend of the adverse effect of arsenic concentration in moisture regime. There was normal length growth in control but as the concentration of arsenic increased the length growth was found to be stunted. The control and treatmentT2 seed elongation resulted in the average growth of 12.33 cm in 15 days were as in treatment T3, T4 and T5 it was measured only 9, 7 and 6.33 cm respectively. Arsenic content was measured by SDDC method and recorded an average concentration of 0.001 in treatment T3 and T4. In treatment T1 and T2, the concentration of arsenic recorded below determination limit. An average concentration of 0.003667 was recorded in treatment T5.

6. Results / Discussion

The result of experimentation conducted for study of the biological persistence of arsenic in tomato's seed require data on various vital parameters on growth and development of plant *viz* germination, root weight, shoot height, number of leaves, number of flowers, number of fruits, dry and fresh weight of fruit at regular periodical interval. The data were tabulated and statistically analysed F0.05 is 3.89 for and f is 14 for all parameters separately, since calculated than the tabulated value of f is less/more than the tabulated value, it is significant at 5% level and found in accordance with expected hypothesis. The results indicated that the tomato's seed can tolerate by a large only lower dose of As (less than 2 ppm) but higher concentration of As (over 2 ppm) severely affect the germination thereby, affecting the valuable yield of tomato which is highly useful, popular, commercial, nutritional, profitable crop of Bihar.

7. Conclusion

Arsenic (As) contamination of water and soil has become a subject of prime interest due to its direct effect on human and livestock's health through drinking water and food. In the present research work, a popular variety of tomato (Lycopersicum esculentum L.) which is a major supplementary food in all over India is a valuable source of nutrition in our diet and therefore has been selected to estimate the effect of Arsenate in germination and various growth and development parameter for tomato by conducting systematic and scientific experimentations.

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

Licensed Under Creative Commons Attribution CC BY

8. Future Scope

The data, result and outcome of this research work may be utilized by policymakers, researchers, government and semi government organization, medical professionals, research institution, pharmaceutical companies and agriculturist. Recommendations of this work may help in mitigating arsenic toxicity which has entered into water and cereals by several sources and can be useful for common people, farmers and agriculturists. Health hazards can be minimized by safe disposal of arsenic. This research work may be useful for techno-commercial obligation and feasibility of the project may be helpful in minimizing the arsenic toxicity in Indo Gangetic plains of Bihar.

References

[1] Abedin, M.J., J. Feldman and A.A. Mehrag (2002) Uptake kinetics of arsenic species in rice plants. Plant Physiol.128, 1120-1128.
[2] Ahsan H, Chen H, Parvez F, Zablotska L, Argo M, Hussain I, Monotaj H, Levy D, Cheng Z, Stankovich V, et al. (2006) Arsenic exposure from drinking water and risk of premalignant skin lesions in Bangladesh: baseline results from the Health Effects of Arsenic Longitudinal Study. Am. J. Epidemiol. 163:1138–1148
[3] Cao, X., Ma, L.Q. and Shiralipour, A. (2003) Effects of compost and phosphate amendments on arsenic mobility in soils and arsenic uptake by hyperaccumulator *Pterisvittata* L. Environ.Poll.126, 157-167.
[4] Carbonell-Barrachina, A.A., Burlo, F., Burgos-Henandez, A., Lopez, E. and Mataix, J. (1997) The influence of arsenite concentration on arsenic accumulation in tomato and bean plants. Scientia Hort. 71, 167-176.
[5] Dhanker, O.P., Rosen, B.P., Mc Kinney, E.C. and Meagher, R.B. (2006) Hyperaccumulation of arsenic in the shoots of Arabidopsis silenced for arsenate reductase. Proc.NatlAcad of Sci.
[6] Heikens, A., Panaullah, G.M. and Mehrag, A.A.(2007) Arsenic behavior from groundwater and soil to crops. Impacts on agriculture and food safety. Rev Environ Contam, Toxicol. 189, 43-87.
[7] Masscheleyen, P.H., Delaune, R.D. and Patrick Jr, W.H. (1991) Effect of redox potential and pH in arsenic speciation and solubility in a contaminated soil. Environ. Sci. Technol. 25, 1414-1419.
[8] Maynard, D.N. (1979) Nutritional disorders of vegetables crops: A review. J. Plant Nutr. 1, 1-23.
[9] Onken, B.M. and Hossner, L.R. (1995) Plant uptake and determination of arsenic species in soil solution under flooded conditions. J. Environ. Qual. 24, 373-381.
[10] Smith, E., Naidu, R. and Alston, A.M (1998) Arsenic in the soil environment: A review. Adv. Argon. 64, 149-195.
[11] Von Ehrenstein OS, Mazumder DN, Yuan Y, Samanta S, Balmes J, Sil A, Ghosh N, Hira-Smith M, Haque R, Purushothaman R,(2005). Decrements in lung function related to arsenic in drinking water in West Bengal, India. Am. J. Epidemiol. 2; 162:533–54.

Author Profile

Amrita Singh, Research scholar – A.N. College, Patna, Magadh University, Bodh Gaya

Licensed Under Creative Commons Attribution CC BY