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RESEARCH PAPER

Investigating the Potential Response of Jute Varieties for Phytoremediation of Arsenic Contaminated Soil

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Abstract
A pot experiment was carried out in the green house of Bangladesh Jute Research Institute (BJRI), Dhaka to study the response of jute (Corchorus capsularies and Corchorus olitorius) to the accumulation of As from soil to plants when various rates of As were applied. In the experiment, four treatments of arsenic (control, 10, 20 and 40 mg/kg) were applied. The salt sodium meta-arsenite (NaAsO2) was used as a source of As. Three jute varieties of CVL-1, 0-9897 and OM-1 were used. CVL-1 variety is As sensitive whereas the 0-9897 and OM-1 varieties appeared to be As tolerant and OM-1 takes up the highest amount of As. Arsenic will be ingested into the body exceeding the maximum allowable daily limit (0.22mg/kg per day) through the consumption of 100g of jute leaves of these three varieties per day. Accumulation of As at 10 and 40 mg/kg treatment, the maximum was observed at 52 days harvest for CVL-1 while for the other two treatments, the maximum was observed at 42 days of growth. In the case of 0-9897 and OM-1 varieties, overall the maximum accumulation of As was observed at 42 days of growth at 40 mg/kg treatment.

Keywords: Arsenic, Bio-accumulation, Jute, Soil, Toxicity.

INTRODUCTION

Earth environment and its pollution has become a widely discussed and debated topic all over the world in recent days. The arsenic contamination is now a major environmental hazard and poses a threat not only to our country but also to the world. Arsenic poisoning is a serious problem in Bangladesh affecting human health. This has been caused through groundwater used for drinking, domestic and irrigation purposes. Arsenic enters into human body through drinking of As contaminated groundwater and ingestion of contaminated foods obtained from groundwater irrigated agricultural fields and it goes on accumulating in the body. Due to arsenic accumulation in the body through drinking water and contaminated food, people are suffering from various diseases. At higher concentration, however, arsenic has been reported to interfere with metabolic processes and to inhibit plant growth, sometimes leading to death (Reed and Sturgis, 1936; Baker et al., 1976; Marin et al., 1992).

Bangladesh is currently facing the challenge of high arsenic concentration in groundwater. Approximately 27% of STWs and 1% of DTWs in 270 upazillas (sub-districts) of the country are

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contaminated with As at Bangladesh standard whereas about 46% of STWs are contaminated at WHO standard (APSU, 2005). Besides domestic use, huge quantities of water from shallow aquifers are also used for irrigation during the dry season. Since its detection in late 1993 in Bangladesh, much of the research works on arsenic have focused on its presence in and exposure through drinking/cooking water. However, widespread use of groundwater for irrigation suggests that ingestion of irrigated crops could be another major exposure route for arsenic (Ali et al., 2003). Besides, phytotoxicity due to increased arsenic in soil/water and its long-term impact on agricultural yield is another major concern (Ali et al., 2003). In Bangladesh about 33% of total arable land is now under irrigation facilities. The use of As contaminated irrigation water may cause accumulation of As in soils and plants and vegetables. It may create hazard both in soil environment and in crop quality (Imamul Huq et al., 2001). Twenty percent loss of crop (cereal) production due to high concentration (30 mg/kg) of As in plant body has been reported by Davis and Coker (1979).

About 86% of total groundwater withdrawn is utilized in agricultural sector. The use of groundwater for irrigation increased from 30 to 72% of total irrigated area during the period 1981 to 2002, while area irrigated by using shallow tube well increased from 12 to 58% during same period (Ministry of Agriculture, 2004).

Since we are increasingly depending on shallow aquifer for irrigation water, a huge quantity of arsenic is being added to the agricultural fields each year with irrigation water (Ali, 2005). This As contaminated groundwater is being used for irrigation purpose, leaving a risk of soil accumulation of this toxic element and eventual exposure to the food chain through plant uptake and animal consumption (Imamul Huq and Naidu, 2005). Jute (*Corchorus* sp.), an important and the largest natural fibre crop once called golden fibre belonging to the family *Tiliaceae*, is an eco-friendly and the major cash crop of Bangladesh. It is cultivated in an area of about 9,93,000 acres and produced 46,19,000 m. ton in 2005-2006 (BBS, 2007). Jute is not only used as an economic crop but it has a tremendous demand as a healthy vegetable as well as medicinal value.

Besides, jute fibre and jute sticks are largely used for different domestic purposes. Jute plants improve soil productivity and also exert its positive role towards soil properties through its cultivation practices with residues viz. root, stubble, and litter full and root proliferation in the field. In addition, jute leaves of certain jute plants are consumed as vegetable (named 'Patshak') by major part of our population. Popular varieties are CVL-1 from white or deshi jute (*Corchorus capsularis*), and OM-1 and 0-9897 from Tossa Jute (*Corchorus olitorius*).

Several research has been conducted to assess arsenic contamination in different vegetables (Imamul Huq et al., 2001) except jute. So, an attempt has been made to see whether As accumulation occurs in jute plants and jute leaves or not due to irrigation with arsenic contaminated groundwater in soil. The specific aim of this research is to-

a) identify whether jute is an arsenic accumulator and thereby likely to contribute to As exposure through its consumption, and b) if it is an accumulator, then it could be used as a phytoremediator to clean the As-contaminated soil. With these views in mind, the present research has been conducted.

MATERIALS AND METHODS

The present experiment was carried out to study the response of jute (*Corchorus capsularies and Corchorus olitorius*) to the accumulation of As from soil to plants when various rates of As were applied. The experiment was conducted in the green house. The soil was obtained from agricultural field, Manikganj, Dhaka, Bangladesh (23° 53.034′ N and 90°02.265′ E) at depths of 0-15 cm by composite soil sampling method. The soil was carefully mixed, air dried in the

Fig. 1. Photograph showing the pot experiment conducted in green house of BJRI, Dhaka.

shade, tiled, and disciplined by a 2-mm sieve to eliminate gravels, visible root and debris before the experiment. The sieved soils were mixed thoroughly for making composite samples and preserved in the same way as above. These soils were used for chemical and physicochemical analyses including; particle size, moisture content, organic matter, organic carbon, pH and available potassium by using Imamul Huq & Alam (2005) proposed protocol. Textural classes were determined by Marshall's Triangular Co-ordinates as designed by the USDA (1951). Available phosphorus was analyzed by a spectrophotometer at 880 nm. The total nitrogen was determined by Kjeldahl's method Jackson (1962). Arsenic, iron and manganese content of the soil samples were determined by Atomic absorption spectrometer (AAS).

A pot experiment was carried out in the green house of Bangladesh Jute Research Institute, Dhaka (Fig. 1).

In the experiment, As was applied at the rate of 0, 10, 20 and 40 mg As/kg soil. The background level of As in soil was 4.2 mg/kg. The salt sodium meta-arsenite ($NaAsO_2$) was used as a source of As. All experiments were done in triplicates. The pots were arranged randomly in the green house. There were a total of 36 pots. Every pot was filled up with 8 kg of air-dried soil. Then the As salt was applied in the pots with water according to treatments. The recommended doses of K and N (urea) as estimated for the soil were mixed with the soil (BARC, 2005). Cultural operations were made whenever necessary. Weeds were removed manually. Seeds of CVL-1 from Deshi jute (*Corchorus capsularies*), and 0-9897 and OM-1 from Tossa jute (*Corchorus olitorius*) were collected from the BJRI, Dhaka. Which were sterilized by 10% (v/v) of commercial bleach for 15 min and then washed thoroughly in distilled water. 25 seeds of the three varieties were sown in every pot. The pots were covered with an opaque plastic paper for germination of seeds.

Soils from each pot were collected. The soils were air dried, crushed and homogenized and was screened to pass through a 0.5 mm sieve for chemical analysis. The soil samples were preserved in plastic bags and labeled for the analysis of arsenic, iron and manganese. The plants in the pots were sampled three times *viz.*, at 42, 52 and 62 days after sowing. This was done manually by uprooting the plants carefully from the pot. The plants were washed first with water. The plants were separated into root, stem and leaf and the fresh weight was taken. The samples

Table 1. Some physical, physico-chemical and chemical properties of the soil sample.

Properties	Soil values
pH (Soil: H_2O = 1: 2.5)	7.17
Particle size analysis	
Sand	56%
Silt	24%
Clay	20%
Texture	Sandy loam
Moisture content	8.64%
Organic carbon	0.70%
Organic matter	1.20%
Available - N_2	504 mg/kg
Available – Phosphorus	30 mg/kg
Available – Potassium	63.33 mg/kg
Arsenic	4.2 mg/kg
Arsenic (water soluble)	bdl (below detection level)
Iron	1.60 %
Manganese	372 mg/kg

were dried in oven at 80°±5°C and dry weight was taken. The oven-dried samples were ground and passed through a 0.2 mm sieve.

0.5 g of plant sample (each of root, stem and leaves) was weighed separately into 100 ml Pyrex glass tubes. Five ml of nitric acid (HNO_3) was added and the tubes were left for half an hour. Then the sample tubes were placed in a digestion block. Samples were normally predigested overnight over a temperature 50-75°C before increasing the temperature to 140°C for the final dissolution of organic material. After dissolution was complete; samples were diluted to 25 ml, shaken and filtered. This extract was used for the determination of As, Fe and Mn content of plant (Portman and Riley, 1964). The experimental data was analyzed by SPSS (V.20) and Microsoft Excel 2010.

RESULTS AND DISCUSSION

The collected soil sample was analyzed in the laboratory before setup of the experiment to see the nutrient and some elemental status of the soil. The values of the initial soil analysis are presented in the Table 1.

The mean values (for three replications) of arsenic concentration in leaf, stem and root of the three varieties of jute are presented in Tables S1 and S2 respectively at various stages of growth. It is important to note that in control plants there were some As accumulation which could be due to the presence of background As in soil. It is observed from Table S1 and the Fig. 2. that roots accumulated the most As irrespective of the varieties, the OM-1 accumulating the most. The As content in any parts of the plants increased with increasing rates of As application. When ANOVA was done for the different plant parts it was observed that that there was significant difference in the concentration of As in leaf among the three varieties (F=4.03 & P=0.03), but there was no significant difference in the concentration of As due to As treatment (F=1.96 & P=0.143). The highest accumulation of As was observed in OM-1 varieties (S2). It is also apparent that the accumulation of As was the maximum in the roots of all the varieties. This tendency of As accumulation has also been reported for rice and wheat (Hasan et al., 2022; Zhang et al., 2009)

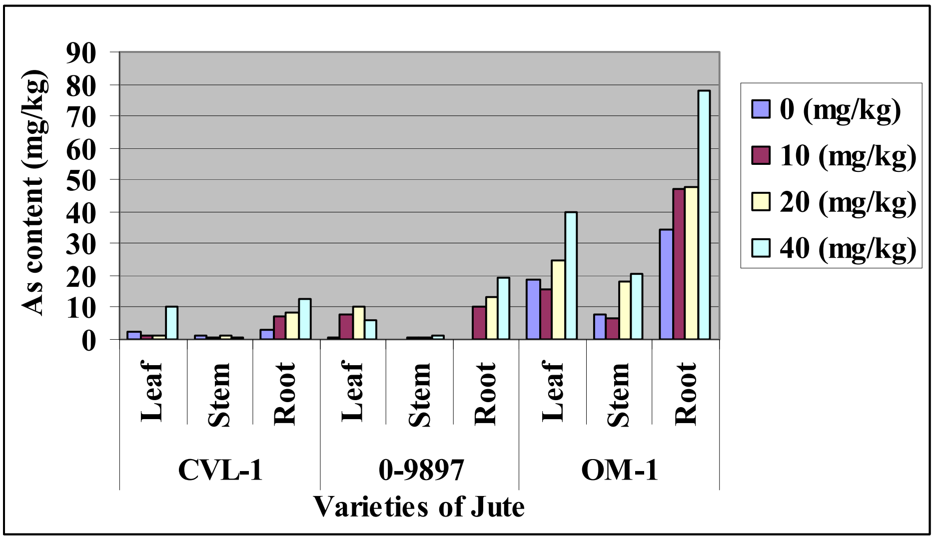

Fig. 2. Accumulation of As (mg/kg d.w.) by different parts of CVL-1, 0-9897 and OM-1 varieties at different rates of As treatment at 42 days of growth.

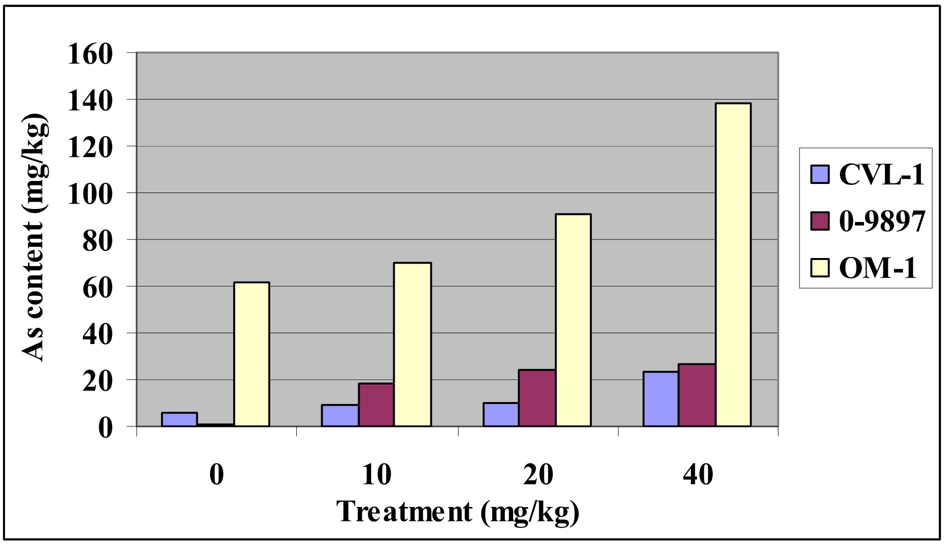

Fig. 3. Accumulation of As (mg/kg d.w.) by whole plant of CVL-1, 0-9897 and OM-1 varieties at 42 days of growth.

As contents in stem increased with increasing rates of As for 0-9897 and OM-1 varieties. The CVL-1 variety however, showed an erratic behavior in this respect which could be due to its high sensitivity to As toxicity. The ANOVA indicates that there was significant difference in the concentration of As in stems among the three varieties (F=4.24 & P=0.03), but there was no significant difference in the concentration of As due to As treatment (F=0.61 & P=0.62). The highest accumulation of As was observed in OM-1 variety.

In the case of roots, the accumulation of As of three varieties increased with increasing rates of As. The ANOVA indicates that there was significant difference in the concentration of As in roots among the three varieties (F=5.68 & P=0.01), but there was no significant difference in the concentration of As due to As treatment (F=2.57 & P=0.07). The highest amount of As was observed in 40 mg/kg As treated soil and the lowest in soil with no As treatment (control). The highest accumulation of As was observed in OM-1 variety.

From Table S2 and the Fig. 3. it is observed that the accumulation of As of three varieties

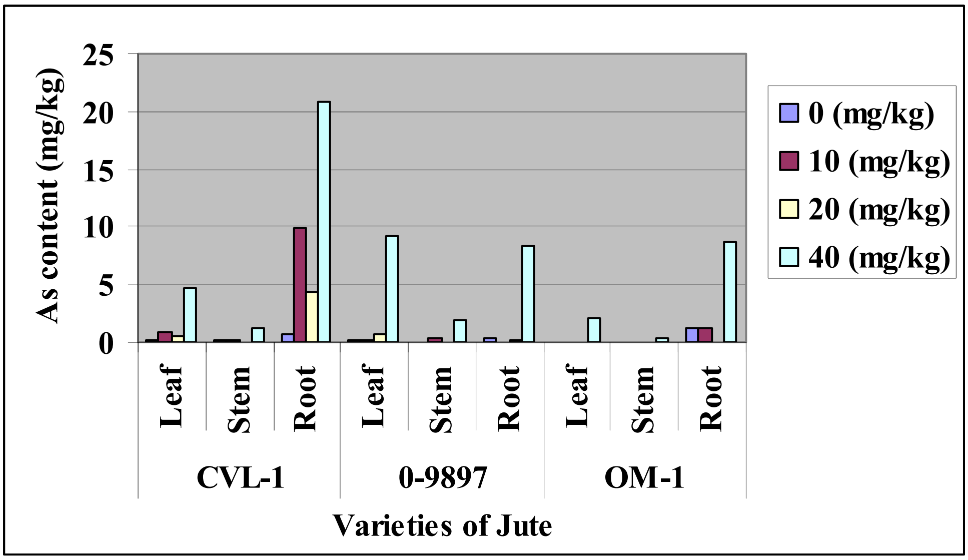

Fig. 4. Accumulation of As (mg/kg d.w.) by different parts of CVL-1, 0-9897 and OM-1 varieties at different rates of As treatment at 52 days of growth.

showed increasing tendency with increasing rates of As. The ANOVA indicates that there was significant difference in the concentration of As in whole plant among the three varieties (F=5.18 & P=0.012), but there was no significant difference in the concentration of As due to As treatment (F=2.04 & P=0.132). The highest amount of As was observed in 40 mg/kg As treated soil and the lowest in soil with no As treatment (control). Among the three varieties, CVL-1 and 0-9897 had equal effect on the accumulation of As. But OM-1 variety showed the highest accumulation of As. So, OM-1 variety had As affinity.

From table S1 and the fig.4, it is observed that the As concentration was relatively much lower than that observed at the 42 days harvest. This could be due to the dilution effect. However, the tendency of accumulation of As remained the same as for 42 days harvest – increasing in all parts with increasing concentration in the growth medium and roots accumulating the most. The ANOVA indicates that there was significant difference in the concentration of As in leaf among the three varieties (F=4.03 & P=0.03), but there was no significant difference in the concentration of As due to As treatment (F=1.96 & P=0.14). The accumulation of As in stem was very negligible. The ANOVA indicates that there was significant difference in the concentration of As in stems among the three varieties (F=4.24 & P=0.03), but there was no significant difference in the concentration of As due to As treatment (F=0.61 & P=0.62).

In the case of roots, the highest accumulation of As was observed and three varieties had increasing tendency with increasing rates of As. The ANOVA indicates that there was significant difference in the concentration of As in roots among the three varieties (F=5.68 & P=0.01), but there was no significant difference in the concentration of As due to As treatment (F=2.57 & P=0.07). It is interesting to note that, at this stage of growth, all the three varieties had a tendency to concentrate most the As in their roots, very little being transported to the leaves.

From Table S2, and the Fig.5. it is observed that the accumulation of As of three varieties showed increasing tendency with increasing rates of As. The ANOVA indicates that there was significant difference in the concentration of As in whole plant among the three varieties (F=5.18 & P=0.01), but there was no significant difference in the concentration of As due to As treatment (F=2.04 & P=0.13). Here the highest amount of As was accumulated in CVL-1 variety and the highest amount of As was observed in 40 mg/kg As treated soil and the lowest in soil with no As

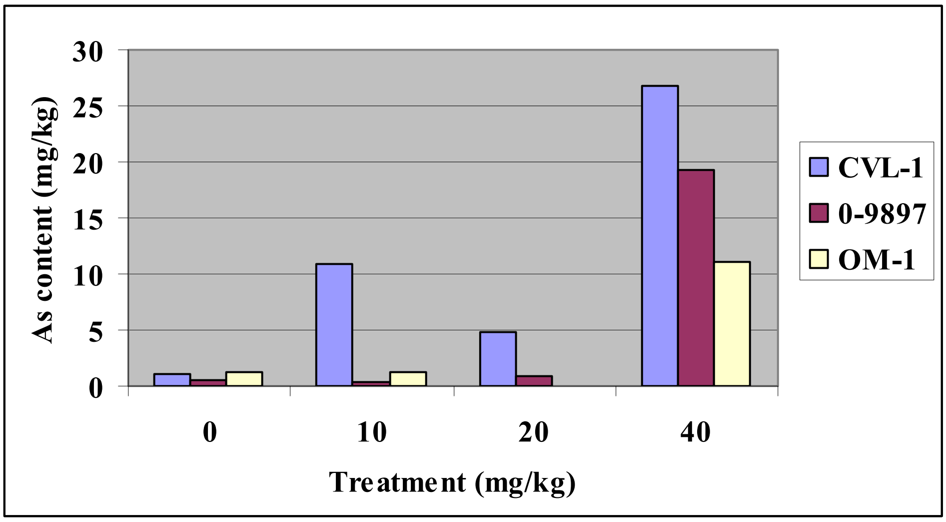

Fig. 5. Accumulation of As (mg/kg d.w.) by whole plant of CVL-1, 0-9897 and OM-1 varieties at 52 days of growth.

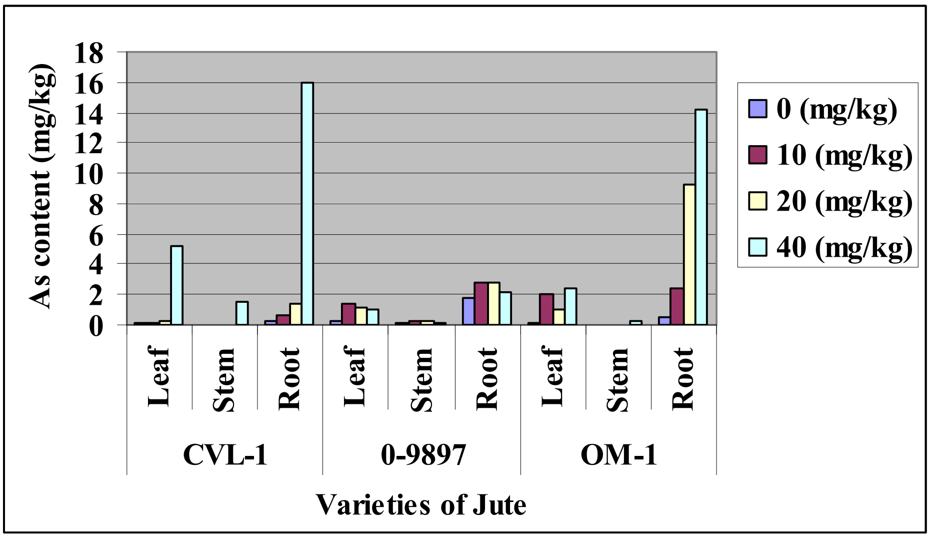

Fig. 6. Accumulation of As (mg/kg d.w.) by different parts of CVL-1, 0-9897 and OM-1 varieties at different rates of As treatment at 62 days of growth.

treatment (control).

It is observed from Table S1 and the Fig. 6. that the As concentration was relatively much lower than that observed at the 42 and 52 days harvest. This could be due to the dilution effect. However, the tendency of accumulation of As remained the same as for 42 and 52 days harvest – increasing in all parts with increasing concentration in the growth medium and roots accumulating the most and the lowest accumulation in stem. The ANOVA indicates that there was significant difference in the concentration of As in leaf among the three varieties (F=4.03 & P=0.03), but there was no significant difference in the concentration of As due to As treatment (F=1.96 & P=0.14). The accumulation of As in stem was also very negligible. The ANOVA indicates that there was significant difference in the concentration of As in stems among the three varieties (F=4.24 & P=0.03), but there was no significant difference in the concentration of As due to As treatment (F=0.61 & P=0.62).

In the case of roots, highest accumulation of As was observed and three varieties had

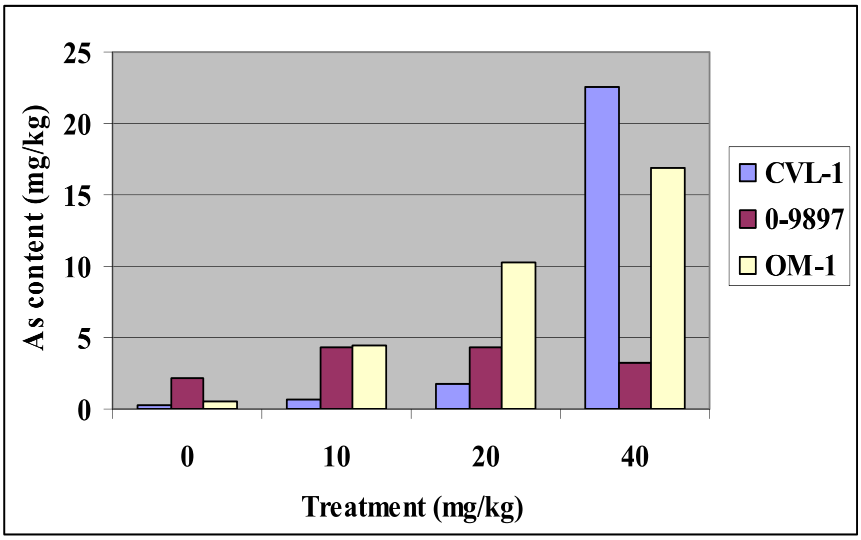

Fig. 7. Accumulation of As (mg/kg d.w.) by whole plant of CVL-1, 0-9897 and OM-1 varieties at 62 days of growth.

Table 2. Regression (R-Sq) values & P- values between treatment and plant As (mg/kg d.w.) for CVL-1, 0-9897 & OM-1 varieties.

Variety	R-Sq Value (%)	P value	Regression Equation
CVL-1	74.7	0.00	As = 0.49 + 0.53 Treatment
0-9897	30.2	0.06	As = 2.40 + 0.36 Treatment
OM-1	9.0	0.34	As = 18.38 + 0.90 Treatment

increasing tendency with increasing rates of As. Highest amount of As was observed in 40 mg/kg As treated soil and lowest in soil with no As treatment (control). The ANOVA indicates that there was significant difference in the concentration of As in roots among the three varieties (F=5.68 & P=0.01), but there was no significant difference in the concentration of As due to As treatment (F=2.57 & P=0.07). At this stage of growth, all the three varieties had also a tendency to concentrate most the As in their roots, very little being transported to the leaves.

From Table S2 and the Fig. 7. it is observed that the accumulation of As of three varieties showed increasing tendency with increasing rates of As. The ANOVA indicates that there was significant difference in the concentration of As in whole plant among the three varieties (F=5.18 & P=0.01), but there was no significant difference in the concentration of As due to As treatment (F=2.04 & P=0.13). The highest amount of As was observed in 40 mg/kg As treated soil and lowest in soil with no As treatment (control).

The regression analysis (Table 2) shows that for CVL-1 variety, treatment effect was significant on the accumulation of As and accumulation increased with increasing rates of As treatment for all varieties. So, from the above observations, it can be concluded that CVL- is As sensitive variety and OM-1 variety accumulates quite high amount of As at 42 days when the jute plant is used for comestible purposes as a green vegetable.

A comparison of arsenic accumulation among three varieties was made and the results are presented in Fig. 8 to 10. It has been observed that there was a significant variation (P=0.01) in the accumulation of As in the three varieties. The highest accumulation was observed in OM-1 variety followed by 0-9897 and CVL-1 at 42 and 62 days of growth. However, at 52 days growth

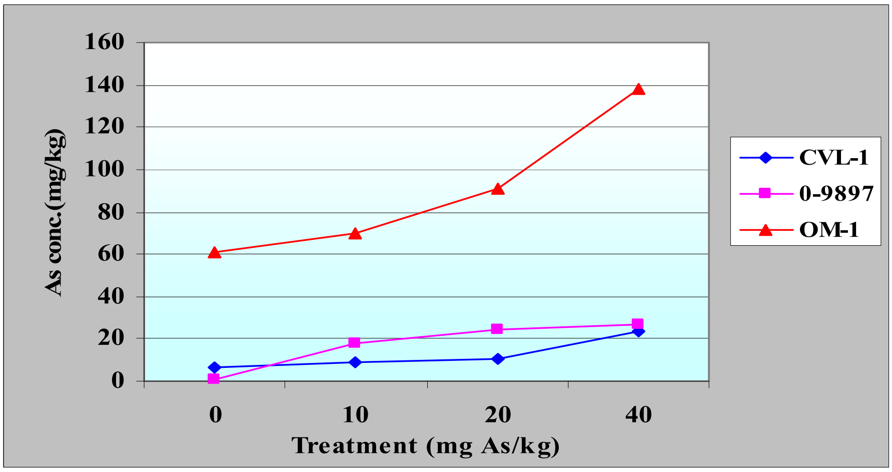

Fig. 8. Content of As (mg/kg) in CVL-1, 0-9897 and OM-1 varieties at 42 days of growth.

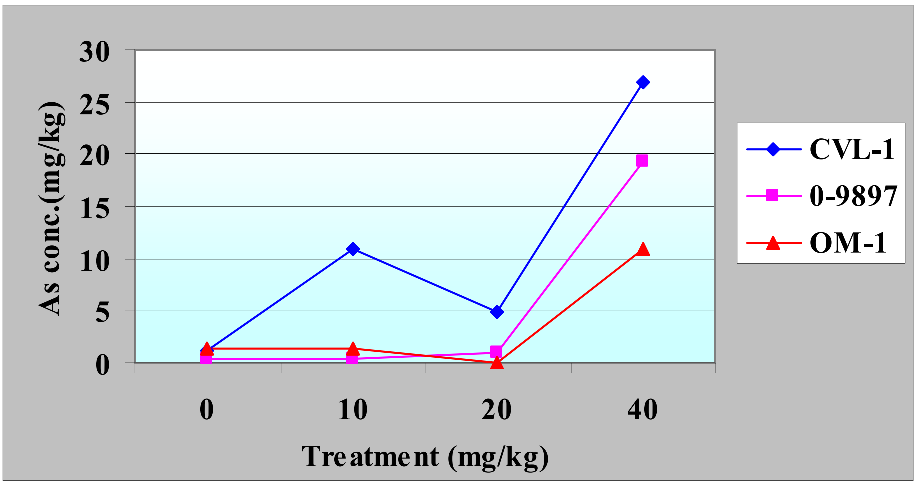

Fig. 9. Content of As (mg/kg) in CVL-1, 0-9897 and OM-1 varieties at 52 days of growth.

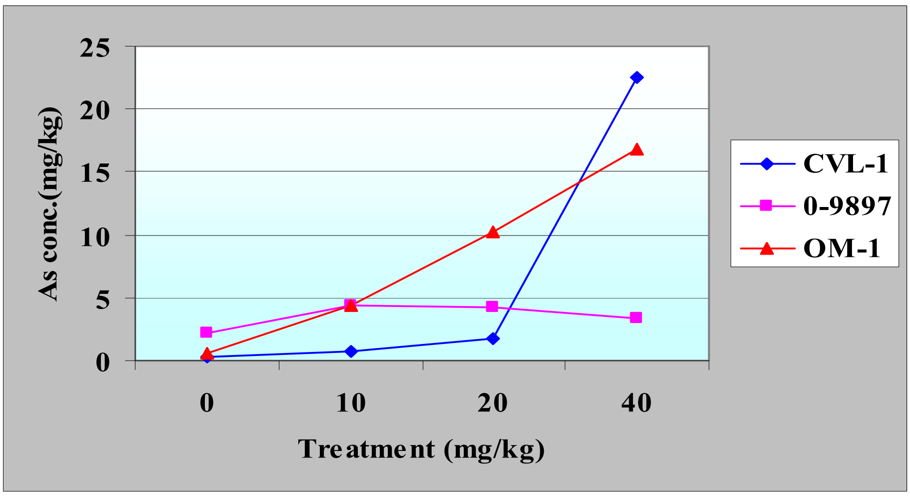

Fig. 10. Content of As (mg/kg) in CVL-1, 0-9897 and OM-1 varieties at 62 days of growth.

stage, CVL-1 showed the highest accumulation.

At any stage of growth, the accumulation of As in the varieties also differed significantly (P=0.001) (Fig. 11 to 13). Accumulation of As at 10 and 40 mg/kg treatment, the maximum was observed at 52 days harvest for CVL-1 while for the other two treatments, the maximum was observed at 42 days of growth. In the case of the other two varieties, overall the maximum accumulation of As was observed at 42 days of growth at 40 mg/kg treatment.

So, it is clear that when the jute is grown for vegetable care must be taken to avoid its cultivation in As affected areas or in areas irrigated with As contaminated water. The amount of As uptake (mg/100 plants) by whole plant of three varieties are presented in the Table S3, The uptake was calculated by using the concentration of As in dry matter and dry weight of plants and the result is expressed as mg/100 plants. It has been found that in most cases As uptake increased with increasing As treatment for all varieties. However, the highest As uptake was observed in OM-1 variety among the three varieties. The maximum As uptake was found at 40 mg As/kg treatment.

Total plant uptake of As was significant for all varieties (for CVL-1, R^2=35.9 %, P=0.04; for 0-9897, R^2=51.0 %, P=0.01 and for OM-1 variety, R^2=35.1%, P=0.04). In this experiment, it is

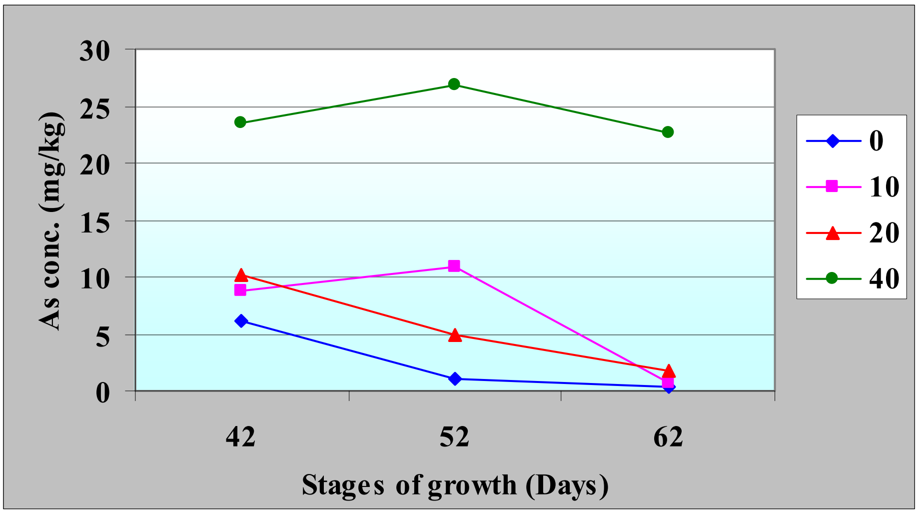

Fig. 11. Content of As (mg/kg) at various stages of growth for CVL-1 variety.

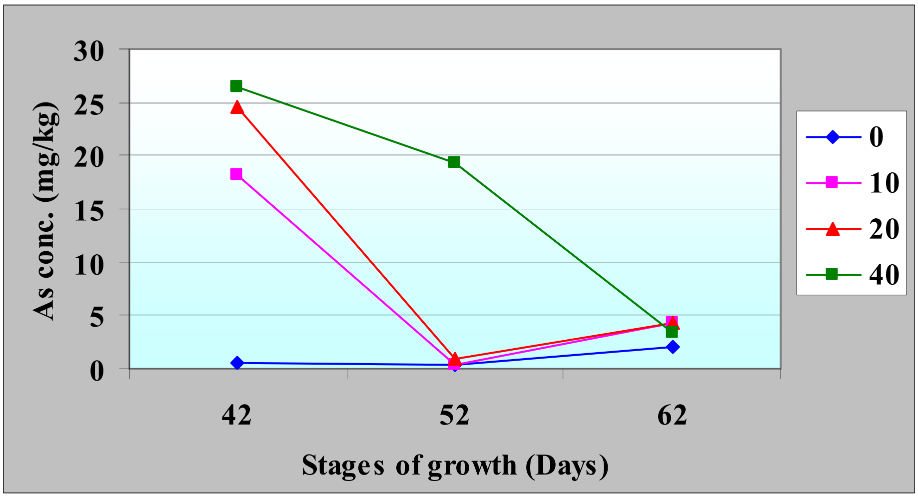

Fig. 12. Content of As (mg/kg) at various stages of growth for 0-9897 variety.

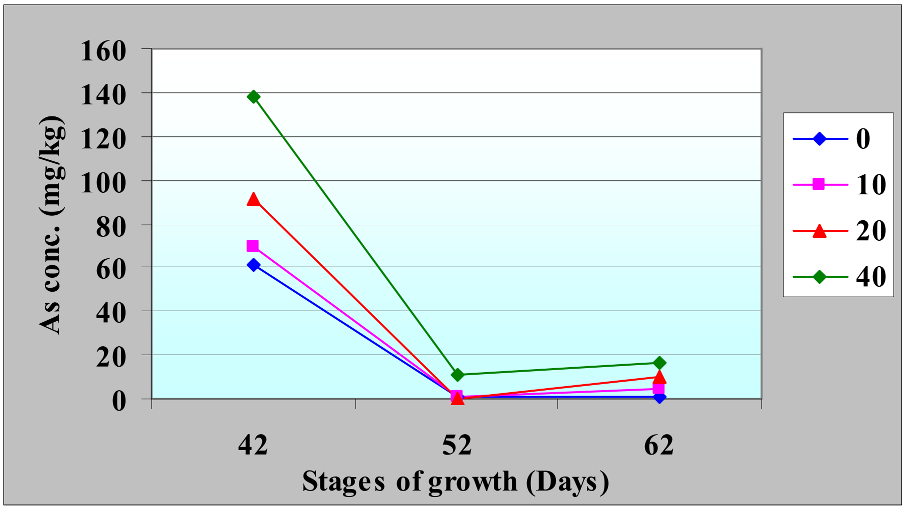

Fig. 13. Content of As (mg/kg) at various stages of growth for OM-1 variety.

Table. 3. % As transferred from soil to plant at various stages of growth for CVL-1.

Treatment (mg As/kg)	Total soil As (mg/kg)	As (mg/kg) in soil after Harvest			% As transferred from soil to plant		
		CVL-1	0-9897	OM-1	CVL-1	0-9897	OM-1
0	**4.2**	0.042	0.042	0.043	99	99	98.10
10	**14.2**	0.042	0.044	0.043	337.10	337.05	337.07
20	**24.2**	0.045	0.047	0.043	575.12	575.07	575.17
40	**44.2**	0.047	0.053	0.053	1051.26	1051.12	1051.12

observed that OM-1 variety takes up the highest amount of As.

Total As in soil (initial) was computed by adding background soil As with the amount of As applied to soil for each treatment. After the harvest, soil samples were collected and analyzed. Deducting the As concentration in soil collected after harvest of jute plants from the total soil As, the amount of As transferred from soil to plant was analyzed. The values are expressed as percentage (%) of applied As.

Transfer factor gives an indication of the affinity of a plant to a particular element in a soil particularly to a toxic one to justify the As tolerance of the three varieties, the transfer factors of As was thus calculated. Total As in soil (initial) was computed by adding background soil As with the amount of As applied to soil for each treatment. After the harvest, soil samples were collected and analyzed. The plant samples were also analyzed. The transfer factor of As was computed by dividing concentration of plant As with the total concentration of soil As.

From the Tables 4 to 6, it can be concluded that further the variety OM-1 shows the maximum affinity to As than the other two varieties.

Calculations were made based on the possibility of exceeding the maximum allowable daily limit (MADL) for jute plants of three varieties analyzed. The maximum allowable limit of consumption of arsenic through food by a person is 0.22 mg/kg per day. Generally, we eat jute leaves of 42 days of growth. For example, if a person consumes 100g of jute leaves of these three varieties per day, it can be observed from the table 4.30 that As will be ingested into the body at that amount which will exceed the maximum allowable daily limit (except leaves of 10 mg/kg treatment for CVL-1 variety).

Table. 4. As content (mg/kg d.w.) and Transfer Factor (T.F.) in CVL-1 variety at various stages of growth.

Treatment (mg As/kg)	Total soil As (mg/kg)	As content (mg/kg d.w.) and Transfer Factor (T.F.)					
		42 Days		52 Days		62 Days	
		As (mg/kg)	T.F.	As (mg/kg)	T.F.	As (mg/kg)	T.F.
0	**4.2**	6.16	1.50	1.11	0.26	0.33	0.10
10	**14.2**	8.80	0.62	10.92	0.77	0.71	0.05
20	**24.2**	10.16	0.42	4.90	0.20	1.70	0.10
40	**44.2**	23.53	0.53	26.84	0.61	22.58	0.51

Table. 5. As content (mg/kg d.w.) and Transfer Factor (T.F.) in 0-9897 variety at various stages of growth.

Treatment (mg As/kg)	Total soil As (mg /kg)	As content (mg/kg d.w.) and Transfer Factor (T.F.)					
		42 Days		52 Days		62 Days	
		As (mg/kg)	T.F.	As (mg/kg)	T.F.	As (mg/kg)	T.F.
0	**4.2**	0.53	0.13	0.45	0.11	2.15	0.51
10	**14.2**	18.12	1.30	0.44	0.03	4.36	0.31
20	**24.2**	24.50	1.01	0.90	0.04	4.30	0.18
40	**44.2**	26.49	0.60	19.36	0.44	3.30	0.07

Table. 6. As content (mg/kg d.w.) and Transfer Factor (T.F.) in OM-1 variety at various stages of growth.

Treatment (mg As/kg)	Total soil As (mg /kg)	As content (mg/kg d.w.) and Transfer Factor (T.F.)					
		42 Days		52 Days		62 Days	
		As (mg/kg)	T.F.	As (mg/kg)	T.F.	As (mg/kg)	T.F.
0	**4.2**	61.25	14.58	1.29	0.31	0.56	0.13
10	**14.2**	69.87	4.92	1.28	0.10	4.44	0.31
20	**24.2**	91.12	3.77	0.00	0.00	10.24	0.42
40	**44.2**	138.26	3.13	11.00	0.25	16.83	0.38

Table. 7. As content (mg) in 100g jute leaves at 42 days of growth for CVL-1, 0-9897 and OM-1.

Treatment (mg As/kg)	As (mg/kg) in leaf at 42 days of growth			As intake (mg) by 100g jute leaves		
	CVL-1	0-9897	OM-1	CVL-1	0-9897	OM-1
10	1.30	7.64	15.86	0.13	0.76	1.60
40	10.43	6.10	39.95	1.04	0.61	3.99

So, when the jute is grown for vegetable, it must be taken care to avoid its cultivation in As affected areas or in areas irrigated with As contaminated water.

CONCLUSION

This experimental study shows the response of jutes (*Corchorus capsularies and Corchorus olitorius*) to the accumulation of As from soil to plants when various rates of As were applied. In the experiment, four treatments of arsenic (control, 10, 20 and 40 mg/kg) were applied. The salt sodium meta-arsenite ($NaAsO_2$) was used as a source of As. Three jute varieties of CVL-1 (*C. capsularis*), 0-9897 and OM-1(*C. olitorius*) were used. The plants in the pots were sampled three times *viz*., at 42, 52 and 62 days after sowing and then it was processed, dried and analyzed.

It was observed that the CVL-1 variety is As sensitive whereas the 0-9897 and OM-1 varieties appeared to be As tolerant. These were evident from the fresh and dry matter production of the two types of jute. The As content in any parts of the plants increased with increasing rates of As application. Roots accumulated the most As irrespective of the varieties, the OM-1 accumulating the most. There was significant difference in the concentration of As in leaf among the three varieties. The highest accumulation was observed in OM-1 variety followed by 0-9897 and CVL-1 at 42 and 62 days of growth. However at 52 days growth stage, CVL-1 showed the highest accumulation.

Accumulation of As in the varieties also differed significantly due to stage of growth. The maximum accumulation of As was observed at 52 days harvest for CVL-1 while for the other two treatments, the maximum was observed at 42 days of growth. The highest As uptake was observed in OM-1 variety among the three varieties and this variety showed the maximum affinity to As than the other two varieties. The maximum As uptake was found at 40 mg As/kg treatment. It has been estimated from the present investigation that if a person consumes 100g of jute leaves of any of these three varieties per day, As will be ingested into the body at that amount which will exceed the maximum allowable daily limit of 0.22 mg. However, there is an exception to the leaves of 10 mg/kg treatment for CVL-1 variety.

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CONFLICT OF INTEREST

The authors declare that there is not any conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/ or falsification, double publication and/or submission, and redundancy has been completely observed by the authors.

LIFE SCIENCE REPORTING

No life science threat was practiced in this research.

REFEENCES

Ali, M. Ashraf. (2005). Fate of arsenic in the environment. In: Arsenic contamination: Bangladesh perspective (Ed. Feroze Ahmed). ITN-Bangladesh, BUET, Dhaka. (pp. 85-99).

Ali, M. A., Badruzzaman, A. B. M., Jalil, M. A., Hossain, M. D., Ahmed, M. F., Masud, A. A. and Rahman, M. A. (2003). Arsenic in plant-soil environment in Bangladesh. Fate of arsenic in the environment. Dhaka: Bangladesh University of Engineering and Technology, 85-112.

APSU (2005). The response to arsenic contamination in Bangladesh: A position paper, DPHE, Dhaka, Bangladesh. (pp. 57).

Baker, R. S., Barrentine, W. L., Bowman, D. H., Hawthorne, W. L. and Pettiet, J. V. (1976). Crop response and arsenic uptake following soil incorporation of MSMA. Weed. Sci. 24(3), 322-326.

BARC (Bangladesh Agricultural Research Council) (2005). Fertilizer Recommendation Guide-2005 (Eds. Rashid, M. M., Ali, M. I., Bhuiyan, N., Hossain, A. K. M., Huq, F., Talukder, A. B., Panaullah, G. M., Nuruzzaman, M. and Miah, M. U.). BARC soil Publication no.41. BARC, Dhaka. (pp. 1-196).

BBS (Bangladesh Bureau of Statistics) (2007). Statistical Pocket Book of Bangladesh-2006. Planning Division, Ministry of Planning Government of the Peoples Republic of Bangladesh. (pp. 173-285).

Davis, R. D. and Coker, E. G. (1979). Proc. Int. Conf. Management and control of Heavy metals in the Environment. 553 CEP consults Ltd. Edinburg, UK.

Hasan, G. M. M., Das, A. K. and Satter, M. A. (2022). Accumulation of Heavy Metals in Rice (Oryza sativa. L) Grains Cultivated in Three Major Industrial Areas of Bangladesh. J. Environ. Health, 2022.

Huq, S. I. and Naidu, R. (2005). Arsenic in groundwater and contamination of the food chain: Bangladesh Scenario. In Natural Arsenic in Groundwater (pp. 111-118). CRC Press.

Huq, S. I., Ara, Q. A. J., Islam, K., Zaher, A. and Naidu, R. (2001). The possible contamination from arsenic through food chain. Groundwater arsenic contamination in the Bengal Delta Plain of Bangladesh, 91-6.

Huq, I., Smith, E., Correll, R., Smith, L., Smith, J., Ahmed, M. and Naidu, R. (2001). Arsenic transfer in water-soil-crop environments in Bangladesh. I.: Assessing potential arsenic exposure pathways in Bangladesh. Arsenic in the Asia-Pacific Region Workshop Adelaide. 2001. (pp. 50-52).

Imamul Huq, S. M. and M. D. Alam. 2005. A Hand book on Analyses of Soil, Plant, and Water. Bangladesh-Australia Centre for Environmental Research (BACER_DU), University of Dhaka, Bangladesh. (pp. 1-246).

Jackson, M. L. (1962). Soil chemical analysis. Prentice Hall Inc., Englewood Cliffs, N. J., USA. (pp. 151).

Marin, A. R., Masscheleyn, P. H. and Patrick, W. H. (1992). The influence of chemical form and concentration of arsenic on rice growth and tissue arsenic concentration. Plant and Soil, *139*(2), 175-183.

Ministry of Agriculture (Sector Monituring Unit) (2004). Handbook of Agricultural Statistics (Ministry of Agriculture, Government of the People's Republic of Bangladesh).

Portman, J. E. and J. P. Riley. 1964. Determination of arsenic in sea water, marine plants and silicate and carbonate sediments. Anal. Chem. Acta 31: 509-519.

Reed, J. F. and Sturgis, M. B. (1936). Toxicity from arsenic compounds to rice on flooded soils. J. Am. Soc. Agron., 28: 432-436.

USDA (United States Department of Agriculture) (1951). Soil Survey Manual by Soil Survey Staff. Bureau of Plant Industry. Soil and Agricultural Engineering. Handbook No. 18. (pp. 205).

Zhang, W. D., Liu, D. S., Tian, J. C. and He, F. L. (2009). Toxicity and accumulation of arsenic in wheat (Triticum aestivum L.) varieties of China. Phyton (Buenos Aires), 78(2), 147-154.