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# Effect of arsenate and Arsenite on early seedling growth of rice

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**Abstract**
Presence of arsenic in ground water is a grave concern now as it is used for drinking and crop irrigation. Arsenic load of soil in the areas of arsenic contaminated ground water is gradually increasing as more than 95% of such contaminated ground water is used for crop irrigation. An experiment was conducted to study effect of arsenate and arsenite on germination and early seedling growth of the popular rice variety shatabdi. Rice seeds were exposed to water contaminated with different concentrations (Control, 2, 4, 6, 8 and 10 ppm) of arsenate and arsenite during germination and seedling growth. Observations were taken on germination at every 24 hour interval up to seven days. Seedling length (cm) and dry weight (g) recorded after seven days and plant height stress index (PHSI) and tolerance index (TI) was calculated. The speed of germination under arsenate at 2 ppm and 4 ppm was at par with the control treatment and under further higher concentration of arsenate and in all concentrations of arsenite it was lower than the control treatment. Length of seedlings, dry weight of seedlings was found to decrease with increase in concentration of arsenic. Such decrease was higher in arsenite than arsenate. The results indicate that arsenate beyond 4 ppm and arsenite beyond 2 ppm only affected germination. But seedling growth was very sensitive to arsenic and was affected at all concentrations of arsenate and arsenite. Arsenite appeared to be more toxic than arsenate.

**Keywords:** Rice, arsenic, speed of germination, seedling growth

## 1. Introduction
Rice (*Oryza sativa* L.) is one of the three major food crops and staple food for the vast part of world including India. Rice cultivation requires huge volume of water, long term use of arsenic contaminated groundwater for irrigation may result in the increase of arsenic concentration in the agricultural soil and eventually its accumulation in rice plants. Arsenic is an element long known for its terrible poisonous effect. Due to its use by the ruling class to murder one another and its incredible potency and discreetness, arsenic has been called the King of Poisons. Once the poison of the kings now is crawling into the food chain to poison millions of common people and the ecology as a whole of the vast arsenic affected areas of Bangladesh, West Bengal of India, Taiwan, Vietnam, pockets of China, USA etc. The efficiency of arsenic translocation from roots to shoots was greater when plants were supplied with arsenite than with arsenate, and in both treatments rice showed the highest translocation efficiency. Arsenite was reported to be the main species of arsenic (86–97%) in the xylem sap from arsenite-treated plants (Su *et al.*, 2010) [10]. Various studies reported that low concentrations of arsenic stimulated the growth of plants; but excessive arsenic did harm to plants (Han *et al.*, 2002) [3]. Hence this present experiment was conducted to study the physiological impact of arsenate and arsenite on early seedling growth of rice.

## 2. Materials and Methods
The experiment was conducted in laboratory condition under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur. The name of the rice genotypes under study are IET-4786 (Shatabdi). Seeds of this rice genotypes were collected from Rice Research Station, Chinsurah, W. B. and temporarily stored in desiccator until use. Sodium arsenate and Sodium arsenite was used for preparation of arsenate and arsenite solution respectively. Seeds were surface sterilized with 0.1% (w/v) $HgCl_2$. Seeds were then soaked separately in different arsenate and arsenite solution (2 ppm, 4 ppm, 6 ppm, 8 ppm and 10 ppm) in petridishes. Control set was prepared similarly using distilled water. All petridishes were kept under controlled laboratory

conditions (BOD) having temperature 25±1$^0$C. Number of germinated seeds was counted every day from the first day and the cumulative index was made to compute the speed of germination by using the formula given below as described by Singh *et al.*, (2010) [8].

Speed of germination = $N_1/1 + N_2/2 \ldots\ldots\ldots\ldots + N_X/X$

Where,
$N_1$ or $N_2$ or $N_X$ = Number of seed germinated on first/second/Xth day respectively. In order to determine seedling growth, seedling length and dry weight of seedlings were measured after seven days. Plant height stress index (PHSI) was calculated as described by Boulsama and Schapaugh (1984) [2].

$$\text{PHSI} = \frac{\text{Plant height under stressed seedling (PHS)}}{\text{Plant height of control seedling (PHC)}} \text{ x } 100$$

On the basis of mean root elongation of stressed and non-stressed (control) plants tolerance index (TI) were calculated by adopting the formula given by Routa *et al.*, (2000) [7].

$$\text{TI} = \frac{\text{Dry wt. of seedling under stress (cm)}}{\text{Dry wt. of seedling under control (cm)}} \times 100$$

## 3. Results and Discussion

### 3.1. Speed of germination

The values of Speed of germination under different concentrations of arsenate and arsenite are presented in the figure 1. The variation in speed of germination response of rice variety shatabdi due to different treatments of arsenate and arsenite was statistically significant among the concentrations. The highest speed of germination was observed in arsenate at 2 ppm followed by 4 ppm, control, 6 ppm, 8 ppm and 10 ppm indicating boosting effect of low doses of arsenate in speed of germination and progressive inhibitory effect of effect at its higher concentration. However, in arsenite treatments, the highest speed of germination was observed at control treatments followed by the arsenite treatments. The result showed that the speed of germination under different concentrations of arsenite was lower than the corresponding concentrations of arsenate and statistical analysis revealed that such difference among the arsenic species was significant clearly indicating that arsenite was more hindering to the speed of germination than arsenate. It is apparent from result that at arsenate concentration up to 4 ppm germination was sped up but at higher concentration of arsenate and in all concentration of arsenite speed of germination was deleteriously affected. Such result regarding speed of germination is in consonance with Li *et al.*, (2007) [4].

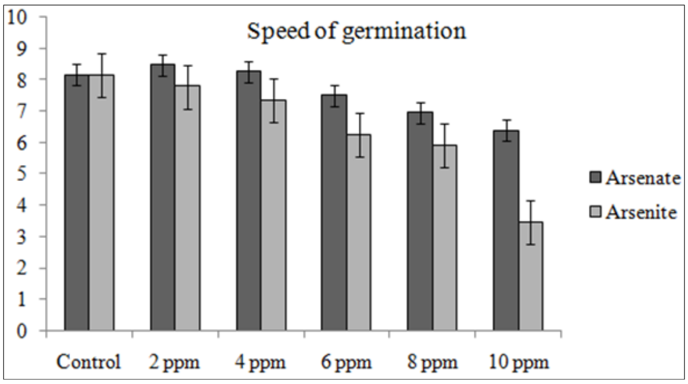


**Fig 1:** Speed of germination under different concentrations of arsenate and arsenite.

### 3.2. Seedling length

The values of seedling length of the rice under different concentrations of arsenate and arsenite are presented in the figure 2. The highest seedling length under arsenate treatment was observed in control which was at par with the arsenate treatment 2 ppm but significantly higher than arsenate @ 4 ppm, 6 ppm, 8 ppm and 10 ppm. In arsenite treatment, highest seedling length was observed at control followed by the arsenite treatments @ 2 ppm, 4 ppm, 6 ppm, 8 ppm and 10 ppm indicating its little detrimental effect on total seedling length. The mean seedling length over different concentrations of arsenate was higher than that of arsenite indicating arsenite as a stronger toxicant. Abedin & Meharg, 2002 [1]; Liu *et al.*, 2005 [5] also observed progressive inhibitory effect of arsenic on early seedling growth with increase in concentration which is in agreement of the results of present experiment.

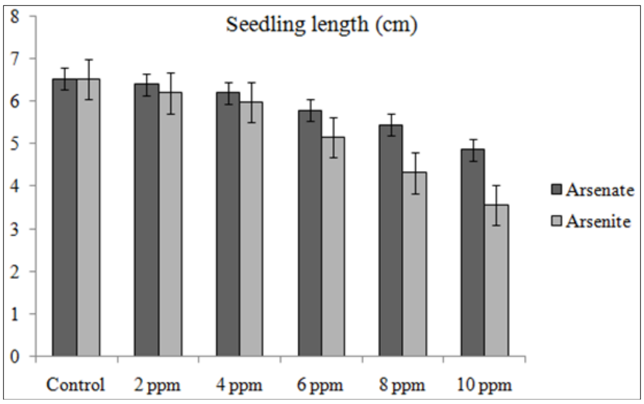


**Fig 2:** Seedling length (*cm)* of the rice seedling under different arsenic treatments.

### 3.3. Dry weight

The values of dry weight of the rice seedlings under different concentrations of arsenate and arsenite are presented in the figure 3. The dry weight of the seedlings in all the arsenic treatments was significantly lower than the control. Such result indicates that the dry matter production even in early seedling growth of rice was seriously affected by the presence of arsenic not only in higher concentrations but in lower concentrations also. The mean dry weight over different concentrations of arsenate was higher than that of arsenite indicating more inhibitory effect of arsenite in dry matter production of rice seedlings than arsenate. Stoeva *et al*., (2003) [9]; Liu *et al*., (2005) [5]; Pigna *et al*., (2010) [6] also reported reduction in root and shoot biomass of wheat crop which is in agreement of the results of present experiment.

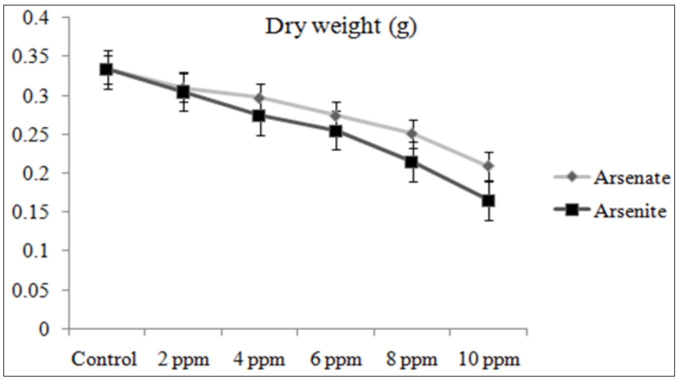


**Fig 3:** Dry weight (g) of the rice seedling under different arsenic treatments.

### 3.4. Plant Height Stress Index (PHSI)

The values of Plant height stress index of the rice seedlings under different concentrations of arsenate and arsenite are presented in the figure 4. The Plant height stress index in the treatments with arsenate at 2 ppm, 4 ppm and arsenite at 2 ppm were statistically as par with the control where as in rest of the arsenate and arsenite treatments it was significantly lower than the control. Such result indicates that at low load of arsenic contamination plant height stress index was not affected but higher load of arsenic in seed negatively affected Plant height stress index of the seedlings. The mean Plant height stress index over different concentrations of arsenate was higher than that of arsenite indicating arsenite as a stronger toxicant.

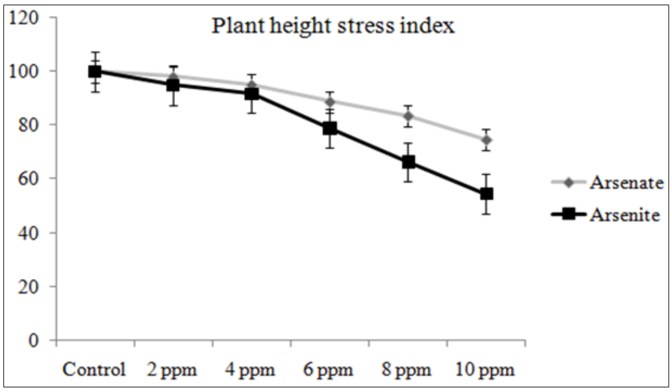


**Fig 4:** Plant height stress index (PHSI) of the rice seedling under different arsenic treatments.

### 3.5. Tolerance index

The values of tolerance index of the rice seedlings under different concentrations of arsenate and arsenite are presented in the figure 5. Findings of present experiment indicates that at low load of arsenic contamination tolerance index was not affected but higher load of arsenic in seed negatively affected tolerance index of the seedlings. The mean tolerance index over different concentrations of arsenate was higher than that of arsenite. Abedin & Meharg (2002) [1] reported that tolerance index decreased with increasing concentrations of arsenite and arsenate which is in agreement of the results of present experiment.

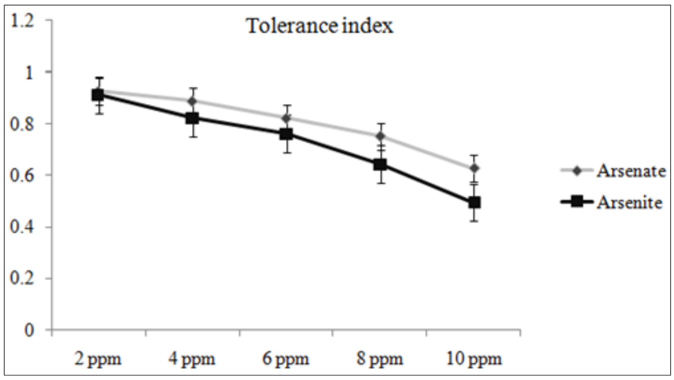


**Fig 5:** Tolerance index of the rice seedling under different arsenic treatments

### 4. Conclusion

Both arsenate and arsenite affected the germination and early seedling growth of rice. Arsenite was more toxic than arsenate to such processes. At low concentration arsenic did not interfere with the conversion of storage food materials of seeds into tissue formation. At low concentration arsenic even did not affect seedling elongation of rice seedling though it did affect the dry weight, plant height stress index and tolerance index**.**

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