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SCREENING OUT OF WHEAT VARIETIES AGAINST ARSENIC CONTAMINATED SOIL AND IRRIGATION WATER

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Abstract

Field trials on wheat were conducted at severely arsenic contaminated areas of Jessore (Chowgacha and Sharsha), Faridpur (Poranpur) and also at low contaminated Shatkhira (Benerpota) during 2010-2011 and 2011-12. The major objective of the study was to screening out of arsenic tolerant wheat varieties. Five varieties of wheat viz. Shatabdi, Bijoy, Prodip, BARI Gom-25 and BARI Gom-26 were tested. Total arsenic contents in the soils were 36.4, 32.8, 28.5 and 6.8 mg kg^{-1} for Sharsha, Chowgacha, Poranpur and Benerpota, respectively. Irrigation waters contained 0.346, 0.272, 0.238 and 0.140 mg L^{-1} arsenic for Sharsha, Chowgacha, Poranpur and Benerpota, respectively. No significant variations in yield and yield components among the tested wheat varieties was observed despite of arsenic contaminations in the irrigation water and soil. The variety, Prodip contains 0.043 and 0.028 mg kg^{-1} arsenic in straw and grain, respectively, which was lower than the other tested varieties. But arsenic contents in all of the tested wheat varieties were found much lower than that of the permissible limit (1 mg kg^{-1}). The transfer coefficient (TC) of arsenic from soil to above ground parts (straw + grain) of wheat varied slightly among the tested varieties where Prodip showed the lowest TC (0.0015-0.0018). However, BARI Gom-24 (Prodip) performed better in terms of arsenic content, uptake, biomass, yield and transfer coefficient and thus can be regarded as arsenic tolerant to a considerable extent.

Key words: Arsenic contamination, Wheat, Tolerant variety, Yield, Permissible limit

Introduction

Bangladesh agricultural sector is facing a big challenge to cope with the potential impact of arsenic (As) contamination in soil and water and its probable entry into the food chain. The average background concentration of arsenic in soils of Bangladesh is < 10 mg kg^{-1} but in some areas where soils receive As contaminated ground water irrigation, the As concentration recorded to be as high as 80 mg kg^{-1}. Sandy sediments contained 3-7 mg kg^{-1} (median: 5 mg kg^{-1}), clayey sediments contained 4-18 mg kg^{-1} (median: 9 mg kg^{-1}), whereas peaty and peaty clay sediments contained 20-111 mg kg^{-1} As (Yamazaki *et al.* 2003). Arsenic concentrations in irrigation water samples were many folds higher than

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FAO permissible limit for irrigation water (0.10 mg L^{-1}). But 24% of the total irrigated boro rice in Bangladesh is grown in areas where ground water As is > 0.05 mg L^{-1}(Karim 2001). High ground water As (0.10 -0.20 mg L^{-1}; > 0.20 mg L^{-1}) was found in the central part of the country near the Padma and Meghna rivers. Use of arsenic contaminated irrigation water leads to soil contamination with high levels of arsenic. Crops receiving arsenic-contaminated irrigation-water take up this toxic element and accumulate it in different degrees depending on the species and variety. Soil As build up during boro season over the years may reduce the yield and increase the As uptake by grain and straw of rice (Van Green *et al*. 2006). Previous studies demonstrated a significant amount of arsenic uptake by rice (Duxbury *et al*. 2003 and Wang *et al*. 2006) and edible parts of vegetable crops (Alam *et al*. 2003). Williams *et al.* (2006) conducted extensive sampling of rice throughout Bangladesh collecting 330 samples of Aman rice and Boro rice and observed a positive correlation between As in the groundwater and As in the rice. This correlation was stronger for Boro rice than that of Aman rice. Arsenic concentrations in agricultural plants varied from 0.007 to about 7.50 mg kg^{-1} (Liao *et al.*, 2005 and Dahal *et al*. 2008). Das *et al.* (2004) reported As contamination in vegetables collected from contaminated areas of Bangladesh. Farid *et al*. (2003) found higher amount of As (0.57 mg kg^{-1}) in amranth. Presence of arsenic in plants and plant products usually does not exceed 1 mg As kg^{-1} (Kiss *et al*. 1992). Wheat the second most cereal crop in Bangladesh is also cultivated in badly arsenic contaminated regions like Jessore and Faridpur. There is a general perception that upland crop like wheat may contain low amount of arsenic than that of rice. Physiological activities of wheat seedlings changed under As stress (Li *et al*. 2007). Seed germination, biomass, root length and shoot height decreased, and As accumulation increased on early seedlings of six wheat varieties as concentration increased (Liu and Zhang 2007). Arsenic concentration in wheat grain varied from (0.013 -0.086 mg kg-1) when soil contained 11-29 mg kg^{-1} As in Europe (Zhao *et al.* 2010). The content and uptake of arsenic in wheat thus need to be thoroughly investigated. Again screening out of tolerant wheat varieties needs to be done for better adaptation in the affected areas. But such studies on wheat are very scanty. It is therefore felt necessary to know the arsenic concentration in and uptake by wheat and to screening out of arsenic tolerant varieties.

Materials and Methods

A screening study was conducted to observe the performance of wheat varieties grown in arsenic contaminated soil and with contaminated irrigation water. In case of first year (2010-2011), the study was conducted in Poranpur (Faridpur) and Benerpota (Satkhira) which represented AEZ 12 and 13, respectively. The initial level of total As in soil was 28.6 mg kg^{-1} at Poranpur while 6.8 mg kg^{-1} at Benerpota. The tested varieties were Shatabdi (V_1), Bijoy (V_2), Prodip (V_3) and BARI Ghom-26 (V_4). However, incase of second year (2011-2012), the study was conducted in highly contaminated area at Chowgacha and Sharsha of Jessore under AEZ 11 and also at Poranpur of Faridpur including one more variety (BARI Gom-25). The background level of total As in soil was 32.8, 36.4 and 28.5 mg kg^{-1} for Poranpur, Chowgacha and Sharsha, respectively (Table 1). Arsenic contents in irrigation waters were 0.272, 0.346, 0.238 and 0.140 mg L^{-1} for

Table 1. Nutrient status and arsenic (As) contents in irrigation water and soils at the experimental sites.

Item	Location				Critical level
Soil properties	Poranpur	Benerpota	Chowgacha	Sharsha	
pH	7.6	7.8	7.2	7.3	-
Organic matter (g kg^{-1})	15.4	11.1	13.2	16.0	-
Total-N (%)	0.06	0.05	0.08	0.09	0.12
Exchangeable Ca (cmol kg^{-1})	11.6	10.4	13.8	12.1	2.0
Exchangeable Mg (cmol kg^{-1})	3.8	2.7	2.9	3.3	0.8
Exchangeable K (cmol kg^{-1})	0.21	0.26	0.18	0.14	0.12
Available P (mg kg^{-1})	13.0	15.6	15.2	11.5	10
Available S (mg kg^{-1})	16.2	19.2	18.4	13.5	10
Available Zn (mg kg^{-1})	0.52	0.32	0.36	0.64	0.60
Available Fe (mg kg^{-1})	42.5	39.2	33.6	38.1	4.0
Available Mn (mg kg^{-1})	6.1	4.8	4.3	5.4	1.0
Available B (mg kg^{-1})	0.32	0.35	0.22	0.26	0.2
Total As content in soil (mg kg^{-1})	28.5	6.8	36.4	32.8	20.0
As content in irrigation water (mg L^{-1})	0.272	0.140	0.346	0.238	0.100

Poranpur, Chowgacha, Sharsha and Benerpota, respectively. The crop was fertilized with $N_{120}P_{30}K_{90}S_{15}Zn_2B_1$ kg ha^{-1} (BARC 2005). Two-third of nitrogen and all of phosphorus, potassium, sulphur, zinc and boron were applied as basal during final land preparation. The remaining one-third of nitrogen was applied at 21 days after sowing (DAS) then a light irrigation was applied. Crop was further irrigated at maximum tillering stage (50 DAS) and also at initial grain filling stage (72 DAS). The crop was harvested at its right stage of maturity. Data on yield and yield components were recorded accordingly.

Soil analysis: The collected samples were analyzed for total As content (Alam *et al*., 2001). The As content in soil and plant parts was determined after digestion with concentrated nitric acid and hydrogen peroxide mixture (2:1). An amount of 0.5 g sample was taken in digestion tube. Then 5 ml of 12 M HNO_3 was added in the tube and mixed with a watch glass or vapour recovery device and allowed to stand for over night. The sample was heated without boiling at $95^0 \pm 5^0$ C for 10-15 hour and was allowed to cool and again 5 ml of 12 M HNO_3 was added, the cover was replaced, and sample was heated at $95^0 \pm 5^0$ C for 30 minutes. This step (addition of 5ml of conc. HNO_3) was repeated until no brown fumes were given off by the sample. After completion of digestion with HNO_3, the sample was allowed to cool. Then 2 ml of water and 3 ml of 30% H_2O_2 were added, and the vessel was covered with a watch glass and returned to the heat source for warming and to start to peroxide reaction. Heating was continued until the effervescence subsides and then the vessel allowed cooling. Then 1 ml of 30% H_2O_2 was added in aliquots with warming until the effervescence was normal or until the general sample appearance was unchanged. After cooling, the digest was removed by filtration and allowed to settle. After that, the sample was transferred in to 100 ml volumetric flask and volume was made up to the mark with distilled water. For the reduction of As^{V} to As^{III}, 1 ml mixture (5% w/v) of KI and ascorbic acid was added to 1 ml of aliquot. The hydride of arsenic (AS_3H_3) was generated using sodium borohydrate and HCl. The total arsenic content in soil and plant was determined by flow injection hydride generation atomic absorption spectroscopy (FI-HG-AAS), using a Varian Model AA 55B instrument. The same procedure (without digestion) was followed for the analysis of water samples.

Plant analysis: A sub-sample weighing 0.5 g. was transferred into a dry clean digestion vessel. Five ml of HNO_3 was added and then the sample was allowed to stand for over night in a fume hood. In the following day, the vessels were placed on heating block and heating was continued for 2-4 hour as the temperature was slowly raised to 120^0 C. When brown fumes were observed, this step (by adding concentrated HNO_3) was repeated until no brown fumes were given off. There after the vessel was allowed to cool and 3 ml of 30% H_2O_2 was added. Again, the vessel was heated at 120^0C until the effervescence was minimal. After cooling, the digest was removed by filtration, by centrifugation, or by allowing the sample to settle.

Statistical analysis: The collected data were analyzed statistically following MSTAT-C program.

Results and Discussion

Yield and yield components: There was no significant variation in yield and yield components among the tested wheat varieties despite of arsenic contamination in the irrigation water and soil (Tables 2-6). In case of first year (2010-11), the experiment was conducted in Benerpota, Satkhira (AEZ 13) and Poranpur, Faridpur (AEZ 12). But arsenic content in soil (6.8 mg kg^{-1}) at Benerpota was much lower than the thresh hold level (20 mg kg^{-1}) (Duxbury and Zavala 2005) while STW irrigation water (0.14 mg L^{-1}) contains slightly higher arsenic than recommended safe level (0.10 mg L^{-1}). After completion of the first year trial, the location Benerpota was dropped for the second year trial because of the low arsenic content in soil. However, in case of second year (2011-12), the trail was conducted in highly arsenic contaminated areas like Sharsha and Chowgacha under Jessore (AEZ 11) in addition to Poranpur of Faridpur.

At Benerpota, Shatkhira during 2010-2011 the grain yield of the tested wheat varieties varied from 3.23 to 3.54 t ha^{-1} but this variation was statistically non-significant (Table 2). Nevertheless, numerically the highest grain yield (3.54 t ha^{-1}) was recorded from the variety, BARI Gom-21 (Shatabdi), which was followed by BARI Gom-24 (Prodip). Shatabi produced 4, 5 and 9% higher grain yield than Prodip, Bijoy and BARI Gom-26, respectively. Almost similar trend of result was observed in case of straw yield where yield varied from 3.05 to 3.48 t ha^{-1}.

Table 2. Performance of wheat varieties to arsenic contaminated soil and irrigation water at Benerpota, Satkhira during 2010-11.

Varieties	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$ (no)	1000 grains weight (g)	Yield (t ha^{-1})	
					Grain	Straw
BARI Gom-21 (Shatabdi)	89.2	319	39.3	47.1	3.54	3.33
BARI Gom-23 (Bijoy)	88.7	310	40.0	47.3	3.36	3.11
BARI Gom-24 (Prodip)	89.5	311	41.8	48.2	3.41	3.48
BARI Gom-26	87.6	305	38.8	47.0	3.23	3.05
Level of significance	NS	NS	NS	NS	NS	NS
CV(%)	2.5	3.1	6.5	2.5	11.4	8.2

NS = Non significant

In case of Poranpur, Faridpur the highest grain yield (3.62 t ha^{-1}) was obtained from BARI Gom-24 (Prodip), which was followed by followed by BARI Gom-23 (Bijoy). The lowest grain yield (3.14 t ha^{-1}) was observed in BARI Gom- 26, which was almost similar to BARI Gom-21 (Shatabdi). Thus the variety, Prodip gave 4, 10 and 15% higher grain yield than Bijoy, Shatabdi and BARI Gom-26, respectively but such variation was statistically non-significant (Table 3). For the second year (2011-12) too, none of the tested five varieties gave significantly higher yield. Besides, numerically higher grain yield (3.41 t ha^{-1}) was obtained from BARI Gom-21 (Shatabdi) followed by Prodip (3.34 tha^{-1}). Almost similar trend of result was obtained from the straw yield but on an average, the straw yield was 5% lower than that of the grain yield (Table 4).

Table 3. Performance of wheat varieties to arsenic contaminated soil and irrigation water at Poranpur, Faridpur during 2010-11.

Varieties	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$ (no)	1000 grains weight (g)	Yield (t ha^{-1})	
					Grain	Straw
BARI Gom-21 (Shatabdi)	87.0	317	42.3	47.6	3.28	3.42
BARI Gom-23 (Bijoy)	88.8	321	37.5	48.2	3.49	3.26
BARI Gom-24 (Prodip)	89.3	320	38.6.	47.9	3.62	3.47
BARI Gom-26	86.5	308	37.3	47.7	3.14	3.07
Level of significance	NS	NS	NS	NS	NS	NS
CV(%)	1.9	5.5	6.4	2.2	9.6	7.2

NS = Non significant

Table 4. Performance of wheat varieties to arsenic contaminated soil and irrigation water at Poranpur, Faridpur during 2011-12.

Varieties	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$ (no)	1000 grains weight (g)	Yield (t ha^{-1})	
					Grain	Straw
BARI Gom-21 (Shatabdi)	87.4	293	38.8	47.0	3.41	3.06
BARI Gom-23 (Bijoy)	85.5	288	40.4	46.3	3.16	3.12
BARI Gom-24 (Prodip)	85.0	285	38.0	48.3	3.34	3.15
BARI Gom-25	85.2	284	38.7	46.0	3.20	3.24
BARI Gom-26	86.3	291	39.3	45.6	3.25	2.98
Level of significance	NS	NS	NS	NS	NS	NS
CV(%)	2.1	1.6	6.1	2.6	10.3	8.7

NS = Non significant

In case of Chowgacha, Jessore the grain yield of the tested wheat varieties ranged from 2.93 – 3.20 t ha^{-1} showing apparently higher result for Shatabdi but this variation was too small to be significant (Table 5).

At the second location, Sharsha under the same district, almost similar trend of result was observed. Numerically, the higher grain yield (3.23 t ha^{-1}) was obtained from Shatabdi followed by Prodip (3.18 t ha^{-1}) and BARI Gom-25 (Table 6).

Table 5. Performance of wheat varieties to arsenic contaminated soil and irrigation water at Chowgacha, Jessore during 2011-12

Varieties	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$ (no)	1000 grains weight (g)	Yield (t ha^{-1})	
					Grain	Straw
BARI Gom-21 (Shatabdi)	87.7	289	44.7	46.0	3.20	2.95
BARI Gom-23 (Bijoy)	86.8	286	41.9	46.3	3.06	2.91
BARI Gom-24 (Prodip)	86.7	284	42.9	45.7	3.12	3.07
BARI Gom-25	87.4	288	43.6	45.7	2.93	3.16
BARI Gom-26	86.9	290	43.7	44.8	3.03	3.01
Level of significance	NS	NS	NS	NS	NS	NS
CV(%)	2.4	1.8	5.0	3.7	9.8	10.2

NS = Non significant

Table 6. Performance of wheat varieties to arsenic contaminated soil and irrigation water at Sharsha, Jessore during 2011-12.

Varieties	Plant height (cm)	Spike m^{-2}	Grains $spike^{-1}$ (no)	1000 grains weight (g)	Yield ($t\ ha^{-1}$)	
					Grain	Straw
BARI Gom-21 (Shatabdi)	89.4	304	46.7	46.2	3.23	3.09
BARI Gom-23 (Bijoy)	86.9	295	43.6	43.7	2.96	3.02
BARI Gom-24 (Prodip)	86.2	296	44.3	46.0	3.18	2.92
BARI Gom-25	88.2	300	42.5	47.4	3.03	2.81
BARI Gom-26	87.1	304	43.4	46.7	2.91	2.70
Level of significance	NS	NS	NS	NS	NS	NS
CV(%)	2.6	2.7	3.3	4.2	8.7	7.5

NS = Non significant

Except for Benerpota, as shown in Table 2, the background level of total arsenic in soil was remarkably higher (28.5 – 36.4 mg kg^{-1}) than the thresh hold level (20 mg kg^{-1}) in addition to excessively higher content of arsenic (0.238 to 0.346 mg L^{-1}) in the adjacent STW irrigation water as compared to FAO permissible limit (0.10 mg L^{-1}). In spite of these, the tested wheat varieties gave static yield even if not up to their potential but still greatly higher than countries average (3.10 t ha^{-1}) from the major hot spots of arsenic polluted areas like Poranpur, Sharsha and Chowgacha. This result signified that there was no remarkable effect of arsenic contaminated irrigation water and soil on the yield of upland crop like wheat. Under oxidized situation, As^{+5} (arsenate) becomes the dominant fraction, which is 60 times less toxic than As^{+3} (arsenite) and that might be the major reason in favor of gaining non significant effect of arsenic contamination on the yield of wheat. These results are in agreement with the findings of Lambkin and Alloway (2003).

Arsenic content and uptake: There was no perceptible variation in arsenic content in wheat among the tested varieties within a particular location irrespective of root, straw and grain (Tables 7-11).

At Benerpota, arsenic content in root varied from 1.21 to 1.88 mg kg^{-1} where the highest (1.88 mg kg-1) was obtained from BARI Gom-26 followed by Bijoy and the lowest content was in Prodip. Similar trend of result was observed for the contents of arsenic in the straw and grain although they contain much lower arsenic than that of root. The variety, Prodip contains 0.043 and 0.028 mg kg^{-1} arsenic in straw and grain, respectively, which was lower than the other tested varieties (Table 7). Lower arsenic content (0.010-0.19 mg kg-1) in wheat grain was also found in India (Bhattacharya *et al*. 2010). The total (straw + grain) arsenic uptake was also highest (333 mg ha^{-1}) in BARI Gom-26 followed by Bijoy and the lowest (245 mg kg^{-1}) was in Prodip. The As content in grain was much lower than that of corresponding straw. The transfer coefficient of arsenic from soil to above ground parts (straw + grain) of wheat varied slightly among the tested varieties. The highest transfer coefficient (0.0025) was recorded in BARI Gom-26, which means that 0.0025% of soil arsenic might have transferred to the grain and straw of wheat. However, the lowest transfer coefficient (0.0018) was found in Prodip.

Table 7. Arsenic content and uptake by wheat varieties at Benerpota, Satkhira during 2010-2011.

Variety	Arsenic content (mg kg^{-1})			Arsenic uptake (mg ha^{-1})			Transfer co-efficient
	Root	Straw	Grain	Straw	Grain	Total	
BARI Gom-21 (Shatabdi)	1.42	0.056	0.032	186.48	113.28	299.76	0.0022
BARI Gom-23 (Bijoy)	1.65	0.061	0.036	189.71	120.96	310.67	0.0023
BARI Gom-24 (Prodip)	1.21	0.043	0.028	149.64	95.48	245.12	0.0018
BARI Gom-26	1.88	0.068	0.039	207.4	125.97	333.37	0.0025

At Poranpur, arsenic content in root, straw and grain was much higher than the corresponding values of Benerpota. This might be due to higher level of As in soil and irrigation water in former than that of the latter. The variety, Prodip showed 3.35, 0.164 and 0.086 mg kg^{-1} arsenic in root, straw and grain, respectively which was lower than rest of the tested varieties (Table 8). The uptake of arsenic was also lowest (880.4 mg kg^{-1}) in Prodip, which resulted in the lower transfer coefficient (0.0015) in it. Similar trend of result (Table 9) was also observed in the second year (2011-12).

Table 8. Arsenic content and uptake by wheat varieties at Paranpur, Faridpur during 2010-2011.

Variety	Arsenic content (mg kg^{-1})			Arsenic uptake (mg ha^{-1})			Transfer co-efficient
	Root	Straw	Grain	Straw	Grain	Total	
BARI Gom-21 (Shatabdi)	3.41	0.168	0.092	574.56	301.76	876.32	0.0015
BARI Gom-23 (Bijoy)	3.48	0.176	0.112	573.76	390.88	964.64	0.0017
BARI Gom-24 (Prodip)	3.35	0.164	0.086	569.08	311.32	880.4	0.0015
BARI Gom-26	3.57	0.171	0.124	524.97	389.36	914.33	0.0016

Table 9. Arsenic content and uptake by wheat varieties at Paranpur, Faridpur during 2011-12.

Variety	Arsenic content (mg kg^{-1})			Arsenic uptake (mg ha^{-1})			Transfer co-efficient
	Root	Straw	Grain	Straw	Grain	Total	
BARI Gom-21 (Shatabdi)	3.53	0.172	0.096	526.32	327.36	853.68	0.0015
BARI Gom-23 (Bijoy)	3.44	0.174	0.105	542.88	331.8	874.68	0.0015
BARI Gom-24 (Prodip)	3.38	0.168	0.090	529.2	300.6	829.8	0.0015
BARI Gom-25	3.64	0.178	0.118	576.72	377.6	954.32	0.0017
BARI Gom-26	3.60	0.183	0.120	545.34	390	935.34	0.0016

In case of Chowgacha and Sharsha too, the arsenic content, uptake and transfer coefficient values were almost similar to that of Poranpur (Tables 10-11). However, the content and uptake values were narrowly higher for Chowgacha and Sharsha than Poranpur in most of the cases. This might be due to the lower transfer coefficient values in former than the later.

Table 10. Arsenic content and uptake by wheat varieties at Chougacha, Jessore during 2011-12.

Variety	Arsenic content (mg kg^{-1})			Arsenic uptake (mg ha^{-1})			Transfer co-efficient
	Root	Straw	Grain	Straw	Grain	Total	
BARI Gom-21 (Shatabdi)	3.48	0.186	0.102	548.70	326.40	875.10	0.0012
BARI Gom-23 (Bijoy)	3.56	0.178	0.098	517.98	299.88	817.86	0.0011
BARI Gom-24 (Prodip)	3.42	0.172	0.094	528.04	293.28	821.32	0.0011
BARI Gom-25	3.71	0.184	0.128	581.44	375.04	956.48	0.0013
BARI Gom-26	3.66	0.182	0.126	547.82	381.78	929.60	0.0013

Table 11. Arsenic content and uptake by wheat varieties at Sharsha, Jessore during 2011-12.

Variety	Arsenic content (mg kg^{-1})			Arsenic uptake (mg ha^{-1})			Transfer co-efficient
	Root	Straw	Grain	Straw	Grain	Total	
BARI Gom-21 (Shatabdi)	3.54	0.182	0.104	562.38	335.92	898.3	0.0014
BARI Gom-23 (Bijoy)	3.58	0.176	0.100	531.52	296	827.52	0.0013
BARI Gom-24 (Prodip)	3.40	0.169	0.090	493.48	286.2	779.68	0.0012
BARI Gom-25	3.68	0.186	0.120	522.66	363.6	886.26	0.0014
BARI Gom-26	3.62	0.180	0.123	513.00	357.93	870.93	0.0013

Generally, As concentration in roots was about 10 times higher than that in straw. This results suggest that arsenic usually is not distributed to the upper plant parts to a great extent rather mostly accumulates in root. This obtained result might be due to its lower mobility. Such absorption nature of As perhaps escapes the human being as well as cattle from the lethal poisoning. Martin *et al*. (1993) reported that uptake of arsenic by plants occurs primarily through the root system and the highest concentrations are reported in plant roots and tubers. Similar findings were observed by Kiss *et al*. (1992) and Tsutsumi (1980).

All the tested wheat varieties under this study appeared as promising and can be grown successfully in the arsenic affected areas. But BARI Gom-24 (*Prodip)* performed better compared with the other varieties in relation to arsenic content, uptake, biomass yield and transfer coefficient and thus can be regarded as arsenic tolerant to a considerable extent.

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