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Short Note

Accumulation and partitioning of arsenic in rice varieties of Ambagarh Chowki, Rajnandgaon district, Chhattisgarh

Vivek Kumar Singhal, Anurag, GR Rathiya and Rakesh Banwasi

Abstract
Six most popular and cultivated rice varieties (*viz*. MTU-1010, Swarna Masuri, MTU-1001, Mahamaya, one Hybrid and one local variety) of Ambagarh Chowki block, Rajnandgaon district, Chhattisgarh, were collected and analyzed for arsenic content in root, straw and grain. The Hybrid variety contained the higher mean value of arsenic content in root (1536 µg kg^{-1}), straw (530 µg kg^{-1}) and grain (189 µg kg^{-1}). Further, local variety (desi) contained the minimum arsenic content in root (mean value of 1276.7 µg kg^{-1}), straw (mean value of 365 µg kg^{-1}) and grain (mean value of 76.7 µg kg^{-1}). The mean arsenic content in rice grain was found in the order of Hybrid (189 µg kg^{-1}) > Mahamaya (120 µg kg^{-1}) > Swarna Masuri (119 µg kg^{-1}) > MTU-1010 (118.8 µg kg^{-1}) > MTU-1001 (103.3 µg kg^{-1}) > local variety (76.7 µg kg^{-1}).

Keywords: Arsenic, Rice plant, Variety

Introduction

The environment of Ambagarh Chowki, Rajnandgaon, India has high levels of arsenic (Patel *et al.,* 2005 and Shukla *et al.,* 2010) [15, 17]. The groundwater arsenic contamination in the Ambagarh Chowki block situated in the Rajnandgaon district of the state of Chhattisgarh was first reported by Chakraborti *et al.* (1999) [8].

Long term use of arsenic-contaminated irrigation water could result in arsenic accumulation in the soil and could reach to toxic level of crops. If absorbed by the crops, this may reduce yield and also substantially to the dietary arsenic intake, thus posing additional human health risks (Flanagan *et al.,* 2012) [10]. People and livestock are being exposed to arsenic *via*. Contamination of drinking water and consumption of food grown in arsenic-contaminated soil or irrigated with arsenic-contaminated water (Benejad and Olyaie, 2011) [4]. The elevated concentrations of arsenic in groundwater observed in different regions of South Asia is of an increasing concern because a large population is exposed to inorganic arsenic through drinking water, contaminated food, dust, *etc*. (Acharyya *et al.,* 2005 and Winkel *et al.,* 2011) [2, 19]. The practice of groundwater for irrigation purpose had increased arsenic concentration and it has a possibility of arsenic accumulation in rice plants from irrigation water (Delowar *et al*., 2005). Soil arsenic levels could be raised by 1 µg g^{-1} per annum due to irrigation with arsenic contaminated water (Meharg and Rahman, 2003) [12]. In a study, Ahsan *et al.* (2008) [3] reported that arsenic rich irrigation water can increase the arsenic level in agricultural soil up to five times than the normal soil. In the unaffected areas, where irrigation water contained little arsenic (< 1 µg L^{-1}), arsenic concentrations of rice field soils ranged from 1.5 to 3.0 mg kg^{-1}, whereas the agricultural soil contains arsenic up to 436 µg $L^{-1}$where irrigated with arsenic rich groundwater (Saha and Ali, 2007) [16]. So, it can be predicted that arsenic contaminated irrigation water applied through bore- wells could easily increase the arsenic level in rice grain, straw and other part of rice plant.

Arsenic ground water of the villages of Ambagarh Chowki block of Rajnandgaon district of Chhattisgarh was found contaminated with arsenic. So, there is a possibility of accumulation of arsenic in the soil as well as rice crop. In view of the above facts the present experiment was conducted in Ambagarh Chowki block, Rajnandgaon.

Materials and Methods

GPS based samples have been collected from the arsenic affected villages (*viz.* Metepar-Gaulitola, Arajkund, Kaudikasa, Biharikala, Pangari-Keshitola, Atargaon, Sangali, Telitola, Joratarai, Jadutola, Dhatutola, Mangatola and Sonsoitola) of Ambagarh Chowki block of Rajanadgaon district to study the arsenic status in rice plant.

Six most popular and cultivated rice varieties (*viz*. MTU-1010, Swarna Masuri, MTU-1001, Mahamaya, one Hybrid and one local variety) of Ambagarh Chowki were collected at harvesting stage of *kharif* season in the year of 2016 (Fig. 1.0). For the analysis of bio- accumulation and distribution of arsenic over the rice plant system (root, straw and grains), full-grown rice plants were carefully uprooted from the farmer's field at the maturity stage of the crop. Total 50 of different rice varieties were collected from 13 arsenic affected villages. The collected plant samples were washed thoroughly with deionized water to remove soil and other contaminants followed by rinsing with deionized water with continuous shaking for several minutes. Finally, the samples were dried in the hot air oven at 60 °C for 72 hours and were stored in airtight polyethylene bags at room temperature with proper labeling for the analysis of accumulation and distribution of arsenic in the plant parts. Arsenic content was determined by atomic absorption spectroscopy (AAS) using vapour generation assembly (VGA) as method described by Behari and Prakash, 2006. [5] Using same principle total arsenic content in plant was determined (Mclaren *et al*., 1998) [11].

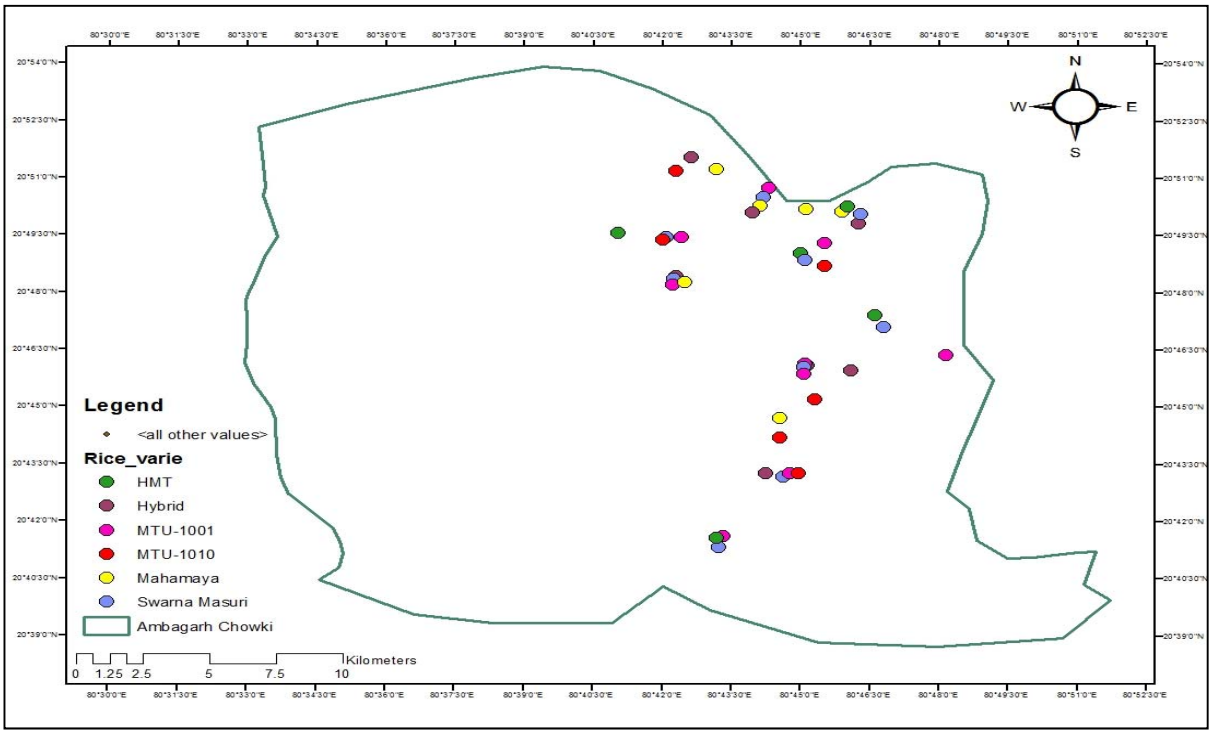

Fig 1: Location of rice samples collected from Ambagarh Chowki block, Rajnandgaon (C.G.)

Table 1: Bio accumulation and partitioning of arsenic in different plant parts of rice cultivars collected from Ambagarh Chowki, Rajnandgaon

Name of Village	Accumulation of As (µg kg^{-1})																	
	MTU-1001			Swarna Masuri			MTU-1010			local			Hybrid			Mahamaya		
	Root	Straw	Grain	Root	Straw	Grain	Root	Straw	Grain	Root	Straw	Grain	Root	Straw	Grain	Root	Straw	Grain
Metepar, Gaulitola	--	--	--	--	--	--	300	130	10	--	--	--	--	--	--	450	160	10
Arajkund	1450	580	100	1420	410	110	--	--	--	1340	400	110	1590	480	180	--	--	--
Kaudikasa	1560	680	120	1650	550	160	1500	560	180	--	--	--	1690	560	200	--	--	--
Biharikala	1490	470	130	1430	400	120	1460	460	130	--	--	--	1650	510	170	--	--	--
Pangari, Keshitola	1210	300	50	1250	440	90	--	--	--	1140	290	30	1290	360	100	--	--	--
Atargaon	1380	420	150	--	--	--	1470	490	150	--	--	--	1520	450	210	1440	520	170
Sangali	1320	400	110	1300	370	100	1310	400	110	1270	350	70	--	--	--	--	--	--
Telitola	--	--	--	1340	390	140	--	--	--	1250	350	60	1490	490	140	1500	450	120
Joratarai	--	--	--	--	--	--	1530	490	150	1390	410	110	1640	650	290	1490	650	190
Jadutola	--	--	--	1340	410	110	1330	400	100	--	--	--	1460	650	140	1380	510	120
Dhatutola	1300	350	90	1380	440	100	--	--	--	--	--	--	1440	560	200	1390	570	100
Mangatola	1320	490	80	1320	390	100	1270	350	120	1270	390	80	--	--	--	--	--	--
Sonsoitola	1430	420	100	1610	500	160	--	--	--	--	--	--	1590	590	260	1390	450	130
Total no. of sample	9			10			8			6			10			7		
Range	1210-1560	300-680	50-150	1250-1650	390-550	90-160	300-1530	130-560	10-180	1140-1390	290-410	30-110	1290-1690	360-650	100-260	450-1500	16-57	10-190
Mean	1384.4	456.7	103.3	1404	430	119	1271.3	410.0	118.8	1276.7	365	76.7	1536	530	189	1291.4	47.29	120

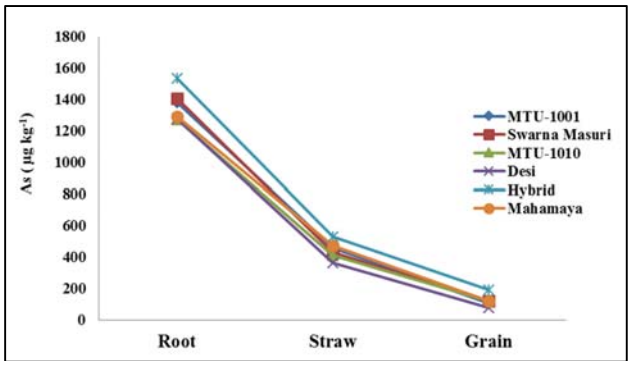

Fig 2: Bioaccumulation and portioning of arsenic in rice varieties collected from Ambagarh Chowki, Rajnandgaon

Results and discussion

The result data revels that the Hybrid rice variety absorbed relatively higher amount arsenic than the other rice varieties. The Hybrid variety contained the highest mean value of arsenic content in root (1536 µg kg^{-1}), straw (530 µg kg^{-1}) and grain (189 µg kg^{-1}). After Hybrid variety, Swarna Masuri (Mean As value 1404 µg kg^{-1}) and MTU-1010 (Mean As value 1271.3 µg kg^{-1}) also contained higher amount of arsenic in roots. While in case of straw arsenic content, Hybrid variety is followed by Mahamaya (Mean As value 472.9 µg kg^{-1}) and MTU-1001 (Mean As value 456.7 µg kg^{-1}). From collected samples, the grain arsenic content varied from 30-110 µg kg^{-1}, 10-180 µg kg^{-1}, 90-160 µg kg^{-1}, 50-150 µg kg^{-1}, 100-260 µg kg^{-1} and 10-190 µg kg^{-1} in local, MTU-1010, Swarna Masuri, MTU-1001, Hybrid and Mahamaya variety, respectively. The mean arsenic content in rice grain is found in the order of Hybrid >Mahamaya >Swarna Masuri >MTU-1010 >MTU-1001 >local variety. Local (desi) variety contained the minimum arsenic in root (mean value of 1276.7 µg kg^{-1}), straw (mean value of 365 µg kg^{-1}) and grain (mean value of 76.7 µg kg^{-1}) (Table 1.0 and Fig. 2.0). All the grain samples were found below FAO limit of arsenic content in food grain (1.00 mg kg^{-1}). The hybrid and high yielding rice varieties were found to be higher accumulator of arsenic as compared to the local rice variety. Similar results have been also reported by Bhattacharya *et al.* (2009) [6]; Singh *et al.* (2014) [18] and Patel *et al.* (2016) [14]. The genotype variation in arsenic uptake may be due to differences in root anatomy, which controls root aeration and Fe-plague formation on the root surfaces, or differences in the arsenic tolerance gene (Norton *et al.,* 2009) [13]. It was also noticed that root arsenic content was much higher than straw and grain of all varieties. Similar findings were also reported by Abedin *et al*. (2002) [1]; Biswas *et al*. (2014) [7] and Patel *et al.* (2016) [14].

Conclusion

Although arsenic content in soil and plant have been below the maximum permissible limits, but it is difficult to fully ignore the possibility of accumulation into soil and plant system through irrigation water, where concentration of arsenic is at an alarming level.

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