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Screening of popular cauliflower cultivars towards arsenic contamination in plant parts under deltaic bengal

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Abstract : Cauliflower (*Brassica oleracea* L. var. botrytis) is grown in all continents of the world, of which Asia is leading one, India have about 38.81 percent of total cauliflower area of the world. Cauliflower is the most important commercial crop of West Bengal. It is used as fried vegetable either separately or with other vegetables. Over the past decade, arsenic contamination in food chain has been reported from the Deltaic Bengal. Arsenic poses serious health hazards for humans and animals under Gangetic delta basin of India and Bangladesh through contamination of groundwater and drinking water. Presence of Arsenic in vegetable crops and its translocation to the edible parts were observed to vary with crops and even among the cultivars of the same crop. Field experiments were conducted at village Nonaghata under Nadia district during 2008-09 and 2009-10 to assess the potential of arsenic poisoning through cauliflower. The experiment was laid out in RBD with three replications having five selected cultivars of cauliflower. The arsenic accumulations were estimated by using AAS, PerkinElmer AAnalyst-200 coupled with FIAS-400. Results revealed that, regarding varietal effect, cv. White marvel accumulated least arsenic in its edible part whereas the maximum accumulation was noted from local cultivar.

Key words: Cauliflower, Arsenic Contamination, Deltaic Bengal

Introduction

Cauliflower (*Brassica oleracea* L. var. botrytis) is grown in all continents of the world, of which Asia is leading one followed by Europe. India and China together have about 60 percent of total cauliflower area of the world and 38.81 percent of it is in India alone (Swarup, 2006). The commercial crop, cauliflower is the most important crop of West Bengal, used as sauted or fried vegetable either separately or with potato, peas, capsicum or other vegetables. In India cabbage and cauliflower are more important and have more area than other cole crops and cauliflower has larger area and production than cabbage. Cultivation of cauliflower, after rainy season (*kharif*) rice is one of the common picture in deltaic Bengal, but over the past decade, arsenic contamination in ground water has been reported from these areas. Arsenic is one of the most toxic metalloid in the environment and widely distributed in nature. Its origin in soil, water and air is due to various natural processes such as volcanic eruption, weathering of minerals, rocks and anthropogenic activities for instances and the application of pesticides for agricultural purpose (Bhattacharya *et al*., 2002). Out of 20 countries in different parts of the world where groundwater arsenic contaminations and human suffering have been reported so far, the magnitude is considered to be the maximum in Bangladesh, followed by West Bengal, India (Sanyal, 2005). It causes serious problem in Genetic delta basin of India and Bangladesh through contamination of groundwater and drinking water. The widespread arsenic contamination in West Bengal, distributed over 111 blocks primarily within twelve districts of the state, adjoining the river Bhagirathi, as well as contiguous districts of Bangladesh is of great concern. The impact of elevated levels of inorganic arsenic in drinking water on the health hazards of adults has been well established. Human mortalities of 20,000 annually occur in Bangladesh as a result of arsenic poisoning, and an estimated 50 million people are at risk for severe health consequence (Pearce, 2001). The emerging areas of arsenic hazards in agricultural systems through use of contaminated irrigation water and entry of toxin in crops has been largely ignored. Increased arsenic levels in ground water-irrigated soil in West Bengal were well documented by Sanyal and Nasar (2002) and uptake of arsenic by plants grown in soils contaminated with high concentration of arsenic and irrigated with arsenic contaminated

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groundwater has been reported by Abedin *et al.* (2002).

An immediate attention is needed so far as arsenic finds its way into the food chain, other than drinking water. Recent studies have shown that the contribution of food-chain towards arsenic pollution in human is many folds greater than that of the drinking water (Roychowdhury *et al*., 2003). Presence of arsenic in vegetable crops and its translocation to the edible parts were observed to vary with crops (Alam *et al*., 2003) and even among the cultivars of the same crop (Kundu and Pal, 2010). It is in this context, a thorough understanding of arsenic-plant-soil interaction is necessary in order to examine arsenic uptake by plants grown in soils contaminated with high concentration of arsenic, and irrigated with arsenic contaminated groundwater as well as entry of arsenic in food chain. This is a serious problem of irrigated crops in the affected zone, where the shallow tube well is the major source of irrigation. Rice-based cropping system is the most predominant in this state, however, *kharif* (rainy season) rice is not a major problem due to its rainfed cultivation, whereas winter and summer crops, mainly cultivated through irrigated ground water through shallow tube well, creates a great problem in point of arsenic uptake. Keeping this point in view our, present investigation, with the prime objective of studying the potential of arsenic poisoning and the varietal tolerance with relative pattern of arsenic accumulation by selected popular cultivars of cauliflower at framers' fields of village Nonaghata under Haringhata block in Nadia district of West Bengal, India.

Materials and Methods

The experiment was conducted at framers' fields of village Nonaghata (Latitude 22^{0}57'N, Longitude 88^{0}33'E and Altitude 7.8m), Haringhata Block during winter (*rabi*) season of 2008-09 and 2009-2010 under alluvial soil of Nadia district of West Bengal, India. The experimental soil is silty clay loam in texture having pH 7.11, EC 0.19 d sm^{-1}, organic carbon 0.49%, available nitrogen 185 kg ha^{-1}, available phosphorus 41 kg ha^{-1} and available potassium 142 kg ha^{-1}, respectively. Arsenic content in the irrigation water and experimental soil was 0.097 mg L^{-1} to 0.115 mg L^{-1} and 8.83 mg kg^{-1} to 8.98 mg kg^{-1}, respectively. The experimental site has subtropical humid climate with an average rainfall of 1275 to 2560 mm and mean minimum and maximum temperature of 11^{O}C and 40^{O}C, respectively. The experiment was laid out in Randomized Block Design (RBD) replicated three with five selected popular cauliflower cultivars *viz*. White flesh, White marvel, Pusa snowball, Pusa synthetic and Late kartik (local). The experiment was conducted for two consecutive years in the same piece of land without changing the experimental layout.

The crop was transplanted in mid October with recommended dose of fertilizers (120:80:80 kg NPK ha^{-1}, ½ N and full P & K applied as basal at the time of final land preparation and rest ½ N was top dressed at 30-35 days after transplanting). The sources of NPK were urea, SSP and MOP. The plant samples were collected at maturity for arsenic analysis. The samples were properly washed, dried, grinded and digested in tri-acid mixture (HNO_3: H_2SO_4: $HClO_4$: 10:1:4, v/v). These digested samples were filtered through Whatman No. 42 filter paper. 10 ml of the filtrate was taken in 50 ml volumetric flask, 5 ml of concentrated HCl and 1 ml of mixed reagent [5% KI (w/v) + 5% Ascorbic acid (w/v)] were added to it, kept for 45 minutes to ensure complete reaction and the volume was made up to 50 ml. The total arsenic content in the solution was determined by using atomic absorption spectrophotometer (AAS), Perkin Elmer AAnalyst 200 coupled with Flow Injection Analysis System (FIAS 400) where the carrier solution was 10% v/v HCl, following Olsen method as described by McLare*n et al.,* 1998. Total nitrogen, available phosphorus and available potassium were estimated by modified Macro Kjeldahl's method, Olsen's method and Flame photometric method, respectively (Jackson, 1967).

Results and Discussion

Arsenic accumulation in different plants parts of cauliflower differed significantly across the tested cultivars (Table-1). At the mature stage of cauliflower, the arsenic accumulation by different plant parts was in the order of root > leaf > stem > edible part (curd) irrespective of the cultivars tested. Results revealed that, maximum accumulation of arsenic by root was observed in local cultivar, namely Late kartik (5.31 mg kg^{-1}) which was statistically at par with Pusa snowball and White flesh, whereas least arsenic concentration found was in White marvel (3.29 mg kg^{-1}) and it was closely followed by Pusa synthetic. In case of cauliflower stem also, similar trend was leaves of the local cultivar (Late kartik) and White marvel accumulated maximum (1.12 mg kg^{-1}) and minimum (0.60 mg kg^{-1}) concentration of arsenic respectively. Edible part of cauliflower that is curd accumulated least arsenic as compare to other plant parts, however, the most popular cultivar White marvel recorded the least concentration of arsenic in its edible part (0.15 mg kg^{-1}), which had no significant difference with the cultivar Pusa synthetic (0.23 mg kg^{-1}). In contrary to cultivars like local cultivar (Late kartik) accumulated the significantly highest concentration of arsenic (0.75 mg kg^{-1}) in its edible part among the all cultivars tested. At mature stage, root: stem, stem: leaf vis-a-vis leaf: edible part ratio in respect of arsenic concentration, were varied among the different cultivars (Table-1). Highest root: stem ratio was observed in cv. White marvel (6.85), while local cultivar showed minimum root: stem ratio (5.65) and maximum stem: leaf ratio (0.84). In case of leaf: edible part ratio, highest value found from cultivar White marvel (4.00), that means less translocation of arsenic from other plant parts to edible part of cauliflower, followed by the cultivar Pusa synthetic (3.52). On the other hand local cultivar (Late kartik) recorded the least leaf: edible part ratio (1.49) among the all cultivars tested.

Comparison of Arsenic accumulation of different plant parts among the selected cultivars of cauliflower clearly depict arsenic accumulation pattern (Fig. 1-5) from where we can observe that all the cultivars accumulated huge concentration of arsenic by their roots (65-73%). On the other hand, stem and leaf recorded approximately five times less concentration of arsenic as compared to arsenic accumulation by roots, among them leaf accumulated higher concentration of arsenic than stem, irrespective of all the cultivars tested. Finally the edible part of cauliflower, accumulated very fewer concentration (3-9%) of this toxic metalloid as compared to the all other pants parts. Result reveled that, cultivar White marvel loaded least concentration of arsenic (3%) by its edible parts followed by cultivar Pusa synthetic (4%), where as highest concentration of arsenic was recorded from local cultivar (9%) irrespective of all the cultivars tested.

The above field based experiment clearly revealed that the different cultivars of cauliflower accumulate different concentration of arsenic in its various plant parts and trend of arsenic translocation to edible part was also different. Root of cauliflower accumulates very higher concentration of arsenic than the other plant parts, but translocates a minimum percentage to its edible part irrespective of all the cultivars tested. The cultivar White marvel showed higher root: stem and leaf: edible part ratio, in respect of arsenic accumulation, that means the arsenic translocation from root to stem simultaneously leaf to edible part is lower than the other cultivars, whereas the local cultivar recorder just the opposite tends. It is possibly due to the varietal specification of cauliflower in respect of arsenic accumulation because arsenic loading changes along with different cultivar. Food quality of cauliflower is highly affected by the level of arsenic concentration in its edible part. Preference should be given for those cultivar having least accumulation of arsenic in its edible parts and this should be a great contribution to the agricultural field as well as the farmers.

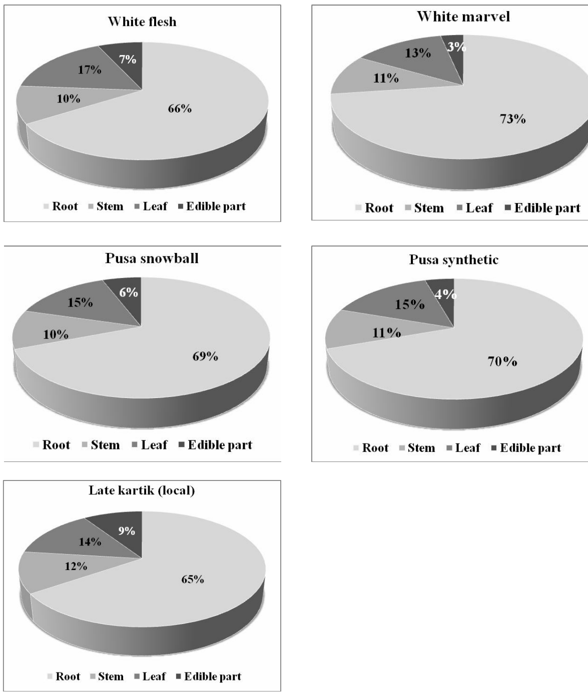

Figure 1-5. Arsenic accumulation pattern by different plant parts of cauliflower

A huge amount of vegetable is required to meet the daily diet of Indian people, so it is necessary to search an appropriate agricultural management practices to

Table 1: Arsenic content (mg kg^{-1}) in different plant parts of cauliflower at mature stages

Cultivar	Arsenic content (mg kg^{-1})				Root: Stem	Stem: Leaf	Leaf: Edible part
	Root	Stem	Leaf	Edible part			
White flesh	4.05	0.63	1.04	0.42	6.43	0.61	2.48
White marvel	3.29	0.48	0.60	0.15	6.85	0.80	4.00
Pusa snowball	4.63	0.70	0.98	0.39	6.61	0.71	2.51
Pusa synthetic	3.67	0.57	0.81	0.23	6.44	0.70	3.52
Late kartik (local)	5.31	0.94	1.12	0.75	5.65	0.84	1.49
S.Em (±)	0.46	0.12	0.15	0.07	---	---	---
CD (P=0.05)	1.32	0.34	0.43	0.20	---	---	---

Arsenic content in irrigation water were 0.097-0.115 mg L^{-1}

minimize the arsenic accumulation in vegetable crops particularly in cauliflower, very common and major vegetable for North and East Indian diet. Further, arsenic accumulation status in stover of different cultivars also has its due implications when stover is fed to animals. Though arsenic accumulation in cauliflower relatively lower than the other winter crops (particularly *boro* rice), but the selection of the suitable cultivar may reduce the arsenic loading from edible parts of the agricultural crops. Some cultivars like White marvel and Pusa synthetic accumulated the lesser amount of arsenic by their edible part. Thus, it may be concluded that arsenic accumulation by cauliflower may vary among the cultivars of the same crop. Selection of the appropriate cultivar of cauliflower which accumulate lesser amount of arsenic in arsenic affected belt have an immense important, as it might have a beneficial role towards mankind.

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सारांश

फूलगोभी, *ब्रेसिका ओलेरेसिया* एल., प्रजाति ब्रोट्राइटिस विश्व के सभी महाद्वीपों में उगाई जाती हैं। जिसमें एशिया प्रथम स्थान पर है। विश्व के कुल फूलगोभी क्षेत्र का 38.81 प्रतिशत क्षेत्रफल भारत में है। फूलगोभी पश्चिम बंगाल की सबसे महत्वपूर्ण व्यापारिक फसल है जिसे या तो अकेले अथवा अन्य सब्जी के साथ पकाते है। पिछले दशक में बंगाल के डेल्टा क्षेत्रों से खाद्य श्रृंखला में संखिया के प्रदूषण की खबरें मिलती रही है। भूमि जल एवं पीने के पानी में संख्यिा के प्रदूषण होने के कारण भारत तथा बंगाल देश के गंगा डेल्टा बेसिन क्षेत्र के अन्तर्गत मनुष्य एवं जानवरों के लिए विभिन्न प्रकार के गम्भीर स्वास्थ समस्यायें प्रारम्भ हुई है। सब्जी फसलों में संखिया की उपस्थिति तथा खाने योग्य भागों में इसका पहुँचना पाया गया है जो कि विभिन्न फसलों में तथा एक ही फसल के विभिन्न प्रजातियों में भिन्न–भिन्न होता है। फूलगोभी में संखिया विष के प्रभाव को जाँच ने के लिए 2008–09 तथा 2009–10 के दौरान नादिया जिले के हरिधटा ब्लाक के नोलाधटा गाँव में प्रक्षेत्र प्रयोग आयोजित किये गये। इस प्रयोग को आर.बी.डी. डिजाइन में किया गया था जिसमें पांच चयनित प्रजातियों की तीन आवृत्तियाँ थी। संखिया के एकत्रीकरण को परकीन एलमर विश्लेषक–200, FIAS-400 तथा AAS का उपयोग करके पता लगाया गया। परिणामों से ज्ञात हुआ कि ेपजम उंतअमस प्रजाति के खाने योग्य भागों में संखिया का एकत्रीकरण सबसे कम था जबकि स्थानीय प्रजाति में यह सर्वाधिक था।

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