Effect of irrigation sources and nutrient management on arsenic accumulation in vegetable pea (*Pisum Sativum* L.) in deltaic West Bengal, India

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**ABSTRACT**

An experiment was conducted at Nonaghata-Uttarpara village under Haringhata block in Nadia district during successive *rabi* seasons of 2007-08 and 2008-09 to study the arsenic contamination in vegetable pea cv. Karishma and to explore possibilities of offloading the accumulation through nutrient management using harvested surface water for irrigation. The experiment has been laid out with two irrigation sources in main plot I; irrigation from Shallow Tube Well (STW) and I; irrigation from Pond Water (PW) and four nutrient management options in sub-plot [N$_1$: 100% RDF (60-80-90 kg ha$^{-1}$) N, P$_2$O$_5$ and K$_2$O), N$_2$: 100% RDF with double the recommended dose of phosphate, N$_3$: 75% RDF + FYM @ 10 t ha$^{-1}$ with double dose of phosphate] in a split plot design, replicated three times. Results revealed that pod yield did not significantly vary with different irrigation sources, but arsenic accumulation and uptake was the lowest with irrigation from harvested rain water i.e. pond water. 75% RDF + 10 t ha$^{-1}$ of FYM with increased phosphate recorded the maximum yield with the least arsenic accumulation (N$_4$).

**Key words:** Arsenic, Irrigation, Nutrient management, Vegetable pea.

**INTRODUCTION**

The widespread groundwater arsenic contamination in different parts of West Bengal, distributed over twelve districts, is a matter of great concern. Arsenic contamination of groundwater in the Gangetic alluvial zones of West Bengal, India (covering about 39,000 sq. km area) has assumed the proportion of arsenic-related health hazards for millions (9-10 millions) of people (Chakraborti et al. 2009).

Recently, in addition to drinking water, workers have become more concerned about the agricultural sector, which contributes more to contamination through groundwater supported irrigation (Diaz et al. 2004; Bhattacharya et al. 2010). Contamination is predominant during the *rabi* and dry season when crops are supported mostly by irrigation from groundwater. The problem is most acute in the lean period of January to April when recharge is at minimum (Williams et al. 2007; Su et al. 2010).

Legumes, reportedly, accumulate relatively less arsenic in plant parts. Vegetable pea is a short season remunerative legume of the region. It requires less irrigation and contaminates the food chain with less arsenic. Harvested rain water contains less arsenic than groundwater thus less arsenic accumulation in plants. Organic management follows formation of metal-humate complexes (Datta et al. 2001), leading to less availability of arsenic to the crop. Presence of phosphate caused a reduction in arsenate uptake by plants due to the greater affinity towards phosphate compared to arsenate (Shi et al. 2015; Lou et al. 2015).

The present experiment envisages to study the arsenic contamination in the crop (vegetable pea) and to explore possibilities of reducing the accumulation through management of nutrients and applying irrigation using harvested water.

**MATERIALS AND METHODS**

The experiment was conducted at farmers’ field at Nonaghata-Uttarpara village under Haringhata block in Nadia district of West Bengal, India during 2007-08 and 2008-09. The experimental site was located at 22°57’N latitude, 89°33’E longitude. The climate of the experimental area is broadly classified as subtropical humid. The soil is silty clay loam with soil pH 6.65 and total arsenic concentration of 16.52 mg Kg$^{-1}$. The arsenic content of irrigation water from shallow tube well water (STW) was 0.122 - 0.169 mg L$^{-1}$ and pond water (PW) contained arsenic to the extent of 0.014 - 0.056 mg L$^{-1}$. The experimental crop was vegetable pea cv. Karishma. The experiment was laid out in a split plot design with two irrigation sources (I; irrigation from STW and I; irrigation from PW) in main plot and four nutrient management options [N$_1$: 100% RDF (60-80-90 kg N, P$_2$O$_5$ and K$_2$O ha$^{-1}$), N$_2$: 75% RDF with double the recommended dose of phosphate, N$_3$: 100% RDF, N$_4$: 100% RDF with double the recommended dose of phosphate, N$_4$: 100% RDF].
+ FYM @ 10 t ha\(^{-1}\), M\(_1\); 75% RDF + FYM @ 10 t ha\(^{-1}\) with double dose of phosphate| in sub-plot, replicated three times. The plant samples were collected from different plots and they were separated into root, stem, leaves, pod and stover at harvest. The samples were dried at 60°C for 48 hours. Dried, ground plant samples were digested with tri-acid mixture (HNO\(_3\); H\(_2\)SO\(_4\); HClO\(_4\): 10 : 1 : 4, v/v) until a clear solution was obtained. These digests were filtered using Whatman No. 42 filter paper. 10 ml of the filtrate was taken and 5 ml concentrated HCl and 2 ml 10% KI-ascorbic acid solution were added. The total arsenic content in the solution was determined by using AAS (Perkin Elmer Analyst 200) coupled with FIAS 400.

RESULTS AND DISCUSSION

Yield parameters and yield: Irrigation with pond water and shallow tube well water sources resulted in yields which were at par among themselves for both pod and stover of vegetable pea. More pod yield of 7.09 t ha\(^{-1}\) was recorded by STW (Table 1). The number of pods per plant did not significantly vary with the different sources of irrigation.

Among the nutrient management options, 25% supplementation with FYM with elevated phosphate (N\(_4\)) registered higher pod yield (7.99 t ha\(^{-1}\)) and stover yield (2.38 t ha\(^{-1}\)) which were at par with N\(_4\) (Table 1). Supply of available P was greater in N\(_2\) and the effect of FYM also contributed to greater P solubility and soil improvement (Sanyal 2005). The minimum yield was recorded by 100% recommended dose of fertiliser (N\(_6\)). Interaction values between irrigation sources and nutrient options proved to be not significant for yield.

Arsenic accumulation and uptake: The pattern of arsenic accumulation followed the order pod < leaves < stem < root. This was also reported by Mondal et al., 2012; Kundu et al., 2013. Arsenic accumulation was significantly less when the crop was irrigated with pond water both in the pods (0.81 mg Kg\(^{-1}\)) and in stover (3.21 mg Kg\(^{-1}\)) as well as root (7.98 mg Kg\(^{-1}\)).

Arsenic accumulation was significantly less in M\(_1\) over M\(_6\) in pods (0.77 mg Kg\(^{-1}\)), in stover (3.10 mg Kg\(^{-1}\)) and other plant parts (Table 1). Total arsenic uptake was also less with pond water (13.55 g Kg\(^{-1}\)). Arsenic accumulation was significantly less in M\(_1\) over M\(_6\) in pods (0.77 mg Kg\(^{-1}\)), in stover (3.10 mg Kg\(^{-1}\)) and other plant parts (Table 2). Total arsenic uptake was also less with pond water (13.55 g Kg\(^{-1}\)). The pattern was similar for total arsenic uptake.

Economic analysis: The net monetary return was the maximum (Rs. 17,53,15/-) with pond water source and it was at par with the other alternative source (Table 1). The net return was also reflective of this parity. The minimum net return and B:C ratio was recorded by 100% recommended dose of fertiliser with double the recommended dose of phosphate (N\(_4\)). Interaction values between irrigation and nutrient options proved that arsenic accumulation was significantly less when N\(_4\) (FYM supplementation with elevated phosphate) was in conjunction with I\(_3\), compared to that of N\(_6\) (FYM supplementation) The pattern was similar for total arsenic uptake.

TABLE 1. Effect of irrigation sources and nutrient management on yield (t ha\(^{-1}\)), yield parameter, and economics of vegetable pea

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield</th>
<th>Economics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Irrigation sources</strong></td>
<td><strong>Pod</strong></td>
<td><strong>Stover</strong></td>
</tr>
<tr>
<td>I(_1)</td>
<td>7.09</td>
<td>2.23</td>
</tr>
<tr>
<td>I(_2)</td>
<td>6.70</td>
<td>2.01</td>
</tr>
<tr>
<td>SEm (±)</td>
<td>0.100</td>
<td>0.057</td>
</tr>
<tr>
<td>C.D. (0.05)</td>
<td>NS</td>
<td>NS</td>
</tr>
<tr>
<td><strong>Nutrient management</strong></td>
<td><strong>Pod</strong></td>
<td><strong>Stover</strong></td>
</tr>
<tr>
<td>N(_3)</td>
<td>6.23</td>
<td>1.96</td>
</tr>
<tr>
<td>N(_4)</td>
<td>5.64</td>
<td>1.82</td>
</tr>
<tr>
<td>N(_5)</td>
<td>7.72</td>
<td>2.34</td>
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<tr>
<td>N(_6)</td>
<td>7.99</td>
<td>2.38</td>
</tr>
<tr>
<td>SEm (±)</td>
<td>0.095</td>
<td>0.047</td>
</tr>
<tr>
<td>C.D. (0.05)</td>
<td>0.277</td>
<td>0.137</td>
</tr>
</tbody>
</table>

I\(_1\) = irrigation from STW, I\(_2\) = irrigation from pond, N\(_3\) = 100% RDF, N\(_4\) = 100% RDF with elevated (double of recommended dose) phosphate, N\(_5\) = 75% RDF + 10 t/ha of FYM, N\(_6\) = 75% RDF + 10 t ha\(^{-1}\) of FYM with elevated phosphate, NS = not significant
The results reveal that the arsenic content of the experimental soil and supported groundwater do not discount the yield and attributes of vegetable pea. But the contamination in the plant parts were less in pond water supported irrigation compared to groundwater irrigation. As content in plant parts and edible portion was least when major nutrients were supplemented with FYM and elevated phosphate. Yield of vegetable pea pods and economics were at par with FYM supplementation in fertilizer dose, with and without elevated phosphate. But B:C ratio had a fair advantage with FYM supplementation in fertilizer dose only.

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REFERENCE


