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Performance of green gram and dry season rice in arsenic uptake under different management options in West Bengal

S. Mondal*, P. Bandopadhyay and S. Pal
ICAR- Niche Area of Excellence, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, W.B.

ABSTRACT

The effect of irrigation sources viz. shallow tube well irrigation (STW) and harvested pond water irrigation (PW) and nutrient sources (100% recommended dose of fertilizer (RDF), 100% RDF with elevated phosphate (double dose of recommended), 75%RDF +FYM @ 10 t ha^{-1}, 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate] on yield and accumulation and uptake of arsenic by greengram and rice in dry season were investigated during 2007-08 and 2008-09. PW led to higher grain and straw yield in rice, as compared to STW, while, no significant difference was observed in green gram. Application of 75%RDF+FYM@10 t ha^{-1} with elevated phosphate favoured yield of both the crops. The arsenic accumulation was much higher in summer rice compared to green gram. Accumulation and uptake was much lower with PW, compared to STW. 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate proved to be the best in reducing arsenic accumulation in both the crops

Key words: *, arsenic, irrigation, nutrient, summer rice, green gram*

The widespread groundwater contamination by arsenic in different parts of West Bengal, distributed over twelve districts, is of great concern. The problem is triggered off by extensive groundwater supported irrigation, mainly for dry season rice during the lean period of January to April when recharge is at the minimum (Mandal *et. al.,* 1996; Sanyal, 2005). Green gram is a short season legume which requires less irrigation and fertilizers contaminates the food chain with less arsenic. Harvested rain water contains less arsenic than groundwater and pond irrigation results in less arsenic in plants. The soil organic fractions including humic acid (HA) and fulvic acid (FA) behave as effective accumulators of toxic heavy metals, following the formation of metal-humate complexes (chelates) with different degrees of stability (Datta *et al.,* 2001; Mukhopadhyay, 2002; Mukhopadhyay and Sanyal, 2004). Presence of phosphate caused a reduction in arsenate uptake by plants due to the greater affinity towards phosphate compared to arsenate. A field investigation was done, in arsenic endemic area of West Bengal, to study the effect of irrigation sources and nutrient management on yield, uptake of arsenic on both the crops..

MATERIALS AND METHODS

The field experiment was conducted at farmer's field at Nonaghata-Uttarpara village under Haringhata block in Nadia district of West Bengal, India during dry (2006-07 and 2007-08) season. The soil is silty clay loam and characterised by 4.0 % organic carbon, soil pH 6.65 and total arsenic concentration of 16.52 mg kg^{-1}. The arsenic content of irrigation water from shallow tube well (STW) was 0.122-0.169 mg L^{-1} and pond water contained arsenic to the extent of 0.014-0.056 mg L^{-1}. The experiment was laid out in split plot design, replicated thrice, with two irrigation sources (Irrigation from shallow tube well water, STW and Irrigation from rain water harvest i.e., pond water, PW) as main plot treatment and nutrient sources (100% recommended dose of fertiliser, 100% recommended dose of fertiliser with elevated (double of recommended dose) phosphate, 75% recommended dose of fertiliser + 10 t ha-^{1} of FYM, 75% recommended dose of fertiliser + 10 t ha-^{1} of FYM with elevated phosphate. Rice variety Satabdi (IET-4786) for dry season rice and green gram varieties B-1 were used in the experiment. The farm yard manure (FYM) was applied 15days before transplanting at the time of land preparation and the inorganic fertilizers were applied as basal except nitrogen, which was splitted thrice, 50% as basal, 25% at tillering and 25% at panicle initiation stage in case of rice and as basal in case of green gram. The plant samples were collected from different plots and they were separated into root, stem and leaves. Samples at harvest were separated into straw and grain.

The filtrate of the tri-acid mixture digests of plant sample 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 AAnalyst 200) coupled with FIAS 400.

RESULT AND DISCUSSION

Grain yield of dry season rice was influenced by the different sources of irrigation water, but straw yield of dry season rice, seed yield and stover yield of green gram was not significantly affected by the application of different sources of irrigation. Nutrient management options significantly influenced yield of both the crops. 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate recorded the highest yield in both the crops, followed by 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate (Table 1). It might be due to the incorporation of organic manure and elevated phosphate indirectly influenced the yield by reducing arsenic accumulation.

Arsenic accumulation as well as uptake was comparatively much higher in dry season rice than that of green gram. Rice crop have the ability to draw arsenic in both the forms, which might have led to increased arsenic in dry season rice (Sanyal and Dhillon 2005). Dry season rice had more water requirement which facilitates higher accumulation of the element. Accumulation and uptake of arsenic was less with the

Table 1. Effect of source of irrigation and nutrient management on grain yield and straw yield of dry season rice

Treatment	Grain yield		Straw yield		Seed yield		Stover yield	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Irrigation sources								
I_1	4.41	4.41	5.94	5.87	0.43	0.43	2.04	2.07
I_2	4.69	4.75	6.14	6.31	0.49	0.49	2.05	2.10
SEm (±)	0.045	0.023	0.051	0.102	0.007	0.011	0.033	0.020
C.D. (0.05)	0.276	0.137	NS	NS	NS	NS	NS	NS
Nutrient management								
N_1	4.11	3.81	5.83	5.66	0.42	0.40	1.88	1.80
N_2	3.77	3.48	5.69	5.49	0.33	0.31	1.74	1.68
N_3	4.83	5.16	6.21	6.50	0.46	0.49	2.07	2.21
N_4	5.48	5.87	6.43	6.71	0.63	0.64	2.49	2.65
SEm (±)	0.059	0.059	0.056	0.061	0.016	0.007	0.061	0.039
C.D. (0.05)	0.182	0.182	0.173	0.188	0.048	0.022	0.189	0.120
Interaction								
I_1N_1	4.05	3.75	5.72	5.49	0.39	0.37	1.91	1.82
I_1N_2	3.68	3.39	5.63	5.45	0.29	0.27	1.72	1.65
I_1N_3	4.61	4.9	6.07	6.12	0.44	0.46	2.11	2.24
I_1N_4	5.28	5.61	6.34	6.43	0.60	0.62	2.42	2.56
I_2N_1	4.16	3.86	5.94	5.83	0.45	0.43	1.85	1.77
I_2N_2	3.85	3.57	5.74	5.52	0.36	0.34	1.76	1.70
I_2N_3	5.05	5.42	6.35	6.88	0.48	0.52	2.03	2.18
I_2N_4	5.68	6.13	6.52	6.99	0.65	0.65	2.55	2.73
SEm (±)	0.084	0.083	0.080	0.171	0.022	0.010	0.087	0.056
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

I_1 = irrigation from STW, I_2 = irrigation from pond, N_1 = 100% RDF, N_2 = 100% RDF with elevated (double of recommended dose) phosphate, N_3 = 75% RDF + 10 t ha^{-1} of FYM, N_4 = 75% RDF + 10 t ha^{-1} of FYM with elevated phosphate, NS = not significant application of pond water irrigation compared to shallow tube well irrigation.

Among the nutrient management options, 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate 75%RDF + FYM @ 10 t ha^{-1} (Table 2). It might be due to the fact that, in anaerobic condition, arsenic is mostly present in arsenite form and phosphate can influence only the arsenic uptake. Arsenic uptake was less with 100% RDF with elevated phosphate in dry season rice,

Table 2. Effect of source of irrigation and nutrient management on arsenic content of produces (mg kg^{-1}) of dry season rice and green gram at harvest

Treatment	dry season rice				Green gram			
	Grain		Straw		Seed		Stover	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Irrigation sources								
I_1	1.61	1.62	2.89	2.89	0.111	0.108	2.22	2.19
I_2	1.34	1.33	2.63	2.64	0.095	0.097	1.89	1.90
SEm (±)	0.013	0.016	0.010	0.031	0.001	0.002	0.016	0.007
C.D. (0.05)	0.079	0.097	0.061	0.189	NS	NS	0.097	0.043
Nutrient management								
N_1	1.73	1.77	3.15	3.23	0.165	0.165	2.46	2.52
N_2	1.54	1.58	2.94	3.01	0.078	0.085	1.91	1.95
N_3	1.38	1.35	2.61	2.55	0.127	0.122	2.20	2.11
N4	1.25	1.21	2.34	2.28	0.042	0.038	1.65	1.62
SEm (±)	0.020	0.022	0.014	0.025	0.003	0.003	0.030	0.026
C.D. (0.05)	0.062	0.068	0.043	0.077	0.009	0.009	0.092	0.080
Interaction								
I_1N_1	1.80	1.84	3.19	3.27	0.180	0.184	2.59	2.65
I_1N_2	1.72	1.76	3.06	3.13	0.083	0.087	2.06	2.11
I_1N_3	1.54	1.51	2.83	2.76	0.130	0.123	2.37	2.25
I_1N_4	1.39	1.35	2.46	2.41	0.050	0.043	1.85	1.76
I_2N_1	1.66	1.69	3.11	3.18	0.150	0.150	2.33	2.38
I_2N_2	1.36	1.39	2.81	2.88	0.073	0.083	1.76	1.79
I_2N_3	1.22	1.18	2.39	2.34	0.123	0.120	2.02	1.96
I_2N_4	1.10	1.07	2.21	2.15	0.033	0.033	1.45	1.48
SEm (+)	0.028	0.032	0.020	0.036	0.005	0.005	0.043	0.037
C.D. (P=0.05)	0.086	0.099	0.062	0.111	0.015	0.015	NS	NS

I_1 = irrigation from STW, I_2 = irrigation from pond, N_1 = 100% RDF, N_2 = 100% RDF with elevated (double of recommended dose) phosphate, N_3 = 75% RDF + 10 t ha^{-1} of FYM, N_4 = 75% RDF + 10 t ha^{-1} of FYM with elevated phosphate

recorded the lowest arsenic accumulation (1.25 and 1.21 mg kg^{-1} in grain respectively), followed by 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate and N_2 in case of dry season rice, whereas, in green gram, the lowest arsenic accumulation was exhibited by 100% RDF with elevated phosphate (0.042 and 0.038 mg kg^{-1} in seed respectively), followed by 100% RDF with elevated phosphate (double dose of recommended) and whereas, in green gram, arsenic uptake was less with 100% RDF with elevated phosphate followed by 100% RDF with elevated phosphate (Table 3). This apparent deviation in arsenic uptake may be attributable to the yield pattern of the crops.

The net return of dry season rice was more than that of green gram, across irrigation and nutrient

Table 3. Effect of source of irrigation and nutrient management on arsenic uptake of produces (mg kg^{-1}) of dry season rice and green gram at harvest

Treatment	Summer rice		Green gram	
	2007-08	2008-09	2007-08	2008-09
Irrigation sources				
I_1	7.01	6.95	0.045	0.044
I_2	6.15	6.11	0.044	0.044
SEm (±)	0.096	0.125	0.001	0.001
C.D. (0.05)	0.584	0.761	NS	0.006
Nutrient management				
N_1	7.10	6.72	0.069	0.066
N_2	5.79	5.46	0.025	0.026
N_3	6.63	6.90	0.058	0.059
N_4	6.80	7.06	0.026	0.024
SEm (±)	0.113	0.082	0.001	0.002
C.D. (0.05)	0.348	0.253	0.003	0.006
Interaction				
I_1N_1	7.27	6.90	0.070	0.068
I_1N_2	6.34	5.96	0.024	0.023
I_1N_3	7.10	7.40	0.057	0.057
I_1N_4	7.34	7.56	0.030	0.027
I_2N_1	6.92	6.54	0.068	0.065
I_2N_2	5.24	4.95	0.026	0.028
I_2N_3	6.16	6.39	0.059	0.062
I_2N_4	6.26	6.56	0.021	0.021
SEm (±)	0.160	0.116	0.002	0.003
C.D. (P=0.05)	NS	0.357	0.006	0.009

I_1 = irrigation from STW, I_2 = irrigation from pond, N_1 = 100% RDF, N_2 = 100% RDF with elevated (double of recommended dose) phosphate, N_3 = 75% RDF + 10 t ha^{-1} of FYM, N_4 = 75% RDF + 10 t ha^{-1} of FYM with elevated phosphate

Table 4. Effect of source of irrigation and nutrient management on economics of dry season rice and green gram (Pooled)

Treatment	Summer rice		Green gram	
	Net return	B:C	Net return	B:C
Irrigation sources				
I_1	7738.46	1.19	10432.50	2.08
I_2	22846.59	1.84	14742.50	3.03
SEm (±)	266.049	0.007	306.067	0.040
C.D. (0.05)	1044.638	0.027	1201.768	0.157
Nutrient management				
N_1	11671.81	1.45	10402.50	2.30
N_2	6895.56	1.27	6032.50	1.77
N_3	18200.11	1.59	13392.50	2.65
N_4	24402.61	1.75	20522.50	3.49
SEm (±)	437.062	0.013	397.448	0.051
C.D. (0.05)	1275.694	0.038	1160.069	0.149
Interaction				
I_1N_1	5121.81	1.14	7845.00	1.82
I_1N_2	39.31	1.00	3245.00	1.34
I_1N_3	9742.61	1.24	11065.00	2.15
I_1N_4	16050.11	1.39	19575.00	3.03
I_2N_1	18221.81	1.76	12960.00	2.78
I_2N_2	13751.81	1.55	8820.00	2.21
I_2N_3	26657.61	1.94	15720.00	3.16
I_2N_4	32755.11	2.12	21470.00	3.95
SEm (±)	618.099	0.019	562.077	0.072
C.D. (P=0.05)	1804.103	0.055	1640.587	NS

I_1 = irrigation from STW, I_2 = irrigation from pond, N_1 = 100% RDF, N_2 = 100% RDF with elevated (double of recommended dose) phosphate, N_3 = 75% RDF + 10 t ha^{-1} of FYM, N_4 = 75% RDF + 10 t ha^{-1} of FYM with elevated phosphate

schedules and the maximum return of ₹ 24402.61 was given by 75%RDF + FYM @ 10 t ha^{-1} with elevated phosphate in rice compared to marginally less return of ₹ 20522 ha^{-1} by green gram. The return per rupee investment was always greater for the legume and the corresponding value for 100% RDF with elevated phosphate was 3.49 for green gram compared to rice which registered only 1.75 (Table 4).

The study reflects that the choice for the marginal farmer should be always in green gram. More affordable farmers can reap benefit in dry season rice by following economy of size. Further the going by the menace of dry season rice as a potential arsenic contaminator of the food chain green gram has a greater advantage.

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