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RESEARCH ARTICLE

Importance Of System Of Rice Intensification Method For Mitigation Of Arsenic In Rice

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Abstract

INTRODUCTION

Our country has greater prospect to grow and exploit rice as it is the dietary staple. High soil arsenic caused by the reduction of phosphate as well as arsenate uptake through phosphate transporters. The effect of arsenic causes inhibition of seed germination decrease in plant height reduction in root growth, leaf area and photosynthesis and low grain yield. Arsenic and its compounds are known to have adverse health effects on humans, including cancers of the skin, bladder, kidney & lung, and diseases of the blood vessels of the legs and feet and diabetes. Atoms of arsenic bond with other elements forms molecules — if carbon is one of these elements, then the arsenic compound is an organic compound. The toxicity of arsenic depends very heavily on inorganic arsenic. which is a known human carcinogen — organic and inorganic together are referred to as "total arsenic. Inorganic Arsenate, Arsenate in ground water have caused tremendous epidemic poisoning across the globe. The persistence of heavy metals in the environment may pollute or contaminate soils and aqueous streams as both natural components. Amongst the various heavy metal contaminants arsenic and lead are recognized as the leading toxicants worldwide and having the various toxic effects on human and animal health as well as on the environment. Arsenic is a metalloid - a natural element that is not actually a metal but which has some of the properties of a metal. It is a natural component of the Earth's crust, generally found in trace quantities in all rock, soil, water and air. In general, inorganic forms of arsenic are more toxic to the environment than organic forms and, among inorganic forms, arsenic is more toxic than arsenate. This is probably because the way in which the various forms are taken up into the body differs and once taken up, they act in different ways in the body. The reason why arsenate is toxic is thought to be because it binds to particular chemical groups – sulfhydryl groups - found on proteins. Arsenate, on the other hand, affects the key energy producing process that take place in all cells. Arsenic compounds cause short-term and long-term effects in individual plants and animals and in populations and communities of organisms. These effects are evident, for example, in aquatic species at concentrations ranging from a few micrograms to milligrams per litre. The nature of the effects depends on the species and time of exposure. However, concentrations may be higher in certain areas due to either natural conditions or human activities. High proportion of arsenic causes inhibition of seed germination, plant height reduction, root growth reduction, reduce in leaf area and photosynthesis and low grain yield. Acute arsenic in humans cause intoxication muscular pain weakness with flicking skin severe nausea and vomiting colicky abdominal pain profuse diarrhoea with rice-water stools Capillary damage transudation of fluid in the bowel lumen numbness in hands and feet reddish rashes in the body intense thirst. In severe poisoning skin becomes cold and clammy circulatory collapse kidney damage decreased urine output. Long-term exposure to high doses of arsenic may change the way cells communicate, and reduce ability to function, causing diabetes, cancer, vascular and lung diseases. High Arsenic causes chromosomal damage so it is not able to participate in cell division. Arsenic hazard has become a global concern to people of the world. The persistence of heavy metals in the environment may pollute or contaminate soils and aqueous streams . Rice is cultivated an aerobically, rather than aerobically which leads to much greater arsenic mobilization. High soil arsenic caused by the reduction of phosphate and arsenate uptake through phosphate transporter. The goal of my work is to find method of reduction of arsenic content Mitigate arsenic in rice Either by making arsenic ineffective or by removing heavy metals. By different methods and find out the best method among these method or by combining these method to get the best sustainable method.

The different method of arsenic mitigation are like like chemical precipitation, Dialysis, Ion- exchange, reverse osmosis, solvent extraction, and bioremediation by microbes are quite effective. while the microbial bioremediation includes the removal of heavy metals by microorganisms (bacteria, fungi, yeast and algae) as absorbents. Phyto-remediation also includes the removal of contaminants with the help of green plants. Arsenic removal plants attached with contaminated tube well are developed to treat Arsenic contaminated ground water, like precipitation processes, adsorption processes ion exchange processes separation (membrane) processes. Amongst the various bioremediation processes, phyto-remediation and bioremediation by microbes are quite effective. Phytoremediation includes the removal of contaminants with the help of green plants, while the microbial bioremediation includes the removal of heavy metals by microorganisms (bacteria, fungi, yeast and algae) as sorbets. Phytoextraction is primarily used for the treatment of contaminated soils. In this method plants absorb the concentrated metals and after precipitated from contaminated soils these metals accumulate were into the above ground parts of plants. There are few plants species known for higher accumulator and show their potential towards the removal of metals from contaminated soils. Phytostabilization is the method used for the remediation of soil, sediment, and sludges. In this method the use of plant roots may limit the contaminant in the soil through mobility and bioavailability process. The plants decrease the amount of water percolating through the soil matrix, which may act as a barrier and prevent direct contact with the contaminated soil. It may also prevent soil erosion and distribution of the toxic metal to other areas. Phytostabilization can occur through the sorption, precipitation, complications, or metal valence reduction. It is helpful in the treatment of contaminated land areas affected by mining activities and Superfund sites. Phytostabilization is commonly used to treat the arsenic, Rhizofiltration---Rhizofiltration is primarily used to remediate extracted groundwater, surface water, and waste water with low concentrations of contaminant. Rhizofiltration can be used for Pb, Cd, Cu, Ni, Zn, and Cr which are primarily retained within the roots. sunflower, INDIAN mustard, tobacco, rye, spinach, and corn have been removed lead from water or soil and soil but the sunflower significantly reduced lead concentrations with in 1hr after treatment. The rhizofiltration is useful for both terrestrial and aquatic plants for *in-situ* or *ex-situ* purposes. In this method the contaminants don't translocated to the shoots. Phytovolatilization---Phytovolatization involves the use of plants to take up contaminants from the soil, transforming them into volatile forms into the atmosphere transpiration. It is basically used for mercury contaminated soil. the contaminants may pass through the xylem vessels towards the leaves and converted into non-toxic forms and it may finally volatilize into the atmosphere. Bioremediation of Arsenic by Microbes---Soil, sediment and water sources were contaminated by hazardous heavy metals through industrial activities, such as mining, refining, and electroplating. Mercury, arsenic, lead, and chromium are often prevalent at contaminated sites. Bacterial remediation is the process of using metal reducing bacteria to break down the contaminants. The metal-reducing bacteria are able to reduce very toxic soluble forms into less toxic forms.Variety improvement by breeding method and bio-engineering are also practiced but it needs more scientific research and time and high cost. . Appropriate water use and spacing and use of improved seed variety cultivation Management in farmers' fields by organic manure while ensuring higher, better quality and quantity soil reclamation and planting of rice by SRI method . The system of rice intensification (SRI), of transplanted rice culture was developed in 1983 by Father Henri de Laulanie in Madagascasr, to increase rice productivity with less external inputs. Thakur *et al.* (2009) suggested that the system of rice intensification (SRI) holds a great promise in increasing the rice productivity. The basic principles of SRI are: planting young seedlings (<14 days) singly in a square pattern (Stoop et al., 2002). The soil is just kept saturated with water and flooding is not allowed till reproductive stage, after which a thin layer of water (1-2 cm) is kept in the field. Weeds are primarily controlled by mechanical weeding (Cono weeder) helps in incorporation of weed biomass and maintains proper aeration in soil (Satyanarayana *et al*., 2007). To increase yields, system of rice intensification (SRI) has been projected. Husain et al. (2004) reported 30% yield advantage from SRI in Bangladesh and Namara et al. (2003) showed an even larger benefit (44%) in Sri Lanka. In such scenario, the SRI appears to be a good alternative of rice cultivation, that saves the expensive inputs (e.g. water, seed, nutrients and pesticides etc.), improves soil health/quality and protects the environment substantially (Satyanarayana et al., 2007). The better performance of the crop under SRI was the outcome of enhanced growth measured in terms of significantly higher plant height, number of tillers/hill, dry matter accumulation and leaf area index at different growth stages as compare to other methods of planting rice. Since water use efficiency is quite less in SRI method as compared to conventional method arsenic uptake is also less in SRI as compared to conventional method . so SRI method is very highly recommended for increased productivity, ecological security and arsenic mitigation and since it is economical and easy to follow for the farmers.

ABSTRACT

Our country has greater prospect to exploit rice as it is the dietary staple of India and Asia, its improvement gives good health to rice eaters. In arsenic affected regions rice assimilates much more arsenic from soils than other grain crops as it is cultivated anaerobically, rather than aerobically. Anaerobic cultivation leads to much greater arsenic mobilization, Unfortunately, extensive areas of land in rice producing regions have been contaminated through irrigation of paddy fields with ground water elevated in arsenic and through contamination from wastewater from base and precious metal activities. The genetics of arsenic uptake and accumulation has been very less studied in plants as compared to animals and human being. Naturally occurring resistance to high soil arsenic, has been observed in some species, which has shown to be caused by the reduction of phosphate as well as arsenate uptake.The persistence of heavy metals in the environment may pollute or contaminate soils and aqueous streams as both natural components or as the result of human activity. Amongst the various heavy metal contaminants arsenic and lead are recognized as the leading toxicants worldwide and having the various toxic effects on human and animal health as well as on the environment. The aim of this article is to give an overview of the arsenic contaminant in soil and also the mechanism of removal of these toxic metals from the contaminated sources by the potent application of plants and microbes and use of SRI method of planting . Rice is the major source of food for half of the world's population. Paddy production entails use of costly resources a quarter to one third of world's annual fresh water supply, fossil fuels and synthetic fertilizers leading to high ecological foot prints. Paddy fields also emit greenhouse gases to global warming, soil and water pollution. The system of Rice Intensification (SRI) is an answer to all these problems and it reverses the trends responsible for climate change. Around 40 countries of the world today are reaping the benefits of SRI. India's focus for improving food security over the years has relied on intensive agriculture by improving yield per unit area using suitable varieties and improved input management. Such highly intensive agriculture dependent on fossil fuels, damaging to soil and fresh water and crop diversity is becoming questionable today. It is also discriminatory against the resource poor rain-fed areas and small and marginal farmers. The real challenge today is perhaps to develop/adopt strategies based on ecological principles and integrating traditional farming practices and biodiversity with scientific knowledge. However, concentrations may be higher in certain areas due to either natural conditions or human activities. High proportion of arsenic inhibition of seed germination decrease plant height reduction root growth, leaf area photosynthesis and low grain yield.According to (WHO), total daily intake should not exceed 2 mg of inorganic arsenic per kilogram of body weight. Acute arsenic intoxication muscular pain weakness with flicking skin severe nausea and vomiting colicky abdominal pain profuse diarrhea with rice-water stools. Capillary damage transudation of fluid in the bowel lumen numbness in hands and feet reddish rashes in the body intense thirst. In severe poisoning skin becomes cold and clammy circulatory collapse kidney damage decreased urine output. The experiment was conducted in split plot design with three replications. The main plots comprised of four planting methods, viz. conventional transplanting, system of rice intensification method, drum seeded and direct seeded. The SRI involved transplanting of 10 days old seedling/ hill at 25 x 25cm, conventional transplanting of 22 days 2-3old seedlings/hill at spacing 20 x 10cm, line sowing with drum seed in puddle field at spacing of 20cm and direct seeded at spacing of 20cm. Sub plots consisted of nutrient management, viz. 100% NPK (120:60:60), 75% NPK + 25% farm yard manure and 50% NPK + 50% farm yard manure. The better performance of the crop under SRI was the outcome of enhanced growth measured in terms of significantly higher plant height, number of tillers/hill, dry matter accumulation and leaf area index at different growth stages as compare to other methods of planting rice. Since water use efficiency is quite less in SRI method as compared to conventional method arsenic uptake is also less in SRI as compared to conventional method . so SRI method is very highly recommended for increased productivity, ecological security and arsenic mitigation and economical .

RICE SPECIES INFORMATION

Scientific name: Oryza sativa L.
Common name: rice, paddy rice, chowdhury rice (English); dhanya, vrihi, nivara, syali (Sanskrit); dhan, chaval (Hindu); chal (Bengal); dangar, choka (Gujarat); nellu, arisi (Tamil).
Conservation status: Widespread in cultivation.
Habitat: Common in river valleys and other areas where water is abundant, but also cultivated in some dryland areas
Taxonomy
Class:Equisetopsida
Subclass: Magnoliidae
Superorder:Lilianae
Order:Poales
Family:Poaceae
Genus: Oryza
The genus oryza contains about 23 wild species ,mostly diploid and some allotetraploid. Rice is grown in 114 countries under about 171 million ha. Nearly 90%of the worlds rice is produced and consumed in Asia. The primary centre of origin of cultivated rice may be south east Himalaya. Archeological evidence suggest that rice is originated5000BCat Hemudusite in Taifu area of eastern China. Rice spread in the Europe particularly in Greece and Mediterranean region during 344-324BCby Alexander then further in southern Europe and north Africa In india rice is the staple food crop and is grown on 42.5m ha, largest among rice growing country in area Rice is used to feed the belly, is a source of directly consumed calories for about half the world's population .Rice are used for different purposes like--- **Rice starch** mixed with honey to nourish the skin and can be used in cosmetics to reduce facial 'shine'. **The rice oil** --- UV-rays , conditioners for hair-care and in shower and shampoo products moisturising and anti-ageing properties for skin. Rice Extracts containing **rice protein** are added to hair products to give a feeling of volume and thickness to the hair . The **husks** and grains of rice are used as bedding for mushroom growing medium, organic manure and a mulch, fuels and building board. **Bran oil** is used in cooking, and has anti-corrosive properties. It is also used as a textile and leather finisher. **Rice straw** is used for animal feed and bedding, and can be made into paper and board pulp. **Sticky glutinous rice** to treat stomach upsets, heart-burn and indigestion.
Extracts from brown rice to treat breast and stomach cancer, warts indigestion, nausea and diarrhoea. **Rice bran** contain 25% fibre, which absorb fats. Decreases levels of cholesterol in the blood, aids digestion and can be used as a mild laxative.

World Rice Production 2014/2015

- (Values in Metric Tons)
- **China:** 144,000,000
- **India:** 102,000,000
- **Others:** 38,096,000
- **Indonesia:** 37,000,000
- **Bangladesh:** 34,600,000
- **Vietnam:** 28,200,000
- **Thailand:** 20,500,000
- **Philippines:** 12,200,000
- **Burma:** 12,150,000
- **Brazil:** 8,350,000
- **Japan:** 7,700,000
- **United States:** 7,069,000
- **Pakistan:** 6,500,000
- **Cambodia:** 4,900,000
- **Egypt:** 4,500,000
- **Korea, South:** 4,180,000
- **Nepal:** 3,100,000
- Rice Production last year (*) was 476.36 million tons. This year's 475.04 estimated million tons could represent a decrease of 1.32 million tons or a 0.28% in **rice production in** globe.
- SOURCE AMERICAN NEWS PAPERS

OBJECTIVE

The aim of this article is to give an overview of the arsenic contaminant in rice plant and mechanism of mitigation of these toxic metals. SRI and Aerobic rice cultivation system which could be the solution towards arsenic contaminated ground water and thereby help in mitigating the arsenic loading of rice crop ecologically and economically and to find rice crop with the lowest possible arsenic Either by making arsenic ineffective or by removing heavy metals

METHODOLOGY –

To characterize soil induced variation of arsenic uptake in rice and study effect of arsenic content in rice A total of 4 diverse rice varieties namely 1) Nayanmoni, 2)GB-1, 3) 4684, and 4)4986 were obtained from the Chakdha seed Research farms . The 3kg seeds of each varieties were stored in deep freeze and used accordingly. Arsenate was supplied as a solution of Na2HASO4 and 7H2O in distilled water to maintain flooded paddy field condition of 3-4 cm ,phosphorus as caH2 Po4H2o @30 kg /ha and k as kcl at 60 kg/ha .N as co(Nh2)2 @160kg/ha. The field trial was conducted during dry season irrigated with flooded arsenic contaminated water of different dose , Seeds were grown on the raised nursery beds which were prepared with vermicompost, FYM and soils above the plastic . After 1week the seeds were transplanted to the field with 3 replication kept randomly, A common dose of 25 kg ZnSO4/ha was applied at the time of transplanting and fertilized with 70kg n /ha ,35kgP,and 35kgK/ha split over two applications at the time of transplanting and after 30 days of sowing . to see which variety absorbs more arsenic and in which stage of growth the concentration of arsenic is more following experiments were done .

1. The dose response and source of Genetic variation for arsenic tolerance uptake and metabolism was done where One replicate beaker containing 15-20 seedlings at six concentrations of arsenic were used to characterize the dose response , the data for each plant in a beaker were averaged and the standard error was calculated.
2. The response of 4 rice varieties to 13.3 μM arsenate was tested. In order to estimate source of variation two rreplicate beakers each containing 10 plants were used for both control and treatment. The vast majority of variance between individual plants in beakers, rather than between beakers was studied by comparing 40 pair-wise beaker
3. The variance of rice variety was confirmed by three-way analysis of variance (factors: genotype, treatment and replicate beaker)
4. To test arsenate tolerance, seeds was allowed to germinate in the lab for 3 days at 37°C and then floated on alkathene beads within 250 ml beakers filled with phosphate-free nutrient solution
5..The seedlings was grown in controlled conditions at 25°C with a 12 hour/day length. After 1 wk the maximum length of the root of plants was measured. The tolerance index was calculated as the percentage of root length in arsenate compared to the control.
6..The distribution of tolerance was indicated in two discrete classes, and a value of > 40% will be taken to indicate tolerance, and < 40% to indicate sensitivity to arsenate to allow the tolerance reaction to be treated as a genetic marker. The arsenate tolerance gene will be placed on the map using Map Maker 3.0 (Lander *et al* ., 1987; Lincoln *et al*, 1992) with the Haldane algorithm.
7.Different technique of rice production were compared for water use efficiency

Direct-seeded rice and drum seeded: The direct-seeded rice and drum seeded was kept moist during the first week to ensure its proper germination. Water was not allowed to accumulate for avoiding seed rotting. Irrigations were applied at 3 day interval throughout up to 15 days before harvesting.

Conventional Transplanting: Continuous pounding of water was kept for the first 15 das for the better establishment or rice. The subsequent irrigations were given, 2 days after the pounded water was infiltrated into the soil. The last irrigation to transplanted rice was applied 15 days before harvesting.

System of rice intensification: In this method Irrigation to the crop was applied by alternate wetting and drying cycles to keep the soil in saturated condition. 1-4 cm water was allowed to stand during reproductive stages. During vegetative stages water was applied to keep the soil moist particularly before the onset of monsoon or excess water was allowed to drain out whenever intense rains occurred. The experiment was conducted in split plot design with three replications. The main plots comprised of four planting methods, viz. conventional transplanting, system of rice intensification method, drum seeded and direct seeded. The SRI involved transplanting of 10 days old seedling/ hill at 25 x 25cm, conventional transplanting of 22 days 2-3old seedlings/hill at spacing 20 x 10cm, line sowing with drum seeder in puddle field at spacing of 20cm and direct seeded at spacing of 20cm. Sub plots consisted of nutrient management, viz. 100% NPK (120:60:60), 75% NPK + 25% farm yard manure and 50% NPK + 50% farm yard manure. The better performance of the crop under SRI was the outcome of enhanced growth measured in terms of significantly higher plant height, number of tillers/hill, dry matter accumulation and leaf area index at different growth stages as compare to other methods of planting rice. Since water use efficiency is quite less in SRI method as compared to conventional method arsenic uptake is also less in SRI as compared to conventional method . so SRI method is very highly recommended for increased productivity, ecological security and arsenic mitigation and economical .

RESULTS

The results of different tests undertaken were more interesting as we found measurable amounts of total arsenic in its two forms in all the rice varieties undertaken for study. we found significant level of inorganic arsenic which is a carcinogen in almost all the varieties undertaken along with organic arsenic which is less toxic but still of concern. since arsenic not only is a potent human carcinogen but also can set up children for other health problems in later life

The increasing scarcity of water is a major threat to rice production in many countries, particularly in the world's leading rice-producing countries, like China and India. Water inputs is a key factor in governing the physiological processes, dry matter production, tiller production, size of panicles and sterility percentage. Under a mild stress, rice plant tends to produce more tillers. If adequate water regime is maintained during reproductive stages, a larger number of tillers can be transformed into healthy panicles particularly under SRI. In the Indo-Gangetic plains (IGP) , the total water requirement for rice ranged from 1566 mm in clay loam to 2262 mm in sandy loam soil (Tripathi, 1990). About 50-80% of total water input percolates deep in soil profile and only 30-40% is utilized consumptively (Sharma, 1989). Water input to rice cultivated even with SRI can be reduced by reducing the deep percolation losses through appropriate irrigation scheduling. The SRI method which envisages alternate wetting and drying reduce water losses and improve productivity. Since, the SRI changes the environment of rice growth from anaerobic to aerobic soil conditions, with no stranding water during the vegetative growth period and only a thin layer of water on the field (1-2 cm) from panicle initiation until 10-15 days before harvest .Under any method of cultivation, optimum water supply is the most important factor governing availability and uptake of essential nutrients, growth, yield and quality of the rice. However, optimum ground space available to each plant is also important for exploitation of available resources.. The system of rice intensification has been reported to increase the yield tremendously with same level of inputs and about 40-50% water savings. From my experiments also it can be concluded that SRI cultivation technique requires less seed to produce 10-20% more quality rice grain and more important it is ecologically and economically favourable as compared with lowland submerged cultivation methods. The fact that even a 10% reduction in rice grain arsenic could save hundreds of thousands of lives from getting different diseases caused due to arsenic intake with consumption of rice. Aappropriate water use and spacing and use of improved arsenic resistant seed variety cultivation Management in farmers' fields by organic manure while ensuring higher, better quality and quantity soil reclamation by SRI method is recommended among these technique which is considered the best option for less ground water use, and mitigating the arsenic problem in rice. For this experiment soil sample were collected from 24 farmers field of Chakdha, of NADIA district of West Bengal research farm, comparison of seed quality by germination test in the field and in the lab was done and agronomy characters are measured and compared.

TABLE 1 soil sample were collected from 24 farmers field of Chakdha,

S No.	Name	Village	Dist	Dag No	Result No	Mineral & Salt	PH	Live Carbon %	Acceptable Phosphoras	Acceptable Potttasium
1	Haran Chandra Das	Phetugachi	Nadia	Jodkhambba	3171	0.16	8.14	High	Low	Low
2	Narayan C Das	Phetugachi	Nadia	Uparer Phali	3178	0.13	8.18	Low	Medium	Low
3	Badsha Mondal	Sajerdhar	Nadia	Sajerdhar	3166	0.11	8.07	Low	Low	Low
4	Badsha Mondal	Chasadhopapara	Nadia	Sajerdhar	3174	0.14	8.14	Low	Low	Low
5	KRISHNA GOPAL DAS	MOHISH DANGA	Nadia	PURBODIPER PHALI	3175	0.19	8.22	Low	Low	Low
6	KRISHNA GOPAL	MOHISH DANGA	Nadia	PASCHIM DIPER MOMI	3168	0.12	8.2	Low	Low	Low

	DAS									
7	MADHAV DAS	MOHISH DANGA	Nadia	DHIJAN DASER	3173	0.1	8.24	Medium	Medium	Low
8	MADHAV DAS	MOHISH DANGA	Nadia	16 SATAK	3165	0.13	8.31	Medium	Medium	Low
9	MADHAV DAS	MOHISH DANGA	Nadia	ACHEYDER JAMIN	3179	0.18	8.15	Low	Medium	Low
10	MADHAV DAS	MOHISH DANGA	Nadia	BIRENDASER	3176	0.14	8.13	Low	Medium	Low
11	ABER ALI MONDAL	JATRAPUR	Nadia	BOROFALI	3159	0.16	8.05	Low	Medium	Low
12	LUTKAR MONDAL	NARAPOTIPARA	Nadia	NH34	3161	0.18	8.25	Low	Medium	Low
13	YAKUB MONDAL	MOLLAPARA	Nadia	CHOUKA PHALI	3164	0.17	8.1	Low	Medium	Low
14	POLASH BURMAN	SIMIRALI	Nadia	JOLEDHAR	3167	0.14	8.17	Low	Medium	Low
15	SUBROTO SARKAR	SIMIRALI	Nadia	BOROFALI	3169	0.15	8.2	Low	Medium	Low
16	BACHU SANTRA	GONTRA	Nadia	BOROPUKURER DHAR	3177	0.17	8.2	Low	Medium	Low
17	NARAYAN GHOSH	MONDALHAT	Nadia	SEGURTALA	3180	0.15	8	Medium	Medium	Low
18	KASSENG MONDAL	MONDALHAT	Nadia	YEDOPUKUR	3172	0.19	8.17	Medium	Medium	Low
19	ACHIR MONDAL	TELULBERE	Nadia	LONARBIR	3170	0.12	8.13	Medium	Low	Low
20	HOSEN MONDAL	DEREPARA	Nadia	OUSERSETU	3160	0.14	8.15	Low	Low	Low
21	ABURSA DUKHA	JAGULI	Nadia	AGERJAMIN	3162	0.11	8.24	Low	Low	Low
22	SERAJ MALLIK	NATUPALLI	Nadia	RASTEDHARE	3163	0.15	8.06	Low	Low	Low
23	NGO	GOINTRA	Nadia	CHAKDHA	2808	0.12	8.2	Low	Low	Low
24	NGO	GOINTRA	Nadia	CHAKDHA	2807	0.16	8.01	Medium	Medium	Low

TABLE 2. Water use efficiency was studied and recorded

Treatment	**Water use efficiency (kg /ha/cm)**					
	S_1	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
M_1	**43.18**	**42.62**	**39.98**	**39.29**	**39.16**	**40.85**
M_2	**75.05**	**74.31**	**72.43**	**72.31**	**71.56**	**73.13**

M_3	**75.80**	**75.52**	**73.28**	**73.68**	**74.98**	**74.66**
Mean	**64.68**	**64.15**	**61.90**	**61.76**	61.9	
			SEm±		**CD (P=0.05)**	
Main treatments (M)			**3.9**		**15.3**	
Sub- treatments (S)			**5.2**		**15.2**	
M at same or different S			**8.9**		**NS**	

TABLE --2
M_1- Normal method (Application of RDF through inorganic with FYM @10 t/ ha and transplanting at 20× 10 cm spacing)
M_2- Modified SRI (Application of RDN through organics and transplanting at 25× 25cm spacing)
M_3- Modified SRI (Application of RDF through in-organics with FYM @ 10 t/ ha and transplanting at 25× 25 cm spacing)
S_1- 9-day seedlings; S_2- 12-day seedlings; S_3- 15-day seedlings; S_4- 18-day seedlings; S_5- 21-day seedlings
Both SRI recorded lower water requirement and higher water use efficiency compared to normal method. In table 2

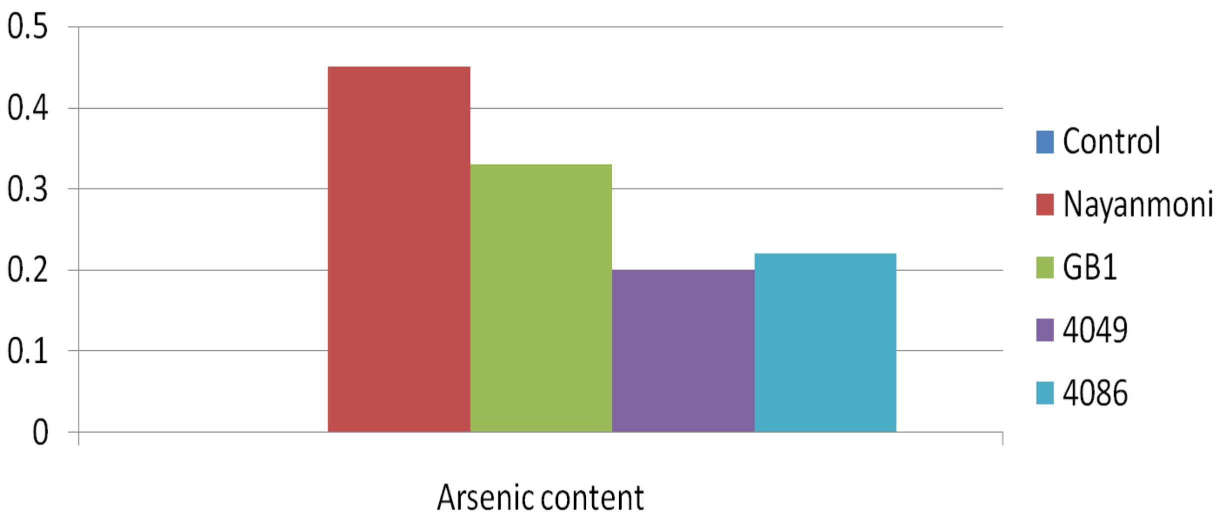
TABLE 3. Grain yield on the age of seedlings

Treatment	**Grain yield (kg /ha)**					
	S_1	**S_2**	**S_3**	**S_4**	**S_5**	**Mean**
M_1	**5397**	**5327**	**4997**	**4910**	**4893**	**5105**
M_2	**6377**	**6313**	**6153**	**6143**	**6080**	**6213**
M_3	**6440**	**6416**	**6226**	**6260**	**6370**	**6342**
Mean	**6071**	**6018**	**5792**	**5771**	**5781**	
			SEm±		**CD (P=0.05)**	
Main treatments (M)			**3.9**		**15.3**	
Sub- treatments (S)			**5.2**		**15.2**	
M at same or different S			**8.9**		**NS**	

M_1- Normal method (Application of RDF through inorganic with FYM @10 t/ ha and transplanting at 20× 10 cm spacing)
M_2- Modified SRI (Application of RDN through organics and transplanting at 25× 25cm spacing)
M_3- Modified SRI (Application of RDF through in-organics with FYM @ 10 t/ ha and transplanting at 25× 25 cm spacing)
S_1- 9-day seedlings; S_2- 12-day seedlings; S_3- 15-day seedlings; S_4- 18-day seedlings; S_5- 21-day seedlings

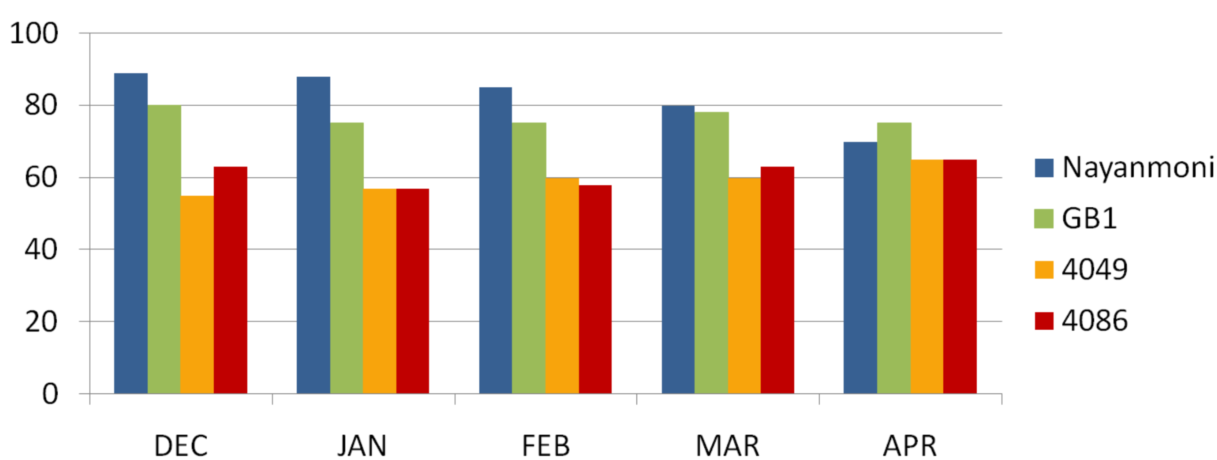
It is observed that younger seedlings of 9 days anf 12 days produced significantly higher grain yield than the rest of the age of seedlings. Modified SRI method resulted in significantly higher yield (3642 kg/ha) when compared to other methods in table 2 Although SRI is a promising technique care should be take while Uprooting the seedlings from the seedbed, so that roots are less injured, replace any damaged seedlings after transplanting, Only land that can be drained freely should be used for SRI, Land preparation should be done carefully to ensure that seedlings are transplanted into a well level field, Clay soil, low land, poor drainage land etc. should be avoided because of drying and cracking problems which are harmful to SRI method, Adequate availability of organic sources of manure should be used, maintenance of alternate wetting and drying during rainy period, since vigorous weed growth increases the cost of production; the last weeding should be done by hand to avoid elimination of old roots. SRI means less water use; two-thirds reduction in per square meter or per hectare number of plants; single seedling per hill or at the most two seedlings for greater root and canopy growth; wider spacing between hills in square, rectangular or triangular planting; transplanting younger seedlings at 2-3 leaf stage or 8 to 12 days and; increasing organic soil matter.

TABLE 4. ARSENIC CONTENT PRESENT ON DIFFERENT VARIETIES



Arsenic value for grain of four different varieties are calculated and compared with the control and found that Nayanmoni has the highest Arsenic content while 4049 has the lowest Arsenic content. So I recommend 4049 as the best variety out of the four.

TABLE 5. RECORD OF GERMINATION PERCENTAGE OF FOUR VARIETIES



The two varieties Nayanmoni and GB1 showed above 80 % germination during December which decreases slowly upto 75%. So this two varieties are very good as their germination % is high which lasts for 4 months. The two varieties 4049 and 4086 showed germination % 50 – 55 which slowly increases upto 65%. This shows that these tow variety were dormant or not matured fully during January. So these varieties can last viable for a longer period. So farmers can use these two varieties as late variety.

DISCUSSION

The aim of this article is to give an overview of the arsenic contaminant in soil and also the mechanism of mitigation of these toxic metals by different method. SRI and Aerobic rice cultivation system could be the best solution towards arsenic contaminated ground water and thereby help in mitigating the arsenic loading of rice crop. Water management strategies have to play important role in enhancing arsenic less rice productivity under SRI method with application of organic sources like green manure, FYM, BGA, and Azolla in integrated manner . From the experiments results it can be concluded that SRI cultivation technique produces quality rice grain and more important ecologically and economically favourable yield as compared with lowland submerged cultivation methods and the fact that it helps in reduction of arsenic uptake . Even a 10% reduction in rice grain arsenic could save hundreds of thousands of lives. It can be concluded that SRI is a better option for less ground water use, and increasing water use efficiency and mitigating the arsenic. System of Rice Intensification for Increased Productivity and Ecological Security as Rice is the major source of food for half of the world's population. Paddy production entails use of costly resources a quarter to one third of world's annual fresh water supply, fossil fuels and synthetic fertilizers. The system of Rice Intensification (SRI) is an answer to all these problems and it reverses the trends responsible for climate change and reduction in arsenic . in the country.

REFERENCES

AbedinMJ, Cresser MS, mehargAA, Feldmann J, Cotter-Howells J (2002) Arsenic accumulation and metabolism in rice (Oryza sativa L.) Environ Sci Technol Vol. 128, 2002

Alam M B, Satter MA (200) Assessment of arsenic contamination in soils andwaters in some areas of Bangladesh. Water Sci Tech 42: 185- 193

Alexander, D., Padanandan, N. and Karunakaran, K. 1988. Azolla growth under different planting methods in Kerala. *International Rice Research Notes* **13**(4):24-25.

Balasubramanian, V., Rajendran, R., Ravi, V., Chellaiah, N., Castro, E., Chandrasekaran, B., Jayaraj, T. and Ramanathan, S. 2005. Integrated crop management for enhancing yield, factor productivity and productivity in Asian rice farms. *International Rice Commission Newsletter* **54** : 63-72.

Balasubramanian, V. and Hill, J. 2000. Direct wet seeding of rice in Asia. Emerging Issues and Strategic Research Needs for the 21st Century. Paper presented at the Annual Workshop of the Directorate of Rice Research. Hyderabad, Andhra Pradesh.

Balasubramanian, V., Sie, M., Hijmans, R.J. and Otsuka, K. 2007. Increasing rice production in Sub-Saharan Africa: challenges and opportunities. *Advances in Agronomy* **94**: 55-126.

Beever RE, Burns DWJ (1980) Ohosphorus uptake, storage and utilization by fungi. Adv Bot Res 8:127-219

Bruderie, K., Shambu, P and Roy, S. 2009. Vulnerability reduction and adaptation experiences from Rajasthan and Andhra Pradesh: The system of rice intensification, Swiss Agency for Development and Coperation, Vulnerability and Assessment Programme, India pp. 1-35.

Bouman, B.A.M., Peng, S., Castan, A.R. and Visperas. R.M. 2005. Yield and water use of irrigated.

Carriger, F. and Vallee, D. 2007. More crop per drop. *Rice Today* **6** (2): 10-13.

Goel, A.C. and Verma, K.S. 2000. Comparative study of direct seeding and transplanted rice. *Indian Journal of Agriculture Research* **34**: 19-196.

Husain, A.M., Chowhan, P.B., Uddin, A.F.M. and Rahman, A.B.M. 2004. Final Evaluation Report on Verification and Refinement of the System of Rice Intensification (SRI) Project in Selected Areas of Bangladesh. PETRRA-Project, IRRI, Dhaka, Bangladesh.

Janardhan, K.V., Murthy, K.S. and Dash, N.D. 1980. Effect of low light during ripening period on grain yield and translocation of assimilates in rice varieties. *Indian Journal of Plant Physiology* **23** : 163-168.

Koga, K. 1992. *Introduction to Paddy Field Engineering, Asian Institute of Technology,* Bankok, Thailand, pp 118.

Latif, M.A., Islam, M.R., Ali, M.Y. and Saleque, M.A. 2005. Validation of the system of rice intensification (SRI) in Bangladesh. *Field Crops Research* **93**: 281-92.

Linhua, Wu., ChunZan, Chen AliLiu., Ding YuYun and Liao ChuanShuang. 2006. Yield increasing mechanism of system of rice intensification (SRI) and its key techniques. *Hybrid Rice. **21** (1): 42-43.*

Lin. X.Q., Zhu, D.F. and Lin, X.J. 2009. Studies of different managements of water and N fertilizer on the growth and root environment of hybrid rice (Zhongyou 218). *Journal of Irrigation and Drainage* **4**(2):31-36.

Makarim, A.K., Balasubramanian, V., Zaini, Z., Syamsiah, I., Diratmadja, I.G.P.A., Handoco, A., Wardana, I.P. and Gani, A. 2002. System of rice intensification (SRI): evaluation of seedling age and selected components in Indonesia. In : Proceedings of International Workshop on Water-wise rice production. *8-11 April, 2002. Los Banos, Philippines. Pp. 129-139.*

McDonald, A.J., Hobbs, P.R. and Riha, S.J. 2006. Does the system of rice intensification out perform conventional bet management? A synopsis of the empirical record. *Field Crops Research* **96**(1): 31-36.

Mepete, M.Z.L., Van Es., Es, H.M. Brito, R.M.L., DeGloria, S.D. and Famba, S. 2008. Evaluation of system of rice intensification (SRI) component practices and their synergies on salt-affected soils. *Field Crops Research* **109**:34-44.

Mishra, D., Ispal asmed, M., Rao, K.V. and Bentor, J.S. 2006. Rice Research in India. Green revolution to gene revolution. *Journal of Rice Resarch***1**(1):38-51.

Pasuquin, D., Lafarge T., Tubana B. 2008. Transplanting young seedlings in irrigated rice fields: Early and high tiller production and enhanced grain yield *Field Crops Research* **105** : 141-55.

Prasad, R. 2011. Aerobic rice systems. *Advances in Agronomy III: 207-47.*

Namara, R.E., Weligamage, P. and Barker, R. 2003. Prospects for Adopting System of Rice *Intensification in Sri Lanka: A Socio-economic Assessment Research Report* 75. International Water Management Institute, Colombo, Sri Lanka.

Qayoom, S., Khan, H.U., Khanday, B.A. 2008. Production recommendations for field crops. Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir pp. 1-11.

Rajendran, R., Balasubramanian, V., Ravi, V., Valliappan, K., Jayaraj, T. and Ramanathan, S. 2004. Nursery technology for early production of robust rice seedlings to transplant under integrated crop management. *International Rice Research Notes* **29** (2): 73-75.

Rangaswamy, R. 2006. *A Text Book of Agricultural Statistics*. New Age International (P) Limited, New Delhi, 496 pp.

Satyanarayana, A., Thiyagarajan, T.M. and Uphoff, N. 2007 Opportunities for water saving with higher yield from the system of rice intensification. *Irrigation Science* **25**: 99-115.

Sinha, S.K. and Talati, J. 2007. Productivity impacts of the system of rice intensification (SRI): a case study in West Bengal. *India. Agricultural Water Management* **87** : 55-60.

Sharma, P.K. and Masand, S.S. 2008. Evaluation of system of rice intensification in a high rainfall area of North-western Himalayas. *Oryza* **45**(3):206-211.

Sharma, P.K. 1989. Effect of periodical moisture stress on water-use efficiency in wetland rice. *Oryza* **26**(3):252-57.

Shrirame, M.D., Rajgire, H.J. and Rajgire, A.H. 2000. Effect of spacing and seedling number per hill on growth attributes and yield of rice hybrids under lowland condition. *Journal of Soils and Crops* **10**(1): 109-113.

Sharma S.D. and Prasada Rao, U. (Eds.)2004. Genetic *Improvement of Rice Varieties of India*, 551-579 pp. Today and Tomorrows Printers and Publishers, New Delhi.

Stoop, W.A., Uphoff, N., Kassam, A., 2002. A review of agricultural research issues raised by the system of rice intensification (SRI) from Madagascar: opportunities for improving farming systems for resource-poor farmers. *Agricultural Systems***71**: 249-274.

Thakur, A.K., Chaudhari, S.K., Singh, R. and Ashwani Kumar 2009. Performance of rice varieties at different spacing grown by the system of rice intensification in eastern India. *Indian Journal of Agricultural Sciences***79**(6): 443-47.

Thakur, A.K., Rath, S., Roychowdhury, S. and Uphoff, N. 2010. Comparative performance of rice with system of rice intensification (SRI) and conventional management using different plant spacings. *Journal of Agronomy & Crop \science* **196** (2): 146-59.

Tripathi, R.P. 1990. Water requirement in rice-wheat system (In): *Proceedings of Rice-wheat Workshop*. October 15-16. Modipuram, U.P.

Uphoff, N. 2003. SRI-Higher yields with fewer external inputs? The system of rice intensification and potential contributions to agricultural sustainability. *International Journal of Agricultural Sustainability* **1** (1): 38-50.

USDA (United State Department of Agriculture) 2004. Producer, supply and distribution online database. Washington, D.C., USDA. *http.www.fas.usda.gov.*

Vijayakumar.M., Singh, S.D.S., Prabhakaran, N.K. and Thiyagarajan,, T.M. 2004. Effect of SRI (System of Rice Intensification) practices on the yield attributes yield and water productivity of rice (*Oryza sativa* L.) Acta Agronomica Hungarica **52(**4):399-408.

WWF-ICRISAT Project 2010. More rice for people, more water for the planet. Africare, Oxfam America, WWF-ICRISAT Project, Hyderabad, India pp. 1-35.

Yoshida, S. and Parao, F.T. 1972. Performance of improved rice varieties in the tropics with special reference to tillering capacity. *Experimental Agriculture* **8**:203-12.6.

Venkateswarlu, B. 1977. Influence of low light intensity on growth and productivity of rice (*Oryza sativa*). Plant Soil **46**: 713-719.

Fageria, N.K., Baligar, V.C. and Clark, R.B. 2006. Physiology of crop production. The Haworth Press: New York.

FAO. 2010. Food and Agriculture Organization, Rome, Italy (http:/faostat.fao.org).

Geethalakshmi, V., Ramesh, T., Palamuthirsolai, A. and Lakshmanan. 2011. Agronomic evaluation of rice cultivation systems for water and grain productivity. *Archives of Agronomy and Soil Science* **57**(2):159-66.

Hugar, A.Y. Chandrappa, H., Jayadeva, H.M., Sathish, A. and Mallikarjun, G.B. 2009. Influence of different establishment methods on yield and economics of rice. *Agriculture Science Digest* **29**(3):202-05.

Styanarayana, A., Thiyagarajan, T.M. and Uphoff, N 2007. Opportunities for water saving with higher yield from the system of rice intensification. *Irrigation Science* **25**:99-115.

Thakur, A.K., Uphoff, N. and Anthony, E. 2010. An assessment of physiological effects of system of rice intensification (SRI) practices compared with recommended rice cultivation practices in India. *Experimental agriculture* **46**(1):77-98.

Yoshida, S. 1981. Fundamentals of Crop Science. Los Banos, Philipines., International Rice Research Institute, Los Banos, Philippines.

Zhao, L., Wu, L., Li, Y, Sarkar, A., Zhu, D. and Uphoff, N. 2010. Comparisons of yield, water use efficiency, and soil microbial biomass as affected by the system of rice intensification. Communications in Soil Science and Plant Analysis **41**:1-12.

Baloch, A.W., Soomro, A.M., Javed, M.A., Ahmed, M., Bughio, H.R., Bughio, M.S., Mastoi, N.N. 2002. Optimum plant density for high yield in rice (*Oryza sativa* L.). *Asian Journal of Plant Science* **1**: 25-27.

Sharma, P.K. 1989. Effect of periodical moisture stress on water-use efficience in wetland rice. *Oryza.***26**(3):252-57.

Tripathi, R.P. 1990. *Water requirement in rice-wheat system*. Rice-wheat Workshop, Modipuram, U.P. Oct. 15-16.

Pingali, P.L. 1994. Agricultural commercialization and farmer product choices: the diversification out of rice. Paper presented at the workshop on 'Social science methods in agriculture. I. System research: coping with increasing resource competition in Asia', held at Chaing Mai, Thailand.

Moorthy, B.T.S. and Saha, Sanjay, 2002. Evaluation of pre and post emergence herbicide for their effects on weeds and upland direct seeded rice *Indian Journal of Weed Science* **37** (34): 195-200.

Manna, G.B. 1991. Weed management for increasing efficiency of fertilizer. Proceedings of Summer *Institute on Nutrient Transformation and Management in Flooded Soil-Rice Ecosystem,* held at CRRI, Cuttack (Orissa) during 1-20 June 1991. pp. 391-401

Kumar, D. and Shivay, Y.S. 2004. System of rice intensification. *Indian Farming* **54**(8):18-21.

Shekhar, J., Mankotia, B.S. and Dev, S.P. 2009. Productivity and economics of rice (Oryaza sativa) in system of rice intensification in north-western Himalayas. Indian Journal of Agronomy **54**(4): 423-27.

Zhao, L., Wu, L., Li, Y., Sarkar, A., Zhu, D. and Uphoff, N. 2010. Comparisons of yield, water use efficiency and soil microbial biomass as affected by the system of rice intensification. *Communication in Soil Science and Plant Analysis* **41**:1-12.

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