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Response of aerobic rice (*Oryza sativa*) to irrigation regimes and methods of zinc application

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ABSTRACT

Field experiments were carried out during 2016 and 2017 at the Agricultural Farm of the Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal) to find out the response of aerobic rice (Sahbhagi Dhan) to different regimes of irrigation and methods of zinc application. The results revealed that irrigation regime at 100% of CPE (I_{100}) improved significantly growth attributes like tiller number, dry matter accumulation, crop growth rate and leaf area index, yield attributes over irrigation regime at 75% of CPE (I_{75}). Irrigation regime at 125% of CPE recorded significantly higher grain yield (4428 kg ha^{-1}) as compared to irrigation regime at 75% of CPE (3223 kg ha^{-1}). The irrigation regime at 100% and 125% of CPE recorded higher nitrogen, phosphorus, potassium and zinc content in grain and straw. Application of zinc sulphate through seed priming and seed coating also recorded significantly higher growth attributes over other methods of zinc application. Application of zinc sulphatethrough seed coating recorded significantly higher grain yield (4475 kg ha^{-1}) than the other methods of zinc application. The minimum grain (3300 kg ha^{-1}) and straw (4543 kg ha^{-1}) yields were recorded under control. The crop receiving zinc coated seed recorded higher nitrogen, phosphorus, potassium and zinc content in grain and straw.

Key words: zinc coating, zinc priming, nutrient content, grain yield, CPE

INTRODUCTION

Water is the top most vital component for sustainable rice production, particularly in the traditional rice growing areas. Rice is not only the staple food, but also creates the major livelihood and a key source of employment and income for the rural people. Cultivation of high-yielding rice cultivar under nonflooded, nonpuddled and unsaturated (aerobic) soil conditions is called ‘aerobic rice’. Aerobic rice varieties should be highly responsive to nutrient supply, should be grown in rainfed or irrigated conditions and tolerate infrequent flooding and drought situations. Aerobic rice crop could be successfully grown with 700 to 900 mm of water in summer and monsoon season and may be yielded about 6.5 t ha^{-1} and saving about 40 to 60 per cent fresh water. Zinc is an important micronutrient required for several biochemical processes in the rice plant, including chlorophyll production and membrane integrity. There are various methods of adding micronutrients to crops: soil application, foliar spraying, seed priming and seed coating. Soil application is generally considered as the most promising approach for applying macronutrients.In contrast, foliar Zn spray is found efficient for achieving crop response, especially where low supply from soil is observed (Imran *et al.*, 2016). The most effective method for enhancing grain content was found as soil along with foliar application that resulted in 3.5-fold increase in grain Zn (Cakmak *et al.*, 2010). Application of zinc through foliar application, seed priming and seed coating have many benefits over soil application, i.e., quantity applied are significantly lower than soil applications, uniform application is possible, crop response to applied micronutrient is almost immediate. Foliar, priming and coating of Zn is found to escape most of the soil reactions. With this background, the present study was carried out to study the response of summer rice to irrigation and zinc application under aerobic condition

MATERIALS AND METHODS

The field experiments were conducted during summerseason of 2016 and 2017 on sandy loam soil at the Institute of Agriculture Farm, Visva-Bharati, Sriniketan of Birbhum in

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district West Bengal ($20^0 39^/$N latitude and $87^0 42^/$E longitude with an average altitude of 58.9 m amsl) under typical semi-arid tropical climate. Total rainfall received during the crop growth period (April to August) 563.06 mm during 2016 and 63.28 mm during 2017. The soil had 140.0 kg N ha^{-1}, 11.9 kg ha^{-1} available phosphorus, 161.0 kg ha^{-1} exchangeable potassium and 5.2 g kg^{-1} organic carbon. The pH of the soil was 6.16. The DTPA extractable Zn in soil was 0.48 mg kg^{-1}. The experiment was laid out in split-plot design. The treatments comprise of three irrigation regimes i.e. I_{75}: Irrigation at 75% of CPE, I_{100}: Irrigation at 100% of CPE, I_{125}: Irrigation at 125% of CPE in the main plot and the sub plots comprising of five method of zinc application Zn_1: Control, Zn_2: Soil application of $ZnSO_4$, $7H_2O$ at 20 kg ha^{-1}, Zn_3: Foliar application of $ZnSO_4$, $7H_2O$ at 0.5%, Zn_4: Seed priming with $ZnSO_4$, $7H_2O$ at 0.3% and Zn5: Seed coating with $ZnSO_4$, $7H_2O$ at 1.2%. The treatments were replicated thrice in 4 m x 3 m plots. Treated and untreated rice seeds were sown with hand drill using seed rate of 60 kg ha^{-1} at a spacing of row to row 25 cm. Rice crop was sown on 6^{th} April in the first year and 3^{rd} April in the second year. The 100 kg N, 50 kg $P_2O_5$and 50 kg K_2O ha^{-1} were applied as urea, single superphosphate and muriate of potash, respectively. Full dose of phosphorus and half dose of potash as basal were applied in the rows before sowing and remaining half dose of the potash was top dressed at 60 DAS. The nitrogen was top dressed in three splits i.e.; half dose of nitrogen at 20 DAS and remaining half dose of N was applied in two equal split each at 40 DAS and 60 DAS. Irrigations treatments were imposed as per treatment details at 20 DAS. Harvesting was done on 10 August in the first year and 5 August in the second year. Number of tillers and dry matter production were recorded at 30, 45, 60, 75 and 90 DAS. Crop growth rate was calculated at 45-60, 60-75 and 75-90 DAS. Yield attributes and yields of grain and straw were recorded at harvest. The nitrogen content in grain and straw was determined by modified Kjeldahl method. Phosphorus and K content in diacid extract were determined by molybdovanadate yellow colour method and flame photometrically, respectively. Zinc content in the grain and straw were determined on atomic absorption spectrophotometer (AAS-4129) from the extract. All the data obtained from rice crop were statistically analyzed as per procedure given by Gomez and Gomez (1984). LSD values at P = 0.05 were used to determine the significance of differences between treatment means. The analysis of data on growth, grain yield, and nutrient content for aerobic rice was also performed using SPSS software.

RESULTS AND DISCUSSION

Growth characters

Number of tillers m^{-2} of aerobic rice responded significantly to irrigation regimes (Table 1). The number of tillers m^{-2} was significantly higher with irrigation regime at 125% of CPE (I_{125}) over at 75% of CPE (I_{75}) but there was no significant difference between I_{100} and I_{125} at 30, 45, 60, 75 and 90 DAS. The lower number of tillers under I_{75} might be due to non-availability of water (Nayak, 2015 and Duary and Pramanik, 2019). Seed coating with $ZnSO_4$ recorded significantly higher number of tillers over soil application and foliar application of $ZnSO_4$. Irrigation regime at 100% and 125% of CPE recorded significantly higher dry matter production than 75% of CPE (Table 1). The lowest dry matter accumulation was recorded by I_{75} at all growth stages which may be due to lower production of tiller with irrigation at 75% of CPE (Duary and Pramanik, 2019). Seed coating with $ZnSO_4$ recorded significantly higher dry matter production over soil application and foliar application of $ZnSO_4$. The irrigation regime at 100% and at 125% of CPE recorded significantly higher crop growth rate over irrigation regime at I_{75} at all the growth stages (Fig. 1 and 2). Higher CGR might be due to higher tiller production that reflected on dry matter production (Duary and Pramanik, 2019). Significantly higher crop growth rate was recorded with seed priming and seed coating over other methods of zinc. The treatment without zinc application recorded significantly lower crop growth rate over all the methods of zinc application. Because seed coating directly deliver precise quantity of zinc close to the germinating seed and enhance nutrient status within the vicinity of seed which helps early stages of growth and root development and therefore aids early crop establishment resulting in higher tillering and dry matter production (Adhikari *et al.*, 2016, Jatav and Singh 2018).

Table 1: Effect of irrigation regime and method of zinc application on number of tillers and dry matter production of aerobic rice (mean of two years)

Treatments	Number of tillers m^{-2}					Dry matter production (g m^{-2})				
	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS	30 DAS	45 DAS	60 DAS	75 DAS	90 DAS
Irrigation regimes										
I_1: Irrigation at 75% of CPE	287	316	359	334	313	121.1	225.9	391.3	581.3	723.9
I_2: Irrigation at 100% of CPE	353	385	433	410	391	140.1	264.6	473.5	773.5	951.4
I_3: Irrigation at 125% of CPE	353	409	434	416	397	142.0	259.7	470.3	750.9	944.8
SEm (±)	6	5	7	7	5	2.9	3.3	6.4	11.9	9.0
P=0.05	25	21	29	29	20	11.2	13.0	25.3	46.8	35.4
Method of zinc application										
Zn_1: Control	296	339	380	353	322	94.8	193.5	358.1	562.6	718.6
Zn_2: 20 kg $ZnSO_4$ ha^{-1} as soil	318	362	408	388	374	136.1	250.7	439.3	651.0	842.2
Zn_3: 0.5 % $ZnSO_4$ as spray	297	339	395	379	359	121.3	216.2	401.0	717.1	899.6
Zn_4: 0.3 % $ZnSO_4$ as seed priming	366	398	420	398	381	151.2	277.7	498.6	765.4	936.2
Zn_5: 1.2% $ZnSO_4$ as seed coating	377	410	440	416	398	168.6	312.2	528.1	813.3	970.4
SEm (±)	6	5	7	5	6	2.2	5.4	9.3	12.3	10.3
P=0.05	17	13	21	14	17	6.3	15.9	27.0	35.8	30.2

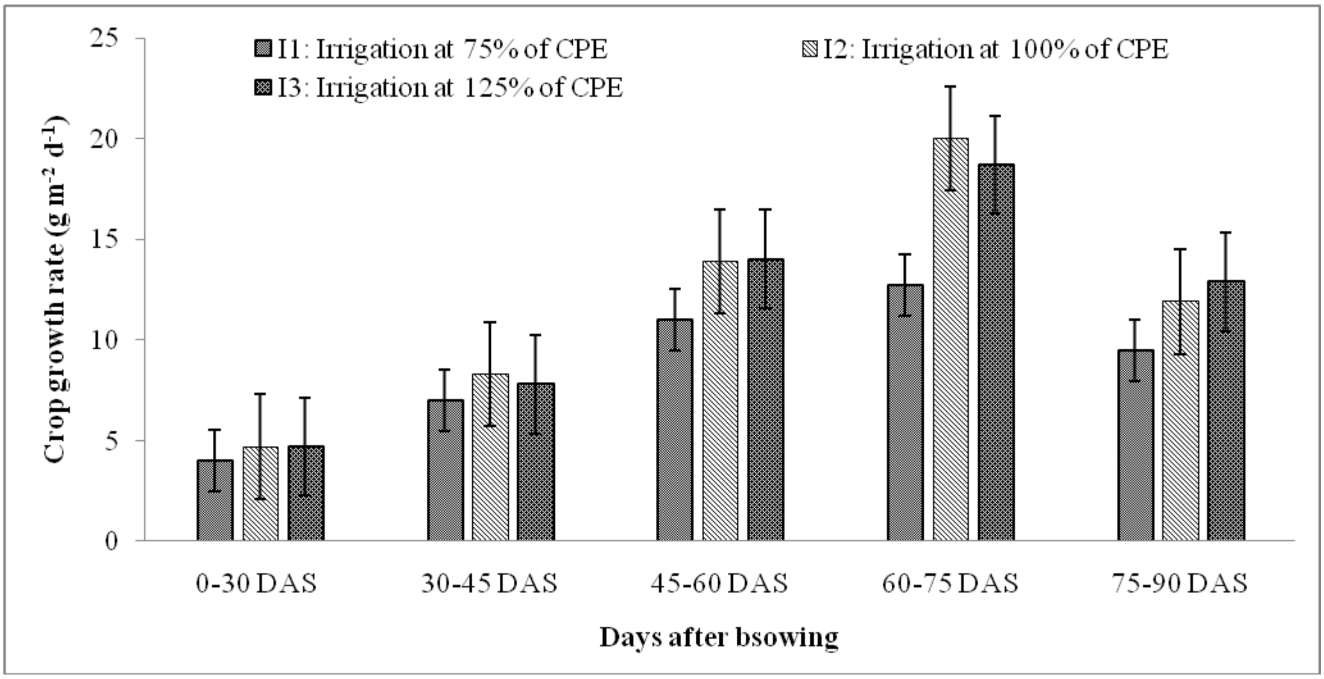

Fig. 1: Effect of irrigation regime on crop growth rate of aerobic rice at different growth stages (mean of two years)

Yield attributes

The number of ear bearing tillers m^{-2}, number of spikelets $panicle^{-1}$ and test weight were significantly higher with irrigation regime at 100% of CPE over irrigation regime at I_{75}but I_{100} was at par with I_{125} (Table 2). This was in accordance with the findings of Balamani *et al.*(2012). Similarly, higher test weight with I_{100} might be due to better availability of nutrients and their translocation which reflected increased test weight. The lower value of test weightunder irrigation regime at I_{75} might have hampered the supply of photosynthates from source to sink resulting in poor setting of poor filling of grains (Narolia *et al.*2014). The results indicated that different methods of Zn application significantly increased the number of ear bearing tillers, spikelets $panicle^{-1}$ and test weight compared with control (Table 2). The highest number of ear bearing tillers, spikelets panicle^{-1} and test weight were recorded with seed priming and seed coating and the minimum in control. Higher growth attributes particularly dry matter production and crop growth rate resulted in enhanced values of yield contributing characters (Ghoneim, 2016).

Table 2: Effect of irrigation regime and method of zinc application on yield attributes and yield of aerobic rice (mean of two years)

Treatments	Number of ear bearing tillers m^{-2}	No. of spikelets panicle^{-1}	Test weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})
Irrigation regimes					
I_1: Irrigation at 75% CPE	260	80.5	20.5	3223	4292
I_2: Irrigation at 100% CPE	313	91.8	22.3	4322	5310
I_3: Irrigation at 125% CPE	309	92.4	21.9	4429	5405
SEm (±)	1.6	1.4	0.29	87	155
LSD at 5%	6.1	5.4	1.13	341	608
Method of zinc application					
Zn_1: Control	256	93	20.1	3300	4543
Zn_2: 20 kg $ZnSO_4$ ha^{-1} as soil	291	99	20.5	3842	4640
Zn_3: 0.5 % $ZnSO_4$ as spray	297	102	21.6	4036	5301
Zn_4: 0.3 % $ZnSO_4$ as seed priming	309	107	22.3	4302	5098
Zn_5: 1.2% $ZnSO_4$ as seed coating	317	109	23.2	4475	5431
SEm (±)	2.2	1.28	0.34	66	165
LSD at 5%	6.3	3.75	0.98	191	482

Yield

The results indicated that the highest grain yield (4429 kg ha^{-1}) was recorded with I_{125} and the lowest grain yield (3223 kg ha^{-1}) was recorded with I_{75} (Table 2). The per cent increases in grain yield with I_{125} and I_{100} were 37.4 and 34.1 over I_{75}, respectively. The higher grain yield might be due to favourable situation for efficient water and nutrients uptake which boost their growth and yield attributes. These results corroborate with those of Mandal *et al.*(2013) and Duary and Pramanik (2019). Similarly, straw yield significantly increased with I_{125} and the lowest yield with I_{75} (Mukherjee and Pramanik, 2017). The grain yield ranged from 3300 kg ha^{-1} to 4475 kg ha^{-1} and straw from 4543 kg ha^{-1} to 5431 kg ha^{-1} due to zinc application. The highest grain (4475 kg ha^{-1}) and straw yield (5431 kg ha^{-1}) was found in the treatment receiving seed coating. The increase in yield was associated with increased panicle production, the number of spikelets and test weight (Table 2). Similar findings were also reported by Medhi (2015) and Farooq *et al.* (2018).

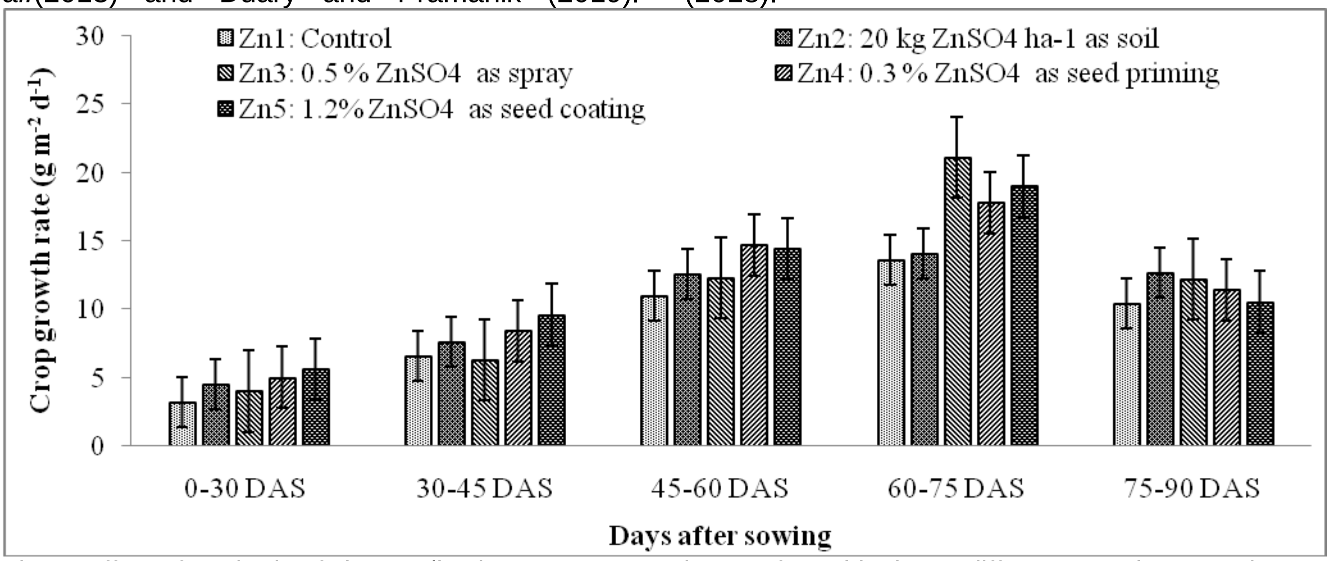

Fig. 2: Effect of methods of zinc application on crop growth rate of aerobic rice at different growth stages (mean of two years)

Nutrient content

The irrigation regime showed a significant influence on nitrogen, phosphorus, potassium and zinc content in grain and straw (Table 3). The irrigation at 100% of CPE recorded higher N, P, K and Zn content in grain and straw over 75% of CPE. Higher nutrient content in rice plants under 100% of CPE over 75% of CPE may be due to higher mobility of inorganic nutrient soil solution and hence facilitated absorption by plant roots. The results were in accordance with those of Tan *et al.* (2015) and Hanan *et al.* (2016). Aerobic rice seed coated with zinc sulphate, priming, soil application and foliar spray also recorded the highest nitrogen, phosphorus, potassium and zinc content in grain and straw and it was significantly greater than that of the crop grown under no zinc sulphate treatment. The higher nutrient content might be due to better growth of the crop as well as more availability of these nutrients to the plant under zinc sulphate.

Table 3: Nutrient content in grain and straw of aerobic rice as influenced by different irrigation regimes and method of zinc application (mean of two years)

Treatments	Nitrogen (%)		Phosphorus (%)		Potassium (%)		Zinc (mg kg^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
Irrigation regimes								
I_1: Irrigation at 75% of CPE	1.42	0.60	0.59	0.20	0.28	2.09	58.0	94.8
I_2: Irrigation at 100% of CPE	1.55	0.64	0.64	0.23	0.32	2.35	61.6	114.9
I_3: Irrigation at 125% of CPE	1.46	0.64	0.63	0.22	0.31	2.25	53.5	92.7
SEm (±)	0.009	0.007	0.008	0.005	0.007	0.041	1.52	3.50
P=0.05	0.036	0.028	0.033	0.019	0.028	0.159	5.97	13.74
Method of zinc application								
Zn_1: Control	1.31	0.60	0.58	0.20	0.26	1.96	53.6	93.7
Zn_2: 20 kg $ZnSO_4$ ha^{-1} as soil	1.46	0.62	0.60	0.21	0.27	2.17	56.8	102.0
Zn_3: 0.5 % $ZnSO_4$ as spray	1.46	0.62	0.62	0.21	0.29	2.19	56.3	98.2
Zn_4: 0.3 % $ZnSO_4$ as seed priming	1.56	0.65	0.65	0.23	0.35	2.39	59.4	102.0
Zn_5: 1.2% $ZnSO_4$ as seed coating	1.60	0.66	0.65	0.25	0.36	2.44	62.3	108.1
SEm (±)	0.012	0.007	0.008	0.006	0.007	0.040	1.52	1.78
P=0.05	0.036	0.019	0.025	0.016	0.022	0.117	4.42	5.20

The present study brings out that for higher yield of aerobic rice and nutrient content in grain and straw were recorded with irrigation at 100% of CPE and seed coating with zinc sulphate at 1.2 %. This package of practice may be recommended in sandy loam soil during summer season in West Bengal.

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