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Effect of irrigation regimes and seed soaking techniques on root growth and yield of rice

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ABSTRACT

A field experiment was conducted to study the effect of irrigation regimes and seed soaking techniques on root growth and yield of rice at Regional Research Station, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya during boro season of 2011 and 2012. The treatment consisted of three irrigation regimes in main plots viz., I_1: IW/CPE =1.0, I_2: IW/CPE =1.5 and I_3: IW/CPE = 2.0 and four treatments on soaking techniques in sub plots viz., P_1: Sprouted seeds, P_2: Dry seeds, P_3: Soaking seeds overnight (12 hrs) and P_4: Soaking seeds overnight (12 hrs) followed by shade drying. The field experiment was laid out in a split plot design with three replications. Statistically analysed data revealed that scheduling of irrigation at IW/CPE ratio of 2.0 produced higher root length, root weight and root volume and consequently the highest grain and straw yield than any other treatment tried. And among the different seed soaking techniques tested, higher root length, root weight and root volume was recorded at sprouted seeds which led to higher grain and straw yield. Gross return, net return and B: C ratio was found to be highest when scheduling of irrigation was done at IW/CPE ratio of 2 coupled with sprouted seeds.

Keywords: Irrigation regimes, rice, root, seed soaking

Water is the vital source for crop production. Agriculture consumes about 70% of the fresh water resource but less water is becoming available for irrigation owing to the global climate change and competition from urbanization and industrial development (Pennisi, 2008). Globally rice enjoys major share (34–43%) of irrigation water resource (Bouman *et al,* 2005). Since, more irrigated land is devoted to rice than to any other crops in the world, wastage of the resource in the rice field should be minimized (IRRI, 2003). Water-saving irrigation technologies can drastically diminish unproductive losses from seepage, percolation, and evaporation. Hence, application of irrigation water based on irrigation water and cummulative pan evaporation (IW/CPE) ratio has proved its feasibility over other methods due to application of water only when required. Improper crop stand combined with improper irrigation leads to serious loss in present agriculture. On the other hand, poor crop establishment is one of the major abiotic constraints encountered by resource poor farmers in marginal areas (Harris, 1992, 1996). Low cost on farm seed soaking make a positive impact on farmers' livelihoods by increasing the rate of crop emergence, thus increasing rates of crop development, reducing crop duration and raising yields. In this context, the present investigation was undertaken to find out the feasibility of scheduling of irrigation based on IW/CPE ratio in rice sown with seeds soaked for certain hours.

MATERIALS AND METHODS

The two years field experiment on rice was conducted in the dry *boro* season of 2011 and 2012 at Regional Research Station, Gayeshpur of Bidhan Chandra Krishi Viswavidyalaya to determine the effect of irrigation regimes and seed soaking techniques on root growth and yield of rice**.** Irrigation was provided based on irrigation water (IW) and CPE (cummulative pan evaporation). Five centimetre of irrigation water was provided in each irrigation. The treatment comprised of three irrigation regimes in main plots *viz*. IW/CPE =1.0, IW/CPE =1.5 and IW/CPE = 2.0 and four treatments on soaking techniques in sub plots *viz*. P_1: Sprouted seeds, P_2: Dry seed, P_3: Soaking seeds overnight (12 hrs), P_4: Soaking seeds overnight (12 hrs) followed by shade drying. The experiment was laid out in split plot design with each treatment combination replicated thrice in plots of size of 4 m × 3 m. Rice variety Satabdi (IET-4786) was sown on 17th February in 2011 and 27th February in 2012 after proper land preparation. Sowing was done using drum seeder maintaining a spacing of 20 cm row to row and 15 cm plant to plant. FYM @ 5 t ha^{-1} was applied 15 days before sowing the crop. Half of N and full dose of P and K were applied in the form of urea, SSP and MOP respectively as basal. The rest half of Nitrogen was divided into two equal part and top

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dressed at 30 days and 60 days after sowing. Weeding and thinning were done at regular interval. Observation on root volume, root length and root weight were recorded at harvest from five representative samples from each plot. The soil column for each hill was cut into 20 cm sections. The root mass of each section was washed carefully. Fresh root samples per hill were taken for measuring root volume using volume displacement methods of water in a measuring cylinder. The sample is then dried with tissue paper for root length measurement. Root length were analysed with commercial software (WinRHIZO v. 2009b; Regent Instruments, Montreal, QC, Canada). After measurement of root length, the sample is oven dried at 70 °C for 72 hrs and weighed for root dry weight. The yield plot^{-1} was recorded from plant sample in an area of 1 m × 4 m area and later converted it to t ha^{-1}. The data were analysed statistically. The treatment comparisons were made using t - test at 5% level of significance. The economics was calculated on the basis of prevailing local market price of rice grains and cost of inputs.

RESULTS AND DISCUSSION

Root characters

Data on root study are summarized in table -1. Different regimes of irrigation showed significant impact on root length. Significantly higher root length of 24.00 cm was recorded when irrigation was scheduled at IW/CPE of 2.0 followed by irrigation regime IW/CPE of 1.5 with a root length of 22.24 cm. Least root length of 21.04 cm was recorded when irrigation was applied at IW/CPE of 1.0. It is, thus, evident from the result that in order to achieve proper length, root zone of a plant must be well supplied with water. Regarding seed soaking techniques, sprouted seeds proved its superiority by showing a root lenth of 24.24 cm which is followed significantly by the treatment where seeds are soaked overnight followed by shade drying (22.70 cm). The lowest root length of 20.98 cm among the soaking techniques was observed at non-sprouted dry seeds. Similar effects of increasing root length in seeds soaked for 48 hrs (sprouted seeds) were also observed in other crops under aerated conditions as in sorghum (Tiryaki and Buyukcingil, 2009).

Perusal of root volume data clearly illustrated that root volume was significantly influenced by different irrigation regimes and seed soaking techniques. Significantly higher root volume of 12.72 cc hill^{-1} was recorded with IW/CPE of 2.0 as compared with IW/CPE of 1.5 level of irrigation (11.76 cc hill^{-1}). Decreased in root volume under IW/CPE = 1.0 might be due to that root volume generally decreases under soil water deficit causing further reduction in Kpa under drought stress (Cruz *et al.,* 1992; Matsuo *et al*., 2009). Among the various seed soaking techniques tested, maximum root volume of 12.59 cc hill^{-1} was observed with sprouted seed and the minimum of 11.37 cc hill^{-1} with non sprouted dry seed. Adequate moisture coupled with suitable soaking technique might have resulted in higher root proliferation. Harris (1992) reported the similar result and demonstrated that seeds that germinated and emerged fastest grew most vigorously and produce deep root systems and higher volume of roots before the upper layers of the soil dried out, hardened or became dangerously hot.

It is obvious from the data presented in table -1 that application of irrigation at IW/CPE of 2.0 resulted in higher value of root weight (121.95 g per m^{-2}) whereas minimum value of 113.22 g per m^{-2} was recorded when irrigation was scheduled at IW/CPE of 1.0. The smaller quantity of roots in a drier soil (IW/CPE =1.0) agrees with the earlier observation made by Stevenson and Laidlaw (1985). The increase in root weight at IW/CPE = 2.0 irrigation regime might be because of maximum water content in tissue which increases turgidity necessary for cell enlargement. Pooled data on seed soaking techniques revealed that sprouted seeds give better root weight (124.05 g per m^{-2}) whereas the least is observed in case of dry seeds (107.99 g per m^{-2}). The effect of interaction between irrigation regimes and seed soaking techniques on root characters was found to be significant. Maximum root length (25.74 cm), root volume (13.80 cc hill^{-1}) and root weight (131.67 per m^{-2}) were recorded in the plots where sprouted seeds was grown with irrigation scheduled at IW/CPE of 2.0 whereas minimum was recorded in dry seeds coupled with IW/CPE of 1.0.

Yield

Data pertaining to yield are presented in table- 2. A close scrutiny of this table revealed that grain yield (4.13 t ha^{-1}) and straw yield (5.84 t ha^{-1}) was better at IW/CPE of 2.0 than any other treatment tested. It was apparent that all root parameters played an important role in deciding the grain yield as well as straw yield of rice and was influenced significantly by both irrigation levels and seed soaking techniques. The lowest stature of grain yield and straw yield was noticed with irrigation scheduled at IW/CPE ratio of 1.0. Similar findings were reported by Belder *et al.* (2005). Zaman *et al.* (2005) also observed lower rice grain yield (cv. IR-36) under limited supply of irrigation water in an Entisol soil of West Bengal. Ghosh *et al.* (2014) also reported that limited supply of irrigation water at different stages of growth decreased grain yield.

The maximum grain yield among soaking techniques was recorded with sprouted seeds (4.16 t ha^{-1}) followed significantly by soaking seeds overnight (12 hrs) followed by shade drying (3.69 t ha^{-1}) and the minimum with dry seeds (3.14 t ha^{-1}). Same trend was followed in case of straw yield also. Sprouted seeds was found significantly superior in case of straw yield (5.85 t ha^{-1}) which was followed significantly by soaking seeds overnight (12 hrs) followed by shade drying (5.53 t ha^{-1}). Lowest was observed in case of dry seeds (5.08 t ha^{-1}). Similar finding are reported by many researchers namely Harris *et al.*, 2002, Thakur *et al.* (2005), Yari *et al.* (2011).

The maximum harvest index was recorded with IW/CPE of 2.0 (41.39 %) and the minimum with IW/CPE of 1.0 (36.91%). Xue *et al.* (2008) reported highest yields of aerobic rice (IW/CPE = 2.0) coincided with high harvest index.

Table 1: Effect of irrigation regimes and soaking techniques on root characters of rice

Treatment	Root length (cm)			Root volume (cc $hill^{-1}$)			Root weight (g m^{-2})		
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled
Moisture regimes									
I_1	20.67	21.40	21.04	10.87	11.17	11.02	112.27	114.16	113.22
I_2	21.19	23.29	22.24	11.42	12.09	11.76	113.04	118.84	115.94
I_3	23.46	24.55	24.00	12.53	12.92	12.72	123.30	120.61	121.95
SEm(±)	**0.26**	**0.22**	**0.17**	**0.31**	**0.21**	**0.19**	**0.81**	**0.29**	**0.43**
LSD (0.05)	**1.02**	**0.85**	**0.55**	**1.23**	**0.82**	**0.61**	**3.17**	**1.12**	**1.40**
Planting techniques									
P_1	24.04	24.45	24.24	12.16	13.01	12.59	121.04	127.06	124.05
P_2	20.25	21.71	20.98	11.42	11.32	11.37	107.88	108.11	107.99
P_3	21.23	22.33	21.78	11.32	11.72	11.52	114.93	115.98	115.46
P_4	21.57	23.83	22.70	11.52	12.20	11.86	120.96	120.34	120.65
SEm(±)	**0.31**	**0.28**	**0.21**	**0.13**	**0.18**	**0.11**	**1.16**	**0.83**	**0.71**
LSD (0.05)	**0.92**	**0.83**	**0.60**	**0.38**	**0.53**	**0.31**	**3.46**	**2.46**	**2.05**
Interaction effects									
I_1P_1	22.61	23.61	23.11	10.86	12.37	11.61	123.83	122.57	123.20
I_1P_2	18.93	19.30	19.12	10.66	10.33	10.50	102.20	103.23	102.72
I_1P_3	19.50	19.33	19.42	10.93	10.56	10.75	109.50	111.48	110.49
I_1P_4	21.65	23.34	22.50	11.01	11.43	11.22	113.56	119.36	116.46
I_2P_1	23.27	24.49	23.88	12.04	12.64	12.34	107.63	126.94	117.29
I_2P_2	20.37	22.22	21.29	11.64	11.87	11.76	106.49	108.42	107.46
I_2P_3	21.43	22.82	22.13	10.80	12.18	11.49	114.87	115.01	114.94
I_2P_4	19.68	23.64	21.66	11.20	11.67	11.43	123.17	125.00	124.08
I_3P_1	26.24	25.23	25.74	13.60	14.01	13.80	131.67	131.67	131.67
I_3P_2	21.44	23.60	22.52	11.97	11.74	11.86	114.93	112.67	113.80
I_3P_3	22.76	24.84	23.80	12.21	12.43	12.32	120.43	121.43	120.93
I_3P_4	23.40	24.52	23.96	12.33	13.50	12.92	126.17	116.67	121.42
I X P SEm(±)	**0.54**	**0.49**	**0.36**	**0.22**	**0.31**	**0.19**	**2.02**	**1.44**	**1.24**
LSD (0.05)	**1.60**	**1.44**	**1.04**	**0.66**	**0.91**	**0.54**	**5.99**	**4.26**	**3.55**
I X P SEm(±)	**0.53**	**0.47**	**0.36**	**0.37**	**0.34**	**0.25**	**1.92**	**1.28**	**1.15**
LSD (0.05)	**1.70**	**1.50**	**1.14**	**1.34**	**1.13**	**0.81**	**6.04**	**3.85**	**3.64**

I_1: IW/CPE =1.0, I_2: IW/CPE =1.5 and I_3: IW/CPE = 2.0, P_1: Sprouted seeds, P_2: Dry seeds, P_3: Soaking seeds overnight (12 hrs), P_4: Soaking seeds overnight (12 hrs) followed by shade drying.

Table 2: Effect of irrigation regimes and soaking techniques on yield of rice

Treatment	Grain yield (t ha^{-1})			Straw yield (t ha^{-1})			Harvest Index (%)		
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	Pooled
Moisture regimes									
I_1	2.93	3.08	3.00	5.02	5.23	5.12	36.74	37.07	36.91
I_2	3.46	3.61	3.54	5.29	5.42	5.35	39.40	39.90	39.65
I_3	4.00	4.26	4.13	5.73	5.96	5.84	40.94	41.39	41.16
SEm(±)	**0.06**	**0.04**	**0.04**	**0.09**	**0.09**	**0.06**	**0.39**	**0.47**	**0.30**
LSD (0.05)	**0.25**	**0.14**	**0.12**	**0.34**	**0.35**	**0.20**	**1.52**	**1.83**	**0.99**
Planting techniques									
P_1	4.07	4.25	4.16	5.70	6.00	5.85	41.43	41.04	41.23
P_2	3.03	3.24	3.14	5.01	5.14	5.08	37.65	38.65	38.15
P_3	3.30	3.34	3.32	5.22	5.38	5.30	38.61	38.23	38.42
P_4	3.45	3.76	3.60	5.44	5.61	5.53	38.42	39.89	39.15
SEm(±)	**0.08**	**0.08**	**0.06**	**0.06**	**0.07**	**0.05**	**0.55**	**0.56**	**0.39**
LSD (0.05)	**0.23**	**0.24**	**0.16**	**0.18**	**0.20**	**0.13**	**1.64**	**1.65**	**1.12**
Interaction effects									
I_1P_1	3.30	3.23	3.27	39.02	37.01	38.01	39.02	37.01	38.01
I_1P_2	2.60	3.00	2.80	35.45	37.65	36.55	35.45	37.65	36.55
I_1P_3	3.13	3.07	3.10	38.23	36.64	37.43	38.23	36.64	37.43
I_1P_4	2.67	3.00	2.83	34.28	36.96	35.62	34.28	36.96	35.62
I_2P_1	4.17	4.19	4.18	41.17	41.34	41.26	41.17	41.34	41.26
I_2P_2	3.30	3.40	3.35	40.75	39.98	40.36	40.75	39.98	40.36
I_2P_3	2.93	3.07	3.00	36.82	37.56	37.19	36.82	37.56	37.19
I_2P_4	3.43	3.80	3.62	38.84	40.72	39.78	38.84	40.72	39.78
I_3P_1	4.73	5.33	5.03	44.09	44.77	44.43	44.09	44.77	44.43
I_3P_2	3.20	3.33	3.27	36.75	38.32	37.54	36.75	38.32	37.54
I_3P_3	3.83	3.90	3.87	40.78	40.49	40.63	40.78	40.49	40.63
I_3P_4	4.25	4.47	4.36	42.13	41.99	42.06	42.13	41.99	42.06
I X P SEm(±)	**0.13**	**0.14**	**0.10**	**0.96**	**0.96**	**0.68**	**0.96**	**0.96**	**0.68**
LSD (0.05)	**0.39**	**0.41**	**0.27**	**2.84**	**2.86**	**1.95**	**2.84**	**2.86**	**1.95**
P X I SEm(±)	**0.13**	**0.12**	**0.09**	**0.91**	**0.95**	**0.66**	**0.91**	**0.95**	**0.66**
LSD (0.05)	**0.42**	**0.38**	**0.29**	**2.87**	**3.05**	**2.09**	**2.87**	**3.05**	**2.09**

I_1: IW/CPE =1.0, I_2: IW/CPE =1.5 and I_3: IW/CPE = 2.0, P_1: Sprouted seeds, P_2: Dry seeds, P_3: Soaking seeds overnight (12 hrs), P_4: Soaking seeds overnight (12 hrs) followed by shade drying

Table 3: Economics of rice as influenced by irrigation regimes and soaking techniques on rice (Pooled)

Treatment	Cost involved (₹)	Gross return (₹)	Net return (₹)	B:C Ratio
I_1P_1	33227.50	42933.34	9705.84	1.29
I_1P_2	33227.50	36997.34	3769.84	1.12
I_1P_3	33227.50	40828.34	7600.84	1.23
I_1P_4	33227.50	37581.67	4354.165	1.13
I_2P_1	34352.50	54273.33	19920.83	1.58
I_2P_2	34352.50	43665.00	9312.50	1.27
I_2P_3	34352.50	39546.67	5194.17	1.15
I_2P_4	34352.50	47226.67	12874.17	1.38
I_3P_1	35702.50	64798.34	29095.84	1.82
I_3P_2	35702.50	43003.34	7300.84	1.21
I_3P_3	35702.50	50355.00	14652.50	1.42
I_3P_4	35702.50	56500.00	20797.50	1.58

Considering seed soaking techniques, sprouted seeds were found superior (41.23 %) among all the seed soaking techniques tested. Use of sprouted seeds with irrigation scheduled at IW/CPE of 2.0 resulted in highest grain yield (5.03 t ha^{-1}), straw yield (44.43 t ha^{-1}) and harvest index (44.43 %) whereas lesser value was registered under dry seeds with irrigation regimes of IW/CPE of 1.0.

Considering the economic returns (gross return, net return and B: C ratio) irrigating the rice crop at IW/CPE of 2.0 using sprouted seeds was recorded to be best treatments (Table 3).

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