

Effect of planting methods, irrigation regimes and soil adjuvant on yield attributes, yield, nutrient uptake and economics in aerobic rice (*Oryza sativa*) in eastern India

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ABSTRACT

A field experiment was carried out in the rice (*Oryza sativa* L.) dominated area of eastern plateau and hill region of India during *kharif* 2016 to study the effect of irrigation schedules, planting methods and soil adjuvant on yield attributes, water-use efficiency (WUE), economics and nutrient uptake in aerobic rice. The experiment was laid-out in a three-time replicated split-plot design, keeping combinations of 4-irrigation schedules, viz., irrigation at 0.9, 1.2, 1.5 IW:CPE (irrigation water requirement: cumulative pan evaporation) ratio and no-irrigation (rainfed), and 2-soil adjuvants (soil adjuvant applied and no-soil adjuvant) in the main-plots and 2-planting methods—conventional dry seeding at 20 cm row spacing and spot-sowing (dibbling of 4-seeds per hill at 20 × 15 cm), in the sub-plots. Irrigation at 1.5 IW:CPE ratio recorded greater magnitude of all yield attributes like panicles/m², field grains/panicle and 1,000-grain weight and enhanced grain yield by 37.3% over rainfed crop, 23% over crop irrigated at IW:CPE ratio 0.9 and 13.5% over IW:CPE ratio 1.2. This irrigation schedule also resulted in the highest net return. However, WUE (water use efficiency) was highest with irrigation at IW:CPE 1.2. Spot-planting significantly improved yield attributes, yield, WUE, net return and nutrient uptake over conventional planting. The increase in grain yield and net returns due to spot-planting was more than 7%.

Key words: Aerobic rice, IW:CPE ratio, Nutrient uptake, Soil adjuvant, Spot planting, Water-use efficiency

Aerobic rice is a production system wherein specially developed aerobic rice varieties are grown in well-drained, non-puddled and non-saturated soils. With appropriate management, the system aims at achieving grain yields that are at least 4–6 t/ha (Kumar *et al.*, 2016). Aerobic rice has been considered as the sustainable rice production methodology for the immediate future to address the issues of growing water scarcity and environmental pollution, in the scenario of global warming. Raj *et al.* (2017) reported 20.5% water saving in aerobic rice compared to transplanted rice in Samastipur region of Bihar.

Jharkhand state has substantial area under rainfed/semi-dry conditions. The climate is warm and humid with

mean maximum and minimum temperature of 31.4°C and 13.7°C, respectively, and the state has a vast scope of growing aerobic rice. The maximum and minimum relative humidity is 67.4% and 36.3%, respectively. The normal rainfall of the district is 1084 mm, June to September are usual monsoon months accounting for 79% of the total rainfall. Although aerobic rice has been shown to use less quantity of water than transplanted rice, but declining irrigation water availability, low water retention in root zone soil and associated occurrence of nutrient deficiencies, and consequent low yields necessitate further optimization of irrigation water-use. Thus, suitable irrigation management practices need to be developed for aerobic rice cultivation to further improve productivity and water-use efficiency (WUE). Moreover, modifying the properties of irrigation water itself can increase water holding capacity (WHC) of soil that helps absorb greater amounts of water and retain it for a longer period; this can be achieved by the use of surfactants that increase the speed of water penetration into the soil and reduce water loss through evaporation. Apart from irrigation management, proper spacing and method of planting can maintain the optimum

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plant population and favourably influence the growth of plants. Several workers have reported that maintenance of a critical level of rice plant population in field was essential to maximize grain yields. Reliable information on potential of aerobic rice, planting methods, water-efficient management options is lacking for the study region. With this back drop, the present study was undertaken to assess the effect of planting methods, irrigation regimes and soil adjuvant on yield attributes, yield, total NPK uptake, economics and WUE of aerobic rice in eastern India.

The field experiment was conducted at Central Rainfed Upland Rice Research Station (CRURRS), Hazaribagh (23°56'34" N and 85°21'46" E and 614 m above mean sea level), Jharkhand. Soil of the experimental field was clay loam in texture, categorised as medium in organic C, low in available N, medium in available P and high in available K. Soil reaction was in neutral range (pH 6.8). Field capacity and permanent wilting point moisture content of soil was 28.72 and 14.87%, respectively. Total rainfall during crop period was 1237 mm which was higher than normal rainfall (1084 mm) of the region. The experiment was laid-out in split-plot design keeping combinations of 4-irrigation schedules, viz. irrigation at 0.9, 1.2, 1.5 IW:CPE ratio and no-irrigation (rainfed), and 2-soil adjuvants (soil adjuvant applied and no-soil adjuvant) in the main-plots and 2-planting methods—conventional dry seeding at 20 cm row spacing and spot-sowing (dibbling of 4-

seeds per hill at 20 × 15 cm), in the sub-plots. Thus there were a total of 16 treatment combinations. Sahabhagi Dhan, a drought tolerant variety, was sown using seed rate of 60 kg/ha in conventional drilling and 30 kg/ha in spot planting method. The crop was uniformly fertilized with 120 kg N, 60 kg P₂O₅, and 30 kg K₂O/ha. Nitrogen was supplied through N-containing fertilizers, urea and diammonium phosphate (DAP). Phosphorus and potassium were supplied through DAP and muriate of potash, respectively. A pre-emergence application of pendimethalin @ 1.0 kg/ha followed by post-emergence application of bispyribac-Na @ 0.025 kg/ha was done for managing weeds. For computing different levels of IW:CPE ratio (0.9, 1.2 and 1.5), IW (irrigation water requirement) was kept constant at 50 mm. Once the CPE (cumulative pan evaporation) reached to a level that would result in desired IW:CPE ratio, irrigation was applied. Irrigations were delayed when sufficient rainfall occurred. Numbers of irrigations were 8 for 1.5 IW:CPE, 4 for 1.2 and 3 for 0.9. Soil adjuvant (APSA 80™) was applied on soil surface twice @ 450 ml/ha dissolved in 500 litres of water, once at tillering stage and subsequently at panicle emergence stage.

Results showed that yield attributing characters, viz., panicles/m², filled grains/panicle and 1,000-grain weight, were significantly affected by the irrigation schedules (Table 1). The highest number of panicle/m², filled grains/

Table 1. Effect of planting methods, irrigation regimes and soil adjuvant on yield attributes, yield, nutrient uptake, economics and water-use efficiency in aerobic rice

Treatment	Panicles/ m ²	1,000- grain (g)	Filled grains/ panicle	Grain yield (t/ha)	Straw yield (t/ha)	Total N uptake (kg/ha)	Total P uptake (kg/ha)	Total K uptake (kg/ha)	Cost of cultivation (×10 ³ ₹/ha)	Net returns (×10 ³ ₹/ha)	Water-use efficiency (kg/ha- mm)
<i>Irrigation (IW:CPE ratio)</i>											
0.9	238	22.4	93	3.35	5.98	64.7	10.1	98.4	30.57	36.7	3.23
1.2	256	22.5	98	3.63	6.10	73.0	11.4	105.2	31.37	40.7	3.37
1.5	280	23.2	104	4.12	6.41	85.6	13.4	121.6	34.55	46.2	3.29
Rainfed	218	21.5	84	3.00	5.72	62.1	9.5	96.1	28.19	32.8	3.35
SEM±	6.5	0.40	2.5	0.10	0.13	1.74	0.26	2.86	–	1.65	0.09
CD (P=0.05)	19.5	NS	7.7	0.30	0.40	5.28	0.78	8.67	–	5.03	NS
<i>Soil adjuvant (Twice @ 450 ml/ha)</i>											
A ₁	252	22.5	97	3.55	6.08	72.0	11.3	106.1	31.70	39.0	3.33
A ₂	244	22.3	92	3.50	6.03	70.7	11.0	104.5	30.65	39.2	3.29
SEM±	4.6	0.29	1.80	0.07	0.09	1.23	0.18	2.02	–	1.173	0.06
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	–	NS	NS
<i>Planting method</i>											
P ₁	241	22.3	91	3.41	5.99	69.3	10.7	102.9	30.46	37.8	3.20
P ₂	255	22.5	99	3.64	6.12	73.4	11.5	107.8	31.88	40.5	3.42
SEM±	3.73	0.18	1.7	0.05	0.06	0.96	0.15	1.46	–	0.74	0.05
CD (P=0.05)	11.2	NS	5.0	0.15	NS	2.88	0.45	4.37	–	2.22	0.16

NS, non-significant; A₁, Soil adjuvant applied; A₂, no-soil adjuvant; P₁, Conventional dry seeding at 20 cm row spacing; P₂, dibbling of 4 - seeds per hill at 20 cm × 15 cm spacing

panicle and 1,000-grain weight were observed with irrigations applied at IW:CPE ratio 1.5. These characteristics did not differ significantly between 0.9 and 1.2 IW:CPE ratio, though numerically higher values were recorded in IW:CPE ratio 1.2. Due to moisture stress, the lowest values of all yield attributing characters were observed in rainfed crop. Similar findings were also reported by Dari *et al.* (2016). The effect of soil adjuvant on yield attributes was non-significant. Spot-sowing method resulted in significantly higher number of panicles/m² with significantly heavier panicles over conventional drilling of seeds. Filled grains and 1,000-grain weight were higher in spot-planting over conventional planting. This might be due to higher availability of nutrients, light and moisture to the crop plants that led to vigorous growth, less competition for nutrients, light and moisture between the plants due to less plant population in spot-sowing method than the conventional dry seeding at 20 cm row spacing.

The highest uptake of N, P and K was recorded with irrigations scheduled at 1.5 IW:CPE ratio followed by irrigation scheduled at 1.2 and 0.9 IW:CPE ratios. The lowest N-P-K-uptakes were observed in rainfed crop. Frequent irrigations under IW:CPE ratio 1.5 and 1.2, created favourable soil moisture regimes resulting in a larger and healthy root system (Dass *et al.*, 2016), increased availability and efficient absorption from the soil and transport of nutrients from roots to shoots and grains, which ultimately improved growth and yield of rice. Higher overall nutrient uptake under wetter irrigation regimes resulted from higher contents of nutrients in grain and straw, and higher grain and straw yields (Dass and Chandra, 2013). Grain yield resulting from irrigations at IW:CPE ratio 1.5 was 37.3% higher over rainfed crop, 23% over crop irrigated at IW:CPE ratio 0.9 and 13.5% over IW:CPE ratio 1.2. The effect of soil adjuvant on nutrient uptake and yield was non-significant. Between planting methods, spot planting significantly improved all N, P and K uptakes compared to conventional planting, and hence the grain and straw yields. Higher yields and greater accumulation of nutrient in wider planted spot-sowing method might be due to a well-developed root system and less competition among plants for the nutrients because under wider-spacing larger soil volume was available to roots to explore for nutrients (Avasthe *et al.*, 2012 and Dass *et al.*, 2017).

The cost of cultivation was highest when irrigations were scheduled at 1.5 IW:CPE ratio (₹34.55 × 10³/ha) and lowest in rainfed treatment. Between two planting methods, spot-sowing involved higher cost of cultivation (₹31.88 × 10³/ha), which was 5% higher than conventional

planting. However, a significant enhancement in grain yield led to about 7% increase in net returns in spot-planting. Similarly, a higher yield produced by crop irrigated at IW:CPE 1.5 led to significantly higher net return from this irrigation schedule. Soil adjuvant did not affect net returns significantly. WUE did not differ significantly among the irrigation treatments, however the highest WUE (3.37 kg/ha-mm) was recorded with irrigations at IW:CPE 1.2, which was very near to WUE of rainfed crop (3.35 kg/ha-mm). The lowest WUE was recorded in IW:CPE ratio 0.9 (3.23 kg/ha-mm). Effect of soil adjuvant application was not significant for WUE. Planting methods significantly affected the WUE and spot-sowing method resulted in significantly higher WUE (3.42 kg/ha-mm) in aerobic rice.

Results of this study demonstrates that spot planting (sowing of 4 seeds per hill at 20 × 15 cm interval) and irrigation at IW:CPE ratio 1.5 resulted in higher yield attributes, yield, nutrient uptake, economics and WUE in aerobic rice in eastern India.

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