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Impact of Water Management and Crop Establishment Methods on Growth and Qualitative Characters of Rice (*Oryza sativa* L.)

Kartikeya Choudhary[1*], V.K. Srivastava[2], U.P. Singh[2], Anoop Kumar Devedee[1] and Ashvin Kumar Meena[1]
[1]Research Scholar, Department of Agronomy,
Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.)-221005, India.
[2]Professor, Department of Agronomy,
Institute of Agricultural Sciences, Banaras Hindu University, Varanasi (U.P.)-221005, India.

(Corresponding author: Kartikeya Choudhary [*])
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ABSTRACT: Water conservation is an integral part of precision agriculture. In rice (*Oryza sativa* L.) producing countries, the looming water crisis necessitates the development of water-saving technologies. Therefore, a field experiment was conducted to study the effect of water management and crop establishment practices on growth and quality of rice during two consecutive *kharif* seasons of years 2018 and 2019, respectively. The experiment was laid out in split plot design with three water management practices in main plot *viz*. flooding throughout crop growth (5±2 cm), saturation maintenance upto PI and flooding (5±2 cm) after PI (Panicle initiation), alternate wetting and drying upto PI and flooding (5±2 cm) after PI and five establishment methods in sub plots *viz.* conventional transplanting, wet seeding on puddled soil (broadcasting), wet seeding on puddled soil (Drum seeder), dry seeding (Broadcasting) anddry seeding (Line sowing). The results reported that the higher growth parameters *viz*. plant height, number of tillers and dry matter accumulation were recorded under alternate wetting and drying upto PI and flooding (5±2) after PI. However it was statistically at par with saturation maintenance upto PI and flooding (5±2) after PI during both the experimental years. Among the crop establishment methods, conventional transplanting recorded higher growth parameters which were at par with wet seeding on puddled soil (Drum seeder). Quality characters were failed to show any significant effect due to above treatments.

Keywords: Alternate wetting and drying, broadcasting, drum seeder, efficiency.

INTRODUCTION

Rice (*Oryza sativa* L.) is a staple food for more than 60 per cent of the world's population has grown by about 112 countries on nearly every continent and it had to 2,500 million people in developing nations, particularly in Asia (90%) and the rest (10%) in south America, Africa, Australia and Europe. It has been estimated that in order to meet the global demand for rice or approximately 114 million extra tonnes of milled rice production by 2035, representing an increase of 26% over the next 25 years (Kumar and Ladha, 2011). The possibility of the extension of the area under rice in the near future is limited. Therefore, this extra rice production has to come by increase in productivity. Productivity of rice is becoming either stagnated or reduced in India due to various reasons like improper establishment methods, water scarcity, weed infestation, unpredictable monsoon seasons, poor quality seeds, over irrigation and over fertilization and soil become less fertile etc.

Water shortage has a critical impact on the world's food self-sufficiency and security (FAO, 2016). Therefore, it is necessary to respond to the growing demand for rice, with limited resources, it may be necessary to increase the productivity per unit of surface area, with less and less water. This is a new water scarcity challenges in the step-up of the alternative for irrigation of rice production systems that require less water than traditional flooded rice (Livsey *et al.*, 2019). The challenge of sustainability in rice production is the reduction of the amount of water available during the maintenance or the increase in the grain yield and to meet the needs of a growing population through improved water-use efficiency (Kang *et al*., 2017).

Alternate wetting and drying (AWD) irrigation is water saving technique in rice production and is an important strategy under climate change scenario where water scarcity may become more prevalent (Hiya *et al*., 2020). It can contribute to agricultural sustainability by reducing water use in irrigated rice by 15-30% (Zhang *et al.*, 2009), increasing rice yield by approximately 10% relative to continuous flooding (Zhang *et al*., 2009; Richards and Sander, 2014).Due to the increasing water scarcity in many parts of India, there has been a downward trend in the water requirement for rice, in which the alternative to rice cultivation methods, aiming at a minimal use of water and high productivity. Each of the approaches that could reduce water consumption without compromising on rice cultivation would certainly be a desirable strategy.

Direct wet seeding by drum seeder can gave 22% higher grain yield and growth of up to 10 days earlier than that of the conventional transplant in (Husain *et al*., 2004). While some researcher reported less crop yield compared to transplanted rice method. Dry direct seeded rice is an alternative cropping technique usually practiced for rainfed and deep water ecosystems that require less water, save labour demand, increase resource use efficiency and improve environmental sustainability than conventional transplanted flooded rice. In this method sowing will be done in dry soil surface, then incorporates the seed by ploughing or harrowing (Liu *et al*., 2015). In such circumstances, direct wet seeding comprising of drum seeding, broadcasting of either dry or sprouted seeds under puddled condition and direct dry seeding under unpuddled condition may be an alternative to transplanting in boosting the rice production. Wet seeding involves sowing of pre-germinated seeds in wet (saturated) puddled soils. As the seeds are sown directly, the dry and wet-seeding methods are often jointly referred to as direct seeding methods. Direct seeding of rice under wet and dry conditions are the alternatives to replace traditional transplanting method. Direct-seeded rice (DSR) methods not only save irrigation water but also help in reducing the cost of cultivation. It also increased the fertilizer and energy use efficiency with early maturity. Direct-seeded rice saves water up to 13 % (Mann *et al*., 2004), labour cost by 50 % (Pandey and Velasco, 1999) and is conducive for mechanization (Khade *et al.,* 1993) over transplanted crop.

However, information regarding water management and crop establishment methods in rice production in Uttar Pradesh is lacking. Keeping in view the above discussed facts of sufficient information and sparce related research, the present investigation was undertaken to find out the effect of crop establishment and water management practices on growth of rice in Varanasi conditions.

MATERIAL AND METHODS

The experiment was conducted during two consecutive *kharif* seasons of years 2018 and 2019, respectively at Agricultural Research Farm, Institute of Agricultural Sciences, Banaras Hindu University, situated at latitude of 25^o 18' North and longitude of 83^o 03' East, with altitude of 128.93 meters above the mean sea level. The total rainfall of 744.4 and 1113.7 mm were received during crop growing season of year, 2018 and 2019, respectively. Soil of the experiment field had sandy loam in texture, slightly alkaline in reaction, low in electrical conductivity, low in organic carbon, available nitrogen and medium in available phosphorus and potassium.

The experiment was laid out in Split Plot Design with three water management practices in main plots *viz*, flooding throughout crop growth (5±2 cm), saturation maintenance upto PI and flooding (5±2 cm) after PI (Panicle initiation), alternate wetting and drying upto PI and flooding (5±2 cm) after PI and five establishment methods in sub plots *viz.* conventional transplanting, wet seeding on puddled soil (broadcasting), wet seeding on puddled soil (Drum seeder), dry seeding (Broadcasting) and dry seeding (Line sowing). Each main plot was surrounded by a buffer of 1.5 m width whereas subplot was surrounded by 0.5 m width to protect the plots from accidental irrigation and gain of water through seepage. The volume of irrigation water was calculated as per treatments by using Parshall flume. The treatments were replicated three times. The recommended dose of fertilizers (120:60:60:5 kg N:P:K:Zn ha^{-1}) were applied through prilled urea for nitrogen, di-ammonium phosphate for phosphorus, muriate of potash for potash and zinc sulphate monohydrate for zinc. Full di-ammonium phosphate, potash and 1/3 part of urea were applied at the time of direct seeding/transplanting by broadcasting and 2/3 part of prilled urea and full zinc was broadcasted in the three equal splits after sowing. Rice variety “HUR 4-3” were used for the investigations which was developed from BHU and matures in 135-140 days. Kernel length and breadth (mm) before and after cooking was measure with graph paper method. However, elongation ration, expansion ratio and elongation index was calculated by the methods suggested by Juliano and Perez, 1984.The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by “F” test (Gomez and Gomez 1984).

RESULTS AND DISCUSSIONS

A. Effect of water management practices on growth characters

Water management practices influenced significantly almost all the growth parameters *viz,* plant height, number of tillers (m^{-2}) and dry matter accumulation (g m^{-2}) at harvest stage (Table 1). Alternate wetting and drying upto PI and flooding (5±2) after PI recorded highest values during both the experimental years for plant height (101.03 and 104.77 cm), number of tillers (277.52 and 280.99 m^{-2}) and dry matter accumulation (751.99 and 794.80 g m^{-2}) with different water management practices. However, saturation maintenance upto PI and flooding (5±2) after PI recorded higher values which were significantly at par with alternate wetting and drying upto PI and flooding (5±2) after PI for all the growth parameters. Taller plant height under alternate wetting and drying might be because of quick growth by maintenance of adequate water supply to crop in alternate wetting and drying, that helps in active metabolic processes that perform higher nutrient mobilization, which resulted in augmented activity of meristematic cells and cell elongation of internodes leading to higher growth rate of stem that inturn increased the plant height of rice. Alternate wetting and drying enhances air exchange between soil and the atmosphere and may have contributed to more tiller numbers.

Table 1: Effect of water management and crop establishment methods on growth characters of rice at harvest.

Treatments	Plant height (cm)		No. of tillers (m^{-2})		Dry matter accumulation ($g\ m^{-2}$)	
	2018	2019	2018	2019	2018	2019
Water management						
I_1: Flooding throughout crop growth (5±2)	87.13	88.79	238.34	246.40	689.82	714.68
I_2: Saturation maintenance upto PI and flooding (5±2) after PI	91.54	94.36	247.71	254.40	717.05	741.58
I_3: Alternate wetting and drying upto PI and flooding (5±2) after PI	101.03	104.77	277.52	280.99	751.99	794.80
SEm±	2.20	2.28	5.53	5.90	7.36	7.49
LSD (p=0.05)	8.63	8.96	21.73	23.17	28.90	29.42
Crop establishment methods						
E_1: Conventional transplanting	103.36	107.27	275.30	280.90	753.88	784.45
E_2: Wet seeding on puddled soil (Broadcasting)	87.83	89.47	246.40	249.08	696.70	727.36
E_3: Wet seeding on puddled soil (Drum seeder)	99.19	102.12	262.80	270.37	746.06	777.83
E_4: Dry seeding (Broadcasting)	83.77	86.66	236.19	242.05	682.06	708.12
E_5: Dry seeding (Line sowing)	92.00	94.34	251.94	260.58	719.38	753.99
SEm±	1.93	2.63	6.20	6.81	5.27	5.89
LSD (p=0.05)	5.64	7.69	18.10	19.87	15.38	17.19

Higher dry matter accumulation due to rapid growth by maintenance of adequate wetness with intermittent water to crop that maintained good plant roots and different metabolic processes that perform better nutrient mobilization. These results were line up with the findings of Sandhu *et al*. (2012); Rahaman and Sinha (2013) and Hiya *et al.* (2020).

B. Effect of crop establishment methods on growth characters

Among the crop establishment methods, conventional transplanting recorded significantly higher plant height (103.36 and 102.27 cm), number of tillers (275.30 and 280.90 m^{-2}) and dry matter accumulation (753.88 and 784.45 g m^{-2}) during *kharif*, 2018 and 2019, respectively. However, wet seeding on puddled soil (Drum seeder) was statistically at par with conventional transplanting. Taller plant height might be owing to the fact that optimum plant population and geometry leads to availability of more resources to plants (Mohanty *et al.*, 2014). Higher number of tillers in transplanted rice could have been due to reduced weed growth and availability of sufficient amount of nutrients and moisture at tiller initiation stage and better establishment of roots and desired plant spacing, which is in agreement with IRRI (2008) observations. However, transplanted rice accumulated maximum dry matter which was almost equal to that of direct seeding by drum seeder under puddled conditions.

Table 2: Effect of water management and crop establishment methods on kernel length (mm) and breadth (mm) of rice.

Treatments	Before cooking				After cooking			
	Kernel length		Kernel breadth		Kernel length		Kernel breadth	
	2018	2019	2018	2019	2018	2019	2018	2019
Water management								
I_1: Flooding throughout crop growth (5±2)	6.17	6.27	1.75	1.79	11.05	11.13	2.91	2.94
I_2: Saturation maintenance upto PI and flooding (5±2) after PI	5.95	6.04	1.69	1.72	10.96	11.07	2.87	2.89
I_3: Alternate wetting and drying upto PI and flooding (5±2) after PI	5.81	5.92	1.65	1.69	10.91	10.99	2.79	2.85
SEm±	0.13	0.24	0.07	0.09	0.28	0.30	0.09	0.11
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Crop establishment methods								
E_1: Conventional transplanting	6.12	6.20	1.77	1.81	11.12	11.22	2.93	2.97
E_2: Wet seeding on puddled soil (Broadcasting)	5.90	6.02	1.67	1.69	10.90	10.97	2.83	2.85
E_3: Wet seeding on puddled soil (Drum seeder)	6.04	6.17	1.72	1.77	11.04	11.13	2.88	2.93
E_4: Dry seeding (Broadcasting)	5.86	5.92	1.63	1.66	10.85	10.91	2.80	2.82
E_5: Dry seeding (Line sowing)	5.97	6.08	1.69	1.73	10.97	11.08	2.85	2.89
SEm±	0.21	0.30	0.04	0.05	0.23	0.24	0.06	0.07
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 3: Effect of water management and crop establishment methods on elongation ratio, expansion ratio and elongation index of rice.

Treatments	Elongation ratio		Expansion ratio		Elongation index	
	2018	2019	2018	2019	2018	2019
Water management						
I_1: Flooding throughout crop growth (5±2)	1.73	1.73	1.49	1.48	1.08	1.09
I_2: Saturation maintenance upto PI and flooding (5±2) after PI	1.78	1.79	1.52	1.52	1.09	1.10
I_3: Alternate wetting and drying upto PI and flooding (5±2) after PI	1.81	1.81	1.51	1.52	1.11	1.11
SEm±	0.03	0.04	0.02	0.03	0.04	0.06
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
Crop establishment methods						
E_1: Conventional transplanting	1.76	1.77	1.49	1.49	1.10	1.11
E_2: Wet seeding on puddled soil (Broadcasting)	1.78	1.78	1.51	1.52	1.09	1.09
E_3: Wet seeding on puddled soil (Drum seeder)	1.77	1.77	1.50	1.50	1.10	1.10
E_4: Dry seeding (Broadcasting)	1.79	1.79	1.53	1.53	1.09	1.09
E_5: Dry seeding (Line sowing)	1.78	1.78	1.51	1.50	1.10	1.10
SEm±	0.02	0.03	0.01	0.01	0.02	0.03
LSD (p=0.05)	NS	NS	NS	NS	NS	NS

It was might be owing to higher plant height and more number of tillers. In line with the above-said facts, the experimental findings of Bhardwaj *et al*. (2018) and Choudhary *et al.* (2018) are also in agreement.

C. Effect on quality

Qualitative characters *viz.* kernel length and breadth before and after cooking (Table 2) and elongation ratio, expansion ratio as well as elongation index (Table 3) were failed to show any significant difference by water management and crop establishment methods during both the experimental years. These results were line up with the findings ofGill (2013) and Ali *et al*. (2012).

CONCLUSIONS

From the above overall study, it is recommended that to obtain higher growth attributes of rice should be grown by wet seeding on puddled soil by drum seeder with alternate wetting and drying upto PI and flooding (5±2 cm) after PI under ago-climatic conditions of Varanasi region of Eastern Uttar Pradesh.

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