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EFFECT OF IRRIGATION REGIMES AND NITROGEN LEVELS ON PRODUCTIVITY AND WATER USE EFFICIENCY OF RICE (*ORYZA SATIVA* L.) UNDER SRI CULTIVATION

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ABSTRACT

A field experiment was conducted during the *kharif* season of 2014 at Indian Institute of Rice Research, Hyderabad, to evaluate effect of irrigation regimes and nitrogen levels on productivity and water use efficiency of rice (*Oryza sativa* L.) under SRI cultivation. The experiment was conducted in split plot design. The treatments composed of three irrigation regimes *i.e.*, I_1: Submergence (3±2 cm) throughout the crop period, I_2: Saturation upto panicle initiation stage followed by maintaining (1±2 cm) standing water till maturity and I_3: Alternate wetting and drying through field water tube (Depletion of 5 cm depth below soil surface) assigned to main plot and four levels of nitrogen (N) (N_1: 0, N_2: 50, N_3:100 and N_4: 150 kg N ha^{-1}) were allotted to sub plot. Irrigation regime I_2 proved significantly superior to irrigation regime I_3& I_1 in producing yield attributes namely number of panicles m^{-2}, filled grains $hill^{-1}$ and grain yield. Among the N levels, N_4 exhibited the maximum yield attributes *viz*., number of panicles m^{-2}, filled grains $hill^{-1}$, test weight and grain as well as straw yield. N_4 produced significantly maximum grain yield 8.98 t ha^{-1} over other N levels.

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INTRODUCTION

Rice being the main source of livelihood for more than 120-150 million rural households is the backbone of the Indian Agriculture. It occupies about 23.3 per cent of the cultivated land and contributed to about 40 per cent of food grain and thus rice plays a very vital role in the national food security. Even then rice self sufficiency in India is precarious to food security. The countries population of more than 1.2 billion is growing at 1.8 per cent per year, outpacing the 1.4 per cent annual growth rate of rice production. To maintain self sufficiency, annual production needs to increase by 2 million tonnes every year. In irrigated lowland rice, which not only consumes more water but also causes wastage of water resulting in degradation of land. In recent year to tackle this problem, many methods of cultivation have been developed; one among them is System of Rice Intensification (SRI).

Water and Nitrogen are two of the most important inputs in rice production. Rice is a heavy water consumer, but water for rice production is increasingly becoming scare and expensive due to the increased demand for water from the ever growing population (Bouman and Tuong, 2001). There was a mean saving of 32% water in SRI as compared to conventional method. Further the amount of water used for 1 kg grain production was higher (3177 lts) for conventional as compared to SRI method (2162 lts). Hence, SRI can become a viable alternative approach to the conventional transplanting having advantage of both in terms of higher yield and water productivity especially in the areas of limited water situations (Kumar *et al.*, 2011). System of Rice Intensification (SRI) is emerging as a low-input technology for increasing rice productivity with less use of water, seed and fertilizer, SRI has attracted attention because of its apparent success in increasing rice yields with less water use (Uphoff *et al.*, 2011). Therefore, the present experiment was undertaken to study the productivity and water use efficiency by rice (*Oryza sativa* L.) under SRI cultivation.

MATERIALS AND METHODS

The field experiment was carried out during *kharif* season of 2014 at Indian Institute of Rice Research, Hyderabad, Telangana. The soil condition of experimental field was sandy clay loam in texture, low in nitrogen, medium in phosphorus and high in potassium contents with alkaline pH. The experiment was laid out in split plot design with three replications keeping irrigation regimes *viz.*, submergence (3±2 cm) throughout the crop period (I_1), saturation upto panicle initiation stage followed by maintaining (1±2 cm) standing water till maturity (I_2) and alternate wetting and drying through field water tube (Depletion of 5 cm depth below soil surface) (I_3) as main plot and nitrogen levels *viz.*, 0 kg ha^{-1} (N_1), 50 kg ha^{-1} (N_2), 100 kg ha^{-1} (N_3) and 150 kg ha^{-1} (N_4) as sub-plot treatments.

A basal dose of P_2O_5at 60 kg ha^{-1} and K_2O at 40 kg ha^{-1} was also applied in the form of single super phosphate and MOP, respectively. Nitrogen was applied in 3 splits with 1/3 nitrogen as basal in the form of Urea. Rest N was given in two equal split doses, one at active tillering stage and rest at panicle initiation stage. Twelve days old seedlings at spacing of 25 x 25 cm were transplanted. The hybrid rice 'DRRH-3' was grown on July 19, 2014 and harvesting was done on December 16, 2014.Water use efficiency has been expressed as the ratio of grain yield (kg ha^{-1}) to the water requirement (mm) of crops.

Data collection and analysis

Different yield attributing parameters such as Number of panicles m^{-2}, Number of filled grains $hill^{-1}$, Sterility percentage, Test weight, Grain yield (t ha^{-1}), Straw yield (t ha^{-1}), Harvest index (HI) were calculated by following standard formulae's shown below:

Number of panicles m^{-2}

Number of panicles m^{-2} was counted randomly from four sites in each plot at harvest by using 1 m^2quadrate.

Number of filled grains $hill^{-1}$

Filled grains per $hill^{-1}$ were averaged from 5 randomly selected hills taken from each plot and seeds are counted by seed counting machine.

Sterility percentage

The sterility percentage was calculated from 5 randomly selected panicles from each plot at harvest. The empty seeds were designated as sterile and rests were considered as normal kernels (Nagato and Chaudhry, 1969). The sterility percentage was worked out by using following formula:

$$\text{Sterility (\%)} = \frac{\text{No. of sterile grains panicle}^{-1}}{\text{No. of total grains panicle}^{-1}} \times 100$$

Test weight

One thousand healthy grains were taken from bulk produce of each treatment and were dried in an oven at 60°C to get constant weight. The weight of grains was recorded in gram.

Grain yield (t ha^{-1})

The weighed bundles were threshed, winnowed and cleaned separately. Treatment wise moisture content of threshed grain samples was recorded gravimetrically and grain yield was recorded and presented in t ha^{-1}.

Straw yield (t ha^{-1})

Straw yield was calculated by deducting the grain yield from bundle weight and converted into t ha^{-1}.

Harvest index (HI)

The harvest index was calculated by following formula and expressed in percentage: HI (%) = Grain yield/Total biological yield X 100. (Donald 1962)

At harvest, grain and straw sample were collected and were statistically using standard statistical methods (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Yield parameters

The number of productive tillers per unit area is the most important yield contributing component. As the number of productive (effective) tillers per plant increases, the yield ha^{-1} also increases. The data presented in Table 1 reveals significant effect of irrigation regimes and N levels on number of panicles m^{-2} in rice. The significantly maximum number of effective tillers (335.8 m^{-2}) was observed in I_2 (Saturation upto panicle initiation stage followed by maintaining, 1±2 cm standing water till maturity) irrigation regime and it was significantly superior as compared to I_3 (Alternate wetting and drying through field water tube) and I_1 (Submergence, 3±2 cm throughout the crop period) irrigation regime, respectively. The I_1 (Submergence, 3±2 cm throughout the crop period) irrigation regime was proved to be inferior over irrigation regimes I_2 (Saturation upto panicle initiation stage followed by maintaining, 1±2 cm standing water till maturity) with respect to production of panicles m^{-2}. Similar results have been found earlier by Rahman and Sinha (2013). Results further revealed that nitrogen levels in rice had significant effects on the number of panicles m^{-2}. The significantly maximum number of panicles(381.7 m^{-2}) was produced in the N_4 (150 kg N ha^{-1})level of nitrogen, while the significantly minimum number of effective tillers (233.6 m^{-2}) was recorded from N_1 level (0 kg N ha^{-1}) devoid of nitrogen application. Similar results have been reported earlier by Pal *et al.* (2008) and Pandey *et al.* (2009).

Irrigation regime I_2 (Saturation upto panicle initiation stage followed by maintaining, 1±2 cm standing water till maturity) registered significantly higher number of filled grains $hill^{-1}$ followed by irrigation regime I_3 (Alternate wetting and drying through field water tube)which was at par with irrigation regime I_2. The lowest number of filled grains $hill^{-1}$ was noted under I_1 (Submergence, 3±2 cm throughout the crop period).

Table 1: Yield attributes, grain yield, straw yield and harvest index of rice as influenced by irrigation regimes and N levels under SRI cultivation

Treatment	Number of paniclesm^{-2}	Filled grains$hill^{-1}$	Sterility (%)	1000- grain weight (g)	Grain yield(t ha^{-1})	Straw yield(t ha^{-1})	Harvest index(%)
Irrigation regimes							
I_1	290.9	2443	26.58	17.81	6.44	7.34	46.78
I_2	335.8	2763	24.77	18.42	7.49	7.99	48.12
I_3	304.0	2630	25.45	18.24	7.01	7.76	47.00
SEm±	5.21	51.51	0.51	0.19	0.123	0.07	0.61
CD (p=0.05)	20.47	202.23	NS	NS	0.481	0.29	NS
Nitrogen Level (kg ha^{-1})							
N_1 : 0	233.6	1846	23.12	16.34	4.07	4.82	45.80
N_2 : 50	292.3	2208	25.62	17.68	6.95	7.89	46.83
N_3 : 100	333.1	2806	26.54	18.73	7.92	8.47	48.27
N_4 : 150	381.7	3587	27.11	19.86	8.98	9.61	48.29
SEm±	7.20	93.93	0.94	0.32	0.074	0.14	0.71
CD (p=0.05)	21.40	279.09	2.79	0.95	0.219	0.41	NS

Table 2: Water use efficiency (kg ha^{-1} mm^{-1}) of rice as influenced by interaction between irrigation regimes and N levels under SRI cultivation

Irrigation regimes (I)	Nitrogen level (kg ha^{-1})				
	0	50	100	150	Mean
I_1	2.41	4.08	4.23	4.38	3.78
I_2	3.09	5.32	5.70	5.64	4.94
I_3	2.64	5.31	4.70	5.27	4.48
Mean	2.71	4.91	4.88	5.10	
	SEm ±		CD (p = 0.05)		
I	0.07		0.29		
N	0.05		0.15		
Interaction					
N at same level of I	0.12		0.37		
I at same or different level of N	0.10		0.28		

Application of different N levels had significant effect on filled grains $hill^{-1}$, sterility per cent and weight of 1000 grains compared to devoid of nitrogen plot. While, N_4 (150 kg N ha^{-1}) level of nitrogen recorded significantly maximum number i.e. 3587, 27.11 and 19.86 of filled grains $hill^{-1}$, sterility per cent and weight of 1000 grains, respectively. The significantly minimum was value recorded under N_1 (0 kg N ha^{-1}). When levels of N had increased, an increase in the number of spikelets $panicle^{-1}$ was observed (Jafari*et al.,* 2013). Whereas, that caused plants not to have enough carbohydrates to fill up all spikelet's produced as the nitrogen fertilization level increased. (Mauad*et al.*, 2003).

The grain yield, the ultimate result of various interacting growth factors, development and yield contributing character influenced significantly due to irrigation regimes and N levels. The data recorded on grain yield of rice and presented in Table 1 shows that, irrigation regime I_2 (Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity) registered significantly highest grain yield (7.49 t ha^{-1}), however, it was found comparable with the irrigation regime I_3 (Alternate wetting and drying through field water tube). The lowest grain yield was recorded under irrigation regime I_1 (Submergence, 3 ± 2 cm throughout the crop period). Similar results were also found by Ramakrishna *et al.* (2007). As regards to nitrogen levels, the grain yield of rice was significantly greater in N levels than in absolute control treatment. The maximum grain yield (8.98 t ha^{-1}) was obtained under N_4 (150 kg N ha^{-1}) level of nitrogen followed by N_3 (100 kg N ha^{-1}). N_1 (0 kg N ha^{-1}) gave significantly less yield (4.07 t ha^{-1}) than other levels of nitrogen. Similar findings were also reported by Maheswari*et al.* (2008).Optimum dose of nitrogen fertilization plays a vital role in growth and development of rice plant. The growth in seriously hampered when lower dose of nitrogen is applied which drastically reduces yield (Alam *et al.,* 2009). Straw yield of rice is the function of an accumulated effect of growth parameters like tillers per unit area and final plant height. The irrigation regimes I_2 (Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity) produced higher amount of straw yield (7.99 t ha^{-1}) followed by I-$_3$ (Alternate wetting and drying through field water tube) which was at par with I_2(Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity). However, significantly minimum straw yield (7.34 t ha^{-1}) was produced by I_1 (Submergence, 3 ± 2 cm throughout the crop period) irrigation regime. The straw yield of rice was also increased significantly by N levels than in control treatment. Like grain yield, the significantly maximum straw yield (9.61 t ha^{-1}) was obtained under N_4 (150 kg N ha^{-1}) followed by N_3 (100 kg N ha^{-1}), however treatment N_4 was significantly superior over rest of the N levels under investigation. Significantly lowest straw yield (4.07 t ha^{-1}) was found under N_1 (0 kg N ha^{-1}) compared to all N levels.

The ability of a crop to convert the total dry matter into economic yield is indicated by its harvest index value. Higher harvest index value, greater is the physiological potential for converting the total dry matter into grain yield. The data reveals that there was no significant effect on harvest index due to irrigation regimes and nitrogen levels. In irrigation regimes, I_2 (Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity) gave comparatively higher harvest index than other irrigation regime and in case of nitrogen levels, 150 kg N ha^{-1} (N_4) gave higher harvest index.

Water use efficiency

Water use efficiency (Table 2) was significantly affected due to irrigation regimes and nitrogen levels. The water use efficiency was recorded highest under irrigation regime I_2 (Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity), followed by I_3 (Alternate wetting and drying through field water tube) and the minimum water use efficiency was recorded under the I_1 (Submergence, 3 ± 2 cm throughout the crop period). Similar result was depicted by (Kumar *et al.*, 2015 and Chowdhury *et al.*, 2014). Kumar *et al.* (2011) found that SRI method saved irrigation water without any penalty on yield compared to conventional method by using intermittent irrigation. Thiyagarajan *et al.* (2002) reported water saving of 50% over the traditional flooding without any effect on grain yield.

It is clear from the Table 2, water use efficiency increased from 2.71 to 5.10 kg ha^{-1} mm^{-1} with increase in level of N from 0 to 150 kg N ha^{-1}.The water use efficiency was recorded highest under the combination of irrigation regime I_2(Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity) and N_3 (100 kg N ha^{-1}) followed by the combination of irrigation regime I_2(Saturation upto panicle initiation stage followed by maintaining, 1 ± 2 cm standing water till maturity) and N_4 (150 kg N ha^{-1}).

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