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Productivity and Water Use Studies in Rice under Different Establishment Methods

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Abstract—*Water is the most crucial input for agricultural production. Rice crop consumes about 90 per cent of the fresh water resources used for agriculture in Asia. Future rice production depends on how to improve the water use efficiency of the rice crop. A field experiment was conducted to assess the water requirement and water- use- efficiency of rice genotypes under System of rice intensification (SRI) and conventional method of establishment at Instructional-cum-Research Farm of Assam Agricultural University, Jorhat during 2013-2014. The experiment was laid out in split plot design with four replications. The treatments consisted of two different method of establishment viz., System of Rice Intensification (SRI) and conventional method of transplanting in main plot and six different rice genotypes involving four hybrids viz., DRRH2(V_1), Arize6444(V_2) , PAC837(V_3), NK5251(V_4) and two high yielding varieties (HYVs) viz., Kanaklata(V_5) and Joymati (V_6) in sub plots. The soil of the experimental plot was sandy loam, acidic in reaction (pH 6.1), medium in organic carbon content (0.62%), medium in available N (294.09kg ha^{-1}) and K_2O(139.01 kg ha^{-1}) and low in available P_2O_5(20.11 kg ha^{-1}). The result of the experiment revealed that higher grain (14.9%) and straw (30.77%) yield, higher water use efficiency (60.2%) and lower water requirement were recorded under the SRI method of establishment as compared to conventional method. Among different rice genotypes the highest grain yield was recorded in rice hybrid PAC837 (52.67q/ha) which was 12.66% and 28.43% more than average yield of other hybrids and HYVs, respectively. The highest water use efficiency (51.16kg/ha-cm) was recorded in rice hybrid PAC 837 which was 12.27% more over other hybrids and 30.31% over HYVs.*

Keywords*: Rice, SRI, water, water-use-efficiency.*

1. INTRODUCTION

Water is the most crucial input for agricultural production. Rice crop consumes about 90 per cent of the fresh water resources used for agriculture in Asia. Eighty per cent of the world's rice is grown under irrigated (55%) and rain fed lowland (25%) ecosystems, both of which depend on fresh water resources (Barker *et al.,* 1999). Rice cultivation is a very water-intensive activity. Irrigated rice production is the largest consumer of water in agricultural sector, and its sustainability is threatened by increasing water shortages. It is estimated that to produce one kilogram of rice requires 3,000-5,000 litres of water. About two or three times more water is needed for rice cultivation than other irrigated crops. Water, which was abundant earlier, will increasingly become scarce in the years to come. Reliable estimates indicate that fresh water availability in India will be reduced to one-third of what is available today by 2025.Therefore, future rice production depends on how to improve the water use efficiency of the rice crop. Production of "more rice crop from every drop of water" will have to be the guiding principle for the future. Reducing amount of water in irrigated rice production has become a matter of global concern and of late water saving irrigation techniques have received renewed attention and as such there are several options to improve the water use efficiency in rice production. Zero tillage, Alternate Wetting and Drying (AWD), Aerobic rice, Integrated Crop Management (ICM) and System of Rice Intensification (SRI) are some of the alternative technologies to combat water scarcity (Bouman and Tuong 2001). System of Rice Intensification (SRI) is considered as one of the technologies to increase the productivity and as a viable alternative of rice cultivation that reduces about 30% of the water requirement when compared to other methods. Uphoff *et al*. (2002) stated that the best SRI yields can be achieved with HYV's or hybrids but even traditional varieties can perform better under SRI. Therefore, the present investigation was conducted to assess productivity and water use in rice hybrids and high yielding varieties under SRI and conventional method of establishment.

2. MATERIALS AND METHODS

A field experiment was conducted instructional-cum-research (ICR) farm of Assam Agricultural University, Jorhat during 2013-2014, to study the productivity and water use of rice genotypes under SRI and Conventional method.The experiment was laid out in split plot design with four replication. The treatments consisted of two different methods of establishment viz., System of rice intensification(SRI) and Conventional method of transplanting in main plot and six different rice genotypes involving four hybrids viz.,DRRH2(V1),Arize6444(V2),PAC837(V3),NK5251(V4) and two high yielding varieties (HYVs) viz., Kanaklata (V5) and Joymati(V6) in sub plots. The soil of the experimental plot was sandy loam, acidic in reaction (pH 6.1), medium in organic carbon content(0.62%), medium in available N(294.09kg ha-1) and K2O(139.01 kg ha-1) and low in available P2O5(20.11 kg ha-1). SRI involved planting of 12 days single seedling /hill at 25cm×25cm and conventional method involved planting of single seedling of 45 days (5-6 leaf stage) at 20cm×20cm spacing. Nursery for SRI method was prepared in tray. The tray was filled with compost and fine soil, mixed thoroughly and the seed was uniformly spread. The bed was kept moist by sprinkling water frequently. The seed requirement in this method is 5 kg/ha. At 12 days the seedlings were uprooted along with soil, without disturbing the root system.

The seedlings for the conventional method were raised in field itself. The field was thoroughly ploughed and raised seed bed of 10m length and 1.25m breadth was prepared with 30cm gap in between the beds. In each seed bed 20kg FYM, 80g Urea, 80g SSP and 40g MOP were applied and mixed thoroughly with soil. The pre sprouted seeds were sown uniformly and the bed was kept moist by sprinkling water as and when required.

In SRI method, manuring was done as per recommendation for SRI method and in conventional method, the recommended doses of FYM were applied to each plot in around 25 days prior to the transplanting of the seedlings. The FYM were mixed thoroughly with the soil after application with the help of hand hoe. The calculated quantity of fertilizers were applied in the conventional plots and mixed uniformly two days before transplanting of the rice seedlings. The fertilizers were applied in the form of Urea, SSP and MOP. For hybrid varieties one fourth of total urea, full doses of SSP and MOP were applied at the time of final land preparation and the remaining 2^{nd} one fourth,3^{rd} one fourth and 4^{th} one fourth of urea are applied as top dressing at maximum tillering, panicle initiation and booting stage respectively. For high yielding genotypes half of Urea and MOP, full dose of SSP were applied at the time of final land preparation and remaining half of urea and MOP was applied in two split doses. After mixing the fertilizers with the soil the plots were leveled properly. In SRI method weeding was done with cono weeder and subsequent weeding were done whenever necessary. First weeding was done at 25 days after transplanting of seedlings in both the methods. In conventional method irrigation was done at 5cm depth at three days after disappearance of ponded water and in SRI method irrigation was done at 2.5cm depth at hair line crake of the soil. The quantity of water required by the rice crop during the growing period under field conditions was calculated out using established methods. Water use efficiency (WUE) of the crop for different treatments was calculated out by using following formula:

$$\text{WUE(kg/ha-cm)} = \frac{\text{Grain yield (kg/ ha)}}{\text{Water requirement (cm)}}$$

3. RESULTS AND DISCUSSION

Growth and yield attributes

The growth and yield attributing characters were significantly affected by both methods and genotypes(Table1). The higher plant height was recorded under the conventional method than SRI method which was in agreement with research findings of Hossain *et al*. (2003) and might be due to the difference in seedling age and spacing. In terms of dry matter higher dry matter production was observed under SRI method than conventional method which was similar with the findings of Wang *et al*. (2002) , Pandey and Prakash (2007) and might be due to transplanting of younger seedlings that have the capacity to recover fast enough due to lower transplanting shock and absorption of nutrients and water to support faster growth and hence resulted in higher dry matter production. The results revealed that SRI method recorded the highest yield attributing characters *viz*., number of panicles per square meter, number of grains per panicle, number of filled grains per panicle and 1000-seed weight of rice. More number of panicles per meter square were recorded under the SRI method than the conventional method which might be due to the production of higher number of effective tiller at wider spacing under SRI method.

Rice genotype Joymati recorded the highest plant height than all the genotypes. PAC 837 recorded the highest dry matter accumulation followed by NK5251 which might be due to more vigorous growth and higher tillering nature of the rice hybrids. The highest yield attributing characters *viz*., number of panicles per $meter^2$, number of grains per panicle, filled grain per panicle and 1000-grain weight were observed in genotype PAC 837 which might be due to the variation in genetical character among the genotypes(Table1).

Grain yield and water use

The results showed that different methods of establishment significantly affected grain and straw yield of rice (Table2)**.** Higher grain and straw yield were recorded in SRI method than conventional method which might be due to the planting of younger seedling leading to increase in yield attributing characters such as effective tillers per hill, number of grains per panicle and higher number of filled grains per panicle under SRI method. Similar results were also reported by Mohanty *et al.* (2014).

Rice genotypes significantly affected grain and straw yield. Higher grain and straw yield were recorded in rice hybrids as compared to the HYVs. Rice hybrid PAC 837 recorded the highest grain yield which might be due to the higher value of yield attributing characters and genetic yield potential of the rice hybrids. The increase in straw yield in rice hybrid PAC837 might be due to the conversion of photosynthates into shoot in contrast to economic parts of the plant (Satyanaryan *et al.*, 2007) (Table2).

Different methods of establishment affected the water requirement of rice. The total water requirement was higher (120.3cm) under conventional method as compared to the SRI method of establishment (86.3cm) (Table3).This might be due to flooding under conventional method as compared to soil saturation under SRI method. The result was in conformity with the findings of Mitra *et al*. (2013). Similarly, different rice genotypes also affected the water requirement of rice (Table3). The highest total water requirement of the rice was recorded in Joymati (104.75cm) followed by Kanaklata (104.15cm) and the lowest water requirement was recorded in Arize6444 (102.05cm) which might be due to the variation in crop duration among the varieties, Which was in full agreement with the findings of Kumari *et al*. (2010).

In terms of water use efficiency (kg/ha-cm) of rice higher water use efficiency (56.79kg/ha-cm) was recorded under the SRI method as compared to the conventional method (35.44kg/ha-cm). SRI method recorded 60.24% higher water use efficiency than conventional method which was similar with the findings of Zhao *et al*. (2011) and might be due to higher yield performances with less water requirement. Similar results were also reported by Mitra *et al*. (2013) (Table3).

The water use efficiency of rice was affected by different genotypes. Higher water use efficiency was recorded under the hybrids compared to the HYVs(Table3). The highest water use efficiency was recorded in hybrid PAC 837 (51.16kg/ha-cm) as compared to other genotypes. Rice hybrid PAC837 recorded the highest (12.26% higher than other hybrids and 30.31% than HYVs) water use efficiency among the all rice genotypes.This might be due to proportionately greater increase in yield with less water requirement. Similar result was also reported by Kumari *et al*. (2010).

Thus it was observed that all the rice genotypes performed better under SRI method in terms of growth, yield with less water requirement. Similar result was also reported by Kumari *et al*. (2010). All the rice genotypes performed better under SRI method in terms of growth and water use efficiency. The genotype PAC837 was found to be best in respect of growth, grain yield and water use among all the rice genotypes under SRI method.

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Table 1: Effect of methods of establishment and genotypes on growth parameters and yield attributes of rice

Treatments	Plant height (cm)	Dry matter g/m^2	No. of panicles/ m^2	No. of grains/panicle	No. of filled grains/ panicle	1000-grain weight (g)
Methods of establishment(M)						
SRI	97.33	1272.47	294.75	171.01	153.24	21.26
Conventional	102.19	1201.79	246.46	154.89	126.38	21.16
SEm ±	0.43	15.46	3.77	2.97	2.08	0.19
CD(P=0.05)	1.93	69.59	16.96	13.38	9.37	NS
Genotypes(V)						
DRRH2	90.04	1222.78	265.38	161.50	141.33	20.07
Arize 6444	91.32	1257.25	278.13	162.00	141.73	21.07
PAC837	95.38	1439.03	292.88	185.83	157.15	26.62
NK5251	95.55	1318.86	286.63	166.75	145.78	21.89
Kanaklata	111.84	1091.82	245.88	146.28	125.15	18.05
Joymati	117.40	1093.05	254.75	155.35	127.75	19.56
SEm ±	2.42	17.80	8.97	6.27	5.94	0.46
CD(P=0.05)	7.00	51.41	25.90	18.12	17.14	1.34

Table 2: Effect of methods of establishment and genotypes on grain and straw yield (q/ha) of rice

Treatments	Grain yield (q/ha)	Straw yield(q/ha)
Methods of establishment(M)		
SRI	49.01	80.86
Conventional	42.64	61.83
SEm ±	0.47	0.71
CD(P=0.05)	2.11	3.21
Genotypes(V)		
DRRH2	45.33	70.67
Arize 6444	46.87	73.11
PAC837	52.67	82.04
NK5251	48.07	74.99
Kanaklata	40.63	63.03
Joymati	41.39	64.21
SEm ±	1.26	2.00
CD(P=0.05)	3.63	5.78

Table 3: Effect of methods of establishment and genotypes on water requirement (cm) and water use efficiency (kg/ha-cm) of rice

Treatments	Water requirement(cm)			Total Water requirement (cm)	Grain yield (kg/ha)	Water use - efficiency (kg/ha-cm)
	Nursery (cm)	Field Preparation (cm)	Transplanting to maturity (cm)			
Methods of establishment(M)						
SRI	0.10	20.0	66.2	86.3	4901	56.79
Conventional	10.0	20.0	90.3	120.3	4264	35.44
Genotypes (V)						
DRRH2	5.05	20.0	77.3	102.35	4533	44.29
Arize 6444	5.05	20.0	77.0	102.05	4687	45.93
PAC837	5.05	20.0	77.9	102.95	5267	51.16
NK5251	5.05	20.0	78.3	103.35	4807	46.51
Kanaklata	5.05	20.0	79.1	104.15	4063	39.01
Joymati	5.05	20.0	79.7	104.75	4139	39.51

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