ENHANCING RICE PRODUCTIVITY THROUGH SYSTEM OF RICE INTENSIFICATION (SRI)

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INTRODUCTION

Rice is the world's prime staple food crop feeding about 2.7 billion people which is almost half of the total global population. The demand for rice increases with increase in population which is expected to rise by a further 38% within 30 years, according to the United Nations (Satyanarayana, 2005).India has largest area 42.5 million hectare with production 106 million tons of rice and average productivity was 3.45 tonne ha^{-1}(Anon. 2013). The rice productivity is less than 2 tons ha^{-1} in most of the states (Dash, 2009).So there is still scope to increase the productivity of the crop. To ensure food security in the rice consuming countries like India, will have to meet consumers demand by enhancing about 125 million tonns of rice by 2020 (Mishra, 2005).

Water for agriculture is becoming increasingly scarce and climate change-induced higher temperatures will increase crops' water requirements, making the water shortages even more serious. By 2025, it is estimated that 15–20 million of the world's 79 million hectares of irrigated rice lowlands, which provide three-quarters of the world's rice supply, are expected to suffer some degree of water scarcity (IWMI, 2007).

In such situation, a set of water saving rice cultivation management practices popularly known as System of Rice Intensification (SRI) has been evolved over the last few decades of the 20th century and offers a radical departure in the way of growing more rice with fewer inputs and this can be alternative to conventional rice cultivation.

When planting densities exceed the optimum level, competition among plants become sever and consequently the plant growth slows and the grain yield decrease. Wider spacing had linearly increasing effect on performance of individual plants. The plants grown with wider spacing had more solar radiation to absorb for better photosynthetic process and hence performed better as individual (Baloch *at al.*, 2002). It is therefore necessary to determine the optimum density of plant population per unit area for obtaining maximum yield.

Investigations in the past have clearly brought out the significance of the cultural practices viz., age of seedling, crop geometry, irrigation, weeding and nutritional strategies as major determinants of rice productivity in rice under SRI. Keeping these aspects in view present study was undertaken in order to elucidate the parameters contributing for yield determination under system of rice intensification method.

MATERIALS AND METHODS

The experiment was conducted at the Indian Agricultural Research Institute during *kharif* seasons of 2003 and 2004. The soil of the experimental field was sand clay loam in soil texture, low in available N (Kjeldahl method), medium in available P (Olesen's method) and high in available K (Flame photometric method)

ABSTRACT

Irrigation one day after disappearance of water (DADW) recorded significantly higher dry matter, tillers m^{-2}, panicles m^{-2}, grains panicle^{-1} and 1000 grain weight, grain yield over three DADW.Maximum dry matter was registered with 30 X 30 cm spacing as compared to 40 X 40 cm which was at par with 20 X 20 cm spacing and significantly higher tillers m^{-2}, panicles m^{-2}, grains panicle^{-1}, grain yield, gross returns, net returns and B: C ratio was recorded with 30 x 30 cm spacing over other spacing's but1000 grain weight was higher with 40x40 cm spacing.Seedlings of 15 day old were registered significantly higher dry matter, tillers m^{-2}, panicles m^{-2}, grains panicle^{-1}, as compared to 20 and 25 days old.Significantly marked variation in 1000 grain weight and grain yield observed with 15 day old seedlings over 25 days old, which was at par with 20 day old seedlings. Thus under SRI, practice of irrigation one DADW, transplanting 15 days old seedlings at 30 x 30 cm spacing should be adopted for achieving higher yield attributes and yield.

and slightly alkaline in reaction with 7.7 pH (Potentiometric method). The treatments were laid out in split plot design with three replications having a combination of two irrigation regimes (Irrigation upto 3 cm at one and 3 days after disappearance of ponded water from the surface), and three plant densities (Square planting at 20 x 20 cm, 30 x 30 cm and 40 x 40 cm spacing) in main plots and three age of seedlings (15, 20 and 25 day old) in sub plots and in addition one conventional practices (20x15 cm spacing, 25 days old seedlings and continuous submergence in separate plots) was also included. In all the treatments recommended doses of 100:60:40 kg NPK ha^{-1} and 5 tons of FYM were applied at the time of transplanting. Rainfall received during 2003 and 2004 *kharif* season of rice was recorded as 423 mm and 316mm, respectively. Irrigation water was measured through low head water meter in every irrigation, this meter recorded water discharge in liters per minute and converted into depth (mm-ha). The experimental data pertaining to each character was analyzed statistically with the help of SPSS-10 package at IASRI, New Delhi, by using Analysis of Variance (ANOVA) technique for spit plot (Cochran and Cox, 1957).

RESULTS AND DISCUSSION

Growthattributes

The photosynthetic activities of the plants are well reflected in their dry matter production. The dry matter accumulation and number of tillers m[-2] are directly related to the growth pattern of the crop, which linearly influences the biological yield. A significant difference in drymatter and number of tillers m[-2] was observed with irrigation given one day after disappearance of ponded water (DADW) over three DADW. This might be due to moisture stress prevailed with irrigation given 3 DADW.

Significant increase in dry matter and tiller production due to one day after disappearance of ponded water has also been reported by Balasubramanian (1998).

Various plant density also significantly influenced growth attributes. Maximum dry matter accumulation was registered with 30 X 30 cm spacing which was statistically at par with 20 X 20 cm spacing but was significantly superior over 40 X 40 cm spacing. These results are closely related with finding of Damini *et al.* (2014). Square planting of rice at 30 cm recorded significantly higher number of tillersm[-2] than all other treatments. These findings are in conformity with Hardev *et al.*(2014). The higher values of dry matter accumulation and number of tillers m[-2] might be due to better utilization of resources under square planting method with wider spacing. It depends upon the photosynthesis and respiration rate which finally increase the plant growth with respect to dry matter and tillers etc.

Transplanting of 15 days old seedling was recorded significantly higher growth parameters *viz.* dry matter accumulation and number of tillers m[-2] compared to other age of seedlings. This might be due to transplanting of seedling from younger stage provide quick and better establishment of younger seedling leads to more utilization of natural resources provided excellent vegetative growth. Thus result is in agreement with the findings of Gani *et al.* (2002) and Damini *et al.*(2014).

System of Rice Intensification had positive influence on dry matter accumulation but which was found at par with conventional rice. Significantly higher number of tillers m[-2] was obtained under SRI than conventional rice. The greater number of tillers with SRI might be largely due to wider spacing and transplanting of young seedlings that are able to complete

Table 1: Effect of irrigation regimes, spacing and age of seedling on growth, yield attributes and yield of rice grown under System of Rice Intensification (Pooled data of two years)

Treatment	Dry matter accumulation at 90 DAT (g m^{-2})	Number of tillers m[-2]	Number of panicles m[-2]	Number of Grains panicle[-1]	1000 grain weight (g)	Grain yield (q ha^{-1})
Irrigation regimes						
One DADW	1232.07	273.83	272.06	117.14	24.41	55.72
Three DADW	1180.32	257.23	254.34	111.83	22.73	53.23
S.Em. ±	16.49	3.55	3.74	1.55	0.31	0.76
CD (P = 0.05)	49.02	10.56	11.1	4.61	0.93	2.25
Spacing (cm)						
20 x 20	1237.13	281.61	278.85	108.27	22.6	56.16
30 x30	1282.21	296.32	294.11	114.35	23.86	60.01
40 x 40	1099.04	218.66	217.38	120.74	24.25	47.25
S.Em. ±	20.2	4.35	4.57	1.95	0.38	0.92
CD (P = 0.05)	60.01	12.93	13.6	5.65	1.14	2.75
Age of seedling (day)						
15	1282.28	280.52	278.18	116.26	24.35	56.08
20	1203.8	262.58	259.83	114.47	23.52	54.23
25	1163.78	253.49	250.85	112.72	22.84	53.12
S.Em. ±	22.37	4.85	5.12	2.08	0.42	0.97
CD (P = 0.05)	63.94	13.86	14.63	NS	1.21	2.92
SRI vs. Conventional						
SRI	1231.13	292.66	291.05	114.48	24.05	54.47
Conventional	1157.93	265.38	262.95	108.61	23.2	47.26
S.Em. ±	51.89	10.35	10.97	4.91	1.00	2.04
CD (P = 0.05)	NS	19.03	NS	NS	NS	4.13

more phyllochrons of growth before anthesis due to their more favorable growing conditions above and below ground compared to rice grown under conventional system (Nemoto et al. (1995); Stoop et al. (2002); Thakur et al. (2010b)). Thakur et al. (2011) observed that the SRI irrigation practice registered the increased plant height and number of tillers m^{-2} than the conventional practice of irrigation.

Yield attributes

The number of panicles m^{-2}, number of grains panicle^{-1} and 1000 grains weight are important yield attributing characters, which directly affects the grain yield of the crop. Significant improvement in yield attributes i.e.number of panicles m^{-2} number of grains panicle^{-1} and 1000 grains weight was recorded with one DADW than 3 DADW. This might be due to increasing the number of irrigation levels and optimum moisture availability at all the time of reproductive stage. These results are closely related to the findings of Thakur et al. (2014).

The highest number of panicles m^{-2} and number of grains panicle^{-1} was recorded significant under the treatment 30 X30 cm spacing in comparison to 20 X 20 cm and 40 X40 cm spacing, due to advantage of space and less competition for resources. Kumar et al. (2006), Thakur et al. (2010) and Hardev et al. (2014) also reported similar results. In case of 1000 grain weight the wider spacing of 40 X 40 cm was registered significantly higher 1000 grain weight over closer spacing of 20 X 20 cm but which was statistically at par with 30 X 30 cm spacing. The increased plant spacing considerably resulted in vigorous plant growth and caused a significant increase in 1000 grain weight. The results are in accordance with Edwin (2008).

Significant variations in yield attributes were visualized due to various ages of seedling. Significantly higher values of all the yield attributes i.e. number of panicles m^{-2} , grains panicle^{-1} and 1000 grain weight were recorded with 15-day old seedling than other age of seedling. Among 20 and 25 days old seedling, maximum number of panicles m^{-2} was recorded with 20 days old seedling which was statically at par with 25 days old seedlings. The number of panicles m^{-2} depends on age of seedling; younger seedlings recorded maximum tillering than aged seedlings Reddy and Reddy (1991). Similarly 15-day old seedling produced significantly marked variation in 1000 grain weight among age of seedlings over 25 days old seedling,which was statistically at par with 20 age of seedlings. Similar findings were reported by Sarwa et al. (2011); Styger et al. (2011); Singh and Singh (2012).Yield attributes viz., number of panicle m^{-2}, number of grains panicle^{-1} and 1000 grain weight under SRI were at par with conventional rice but remained superior to conventional rice.

Grain yield

The crop raised by application of irrigation one DADW gave significantly higher grain yield of 4.68 % over 3DADW.Thakur et al., 2014)also reported that compared with continuous flooding, 1 DADW to 5 DADW treatments produced higher grain yield under SRI. The results of the present investigation was in agreement with Balasubramanian and Krishnarajan (2000). Almost all the growth and yield attributing characters seems to be affected by the increasing level of irrigation while at the moisture stress condition for longer period, the photosynthetic activities were reduced owing to the closure

of stomata which resulted the supply of CO_2 and the capacity of protoplasm to carry on photosynthetic efficiency and reduced translocation of the end products (Chowdhury et al., 2014). Reduced translocation might have hindered further accumulation of the end product while it was just reversed in the case of the treatment received sufficient water throughout growing period (Sarath and Thilak, 2004) .

The results pertaining to grain yield of rice revealed that Spacing of 30 X 30 cm resulted significantly higher grain yield. The percentage increase in grain yield owing to spacing of 30 X 30 cm was 6.86% and 27.00 % over closer spacing of 20 X 20 cm and wider spacing of 40 X 40 cm respectively. The optimum level of plant population coupled with better yield attributing parameters might have resulted in higher grain yield of rice under 30 X 30 cm spacing. These findings are in conformity with findings of Lhendup (2006) and Krishna et al. (2008).

Among the age of seedlings, 15 day old seedling registered significantly higher grain yield (56.08 q ha^{-1}) over 25 days old seedlings which was statistically at par with 20 days old seedlings. However the grain yield among 20 and 25 day aged seedling was differed non significantly. These results in close accordance with Thiyagarajan et al.(2002) , Vijaykumar et al.(2006), Damini et al. (2014). Such increased yield might be due to maximum number of panicle $m^{-2,}$ number of grain spanicles^{-1} and 1000 grain weight.The treatment 15 days old seedling was recorded significantly highest gross returns than 25 days old seedling but statistically found at par with 20 days aged seedling.

Significantly superior grain yield was obtained under SRI (54.47 q ha^{-1}) compared to conventional rice (47.26 q ha^{-1}).SRI practice produced 15.26 % higher grain yield over conventional rice.The present findings are in agreement with those reported by Krishna et al. (2008) and Islam et al. (2014). Such increased yield might be mainly due to significantly higher number of tillers m^{-2} and cumulative effect of superior yield attribute viz., Number of panicle m^{-2}, number of grain spanicle^{-1} and 1000 grain weight under SRI. Tillering was an important agronomic trait, which finally determines the number of panicles, grains and grain yield per unit land area (Liu-Guo Hua et al.,2003).

SRI practices for planting space of 30 X 30 cm, irrigation one day after disappearance of ponded water and younger seedling of 15 days are recommended as good combinations for SRI. These results are in agreement with those found by other researchers like Krishna et al. (2008) and Vijayakumar et al. (2001). That higher grain yield is achieved in the treatment with younger seedlings (14 days old) transplanted at wider spacing (25x25 cm^2 to 30x30 cm^2) under non-flooded soil moisture conditions.

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