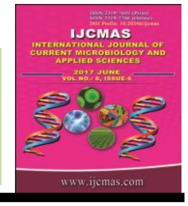
Int.J.Curr.Microbiol.App.Sci (2017) *6*(6): 130-135

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 6 Number 6 (2017) pp. 130-135**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2017.606.015

Effect of Irrigation Scheduling and Nitrogen Application on Yield, Grain Quality and Soil Microbial Activities in Direct–Seeded Rice

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Keywords

Hulling,
Head rice recovery,
Milling,
Protein content,
Soil microbial activities

Article Info

Accepted:
04 May 2017
Available Online:
10 June 2017

A B S T R A C T

A field experiment was carried out to study the response of irrigation scheduling and split application of nitrogen on yield, grain quality parameters and soil microbial activities of direct-seeded rice (DSR) during the kharif season 2015 at New Delhi. The experiment was laid out in split plot design with 12 treatments combination of irrigation scheduling viz., 0 kPa; 10 kPa, 20 kPa and 40 kPa irrigation scheduling threshold was maintained between tillering to flowering stages in main plot and application of N @ 120 kg/ha as control (N0), half recommended dose of nitrogen (RDN) as basal + one-fourth RDN at week 2 + one-fourth RDN at week 5, and one-fourth RDN as basal + one-fourth RDN at week 2 + one-fourth RDN at week 5 + one-fourth RDN at week 9 after sowing in sub plot with three replications. The results bring to light that irrigation scheduling at 0 kPa recorded the highest yield, grain quality parameters and soil microbial activities. As regards of N application the yield, grain quality parameters and soil microbial activities were significantly influenced by split application of N. With increase in the number of splits application along with basal application found more effective over control.

Introduction

Rice (*Oryza sativa* L.) is the staple food for more than half of the world's population, and more than 90% of the world's rice is produced in Asia (FAO, 2009). However, the high water requirement of conventional, continuously flooded puddled transplanted rice (PTR) has become a major threat to the sustainability of rice production in regions facing current or future water scarcity. This is especially the case in the northwest Indo-Gangetic plains (IGP) of India, where the production of irrigated rice and wheat is critical for food security of the country (Humphreys *et al.*, 2010). The steady decline of ground water has led to general acceptance of the need to find ways to reduce irrigation water input while maintaining yield (Yadav *et al.*, 2011). One way to reduce water input to rice is by improved irrigation management such as reduction in ponded water depth (Kukal and Aggarwal, 2002), use of saturated soil culture (Borrell *et al.*, 1997) and direct-seeding of rice (Bhushan *et al.*, 2007). Direct–seeded rice (DSR) is the technology which is water, labour and energy efficient along with eco-friendly characteristics and can be a potential alternative to conventional PTR (Kumar and Ladha, 2011). Here, sowing of rice is done under non-puddled conditions and the crop is not subjected to transplanting stress (Singh *et al.*, 2008). Crop-weed competition, iron deficiency and nematodes are the major problems in DSR (Kreye *et al.*, 2009). Nonetheless, the shifting from TPR to DSR technologies can save resources in long run. Likewise, the nitrogen use efficiency (NUE) in rice is very low ~ 33% as applied N is lost through various processes. The different moisture conditions in DSR as compared to PTR lead to temporal variability of crop response to N (Cassman *et al.*, 1996). Greater fertiliser NUE in rice can be achieved by using Nefficient varieties, improving timing and application methods and better incorporation of basal N fertiliser application without standing water (Ali *et al.*, 2007). In the light of the above context the present study was undertaken to investigate the effect of water and nitrogen management practices to improve the yield, grain quality and soil microbial activities of DSR.

Materials and Methods

A field experiment was conducted during the kharif season 2015 at the research farm of ICAR-Indian Agricultural Research Institute, New Delhi, India. The farm was situated at latitude of 28º40’ N and longitude of 77º12’ E, altitude of 228.6 m above the mean sea level. The soil was sandy clay loam with low in organic C and available N, medium in available P and high in available K with pH 7.9 at the experimental site. The total rainfall received during the period of experimentation was 748.5 mm. The experiment was laid out in split plot design with 12 treatments combination of irrigation scheduling (0 kPa; 10 kPa, 20 kPa and 40 kPa irrigation scheduling threshold was maintained between tillering to flowering stages) in main plot and N application @ 120 kg/ha (control (N0), half RDN basal + one-fourth at week 2 + one-fourth at week 5 and one-fourth RDN basal + one-fourth at week 2 + one-fourth at week 5 + one fourth at 9 week after sowing) in sub plot with three replications. The rice variety ‘Pusa Basmati 1509’ was sown with the help of multi-row crop planter at 22.5 cm row to row spacing on June 24, 2015. The seed rate was 30 kg/ha. The recommended dose of 60 kg P2O5 through single super phosphate and 60 kg K2O/ha through Muriate of potash was applied basal. A pre-emergence application of pendimethalin @ 0.75 kg/ha followed by post emergence application of bispyribac @ 0.025 kg/ha was done for effective weed management. Irrigations were given as per irrigation scheduling in different plots during the crop season. Data on yield, grain quality parameters and soil microbial activities were analysed as per the standard procedures. The grain yield was calibrated after the produce was sun dried for three days. The weighing for yield was done when the moisture content in grain was 12.5%. The physical characters of grain were recorded using standard procedures as per the details given below:

$$\text{Hulling (\%)} = \frac{\text{Weight of brown rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

$$\text{Milling (\%)} = \frac{\text{Weight of milled rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

$$\text{Head rice recovery (\%)} = \frac{\text{Weight of whole milled rice (g)}}{\text{Weight of rough rice (g)}} \times 100$$

Results and Discussion

Yield and grain quality

The outcomes of the study showed that scheduling of irrigation at various thresholds and split application of N significantly influenced the yield, rice grain quality parameters (Table 1) and microbial activities (Table 2) of DSR. The highest yield was observed with irrigation scheduling at 0 kPa i.e. in saturated condition which was found at par with maintaining water threshold in soil through irrigation at 10 kPa. Thereafter irrigation scheduling at higher threshold i.e. 20 kPa and 10 kPa throughout the growing season except 40 kPa during tillering to flowering recorded a decline in grain yield of DSR during the growing season. Though, the treatments 10 kPa throughout the growing season except 40 kPa during tillering to flowering was found comparable with 20 KPa during the experimentation season. The similar findings also reported by Mahajan *et al.*, (2006) and Maheswari *et al.*, (2007). Regarding N application, the yield was significantly improved by increasing number of splits of N fertilizer over control. The lowest values of yield were recorded in control (N0) plots which were significantly lower than the N application treatments. The highest yield was observed with split application of RDN as one-fourth basal + one-fourth at week 2 + one-fourth at week 5 + one fourth at week 9 after sowing was found comparable with one-fourth RDN basal + one-fourth at week 2 + one-fourth at week 5. The variation in partitioning of photo synthates in grain and vegetative organs of different treatments possibly caused a significant variation in yield (Jat *et al.*, 2014). The significant differences were recorded in the quality parameters of rice grain along with different irrigation scheduling thresholds and nitrogen. The highest value was observed with irrigation scheduling at 0 kPa which was found at par with 10 kPa in terms of quality parameters such as hulling, milling, head rice recovery, protein content and protein yield in DSR.

Table.1 Effect of irrigation scheduling and N application on yield and Rice grain quality parameters of direct seeded rice

Treatment	Grain yield (t/ha)	Hulling (%)	Milling (%)	Head rice recovery (%)	Protein content (%)	Protein yield (kg/ha)
Irrigation scheduling						
0 kPa	4.83	70.3	64.7	54.7	7.72	376.9
10 kPa	4.68	68.0	63.7	52.7	7.64	361.6
20 kPa	4.24	67.3	63.3	50.7	7.50	324.2
40 kPa*	3.96	67.0	62.0	48.8	7.24	291.9
SEm±	0.13	0.61	0.67	0.75	0.10	11.71
LSD (*P*=0.05)	0.46	2.11	NS	2.58	NS	40.51
Nitrogen application						
Control (N_0)	3.60	65.0	61.3	48.7	6.70	229.3
N_1**	4.62	67.7	63.0	50.7	7.76	359.6
N_2***	5.06	71.7	66.0	55.8	8.12	427.0
SEm±	0.06	0.53	0.50	0.40	0.07	8.35
LSD (*P*=0.05)	0.18	1.58	1.50	1.21	0.20	25.04

*10 kPa throughout the growing season except 40 kPa during tillering to flowering;
**Half basal + one-fourth at week 2 + one-fourth at week 5
***One-fourth basal + one-fourth at week 2 + one-fourth at week 5 + one-fourth at week 9

Table.2 Effect of irrigation scheduling and nitrogen application on soil Microbial activities in direct seeded rice

Treatment	Dehydrogenase activity (µg TPF/g soil/day)	Alkaline Phosphatase activity (µg/g soil/hr)	Microbial biomass carbon(µg/g soil)	Fluorescein diacetate activity (µg/g soil/hr)
Irrigation scheduling				
0 kPa	138.5	36.6	143.4	1.21
10 kPa	141.4	34.0	138.9	1.18
20 kPa	158.2	32.6	127.7	1.01
40 kPa*	161.1	31.6	113.4	0.94
SEm±	1.45	1.02	4.22	0.02
LSD (*P*=0.05)	5.02	NS	14.60	0.08
Nitrogen application				
Control (N_0)	124.1	26.0	105.6	0.88
N_1**	138.8	34.3	134.0	1.14
N_2***	186.5	40.7	153.1	1.24
SEm±	0.97	0.92	2.86	0.01
LSD (*P*=0.05)	2.92	2.75	8.59	0.03

*10 kPa throughout the growing season except 40 kPa during tillering to flowering;
**Half basal + one-fourth at week 2 + one-fourth at week 5
***One-fourth basal + one-fourth at week 2 + one-fourth at week 5 + one-fourth at week 9

Likewise, N management also significantly influenced the value of hulling, milling, head rice recovery, protein content and protein yield. Application of one-fourth RDN basal + one-fourth at week 2 + one-fourth at 5 week + one fourth at week 9 after sowing recorded highest values followed by N application as one-fourth RDN basal + one-fourth at week 2 + one-fourth at week 5. The higher values of grain quality parameters with irrigation scheduling and N fertilization might be due to increase in N concentrations in rice grain and this attributed to increase in protein content which gave less breakage (Singh *et al.*, 2015). Therefore, higher protein content imparts strength to the grains resulted in greater head rice recovery (Kaushal *et al.*, 2010).

Soil microbial activities

Soil microbial activities viz. dehydrogenase activity, microbial biomass carbon (MBC) and fluorescein diacetate activity (FDA) were significantly influenced by different irrigation scheduling thresholds at flowering stage except alkaline phosphatase activity (APA). The maximum soil dehydrogenase activity was recorded in the treatments with irrigation scheduling at 10 kPa throughout the growing season except 40 kPa during tillering to flowering which was at par with 20 KPa. The higher dehydrogenase activity might be owing to availability of aerobic environment with higher levels of irrigation threshold (Saha, 2013). However, the maximum activity of APA, MBC and FDA was observed with 0 kPa irrigation scheduling threshold which was statistically at par with 10 kPa. This could be due to optimum moisture availability which gave a favourable environment for soil habituating microbes (Jedidi *et al.*, 2004). The significant effect of split application of N was recorded on soil microbial activities over control. The soil microbial activities were higher with split application of one-fourth RDN basal + one-fourth at week 2 + one-fourth at week 5 + one fourth at week 9 after sowing recorded highest values followed by N application as one-fourth RDN basal + one-fourth at week 2 + one-fourth at week 5. The microbial parameters indicated the biological redox system respiratory chain enzyme of soil microorganisms, which denoted that microbial activities were influenced with N application. The MBC is component of soil organic matter and it plays a vital role in nutrient cycling and stabilization of soil organic matter (Dhull *et al.,* 2004).

In conclusion, the study concludes that irrigation scheduling at 0 kPa *i.e.* in saturated condition recorded the highest productivity, grain quality parameters such as hulling, milling, head rice recovery, protein content and protein yield, and the soil microbial activities which were found on par with maintaining water threshold in soil through irrigation at 10 kPa. Likewise, the highest yield, grain quality parameters and soil microbial activities were observed with split application of RDN as one-fourth basal + one-fourth at week 2 + one-fourth at week 5 + one fourth at week 9 after sowing was found comparable with one-fourth RDN basal + one-fourth at week 2 + one-fourth at week 5.

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How to cite this article:

Anita Kumawat, Seema Sepat, Dinesh Kumr, Surender Singh, Dinesh Jinger, Shanti Devi Bamboriya and Anil Kumar Verma. 2017. Effect of Irrigation Scheduling and Nitrogen Application on Yield, Grain Quality and Soil Microbial Activities in Direct–Seeded Rice. *Int.J.Curr.Microbiol.App.Sci.* 6(6): 130-135. doi: https://doi.org/10.20546/ijcmas.2017.606.015