Bulletin of Environment, Pharmacology and Life Sciences
Bull. Env. Pharmacol. Life Sci., Vol 8 [10] September 2019 : 58-63
©2019 Academy for Environment and Life Sciences, India
Online ISSN 2277-1808
Journal's URL:http://www.bepls.com
CODEN: BEPLAD
Global Impact Factor 0.876
Universal Impact Factor 0.9804
NAAS Rating 4.95

ORIGINAL ARTICLE **OPEN ACCESS**

Combined Influence of Different Rice Cultivation Systems with Azolla and Blue Green Algae on Water Productivity and Yield

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ABSTRACT

Study was to compare the effects of different systems of rice cultivation such as System of Rice Intensification (SRI), Alternate Wetting and Drying (AWD), Conventional method and Direct Wet Seeding (DWS) for water productivity and yield. The experiments were carried out in Ponnaniar Basin, Trichy District, Tamil Nadu during rabi and kharif seasons. The short duration rice hybrid 'CO47' was used in both seasons as test crop. The main plots at each site were allotted with different cultivation systems and in sub plots, recommended dose of fertilizer (RDF), RDF with Azolla, RDF with Blue green algae (BGA) and RDF with Azolla and BGA, respectively. In the study, the water productivity was found to be high in SRI followed by AWD, Conventional and direct wet seeding. SRI registered maximum water productivity of 0.320 and 0.351 kg of grains per m^3 of water in rabi and kharif. SRI plots applied with RDF, Azolla and BGA consumed 58.05 per cent and 49.90 per cent lesser water compared to Direct Wet Seeding system of cultivation. In Rabi season, SRI plots applied with RDF, Azolla and BGA registered the maximum grain yield of 6316 kg ha^{-1} and the increase was to the tune of 34.14 per cent over the direct wet seeding system with RDF and in kharif, SRI with RDF, Azolla and BGA recorded the maximum harvest index of 0.43. Systems without alternate wetting and drying of irrigation recorded lower grain yield per unit quantity of water used.

Keywords: Cultivation systems, yield, Water productivity, Azolla and Blue Green Algae

Received 29.07.2019 Revised 14.08.2019 Accepted 01.09. 2019

INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food for billions of people. To assure food security in the rice-consuming countries of the world, farmers must produce more rice of better quality to meet the demands of consumers in coming years [1]. Hence high priority needs to be given to enhance the conveyance and application efficiencies of irrigation water in Agriculture. Rice is very sensitive to water stress and attempts to reduce water inputs may cause yield reduction. The challenge is to develop novel technologies and production systems that would allow rice production to be maintained or increased at the face of declining water availability. Two possible options are to minimize water losses through better management thus ensuring more water for crop production, and improve water use efficiency by increasing production per unit of water [2]. Lowland rice can produce high yield but with high water input since it is grown in puddled lowland field that requires continuous flooding [3]. Generally, 3 000 to 5 000 L water is needed to produce 1 kg rice [4] depending on the different rice cultivation methods such as transplanted rice, direct sown rice (wet seeded), alternate wetting and drying method (AWD), system of rice intensification (SRI) and aerobic rice. There are evidences that cultivation of rice through system of rice intensification (SRI) can increase rice yields by two to threefold compared to current yield levels [5]. Rice having drainage period after irrigation gives maximum water use efficiency compared to continuous submergence or submergence at critical stages such as tillering, panicle initiation, flowering and milk, followed by saturation or field capacity between intermittent periods [6]. Alternate wetting and drying with spacing gives higher yield in rice [7].

MATERIAL AND METHODS

Field experiments were carried out during rabir and kharif at Ponnaniar Basin, Trichy District to evaluate the performance of different systems of rice cultivation. Treatments consisted of different rice cultivation methods viz., system of rice intensification (I_1), alternate wetting and drying method (I_2) conventional method (I_3) and Direct wet seeded (I_4) cultivation with recommended dose of fertilizer (RDF-T_1), RDF + *Azolla* (T_2), RDF+ Blue green algae (BGA) (T_3) and RDF+ *Azolla* + BGA (T_4), in three replications. Rice hybrid CO47 was studied as test crop. All the agronomic practices for conventional method and direct puddle sowing method were followed as per the standard recommendations given in Crop Production Guide for Tamil Nadu [8]. Water management varied in different treatments as per the recommended practices. Immediately after decrease in the standing water level, irrigation at 5 cm depth was applied in conventional and direct wet seeded methods. Application of 2.5 cm depth of water after the formation of hairline crack was followed in SRI and AWD. Azolla (@ 250 kg ha^{-1}) and BGA (@ 10 kg ha^{-1}) were applied during active tillering stage. Observations on growth and yield characters were done at critical stags of crop growth. The quantum of water used per irrigation was measured using water meter and from the number of irrigations the total quantity of water used was calculated. Water Productivity (WP) was calculated on agronomic yield (kg of grain) per unit of water used (m^3 of water) as follows [9],

$$\mathbf{WP} = \frac{\text{Yield}}{\Sigma(\text{ I+R})} \text{ kg m}^{-3}$$

WP = Water productivity; Y = Yield; I = Irrigation water applied; R = Amount of rainfall

The data on various parameters studied during the course of investigation were statistically analyzed [10]. Wherever the treatment differences were found significant, critical difference (CD) were worked out at the 5 per cent level of significance with mean separation by least significant difference.

Results and Discussion

Grain yield of different systems of rice cultivation

Among the different systems of rice cultivation, System of Rice Intensification (SRI) recorded higher yield followed by Alternate Wetting and Drying (AWD), Conventional and Direct wet seeding systems. The grain yield under SRI system was significantly higher than AWD, conventional and DWS in both seasons. Grain yield ranged from 6018 to 6316 kg ha^{-1} and 6117 to 5933 kg ha^{-1} in SRI during *rabi* and *kharif* season respectively. The SRI plots treated with *Azolla* and BGA (I_1T_4) produced significantly higher grains yield (6316 kg ha^{-1} and 6117 kg ha^{-1}) in both seasons.

The DWS plots applied with RDF alone recorded lowest yield of 4160 and 3660 kg ha^{-1} respectively during *Rabi* and *Kharif* season. Rice yield was significantly higher in the SRI plots applied with BGA and *Azolla*. It was emphasized that application of BGA and *Azolla* reduced GHG flux without reducing rice yields and can be used as a practical mitigation option for minimizing the global warming potential of rice ecosystem [11]. The effect of *Azolla* and BGA on the yield of crops in the presence of N fertilizers has commonly been ascribed to the production of growth promoting substances by these organisms [12]. The present field study reiterates that biofertilization of paddy fields with blue green algae is a potential climate change mitigation strategy due to their effect in minimizing methane emission, besides yield enhancement by nitrogen fixation. The higher yields were reported in *Azolla* and BGA treated plots due to the high algal and *Azolla* biomass which can be explained by the earlier results obtained [13].

Yield improvement of rice between 5 per cent and 25 per cent was found when fields were inoculated with BGA even in the presence of 100 to 150 kg N ha^{-1} as fertilizer. N-fixing blue-green algae (BGA) or cyanobacteria and *Azolla*, have been shown to be the most important in maintaining and improving the productivity of rice fields [14]. It has been demonstrated that the N fertility of soil is sustained better under flooded conditions than under dryland conditions [15]. In our study Biological N_2 fixation by BGA and *Azolla* (*Anabaena azollae*) is considered to be one of the reasons for the relatively high yield of rice in plots applied with these organisms in all the systems of cultivation.

Water usage and productivity of different systems

Combined influence of different cultivation systems on total amount of water used and water productivity of rice in *rabi* and *kharif* seasons are presented in Table 2. In the present investigation Direct Wet Seeding and Conventional system of rice cultivation consumed more amount of water than the SRI and AWD method. On an average SRI cultivation consumed 2844.5 and 3063.39 m^3 of water to produce per ton of rice which is 34.2 per cent lesser than conventional system in both seasons (Fig.1). Conventional rice cultivation used high amount of water (23015 to 23437 and 21108 to 21887 m^3), followed by direct wet seeded rice and AWD. SRI used minimum quantity of water (18015 to 18795 and 17105 to 17898 m^3, respectively) during both the seasons compared to other methods.

Similarly 3086.59 and 3774.05 m^3 of water was used in AWD to produce one ton of rice in *rabi* and *kharif* seasons. It was found that an average of 9204 m^3ha^{-1} is required for an average yield of 4465 kg ha^{-1} in

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India [16]. In our study the water productivity for SRI, AWD, Conventional and DWS were 0.333 and 0.338, 0.306 and 0.324, 0.214 and 0.232, 0.190 and 0.202 kg m^3 in *rabi* and *kharif* seasons, respectively. To produce 1 kg of rice, on an average 2500 litres of water is used under the controlled irrigation rice production system (equal to a water productivity of 0.4 kg m^3). With respect to water productivity, SRI method of rice cultivation registered the higher water productivity (0.320 to 0.351 and 0.358 to 0.331 kgm^{-3}), followed by AWD method during both the seasons. The conventional rice cultivation and direct wet sowing rice produced lower grain yield per unit quantity of water used.

Under the SRI system, reducing irrigation water application through alternate wetting and drying is one of the main principles. This is reported in a number of studies in India and China, confirming water productivity improvements from 32 to 100 per cent, with associated yield increases of 5 to 51 per cent [17 & 18]. It was reported 30 to 50 per cent less irrigation water is used per hectare, which translates to reduced costs for water pumping, infrastructure maintenance and lower amortization rate as pumps can last longer when used less intensively [19].

The productivity of water for SRI was twice (0.30 kg m^{-3}) compared with continuous flooding (0.13 kg m^{-3}). SRI crop and water management practices with conventional flooded rice production, it was seen that with SRI methods, higher yields were attained consistently in all of the treatments when using less irrigation water. Among the notable savings of irrigation water were also reported, 74 per cent [20], 57 per cent [21] and 52 per cent [22]. It was [23] found that 0.24 kg m^{-3} in the SRI trials, and 0.11 kg m^{-3} in the non-SRI trials and 44 per cent average reduction in water use ranged from 24 to 60 per cent.

In the present study, shows significant difference in water use efficiency under different irrigation levels. The value of WUE was found to be the maximum with SRI with RDF and combined use of *Azolla* & BGA) and the minimum with DWS and RDF). Increase in yield was relatively lesser than increase in quantity of irrigation which consequently decreased WUE under higher number of irrigations. Similar results were reported [24 & 25]. In *Rabi* season, SRI plots applied with recommended doze of fertilizer, *Azolla* and BGA registered the maximum grain yield of 6316 kg ha^{-1} and the increase was to the tune of 34.14 per cent over the direct wet seeding system with recommended doze of fertilizer. Similarly in *kharif*, SRI with recommended doze of fertilizer, *Azolla* and BGA recorded the maximum harvest index of 0.43. The application of photosynthetic diazotrophic systems such as Blue Green Algae and *Azolla* enhanced the water productivity in all systems of cultivation by improving the grain yield.

Table 1.Combined influence of different rice cultivation systems with Azolla and BGA on yield and Harvest Index

Treatments		***Rabi* season**		***Kharif Season***	
		Grain Yield (Kg ha^{-1})	**Harvest Index**	**Grain Yield (Kg ha^{-1})**	**Harvest Index**
I_1	**T_1**	6018	0.41	5933	0.41
	T_2	6068	0.40	5967	0.40
	T_3	6120	0.41	6033	0.41
	T_4	6316	0.43	6117	0.43
I_2	**T_1**	5656	0.38	5617	0.38
	T_2	5895	0.40	5833	0.40
	T_3	5921	0.41	5950	0.41
	T_4	5973	0.42	6017	0.42
I_3	**T_1**	4933	0.39	4917	0.39
	T_2	4913	0.38	4950	0.38
	T_3	4963	0.38	4983	0.38
	T_4	5065	0.40	5083	0.40
I_4	**T_1**	4160	0.38	3660	0.36
	T_2	4275	0.38	3790	0.36
	T_3	4305	0.40	4015	0.37
	T_4	4440	0.40	4055	0.37
Mean		**5314**	**0.40**	**5183**	**0.39**

	SED	**CD**	**SED**	**CD**	**SED**	**CD**	**SED**	**CD)**
I	48.48	119.55	0.003	0.008	81.81	200.19	0.004	0.011
T	65.93	136.67	0.004	0.008	53.22	109.85	0.004	0.008
I x T	112.2	*	0.007	*	123.25	*	0.008	0.018
T x I	1.86	*	0.007	*	106.45	*	0.008	0.017

* Non significant

Table 2. Combined influence of different rice cultivation systems on water usage and water productivity

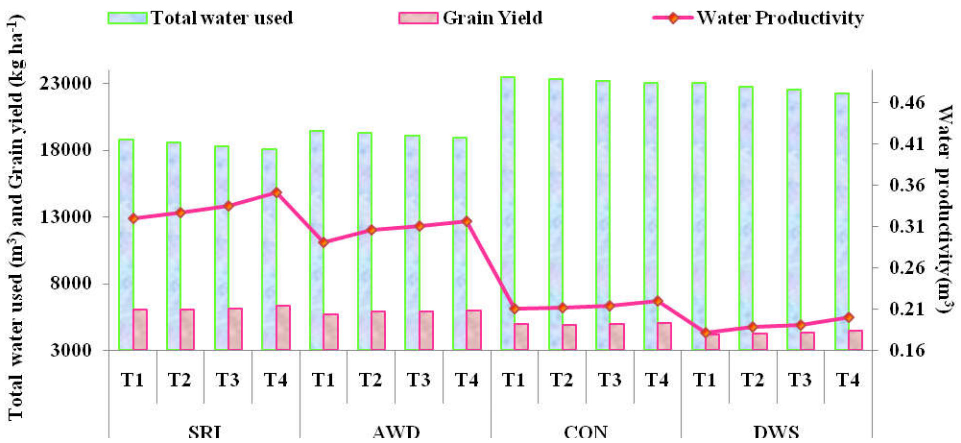
Treatments		*Rabi* season		*Kharif* Season	
		Total water used ($m^3 ha^{-1}$)	Water Productivity ($Kg\ m^{-3}$)	Total water used ($m^3 ha^{-1}$)	Water Productivity ($Kg\ m^{-3}$)
I_1	T_1	18795	0.320	17898	0.331
	T_2	18581	0.327	17475	0.341
	T_3	18260	0.335	17227	0.350
	T_4	18015	0.351	17105	0.358
I_2	T_1	19405	0.291	18373	0.306
	T_2	19234	0.306	18129	0.322
	T_3	19030	0.311	18007	0.330
	T_4	18928	0.316	17808	0.338
I_3	T_1	23437	0.210	21887	0.225
	T_2	23295	0.211	21610	0.229
	T_3	23140	0.214	21372	0.233
	T_4	23015	0.220	21108	0.241
I_4	T_1	22980	0.181	19405	0.189
	T_2	22735	0.188	19326	0.196
	T_3	22524	0.191	19185	0.209
	T_4	22187	0.200	18890	0.215
Mean		**20848**	**0.261**	**19050**	**0.276**

	SED	CD	SED	CD	SED	CD	SED	CD
I	99.84	244.31	0.003	0.008	170.61	417.49	0.002	0.006
T	227.07	468.65	0.002	0.004	190.70	393.59	0.003	0.006
I x T	405.77	*	0.005	*	371.77	*	0.005	*
T x I	454.14	*	0.004	*	381.41	*	0.006	*

* Non significant

Figure 1. Systems of cultivation on water used, water productivity and grain yield

Rabi season



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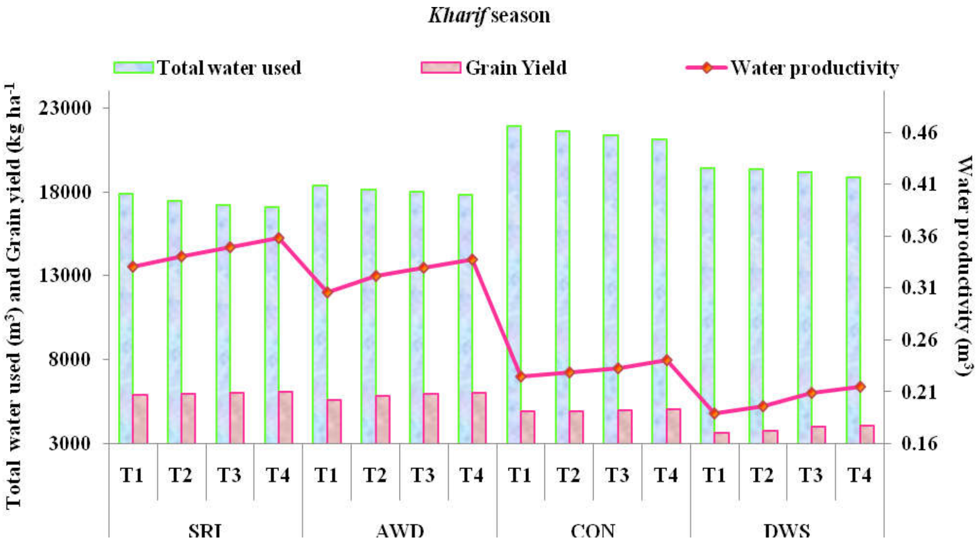

ACKNOWLEDGEMENTS

We wish to express our appreciation to Royal Norwegian Embassy, New Delhi for providing financial assistance to carry out this study under the ClimaAdapt research programme.

REFERENCES

1. Peng, S.B. and J.C. Yang. (2003). Current status of the research on high yielding and high efficiency in resource use and improving grain quality in rice. China J. Rice Sci., 17: 275-280
2. Peng, S., B. A. M. Bouman, R.M.Visperas, A.R. Castaneda, L. Nie, and H. Park, (2006). Comparison between aerobic and flooded rice in the tropics: Agronomic performance in an eight-season experiment. Field Crops Research., 96: 252-259.
3. Chan C S, Zainudin H, Saad A, Azmi M. (2012). Productive water use in aerobic rice cultivation. J. Trop. Agric. Food Sci., 49(1): 117–126.
4. Bouman B A M, Hengsdijk H, Hardy B, Bindraban P S, Tuong T P, Ladha J K. (2002). Water-wise rice production. In: Proceedings of the International Workshop on Water-Wise Rice Production. 8–11 April 2002. Los Baños, the Phillipines: International Rice Research Institute.
5. Uphoff, N. (2005). The development of the System of Rice Intensification," in J. Gonsalves et al. (eds.), *Participatory Research and Development for Sustainable Agriculture and Rural Development*, Vol. 3, 119-125, International Potato Center-UPWARD and International Development Research Centre, Ottawa.
6. Jaffar Basha S. and A. Sitha Rama Sarma. (2017). Yield and water use efficiency of rice (Oryza sativa L.) relative to scheduling of irrigations. Annals of Plant Sciences 6.(2): 1559-1565.
7. Tao Song, Feiyun Xu, Wei Yuan, Moxian Chen, Qijuan Hu, Yuan Tian, Jianhua Zhang, Weifeng Xu. (2019). Combining alternate wetting and drying irrigation with reduced phosphorus fertilizer application reduces water use and promotes phosphorus use efficiency without yield loss in rice plants. Agricultural water management, 223: 105686
8. Crop production guide.(2012). Tamil Nadu Agricultural University, Coimbatore. pp 3-38.
9. Grassi, C.(2009). Aerobic rice: crop performance and water use efficiency. Journal of Agriculture and Environment for International Development., 103 (4): 259-270.
10. Gomez, A. and A. Gomez. (1984). Statistical procedures for agricultural research. Willey inter-science publication, U.S.A.
11. Bharati, K . and S. R. Mohanty. (2000). Influence of incorporation or dual cropping of *Azolla* on methane emission from a flooded alluvial soil planted to rice in eastern india. Agric. Ecosyst. Environ. 79: 73-83.
12. Tupik , N.D. 1973. Study of the content of group B vitamins in cells of some blue green algae in dependence on the culture age. Ukr . Bot. Zh. 30: 636–639.
13. Roger, P.A., and A. Kulasoorisya. (1980). Blue-green Algae and Rice. Manila, Philippines: International Rice Research Institute.
14. Roger, P. A. (1996). Biology and management of the floodwater ecosystem in ricefields. International Rice Research Institute, Los Banos, Philippines, pp. 250.
15. Watanabe, A., R. Ito, C. Khonishi C. (1951). Effect of nitrogen-fixing blue-green algae on the growth of rice plants. Nature., 168: 748–749.
16. Pandian, B.J. (2010). The system of rice intensification: A unique system to produce more with less input. 28th International Rice Research Conference, 8-12 November 2010, Hanoi.
17. Geethalakshmi, V., T. Ramesh, A. Palamuthirsolai and A. Lakshmanan. (2011). Agronomic evaluation of rice cultivation systems for water and grain productivity', Archives of Agronomy and Soil Science, 57(2): 159 -166.

18. Ndiiri, J. A., B.M. Mati, P.G. Home, B. Odongo and N. Uphoff. (2012). Comparison of water savings of paddy rice under system of rice intensification (SRI) growing rice in Mwea, Kenya. International Journal of Current Research and Review, 4: 63-73.
19. Satyanarayana, A., T.M. Thiyagarajan and N. Uphoff. (2007). Opportunities for water saving with higher yield from the system of rice intensification. Irrigation Sci., 25: 99 – 115.
20. Singh, Y., Singh, K.K. and Sharma, S.K. (2013). Influence of crop nutrition on grain yield, seed quality and water productivity under two systems of rice cultivation. Rice Science, 20: 531-542.
21. Zhao, L., W.U. Lianghuan, L.I. Yongshan, Sarkar Animesh, Defeng Zhu and Norman Uphoff. (2010). Comparisons of yield, water use efficiency, and Soil Microbial Biomass as Affected by the System of Rice Intensification. Commun. Soil Sci. Plan. Anal., 41: 1 - 12.
22. Senthilkumar, K., P. Bindraban, T.M. Thiyagarajan, N. Ridderand and K. Giller. (2008). Modified rice cultivation in Tamil Nadu, India: Yield gains and farmers' (lack of) acceptance. Agricultural Systems, 98: 82-94.
23. Hameed, K. A., A. K. Mosa and F.A Jaber. (2011). Irrigation water reduction using system of rice intensification compared with. conventional cultivation methods in Iraq. Paddy and Water Environment, 9: 121-127.
24. Tripathi, H. P. and L. M. Jaishwal. (2006). Effect of nitrogen on yield and yield attributes of rice hybrids under irrigated condition. Oryza, 43(3): 249-250.
25. Ramakrishna, Y., S.Singh and S.Parihar. (2007). Influence of irrigation regime and nitrogen management on productivity, nitrogen uptake and water use by rice (Oryza sativa). Indian J. Agronomy. 52(2): 102-106.

CITATION OF THIS ARTICLE

Jeyapandiyan, N., A. Lakshmanan and V. Geethalaksmi. Combined Influence of Different Rice Cultivation Systems with Azolla and Blue Green Algae on Water Productivity and Yield. Bull. Env. Pharmacol. Life Sci., Vol 8 [10] September 2019: 58-63