Madras Agric.J., 2022; https://doi.org/10.29321/MAJ.10.000590

RESEARCH ARTICLE

Water Productivity of Red Rice Landraces under Organic Practices

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Received : 17th January,2022
Revised : 31st January,2022
Revised: 08th February,2022
Accepted : 17th February,2022

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ABSTRACT

Rice is a high yielding crop among the the cereals group. Even under adverse conditions, it performs fairly when compared to other cereals crops including wheat. The number of productive tillers hill^{-1} and panicle density (number of grains panicle^{-1}) and grain weight are the rice vital characteristics that determine the yield potential of the cultivars. Many native varieties have greater mean panicle density and grain weight than most high-yielding varieties (HYV). The yield efficiency of rice crop is calculated as production of grains per unit of inputs *viz.,* water and agrochemicals. Land races have the potential to yield upto 2 t ha^{-1} under adequate water supply and healthy build of soil fauna their rice fields. In

this study, field investigation was carried out to find out the best performing red rice variety/land races and identifying the best organic practices in the terms of higher water productivity and water use efficiency. The experiment revealed that TKM 9 (developed from *Kullakar* x IR 8) and organic amendment of vermicompost + *Azospirillum* + *phosphobacteria* + pink pigmented facultative methylotrops were found to have maximum water productivity and water use efficiency.

Keywords: *Red rice; Land races;Water productivity; Water use efficiency*

INTRODUCTION

Paddy can grow at an altitude of 7000 feet above sea level,and at an altitude of 10 feet below sea level. There are paddy varieties which can grow even if the annual rainfall is minimum of 500 mm or maximum of 5000 mm. Samhitas of the Yajurveda mention different varieties of grains such as *Vrihi, Yava, Masha, Tila, Mudga, Khalavarsha, Godhuma, Masura, Syamaka, Priyangu, Menava,* and *Nivara*. Regarding the other rice varieties mentioned, hill paddy and deep-water red rice varieties are prominent, as mentioned in the Jatakas (Cowell, 1957). *Udaraka* and *Varaka* are two new varieties of rice introduced during the Mauryan rule. Well-known Indian rice researchers, Richharia and Govindasamy, have reported in their book "Rice of India" which provides Vedic and present-day literature evidence to show that the country had been endowed with more than 2 lakh (200,000) rice varieties, rich biodiversity that no other country on earth possesses. Paddy can grow even in certain environmental conditions where other crops cannot grow.

In India, there are many varieties of paddy, which can be cultivated throughout the year. In an evaluation programme for biotic stresses, with around 12,750 rice entries reported by Indian Institute of Rice Research, Hyderabad, India, 28.31 per cent of entries were coloured rice. Of these 10.48 per cent, 9.41 per cent and 8.40 per cent were red, brown, and purple pericarps. The collection from Central Rice Research Institute, Cuttack, Orissa with 2,960 entries, mainly from the eastern states of India, had a relatively high number of red rice of which 20 per cent were colored rice. This colored rice is rich in minerals like iron, zinc, and polyphenol with antioxidant properties. So, these landraces are gaining interest for research studies. In Tamil Nadu, a greater number of red rice land races exist in Ramnad district and are found to be drought resistant.

Rice with a red bran layer is called red rice. Red rice was found to be a rich mineral source. The bran layer contains polyphenols and anthocyanin, and possesses antioxidant properties. The inner portion of red and white rice is white alike. The zinc and iron content of red rice is two to three times higher than white rice (Deb, 2000). The change in food habits from traditional foods to junk foods has increased the risk of lifestyle-related health issues and diseases like diabetes, cancer, and heart problems. Demand for red rice land races is increasing among the common people due to increased awarenessof red rice health benefits. This higher demand favors the small and marginal farmers to market their produce at comparatively higher prices than the high yielding varieties and thus, they get benefited with good returns from less inputs even under aberrant weather conditions. In addition to being nutritive and having medicinal value, rice land races possess many other special features. It is common that red- and black-husked rice are comparatively more resistant to storage insect pests than brown-husked rice. Red rice, too possess this feature. In Japan, red rice grains stored since 1905 have remained intact and preserved their original status, as against white-colored rice that was seriously damaged. The *Patni* rice of Maharashtra and the *Jatu* of Himachal Pradesh are well known for such hardiness and resistance. Agronomically, or from the cultivation point of view, such rice possess resistance to drought, flood, submergence, alkalinity, salinity, and resistance to pests and diseases.

So, on farmers point of interest, studies on red rice productivity factor under organic practices is a need of the hour, as organic practices minimize farm inputs (excluding agrochemicals). This research paper details the water productivity studies of red rice lands *viz., Kullakar, Kuzhiyadichan* and *Kattuyanam* compared to TKM 9 red variety released by rice research station, Tirur, Tamil Nadu.

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MATERIAL AND METHODS

The experimental research trial was carried out in Rice Research Station, Tirur, Tamil Nadu, during samba seasons of 2019 – 2020 and 2020-2021 to find the performance of traditional red rice varieties compared to TKM 9 (red rice variety released by RRS, Tirur). Its geographical coordinates are 13˚7'N latitude and 79˚58'E longitude. The altitude of the research station is 39.47m MSL. The average annual precipitation is 1104.4 mm, with 52 per cent benefitting from North-East monsoon and 41 per cent from South-West monsoon and the remaining 7 per cent from summer showers and winter rains, respectively. The mean maximum and minimum temperatures are 37.9 ^{o}C and 18.5 ^{o}C, respectively. The area has semi-arid tropical climate. Its soil type is moderately deep, red coloured, sandy clay, and non-calcareous light brown with a pH 5.7. Field experiments were laid out in strip plot design with three replications. The treatments comprised of four levels of factor A and five levels of factor B. Different varieties of factor A are *Kullakar* (V1), *Kuzhiyadichan* (V2), *Kattuyanam* (V3) TKM9 (V4) and different organic sources of factor B are Control (N1), Greenleaf manure (GLM) + *Azospirillum* + Phosphobacteria (N2), Pressmud + *Azospirillum* + Phosphobacteria (N3), Farmyard manure + *Azospirillum* + Phosphobacteria + Pink Pigmented Facultative Methylotrops (PPFM) (N4), Vermicompost + *Azospirillum* + Phosphobacteria + Pink Pigmented Facultative Methylotrops(PPFM) (N5). The performance of traditional red rice varieties with varied duration under scheduled organic manure treatment viz., *Kullakar* (V1), *Kuzhiyadichan* (V2) and *Kattuyanam* (V3) were tested with TKM 9 (V4) red rice check variety. Twenty-five old rice seedlings were planted @ 2 seedlings hill^{-1}. A spacing of 20 x 15 cm was adopted to accommodate a plant population of 33 plants m^{-2}.

Water management was done by subsequent irrigation of trial plots and a water level of 5 cm was maintained throughout the crop period. The irrigation was stopped 15 days prior to harvest and water was drained from the field to hasten the grain hardening process. The methodology used for water use studies are given below. The total water consumed was calculated by summing the applied irrigation water and the effective precipitation. Effective rainfall over the cropping period was calculated as fifty per cent of total rainfall. The grain yield was recorded from the net plot area and expressed in kg ha^{-1} at 14 per cent moisture level. The straw yield of rice was recorded from the net plot area after enough sun drying and expressed in kg ha^{-1}. The data on various characters studied during the investigation were statistically analysed as suggested by Gomez and Gomez (1984) and wherever the treatment differences were found significant (F test), critical differences were worked out at five per cent probability level and the values are furnished.

Total water applied (mm) = total irrigation water + effective rainfall

$$\text{Water use efficiency (WUE) (kg ha-mm}^{-1}\text{)} = \frac{\text{Yield (kg ha}^{-1}\text{)}}{\text{Total water consumed (mm)}}$$

$$\text{Water productivity (kg m}^{-3}\text{)} = \frac{\text{Grain yield (kg)}}{\text{Total water consumed (m}^{3}\text{)}}$$

The pooled analysis data of yield and water use studies for two years samba season research crop (2019 – 2020 & 2020 – 2021) is furnished and discussed in this article.

RESULTS AND DISCUSSION

The observations on growth attributes and yield attributes *viz*., plant height, leaf length, tillers, productive tillers, grain and straw yield were recorded periodically. The crop duration under the north eastern agroclimatic zone of Tamil Nadu was found to be *Kullakar* - 100 days, *Kuzhiyadichan* -110 days, TKM 9 - 115 days, and *Kattuyanam* - 150 days (Subbalakshmi *et al.,* 2020). It was observed from the study that among different organic practices, the treatment vermicompost + *Azospirillum* + phosphobacteria + pink pigmented facultative methylotrophs (PPFM) recorded maximum values under growth cum yield attributes

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and yield of all varieties (Fig. 1). *viz., Kullakar, Kuzhiyadichan, Kattuyanam,* TKM 9. This increase in growth and yield components of different red rice varieties under vermicompost and biofertilizers is mainly because of microbial stimulation effect and N supplied through gradual mineralization in a steady manner throughout the crop growth period (Roy and Singh,2006).

Grain & straw yield: Productive tillers plays a key role in grain yield. TKM 9 (V4) records maximum tillers number per hill (35), which is followed by the land race variety *Kuzhiyadichan* (V2) (27) under the best organic manure treatment *i.e.,* vermicompost + *Azospirillum* + phosphobacteria + PPFM (N5). The harvest was done at the physiological maturity stage of every individual variety. TKM 9 red rice variety recorded the maximum grain yield of 4980 Kg ha^{-1} under the organic manure treatment N5 followed by *kuzhiyadichan* which has recorded 3804 Kg ha^{-1} and the minimum value was recorded in *kattuyanam* of 2275 Kg ha^{-1}. The straw yield was found to be higher in TKM 9 (9961 Kg ha^{-1}), followed by *kuzhiyadichan* (8826 Kg ha^{-1}) and minimum straw yield was observed in the *Kullakar* variety (6814 Kg ha^{-1}).

Water use studies

Total water used or consumptive water use of a crop is the amount of water that transpired during crop growth and water evaporates from crop foliage and soil surface (Liu *et al.,* 2009). As the crop duration influences the total water requirement of crop, the number of irrigations and consumptive water use of a crop (CU) was recorded significant in horizontal factor (A) varieties, whereas it's not significant under vertical factor (B) different organic practices (Table. 1). *Kattuyanam* red rice land race registered maximum values in number of irrigations (30) and CU of a crop (1406 mm) which is due to its longer duration (150 days) physiological character. *Kullakar* registered minimum values under the number of irrigations and crop CU as it's a short duration (100) red rice land race. Improvement in WUE of a crop depends on the increase in performance or decrease in evaporation and transpiration, which depends on varietal character (Sohani, 2000). Water use efficiency (WUE) and water productivity (WP) was found to be higher in TKM 9 (4.06 kg ha^{-1} mm^{-1}, 0.406 kg m^{-3} respectively) red rice variety which is followed by *Kuzhiyadichan* red rice land race (2.98 kg ha^{-1} mm^{-1}, 0.298 kg m^{-3} respectively) under the horizontal factor A(Varieties) (Table. 2). Under the vertical factor B (organic practices) N5 treatment was observed to be the best treatment as it is noted higher WUE and WP (3.61 kg ha^{-1} mm^{-1} and 0.361 kg m^{-3}), which is followed by N3 (3.21 kg ha^{-1} mm^{-1} and 0.321 kg m^{-3}). This higher WUE and WP might be due to adding vermicompost + *Azospirillum* + phosphobacteria + pink pigmented facultative methylotrops (N5) to the crops leads to an increase in water maintenance and thus to an increase in expansion of the plant root, leading to an increase in water and nutrients uptake and finally to improvement in economic produce, under irrigated conditions (Mohammad Javad Nazarideljou and Zahra Heidari, 2014).

CONCLUSION

The red rice variety TKM 9 and land race *Kuzhiyadichan* were found to have better water use efficiency and water productivity. With regard to crop water productivity and organic practices, it can be concluded that, vermicompost + azospirillum + phosphobacteria + PPFM were observed to be best performing across all the varieties. Conserving biological diversity within food crops such as rice is crucial for sustainable agricultural systems and for maintaining global food security. Therefore encouraging the farmers to take up the cultivation of red rice landraces is in need of hour. That would fetch the farmers good returns with the less inputs and also, it stands as the best option for climate resilience.

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Funding and Acknowledgment

The author(s) received no financial support for the research, authorship, and/or publication of this article. However, author(s) wish to appreciate and acknowledge the support of field trail land facilitated by Rice Research Station, Tirur and laboratory provision by department of Agronomy, Tamil Nadu Agricultural University, Coimbatore.

Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Originality and plagiarism

Authors ensure that the article written and submitted is entirely our original research works, and the used words of others, has been appropriately cited.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required. If anything is required from the MS, certainly, this will be extended by communicating with the corresponding author through official mail: mano.darthiya@gmail.com

Author contributions

Idea conceptualization- DM, SL, Experiments- DM (Field trial & lab analysis), Guidance -SL, MC, SVM, MS, RV, Writing original draft – DM, Reviewing & editing – DM, SL.

REFERENCES

Cowell, E. B. 1957.The Jatushaakas London. Referred in Tuk-Tuk Kumar. 1985. History of rice in India: Mythology, culture and agriculture. Gyan Publishing House. New Delhi.

Deb, D. 2000. Folk rice varieties of West Bengal; agronomic and morphological characteristics. Research Foundation for Science, Technology and Ecology (RFSTE/ Vrihi), New Delhi.

Gomez, K.A. and A.A. Gomez.1984. Statistical procedures for agricultural research (2 ed.). John wiley and sons, New York, 680p.

Liu, J., Alexander, Z., and Hong, Y. 2009. Global consumptive water use for crop production: The importance of green water and virtual water. *Water Resources Res.,* **45:**10. 1029/2007WR006051.

Nazarideljou, M.N. and Heidari, Z. 2014. Effects of vermicompost on growth parameters, water use efficiency and quality of zinnia bedding plants (Zinnia elegance 'Dreamland Red') under different irrigation regimes. *Internl. J. of horti. sci. and tech.,* **1(2):** 141-150.

Richharia, R., and S. Govindasamy. 1990. Rices of India. Academy of Development Science. Karjat.

Roy, D. K. and B. P. Singh. 2006. Effect of level and time of N application with and without vermicompost on yield, yield attributes and quality malt barley. *Indian J. of Agron.,* **51(1)**: 40-42.

Sohani, A. 2000. Investigation on physiology aspects of water deficit and potassium nutrition on potato. Ph.D. Thesis. Islamic Azad University. Science and Research Branch. Tehran. Iran.

Subbalakshmi, L., Darthiya, M. and Sankaran, V. M. 2020. Potential yield assessment of red rice land races under north-eastern agro climatic zone of Tamil Nadu. *J. of Rice Res.,* **13(1)**: 86-87.

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Figure 1. Influence of vermicompost + *Azospirillum* + *phosphobacteria* + PPFM (N5) over grain and straw yield of different red rice land races (pooled data of 2019 – 2020 & 2020 – 2021)

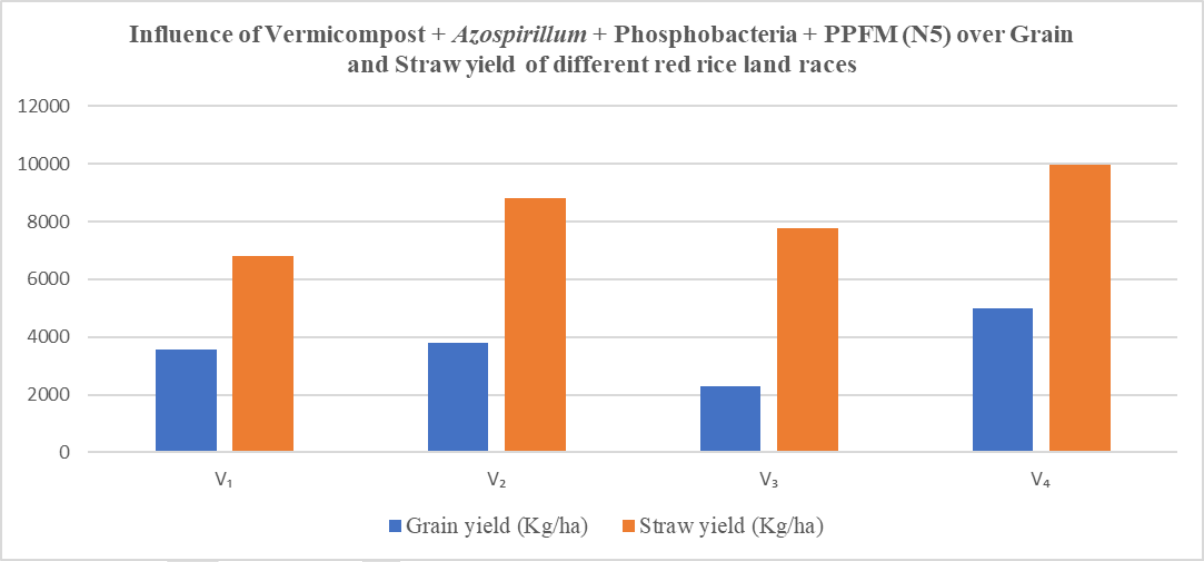

Table 1. Influence of different organic manures on Irrigation scheduling and consumptive water use of red rice varieties (pooled data of 2019 – 2020 & 2020 – 2021)

	No. of Irrigations							Consumptive water use of crop (mm)					
Treatments	N_1	N_2	N_3	N_4	N_5	Mean		N_1	N_2	N_3	N_4	N_5	Mean
V_1	21	21	21	21	21	**21**	V_1	924	924	924	924	924	**924**
V_2	23	23	23	23	23	**23**	V_2	964	964	964	964	964	**964**
V_3	32	32	32	32	32	**32**	V_3	1399	1399	1399	1399	1399	**1399**
V_4	23	23	23	23	23	**23**	V_4	974	974	974	974	974	**974**
Mean	**24**	**24**	**24**	**24**	**24**		Mean	**1065**	**1065**	**1065**	**1065**	**1065**	

*Data not statistically analyzed

Table 2. influence of different organic manures on water use efficiency and water productivity of red rice varieties (pooled data of 2019 – 2020 & 2020 – 2021).

	WUE (kg ha^{-1} mm^{-1})							Water productivity (kg m^{-3})					
Treatments	N_1	N_2	N_3	N_4	N_5	Mean		N_1	N_2	N_3	N_4	N_5	Mean
V_1	1.51	2.47	3.06	2.66	3.82	**2.70**	V_1	0.15	0.25	0.31	0.27	0.38	**0.27**
V_2	1.60	2.69	3.38	3.12	3.87	**2.93**	V_2	0.16	0.27	0.34	0.31	0.39	**0.29**
V_3	0.78	1.36	1.51	1.44	1.61	**1.34**	V_3	0.08	0.14	0.15	0.14	0.16	**0.13**
V_4	1.81	4.05	4.71	4.50	4.97	**4.01**	V_4	0.18	0.40	0.47	0.45	0.50	**0.40**
Mean	**1.42**	**2.64**	**3.17**	**2.93**	**3.57**		Mean	**0.14**	**0.26**	**0.32**	**0.29**	**0.36**	
	A	B	A at B	B at A				A	B	A at B	B at A		
SEd	0.09	0.10	0.04	0.05			SEd	0.007	0.007	0.004	0.004		
CD (p=0.05)	0.21	0.22	0.10	0.10			CD (p=0.05)	0.018	0.016	0.008	0.008		

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