Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; 6(5): 2413-2417
Received: 15-07-2017
Accepted: 16-08-2017

N Krishnaprabu
Assistant Professor, Agronomy, RVS Agricultural College, Thanjavur, Tamil Nadu, India

T Myrtle Grace
Professor and Head & Project Coordinator, Dry land Agricultural Research Station, TNAU, Chettinad, Tamil Nadu, India

K Balakrishnan
Professor, Crop Physiology, Department of Seed Science and Technology, TNAU, Madurai, Tamil Nadu, India

R Vijayalakshmi
Associate Professor, Agronomy, Regional Research Station, TNAU, Aruppukottai, Tamil Nadu, India

Correspondence
N Krishnaprabu
Assistant Professor, Agronomy, RVS Agricultural College, Thanjavur, Tamil Nadu, India

Influence of Integrated and Organic Nutrient Management on Yield and Biochemical Properties in Traditional Red Rice Landraces (*Oryza sativa* L.)

N Krishnaprabu, T Myrtle Grace, K Balakrishnan, R Vijayalakshmi

Abstract
Field experiment was conducted at Agricultural College and Research Institute, TNAU, Madurai, to study the feasibility of yield and biochemical properties in traditional red rice landraces cultivation with different nutrient management *viz.*, FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos 2 kg ha^{-1} and FYM 12.5 t ha^{-1}+ Azophos 2 kg ha^{-1}. Red rice land races from Southern Districts of Tamil Nadu *viz.*, V_1 Kallurundaikar, V_2 White Chithiraikar, V_3 Sivappu Chithiraikar, V_4 Mattaikar, V_5 Kuruvaikalangiyam, V_6 Kuliyadichan, V_7 Norungan, V_8 Nootripattu, V_9 Chandikar, V_{10} Kattanur and V_{11} TKM 9 improved TNAU red rice variety taken as a check. Among the Variety (V_9) recorded significantly highest grain and straw yield (4031 and 9350 kg ha^{-1}), and higher biochemical properties *viz.*, carbohydrates, protein, fiber, Zinc content was found in variety TKM 9 (V_{11}) with application of organic source, FYM + Azophos (F_2 V_{11}). Higher Iron and fat content was recorded in combination of Chandikar (V_9) and Nootripathu (V_8) with organic nutrient sources of FYM + Azophos (F_2 V_9 & V_8) respectively.

Keywords: Red Rice landraces, INM, Organic Nutrient, Biochemical properties

1. Introduction
Agriculture is an integral part of India's economy and society. It has about 130 million farming families; the majority of them are small and marginal farmers who practice subsistence agriculture. The green revolution which occurred in late 1960s was a turning point in Indian agriculture. There was remarkable growth in agriculture during the Green Revolution period and this sector has been successful in keeping pace with growing demand for food grains in the country. (Shetty *et al.*, 2013) [15]. In India, rice is the staple food for over three billion people of Asia, which accounts for the production and consumption of 70 per cent of world rice. India has the largest acreage under rice, (44.6 m.ha) with a production of about 90 million tones and ranks next to China (Krishnamurthy, 2012) [8].
Rice is India's preeminent crop and is cultivated under a remarkably wide range of agro-ecologies across the country. Although semi dwarf rice varieties now occupy most of the cultivated area in India, yet ancestral varieties can still be found in almost all upland subsistence farming. Selection made by various ethnic groups inhabiting different altitudes and climatic conditions in the upland regions, practicing different forms of cultivation, and diverse culture and traditions, have contributed to the diversity of the rice crop in these regions. Red rice is high in fibre because of the bran, and the flavour is much stronger than that of hulled rice, tasting more nutty and full. Red rice is considered to be rich in antioxidants, calcium, zinc, iron and other minerals, and is a good source of thiamine (vitamin B1), riboflavin (vitamin B2) and fibre. Beside red rice, there are several other native landraces those are popular under subsistence farming and have the potential to fetch a premium price in local and distant markets (Gayacharan *et al.*, 2015) [5].

2. Materials and Methods
A field experiment was conducted at Agricultural College and Research Institute, TNAU, Madurai, to study the yield and biochemical properties of traditional red rice land races under different nutrient management system. The field is located in the southern agro climatic zone of Tamil Nadu. The farm experiences the mean annual rainfall of 893 mm in 45 rainy days and the mean annual maximum and minimum temperature are 33.7 ºC and 23.8 ºC, respectively. The relative humidity is 83.4 per cent. The biochemical study used Micro kjeldahl for protein Ranganna (1986) [153], Soxhlet apparatus method for fat and Acid and alkali titration for fiber

Aadil Abbas *et al*. (2011) [1], Atomic Absorption Spectrophotometer (AAS) method for Iron and Zinc Yodmanee *et al*. (2011) [18] and Anthrone method for Carbohydrate Deepa *et al*. (2008) [3].

The experiment was laid out in Factorial Randomized Block Design (FRBD) and Factorial Completely Randomized Designed (FCRD) and replicated thrice, keeping two nutrient management practices viz. F_1 - INM : Organic source (FYM) 12.5 tons ha^{-1} + Inorganic source (50:25:25 N P K Kg ha^{-1}) + Biological source (Azophos) seed treatment and soil application and F_2 - Organic alone : FYM + Azophos seed treatment and soil application as a main plot and ten red rice land races viz. V_1 Kallurundaikar, V_2 White chithiraikar, V_3 Sivappu chithiraikar, V_4 Mattaikar, V_5 Kuruvaikalangiyam, V_6 Kuliyadichan, V_7 Norungan,V_8 Nootripattu, V_9 Chandikar, V_{10} Kattanur, and one V_{11} TKM 9 improved TNAU red rice variety taken as a check.

3. Results and discussion

3.1 Grain and straw yield (Fig.1)

The yield of red rice land races was significantly influenced by different nutrient management practices. Chandikar (V_9) recorded significantly highest grain and straw yield (4031 and 9350 kg ha^{-1}) followed by TKM 9 (V_{11}) 3376 and 9080 kg ha^{-1}. With regard to other agronomic management, application of FYM 12.5 kg ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) recorded significantly highest grain and straw yield (3050 and 7622 kg ha^{-1}). Interaction between the varieties and different nutrient management practices was found to be significant. Among the combinations, Chandikar (V_9) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_9) registered higher grain and straw yield of 4100 and 9450 kg ha^{-1}. The lowest grain and straw yield was registered in Nootripathu (V_8) with FYM + Azophos (F_2 V_8) 1918 and 6107 kg ha^{-1}.

Comparable rice yield from both complementary application of organic and inorganic fertilizers and from sole inorganic fertilizer is a further indication that the nutrients supplied from the complementary application were effective enough. The above similar study was reported by Makinde *et al.*, (2001) [9]. It was also observed that sole organic fertilizer application did not benefit the yield of rice significantly. A significant loss of grain occurred due to less fertility mediated by only single application of manures. It was due to less nutrient capacity of organic manures which did not meet the requirements of the rice plant to produce fertile grains. In physiological term, yield of most cereals is largely governed by source (photosynthesis) and sink (grain growth) relationship **(**Tayebeh *et al*., 2011) [17]. However, capacity of system transporting the photosynthates and partitioning of assimilates between their sites of utilization i.e., sink, are the major determinants of crop yield (Gifford and Evans, 1981) [6]. The favorable growth in terms of higher LAI and DMP with higher nutrient uptake along with increased yield attributes *viz.*, productive tillers m^{-2}, panicle length and number of filled grains per panicle which resulted in producing higher grain yield. Increase in grain and straw yield due to the INM practice observed in present study was also in conformity with the earlier reports of Saidu Adamu *et al.* (2012) [14].

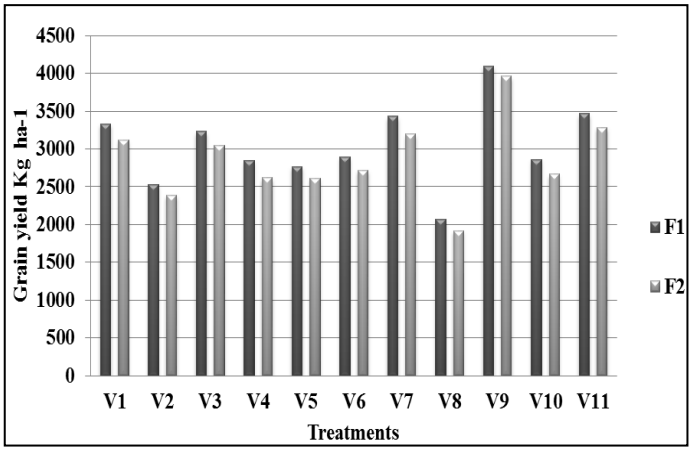

Fig1: Influence of differnt nutrient nutrient management on grain yield kg $ha^{-1}$of red rice landraces

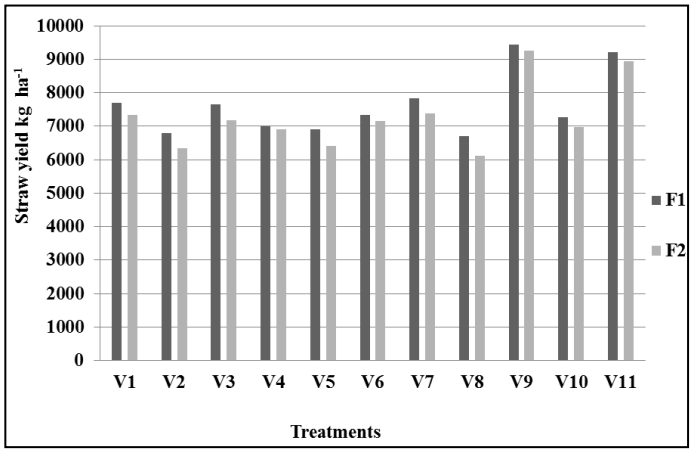

Fig 2: Influence of nutrient management on straw yield kg ha^{-1} of red rice landraces

4. Biochemical attributes

4.1 Carbohydrates

Among the varieties tested, TKM 9 (V_{11}) has recorded highest amount of carbohydrates (76.06 per cent) followed by Sivappu chithiraikar (V_3) (74.60 percent). The lowest content of carbohydrates was registered in White Chithiraikar (61.71 per cent) (Table. 1). Application of FYM + Azophos (F_2) registered significantly highest amount of carbohydrates (71.44 per cent). The lower carbohydrate content was due to the application of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) (68.11 per cent). Interaction effect between the varieties and other management practices were found to be significant. Variety TKM 9 (V_{11}) with FYM + Azophos (F_2 V_{11}) (77.08) was observed highest content of carbohydrates followed by Sivappu chithiraikar (V_3) with FYM + Azophos (F_2 V_3) (75.75 per cent). The lower amount of carbohydrates was observed in White chithiraikar (V_2) with FYM 12.5 t ha^{-1}+ RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_2) (58.97 per cent).

4.1.1 Protein content

Varieties and nutrient management practices exhibited a significant influence on the protein content. The highest protein content (9 per cent) was recorded in Chandikar (V_9) followed by Kuruvai kalangiyam (7.88 per cent) (Table. 1). The lowest content of protein was registered variety Kallurandaikar (V_1) (4.00 per cent). With regard to other management options, FYM + Azophos (F_2) registered significantly higher protein content (6.52 per cent) than the after treatments. Protein content was found to be lower under FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) (5.56 per cent). Regarding the interaction effect between

varieties and other management practices, the variety Chandikar (V_9) with FYM + Azophos (F_2 V_9) was found to be better as it recorded the highest protein content (9.25 per cent), followed by Kuruvai kalangiyam (V_5) with FYM + Azophos (F_2 V_5) (8.25 per cent). Kallurundaikar (V_1) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_1) recorded lower content of protein (3.75).

Table 1: Influence of different nutrient management on Carbohydrates and Protein content

Stage		Carbohydrates (%)			Protein content (%)		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	65.37	69.37	67.37	3.75	4.25	4.00
V_2	White Chithiraikar	58.97	64.45	61.71	5.00	5.65	5.33
V_3	Sivappu Chithiraikar	73.45	75.75	74.60	6.80	7.00	6.90
V_4	Mattaikar	69.34	72.06	70.70	4.37	5.75	5.06
V_5	Kuruvai kalanjiyam	61.45	65.97	63.71	7.50	8.25	7.88
V_6	Kuliyadichan	72.65	74.80	73.73	6.25	7.25	6.75
V_7	Norungan	70.08	71.86	70.97	3.75	5.25	4.50
V_8	Nootripathu	64.77	69.01	66.89	5.00	6.65	5.83
V_9	Chandikar	67.46	72.55	70.01	8.75	9.25	9.00
V_{10}	Kattanur	70.65	72.90	71.78	4.37	5.65	5.01
V_{11}	TKM 9	75.03	77.08	76.06	5.63	6.75	6.19
	Mean	68.11	71.44		5.56	6.52	
		SEd		CD (P=0.05)	SEd		CD (P=0.05)
F		1.39		2.72	0.12		0.23
V		1.45		2.85	0.14		0.28
F x V		2.80		5.55	0.26		0.50

4.1.2 Fiber

The result indicated that the fiber content was highly influence by treatments and different management practices. Among the varieties TKM 9 (V_{11}) recorded higher fiber content (2.1 per cent) followed by variety Kattanur (V_{10}) (1.8 per cent) (Table.2). The lowest fiber content was recorded variety Norungan (V_7) (0.7 per cent). Among the different nutrient management practices, application of FYM + Azophos (F_2) recorded the highest content of fiber (1.4 per cent). The lowest fiber content was recorded (1.3 per cent) in FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) significant interaction effect was noticed between the different nutrient management practices and varieties. The treatment combination of TKM 9 (V_{11}) with FYM + Azophos (F_2 V_{11}) recorded highest content of fiber (2.2 per cent). The lower fiber content was recorded under Norungan (V_7) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_7) (0.6 per cent).

4.1.3 Fat

Varieties and different nutrient management techniques exerted significant influence on the fat content of red rice (Table. 2). The higher fat content was recorded by the varieties TKM 9 (V_{11}) (2.1 per cent), Nootripathu (V_8) (2.1), and Kuruvaikalangiyam (V_5) (2.1 per cent). The lowest fat content was registered variety Chandikar (V_9) (0.7 per cent). Application of FYM + Azophos (F_2) registered significantly higher (1.7 per cent) fat content than that of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) (1.3 per cent) respectively. Significant interaction effect was observed, accumulation of higher fat content was noticed by the varieties Nootripathu (V_8) with FYM + Azophos (F_2 V_8) (2.2 per cent), TKM 9 (V_{11}) with FYM + Azophos (F_2 V_{11}) (2.1 per cent), and Kuruvaikalangiyam (V_5) with FYM + Azophos (F_2 V_5) (2.1 per cent). The lowest fat content was registered variety Chandikar (V_9) with 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_9) (0.4 per cent) respectively.

Table 2: Influence of different nutrient management on Fiber and Fat content

Stage		Fiber (%)			Fat (%)		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	1.2	1.3	1.3	1.2	1.4	1.3
V_2	White Chithiraikar	1.4	1.4	1.4	1.2	1.2	1.2
V_3	Sivappu Chithiraikar	0.8	1.0	0.9	1.4	1.6	1.5
V_4	Mattaikar	1.2	1.4	1.3	1.3	1.7	1.5
V_5	Kuruvai kalanjiyam	0.6	0.9	0.8	2.0	2.2	2.1
V_6	Kuliyadichan	1.8	1.8	1.8	1.1	1.6	1.4
V_7	Norungan	0.6	0.8	0.7	1.2	1.9	1.6
V_8	Nootripathu	1.0	1.2	1.1	2.0	2.2	2.1
V_9	Chandikar	1.4	1.4	1.4	0.4	0.9	0.7
V_{10}	Kattanur	1.8	1.8	1.8	1.0	1.4	1.2
V_{11}	TKM 9	2.0	2.2	2.1	2.0	2.1	2.1
	Mean	1.3	1.4		1.3	1.7	
		SEd		CD (P=0.05)	SEd		CD (P=0.05)
F		0.006		0.01	0.01		0.02
V		0.01		0.03	0.03		0.06
F x V		0.02		0.04	0.04		0.08

4.1.4 Iron

The higher iron content of (5.9 per cent) was recorded in Chandikar (V_9), followed by Mattaikar (V_4) (5.6 per cent) and Kuliyadichan (V_6) (5.6 per cent) (Table.3). The lowest iron

content was registered Nootripathu (V_8) (3.6 per cent). With regard to other management practices, application of FYM + Azophos (F_2) registered the highest iron content (5.1 per cent). The iron content was found to be lowest FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) (4.6 per cent). Regarding the interaction effect between the varieties and different management practices, the treatment combination of Chandikar (V_9) with FYM + Azophos (F_2 V_9) was found to be better as it recorded the maximum iron content of 6.0 percent, followed by Mattaikar (V_4) with FYM + Azophos (F_2 V_4) (5.6 per cent) and Kuliyadichan (V_6) with FYM + Azophos (F_2 V_6) (5.6 per cent). The combination of Nootripathu (V_8) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_8) (3.3 per cent) recorded lower iron content.

Table 3: Influence of different nutrient management on Iron and Zinc content

Stage		Iron (%)			Zinc (%)		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	5.1	5.6	5.4	3.1	3.3	3.2
V_2	White Chithiraikar	4.6	5.2	4.9	2.8	2.8	2.8
V_3	Sivappu Chithiraikar	4.1	4.9	4.5	2.6	2.8	2.7
V_4	Mattaikar	5.5	5.6	5.6	3.2	3.3	3.3
V_5	Kuruvai kalanjiyam	3.8	4.3	4.1	2.3	2.5	2.4
V_6	Kuliyadichan	5.6	5.6	5.6	3.3	3.5	3.4
V_7	Norungan	3.6	4.1	3.9	2.5	2.8	2.7
V_8	Nootripathu	3.3	3.9	3.6	3.0	3.1	3.1
V_9	Chandikar	5.7	6.0	5.9	3.5	3.8	3.7
V_{10}	Kattanur	4.4	5.1	4.8	3.2	3.5	3.4
V_{11}	TKM 9	5.4	5.6	5.5	3.7	4.0	3.9
	Mean	4.6	5.1		3.0	3.2	
		SEd		CD (P=0.05)	SEd		CD (P=0.05)
F		0.03		0.06	0.01		0.03
V		0.07		0.15	0.04		0.09
F x V		0.10		0.22	0.06		0.12

4.1.5. Zinc

The result indicated that the zinc content was highly influenced by different management practices and varieties (Table. 3). Among the varieties, TKM 9 (V_{11}) recorded highest zinc content (3.9 per cent) followed by Chandikar (V_9) (3.7 per cent). The lowest zinc content was recorded Kuruvai kalangiyam (V_5) (2.4 per cent). Among the nutrient management practices, application of FYM + Azophos (F_2) recorded highest zinc content (3.2 per cent). The lowest zinc content was recorded under FYM 12.5 t ha^{-1}+ RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) (3.0 per cent). The interaction effect between the varieties and other management practices, were found be significant. The treatment combination of TKM 9 (V_{11}) with FYM + Azophos (F_2 V_{11}) recorded highest zinc content (4 per cent). The lowest zinc content was recorded in Kuruvaikalangiyam (V_5) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_5) (2.3 per cent).

Application of organic sources supplies all the nutrients which may enhance the nutrition quality of the red rice in organic treated plots. Among all the nutrients significantly increased (CHO, Protein, Fat, Fiber, Iron and Zinc) under FYM + Azophos. Increases in protein content might be due to more nitrogen uptake by plants. The nitrogen is the essential constituent which influenced the protein content Basavaraju (2007) [2] in maize supported to this finding. The protein content was high in fertilized plot due to high nitrogen available soil nitrogen and uptake by plants. Micro nutrients improve the chemical composition of grain and are known to act as catalyst in promoting organic reactions taking place in plants (Ranganathan and Perumal, 1995). Adequate supply of nutrients due to the organic nutrition ensured vigorous growth of plant, which favored improved quality of rice. The results are in accordance with the findings of Hemalatha *et al*., (2000) [7] and Dixit and Gupta (2000) [4]. Nakagawa *et al*. (2000) [11], Singh *et al.* (2007) [16] and Moola ram *et al.* (2011) [10] also reported positive influence of organic manuring on quality traits of rice.

5. Conclusion

Thus, it may be concluded that, suitable varieties and management techniques are essential for the yield of red rice landraces. Generally varieties and integrated nutrient management favored improved performance of the red rice with higher yield. All the eleven varieties responded favorably to the management options, FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos recorded higher growth rate, yield attributes grain and straw yield and FYM + Azophos would be an ideal practice to achieve higher biochemical properties in red rice landraces cultivation.

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