International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
IJCS 2017; 5(6): 180-186

Received: 27-09-2017
Accepted: 30-10-2017

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Effect of nutrient management on growth and yield of traditional red rice land races (*Oryza sativa* L.)

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Abstract
Field experiment was conducted at Agricultural College and Research Institute, Madurai,Tamil Nadu, to study the feasibility of yield enhancement for traditional red rice cultivation with different nutrient sources *viz.*,FYM 12.5 t ha^{-1}+ Azophos 2 kg ha^{-1} and FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg 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 this land races, Chandikar had significantincrease the growth and yield parameters by application of 12.5 t ha^{-1}+ 50:25:25 kg NPK ha^{-1}+ Azophos 2 kg ha^{-1}.Rice variety Chandikar (V_9) recorded significantly higher number of productive tillers m^{-2} (424), filled grains per panicle (125) and lowest sterility percentage (3.35 per cent). Among the combinationsF_1 V_9 registered higher grain yield of 4100 kg ha^{-1}. When compared to check chandikar had 18.25 per cent yield increase and 3.25 per cent over Organic nutrient management.

Keywords: Red Rice landraces, Nutrient management

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. However during 1990-2010 the food grain production in the country grew at an average 1.4 per cent, whereas the population growth was at 1.6 per cent. Fortunately, we have achieved a food surplus during last two years. But in the long run, concern of food security is likely to become more intense with increasing population and decreasing land availability. By 2020, to meet the food demand of 1.3 billion populations, India needs to produce 281 MT of food grains with an annual growth target of 2 per cent (Shetty *et al.*, 2013) [25].

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) [12]. The planning commission estimates that our country requires 122.1 million tonnes of rice by 2020, to meet food security norms (Prabhakaran Nair, 2011) [18].

2. Materials and Methods

A field experiment was conducted at Central farm, Agricultural College and Research Institute, Madurai, Tamil Nadu, to study the response of traditional red rice varieties under different nutrient management system. The field is located in the southern agro climatic zone of Tamil Nadu. The farm is geographically located at 9°54' N latitude 78°54' E longitude and at an elevation of 147 m above mean sea level. 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 °C and 23.8 °C, respectively. The relative humidity is 83.4 per cent. The rainfall received during the experimental period was 456 mm in 29 rainy days. The mean maximum and minimum temperature were 33.7 °C and 20.6 °C, respectively.

The relative humidity was 82.75 per cent. The soils of the experimental field pH 7.20, EC 0.32, (Jackson, 1973) [11], 230 kg of available nitrogen Subbiah and Asija (1956) [29], 24 kg of available phosphorus Olsen *et al*. (1954) [17] and 270 kg of available potassium Stanford and English (1949) [28].

The experiment was laid out in Factorial Randomized Block Design (FRBD) 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 Growth and physiological attributes

3.1.1 Plant height

The plant height of rice was significantly influenced by different varieties and other management practices. Plant height gradually increased as the stage of 90 days after sowing

(Table 1). Among the varieties Mattaikar (V_4) recorded highest plant height of 112.3 cm followed by Norungan (V_7) (108.6 cm). Nutrient management, combined application of organic and inorganic fertilizer registered highest plant height than organic alone. FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) recorded significantly higher plant height (101.9 cm). The interaction effect of varieties and other management practices were found to be, significant at all the stage of crop growth. The maximum plant height was recorded by Norungan (V_7) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_7) (111.9 cm). The variation in plant height among varieties may be the ability of the variety which response to the nutrient applied. The uneven plant height among the nutrient sources was considered to be due to variation in the availability and uptake of nutrients. Chemical fertilizer offers nutrients which are readily soluble in soil solution and thereby instantaneously available to plants. Nutrient availability from organic sources is due to microbial action and improved physical condition of soil. These results were supported by Sarker *et al.* (2004) [20]. The above result is in conformity with the findings of Manjunath *et al.* (2012) [14], Senthivelu and Surya prabha, 2007 [22], Umashankar *et al.* (2005) [34] and Babu *et al.* (2001) [2]. Inorganic fertilizers are known to have the peculiarity of fast release of their nutrient contents. Nutrients supplied from the inorganic fertilizer seemed to be released fast enough at 30 DAS to give significantly taller plants. Even nutrients supplied from the complementary application of organic and inorganic fertilizers seemed enough to have plants not significantly shorter than plants treated with sole organic fertilizer application. Organic fertilizers are known for the characteristics nature of slow release of nutrients. The observed shorter plants from the sole organic fertilized plants can be attributed to the slow release nature of the fertilizer as assessed throughout the growing period. A similar observation has been made with other in other studies (Ayoola and Makinde, 2007) [7]. Rice plant heights with complementary application of organic and inorganic fertilizers were observed to be similar and were significantly greater than those from sole organic fertilizer application.

Table 1: Effect of different nutrient management on growth attributes

Stage		Plant height (cm)			number of tillers hill^{-1}			Leaf Area Index		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	105.2	103.7	104.4	36	34	35	8.7	7.9	8.3
V_2	White Chithiraikar	108.6	103.0	105.8	33	29	31	6.5	5.8	6.2
V_3	Sivappu Chithiraikar	110.5	97.3	103.9	36	32	34	8.5	7.7	8.1
V_4	Mattaikar	111.6	113.0	112.3	34	30	32	7.0	6.1	6.6
V_5	Kuruvai kalanjiyam	105.2	105.4	105.3	35	29	32	6.6	5.9	6.3
V_6	Kuliyadichan	106.0	99.3	102.6	36	30	33	8.2	7.6	7.9
V_7	Norungan	111.9	105.2	108.6	37	33	35	8.9	8.1	8.5
V_8	Nootripathu	109.3	101.1	105.2	28	24	26	6.2	5.3	5.8
V_9	Chandikar	70.1	59.3	64.7	43	39	41	10.4	9.6	10.0
V_{10}	Kattanur	105.9	104.7	105.3	35	31	33	7.8	6.9	7.4
V_{11}	TKM 9	76.9	67.0	72.0	38	36	37	9.0	8.8	8.9
	Mean	101.9	96.3		36	32		8.0	7.2	
		SEd	CD (P=0.05)		SEd	CD (P=0.05)		SEd	CD (P=0.05)	
F		4.2	9.0		1.24	2.62		0.20	0.44	
V		3.8	8.0		1.10	2.32		0.18	0.39	
F x V		7.9	16.0		2.34	4.91		0.37	0.82	

3.1.2. Number of tillers per hill

Among the varieties, the maximum number of tillers per hill was produced by Chandikar (V_9) 41 tillers per hill (Table.1). Nootripathu (V_8) produced minimum number of tillers per hill at maximum tillering stage (26 tillers per hill), nutrient management with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) recorded significantly higher number of tillers per hill (36 tillers per hill). Interaction effect of varieties and other management practices were found to be significant at all the stages of crop growth. Chandikar (V_9) under FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1}+ Azophos (F_1 V_9) registered significantly, the highest number of tillers per hill (43 tillers per hill. The lowest number of tillers per hill was recorded by Nootripathu (V_8) with FYM + Azophos (F2 V_8) 24 tillers per hill. The increase in plant height, number of tillers per hill, in response to application of organic and chemical fertilizers is probably due to enhanced availability of nutrients. The available nutrients might have helped in enhancing leaf area, which thereby resulted in higher photo-assimilates and more dry matter accumulation. These results are supported by the findings of Swarup and Yaduvanshi, (2000) [30] and Yadana *et al*. (2009) [36].

Tillering is an important trait for grain production and is thereby an important aspect in rice yield. Mirza *et al*. (2010)

[15] reported increase in number of tillers in rice plants due to influence of different fertilizer combinations. Tillering is largely related with genetic behavior of a variety. It is the outcome of the expansion of auxiliary buds, which is closely associated with the nutritional condition of the mother culm, and a tiller receives carbohydrates and nutrients from the mother culm during its early growth period which gets improved by the application of N (Tisdale and Nelson, 1975) [33]. The present investigation showed that the variety Chandikar (V_9) exhibited more number of tillers per hill under FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos. Combination of chemical and organic fertilizer led to higher tillering capacity compared to organic alone. According to the results obtained more number of tillers per square meter might be due to the higher availability of nitrogen, which plays a vital role in cell division. Increase in tiller production might probably be due to the greater supply of N with efficient utilization for cell multiplication and enlargement and formation of nucleic acids and other vitally important organic compounds in the cell sap (Chandravanshi and Singh, 1974; Simons, 1982) [5, 26].

3.1.3. Leaf Area Index

Measurement of leaf area is a basic tool of growth analysis and it is directly related with both biological and economical yield. In general, leaf area index (LAI) increased linearly and attained maximum level at maximum growth stage and there after declined. Among the Varieties Chandikar (V_9) registered highest LAI than other varieties (10.0) at maximum growth stage (Table.1). The lowest LAI was recorded in Nootripathu (V_8), 5.8. The interaction effect between varieties and management techniques were found to be significant at all the stages of crop growth. The higher LAI was recorded by Chandikar (F_1 V_9) with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos 3.4, at maximum growth stage 10.4. The lowest LAI was registered variety Nootripathu (V_8) under FYM + Azophos (F_2V_8) (5.3). Higher Leaf area index is one of the important growth attributes found to be increasing with increasing level of nutrient application and it is directly and positively related to crop photosynthesis (Nguyen *et al.*, 2004). The result of this experiment clearly indicated that variety Chandikar (V_9) with combined application of organic and inorganic fertilizers markedly increased the LAI compared to application of organic alone. Similar reports were obtained by Balasubramanian and Wahab (2012) [3]. Sarker *et al*. (2004) [20] also reported the increased LAI with manure application in combination of inorganic N fertilizers. In case of any plant, leaves are important organs which have an active role in photosynthesis. To achieve high yield, maximization of leaf area is an important factor. In the present investigation we found that organic fertilizer and in combination with chemical fertilizers significantly increased the flag leaf length. Similar findings are reported by Mirza *et al*. (2010) [15]. The increase in leaf number as well as size due to enough nutrition can be explained in terms of possible increase in nutrient absorption capacity of plant as a result of better root development and increased translocation of carbohydrates from source to growing points (Singh and Agarwal, 2001) [27].

3.1.4. Dry matter production

Varieties and different nutrient management techniques significantly influenced the DMP of red rice at all the crop growth stages. The highest DMP was recorded in Chandikar (V_9), 13495 kg ha^{-1} followed by TKM 9 (V_{11}) 12924 kg ha^{-1} (Table.2). Nootripathu registered lowest dry matter production of (V_8) 8110 kg ha^{-1}. Application of FYM 12.5 t ha^{-1}+ RDF 50:25:25 NPK kg ha^{-1}+ Azophos registered significantly higher (10435 kg ha^{-1}) plant DMP than that of FYM + Azophos (9987 kg ha^{-1}) at maximum growth stage. Interaction effect was found to be significant the highest DMP was observed in Chandikar (V_9) along with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1 V_9) (13776 kg ha^{-1}). The lowest plant DMP was observed in Nootripathu with FYM + Azophos (F_1 V_8) (8280 kg ha^{-1}) and (F_2 V_8) (7940 kg ha^{-1} respectively). Among the variety tested, Chandikar (V_9) with application of organic and inorganic fertilizer increased the dry matter production compared to application of organic alone due to increasing rates of N fertilizer is apparently attributed to its effect in enhancing vigorous vegetative growth of the rice plant. In this study, dry matter accumulation was associated positively and significantly with plant height. The results of the present study are in agreement with the findings of Hari *et al.* (1997) [9] who observed increasing dry matter accumulations due to increasing rates of applied mineral N fertilizer. This is attributed to enhanced plant N uptake thereby promoting vigorous vegetative growth of the rice crop plants (Mulugeta Seyoum and Heluf Gebrekidan, 2005) [16]. Likewise, Zaman *et al.* (1995) [37] also reported that increasing rates of P increased dry matter accumulation as a result of increased vegetative growth favored by enhanced nutrient uptake by rice plants.

3.1.5. Chlorophyll Content

The SPAD meter readings were taken to assess the chlorophyll content of red rice and this was significantly influenced by varieties and other agronomic managements. Between the varieties, Chandikar (V_9) recorded highest chlorophyll content (46.91) (Table. 2). The lowest chlorophyll content was registered by variety Nootripathu (V_8) 43.58. Chlorophyll content was enhanced due to the application of FYM 12.5 t ha^{-1}+ RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) 45.52. The lowest chlorophyll content was registered with FYM + Azophos (F_2) 44.76. The interaction effect between varieties and other nutrient management practices exhibited significant variations in chlorophyll content. 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 chlorophyll content 47.88. The investigation showed that the combinations of organic and chemical fertilizer along with split application in different stages facilitated to accumulate more chlorophyll in rice plant which resulted in more chlorophyll and this is apparent with the findings of Shaiful Islam *et al.* (2009) [23]. It reveals that split application of nitrogen at three times increased chlorophyll content compared to basal application Chlorophyll content at panicle initiation stage had positive significant correlation with grain yield was reported by Barison and Uphoff (2011) [4].

Table 2: Effect of different nutrient management on DMP and LAI

Stage		Dry Matter Production (DMP)			Chlorophyll Content (SAPD value)		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	11409	10877	11143	46.29	44.10	45.20
V_2	White Chithiraikar	8449	8112	8281	44.08	43.06	43.57
V_3	Sivappu Chithiraikar	10112	9708	9910	46.03	44.86	45.45
V_4	Mattaikar	9140	8729	8935	45.26	43.60	44.43
V_5	Kuruvai kalanjiyam	8979	8516	8748	44.90	44.12	44.51
V_6	Kuliyadichan	9872	9399	9636	45.37	42.91	44.14
V_7	Norungan	12216	11689	11953	46.38	41.01	43.70
V_8	Nootripathu	8280	7940	8110	44.60	42.55	43.58
V_9	Chandikar	13776	13213	13495	47.88	45.93	46.91
V_{10}	Kattanur	9401	8975	9188	45.35	43.98	44.67
V_{11}	TKM 9	13152	12696	12924	46.53	42.98	44.76
	Mean	10435	9987		45.52	43.74	
		SEd		CD (P=0.05)	SEd		CD (P=0.05)
F		248		521	1.67		3.18
V		237		499	1.61		3.06
F x V		482		944	3.10		6.20

4.1. Yield and yield attributes

Rice variety Chandikar (V_9) recorded significantly higher number of productive tillers per meter square, panicle length and number of filled grains per panicle (424, 22 cm and 125) followed by TKM 9 (V_{11}) 332, 21.9 cm and 118 (Table.3). Lowest number of productive tillers per meter square, panicle length and number of filled grains per panicle was observed in Nootripathu (V_8) 244 and 19.7 cm and 71.

Nutrient management, application of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos recorded more number of productive tillers per meter square, panicle length and number of filled grains per panicle (293, 21.3cm and 91). Lowest number of productive tillers per meter square, panicle length and number of filled grains was obtained in FYM + Azophos (280 and 20.5 cm and 85).

The interaction effect between nutrient management and varieties exhibited significant variations. The higher number of productive tillers per meter square, panicle length and number of fillrd grains per panicle was noticed under rice variety Chandikar (V_9) along with FYM 12.5 t ha^{-1}+ RDF 50:25:25 NPK kg ha^{-1}+ Azophos (F_1V_9) (441, 21.3 cm and 129). The lowest number of productive tillers per meter square, panicle length and number of filled grains was recorded under in Nootripathu (V_8) with FYM + Azophos (F_2 V_8) (243, 19.5 cm and 68). Economic yield is a complex inter-relationship of its components, which are determined from the growth rhythm in vegetative phase and its subsequent reflection in reproductive phase.

Table 3: Effect of different nutrient management on yield attributes

Stage		Number of productive tillers m^{-2}			Panicle length (cm)			Number of filled grains $panicle^{-1}$		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	286	275	281	22.0	21.9	21.1	89	82	86
V_2	White Chithiraikar	253	248	250	20.1	20.1	20.1	77	71	74
V_3	Sivappu Chithiraikar	280	271	276	21.2	20.5	20.8	88	81	85
V_4	Mattaikar	266	233	260	20.5	20.1	20.3	82	76	79
V_5	Kuruvai kalanjiyam	262	257	251	20.2	19.8	20.1	81	74	78
V_6	Kuliyadichan	278	269	274	21.1	20.5	20.8	84	79	82
V_7	Norungan	297	277	287	22.1	21.5	21.8	96	88	92
V_8	Nootripathu	245	243	244	20.0	19.5	19.7	73	68	71
V_9	Chandikar	441	406	424	23.1	21.2	22.1	129	121	125
V_{10}	Kattanur	278	271	275	21.0	20.2	20.6	83	77	80
V_{11}	TKM 9	336	327	332	22.7	21.0	21.9	120	116	118
	Mean	293	280		21.3	20.5		91	85	
		SEd		CD (P=0.05)	SEd		CD (P=0.05)	SEd		CD (P=0.05)
F		10.7		22.5	0.65		1.27	3.3		6.3
V		10.2		21.5	0.62		1.23	3.1		5.9
F x V		20.0		43.1	1.27		2.48	6.2		12.1

The productivity of rice plant is greatly dependent on the number of productive tiller rather than the total number of tillers. In the above findings, characters v*iz.*, number of productive tillers per m^{-2}, panicle length, filled grains per panicle and test weight were more under variety Chandikar (V_9) followed by variety TKM 9 (V_{11}) with combined application of organic and inorganic fertilizer due to the availability and translocation of nutrients as well as photosynthates from source to sink resulting in increased panicle length, filled grain and test weight. The above results are in agreement with the findings of Saidu Adamu *et al.*, 2012 [19]. Increased number of spikelets and vigorous growth of rice due to high rates of N fertilizer application induce competition for carbohydrate available for grain filling and spikelet formation. The above finding was conformity with Hasegawa *et al.* (1994) [10].

4.1.1. Grain and straw yield

Varieties and different nutrient management practices had significant influence on the grain and straw yield. Between the varieties 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} (Table. 4). The lowest grain and straw yield was recorded in Nootripathu (V_8) (1993 and 6404 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}). Grain and straw yield was found to be lowest in FYM + Azophos (F_2) (2867 and 7272 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}.

The harvest index numerically higher in variety and other management practices, among the varieties Chandikar (V_9) registered highest harvest index of 0.38 with FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos followed by TKM 9 (V_{11}) 0.32. The lowest harvest index was found to be in Nootripathu (V_8) 0.21 with FYM + Azophos alone. The increase in grain yield components can be due to the fact that more nutrient availability would have improved the nitrogen and other macro- and micro-elements absorption as well as enhancing the production and translocation of the dry matter content from source to sink. Ebaid, *et al.* (2007) [6]. Similar results were reported by El-Refaee *et al*. (2006) [7]. Better nutrition at grain filling period due to integrated fertilizer management led to higher filled grain per panicle. Thakur, *et al* (2011) [32].

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) [13]. 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) [31]. 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) [8].

The yield data showed the favorable effect of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos recorded significantly higher grain yield. 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) [19].

Table 4: Effect of different nutrient management on grain and straw yield

Stage		Grain yield kg ha^{-1}			Straw yield kg ha^{-1}		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	3335	3122	3229	7700	7330	7515
V_2	White Chithiraikar	2533	2392	2463	6800	6350	6575
V_3	Sivappu Chithiraikar	3233	3046	3140	7650	7183	7417
V_4	Mattaikar	2850	2620	2735	7000	6900	6950
V_5	Kuruvai kalanjiyam	2767	2612	2690	6900	6417	6659
V_6	Kuliyadichan	2900	2719	2810	7333	7146	7240
V_7	Norungan	3433	3198	3316	7833	7390	7612
V_8	Nootripathu	2067	1918	1993	6700	6107	6404
V_9	Chandikar	4100	3962	4031	9450	9250	9350
V_{10}	Kattanur	2865	2667	2766	7267	6967	7117
V_{11}	TKM 9	3467	3285	3376	9210	8950	9080
	Mean	3050	2867		7622	7272	
		SEd	CD (P=0.05)		SEd	CD (P=0.05)	
F		86.0	189.2		176.6	388.7	
V		80.7	177.7		168.5	370.8	
F x V		166.4	365.0		345.2	759.5	

4.2. Nutrient Uptake

The higher Nitrogen, phosphorus and potassium uptake was estimated with variety Chandikar (V_9) 118.90, 40.70 and 95.50 kg ha^{-1} and variety TKM 9 (V_{11}) 113.10, 38.90 and 91.40 kg ha^{-1} (Table. 5). The lowest Nitrogen, phosphorus and potassium uptake was registered variety Nootripathu (V_8) 101.30, 31.80 and 79.50 kg ha^{-1}. Application of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1) registered higher Nitrogen, phosphorus and potassium uptake of (110, 36.90 and 86.30 kg ha^{-1}) and FYM + Azophos (F_2) showed lower Nitrogen, phosphorus and potassium uptake (105.70 33.70 and 83.50 kg ha^{-1}). Interaction effect was not significant. In general, the nutrient uptake gradually increased from tillering to harvest in rice crop. The concentration and availability of various nutrients in the soil for plant uptake depends on the soil solution phase, plant genetic characters, ability to absorption of nutrients by plants, response of nutrients and soil moisture availability. The uptake of N, P and K was significantly higher due to the application of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos than the other treatment. This significant response might be due to the enhanced nutrient availability to the crops by the application of organic manure in combination with inorganic fertilizer. This may induce the nutrient uptake of the crop plant. The similar result was opined by Satyanarayana *et al.* (2002) [21]. A combined use of organic manures and inorganic fertilizers checks nitrogen losses conserves soil N by forming organic-mineral complexes and thus ensures continuous N availability to rice plants and greater yields (Sharma and Mittra 1988) [24].

Table 5: Effect of different nutrient management on Nutrients uptake

Stage		Nitrogen (kg ha^{-1})			Phosphorus (kg ha^{-1})			Potassium (kg ha^{-1})		
Treatments		F_1	F_2	Mean	F_1	F_2	Mean	F_1	F_2	Mean
V_1	Kallurundaikar	111.8	107.5	109.7	38.2	34.6	36.4	86.9	84.9	85.9
V_2	White Chithiraikar	104.9	100.8	102.9	33.8	31.9	32.9	81.9	79.9	80.4
V_3	Sivappu Chithiraikar	110.6	104.8	108.3	36.9	33.6	35.3	86.3	84.8	85.6
V_4	Mattaikar	107.3	102.6	105.0	34.9	32.8	33.9	82.5	78.2	81.3
V_5	Kuruvai kalanjiyam	105.3	101.9	103.6	34.2	31.9	33.1	82.4	80.1	80.9
V_6	Kuliyadichan	109.9	106.6	107.7	36.5	32.7	34.6	85.4	82.2	83.8
V_7	Norungan	112.6	107.1	109.9	38.9	35.4	37.2	87.5	85.8	86.7
V_8	Nootripathu	103.2	99.4	101.3	33.4	30.2	31.8	80.2	78.7	79.5
V_9	Chandikar	119.6	118.2	118.9	42.6	38.8	40.7	97.6	93.3	95.5
V_{10}	Kattanur	108.8	103.7	106.3	35.9	32.2	34.1	84.6	81.5	83.1
V_{11}	TKM 9	116.3	109.8	113.1	40.8	36.9	38.9	93.8	88.9	91.4
	Mean	110.0	105.7		36.9	33.7		86.3	83.5	
		SEd	CD (P=0.05)		SEd	CD (P=0.05)		SEd	CD (P=0.05)	
F		3.60	7.70		1.23	2.58		3.08	6.47	
V		3.52	7.39		1.17	2.35		2.98	6.26	
F x V		NS	NS		NS	NS		NS	NS	

4.3. Economics

Generally organic treatments recorded highest gross return compared to integrated nutrient management practices. Among the varieties, highest gross return, net return and benefit cost ratio was recorded (94441, 67231 Rs. ha^{-1} and 3.47) by Chandikar (V_9) with application of FYM + Azophos (F_2V_9) followed by TKM 9 (V_{11}) (81505, 54295 Rs. ha^{-1} and 3.0) (Table. 6). The lowest gross return net return and benefit cost ratio was recorded (41554, 14223 Rs. ha^{-1} and 1.52) Nootripathu (V_8) with application of FYM 12.5 t ha^{-1} + RDF 50:25:25 NPK kg ha^{-1} + Azophos (F_1V_8). Above findings showed that, the higher Benefit cost ratio of 3.47 under organic nutrient management practices with Chandikar, which was superior over rest of the combinations was recorded. This is due to lower cost of cultivation, higher gross returns and higher market price of organic rice. The similar result was indicated by Vidyavathi *et al*. (2011) [35].

Table 6: Effect of different nutrient management on Economics

Treatments		F_1				F_2			
		Cost of cultivation (Rs ha^{1})	Gross return (Rs ha^{1})	Net return (Rs ha^{1})	B:C ratio	Cost of cultivation (Rs ha^{1})	Gross return (Rs ha^{1})	Net return (Rs ha^{1})	B:C ratio
V_1	Kallurundaikar	27331	59270	31939	2.17	27210	74521	47311	2.74
V_2	White Chithiraikar	27331	47396	20065	1.73	27210	58931	31721	2.17
V_3	Sivappu Chithiraikar	27331	57921	30590	2.12	27210	72786	45576	2.67
V_4	Mattaikar	27331	51700	24369	1.89	27210	64410	37200	2.37
V_5	Kuruvai kalanjiyam	27331	50454	23123	1.85	27210	63059	35849	2.32
V_6	Kuliyadichan	27331	53133	25802	1.94	27210	66807	39597	2.46
V_7	Norungan	27331	60779	33448	2.22	27210	76039	48829	2.79
V_8	Nootripathu	27331	41554	14223	1.52	27210	49792	22582	1.83
V_9	Chandikar	27331	72825	45494	2.66	27210	94441	67231	3.47
V_{10}	Kattanur	27331	52548	25217	1.92	27210	65424	38214	2.40
V_{11}	TKM 9	27331	64629	37298	2.36	27210	81505	54295	3.00

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