

Original Research Article

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Effect of Organic Nutrient Management on Productivity, Nutrient Uptake and Nutrient Balance Sheet in Scented Rice-rice Sequence in a Sandy Loam Soil of Odisha

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ABSTRACT

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A field experiment was carried out at Agronomy Research Farm, Central Research Station, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, during both *kharif* and *rabi* seasons of 2015-16 and 2016-17, to find out the suitable organic nutrient management practice for higher productivity, and maintenance of soil fertility in scented rice-rice sequence. Application of recommended dose of fertilizer to scented rice-rice sequence (Geetanjali) produced higher grain yield but similar yield also obtained from the sequence grown with 100% RDN through poultry manure along with top dressing with liquid manure twice at 25 and 50 DAT and soil health also maintained properly. The maximum organic carbon (0.63%), available N (296.87kg/ha), available P (62.94kg/ha), available K (189.23kg/ha) was recorded with the same treatment which ultimately induced the content and uptake of nutrients. Comparatively lesser gain in soil NPK after completion of the two-year sequence was noticed in fully inorganic treatment as compared to the organic treatments. However, negative balance in NPK was observed when no fertilizer or manures were applied to all the rice crops in sequence. Similarly mining of potassium was also noticed when FYM was used as one of the source of organic nutrient management in scented rice-rice sequence.

Introduction

Scented rice is rated best in quality and fetches much higher price than high quality non-aromatic rice in the domestic and international market. The area under scented

rice varieties is increasing day by day with the opening of the world market as well as increased domestic consumption due to their superior cooking and eating quality (Singh *et al.*, 2008). At present, the farmers cultivate such premium scented rice in native areas

following chemical-based agricultural practices, which has led to increased productivity but has adversely affected the grain quality, soil health and environment. However, organic nutrient management is getting much attention in present-day agricultural system, as it is associated with maintenance of soil health through increase in soil – organic carbon on which so many macro and micro organisms depends. During their growth and development the property of slow release of nutrients involved in different enzymatic process leads to not only increase in soil fertility but also increase in quantity and quality of produce. Geetanjali is a long slender aromatic rice variety mainly cultivated in Mahanadi river belts of Odisha. It is very popular in market for preparation of polao, biryani as well as for making, payash (dessert) etc. To promote organic cultivation of Geetanjali rice in Odisha, The present study aims to identify the best suitable organic nutrient management practice for higher yield, nutrient uptake and better soil residual status for scented rice-rice in Odisha.

Materials and Methods

The experiment was carried out at the Agronomy Research Farm, Central Research Station, Odisha University of Agriculture and Technology, Bhubaneswar during both *khari* and *rabi* seasons of 2015-16 and 2016-17. The soil property of the experimental site was sandy loam (72.3% sand, 11.5% silt and 16.2% clay) with slightly acidic in reaction (pH 5.92), medium in organic carbon (0.52%), low in available N (247.21kg/ha), high in available P₂O₅ (44.38 kg/ha) and medium in K₂O content (168.84 kg/ha). Sixteen treatments consisting of fourteen organic from three different sources either alone or its combination as well as one inorganic and one control without organic or inorganic, viz. T1: 100% Recommended Dose of Nitrogen (RDN) through Farm Yard

Manure (FYM), T2: 100% RDN through Concentrated manure (CM), T3: 100% RDN through Poultry manure (PM), T4:50% RDN through FYM + 50% RDN through CM, T5:50% RDN through FYM + 50% RDN through PM, T6:50% RDN through CM + 50% RDN through PM, T7:1/3rd RDN through FYM + 1/3rd RDN through CM + 1/3rd RDN through PM, T8: T1 + TD{Top dressing with Liquid manure twice at 25 and 50 Days after transplanting (DAT)}, T9: T2 + TD, T10: T3 + TD, T11: T4 + TD, T12: T5 + TD, T13: T6 + TD, T14: T7 + TD, T15: Recommended Dose of Fertilizer (RDF) (80:40:40 kg N:P:K/ha), T16: Control without organic or inorganic were laid out in randomized block design in three replicates.

Of the three different sources of organic manure i. e. FYM, PM and CM, the first two were collected from different sources and the third one was self-prepared. The liquid manure (LM) “Sanjivak” was also self-prepared following the procedure given by A.K Yadav (2015). The nutrient composition of these organic manures (FYM, CM, PM and LM) are 0.58-0.31-0.58, 2.1-1.32-1.71, 2.24-2.3-2.1, 0.57-0.06-0.37 % N-P-K, respectively. From these organic manures FYM, PM and CM were incorporated as per the standard treatments i.e. one day before transplanting in the puddled field. The recommended dose of fertilizers (RDF) i.e. 80-40-40 kg NPK /ha were applied through urea, Single Super Phosphate and Murate of patash. Half of the N and full of P and K were applied at the time of puddling while remaining N was applied in three equal splits i.e. at early tillering, late tillering and panicle initiation stage. Twenty five days old seedlings of “Geetanjali” scented rice were transplanted in the main experimental field on 14th and 19th August in *Khari* and 26th and 28th December in *Rabi* during 2015-16 and 2016-17, respectively, at a spacing of 20 cm x 10 cm. Nutrient balance of the soil was

calculated by subtracting the initial value from the soil residual status of nutrients after final rice crop harvest adopting the method suggested by Palaniappan (1985).

Results and Discussion

Yield and yield attributes

Yield is the better manifestation of growth and yield attributing characters (Table 1). During both the years of study, irrespective of the treatments, the rice cultivar Geetanjali produced higher yield (Table 2) in *kharif* season as compared to the *rabi*. This could be due to the fact that the reproductive stage of the *rabi* crop was exposed to relatively higher temperature resulting in poor sink size i.e. smaller panicles and lesser number of grains per panicle. Besides, the number of productive tillers was also less during *rabi* season. Yield outcome from the organic treatments were higher than no fertilizer application (T₁₆) but lower than the 100% inorganic fertilizer application (T₁₅) (Table 2). Application of liquid manure twice at 25 and 50 days after transplanting (DAT) marginally enhanced the growth and yield of rice in both the years of experiment. But interestingly the yield obtained from rice crop when supplemented with organic sources like PM and CM either in isolation or in combination were almost at par with the yield recorded from the rice crop fertilized inorganically in both the seasons during the period of study. The advantage of PM than other sources of organic manures was also registered earlier in a clay loam soil of Bapatla, A.P. (Sujatha *et al.*, 2014) and the advantage of chemical fertilizer over the organic manures was reported by Kumari *et al.*, 2010. Among the organic treatment crop receiving PM along with top dressing twice with liquid manure (T₁₀) recorded 15.11% and 17% higher yield over FYM 100% RDN + TD with liquid manure during both *kharif* and *rabi* season,

respectively, and at par with the yield obtained from PM100% RDN and CM 100%RDN+TD with liquid manure. More nutrient content and steady nutrient release pattern of Poultry manure and concentrated manure enhanced the yield of scented rice compared to FYM. Devegowda (1997) reported that the superiority of Poultry manure was mostly because it contains both urinary and fecal excretions which lead to three times more nutrient value than FYM. The major yield attributes like panicle/m², grain/panicle and 1000 grain weight followed the similar trend as that of yield in both the seasons. Increased production of tiller/m² and filled grain in rice recorded through the application of enriched poultry manure or composted Poultry manure was also reported earlier by Sangeetha *et al.*, 2010. Harvest Index (HI) is the indication of the quantum of partitioning of photosynthates from vegetative towards the reproductive part of the plant. Higher value of HI was recorded in *kharif* season as compared to the *rabi* season (Table 2). This may be attributed to the fact that the exposure of reproductive stage of *rabi* rice to a relatively higher temperature might have restricted the photosynthetic rate as well as the partitioning of photosynthates from vegetative towards the reproductive part. The influence of nutrient management on HI of rice was only significant during *kharif* season. Highest value of HI was noticed in crop supplemented with all three sources of organic manures in equal proportions which was superior to T₂, T₅, T₆, T₉, T₁₂, T₁₃ and T₁₆ (control)treatments. Lowest HI value recorded in the control treatment in both the seasons.

Nutrient content and uptake

The nutrient contents in grain and straw were non-significant excepting the nitrogen and phosphorus content in grain and nitrogen content in straw in both the seasons (Table 3).

Table.1 Yield attributes of scented rice as influenced by organic nutrient management (mean of 2 years)

Treatments	Panicles/m ²		Grains/Panicle		Sterility percentage		Panicle length (cm)		1000 grain weight (g)	
	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>
T1: FYM 100%RDN	335	299	88	71	18.6	15.8	30.6	23.6	22.49	22.00
T2: CM 100%RDN	355	323	100	85	13.7	9.8	32	24.2	22.68	22.32
T3: PM 100%RDN	378	311	105	89	11.8	9.5	34.4	25.1	22.86	22.44
T4: FYM 50%RDN+CM 50%RDN	299	294	79	60	23.7	21.3	29.6	23.2	22.25	21.65
T5: FYM 50% RDN+PM 50% RDN	341	303	94	76	15.8	12.5	31.2	23.9	22.55	22.04
T6: PM 50% RDN+CM 50% RDN	348	312	96	81	15.0	10.7	31.9	24.1	22.64	22.07
T7: FYM1/3rd RDN+CM1/3rdRDN+PM1/3rdRDN	318	294	79	67	22.3	18.2	29.7	23.3	22.35	21.68
T8: T1+Top dressing with liquid manure	339	303	88	75	16.9	14.4	30.6	23.6	22.51	22.03
T9: T2+Top dressing with liquid manure	374	333	102	87	12.6	9.3	32.6	24.4	22.83	22.34
T10: T3+Top dressing with liquid manure	396	342	106	97	11.0	7.2	34.6	25.1	22.88	22.45
T11: T4+Top dressing with liquid manure	325	296	81	68	21.2	24.4	30.1	23.5	22.43	21.83
T12: T5+Top dressing with liquid manure	344	311	96	76	15.2	12.2	31.9	24.1	22.62	22.05
T13: T6+Top dressing with liquid manure	351	315	96	84	13.9	12.0	32	24.1	22.67	22.22
T14: T7+Top dressing with liquid manure	328	298	83	69	18.9	15.8	30.3	23.5	22.46	21.88
T15: 80:40:40 RDF	459	425	123	108	6.9	6.7	35.3	25.4	22.95	22.47
T16: Control	276	204	73	48	25.3	27.5	28.4	22.7	22.09	21.56
SEM±	16	19	10	11	3.0	4.5	0.31	0.45	0.23	0.24
CD 5%	47	54	29	33	8.7	13.1	0.92	1.29	0.65	0.68

FYM: Farm Yard Manure, CM: Concentrated manure, PM: Poultry manure, RDN: Recommended dose of Nitrogen, RDF: Recommended dose of fertilizer

Table.2 Grain yield (t/ha), Straw yield (t/ha) and Harvest index of scented rice as influenced by organic nutrient management (mean of 2 years)

Treatments	Grain yield (t/ha)		Straw yield (t/ha)		Harvest Index	
	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>	<i>kharif</i>	<i>rabi</i>
T1: FYM 100%RDN	3.50	3.09	5.42	5.78	39.2	34.8
T2: CM 100%RDN	3.72	3.36	6.08	6.42	37.9	34.3
T3: PM 100%RDN	3.98	3.58	6.23	6.48	39.0	35.6
T4: FYM 50%RDN+CM 50%RDN	3.27	2.81	4.97	4.95	39.7	36.3
T5: FYM 50% RDN+PM 50% RDN	3.57	3.22	5.73	5.97	38.4	35.0
T6: PM 50% RDN+CM 50% RDN	3.67	3.29	6.00	6.20	37.9	34.7
T7: FYM1/3rd RDN+CM1/3rdRDN+PM1/3rdRDN	3.32	2.95	4.99	5.16	40.0	36.4
T8: T1+Top dressing with liquid manure	3.54	3.11	5.56	5.87	38.9	34.6
T9: T2+Top dressing with liquid manure	3.75	3.41	6.10	6.45	38.0	34.6
T10: T3+Top dressing with liquid manure	4.17	3.75	6.44	6.61	39.3	36.2
T11: T4+Top dressing with liquid manure	3.42	3.02	5.34	5.34	39.1	36.2
T12: T5+Top dressing with liquid manure	3.59	3.24	5.83	6.14	38.1	34.6
T13: T6+Top dressing with liquid manure	3.70	3.30	6.03	6.29	38.0	34.4
T14: T7+Top dressing with liquid manure	3.44	3.04	5.36	5.49	39.1	35.7
T15: 80:40:40 RDF	4.19	3.80	6.51	6.64	39.2	36.4
T16: Control	2.48	1.83	4.83	4.21	33.9	30.3
SEM±	0.19	0.18	0.31	0.43	1.71	3.07
CD 5%	0.55	0.51	0.91	1.23	4.94	8.88

FYM: Farm Yard Manure, CM: Concentrated manure, PM: Poultry manure, RDN: Recommended dose of Nitrogen, RDF: Recommended dose of fertilizer

Table.3 Nutrient content (%) of scented rice as influenced by organic nutrient management (mean of 2 years)

Treatments	Nutrient content (%)						Nutrient content (%)					
	<i>kharif mean</i>						<i>rabi mean</i>					
	Grain				Straw		Grain				Straw	
	N	P	K	N	P	K	N	P	K	N	P	K
T1: FYM 100%RDN	0.99	0.220	0.363	0.406	0.041	1.346	0.96	0.221	0.362	0.410	0.040	1.348
T2: CM 100%RDN	1.07	0.239	0.378	0.440	0.044	1.364	1.05	0.240	0.374	0.445	0.043	1.366
T3: PM 100%RDN	1.13	0.252	0.382	0.466	0.047	1.365	1.10	0.252	0.378	0.471	0.045	1.367
T4: FYM 50%RDN+CM 50%RDN	0.94	0.209	0.352	0.387	0.039	1.332	0.91	0.210	0.349	0.391	0.038	1.333
T5: FYM 50% RDN+PM 50% RDN	1.02	0.227	0.371	0.419	0.042	1.353	0.99	0.228	0.368	0.423	0.041	1.355
T6: PM 50% RDN+CM 50% RDN	1.05	0.234	0.375	0.433	0.043	1.360	1.02	0.234	0.371	0.437	0.042	1.361
T7: FYM1/3rd RDN +CM1/3rdRDN + PM1/3rdRDN	0.94	0.210	0.354	0.380	0.038	1.331	0.92	0.210	0.350	0.384	0.037	1.332
T8: T1+Top dressing with liquid manure	0.99	0.222	0.367	0.411	0.041	1.347	0.97	0.222	0.363	0.415	0.040	1.349
T9: T2+Top dressing with liquid manure	1.08	0.241	0.379	0.447	0.045	1.370	1.06	0.242	0.376	0.451	0.044	1.371
T10: T3+Top dressing with liquid manure	1.16	0.259	0.385	0.480	0.048	1.369	1.13	0.260	0.381	0.485	0.047	1.370
T11: T4+Top dressing with liquid manure	0.96	0.214	0.360	0.396	0.040	1.341	0.93	0.214	0.356	0.400	0.039	1.342
T12: T5+Top dressing with liquid manure	1.03	0.229	0.374	0.425	0.042	1.356	1.00	0.230	0.370	0.429	0.041	1.357
T13: T6+Top dressing with liquid manure	1.06	0.237	0.376	0.439	0.044	1.360	1.04	0.237	0.372	0.443	0.043	1.361
T14: T7+Top dressing with liquid manure	0.96	0.215	0.363	0.399	0.040	1.333	0.94	0.216	0.359	0.402	0.039	1.335
T15: 80:40:40 RDF	1.20	0.268	0.386	0.490	0.050	1.374	1.17	0.268	0.383	0.490	0.048	1.375
T16: Control	0.92	0.208	0.348	0.387	0.04	1.326	0.92	0.206	0.345	0.394	0.037	1.327
SEM±	0.02	0.004	0.005	0.019	0.002	0.018	0.02	0.004	0.005	0.018	0.002	0.018
CD 5%	0.05	0.013	NS	0.06	NS	NS	0.04	0.013	NS	0.05	NS	NS

FYM: Farm Yard Manure, CM: Concentrated manure, PM: Poultry manure, RDN: Recommended dose of Nitrogen, RDF: Recommended dose of fertilizer

Table.4 Nutrient uptake (kg/ha)and System nutrient uptake (kg/ha) of scented rice as influenced by organic nutrient management (mean of 2 years)

Treatments	Total Nutrient Uptake (kg/ha)						Total Nutrient Uptake in the system (kg/ha)		
	<i>kharif mean</i>			<i>rabi mean</i>			<i>kharif mean +rabi mean</i>		
	Grain+Straw			Grain+Straw					
	N	P	K	N	P	K	N	P	K
T1: FYM 100%RDN	56.58	9.91	85.67	53.49	9.11	89.07	110.08	19.03	174.73
T2: CM 100%RDN	66.65	11.58	97.16	63.69	10.81	100.00	130.34	22.39	197.16
T3: PM 100%RDN	73.40	12.91	100.40	69.82	11.95	102.12	143.22	24.86	202.51
T4: FYM 50%RDN+CM 50%RDN	49.84	8.75	77.68	45.12	7.76	75.79	94.96	16.51	153.47
T5: FYM 50% RDN+PM 50% RDN	60.49	10.54	90.72	57.19	9.76	92.80	117.67	20.30	183.52
T6: PM 50% RDN+CM 50% RDN	64.63	11.20	95.56	60.61	10.34	96.71	125.24	21.54	192.27
T7: FYM1/3rd RDN+CM1/3rdRDN+PM1/3rdRDN	50.13	8.85	78.10	46.45	8.06	78.80	96.58	16.92	156.90
T8: T1+Top dressing with liquid manure	58.52	10.19	89.28	54.55	9.26	90.61	113.06	19.45	179.89
T9: T2+Top dressing with liquid manure	67.89	11.79	97.86	65.21	11.07	101.33	133.10	22.86	199.19
T10: T3+Top dressing with liquid manure	73.68	13.87	103.93	74.56	12.84	104.94	148.24	26.71	208.86
T11: T4+Top dressing with liquid manure	53.94	9.43	84.06	49.58	8.54	82.50	103.52	17.97	166.56
T12: T5+Top dressing with liquid manure	61.79	10.74	92.57	58.98	10.02	95.43	120.78	20.75	188.01
T13: T6+Top dressing with liquid manure	65.83	11.41	96.13	62.05	10.53	98.01	127.87	21.94	194.14
T14: T7+Top dressing with liquid manure	54.66	9.57	83.95	50.72	8.69	84.35	105.38	18.25	168.29
T15: 80:40:40 RDF	75.18	14.44	105.62	77.04	13.40	105.69	152.22	27.84	211.32
T16: Control	41.62	7.01	72.73	38.73	5.51	67.58	80.35	12.52	140.31
SEM±	1.68	0.62	4.48	3.10	0.62	9.13			
CD 5%	4.85	1.80	12.92	8.94	1.80	26.36			

FYM: Farm Yard Manure, CM: Concentrated manure, PM: Poultry manure, RDN: Recommended dose of Nitrogen, RDF: Recommended dose of fertilizer

Table.5 Residual status of soil as influenced by organic nutrient management after 2 years

Treatments	Available nutrients (Kg/ha) (D)						Actual gain or loss (D-A) after 2 years		
	Soil pH	Soil EC (dS/m)	OC(%)	N	P ₂ O ₅	K ₂ O	N	P	K
T1: FYM 100%RDN	6.14	0.043	0.56	276.65	51.10	160.14	29.4	6.72	-8.7
T2: CM 100%RDN	6.23	0.044	0.6	291.23	54.81	179.57	44.0	10.43	10.7
T3: PM 100%RDN	6.32	0.045	0.61	292.69	60.12	187.28	45.5	15.74	18.4
T4: FYM 50%RDN+CM 50%RDN	6.16	0.043	0.57	269.70	49.23	150.33	22.5	4.85	-18.5
T5: FYM 50% RDN+PM 50% RDN	6.2	0.043	0.58	279.13	52.91	169.64	31.9	8.53	0.8
T6: PM 50% RDN+CM 50% RDN	6.21	0.041	0.59	280.12	53.25	171.42	32.9	8.87	2.6
T7: FYM1/3rd RDN+CM1/3rdRDN+PM1/3rdRDN	6.17	0.04	0.57	265.55	49.83	153.44	18.3	5.45	-15.4
T8: T1+Top dressing with liquid manure	6.15	0.043	0.58	279.55	51.29	161.14	32.3	6.91	-7.7
T9: T2+Top dressing with liquid manure	6.23	0.044	0.61	288.51	56.74	187.71	41.3	12.36	18.9
T10: T3+Top dressing with liquid manure	6.28	0.045	0.63	296.87	62.94	189.23	49.7	18.56	20.4
T11: T4+Top dressing with liquid manure	6.16	0.043	0.58	276.42	51.09	160.06	29.2	6.71	-8.8
T12: T5+Top dressing with liquid manure	6.21	0.043	0.59	285.24	54.69	178.95	38.0	10.31	10.1
T13: T6+Top dressing with liquid manure	6.22	0.041	0.6	290.66	54.77	179.38	43.4	10.39	10.5
T14: T7+Top dressing with liquid manure	6.2	0.04	0.58	272.12	50.81	158.58	24.9	6.43	-10.3
T15: 80:40:40 RDF	6.18	0.045	0.58	263.42	47.22	184.11	16.2	2.84	15.3
T16: Control	6.07	0.039	0.52	202.52	41.18	135.39	-44.7	-3.20	-33.4
SEM±	0.01	0.001	0.02	10.03	0.73	3.84			
CD 5%	0.04	0.002	0.07	28.95	2.10	11.09			
Initial (A)	5.92	0.039	0.52	247.21	44.38	168.84			

Maximum nitrogen content in grain was noticed when rice crop was grown inorganically which was superior to T₄, T₇, T₁₁, T₁₄ and control in both the seasons whereas, the straw nitrogen content was also highest in the same inorganically grown crop but only superior to the crops supplemented with PM alone or in combination with top dressing of liquid manure twice at 25 and 50 DAT in both the seasons. This corroborated the findings of Anan Polthanee *et al.*, (2011) from Thailand and Padmanabhan *et al.*, (2014) from Bengaluru.

Maximum amount of nutrients removed by the scented rice when grown with inorganic fertilizers alone which was closely followed by the removal by the rice crop when supplemented with poultry manure in combination with liquid manure or alone during both the seasons of study (Table 4). Lowest nutrient removal from soil was observed when the crop was grown without any fertilizer or manure. Total nutrient uptake by the rice-rice system was also followed the similar trend (Table 5). This is in agreement with the findings of Hossain *et al.*, (2010).

Soil residual status

The detail introspection of the soil residual status after completion of two year sequence clearly revealed that there was a significant improvement in soil reaction status in the all the treatments including control (Table 5). The soil EC has also improved significantly in all the treatments excepting the treatments T₇ and T₁₄ where there was only marginal improvement but no improvement in EC value was noticed in control treatment. Soil organic carbon was increased in all the treatments excepting in control treatment but the increments were more pronounced when the soil received nutrients through organic sources like CM, PM and CM+PM alone and in combination with liquid manure twice at 25

and 50 DAT. When the balance sheet of nutrients (Table 5) reviewed it clearly reflected that clear cut positive gain was noticed in nitrogen and phosphorus in all the treatments excepting the control where there was nutrient mining from soil. However, the gain was more pronounced with the organic treatments as compared to the complete inorganic treatment. Similarly, Hossain *et al.*, (2010) observed that nitrogen based manure or compost resulted significantly higher available P than those for the phosphorous based manure or compost application. But the potassium mining was mostly observed in plots receiving FYM as one of the organic source. Control plot (without fertilizer or manure) recorded significantly highest NPK loss and lowest NPK residual status after 2 years. Maintenance or enrichment of soil health was observed in the organically grown scented rice by improving the chemical properties of soil as reported by Banarjee *et al.*, 2013 from Mohanpur, West Bengal and also by Rao *et al.*, (2013) from Seethampet, A.P.

Scented rice Geetanjali grown organically with PM alone or in combination i.e. PM100% RDN + Top dressing with liquid manure at 25 and 50 DAT was found to be the most suitable organic nutrient management system not only for higher productivity but also for maintaining soil health. Application of recommended dose of chemical fertilizer to scented rice recorded the higher productivity and profit but the adaptation of organic nutrient management practices has enriched the soil fertility status after 2 years of study which can sustain the productivity for a longer period of time once the soil fertility status is maintained.

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