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Research Article

SOIL TEST CROP RESPONSE BASED FERTILIZER DOSES UNDER INTEGRATED NUTRIENT MANAGEMENT IN RICE-BLACKGRAM SEQUENCE

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Abstract: A field experiment was conducted at the Agricultural College farm, Bapatla, during *kharif* and *rabi* 2017-18 and 2018-19. The experiment was conducted with variety BPT-5204 in a Randomized Block Design with ten treatments and three replications. Uptake and content of N, P and K in grain and straw at harvest were found significantly higher with the treatments that received soil test-based fertilizer recommendation with 10 t ha^{-1} FYM application, followed by soil test-based fertilizer recommendation (T2). Fertilizer use efficiency (FUE) was significantly the highest with application of 5.5 t ha^{-1} target yield recommendation with FYM (T8) compared to all other treatments. Grain yield of rice was significantly higher with soil test-based fertilizer recommendation with 10 t ha^{-1} FYM application which was statistically at par with soil test-based fertilizer recommendation alone (T2) and 7.5 t ha^{-1} targeted yield fertilizer recommendation with FYM (T10) compared to the rest of the treatments.

Keywords: *Rice, Fertilizer Use Efficiency, Uptake, STCR*

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Introduction

Rice is a staple food crop not only in India but also in entire South Asia. Of the total rice (*Oryza sativa* L.) production in the world, more than 90 % is in Asia. Rice is cultivated in 111 countries of all continents, except Antarctica. India and China are the leading producers as well as consumers of rice. In India, it is grown in an area of 43.9 m ha with a production of 99.24 m t and productivity of 2494 kg ha^{-1}. In Andhra Pradesh, it is grown in an area of 2.152 m ha with a production of 8.05 m t and productivity of 3741 kg ha^{-1} [1]. To get more and more yield, farmers inclined to the excess use of chemical fertilizer, but the decision on fertilizer use requires knowledge of the expected crop yield response to nutrient application, which is a function of crop nutrient needs, supply of nutrients from indigenous sources, and the short and long term fate of fertilizer applied. Application of fertilizers by the farmers in the fields without information on soil fertility status and nutrient requirement by the crop causes adverse effects in soil and crop regarding both nutrient toxicity and deficiency either by over use or inadequate use.

Materials and Methods

A field experiment was conducted at the Agricultural College farm, Bapatla, during *kharif* and *rabi* 2017-18 and 2018-19. The experiment was conducted with variety BPT-5204 in a Randomized Block Design with ten treatments and three replications. The treatments comprised of, Recommended Dose of Fertilizer (T1), Soil test based fertilizer recommendation(T2); Targeted yield fertilizer recommendations for 5.5 tons ha^{-1} (T3) , 6.5 t ha^{-1} (T4) and 7.5 t ha^{-1} (T5); Treatment T1 + FYM @ 10 t ha^{-1} (T6); Treatment T2 + FYM @ 10 t ha^{-1} (T7); Treatment T3 + FYM @ 10 t ha^{-1} (T8); Treatment T4 + FYM @ 10 t ha^{-1} (T9); and Treatment T5 + FYM @ 10 t ha^{-1} (T10). The experimental soil was clay loam in texture, slightly alkaline in reaction, non-saline, low in available nitrogen, low in organic carbon, high available phosphorus and potassium. The application of nutrients was done following the soil test-based fertilizer recommendations as per the treatment. Target yield fertilizer recommendations were based on using the target yield equations developed for Krishna Godavari agro ecological region.

By using formulae Targeted yield (qha^{-1}) equation for *kharif*- Rice [2]:

*FN= 2.30 x T 0.32 x SN	SN= Soil Nitrogen
*FP_2O_5=1.91 x T - 1.90 x SP	SP= Soil Phosphorous
*FK=2.27 x T - 0.27 x SK	SK= Soil Potassium

Fertilizer schedule during *kharif* rice- during 2017and 2018 (As Per Initial soil analysis data).

Treatments	2017-18	2018-19
	N-P-K (kg ha^{-1})	N-P-K (kg ha^{-1})
T_1	120-60-40	120-60-40
T_2	156-42-28	156-42-28
T_3	80-30-30	70-30-28
T_4	102-30-52	98-30-50
T_5	125-30-75	123-30-73
T_6	T_1+FYM@10 t ha^{-1}	T_1+FYM@10 t ha^{-1}
T_7	T_2+FYM@10 t ha^{-1}	T_2+FYM@10 t ha^{-1}
T_8	T_3+FYM@10 t ha^{-1}	T_3+FYM@10 t ha^{-1}
T_9	T_4+FYM@10 t ha^{-1}	T_4+FYM@10 t ha^{-1}
T_{10}	T_5+FYM@10 t ha^{-1}	T_5+FYM@10 t ha^{-1}

Results and discussion

A perusal of data presented in [Table-1], [Fig-1a, 1b] showed significant differences in nitrogen uptake in plant at maturity (grain and straw) due to site specific nutrient management practices along with application of FYM during both the years of experimentation and pooled data.

Soil Test Crop Response Based Fertilizer Doses Under Integrated Nutrient Management in Rice-Blackgram Sequence

Table-1 *Nitrogen content (%) and uptake (kg ha^{-1}), of kharif rice as influenced by Soil Test Crop Response Based Fertilizer Doses Under Integrated Nutrient Management during 2017, 2018 and pooled data*

Treatments	2017					2018					Pooled data				
	Grain		Straw		Total uptake	Grain		Straw		Total uptake	Grain		Straw		Total uptake
	Content	Uptake	Content	Uptake		Content	Uptake	Content	Uptake		Content	Uptake	Content	Uptake	
T_1- Recommended dose of fertilizer (RDF) 120-60-40 kg ha^{-1})	1.22	54.1	0.77	43.2	97.3	1.24	65.1	0.80	46.4	111.6	1.23	59.4	0.79	44.8	104.2
T_2- Soil test-based fertilizer recommendation (STFR)	1.40	71.3	0.82	50.7	122.1	1.43	83.2	0.84	52.1	135.3	1.42	80.5	0.83	51.4	131.9
T_3- Targeted yield fertilizer recommendation for 5.5 t ha^{-1} (TYFR)	1.00	42.3	0.72	35.4	77.7	1.02	48.9	0.72	35.4	84.4	1.01	45.6	0.72	35.4	81.0
T_4- Targeted yield fertilizer recommendation for 6.5 t ha^{-1} (TYFR)	1.11	48.6	0.75	41.8	90.4	1.13	58.1	0.78	44.4	102.5	1.12	53.3	0.77	43.0	96.4
T_5- Targeted yield fertilizer recommendation for 7.5 t ha^{-1} (TYFR)	1.27	61.5	0.79	46.7	108.2	1.30	72.0	0.82	49.3	121.4	1.29	68.7	0.80	48.1	116.8
T_6- T_1+FYM @ 10 t ha^{-1}	1.23	57.4	0.78	44.4	101.8	1.26	67.3	0.81	48.0	115.3	1.25	64.2	0.80	46.2	110.4
T_7- T_2+FYM @ 10 t ha^{-1}	1.42	73.1	0.84	51.2	124.3	1.45	87.5	0.86	55.1	142.6	1.44	86.3	0.85	53.1	139.5
T_8- T_3+FYM @ 10 t ha^{-1}	1.09	47.3	0.74	37.2	84.6	1.11	53.8	0.75	37.4	91.3	1.10	50.5	0.75	37.3	87.9
T_9- T_4+FYM @ 10 t ha^{-1}	1.21	52.8	0.76	42.3	95.2	1.15	60.0	0.79	44.7	104.8	1.18	56.8	0.77	43.5	100.4
T_{10}- T_5+FYM @ 10t ha^{-1}	1.33	65.2	0.81	49.0	114.2	1.36	76.8	0.83	50.9	127.8	1.35	74.5	0.82	50.0	124.5
SEm±	0.08	4.56	0.02	2.34	5.19	0.08	5.06	0.03	1.79	4.85	0.07	2.91	0.02	1.62	3.33
CD (p = 0.05)	0.22	13.5	0.07	6.9	15.4	0.23	15.0	0.08	5.3	14.4	0.19	8.6	0.06	4.8	9.9
CV (%)	10.6	13.7	5.13	9.1	8.8	10.8	13.0	5.5	6.6	7.3	9.1	7.8	4.4	6.1	5.2

Table-2 *Phosphorus content (%) and uptake (kg ha^{-1}), of kharif rice as influenced by Soil Test Crop Response Based Fertilizer Doses Under Integrated Nutrient Management during 2017, 2018 and pooled data*

Treatments	2017					2018					Pooled data				
	Grain		Straw		Total uptake	Grain		Straw		Total uptake	Grain		Straw		Total uptake
	Content	Uptake	Content	Uptake		Content	Uptake	Content	Uptake		Content	Uptake	Content	Uptake	
T_1- Recommended dose of fertilizer (RDF) 120-60-40 kg ha^{-1})	0.21	9.25	0.11	6.00	15.25	0.23	12.07	0.13	7.52	19.59	0.22	10.57	0.12	6.75	17.33
T_2- Soil test-based fertilizer recommendation (STFR)	0.28	14.05	0.16	9.94	24.00	0.30	17.27	0.17	10.86	28.13	0.29	16.33	0.17	10.40	26.73
T_3- Targeted yield fertilizer recommendation for 5.5 t ha^{-1} (TYFR)	0.15	6.50	0.05	2.30	8.80	0.16	7.86	0.09	4.66	12.51	0.16	7.15	0.07	3.48	10.63
T_4- Targeted yield fertilizer recommendation for 6.5 t ha^{-1} (TYFR)	0.18	7.88	0.08	4.47	12.35	0.20	10.29	0.11	6.08	16.38	0.19	9.05	0.09	5.27	14.32
T_5- Targeted yield fertilizer recommendation for 7.5 t ha^{-1} (TYFR)	0.25	12.24	0.14	8.41	20.64	0.27	15.12	0.15	9.22	24.34	0.26	14.05	0.15	8.78	22.83
T_6- T_1+FYM @ 10 t ha^{-1}	0.22	10.27	0.13	7.41	17.68	0.26	13.89	0.14	8.45	22.34	0.24	12.39	0.14	7.92	20.32
T_7- T_2+FYM @ 10 t ha^{-1}	0.34	17.39	0.17	10.57	27.96	0.35	21.01	0.18	11.45	32.46	0.35	20.90	0.18	11.01	31.90
T_8- T_3+FYM @ 10 t ha^{-1}	0.16	7.12	0.06	3.17	10.29	0.19	9.26	0.10	4.90	14.16	0.18	8.16	0.08	4.04	12.20
T_9- T_4+FYM @ 10 t ha^{-1}	0.20	8.93	0.10	5.46	14.39	0.22	11.29	0.12	6.63	17.92	0.21	10.10	0.11	6.04	16.14
T_{10}- T_5+FYM @ 10t ha^{-1}	0.27	13.17	0.15	9.23	22.40	0.29	16.31	0.16	9.82	26.12	0.28	15.41	0.16	9.51	24.92
SEm±	0.01	0.54	0.01	0.61	1.00	0.01	1.10	0.01	0.85	1.40	0.01	0.58	0.01	0.63	0.96
CD (p = 0.05)	0.04	1.61	0.03	1.82	2.98	0.04	3.27	0.03	2.52	11.37	0.02	1.73	0.03	1.87	2.86
CV (%)	10.5	8.8	12.87	15.8	6.6	9.7	14.2	15.01	18.4	4.17	5.7	8.1	12.63	14.8	8.4

Table-3 *Potassium content (%) and uptake (kg ha^{-1}), of kharif rice as influenced by Soil Test Crop Response Based Fertilizer Doses Under Integrated Nutrient Management during 2017, 2018 and pooled data*

Treatments	2017					2018					Pooled data				
	grain		straw		Total uptake	grain		straw		Total uptake	Grain		Straw		Total uptake
	Content	Uptake	Content	Uptake		Content	Uptake	Content	Uptake		Content	Uptake	Content	Uptake	
T_1- Recommended dose of fertilizer (RDF) 120-60-40 kg ha^{-1})	0.31	13.73	1.15	65.15	78.88	0.32	16.80	1.17	67.88	84.67	0.32	15.24	1.19	68.05	83.29
T_2- Soil test-based fertilizer recommendation (STFR)	0.37	18.65	1.23	75.63	94.28	0.40	23.31	1.29	80.22	103.53	0.39	22.02	1.26	77.93	99.95
T_3- Targeted yield fertilizer recommendation for 5.5 t ha^{-1} (TYFR)	0.25	10.44	1.03	50.83	61.27	0.27	13.12	1.06	52.77	65.89	0.26	11.75	1.05	51.80	63.55
T_4- Targeted yield fertilizer recommendation for 6.5 t ha^{-1} (TYFR)	0.28	12.11	1.10	61.13	73.23	0.28	14.59	1.14	64.71	79.30	0.28	13.34	1.16	65.20	78.54
T_5- Targeted yield fertilizer recommendation for 7.5 t ha^{-1} (TYFR)	0.35	16.92	1.19	71.14	88.06	0.38	20.97	1.23	74.01	94.97	0.36	19.56	1.21	72.69	92.25
T_6- T_1+FYM @ 10 t ha^{-1}	0.33	15.56	1.17	66.69	82.25	0.36	19.27	1.18	69.65	88.93	0.35	17.92	1.20	69.31	87.23
T_7- T_2+FYM @ 10 t ha^{-1}	0.39	19.82	1.24	75.89	95.71	0.43	25.71	1.31	84.01	109.72	0.41	24.85	1.32	82.61	107.46
T_8- T_3+FYM @ 10 t ha^{-1}	0.27	11.91	1.06	52.81	64.72	0.29	14.36	1.10	54.65	69.01	0.28	13.09	1.08	53.97	67.06
T_9- T_4+FYM @ 10 t ha^{-1}	0.29	12.75	1.14	63.37	76.12	0.30	15.48	1.15	65.81	81.29	0.29	14.10	1.18	66.60	80.71
T_{10}- T_5+FYM @ 10t ha^{-1}	0.36	17.78	1.22	73.42	91.19	0.39	21.68	1.26	77.40	99.08	0.38	20.89	1.24	75.43	96.33
SEm±	0.02	1.19	0.04	3.51	3.85	0.02	1.37	0.04	3.05	3.57	0.02	1.46	0.04	3.12	3.30
CD (p = 0.05)	0.07	3.54	0.11	10.43	11.45	0.07	4.07	0.12	9.06	10.61	0.06	4.33	0.11	9.27	9.81
CV (%)	12.44	13.7	5.55	9.2	8.2	12.23	12.8	5.99	7.6	7.0	9.92	14.6	5.29	7.9	6.6

Table-4 *Fertilizer use efficiency of kharif rice as influenced by Soil Test Crop Response Based Fertilizer Doses Under Integrated Nutrient Management during 2017, 2018 and pooled data*

Treatments		2017	2018	Pooled data
T_1-	Recommended dose of fertilizer (RDF) 120-60-40 kg ha^{-1}	20.23	23.80	22.02
T_2-	Soil test-based fertilizer recommendation (STFR)	23.82	27.13	25.48
T_3-	Targeted yield fertilizer recommendation for 5.5 t ha^{-1} (TYFR)	30.24	37.50	33.71
T_4-	Targeted yield fertilizer recommendation for 6.5 t ha^{-1} (TYFR)	23.75	29.01	26.33
T_5-	Targeted yield fertilizer recommendation for 7.5 t ha^{-1} (TYFR)	21.00	24.52	22.74
T_6-	T_1+FYM @ 10 t ha^{-1}	21.21	24.30	22.76
T_7-	T_2+FYM @ 10 t ha^{-1}	23.91	28.15	26.03
T_8-	T_3+FYM @ 10 t ha^{-1}	31.13	38.05	34.43
T_9-	T_4+FYM @ 10 t ha^{-1}	23.89	29.36	26.58
T_{10}-	T_5+FYM @ 10t ha^{-1}	21.20	24.84	23.01
SEm±		0.66	0.91	0.53
CD (p = 0.05)		1.97	2.70	1.59
CV (%)		4.78	5.49	3.52

Table-5 *Grain yield (kg ha-1) of kharif rice as influenced by Targeted Yield Equation Based Fertilizer Doses Under Integrated Nutrient Management during 2017, 2018 and pooled data*

Treatments		2017	2018	Pooled data
T_1-	Recommended dose of fertilizer (RDF) 120-60-40 kg ha^{-1})	4450	5236	4843
T_2-	Soil test-based fertilizer recommendation (STFR)	5099	5805	5452
T_3-	Targeted yield fertilizer recommendation for 5.5 t ha^{-1} (TYFR)	4234	4800	4517
T_4-	Targeted yield fertilizer recommendation for 6.5 t ha^{-1} (TYFR)	4370	5163	4766
T_5-	Targeted yield fertilizer recommendation for 7.5 t ha^{-1} (TYFR)	4831	5540	5186
T_6-	T_1+FYM @ 10 t ha^{-1}	4667	5346	5007
T_7-	T_2+FYM @ 10 t ha^{-1}	5117	6023	5570
T_8-	T_3+FYM @ 10 t ha^{-1}	4358	4870	4614
T_9-	T_4+FYM @ 10 t ha^{-1}	4396	5226	4811
T_{10}-	T_5+FYM @ 10t ha^{-1}	4876	5614	5245
SEm±		141.2	157.1	108.92
CD (p = 0.05)		419.2	466.9	323.6
CV (%)		5.2	5.0	3.77

During the year 2017, N content in grain was significantly higher in the treatment STFR with FYM (T7) over the rest of the treatments. The differences between the treatments T7 and T2 were not significant. The lowest N content in grain was obtained with the treatment T3 followed by T8 and these were found significantly inferior to all the treatments. Whereas, during 2018 the highest N content in grain obtained in T7 was found on par with other treatments T2, T10, T5 and T6. Among the remaining treatments T3 was found to be significantly inferior and found on par with each other.

Similarly, trend as that of nitrogen content also reflected in nitrogen uptake also. The treatment T7, followed by T2, T10 and T5 recorded the higher nitrogen uptake in grain over other treatments during both the years and pooled data as well. Differences in N uptake in the remaining treatments were not significant. Nitrogen uptake in grain with 7.5 t ha^{-1} targeted yield fertilizer recommendation with FYM (T10) was found on par with 7.5 t ha^{-1} targeted yield fertilizer recommendation alone (T5) RDF with FYM T6 and T1 during the year 2018.

The lowest N uptake in grain was obtained with the treatment T3 followed by T8 and these were found significantly inferior to all the treatments. Whereas, during 2018 and pooled data the lowest N uptake in grain obtained in treatments T3 was found to be significantly inferior and found on par with each other.

The higher nutrient uptake could be due to higher doses (30% extra) of N application in T7 due to its low soil N status. Addition of FYM might have released some organic acids due to organic decomposition and reduced the soil pH and improved nutrient availability.

The success of soil test-based fertilizer recommendations depends on measurement of the amount of nutrient removed by the crop, initial soil fertility, efficiency of nutrients already presents in soil and added through the fertilizers. Ahamed and Krishna Reddy (2002) while studying on optimization of fertilizer recommendations through chemical fertilizers and FYM using STFR methodology concluded that fertilizer N, P and K requirement was the lowest when green manure was used followed by FYM and only inorganic source of fertilizer.

Among the treatments, STFR recommendation with 10 t ha^{-1} FYM (T7), recorded significantly higher nitrogen content in straw 0.84 %, 0.86 and 0.85 % during 1st year, 2nd year and pooled data respectively; and it was statistically on a par with treatments T2, T10, T5, T6 and T1 during both the years and pooled data. Treatment T7, followed by T2, T10, T5 and T6 recorded the higher nitrogen in straw over other treatments during both the year and pooled data as well. Lower target yield recommendation treatments T3 and T4 along with FYM T8 and T9 observed with lower N content in straw compared with the rest of the treatments. Nitrogen uptake in straw with 7.5 t ha^{-1} targeted yield fertilizer recommendation with FYM (T10) was found on par with 7.5 t ha^{-1} targeted yield fertilizer recommendation alone (T5) and RDF with FYM (T6) during the year 2018 and pooled data also. Nitrogen uptake in straw with treatment T7 was found significantly higher along with T2, T10 and T5 compared with other treatments during both the years of study. The percent increase in N uptake with STFR recommendation with10 t ha^{-1} FYM (T7), STFR recommendation alone (T2) are (33.3 %, 19.0 %, 18.1 % and 29.8 %), (31.1, 16.3 , 15.4 and 27.4 %), over the targeted yield fertilizer recommendation T3, T4, T9 and T8 respectively at maturity in pooled data. Treatments with FYM found significantly higher N uptake compared with those of without FYM. Use of organic manures and inorganic fertilizers together is helpful in maintaining higher concentration of soil NH4 + N for a longer period and restore humus status of the soil ecosystem to holds its fertility and productivity, thus realizing higher N uptake of rice. Higher N content in both grain and straw might have facilitated higher uptake due to increased dry matter accumulation in those treatments which received higher doses of N fertilization. Kabat *et al.,* (2006) [3] and Yadav *et al.,* (2015) [4] also expressed similar views.

A perusal of the data presented in [Table-2], [Fig-2a,2b] showed significant differences in phosphorus content and uptake in plant at maturity (grain and straw) due to effect of nutrient management treatments during both the years of experimentation and pooled data. Treatment T7 recorded with significantly higher P content in grain over the remaining all the treatments. It was followed by T2, T10 and T5 and among these treatments the differences were not significant. Treatment with targeted yield fertilizer recommendation T3, T8, T4 and T9 were found with significantly inferior P content and uptake compared to the remaining treatments during both the years of study and pooled data. Phosphorus uptake in grain was significantly higher in the treatment T7 over the rest of the treatments. On the differences between T7 and T2 were not significant. The lowest P content in grain was obtained with the treatment T3 followed by T8 and these were found significantly inferior to all the treatments. Whereas the highest P uptake in straw was obtained in T7 was found on par with T2, T10, and T5. Remaining all treatments except T3 and T8 found on par with each other with respect to N uptake in straw. Among the treatments, significantly highest phosphorus uptake was noticed with soil test-based fertilizer recommendation with application of 10 t ha^{-1} FYM (T7) which was statistically at par with STFR alone (T2) and proved significantly superior to the rest of the treatments.

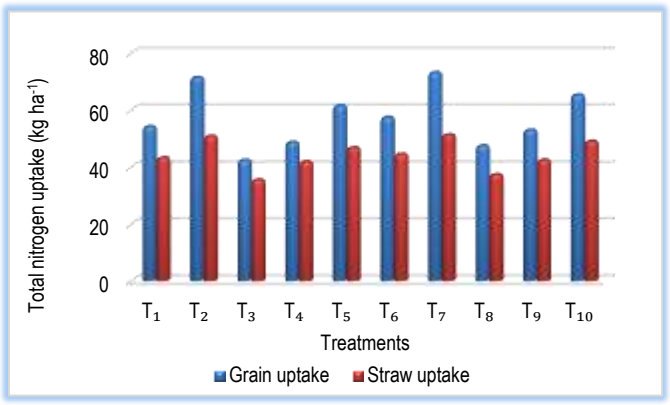

Fig-1a Total nitrogen uptake (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management during 2017

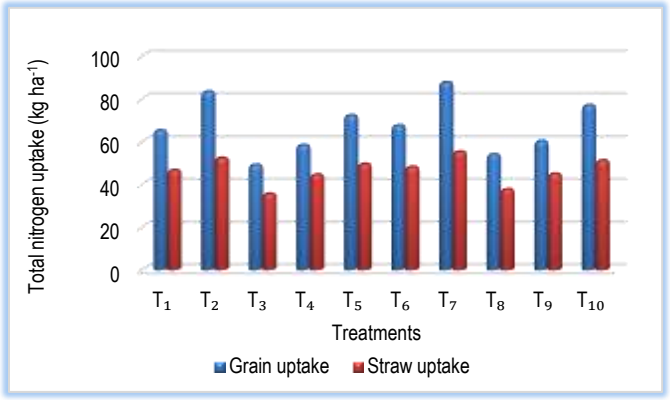

Fig-1b Total nitrogen uptake (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management during 2018

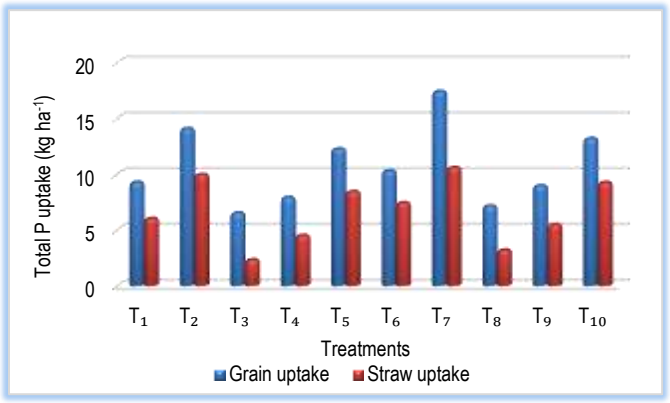

Fig-2a Total phosphorus uptake (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management during 2017

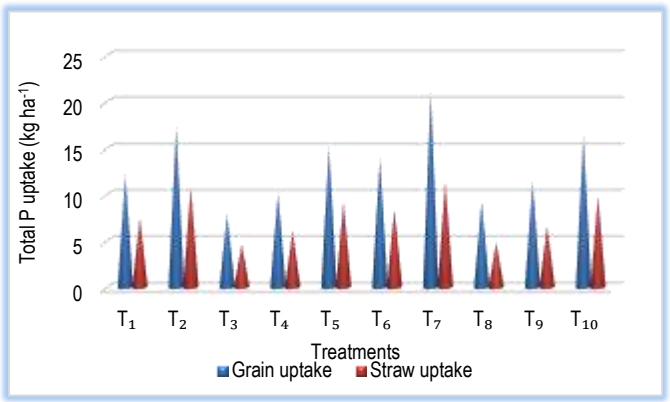

Fig-2b Total phosphorus uptake (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management during 2018

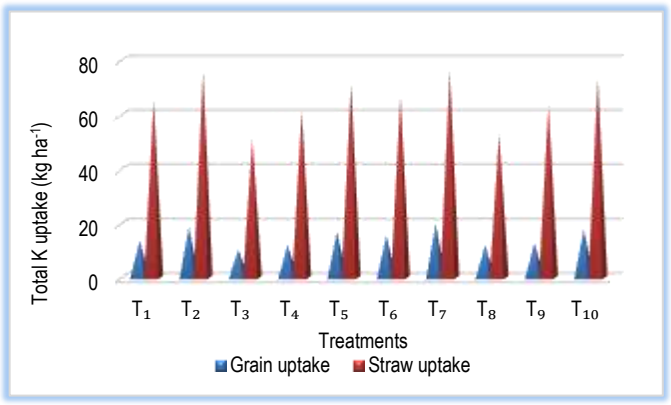

Fig-3a Total potassium uptake (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management during 2017

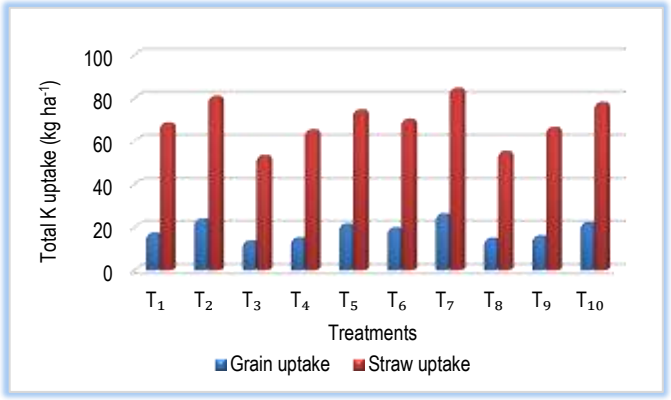

Fig-3b Total potassium uptake (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management during 2018

The lowest phosphorus uptake in straw was observed with the application of inorganic NP and K through targeted yield fertilizer recommendation at 5.5 t ha^{-1} alone and it was at par with T9, T4 and T8 treatments during both years of study and in pooled data. The percent increase in P uptake with STFR fertilizer recommendation with 10 t ha^{-1} FYM (T7), STFR fertilizer recommendation alone (T2) are (68.4%, 52.1 %, 45.1 % and 63.3 %), (66.5, 49.3 , 41.9 and 61.2%), over the targeted yield fertilizer recommendation T3, T4, T9 and T8 respectively at maturity in pooled data. Further it was observed that addition of FYM with fertilizer recommendations proved beneficial in increasing nutrient uptake. Vetrivel *et al*., (2017) [5] also opined that "application of organic manures not only increased the supply of easily assimilated major nutrients to plants, besides mobilizing unavailable nutrients into available form; due to improvement in soil physico-chemical and biological properties by providing carbon and nitrogen source to microbes, further it also increased the activity of soil enzymes". Such effects on soil P and plant uptake were also reported by Satheesh and Balasubramanian (2003) [6].

The data on potassium content at maturity both in grain and straw were furnished in [Table-3], [Fig-3a, 3b] which showed that there was significant difference in potassium content with relevance to the effect of site-specific nutrient management

Treatment T7, followed by T2, T10, T5 and T6 recorded the higher potassium content in grain over other treatments during both the years and pooled data as well. Differences in K content in the remaining treatments was not significant Similar trend in K uptake in grain was also observed in year 2017. Potassium content and uptake in grain with 7.5 t ha^{-1} targeted yield fertilizer recommendation with FYM (T10) was found on par with 7.5 t ha^{-1} targeted yield fertilizer recommendation alone (T5) and RDF with FYM (T6) during the year 2018 and pooled data also. In the year 2017 the treatment T7 recorded higher potassium uptake in straw; however, it was on par with all the treatment except with the treatments T3, T8, T4 and T9. However, during the year 2018 and pooled data T7 recorded K content and uptake in straw significantly higher along with T10 and T5 compared to the rest of the treatments.

The percent increase in K uptake with STFR fertilizer recommendation with 10 t ha^{-1} FYM (T7), STFR fertilizer recommendation alone (T2) are (37.3%, 21.1 %, 19.4 % and 34.7 %), (33.3, 16.0 , 14.2 and 30.5 %), over the targeted yield fertilizer recommendation T3, T4, T9 and T8 respectively at maturity in pooled data. From above finding, it can be concluded that STFR with combination of 10 t ha^{-1} FYM applications were superior over the sole application of inorganic fertilizer treatments alone in recording both higher yield and nutrient uptake by rice. High efficiency of applied fertilizer K observed seems to be due to higher uptake of this nutrient as soil K status was high in experimental field. Ray *et al*., (2000) [7] reported that "high values of potassium could be due to the interaction effect of higher doses of N, P and the primary effect of starter K doses in the treated plots, which might have caused the release of soil potassium form, resulting in the higher uptake from the native soil sources by the crop". Ahmed *et al*., (2002) [8] also reported similar type of higher efficiency K fertilizer in rice.

On perusal of [Table-4] on fertilizer use efficiency it is revealed that 5.5 t ha^{-1} target yield recommendation with FYM (T8) had significantly the highest fertilizer use efficiency compared to all other treatments. And the differences in FUE between the treatments 5.5 t fertilizer recommendation with or without FYM (T8 and T3) were not found significant during the both the years of study. The treatment RDF worked out to be with the lowest FUE among the treatments and it was found on par with treatments T5, T6 and T10.

Higher FUE in lower target yield fertilizer recommendations might be due efficient utilization of applied fertilizers in these treatments. Earlier, improved use efficiency of applied NPK fertilizers at low yield target levels was also reported by Santhi *et al*., (2010) [9] and Bera *et al*., (2006) [10].

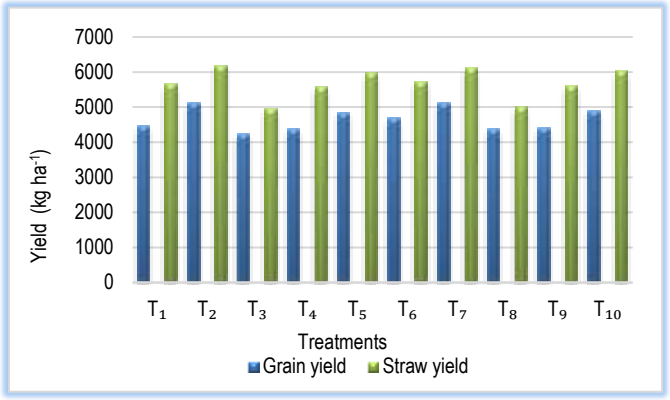

Fig-4a Grain yield and straw Yield (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management in rice during 2017

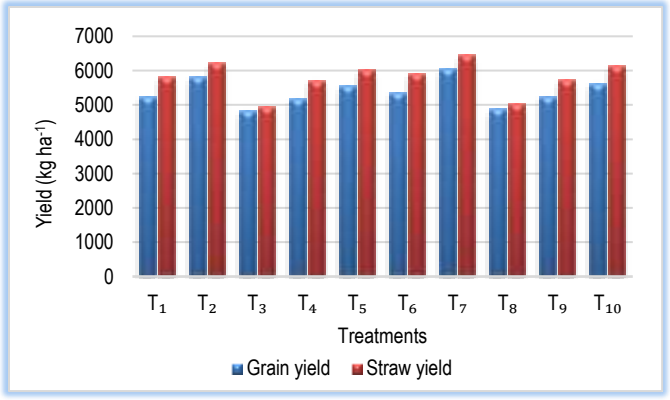

Fig-4b Grain yield and straw yield (kg ha^{-1}) of *kharif* rice as influenced by site specific nutrient management in rice during 2018

Data pertaining to grain yield [Table-5] [Fig-4a, 4b] indicated that STFR with 10 t ha^{-1} FYM (T7), followed by T2 produced significantly higher grain yield compare to the rest of the treatments. However, they were on par with that of T10 in the year 2018 and T10 and T5 in 2017. The higher yields recorded with STFR+ FYM (T7) were 5117, 6023 and 5570 kg ha^{-1} statistically on par with STFR application alone (T2) *i.e*., 5099, 5805 and 5452 kg ha^{-1} during 1st and 2nd years and in pooled data.

Increased use of fertilizers in the fields without information on soil fertility status and nutrient requirement by crop causes undesirable effects on soil and crop. Management of site-specific variability in nutrient supply is a key strategy to overcome the imbalances in fertilizer applications. Soil test-based application of plant nutrients facilitate the exact application of nutrients in proportion to the extent of the deficiency of a particular nutrient. The lowest yields observed with the targeted yield fertilizer recommendation @ 5.5 t ha^{-1} alone (T3) followed by other targeted yield fertilizer recommendation treatments (T4, T8 and T9) were significantly inferior compared with other treatments. However, differences among the treatments based targeted yield fertilizer recommendation treatments T4, T3, T8 and T9 and RDF (T1) were not statistically significant.

Grain yield recorded with 7.5 t ha^{-1} targeted yield fertilizer recommendation with FYM (T10) found significantly superior over the targeted yield fertilizer recommendation treatments (T3, T4, T8 and T9) at harvest during the year 2017and in pooled data. The differences were not significant among the treatments T10, T9 and T4. Sharma *et al*., (2015) [11] from eastern India worked on soil test based optimum fertilizer doses for attaining yield targets of rice on soils of poor to medium N and P and medium to good for K, calibrated fertilizer adjustment equation for rice to achieve a definite yield target. The results confirm the findings of Ahmed and Krishna Reddy (2002) [12]. The per cent increase in grain yield with STFR recommendation with 10 t ha^{-1} FYM (T7), STFR fertilizer recommendation alone (T2) was (18.9%, 14.4 %, 13.6 % and 17.2 %), (17.1, 12.6, 11.8 and 15.4 %), over the targeted yield fertilizer recommendation (T3, T4, T9 and T8) at harvest during both the years 2017-2018 and pooled data respectively.

Conclusion

Based on the Nitrogen, Phosphorous, Potassium, and grain yield it can be recommended to go for up to soil test-based fertilizer recommendation with 10 t ha^{-1} FYM application (156-42-28 kg NPK ha^{-1}), applied. Among the treatments with soil test-based fertilizer recommendation with 10 t ha^{-1} FYM application which was at par with soil test-based fertilizer recommendation alone and 7.5 t ha^{-1} targeted yield recommendation along with FYM (T5 and T10) and RDF with FYM (T6). Whereas targeted yield recommendation 5.5 and 6.5 t ha^{-1} (T3 and T4) found with significantly lower Nitrogen, Phosphorous, Potassium, and grain yield compared to the rest of treatments during both the years of study.

Application of research: Fertilizer use efficiency (FUE) was significantly the highest with application of 5.5 t ha^{-1} target yield recommendation with FYM (T8) compared to all other treatments. And the differences in FUE between the treatments 5.5 t fertilizer recommendation with or without FYM (T8 and T3) were not found significant. The treatment RDF worked out to be with the lowest FUE among the treatments.

Research Category: Agronomy

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Research project name or number: PhD Thesis

Author Contributions: All authors equally contributed

Author statement: All authors read, reviewed, agreed and approved the final manuscript. Note-All authors agreed that- Written informed consent was obtained from all participants prior to publish / enrolment

Study area / Sample Collection: Agricultural College Farm, Bapatla

Cultivar / Variety / Breed name: Rice, Blackgram

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.
Ethical Committee Approval Number: Nil

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