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Rescheduling of fertilisers and fertilisation strategies for rice crop

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Abstract
A field experiment was conducted for three *Kharif* seasons (2014-15,2015-16 & 2016-17) at Regional Agricultural Research Station, Nandyala, Andhra Pradesh to study the rescheduling of fertilizer doses in Rice crop for Scarce rainfall zone of Andhra Pradesh. The results revealed that the Panicle Length (cm), No of grains per panicle, Grain yield (5714 kg/ha), and straw yield (9389 kg/ha) were obtained with STBF + Vermicompost @ 2 t ha^{-1} (T3 treatment), while the minimum values of yield attributes and grain yield (4628 kg ha^{-1}) and yield attributes were recorded with treatment of STCR equation (T4 treatment). The highest benefit cost ratio (2.60) and net income (47,245/-) was recorded by the application of soil test based fertilization over the other fertilizer doses. Lowest benefit cost ratio (1.71) was observed with the farmers practice application of fertlization. The study indicated that nutrient management based on soil tested data lead to positive nutrient balance.

Keywords: Paddy crop, rescheduling of fertilizers, STBF, STCR equation and benefit cost ratio

Introduction
Rice is a major cereal crop, contributes about 40 per cent of total food grain production and staple food for more than 50 per cent of the world's population. It plays an important role in food security and livelihood for almost every household. Rice (Oryza sativa L.), with global production of more than 740 M t in 2014 (FAOSTAT 2016) [3] is the staple food for nearly half the world population. With the advent of Green Revolution, food grain production in India increased substantially over time, however fertilizer response ratio (i.e. grain yield per unit of fertilizer use) decreased dramatically from 13.4 to 3.7 kg grain/ kg NPK during 1970 to 2005 (Biswas and Sharma, 2008) due to inappropriate nutrient management approaches. A large potential exists for increasing rice yield but inefficient nutrient use is one of the most limiting factors. To ensure higher rice productivity, appropriate nutrient management practices have become an essential component of the modern rice production technology.

Several approaches have been used for fertilizer recommendation based on chemical soil test so as to attain maximum yield per unit of fertilizer use. Among the various approaches, the targeted yield approach (Ramamoorthy *et al.* 1967) [13] had received wide acceptability and popularity in India. Targeted yield concept is based on quantitative idea of the fertilizer needs based on yield and nutritional requirement of the crop, per cent contribution of soil available nutrient and that of the applied fertilizer. This method not only estimates soil test based fertilizer dose but also the level of yield the farmer can achieve with that particular dose. Targeted yield approach also provides scientific basis for balanced fertilization not only between the nutrients from the external sources but also from the internal sources. Assessment of the nutrient requirements of the different crops for desired yield levels from a cropping sequence is an important step in developing fertilizer management practices.

Degradation of soil health has also been reported due to long-term imbalanced use of fertilizer nutrients. Although, overall nutrient use (N: P2O5:K2O) of 4:2:1 is considered ideal for Indian soils, the present use ratio of 6.8:2.8:1 is far off the mark. This imbalance of nutrient use has resulted in wide gap between crop removal and fertilizer application. For over 40 years, soil testing has been a recommended means of predicting the kind and amount of fertilizers needed. Yet many farmers still do not use this relatively simple tool but apply fertilizers as per their will. Farmers still apply fertilizer where none is required or at lower rates than required or at higher rates than required to optimize yields. Farmers also apply inadequate rates or use ineffective application methods (Prabhakar *et al.*, 2017) [11].

The objective of the study is to revision of fertilizer doses for rice crop in scarce rainfall zone of Andhra Pradesh to demonstrate the effect of soil test based fertilization on the soil nutrient status and grain yield of the rice crop so that farmers of the region would be benefitted by the judicious use of the fertilizers after testing their soil.

Materials and Methods

The field experiments were conducted during the kharif seasons of crop years, 2014-15,2015-16 and 2016-17 at Regional Agricultural Research Station, Nandyala, Andhra Pradesh, under Irrigated conditions. The soil of experimental site was medium deep black, low in organic carbon (0.36%), low in Nitrogen (116 kg/ha) high in available P_2O_5 (69.5 kg ha^{-1}) and available K_2O (536 kg ha^{-1}). A composite soil sample was collected from 0-20 cm depth during the study years, processed and analysed in laboratory for pH and Electrical Conductivity(EC) (1:2 soil : water suspension), by pH and Ec meters, respectively (Jackson 1973) [6]. Organic Carbon percentage (OC) was estimated by rapid titration method (Walkley and Black method 1934) [7]. Available nitrogen was estimated by alkaline permanganate method (Subbaiah and Asija 1956) [15]. Available phosphorus by Olsens method (Olsen *et al.*1954). Available potassium by ammonium acetate extraction method (Jackson 1973) [6]. Available Zinc, Copper, Iron and Manganese were extracted with DTPA and estimated by using AAS as described by Lindsay and Norvell (1978) [8]. The experiment was laid out in randomized block design with 12 treatments and replicated in three times. The details of treatments were depicted in Table-1. Rice (NDLR-7) was sown during second week of July, transplanted in second week of August by adopting 15x15cm spacing with three seedlings per hill and fertilizers applied as per the treatments protocol. The crop cultural practices were carried out according to the standard practices in the rice fields and harvested at 145 days after sowing. The grain and straw samples were collected at harvest, oven dried at 70^0C processed and analysed for total content of N, P, K, Zn, Cu, Fe and Mn following standard procedures. The data related to plant height and yield attributes was recorded on ten randomly selected plants in each plot. Net grain and straw yield were recorded for net plot and computed as kg ha^{-1}. Soil and plant samples were collected in each treatment and analysed by following standard procedures. All the data was subjected to statistical analysis. Revision of Fertilizer doses for different crops is essential with the changed scenario of soil fertility status chopping up to micronutrient deficiencies, build up of some of the nutrients like phosphorus and change of cropping pattern and introduction of new varieties etc; Infact, this revision is overdue long pending need. Hence, an experiment for revising the fertilizer recommendations paddy crop at RARS Nandyal has been formulated with following treatments. Rice is the major crop cultivated in Scarce Rainfall Zone of Andhra Pradesh, hence the experiment was taken up in rice crop.

Treatments details

T1- Current RDF (N, P, K, Zn, S, B)
T2- ST based Fert Usage (N,P,K,) (30% Excess / Less)+Zn, S,B, if deficient- Full Rec. Dose
T3- T2+ 2 t Vermicompost /ha
T4- STCR based Eq : Prod-I (Current Highest in Dist / Zone) + R.D of Zn / B / S if soil is deficient)
(FN = 3.35 T – 0.33 SN, FP_2O5 = 2.52 T – 4.53 SP, FK_2O = 1.24 T– 0.12 SK)
T5-T4+ 2 t Vermicompost /ha
T6- STCR based Eq : Prod-II (15% Higher) + RD of Zn / B / S if soil is deficient)
T7-T6+2 t Vermicompost /ha
T8- New Treatment For P-I: N=150% RDN if avail is < 140 kg /ha else 125% RDN P=100% RDP if avail P is high, Else125%, K=125% RDK if Low Else 100% RDK: Zinc = 125% RD ZN if Def, Else 25% RD Zn, S = 125% RD S if Def, Else 25% RD S, B = 125% RD B if Def, Else 25% RD B
T9-T8+2 t Vermicompost /ha
T10- New Treatment For P-II: N=200% RDN if avail is < 140 kg /ha else150% RDN P=100% RDP if avail P is high, Else150%, K=125% if Low Else 100% RDK, Zinc = 125% RD ZN if Def, Else 25% RD Zn, S = 125% RD S if Def, Else 25% RD S, B = 125% RD B if Def, Else 25% RD B
T11-T10+ 2 t Vermicompost /ha
T12- Farmers Practice

Results and Discussion

Data present in Table 1 shows that there is no significant difference between any treatment for yield attributes like plant height, production tillers per hill and panicle length. Highest no of grains per panicle (203) was observed in T3 treatment i.e STBF +Vermi compost, which is on par with other treatment like T7 treatment (197 grains per panicle). Lowest no of grains per panicle was observed in T4 treatment (154 grains) may be due to lower nitrogen fertilization than recommended dose of fertilization. These results were in accordance with the findings of Prasada Rao *et al*. (2013) [12].

Grain yield

Kharif rice grain yields were significantly higher with soil test based fertilizer application. Higher doses of fertilizers leads to record higher seed yield ranging from 5276 to 5714 kg/ha. The lowest yield was recorded with STCR eq-1 (T4) 4628 kg/ha followed by T5 (STCR eq-1 +VC 2t/ha) 4826 kg/ha may be due to lower application of Nitrogen than recommended dose of Nitrogen of scarce rainfall zone. There is a high response of rice crop to Nitrogen fertilization in scarce rainfall zone (RDN is 240 kg/ha) up to 320 kg/ha in this experiment. The increase in growth might be due to enhanced cell division and cell elongation induced by abundant nitrogen supply with increase in nitrogen levels, favouring enlargement and better development of panicle resulting in more number of total grains panicle-1 and keep leaves green even at the time of maturity. Hence, the contribution of carbohydrates from photosynthetic activity resulting in efficient translocation of food material into the sink (grain) thereby increased number of filled grains panicle-1. These results were in accordance with the findings of Prasada Rao *et al.* (2013) [12]. The significant increase in grain and straw yields of rice with increase in N rates was accompanied by significant increase in total N, P and K uptake. This increase in total N, P and K uptake can be attributed to higher grain and straw yields. Cong *et al*. (2009) [2] also observed that total N and P uptake was related to grain and straw yields of rice. The increased yields of rice from the application of vermicompost and fertilizer N was accompanied by significant increase in total uptake of N, P and K. These results were accordance with the findings of Ramulu Ch and Raghu Rami Reddy P. (2018) [14].

Straw yield

The results presented in table-1 indicated that, the application of varying levels of N, P and K arrived by different concepts of fertilizers application without vermicompost and with vermicompost to the kharif rice and observed that the overall straw yield was significantly influenced by varying N, P and K levels in kharif 2015, 2016 and in 2017. However, higher straw yields 9495, 9389, 9314 and 9263 kg/ha were recorded by treatments T10, T3, T11 & T12 treatments which were on par with other treatments in pooled mean, respectively and lower straw yields of 7401 and 7635 kg/ha were recorded by T5 treatment & T1 treatment pooled mean, respectively. The dry matter production at all growth stages and harvest index were maximum at 504 kg N ha^{-1} over low level of 226 kg N ha^{-1} . These results were in accordance with the findings of Prasada Rao *et al*. (2013) [12].

Table 1: Influence soil Fertilization on Paddy yield & yield attributes from *kharif* 2014-15 to 2016-17

T.N	Treatments	Fertilisers kg/ha	Plant height (cm)	Prod. tillers/ hill	Panicle length (cm)	No. grains/ panicle	Grain yield (kg/ha)	Straw yield (kg/ha)
T1	Current RDF	240:80:80	88.2	18	21	183	5152	7635
T2	STBF	312:56:56	87.0	19	21	195	5276	8683
T3	STBF +VC 2t/ha	326:60:64	90.1	21	21	204	5714	9389
T4	STCR eq-1	202:49:43	79.5	16	18	154	4628	6442
T5	STCR eq-1 +VC 2t/ha	226:53:51	84.0	17	19	162	4826	7401
T6	STCR eq-2	239:76:56	86.3	18	19	183	5050	8233
T7	STCR eq-2 + VC 2t/ha	263 :80:64	85.9	20	21	197	5351	8450
T8	New treatment prod.-1	360:80:80	87.0	18	22	194	5297	8168
T9	New treatment prod.-1 + VC 2t/ha	384:84:88	83.5	18	19	191	5332	8862
T10	New treatment prod.-1	480:80:80	87.1	20	21	196	5484	9495
T11	New treatment prod.-1 + VC 2t/ha	504:84:88	87.3	18	19	193	5446	9314
T12	Farmers practice	380:150:75 :65	91.6	22	21	192	5214	9263
	S.Em +		3.1	0.8	1.0	7.0	244	521
	C. D. (P=0.05)		NS	NS	NS	20	685	1459
	C V (%)		-	-	-	13.6	13.4	14.6

Table 2: Economics of Paddy crop as influenced by different soil test based nutrient management practices for 3 years (Pooled data for three years 2014-17)

T.N	Treatments	Fertilisers (kg/ha)	Grain yield (kg/ha)	Straw yield (kg/ha)	Cost of cultivation	Gross returns	Net returns	B:C Ratio
T1	Current RDF	240:80:80	5152	7635	48500	161823	113323	2.34
T2	STBF	312:56:56	5276	8683	47245	170039	122794	2.60
T3	STBF +VC 2t/ha	326:60:64	5714	9389	57260	184081	126821	2.21
T4	STCR eq-1	202:49:43	4628	6442	45637	143282	97645	2.14
T5	STCR eq-1 +VC 2t/ha	226:53:51	4826	7401	55680	152829	97149	1.74
T6	STCR eq-2	239:76:56	5050	8233	47703	162365	114662	2.40
T7	STCR eq-2 + VC 2t/ha	263 :80:64	5351	8450	57800	170674	112874	1.95
T8	New treatment prod.-1	360:80:80	5297	8168	50195	167968	117773	2.35
T9	New treatment prod.-1 + VC2t/ha	384:84:88	5332	8862	61000	172278	111278	1.82
T10	New treatment prod.-1	480:80:80	5484	9495	50681	179091	128410	2.53
T11	New treatment prod.-1 + VC 2t/ha	504:84:88	5446	9314	60708	177274	116566	1.92
T12	Farmers practice	380:150:75:65	5214	9263	63331	171451	108120	1.71
	S. Em +		244	521				
	C. D. (P=0.05)		685	1459				
	C V (%)		13.4	14.6				

*price 24/- per kg of rice grain & 5/- per kg straw of rice.

Table 3: Influence of Fertilization on soil Properties at the time of Harvesting

T.N	Treatments	Fertilisers kg/ha	Available N (Kg/ha)	Available P_2O_5 (Kg/ha)	Available K_2O (Kg/ha)
T1	Current RDF	240:80:80	214.0	61.6	412.2
T2	STBF	312:56:56	237.7	58.6	409.2
T3	STBF +VC 2t/ha	326:60:64	261.0	61.0	416.7
T4	STCR eq-1	202:49:43	198.3	53.3	430.1
T5	STCR eq-1 +VC 2t/ha	226:53:51	213.3	59.2	438.1
T6	STCR eq-2	239:76:56	226.0	56.6	403.5
T7	STCR eq-2 + VC 2t/ha	263 :80:64	234.3	58.5	429.0
T8	New treatment prod.-1	360:80:80	248.7	60.7	411.8
T9	New treatment prod.-1 + VC 2t/ha	384:84:88	251.3	61.9	433.4
T10	New treatment prod.-1	480:80:80	262.8	58.6	427.9
T11	New treatment prod.-1 + VC 2t/ha	504:84:88	280.3	62.8	462.5
T12	Farmers practice	380:150:75 :65	249.3	65.3	428.9
	S.Em $\pm$		16.56	5.26	17.02
	C.D. (P=0.05)		46.36	NS	NS
	C V (%)		11.96	15.22	6.93
	Soil initial properties		116.0	69.5	459.7

Economics

The economic evaluation of soil test-based fertilization in paddy crop revealed that maximum net returns were obtained in application of STBF for a target yield of 60 q/ha (T4: Rs. 47245 ha^{-1}). The cost incurred on vermicompost application reduced the net returns and B: C ratio (1.74) in T5 treatment and higher B: C ratio was obtained with application of fertilizers based on STBF equation for a target yield of 6.5 t ha^{-1} (T10: 2.53) due to higher economic yields obtained in these treatments. But the application of farmers practice fertilizers (T12) recorded lowest B: C ratio (1.71). Similar economic benefits have been reported by Thavaprakash and Malligawad (2002) [16] in sunflower and Anand (2010) in chickpea and maize.

Soil Nutrient Status after Crop Harvest

Data from table 3 indicates that highest available Nitrogen in soil was present in T11 treatment i.e New treatment production-1 + vermicompost@ 2 t/ha treatment (280.3 kg/ha) may be due to the application of higher dose of Nitrogen nutrition (504 kg/ha) than normal recommended Nitrogen (240 kg/ha) and available P_2O_5 (65.3 kg/ha) and available K_2O (438.1 kg/ha) in farmers practice & STCR equation-1+vermicompost treatments. There is no significant change in available phosphorous and available potassium in soil than initial soil properties of the experimental site. The increased nutrient application through site specific nutrient management (SSNM) approach resulted in greater absorption of nutrients from soil and this in turn led to higher NPK content in seed and stalk. The results are in line with the findings of Mishra *et al*. (1995) [9] and Thavaprakash (2002) [16]. A significant and positive relation was observed between applied fertilizer levels of N, P and K and their available forms in the soil. Similar results were also reported by Gebremedhin *et al*, (2015) [4].

Conclusion

Afetr three years of the study, STBF (326-60-64 N,P_2O_5 and K_2O) + Vermi compost 2 t/ha application yielded significantly higher grain yield and B:C ratio of 5714 kg/ha and 2.60 respectively, which is statistically on par with T10 (New treatment prod.-1) and T11 (New treatment prod.-1 + VC 2t/ha) 5484 and 5446 kg/ha respectively. The lowest yield was recorded with STCR eq-1 (T4) 4628 kg/ha followed by T5 (STCR eq-1 +VC 2t/ha) 4826 kg/ha. Farmers practice recorded (380:150:75:65 N, P_2O_5, K_2O and S) grain yield of 5214 kg/ha.

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