Effect of Nutrient Management on Soil Availability, Plant Content and Uptake of Nitrogen, Phosphorous and Potassium under Rice Cultivation in Black Soils of Kerala

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Abstract- A field experiment was conducted during 2012 to find the effect of nutrient management on availability and plant content at critical growth stages as well as uptake of nitrogen, phosphorous and potassium under rice cultivation in the black soils of Kerala. Higher available N (335.55 kg ha^{-1}), total P (0.18%) and uptake of P (26.91 kg ha^{-1}) and K (142.69 kg ha^{-1}) was found with the application of treatment T_{11} (STCR+$ZnSO_4$+FYM) as compared to control. Higher N uptake (149.40 kg ha^{-1}) was found with application of T_7 (farmers practice +$ZnSO_4$). Total dry matter yield was found to be highest in T_2 (farmers practice) followed by T_9 (STL+$ZnSO_4$) which was 6688.54 and 6427.35 kg. Application of $ZnSO_4$ reduced the yield. Application of water soluble phosphorous is recommended for the black soils of Kerala.

Key words: Black soils, Rice, Available nutrients, Plant content, Nutrient uptake, Zinc sulphate.

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1 INTRODUCTION

The importance of nitrogen, phosphorous and potassium as essential major nutrient has been documented in several literatures (Sathiya and Ramesh 2009; Saleque, *et al* ,2001; Mansoor ,*et al*, 2008). The record production of 245.45 MT during 2010-11 was possible due to the large scale use of fertilizers. The fertilizers which mainly supplied the three primary nutrient viz. nitrogen (N), phosphorous (P) and potassium (K) with additional application of other need based secondary and micro nutrients. Rice is the staple food of our country. The importance of application of N, P and K to rice has been reported by many authors for conceiving enhanced productivity either from organic or inorganic source or from both. The black soil area is considered as one of the most productive area for rice cultivation in Kerala. These soils cover an area of approximately 2000 ha (Padmaja, *et a.*, 1994) in Chittur taluk and is mainly located in the Palakkad gap of Western Ghat. Though the black soil in Kerala is comparatively productive, certain yield limiting factors, especially poor physical condition due to high exchangeable sodium percentage and nutrient imbalance may adversely affect the yield of the crop (Krishnakumar, 1978; George, 1981 ; Padmaja ,*et al.* ,1994). Hence an attempt was made to evaluate and assess the extent of soil availability and plant content at different critical growth stages as well as uptake of N, P and K by rice under different nutrient management practices in the black soils.

2 MATERIAL AND METHODS

A detailed study was undertaken to assess the soil availability, plant content and uptake of nitrogen, phosphorous and potassium by rice. For this purpose a farmer's field was selected at

Vandithavalam, Chittur Takuk, Palakkad district. Rice crop (kharif) was raised during June 2010 to October 2010. This soil showed similarities to the soil order vertisols (SSO, 2007). Chittur lies in the eastern side of Palakkad. The field is located at 10°38'03.88" N latitude, 76°44'53.90" E longitude, at an elevation of 129m from mean sea level. The sandy loam soil had 0.74% organic C with the available N, P and K contents of 310.50, 5.67 and 154.40 kg ha^{-1} respectively. The pH of the soil was 6.4. Medium duration (110-130 days) 'Uma' variety was transplanted at a spacing of 20cm x 15cm. The selected field was divided into three blocks and each block into eleven treatment plots. The experiment was laid down in randomized block design with three replications. Treatments comprised eleven nutrient management practice to rice [Absolute control (T_1); 107.5 N+50.0 P_2O_5+112.50 K_2O kg ha^{-1} FP (T_2); 91.0 N+ 45 P_2O_5+45 K_2O kg ha^{-1}KAU (T_3); 87.30 N+52.65 P_2O_5+ 42.30 K_2O kg ha^{-1} STL (T_4); 247.20 N+ 135.00 P_2O_5 +205.0 K_2O kg ha^{-1} STCR (T_5); 234.00N + 115.26 P_2O_5+ 187.00 K_2O kg ha^{-1} STCR+FYM (T_6); 107.50N+ 50.00 P_2O_5+ 112.50 K_2O+ 9.1 Zinc kg ha^{-1} FP+$ZnSO_4$ (T_7); 90 N+ 45 P_2O_5+ 45 K_2O + 9.1 Zn kg ha^{-1} KAU+$ZnSO_4$ (T_8); 87.30N+ 52.65 P_2O_5+42.30 K_2O+ 9.1 Zn kg ha^{-1} STL+$ZnSO_4$ (T_9); 247.20N+ 135.00 P_2O_5+ 205.00 K_2O+ 9.1 Zn kg ha^{-1} STCR+$ZnSO_4$ (T_{10}); 234.00N+ 115.26 P_2O_5+ 187.00 K_2O + 9.1 Zn kg ha^{-1} STCR+$ZnSO_4$+FYM (T_{11}). The rate of application of fertilizers and manures in the experimental site as per the treatments are given in table 1. Available N, P and K as well as plant content of N, P and K was recorded at critical growth stages of rice viz., maximum tillering (MT), panicle initiation (PI), flowering (F) and harvest (H). Plant uptake of N, P and K was calculated by the product of respective per cent nutrient content and dry matter yield (kg).

Table1. The rate of application of fertilizers and manures in the experimental site as per the treatments

Treatments	Urea (kg ha^{-1})	Rajphos/factomphos (kg ha^{-1})	Muriate of potash (kg ha^{-1})	FYM (t ha^{-1})	Zinc Sulphate (kg ha^{-1})
T_1 -control	0	0	0	0	0
T_2 -Farmer's practice	57.50	250.00 (factomphos)	187.50	5	0
T_3- KAU	196	250	75	5	0
T_4-STL	189.66	292.66	70.66	5	0
T_5- STCR	537.33	748	341	0	0
T_6- STCR+FYM	509	640.33	311.33	5	0
T_7- F.P + $ZnSO_4$	57.50	250.00 (factomphos)	187.50	5	0
T_8- KAU+ $ZnSO_4$	196	250	75	5	25
T_9- STL+ $ZnSO_4$	189.66	292.66	70.66	5	25
T_{10}- STCR+ $ZnSO_4$	537.33	748	341	0	25
T_{11}-STCR+ FYM +$ZnSO_4$	509	640.33	311.33	5	25

Elemental S @ 4.5 kg ha^{-1} was applied to the treatments where zinc sulphate was not applied except absolute control.

Farm yard manure was applied in all the plots except control (T_1), STCR (T_5) and STCR (Soil Test Crop Response) along with zinc sulphate (T_{10}). Half of nitrogen, full phosphorous and half of potassium were applied as basal dose. The remaining half of nitrogen and potassium were applied at active tillering stage of the crop. Zinc sulphate was applied 20 days after transplanting. Sulphur application was done to the plots which did not receive zinc sulphate except control (T_1). The nutrient contents of fertilizers and organic manures are being furnished in table 2.

Table 2. Nutrient content of fertilizers and organic manure

Fertilizers	Nutrient content (%)				
	N	P_2O_5	K_2O	Zinc	Sulphur
Urea	46.00	0.00	0.00	0.00	0.00
Rajphos	0.00	18.00	0.00	0.00	0.00
Muriate of potash	0.00	0.00	60.00	0.00	0.00
Zinc sulphate	0.00	0.00	0.00	36.43	17.86
Organic manure	N	P	K		
Farmyard manure	0.84	0.17	0.49	0.00	0.00

Soil samples were collected and analyzed at critical growth stages of crop viz. maximum tillering, panicle initiation, flowering and harvest for the available nutrients, N, P and K by following standard methods. Plant samples were collected by uprooting two hills randomly from each treatment at different growth stages viz. maximum tillering, panicle initiation, flowering and harvest. The plant samples were oven dried to constant weight at 70^0C, ground, digested and analysed for the contents of N, P and K. grain samples after harvest were collected from various treatments and they were dried to constant weight 70^0C and then powdered. These samples were analysed for the contents of N, P and K, by following standard methods.

3 RESULTS AND DISCUSSION

3.1 Available N, P and K

A perusal of data in table 3 reveals that available N (kg ha^{-1}) content ranged between 372.30 (T_1) to 560.96 (T_5) at MT, 216.41 (T_8) to 290.70 (T_9) at PI, 231.48 (T_{10}) to 345.61 (T_5)

at flowering and 240.62 (T_3) to 335.55 (T_{11}) at harvest. Due to second split of N application coinciding with MT stage, the availability was relatively higher compared to other growth stages. Higher availability of N in plots receiving STCR and STCR+$ZnSO_4$+FYM (Farm Yard Manure) can be attributed to higher application rate. A decreasing trend in available N from MT to flowering was observed. This may be due to higher requirement of N during vegetative stages as compared to post flowering stages.

The range of available P (kg ha^{-1}) at MT, PI, F and H was 20.80 (T_5 and T_7) to 27.60 (T_2), 12.89 (T_6) to 25.78 (T_2), 11.73 (T_2) to 21.54 (T_5) and 23.10 (T_5) to 35.79 (T_8) respectively. The availability of P decreased from the vegetative stage till flowering and again increased in the post flowering to harvest stage. The availability of P differ significantly at PI and at harvest stage with maximum availability observed in T_2 (25.78) at PI stage and T_8 (35.79) at harvest stage. The higher availability of P in T_2 (farmers practice) at PI may be attributed to use of factamphos containing ammonium phophate which contains P in water soluble form. The subsequent increase in P availability in T_8 may be due to enhanced solubility of P in rock phosphate with the passage of time towards harvest. The increased availability of P from rock phosphate can reduce the need of P fertilization for the next crop in sequence after rice.

Data in table 3 exhibits that the availability of K differ significantly among the treatments at all the critical growth stages of rice. Available K (kg ha^{-1}) at MT, PI, F and H ranged from 67.20 (T_7) to 141.86 (T_{11}), 63.46 (T_8) to 149.33 (T_{11}), 89.60 (T_1) to 168.00 (T_5) and 82.13 (T_3) to 141.86 (T_{10}). It was found that available K was highest in plots receiving STCR with or without FYM and zinc sulphate. This may be attributed to higher rate of application of K in STCR treatments. Among the STCR treatments irrespective of addition of zinc sulphate, it was found that application of FYM increased available K status in the soil

Table3. Effect of treatment on available nitrogen, phosphorous and potassium content of surface soil at critical growth stages

Treatments	Maximum tillering			Panicle initiation			Flowering			Harvest		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1 control	372.30[a]	22.80[a]	82.13[a bc]	257.33[ab]	20.95[ab]	102.66[abc]	279.94[ab]	16.00[a]	89.60[d]	286.40[ab]	27.18[ab]	78.40[d]
T_2 -Farmer's practice	449.57[a]	27.60[a]	89.60[a bc]	237.94[ab]	25.78[a]	100.80[abc]	241.17[ab]	11.73[a]	97.06[c d]	290.70[ab]	33.98[ab]	89.60[bc d]
T_3- KAU	423.48[a]	21.20[a]	74.66[b c]	272.40[ab]	18.80[abc]	82.13[bc]	265.94[ab]	17.06[a]	112.00[bcd]	240.62[b]	28.09[ab]	82.13[cd]
T_4-STL	447.57[a]	24.40[a]	89.60[a bc]	258.40[ab]	19.33[abc]	65.33[c]	296.09[ab]	16.64[a]	93.33[d]	297.92[ab]	30.81[ab]	104.53[a bc]
T_5- STCR	560.96[a]	20.80[a]	74.66[b c]	230.41[b]	13.96[bc]	87.73[ab c]	345.61[a]	21.54[a]	168.00[a]	295.82[ab]	23.10[b]	104.53[a bc]
T_6- STCR+FYM	488.71[a]	22.80[a]	134.40[ab]	234.71[ab]	12.89[c]	112.00[abc]	244.40[ab]	13.86[a]	138.13[ab]	295.82[ab]	30.35[ab]	126.93[a bc]
T_7- F.P + $ZnSO_4$	451.58[a]	20.80[a]	67.20[c]	222.87[b]	17.72[bc]	80.26[bc]	248.71[ab]	18.34[a]	97.06[c d]	308.37[ab]	28.09[ab]	85.86[bc d]
T_8- KAU+ $ZnSO_4$	530.86[a]	26.40[a]	82.13[a bc]	216.41[b]	15.04[bc]	63.46[c]	260.56[ab]	16.21[a]	100.80[bcd]	319.87[a]	35.79[a]	89.60[bc d]
T_9- STL+ $ZnSO_4$	430.51[a]	24.00[a]	82.13[a bc]	290.70[a]	18.26[abc]	87.73[ab c]	265.94[ab]	20.05[a]	104.53[bcd]	301.05[ab]	30.35[ab]	115.73[a bc]
T_{10}- STCR+ $ZnSO_4$	485.70[a]	24.60[a]	89.60[a bc]	265.94[ab]	17.72[bc]	138.13[ab]	231.48[a]	19.20[a]	134.40[abc]	306.28[ab]	29.45[ab]	141.86[a]
T_{11}- STCR+$ZnSO_4$+FYM	556.95[a]	26.00[a]	141.86[a]	245.48[ab]	20.95[ab]	149.33[a]	258.40[ab]	20.26[a]	134.40[abc]	335.55[a]	24.01[b]	130.66[a b]
CD (0.05)	NS	NS	57.97	49.79	6.83	56.98	93.40	NS	34.46	59.23	9.41	41.91

3.2 Plant N, P and K content

A perusal of data in table 4 reveals that the total N content (%) varied significantly among the treatments at all the critical growth stages of rice. Total N at MT, PI, F and H varied between 1.86 (T_1) to 3.22 (T_{11}), 1.40 (T_1) to 2.52 (T_9), 0.65 (T_4) to 2.10 (T_6) and 0.46 (T_1) to 1.07 (T_7) respectively. The N content decreased from the vegetative (MT and PI) to reproductive stages (F and H). This may be attributed to higher N requirement during the early part of the crop cycle. A comparison between T_5 and T_6 i.e. STCR with ad without FYM reveals higher plant N content was observed in STCR along with FYM. Treatment receiving zinc sulphate showed towards the harvest stage. The increased availability of P from rock phosphate after harvest of crop may reduce the need of P fertilization for the next crop in sequence.

Table 4. Effect of treatments on plant nutrient content of nitrogen, phosphorous and potassium at critical growth stages.

Treatments	Maximum tillering			Panicle initiation			Flowering			Harvest		
	N	P	K	N	P	K	N	P	K	N	P	K
T_1 control	1.86^{c}	0.11^{ab}	2.16^{a}	1.40^{b}	0.09^{b}	1.51^{d}	0.98^{b}	0.24^{b}	1.54^{b}	0.46^{c}	0.16^{ab}	1.25^{a}
T_2 -Farmer's practice	2.00^{bc}	0.11^{ab}	1.29^{a}	2.47^{a}	0.13^{ab}	1.73^{cd}	1.02^{b}	0.21^{b}	1.33^{b}	0.65^{abc}	0.14^{abc}	1.25^{a}
T_3- KAU	2.66^{abc}	0.10^{b}	2.41^{a}	2.19^{ab}	0.12^{ab}	2.21^{abcd}	0.74^{b}	0.20^{b}	1.20^{b}	0.79^{abc}	0.13^{abc}	1.54^{a}
T_4-STL	2.31^{bc}	0.09^{b}	1.37^{a}	1.54^{ab}	0.11^{b}	1.90^{bcd}	0.65^{b}	0.19^{b}	1.16^{b}	0.56^{bc}	0.12^{abc}	1.41^{a}
T_5- STCR	2.61^{abc}	0.10^{b}	2.16^{a}	2.14^{ab}	0.13^{ab}	2.71^{abc}	1.02^{b}	0.24^{b}	1.58^{b}	0.88^{abc}	0.15^{abc}	1.66^{a}
T_6- STCR+FYM	2.87^{ab}	0.13^{ab}	2.16^{a}	2.33^{ab}	0.14^{ab}	2.91^{ab}	2.10^{a}	0.47^{a}	3.33^{a}	0.84^{abc}	0.10^{c}	1.41^{a}
T_7- F.P + $ZnSO_4$	2.84^{ab}	0.15^{ab}	1.58^{a}	2.10^{ab}	0.12^{ab}	1.73^{cd}	1.12^{b}	0.27^{b}	1.50^{b}	1.07^{a}	0.14^{abc}	1.37^{a}
T_8- KAU+ $ZnSO_4$	1.96^{c}	0.10^{b}	1.41^{a}	1.86^{ab}	0.11^{b}	1.95^{bcd}	0.74^{b}	0.21^{b}	1.54^{b}	0.51^{c}	0.10^{bc}	1.41^{a}
T_9- STL+ $ZnSO_4$	2.38^{abc}	0.14^{ab}	2.00^{a}	2.52^{a}	0.17^{a}	3.11^{a}	1.89^{a}	0.30^{b}	3.54^{a}	0.88^{abc}	0.12^{abc}	1.37^{a}
T_{10}- STCR+ $ZnSO_4$	2.52^{abc}	0.10^{b}	1.70^{a}	2.33^{ab}	0.12^{ab}	2.43^{abcd}	1.02^{b}	0.16^{b}	1.37^{b}	1.02^{ab}	0.16^{a}	1.70^{a}
T_{11}- STCR+$ZnSO_4$+FYM	3.22^{a}	0.17^{a}	2.58^{a}	2.10^{ab}	0.13^{ab}	2.58^{abcd}	0.70^{b}	0.15^{b}	1.33^{b}	0.93^{abc}	0.18^{a}	1.70^{a}
CD (0.05)	0.77	0.05	NS	0.84	0.05	0.95	0.68	0.15	1.68	0.42	0.05	NS

The total P content (%) was invariably higher in plants at flowering stage (0.15-0.47) compared to MT (0.09-0.17), PI (0.11-0.17) and harvest (0.10-0.18). There was significant difference among the treatments. The STCR treatment with FYM showed higher P content compared to STCR without FYM at all the growth stages except at harvest. The effect of zinc sulphate was found to be synergistic with P content between STL recommendation at MT and PI and STCR+FYM at harvest with higher P content found in treatment receiving zinc sulphate.

Potassium content (%) in rice at MT, PI, F and H ranged between 1.29 (T_2) and 2.58 (T_{11}), 1.51 (T_1) and 3.11 (T_9), 1.16 (T_4) and 3.54 (T_9) and 1.25 (T_1 and T_2) and 1.70 (T_{10} and T_{11}) respectively. Except at MT and harvest stage, the K content in plants receiving STCR along with FYM was higher than STCR with or without FYM. Application of zinc sulphate did not have significant impact on enhancing K content in rice plant.

3.3 N, P and K uptake and total dry matter yield-

A comparison of uptake data in table 5 reveals that uptake of N, P and K (kg ha^{-1}) ranged between 75.54 (T_8) and 135.25 (T_{11}), 13.52 (T_{10}) and 26.91 (T_{11}) and 80.20 (T_1) and 142.69 (T_{11}) respectively. The uptake of P was found to be highest for T_{11} (STCR+$ZnSO_4$ + FYM 5 t ha^{-1}). But if we compare the amount of fertilizers applied to each treatment (Table 1) the percentage of uptake was highest for the farmer's practice. This might be due to application of soluble ammonium phosphate through factamphos as source of P in this treatment. The uptake of nutrients was in the order K>N>P. uptake of N, P and K was invariably higher for STCR alongwith FYM than without FYM. Higher uptake was associated with STCR+FYM along with zinc sulphate than without it. Application of FYM with fertilizers significantly increased the

NPK uptake by the crop than application of fertilizers alone or in combination with zinc sulphate.

Table 5. Effect of treatments on the nutrient uptake of crop and total dry matter yield

Treatments	N Kg/ha	P Kg/ha	K Kg/ha	Total dry matter yield (kg ha^{-1})
T_1 control	80.32^{c}	19.43^{bcd}	80.20^{c}	5155.97^{de}
T_2 -Farmer's practice	120.50^{abc}	24.38^{ab}	115.66^{abc}	6688.54^{a}
T_3- KAU	131.99^{ab}	22.61^{ab}	141.61^{ab}	6133.97^{abc}
T_4-STL	99.95^{abc}	20.48^{abc}	123.39^{abc}	6389.19^{ab}
T_5- STCR	83.67^{bc}	15.20^{cd}	92.00^{bc}	3686.03^{f}
T_6- STCR+FYM	118.21^{abc}	19.84^{bcd}	123.35^{abc}	6046.28^{abc}
T_7- F.P + $ZnSO_4$	149.40^{a}	23.47^{ab}	113^{abc}	5651.83^{bcd}
T_8- KAU+ $ZnSO_4$	75.54^{c}	14.95^{cd}	80.93^{c}	4560.91^{e}
T_9- STL+ $ZnSO_4$	133.10^{ab}	23.23^{ab}	116.37^{abc}	6427.35^{ab}
T_{10}- STCR+ $ZnSO_4$	81.86^{bc}	13.52^{d}	93.83^{abc}	3779.05^{f}
T_{11}-STCR+ $ZnSO_4$+FYM	135.25^{ab}	26.91^{a}	142.69^{a}	5479.18^{cd}
CD (0.05)	45.30	6.03	43.51	750.30

This can also be attributed to increased efficiency of fertilizers in the presence of FYM resulting in increased uptake (Dwivedi and Thakur 2000). Total N, P and K uptake in plants increased with the age of the plant. Similar observation was reported by Sarkar and Debnath (1996). The total dry matter yield (kg ha^{-1}) varied between 3686.03 (T_5) and 6688.54 (T_2). Application of FYM along with STCR dose of fertilizer gave almost double the yield than without FYM. Application of zinc sulphate decreased the total dry matter yield except in T_9 and T_{10}.

4 CONCLUSION

Application of nutrient through combined sources of organic and inorganic fertilizer invariably improved the soil availability, plant content and uptake of N, P and K. Inclusion of organic nutrients from varied sources viz., green manure, compost, vermicompost etc can be seen as a supplemental alternative to enhance the fertility basket which will ensure higher productivity and profitability to farmers. Application of zinc sulphate should be withheld for a couple of years as the black soil of chittur are found to be sufficient in available zinc.

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