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RESEARCH ARTICLE

EFFECT OF SECONDARY AND MICRONUTRIENTS ON NUTRIENT UPTAKE AND YIELD OF RICE IN KOLE LANDS

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ABSTRACT

The Kole lands a unique wetland ecosystem of Kerala, is located 0.5-1.0m below mean sea level. An experiment was conducted in the College of Horticulture, Vellanikkara, Kerala to study the influence of secondary and micronutrients viz. calcium, magnesium and boron on nutrient uptake and yield of rice in Kole lands. Six treatments including the soil test based nutrient application, package of practices recommendation (POPR) of Kerala Agricultural University for rice, combinations of the POPR with magnesium, calcium silicate, boron and absolute control were applied in the crop in a randomized block design with three replications. Higher uptake of nutrients especially primary and micronutrients were noticed by boron and calcium silicate application and lower uptake of Fe and Mn, thereby resulted in higher grain yields of 7.67 t ha-1 and 7.18 t ha-1 respectively indicating and straw yield was higher by application of magnesium. Correlation analysis revealed that total uptake of boron, calcium and magnesium had positive and significant correlation with yield whereas negative correlation existed between Fe uptake and yield.

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INTRODUCTION

Kole lands are low lying wet land tracts located 0.5-0.1m below mean sea level spread over Thrissur and Malappuram districts of Kerala. The cyclical nutrient recharging of the wetland during the flood season rendered the areas one of the most fertile soils of Kerala. Soil acidity, toxicity of iron and manganese and deficiency of K, secondary and micronutrients are the major soil factors limiting productivity of rice in Kole lands (Johnkutty and Venugopal, 1993). Large scale use of fertilizers containing only major nutrients can result in the deficiencies of secondary and micro nutrients (Ponnusamy, 2006). The incidence of micro nutrient deficiencies has increased markedly in recent years due to intensive cropping, loss of top soil by erosion, loss of micro nutrients through leaching, liming of acid soils and decreased proportion of manures compared to chemical fertilizers. By the time the deficiency symptoms of a particular nutrient appear on the plant, the crop might have undergone considerable damage in respect of its ultimate yield. It is therefore, desirable to test soils for their available nutrient status before sowing or transplanting a crop in order to ensure timely corrective measures (Muralidharan and Jose, 1994).

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Application of calcium as calcium silicate found to ameliorate the limiting influence of Fe and Mn enabling increased rice production. Magnesium has important role in photosynthesis due to primary constituent of chlorophyll. Magnesium alone has been reported to increase the productive factors of rice. Boron is responsible for better pollination, seed setting, low spike sterility and more grain formation in different varieties of rice (Aslam *et al*., 2002). The experiment was carried out in farmer's field of Kole lands at Ponnamutha Kole padavu of Venkitangu Panchayath in Thrissur District during November, 2013 to March, 2014. Six treatments were imposed in a randomized block design with three replications.

Treatments comprised of:

*Soil test based nutrient package + FYM @ 5t/ha + lime600kg/ha (T1)
FYM 5t/ha+110:45:55kg NPK/ha + + lime 600kg/ha (Existing POPR) (T2)
FYM 5t/ha+ POPR NPK + MgO 20 kg /ha + lime 600 kg/ha (T3)
FYM 5t/ha + POPR NPK + Silica (calcium silicate) 100 kg/ha + lime 600 kg/ha (T4)
FYM 5t/ha + POPR NPK + Borax 10 kg/ha +lime 600kg/ha (T5)
Absolute control (T6)
*The soil test based nutrient requirement was estimated as 93:48:59 kg N, P_2O_5 and K_2O ha^{-1}.

Table 1. Effect of secondary and micronutrients on biometric characters of rice at harvest

Treatments		Plant height (cm)	Tiller count (m^2)	LAI	Dry matter (t ha^{-1})
T_1	STNP+ FYM+ lime	81.57^{cd}	371.80^{ab}	4.20^{d}	13.75^{d}
T_2	POPR	80.47^{cd}	365.50^{b}	4.28^{d}	13.68^{d}
T_3	POPR+ MgO	86.40^{b}	371.80^{ab}	4.65^{b}	14.51^{c}
T_4	POPR+ calcium silicate	87.63^{b}	378.20^{ab}	4.81^{ab}	15.37^{b}
T_5	POPR+ borax	91.23^{a}	382.80^{ab}	4.75^{ab}	15.57^{b}
T_6	Absolute control	66.60^{e}	211.70^{d}	2.89^{f}	8.27^{f}

*The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 2. Effect of secondary and micronutrients on yield attributes, grain and straw yield of rice

Treatments		Spikelets/ panicle	Filled grain/ panicle	1000 grain wt.	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})
T_1	STNP+ FYM+ lime	87.63^{e}	85.68^{de}	23.57^{d}	6.45^{c}	7.11^{e}
T_2	POPR	87.60^{e}	85.45^{de}	24.61^{bc}	6.32^{c}	7.35^{d}
T_3	POPR+ MgO	90.32^{de}	88.29^{cd}	25.39^{ab}	6.23^{c}	8.27^{a}
T_4	POPR+ calcium silicate	91.61^{d}	90.20^{bc}	25.76^{a}	7.18^{b}	8.18^{ab}
T_5	POPR+ borax	96.41^{bc}	94.30^{a}	26.07^{a}	7.67^{a}	7.89^{c}
T_6	Absolute control	52.07^{g}	64.94^{f}	21.05^{e}	3.77^{e}	4.50^{g}

*The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 3. Effect of secondary and micronutrients on nutrient uptake (kg ha^{-1}) of primary and secondary nutrients by rice

Treatments		N	P	K	Ca	Mg	S
T_1	STNP+ FYM+ lime	138.80^{cd}	53.83^{a}	197.89^{b}	31.33^{b}	11.63^{c}	20.72^{d}
T_2	POPR	132.80^{d}	46.69^{a}	194.38^{b}	32.57^{b}	11.55^{c}	21.85^{cd}
T_3	POPR+ MgO	144.40^{bc}	47.74^{a}	233.34^{a}	30.42^{b}	14.71^{a}	25.96^{ab}
T_4	POPR+ calcium silicate	158.40^{a}	50.18^{a}	201.76^{b}	39.39^{a}	14.37^{ab}	24.53^{bc}
T_5	POPR+ borax	152.60^{ab}	53.62^{a}	196.31^{b}	33.30^{b}	13.90^{b}	28.77^{a}
T_6	Absolute control	48.01^{e}	13.46^{b}	72.04^{c}	17.40^{c}	5.56^{d}	7.51^{e}

*The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 4. Effect of secondary and micronutrients on nutrient uptake (kg ha^{-1}) of micronutrients and Si by rice

Treatments		Fe	Mn	Zn	B	Si
T_1	STNP+ FYM+ lime	4.18^{b}	1.84^{a}	0.43^{bc}	0.076^{d}	436.30^{d}
T_2	POPR	4.57^{ab}	1.90^{a}	0.38^{c}	0.081^{c}	436.00^{d}
T_3	POPR+ MgO	4.68^{a}	1.65^{b}	0.46^{ab}	0.082^{c}	475.70^{c}
T_4	POPR+ calcium silicate	3.58^{d}	1.87^{a}	0.49^{ab}	0.095^{b}	631.50^{a}
T_5	POPR+ borax	4.02^{b}	1.85^{a}	0.53^{a}	0.104^{a}	608.40^{b}
T_6	Absolute control	3.88^{c}	1.35^{c}	0.14^{d}	0.030^{e}	176.60^{e}

*The means followed by common alphabets do not differ significantly at 5% level in DMRT

Table 5. Correlation between uptake of nutrients and yield

Nutrient	Grain Yield
	Total uptake
Nitrogen	0.94**
Phosphorous	0.85**
Potassium	0.73**
Calcium	0.84**
Magnesium	0.90**
Sulphur	0.85**
Iron	-0.15
Manganese	0.60**
Zinc	0.89**
Boron	0.94**
Silicon	0.95**

Lime was applied @350kg/ha as basal and 250kg/ha one month after sowing. MgO was applied as magnesium sulphate at basal and borax was applied in two equal split doses at basal and flowering. NPK were applied as per POPR. Observations on biometric characters, yield attributes and yield were recorded. Plants in the two border rows from all sides of each plot were harvested first and net plot area was harvested. Threshing was done with mechanical thresher (Redlands mechanical thresher and winnower) and grain and straw were separated and the weight was recorded.

Plants were analyzed for macro and micronutrients content and uptake was calculated. The data were subjected to analysis of variance using the statistical package MSTAT-C (Freed, 1986). Duncan's Multiple Range Test (DMRT) was used to compare means (Duncan, 1955; Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of secondary and micronutrients on growth characters and yield are presented in Table 1 and 2 respectively. Both grain and straw yield showed significant difference between the treatments. Application of boron along with POPR recorded highest grain yield (7.67 t ha^{-1}) followed by application of calcium silicate. Application of boron produced higher yield, addition of boron alone resulted in 1.37 t ha^{-1} of yield increase over control. This is mainly attributed to higher number of filled grains per panicles which was 45 per cent more compared to control and the highest among the treatments. Ahamad *et al.* (2009) reported the function of boron in plant relate to sugar transport, flower production, retention, pollen tube elongation and germination and translocation of carbohydrate and sugars to reproductive organs, which in turn improved the spikelet number and fertility that influenced the yield and productivity.

Increased boron content and uptake in the plant and grain indicated that the applied boron was efficiently translocated to the plant tissues for utilisation. Increased yield due to boron application was also reported by Sakal *et al*. (2002) and Dunn *et al*. (2005) Soil test based nutrient application, POPR and magnesium application recorded comparable grain yields. The application of nutrients as per Package of Practices recommendation and soil test based nutrient package did not register significant yield variation. But the straw yield was significantly higher when nutrients were applied as per Package of Practices recommendation. The grain yield (3.77 t ha^{-1}) was the lowest in control treatment. Highest straw yield was recorded by application of magnesium (8.27 t ha^{-1}) and it was on par with calcium silicate application. The increased tiller number due to calcium silicate application advantageously reflected in increased straw yield.

The effect of application of $MgSO_4$ was conspicuous compared to control but not to the extent of application of silica and borax. The straw yield was increased by 720 kg ha^{-1} due to application of magnesium. This was also supported by the fact that the uptake of N, P and K by straw was significantly higher in magnesium applied plots, while the uptake of nutrients by grain was comparatively low. POPR recorded better straw yield compared to soil test based nutrient applied treatment. There was a profound decrease in straw yield in control treatment and it recorded the lowest straw yield of 4.50 t ha^{-1}. Effect of secondary and micronutrients on nutrient content and uptake is presented in Table 3 and 4 respectively. Uptake of nutrients in grain and straw was greatly influenced by secondary and micronutrients. Uptake of primary and secondary nutrients was higher in calcium silicate and boron applied treatments. Soil test based nutrient application showed higher uptake of nutrients when compared to POPR. When nutrients were applied as per need basis it resulted in balanced fertilization and increased absorption of other nutrients. Magnesium treatment recorded higher Mg uptake.

Borax application failed to register higher status of major nutrients in plants but it was found that it resulted in reduction in absorption of Fe and Mn by plant and increased absorption of Zn, B and Si as evident from the data. This might have favoured the enhanced grain yield due to their functional role in rice. The increased content of boron in grain and straw due to boron application @10 kg borax ha^{-1} was noticed by Hosseini *et al*., 2005. The uptake pattern showed that borax application was associated with high N and boron uptake and low Fe and Mn uptake. The content of all nutrients except Fe and Mn established a significant positive correlation with grain yield. The data on correlation between uptake of nutrients and yield is presented in Table 5. Significant positive correlation was recorded between uptake of all nutrients and grain yield except Fe and Mn. Uptake of silicon and N was found to be highly correlated with yield. A negative relationship was noticed between Fe uptake and yield though not significant.

Conclusion

Application of borax along with NPK and lime as per package of practice recommendations was able to maintain relatively high level of major nutrients with reduced levels of Fe and Mn. The treatment effect was aggravated by the role of boron in reducing spikelet sterility and increasing seed setting and grain formation which resulted in higher yield. Silica application as calcium silicate was better for increased growth and yield of rice and also reduced Fe and Mn content of soil and increased the availability of other nutrients.

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