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Silicon Nutrition for Sustainable Rice Production in Iron Toxic Laterite Soils of Kollam District in Kerala

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ABSTRACT

In iron toxic laterite soil of Kerala, the major soil related constraints affecting rice production are acidity and toxicity of metals like iron (Fe), aluminium (Al) and manganese (Mn). In Kollam district approximately 60 per cent of area under rice is coming under iron toxic iron laterite soil. The presence of high concentration of these metals in soil hinders the absorption of other nutrients leading to poor nutrient use efficiency. A suitable nutrient management system which reduces the toxic level of these metals prevalent in low pH soil, will certainly improve the yield of rice. The trial consisted of three technology options viz., farmers practice i.e., unscientific use of high analysis fertilizers (TO1), recommended practice i.e., 5 t/ha OM + 90:45:45 kg N:P:K/ha +600 kg lime/ha (TO2) and alternate practice i.e., 90:45:120 kg N:P:K/ha +OM 5 t/ha + 150 kg lime/ha+100 kg silica/ha (TO3). The study revealed that compared to the technology TO1 and TO2, the technology option TO3 (OM 5 t/ha+ 90:45:120 kg N:P:K/ha + 150 kg lime+100 kg silica) gave significantly higher grain and straw yield i.e., 6.61 t/ha (17.62%) increase in grain and 9.29 t/ha (20.65%) increase in straw over recommended practice (TO2). Benefit cost ratio was also highest for this treatment (2.26). The lowest incidence of pests was recorded in silica applied plots. This shows that in addition to yield enhancement, this technology has an additional benefit i.e., reduction of pest incidence. Hence the outcomes of this farmer participatory experiment emphasized the importance of the special nutrient package for yield increase in rice under iron toxic laterite soils. The feedback of the farmers who visited the trial plots was positive and they recorded that silica application has increased the growth and number of productive tillers. They also observed that silica application reduced the incidence of pests.

Key Words: Al, Fe, Grain yield, Incidence of pests, Mn, Toxicity, Rice, Silica, Straw yield.

INTRODUCTION

The rice farming sector in Kerala is facing a multitude of problems which led to drastic decline in area under cultivation and production. The main problem yet to be addressed in detail is soil related constraints. About 65 per cent of soils in Kerala is iron toxic laterite, which require special management package as the soils are low to medium in organic carbon, N and K, very low in Ca, Mg and B. Apart from low nutrient status, high acidity and toxicities of iron, aluminium and manganese are other major soil related constraints in iron toxic laterite soils of Kerala.

Silicon the wonder element can alleviate various abiotic stresses including, metal toxicity, drought stress, nutrient imbalance, high temperature, freezing and so on as reported by Matichenkov and Calvert (2002), Ma, 2003; and Singh *et al(*2005). Though silicon is abundantly present in the earth crust, continuous and intensive monoculture of nitrogen responsive high yielding cultivars depletes the available silicon from soil. Nutrient management systems including silicon fertilizer which reduce the toxic levels of Al, Fe & Mn which is prevalent in low pH soil will certainly improve the yield. In this context, KVK, Kollam has conducted on farm testing to assess the feasibility of the alternate Kerala Agricultural University nutrient package that includes silicon fertilizer for yield enhancement

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in iron toxic laterite soils in the selected farmer's fields of Kollam district of Kerala through a farmer participatory approach during 2012-2013.

MATERIALS AND METHODS

The trial was carried out in 7 randomly selected farmer's fields at Elamadu and Thevannur panchayats of Kollam district during rabi season of 2012-13. Different farmers' fields were taken as replications. The variety selected was Uma. The plot size was 100 m2 for each technology options. The soils are acidic in nature with a pH of 4.9 to 5.14. The fertility status of selected plots were medium in organic carbon, medium to high in available P and low to medium in available K. The iron content in soil before the experiment was analyzed and found that it was high in all plots.

The trial consisted of three technology options (TO); viz., farmers practice i.e., unscientific use of fertilizers (TO1), recommended practice ie. 5 t/ha OM + 90:45:45 kg NPK/ha +600 kg lime/ha (TO2) and alternate practice i.e., 90:45:120 kg N:P:K/ha +OM 5 t/ha + 150 kg lime/ha+100 kg silica/ha (TO3). The technologies were evaluated by collecting data on plant height, total number of productive tillers, grain yield, straw yield, and incidence of pests and disease with farmer participation. The study also explored the feedback of visiting farmers of sample size 21 from different areas of Chadayamangalam block under ATMA exposure visit programme organized by Department of Agriculture, Kollam. The response of farmers on these technologies were recorded after observing the parameters on growth, productive tillers and pest incidence, as, low, medium and high.

RESULTS AND DISCUSSION

Growth and yield

The data on growth and yield parameters are given in Table 1. The results showed that growth, yield parameters and yield were high for TO3, it recorded the highest grain yield (6.61t/ha) nearly 17.62 per cent over the recommended practice (TO2). The same treatment recorded an increase in straw yield also i.e., 9.29 t/ha which was 20.65 per cent increase over the recommended practice (TO2). Application of silica helped to increase growth and yield attributes which in turn increased grain yield and straw yield.

The similar studies reported that important constraints limiting productivity of rice in the iron toxic laterite soils, viz., high acidity and toxicity of Al, Fe and Mn can be alleviated to a greater extent through the application of silicon fertilizer (Ma *et al*, 2006 and Matichenkov and Calvert (2002). The possible mechanisms through which Si alleviates the metal toxicity are: (1) Plant available silicon (PAS) increase the pH of acidic soil, (2) PAS can form ions with the toxic metals thereby precipitating it out of soil solution, (3) Silica deposition in roots reduce the binding sites for metals resulting in decreased uptake and translocation of salts and toxic metals from roots to shoot, (4) Another way is interaction between Si and Al occurs in the solution, presumably by the formation of AI-Si complexes, a

Table 1. Effect of nutrient management systems on growth and yield attributes of rice

Technology options	Plant height (cm) at harvest	No. of tillers/hill at harvest	No. of productive tillers/hill	Pest incidence (%)
Farmers' practice (TO1)	101.4	8.85	8.14	35.85
Recommended practice (TO2)	103	10.5	7.85	27.42
Alternate practice (TO3).	102.7	11.42	9.14	7.11

non-toxic form (5) Silicon enhanced the oxidative power of rice roots, resulting in enhanced oxidation of Fe from ferrous iron to insoluble ferric iron. Similar mechanism is applicable for Mn also (Matichenkov and Calvert, 1999). In this trial also alleviation of metal toxicities proved to be the reason for enhanced productivity along with other positive benefits of silicon.

Pest incidence

The data on pest incidence is given in Table 2. Better reduction of pests was observed in silica applied plots (7.11%) whereas the pest incidence was 35.85 per cent in the plots under farmers practice. This may be due to the deposition of silica on epidermal layers that in turn offers a physical barrier to insects. Sucking pests and leaf eating caterpillers have a low preference for the silicic tissue than low silica containing succulent parts. Suppression of insect pests by the application of silicon was reported by many scientists (Ma and Takahashi, 2002).

Economics

The data on economics is given in Table 2. Among the different technology options, the maximum net return (Rs.76,900/-) and BCR (2.27) was observed for TO3 followed by TO2 (1.78). The lowest net income and BCR (1.36) was recorded by TO1.

Perception of farmers, who visited the experimental plots on the relative performance of crop

Feedback of farmers, who visited the experimental plots on the relative performance of crops under different technological options were elicited and quantified (Table 3). 21 Farmers from Chadayamangalam block of Kollam district visited the experimental plots and recorded their observations. According to their opinion the number of tillers and productive tillers were more in silica applied plots. The disease and pest incidence was also lower in these plots i.e., plots under TO3.

Wide scale adoption of technology through ATMA, Department of Agriculture,Kollam

In active collaboration with the Department of Agriculture front line demonstrations of this technology were carried out for the previous three years (2013-2016) and covered 197 ha of rice field with severe iron, aluminum and manganese toxicity under 19 padasekharams. Outstanding yield was obtained from these plots (5.65 t/ha which was 32 per cent over the conventional method) i.e., adopting this new technology the farmers could harvest superior yield with reduced use of pesticides. The incidence of leaf folder and stem borer were reduced to 50% over traditional method. Hitherto rice fields of 17 panchayaths under 6 blocks have been successfully utilized the technology in Kollam district.

CONCLUSION

Silicon depletion coupled with Fe, Al and Mn toxicity and high acidity are more common in our tropical soil leading to poor productivity of rice. Approximately 60% rice area under Kollam district faces this problem. The outcomes of this farmer participatory experiment emphasized the importance of the alternate nutrient package including silica (OM 5 t/ha+ 90:45:120 kg N:P:K /

Table 2. Effect of nutrient management systems on yield and economics of rice

Technology options	Grain yield (t/ha)	Straw yield (t/ha)	Net returns (Rs/ha)	B:C Ratio
Farmers practice (TO1)	4.47	7.5	23,470/-	1.36
Recommended practice (TO2)	5.62	7.7	51,100/-	1.78
Alternate practice (TO3).	6.61	9.29	76,900/-	2.27
CD(0.05)	0.463	0.804	-	-

Table 3.Perception of farmers visited the experimental plots, relative performance of crop

Technological Options	Visual growth			Productive tillers			Pest incidence		
	Low	Medium	High	Low	Medium	High	Low	Medium	High
Farmers' practice (TO1)	7	14	0	19	2	0	0	0	21
Recommended practice (TO2)	0	16	5	6	15	0	0	0	21
Alternate practice (TO3).	0	6	15	0	10	11	21	0	0

ha + 150 kg lime+100 kg silica) for yield increase in rice under iron toxic laterite soils. In addition to yield enhancement, the technology including silica has an additional benefit i.e., reduction of pest incidence. The response of the participating farmers on the technology option 3 was positive. The feedback of the farmers who visited the trial plots was also positive where they recorded that silica application has increased the growth and number of productive tillers. They also observed that silica application has reduced the incidence of pests. Hence the present investigation suggests the use of silica in the nutrient management programme of rice for enhanced productivity by alleviating the abiotic and biotic stresses along with beneficial effects of silicon fertilizer.

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