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Rice Husk Ash as a Low Cost Soil Ameliorant for Abating Iron Toxicity in Lowland Rice

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ABSTRACT

Background: The Fe toxicity is a perpetual problem of low lying poorly drained acid soils. It also affects the solubility and availability of most of the plant nutrients, by reducing toxic concentrations of iron, aluminum and manganese. To overcome these constraint, application of lime is inevitable but high cost of liming materials necessitate the use of low-cost, internally sourced, environmentally friendly and adoptable organic sources. In present study rice husk ash was used as a soil ameliorant in lieu of liming.

Methods: A field experiment was conducted at Rice Research Station, Moncompu during 2017-2018 with nine treatments replicated thrice in RBD using rice variety Uma. A customized formulation with composition of K (8.9%), Mg (3.2%), Ca (3.7%), Zn (2.1%), Mn (0.23%), B (3.5%) and Cu (0.96%) was developed based on the available nutrient status of the region and crop requirement and used for supplementary foliar nutrition.

Result: It was found that treatment comprising of Soil test based RDF + Rice husk ash @ lime (based on pH) + foliar spray of 0.5% solution of customized formulation @ 5 kg ha^{-1} as foliar application of 0.5% solution in two splits at maximum tillering and panicle initiation stage was the best treatment in increasing yield by 23% compared to recommended dose of lime and fertilizer application and B:C ratio increased from 1.53 to 1.91. Effect of rice husk ash in ameliorating soil acidity was found to be on par with application of lime based on pH in acid sulphate soils of Kuttanad zone.

Key words: Acidity, Iron toxicity, Liming, Rice cultivation, Rice husk ash, Silica.

INTRODUCTION

The submerged soils are generally associated with large concentrations of reduced iron (Fe^{2+}) in the soil solution. Higher concentration of Fe^{2+} in the rhizosphere has antagonistic effects on the uptake of many essential nutrients and consequently yields reduction. In the recent past, Fe toxicity has emerged as a serious nutrient disorder of lowland rice and can reduce the yield of rice by 12-100%, depending on the Fe tolerance of the genotype, intensity of Fe toxicity stress and fertility status of the soil. The acid soils and low-lying poorly drained alluvial and colluvial soils are prone to Fe toxicity. The rice cultivation in acid sulphate soils face risks of waterlogging, acidity and toxicities of iron and aluminium (Thampatti and Jose, 2000). To improve these soils for better crop performance liming is inevitable. Liming not only raises the soil pH, it also affects the solubility and availability of most of the plant nutrients by reducing the toxic concentrations of iron, aluminum and manganese. The high cost of conventional liming materials necessitate the use of low-cost, internally sourced, environmentally friendly and adoptable organic sources that could serve as liming agents and fertilizer for rice production. Application of rice husk ash improved soil properties and rice yield by increasing the soil pH and available nutrients in peat soils (Sitio *et al*. 2007). Rice husk ash is relatively cheaper and abundantly available in Kuttanad and moreover it is also a rich source of silica. Silicon as a beneficial element and its use as a substitute for lime can reduce concentration and uptake of iron in the plant and iron toxicity. Hence the present study was undertaken to evaluate the effect of rice husk ash as a potential low cost soil amendment in abating iron toxicity in the low land rice fields of acid sulphate soils of Kuttanad in Kerala.

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MATERIALS AND METHODS

A field experiment was conducted at Rice Research Station, Moncompu during 2017- 2018 with nine treatments *viz*.T1 [Recommended dose of fertilizer and lime (RDF)]; T2 [Soil test based RDF and lime (based on pH)]; T3 [(Soil test based RDF + Rice husk ash (RHA) @ lime based on pH)]; T4 (Soil test based RDF + RHA @ ½ lime based on pH); T5 (T1 + foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage); T6 (T2 + foliar spray of 0.5% solution of customized formulation); T7 (T3 + foliar spray of 0.5% solution of customized formulation); T8 (T4 + foliar spray of 0.5% solution of customized formulation) and T9 (50% Soil test based RDF + RHA @ lime based on pH + foliar spray of 0.5% solution of customized formulation)

replicated thrice in RBD using rice variety Uma. A customized nutrient formulation with a composition of K (8.9%), Mg (3.2%), Ca (3.7%), Zn (2.1%), Mn (0.23%), B (3.5%) and Cu (0.96 %) was developed based on the available nutrient status of the region and crop requirement (Lekshmi *et al.* 2017). This formulation was used for supplementary foliar nutrition @ 5 kg ha^{-1} as foliar application of 0.5 % solution in two splits at maximum tillering and panicle initiation stage to reduce the nutritional constraints at critical growth stages.

RESULTS AND DISCUSSION

The treatment T7 (Soil test based RDF+RHA @ lime based on pH + Foliar spray of 0.5 % solution of customized formulation) recorded the highest grain yield (6.83 t ha^{-1}) and straw yield (8.57 t ha^{-1}) and was on par with T5 (Recommended Dose of fertilizers + lime + foliar spray of 0.5% solution of customized formulation and T6 (Soil test based RDF and lime based on pH+ foliar spray of 0.5% solution of customized formulation) (Table 1). This indicates that application of rice husk ash as soil ameliorant is equally effective as lime in ameliorating the soil acidity and thereby increasing the rice yield. Prakash *et al*. (2007) also reported RHA increased the grain yield and straw yield of rice owing to Si supplying power of RHA. Treatments T7 had highest pH (5.5) which was on par with treatments T3, T4, T5, T8 and T9 (Fig 1). Islabao *et al.* (2014) also reported increased pH and nutrient availability due to application of RHA. This can be attributed to the high pH of rice husk ash due to the presence of oxides of K, Mg and other basic cations and hence the rice husk ash treated plots have a higher pH than lime treated plots as reported by Masulili *et al*. (2010). The variation in pH was recorded at different intervals (Fig 1) and change in pH in rice husk ash receiving plots were more stabilized than lime applied plots because of the slow release of bases in rice husk ash.

The leaf Fe at the time of maximum tillering stage and panicle initiation stages indicated that the treatments had a significant influence in reducing the iron toxicity. Treatment T7 had lowest leaf iron content (125 and 141 mg kg^{-1}) during both the stages while the treatment T1 recorded the highest value (202.3 and 217.7 mg kg^{-1}) (Fig 2). The treatment T7

Table 1: Effect of rice husk ash and supplementary foliar nutrition on yield and B:C ratio.

Treatments	Yield (t ha^{-1})		B: C ratio
	Grain	Straw	
T1: Recommended dose of fertilizers (RDF) + lime	5.57	8.57	1.53
T2: Soil test based RDF (Stb RDF) and lime based on pH	5.86	8.44	1.55
T3: Stb RDF+RHA @ lime based on pH	5.93	8.37	1.75
T4: Stb RDF+ RHA @1/2 lime based on pH	5.4	8.3	1.63
T5: T1 + foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage	6.43	8.5	1.65
T6: T2 + Foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage	6.5	8.4	1.65
T7: T3 + Foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage	6.83	8.57	1.91
T8: T4 + Foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage	6.02	8.35	1.73
T9: 50% Stb RD + RHA@ lime in T2 + Foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage	4.23	7.41	1.32
CD(0.05)	0.53	0.83	

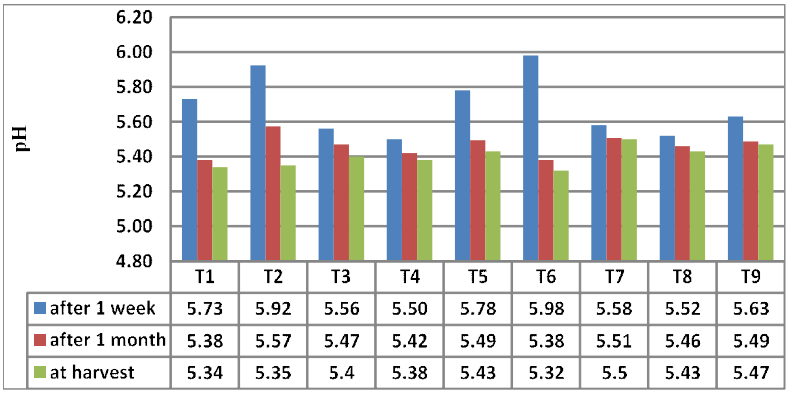


Fig 1: Effect of RHA on pH after different intervals of application.

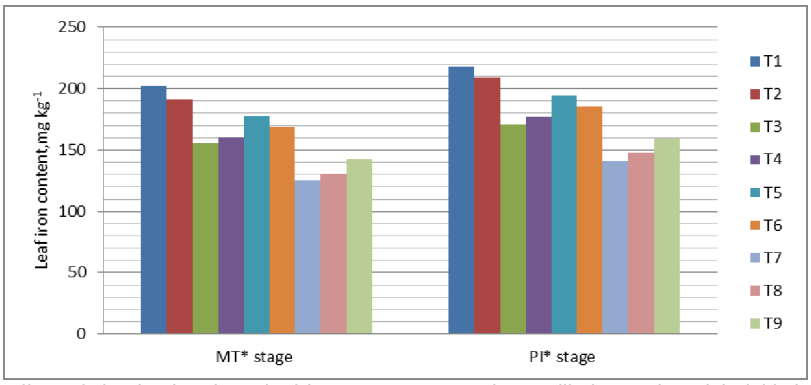


Fig 2: Effect of rice husk ash on leaf iron content at maximum tillering and panicle initiation stage.

Table 2: effect of rice husk ash and supplementary foliar nutrition on iron and silicon content in grain and straw.

Treatments	Fe content (mg kg^{-1})		Si content (per cent)	
	Grain	Straw	Grain	Straw
T1: Recommended dose of fertilizers (RDF) + lime	125.3	230.3	0.436	1.74
T2: Soil test based RDF (Stb RDF) and lime	113.0	221.7	0.456	1.86
T3: Stb RDF+Rice husk ash (RHA) @ lime in T2	78.3	184.3	0.763	3.93
T4: Stb RDF+ RHA @1/2 lime in T2	91.3	190.3	0.643	3.47
T5: T1 + Foliar spray @ 0.5% (FS)	100.3	207.7	0.466	2.05
T6: T2 + FS	94.0	198.7	0.463	2.13
T7: T3 + FS	65.0	154.3	0.810	3.98
T8: T4 + FS	70.7	160.3	0.613	3.42
T9: 50% Stb RD + RHA@ lime in T2 + FS	73.7	173.3	0.806	3.89
CD(0.05)	2.47	2.49	0.0511	0.065

recorded the lowest iron content in grain (65 mg kg^{-1}) and straw (154.3 mg kg^{-1}). Contrary to it, highest Fe content in grain (125.3 mg kg^{-1}) and straw (230.3 mg kg^{-1}) was recorded in T1 (Table 2). This may be due to the influence of Si in reducing the Fe uptake by increasing the oxidizing capacity of roots, which converts ferrous iron into ferric iron (Ma, 2004) it has also been suggested that Si regulate Fe uptake through the release of OH^- by roots. Treatment T7 recorded the highest content of Si in both grain (0.81%) and straw (3.98%). The plots having RHA increased available Si and nutrient availability (Baburao, 2017).

CONCLUSION

Use of rice husk ash as soil ameliorant along with soil test based RDF and supplementary foliar nutrition improved rice yield in the acid sulphate soils of Kuttanad and reduced the nutritional constraints due to iron toxicity. Soil test based RDF + Rice husk ash @ lime (based on pH) + foliar spray of 0.5% solution of customized formulation at tillering and panicle initiation stage) was the best treatment in increasing the yield by 23% compared to RDF and B:C ratio from 1.53 to 1.91. Effect of rice husk ash in ameliorating soil acidity was found to be on par with application of lime based on pH. The available Si content in soil increased as RHA served as good source of Si and reduced the iron uptake. Therefore rice husk ash can be utilized as a potential low cost soil ameliorant in abating the iron toxicity in low land rice cultivation.

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