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# Acidity amelioration for rice yield enhancement in acid sulphate (*Vaikom kari*) soils of Kuttanad in Kerala

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## ABSTRACT

*The experiment was carried out during 2014 in acid sulphate soils (Vaikom Kari) in Kottayam district with the objective of ameliorating soil acidity and enhancing rice yield. Kari soil of Kuttanad the rice bowl of Kerala, is a problem soil affected by severe acidity and periodic saline water inundation with consequent accumulation of soluble salts which results in a lower yield. The study consisted of seven treatments with lime @ 600 kg $ha^{-1}$, dolomite @ 500 kg $ha^{-1}$ and rice husk ash (RHA) @ 500 kg $ha^{-1}$ at two different times of application i.e.; as basal and at 30 days after sowing (DAS) or as basal and one week before third dose of fertilizer application (panicle initiation (PI) stage) along with a control without ameliorants. The application of lime, dolomite as well as RHA had a significant influence on grain yield and higher yield was obtained when applied as basal and 30 DAS. The number of panicles was higher and the sterility percentage was lower for dolomite and RHA applied as basal and 30 DAS. The benefit cost ratio was also the highest for dolomite applied as basal and 30 DAS but was on par with lime applied similarly and both treatments of RHA. The soil pH, increased by the application of ameliorants at both stages had a positive influence on available P. Lime and dolomite application increased soil available Ca and available Mg content was raised by applying dolomite.*

***Keywords*** : Acidity amelioration, acid sulphate soil, dolomite, lime, rice, rice husk ash

Kuttanad, the rice bowl of Kerala is distributed in and around Vembanad Lake in Alappuzha, Kottayam and Pathanamthitta districts. It is lying 1-2 m below mean sea level and is characterized by high organic matter content. Kuttanad soil is classified and named according to morphological conditions into kari, karappadam and kayal lands. Unlike kayal and karappadam soils of Kuttanad, kari soils extending to 9000 ha have a different genesis making it difficult in attaining high productivity for rice. Kari soils are deep black in colour, heavy in texture, poorly aerated and ill drained. The soils are affected by severe acidity and periodic saline water inundation with consequent accumulation of soluble salts. Based on location, kari soils are divided into Purakkad and Vaikom Kari, among which the later is affected by severe acidity and salinity problems resulting in yield constraints. Soil acidity is a major growth-limiting factor for plants in many parts of the world (Foy, 1984). Globally around 26 per cent of total ice-free land has soil acidity constraints for crop production (Eswaran *et al*., 1997). Soil acidity causes nutrient stress to rice (Mandal *et al*., 2003) and is a main barrier to rice production. In Kerala also 94.7 per cent of soils are acidic (Maji *et al*., 2012).

To ameliorate soil acidity, liming is an important practice adopted in many parts of the world. Liming enhances the physical, chemical and biological properties of acid soils (Bolan, 2003). Low soil pH and resultant problems like Fe toxicity and low availability of other nutrients are the most important soil related yield limiting factors in rice soils of Kerala. Due to low response to added nutrients in acid soil, farmers will resort to addition of more nutrients in the form of inorganic fertilizers for increasing yield which not only affect the economics of crop production but also the environmental safety of the production system (Moossa *et al*., 2012). Burnt lime shell (calcium oxide) is the most common liming material used in Kerala. However, due to ecological constraints its collection and extraction are restricted in many places and its availability is also limited leading to a high cost. Dolomite (calcium magnesium carbonate), which is comparatively cheaper liming material is also being imported from the neighbouring states. Another potential liming material is rice husk ash (RHA) a waste product from rice mills, which is cheap and environment friendly. This study aims at a comparison of using lime and dolomite (KAU, 2011) and RHA as soil acidity ameliorants in kari soils for enhancing rice yield. Two different times of application are compared that is basal + 30 days after sowing (DAS) and basal+ one week before third dose of fertilizer application. The recommendation being as basal + 30 DAS, it is found that the rice crop faces root damage due to Fe and Al toxicity in these soils which aggravates during the panicle initiation (PI) stage affecting the nutrient uptake. Hence the application of ameliorants as basal + one week before third dose of fertilizer application (just before PI stage) was included as a treatment in the study.

## MATERIALS AND METHODS

The experiment was carried out in farmer's field in Vaikom kari soils of very strongly acidic (pH 4.6 to 5.0)

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nature in Kallara village in Kottayam district during the main season (Puncha- Oct-Nov to Jan-Feb) of the year 2014-15 in Kuttanad. The initial soil testing showed that soils are very strongly acidic (4.6 to 5) with low available P, Ca and Mg, high available K, and toxic concentrations of available Fe. The experiment consisted of seven treatments and three replications. The treatments were $T_1$-Lime in two splits as basal and at 30 DAS; $T_2$- Lime in two splits as basal and one week before third dose of fertilizer application; $T_3$- Dolomite in two splits as basal and at 30 DAS; $T_4$- Dolomite in two splits as basal and one week before third dose of fertilizer application (45 days); $T_5$- RHA in two splits as basal and at 30 DAS; $T_6$- RHA in two splits as basal and one week before third dose of fertilizer application and $T_7$- Control, where no liming material was applied. (Lime @ 600 kg $ha^{-1}$, two splits of 350 and 250 kg $ha^{-1}$, dolomite @ 500 kg $ha^{-1}$ as 300 and 200 kg $ha^{-1}$ and RHA @ 500 kg $ha^{-1}$ as 300 and 200 kg $ha^{-1}$ were applied as per treatments). The high yielding medium duration variety Uma (MO-16), popular in the region was used for the study. Fertilizers were uniformly applied to all plots as per KAU recommendation (KAU, 2011). All other operations were done as prepackage of practices (KAU, 2011). Sprouted seeds were dibbled at a spacing of 20 x 10 cm, in plots of size 5 x 2 m. Soil samples were taken before the experiment one week after treatment application but before fertilizer application at basal and two topdressings and at harvest during the experiment and wet soils were analysed for pH and nutrient content. The observations on panicle number, 1000 grain weight and sterility percentage were recorded at harvest.

## RESULTS AND DISCUSSION

### Effect on yield attributes and grain yield

The highest grain yield was obtained for dolomite application but it was on par with RHA and lime applied at basal and 30 DAS (Table 1). Higher yield obtained for dolomite is due to its contribution of Mg in addition to Ca present in it as both are deficient in acidic soil conditions of Kuttanad. The amelioration of soil acidity by dolomite also helps in better Ca and Mg availability to the crop. The yield obtained for lime was also *on par* with dolomite due to the supply of Ca as well as correction of soil acidity. Though the RHA is less in Ca and Mg contents the yield was *on par* with lime and dolomite due to the alkaline nature of the ash which helped to improve the soil pH and also owing to the supply of Si (Okon *et al.*, 2005; Ma *et al.*, 1989) which is usually deficient in soils in frequently cultivated rice fields (Desplanques *et al*., 2006). Reichenauer *et al.*, (2009) has also reported that rice-husk-charcoal, which contains no Ca but high amounts of Si, lead to a significant increase in straw biomass and a significant decrease of unfilled ears in rice grown in the salt affected areas. Effect of Si on alleviating Al toxicity in rice has also been reported by Ming-hua and Xiao-feng (2002). Chalmardi *et al*., (2014) has reported that silicon nutrition could ameliorate harmful effects of Fe toxicity possibly through reduction of plant Fe concentration and improvement of antioxidant enzyme activity. The yield from control plot was low owing to high acidity in the soil that reduce the nutrient availability as well as its damaging effect on plant roots due to Fe and Al toxicity reducing the nutrient uptake. This is evident from the high sterility percentage or poor grain filling for the control plots (Table 1). In acid soils, Fe toxicity is a yield-limiting factor in wetland rice which results in very few long roots, fewer tillers and low dry matter leading to low yield (Bridgit and Potty, 2002). Majumder *et al.* (1995) also reported stunted growth, extremely limited tillering, extended vegetative period, increased spikelet sterility and reduced grain yield in rice due to Fe toxicity. According to Sahrawat (2010), Fe toxicity reduces lowland rice yield by 12-100 per cent depending on genotype, intensity of Fe toxicity and soil nutrient status. Also Al accumulates in the root tip, which is the site of cell elongation and cell division (Dobermann and Fairhurst, 2000) affecting plasma membrane functions leading to poor water and nutrient uptake.

The number of panicles was the highest for dolomite applied as basal and 30 DAS which was *on par* with RHA applied in the similar manner. The sterility percentage was lower for dolomite and RHA applied as basal and 30 DAS and the highest for control. The 1000 grain weight was also higher for ameliorants applied compared to control though not significant (Table 1.). higher yield attributes obtained for the ameliorants applied as basal and 30 DAS lead to a significant influence on grain yield compared to their application as basal and one week before PI stage.

### Benefit cost ratio

The benefit cost ratio was also the highest for dolomite applied as basal and 30 DAS but was *on par* with lime applied at basal and 30 DAS as well as both treatments of RHA (Table 1.). Both dolomite and RHA are cheaper than lime and hence their application is comparatively cost effective.

### Soil pH, available P, Ca and Mg

The pH of the strongly acidic soil in the experimental site was increased by the application of ameliorants at 30 DAS as well as before PI stage (Table 2). At 30 DAS, lime applied as basal and before PI stage, dolomite as basal and before PI stage and RHA as basal and before PI stage recorded a lower soil pH compared to lime applied as basal and 30 DAS, dolomite as basal and 30 DAS and RHA as basal and 30 DAS because the later treatments received two splits of ameliorant application second being at 30 DAS whereas the former received

**Table 1: Effect of ameliorants and their time of application on yield attributes, grain and benefit cost ratio**

| Treatments | Number of panicles | Sterility percentage | 1000 grain weight | Grain yield (t ha$^{-1}$) | Benefit-cost ratio |
|---|---|---|---|---|---|
| $T_1$ | 216.67 | 8.93 | 26 | 7.58[a] | 2.69 |
| $T_2$ | 223.33 | 9.60 | 24.33 | 6.46 | 2.3 |
| $T_3$ | 290 | 8.40 | 25.33 | 7.92 | 2.84 |
| $T_4$ | 200 | 9.27 | 26.33 | 7.02 | 2.52 |
| $T_5$ | 256.67 | 8.00 | 25.67 | 7.59 | 2.72 |
| $T_6$ | 210 | 8.67b | 25.67 | 6.98 | 2.63 |
| $T_7$ | 130 | 16.87 | 23 | 4.31 | 1.62 |
| **LSD(0.05)** | **38.986** | **1.315** | **NS** | **0.851** | **0.308** |

**Table 2: Effect of ameliorants and their time of application on soil pH and available P**

| Treatments | 30 DAS | | Before PI Stage | |
|---|---|---|---|---|
| | Soil pH | Soil available P (kg ha$^{-1}$) | Soil pH | Soil available P (kg ha$^{-1}$) |
| $T_1$ | **6.13** | **18.86** | **5.4** | **19.19** |
| $T_2$ | 5.07 | 14.58 | 6.07 | 15.35 |
| $T_3$ | 5.47 | 18.05 | 5.13 | 17.20 |
| $T_4$ | 5.07 | 12.63 | 5.53[b] | 13.80 |
| $T_5$ | 5.03 | 17.51 | 5.03 | 14.57 |
| $T_6$ | 4.7 | 13.96 | 4.8 | 12.65 |
| $T_7$ | 4.53 | 8.62 | 4.6 | 9.53 |
| **LSD(0.05)** | **0.258** | **3.502** | **0.289** | **3.204** |

*Note: $T_1$-Lime in two splits as basal and at 30 DAS; $T_2$- Lime in two splits as basal and one week before third dose of fertilizer application; $T_3$- Dolomite in two splits as basal and at 30 DAS; $T_4$- Dolomite in two splits as basal and one week before third dose of fertilizer application (45 days); $T_5$- Rice husk ash in two splits as basal and at 30 DAS; $T_6$- Rice husk ash in two splits as basal and one week before third dose of fertilizer application and $T_7$- Control*

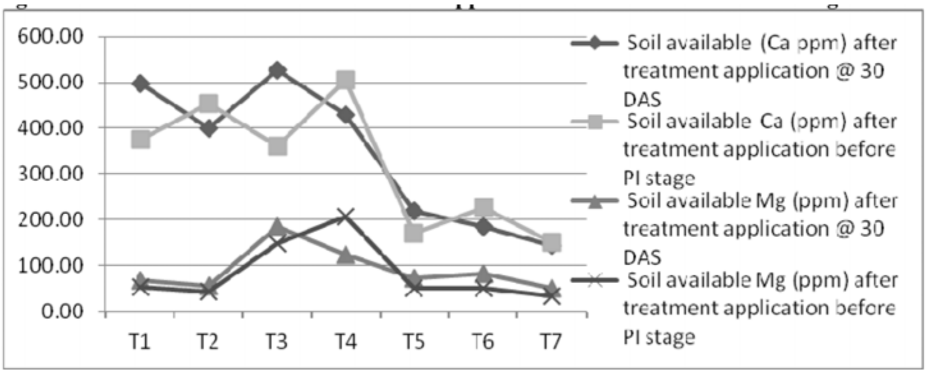


**Fig. 1 : Effect of ameliorants and their time of application on soil available Ca and Mg**

only one ie, basal application only. Soil test at before PI stage showed better pH for lime applied as basal and before PI stage, dolomite as basal and before PI stage and RHA as basal and before PI stage compared to lime applied as basal and 30 DAS, dolomite as basal and 30 DAS and RHA as basal and 30 DAS as the former received second split at this stage while the second split was completed for later at 30 DAS and the effect of liming materials reduced with time. However the increase in soil pH attributed by former treatments at this stage was comparatively lower than the other treatments at 30 DAS. The soil was low in available P initially due to higher available Fe content causing fixation of P. However the application of ameliorants reduced soil acidity and was effective in improving P availability (Table 2.). Soil available P status also followed similar trend as that of soil pH indicating the positive effect of increased pH or reduced acidity on P availability caused by the application of liming materials at both stages of split application.

Soil available Ca was found to be increased by lime as well as dolomite applications (Fig 1). Calcium is referred to as 'liming element' because it amends soil pH and plays a greater role in neutralizing the acid forming effects of H+. Dolomite application also increased the available Mg (Fig 1). Magnesium is an important element for chlorophyll synthesis in plants and its supply helps in improving crop yield. According to Bose *et al*., (2011) Mg can ameliorate Al phytotoxicity that is commonly occurring in acid soils having pH less than 5. The time of application of liming material was found to be better when applied as basal and 30 DAS with respect to yield and other parameters. comparatively lesser effect of liming material applied at one week before third dose of fertilizer application (PI stage) may be because the fully grown crop canopy at this stage acts as a barrier leading to reduced reach of sufficient liming material to the soil.

From the experiment, it can be concluded that application of dolomite, lime or RHA can be effective for reducing acidity in very strongly acidic soils of Vaikom Kari in Kuttanad region to enhance rice yield. The liming materials significantly improved grain yield and yield attributes like panicle number and reduced sterility percentage over control. The soil pH was increased or acidity reduced along with improvement in soil available P. The dolomite and lime application improved soil available Ca at both stages of split application. The soil available Mg was increased by the application of dolomite at both stages. Also the application of these liming materials gave the best result when applied in two splits as basal and 30 days after sowing.

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