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Short communication

Soil amelioration for rice productivity enhancement in lateritic soil

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Abstract

The correction of soil pH, reduction of toxic accumulation of native elements and supplementation of secondary nutrients may enhance the growth and productivity of rice grown in lateritic lowlands. A field study was conducted during January to May, 2013 at the rice field of College of Horticulture, Vellanikkara to evaluate the effect of soil ameliorants on growth and yield of rice. The soil was having an initial pH of 5.3. The treatments included different soil amendments *viz*., CaO, dolomite, and 'Mangala setright', a new commercial product. The ameliorants were applied with or without fertilizer. The package of practices (POP) for rice nutrition and non- application of soil ameliorant/ organic manure/ fertilizers were the controls. Soil amelioration significantly increased the growth parameters such as height and tiller count in the presence or absence of fertilizers. The leaf chlorophyll content was improved due to the combined effect of soil amelioration, organic manure addition and fertilizer application. Amelioration improved all the yield attributes and consequently the yield. Among different ameliorants 'Mangala setright' performed better than CaO and the lowest effect was observed for dolomite. The superiority of 'Mangala setright' even in the absence of organic manure addition is attributed to its Mg and S contents.

Key words: Soil amelioration, Laterite soil, Liming materials, Secondary nutrients, Fertilizers

Soil acidity is a major constraint in the wetland rice soils of the tropics. More than 68 per cent of the Kerala soils are lateritic, which is predominantly acidic. Liming is a dominant and effective practice to overcome constraints and improve crop production in acid soils. Benefits of liming include increased nutrient availability, improved soil structure, and increased rates of infiltration. A liming material is any compound capable of increasing soil pH by combining with hydrogen ions in the soil solution. Although most agricultural liming materials contain calcium, it is the negatively charged component of the compound, i.e. the carbonate (CO_3^{2-}) which actually neutralizes the acidity. Currently, a variety of liming materials are available to farmers. The materials differ in place of origin, amount of neutralizing power, and nutrients or other elements associated with the liming agent. Liming of acidic red and lateritic soil not only ameliorate soil acidity related problems but also supply and increase uptake of calcium (Samui and Mandal, 2003).

Numerous studies have shown that acid soils, besides having a lower pH, are low in bases like calcium, magnesium and potassium, deficient in phosphorus and high in iron, manganese and aluminium. Liming the soil decreased available Fe and Mn and increased pH to a great extent, and reduced iron toxicity (Patra and Mohanty, 1994). The correction of soil pH, reduction of toxic accumulation of native elements and supplementation of secondary nutrients may enhance the growth and productivity of rice grown in lateritic lowlands. The present investigation aims at studying the relative efficiency of natural soil ameliorants such as lime, dolomite and a commercial ameliorant 'Mangala setright' on growth and yield of rice grown in laterite soil.

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The experiment was conducted in the rice field of Department of Agronomy, College of Horticulture, Vellanikkara during January to May, 2013 to analyze the response of rice grown in laterite soil to various ameliorants. The experiment consisted of 9 treatments and 3 replications and was laid out in a randomized block design. The rice variety Jyothi was used for the experiment. The plot size was 5.0 m X 4.0 m and the spacing adopted was 15 cm X 10 cm. The treatments included varying quantities of soil ameliorants *viz*. CaO, dolomite, and 'Mangala setright'. Dose of ameliorants was fixed as the equivalent to 600 kg ha^{-1} of $CaCO_3$, which is the recommendation for liming acid soils in Kerala (KAU, 2011). The $CaCO_3$ equivalence of CaO, dolomite, and 'Mangala setright' was 159%, 88.5%, 77.5% respectively. 'Mangala setright' is a commercial ameliorant produced by MCF Ltd, Mangalore which contains 20% Ca, 6.8% Mg and 6.4% S. Ameliorants were applied in two doses, 2/3 as basal application and 1/3 before the first top dressing of fertilizers. Supply of nutrients was based on the existing package of practices recommendations for rice i.e. 90:45:45 kg N, P_2O_5 and K_2O ha^{-1} (KAU, 2011). Urea, rajphos and muriate of potash were used as the sources of nutrients. Nitrogen and potassium were applied in three equal split doses, first as basal dressing, second at tillering stage and third at panicle initiation stage. The full dose of phosphorus was applied as basal dressing. T_8 was the entire package of practices recommendation for rice nutrition. T_9 was the absolute control where no ameliorants, organic manure or fertilizer was applied. Statistical analysis was done by using statistical package MSTATC.

Soil amelioration resulted in significantly higher plant height both at 30 DAT and harvest (Table 1). The treatment POP for rice nutrition (T_8) produced the tallest plants at harvest, possibly due to the multifunctional advantage of organic manure included in the treatment. Rajput and Singh (1995) reported that the greatest plant height was recorded under the application of FYM @ 10 Mg ha^{-1} as basal + full N as foliar in 3 splits. Among the different ameliorants applied without the fertilizer component, CaO and 'Mangala setright' performed better than dolomite. However, when the ameliorants were applied together with fertilizers the plant height was at par even though 'Mangala setright' produced the tallest plants.

The tiller count at 30 DAT and 60 DAT was significantly higher when 'Mangala setright' was applied @ 774 kg ha^{-1} However it was at par with the lower doses of other ameliorants. The enhanced growth reflected by the increased height and tiller number is a direct effect of absorption of nitrogen and sulphur supplied either through soil ameliorants or directly through the fertilizers. Uddin et al. (2002)

Table 1. Effect of soil ameliorants on growth characters of rice

Treatments		Plant height (cm)		Tiller count		LAI	Chlorophyll
		30DAT	Harvest	30DAT	60DAT	60DAT	(mg /kg)
T_1	CaO 377 kg ha^{-1} + NPK	43.4^{abc*}	86.7^{bcd}	10.6^{abcd}	14.0^{abcd}	5.2^{a}	2.9^{ab}
T_2	Dolomite 676 kg ha^{-1} + NPK	42.5^{abc}	85.7^{bcd}	9.6^{bcd}	13.3^{abcde}	5.0^{ab}	2.4^{bc}
T_3	'Mangala setright' 774 kg ha^{-1} + NPK	44.2^{a}	88.9^{bcd}	11.5^{ab}	15.9^{a}	5.7^{a}	2.3^{bc}
T_4	CaO 377 kg ha^{-1}	40.6^{bc}	84.8^{bcd}	8.9^{d}	9.3^{de}	3.7^{cd}	2.4^{bc}
T_5	Dolomite 676 kg ha^{-1}	40.4^{c}	82.3^{cd}	9.5^{cd}	10.7^{bcde}	3.9^{bc}	1.8^{c}
T_6	'Mangala setright' 774 kg ha^{-1}	41.2^{abc}	85.3^{bcd}	8.8^{d}	10.6^{cde}	4.9^{ab}	2.3^{bc}
T_7	NPK only	44.3^{a}	85.9^{bcd}	10.7^{abcd}	13.8^{abcd}	5.5^{a}	1.9^{c}
T_8	5t FYM + CaO 377 kg ha^{-1} + NPK**	44.4^{a}	100.4^{a}	11.1^{abc}	15.6^{ab}	5.9^{a}	3.3^{a}
T_9	Control	40.3^{c}	81.3^{d}	9.3^{cd}	8.6^{e}	2.7^{d}	1.8^{c}

* The values followed by same superscript do not differ significantly
**POP recommendation for rice in Kerala

found that the application of S along with NPK fertilizers recorded the highest number of effective tillers per plant.

Leaf area index was significantly lower for CaO and dolomite than 'Mangala setright' when ameliorants were applied without fertilizers. However, in the presence of fertilizer all the ameliorants resulted in almost similar LAI. The total chlorophyll content at 60 DAT was notably higher, evidently due to the combined effect of soil amelioration, organic manure and fertilizer application. In the absence of soil ameliorants, the fertilizer applied and non- applied treatments resulted in statistically similar chlorophyll content bringing out the importance of soil amelioration. Among the different ameliorants, dolomite without fertilizer (T_5) resulted in lower chlorophyll content. Rice grain yield is the product of productive tiller or panicles/hill, spikelets/panicle, fertility or filled grain percentage and the test weight of grain. The number of panicles per hill was significantly increased when the soil was ameliorated (Table 2). Similarly it was improved when the fertilizer was applied both in the absence and the presence of ameliorants. The highest number of panicles/ hill was observed with the POP recommendation. 'Mangala setright' at 774 kg ha^{-1}, both in the absence or presence of fertilizers, produced higher number of panicles which was statistically similar to T_8, which received the organic manure component too. Mondal et al. (1994) observed an increase in number of panicles, number of spikelets and thousand grain weight in rice with increased NPK rates along with FYM application. Anilakumar et al. (1993) obtained 7.6 percent increase in grain yield of rice by the combined application of FYM and NPK than the application of NPK alone. Singh et al. (1996) reported that the substitution of 25 percent of N through FYM, particularly at higher N rates, increased the rice yield.

Ameliorants, except dolomite, irrespective of the doses, improved the filled grain percentage over control. The yield attributes are primarily influenced by the nutrient availability, uptake and its metabolism within the plant mainly during and after the panicle initiation stage. The rhizosphere pH largely determines the uptake of nutrients. The ameliorant dolomite though it increased the pH at the initial stage, could not maintain it affecting the balanced nutrient uptake and hence adversely influenced panicle characteristics.

The test weight in terms of 1000 grain weight was also significantly increased over control when either the ameliorant or fertilizer or both were applied. Nitrogen absorbed at PI stage increases spikelet

Table 2. Effect of soil ameliorants on yield attributes and yield

	Treatments	Yield Attributes				Yield(Mg ha $^{-1}$)	
		Panicles/ hill	Spikelets/ panicle	Filled grains/ panicle (%)	1000 grain wt.(g)	Grain	Straw
T_1	CaO 377 kg ha^{-1} + NPK	8.33^{abc*}	90.50^{ab}	94.85^{abc}	28.94^{a}	6.23^{abc}	6.03^{ab}
T_2	Dolomite 676 kg ha^{-1} + NPK	8.93^{a}	88.53^{ab}	94.78^{abc}	28.80^{a}	5.33^{c}	5.61^{bc}
T_3	'Mangala setright' 774 kg ha^{-1} + NPK	8.93^{a}	94.50^{a}	94.97^{abc}	28.84^{a}	6.72^{a}	6.99^{a}
T_4	CaO 377 kg ha^{-1}	6.93^{cd}	82.03^{bc}	93.53^{bcd}	28.40^{ab}	4.21^{d}	5.87^{ab}
T_5	Dolomite 676 kg ha^{-1}	7.10^{bcd}	75.57^{cd}	92.27^{d}	28.56^{a}	4.12^{d}	5.35^{bc}
T_6	'Mangala setright' 774 kg ha^{-1}	8.53^{ab}	92.20^{a}	94.68^{abc}	28.86^{a}	4.30^{d}	5.40^{bc}
T_7	NPK only	8.00^{abcd}	90.10^{ab}	95.16^{ab}	28.60^{a}	5.59^{bc}	6.48^{ab}
T_8	5t FYM + CaO 377 kg ha^{-1} + NPK**	9.23^{a}	95.73^{a}	95.90^{a}	28.70^{a}	6.75^{a}	6.42^{ab}
T_9	Control	6.67^{d}	72.20^{d}	92.86^{cd}	27.91^{b}	3.90^{d}	4.36^{c}

* The values followed by same superscript do not differ significantly

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number and that absorbed at maturity helps better filling of grains (De Datta, 1981). Early nitrogen absorption is known to favour tiller and panicle production (Tisdale et al., 1993). Similar improvement in the percentage of filled grains and 1000 grain weight was also observed with organics and higher rate of sulphur and nitrogen. Oh (1991) observed enhanced growth and improved yield attributes due to sulphur nutrition.

'Mangala setright' at 774 kg ha^{-1} (T_3) and the treatment which received POP recommendation (T_8) produced the highest and similar yields of 6.7 Mg ha^{-1}. The grain yield in the treatments which received the POP recommendation without organic manure produced yield of 5.59 Mg ha^{-1}. In the presence of ameliorants but in the absence of fertilizers (T_4) higher grain yields over control were observed though they were not statistically significant. The straw yield had showed almost similar response to the treatments as that of grain.

The results showed the positive effects of soil amelioration particularly in the presence of fertilizers. 'Mangala setright' and CaO performed better than dolomite under the same equivalence to $CaCO_3$. The higher yield by the application of higher dose of 'Mangala setright' even in the absence of organic manure can be attributed to the supplementation of secondary nutrients contained in it *viz*. Mg and S together with the ameliorating effect and supply of Ca. Morales et al. (2002) observed that liming acid soils improved soil pH, reduced P fixation and toxic accumulation of Fe, Mn and Al and created a favorable soil environment. The enhanced growth and yield characters of rice as observed in the ameliorated treatments are due to the favorable nutritional rhizosphere environment in the soil and consequent nutrient availability and uptake. While CaO did the ameliorative function 'Mangala setright' did both soil amelioration and secondary nutrient supplementation.

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