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Effect of basic slag and dolomite on changes in soil properties and yield of rice in lateritic soil

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Abstract
Soil acidity is a major constraint for rice cultivation in lateritic soils of the Konkan region, Maharashtra. A field experiment was conducted during Kharif 2024–25 at the Research Farm of AICRP on Agroforestry, Dapoli, to evaluate the effect of basic slag and dolomite as soil amendments along with recommended dose of fertilizers (RDF) on soil chemical properties, nutrient uptake, and rice yield. The experiment was laid out in a Randomized Block Design with eight treatments and three replications. Results revealed that application of RDF + basic slag @ 8 t ha^{-1} (100% LR) significantly increased grain (66.42 q ha^{-1}) and straw (92.17 q ha^{-1}) yields, followed by RDF + dolomite @ 5.75 t ha^{-1}. Nutrient uptake (N, P, K) and soil pH were also enhanced, while organic carbon improved marginally. The study indicated that integration of basic slag or dolomite with RDF is effective in improving soil fertility and sustaining rice productivity in acidic lateritic soils.

Keywords: Rice cultivation, soil acidity, lateritic soil

Introduction
Rice is the principal food crop of the Konkan region of Maharashtra, where it is mainly cultivated under lateritic soils. These soils are strongly acidic, low in available phosphorus and organic carbon, and deficient in essential bases, which restrict nutrient availability and crop productivity. Acid soil conditions often lead to phosphorus fixation and aluminum toxicity, creating unfavorable conditions for root growth and nutrient uptake.

Application of soil amendments has been recognized as an effective strategy to neutralize soil acidity and improve soil fertility. Basic slag, a by-product of the steel industry, and dolomite are potential liming materials that not only ameliorate soil acidity but also supply secondary and micronutrients, thereby enhancing nutrient use efficiency and crop performance. Earlier reports have shown that incorporation of liming materials improves soil reaction, nutrient availability, and yield of crops in acid soils (Khan *et al*., 2007; Mamatha *et al*., 2018) [7, 10].

Keeping these points in view, the present investigation was undertaken to study the effect of basic slag and dolomite on soil chemical properties, nutrient uptake, and yield of rice under lateritic acid soils of Konkan.

Materials and Methods
Site description
The field experiment was conducted during the Kharif season of 2024–25 at the Research Farm of AICRP on Agroforestry, Central Experimental Station, Tetavali Block, Wakawali, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, Maharashtra. The experimental site lies in the Konkan coastal belt of Maharashtra and is characterized by a humid climate with annual rainfall exceeding 4000 mm. The soil was lateritic in nature, classified as Typic Haplustalf, reddish in colour, and acidic in reaction.

Before the start of the experiment, composite soil samples from the surface layer (0–20 cm) were collected and analyzed for their initial properties. The soil had a pH of 5.04, electrical conductivity of 0.091 dSm^{-1}, and organic carbon content of 13.61 g kg^{-1}. The available nitrogen, phosphorus (P_2O_5), and potassium (K_2O) were 313.28, 11.27, and 323.68 kg ha^{-1}, respectively.

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Experimental details

The field experiment was conducted with eight treatments laid out in a Randomized Block Design with three replications. The treatments comprised absolute control (T1), recommended dose of fertilizers (T2), and RDF in combination with basic slag and dolomite at different lime requirement (LR) levels. Basic slag was applied at 50, 75 and 100% LR corresponding to 4, 6 and 8 t ha^{-1} (T3, T4 and T5), while dolomite was applied at 50, 75 and 100% LR corresponding to 2.87, 4.31 and 5.75 t ha^{-1} (T6, T7 and T8), respectively. The recommended dose of fertilizers was 100:50:50 kg N:P_2O_5:K_2O ha^{-1} along with vermicompost @ 5 t ha^{-1} applied uniformly to all relevant treatments.Rice variety *Konkan Suhas* was transplanted at a spacing of 20 × 10 cm using 21-day-old healthy seedlings. All recommended agronomic practices, including puddling, transplanting, water management (8–10 cm continuous standing water), and plant protection measures, were followed. Harvesting was done at physiological maturity, and grain and straw yield were recorded and expressed in quintals per hectare.

Soil and Plant analysis

Soil samples were collected at tillering, flowering, and harvest stages to determine the chemical properties. Soil pH was determined using a digital pH meter with a 1:2.5 soil–water suspension, while electrical conductivity was measured in a 1:2.5 soil–water extract using a digital conductivity meter (Jackson, 1973) [5]. Organic carbon was estimated by Walkley and Black's wet oxidation method (Piper, 1966) [13]. Available nitrogen was determined by the alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [15], available phosphorus by Bray's No. 1 method (Bray and Kurtz, 1945) [2], and available potassium by ammonium acetate extraction followed by flame photometry (Jackson, 1973) [5].

For plant analysis, grain and straw samples were oven-dried and ground for nutrient estimation. Nitrogen was estimated by the Kjeldahl method, phosphorus by the vanadomolybdate yellow colour method, and potassium by flame photometry. Nutrient uptake was calculated by multiplying the nutrient concentration with the respective biomass yield. Grain and straw yields from each plot were sun-dried, weighed, and expressed on a hectare basis.

The experimental data on yield, nutrient content, and soil properties were statistically analyzed using the analysis of variance (ANOVA) technique as described by Panse and Sukhatme (1985). Critical difference (CD) at the 5% probability level was worked out to compare the treatment means.

Results and Discussion

Effect on grain and straw yield: Application of basic slag and dolomite significantly improved rice grain and straw yields in lateritic soils. The maximum grain and straw yields were obtained in T5 (RDF + Basic slag @ 8 t ha^{-1}, 100% LR) followed by T8 (RDF + Dolomite @ 5.75 t ha^{-1}, 100% LR). The yield improvement can be ascribed to the amelioration of soil acidity, increased nutrient availability, and favorable root environment created by liming materials. Similar positive effects of basic slag on crop yield in acid soils were reported by Mamatha *et al*. (2018) [10] and Masud *et al*. (2014) [11].

Effect on Chemical properties of soil

The soil pH increased markedly with basic slag and dolomite applications compared to control. The highest pH (6.42) was recorded in T5, followed closely by T8 (6.40). Both amendments neutralized exchangeable acidity by releasing Ca^{2+} and Mg^{2+} ions which replaced Al^{3+} and H^{+}, thereby improving soil reaction. These results confirm the strong liming potential of basic slag and dolomite, consistent with findings of Khan *et al*. (2007) [7] and Shamim *et al*. (2009) [14].

Electrical conductivity values ranged between 0.083 and 0.328 dS m^{-1}. Maximum EC was noted in T5 (0.328 dS m^{-1}), while the lowest occurred in control (0.083 dS m^{-1}). The increase in EC reflects the release of basic cations from slag and dolomite into the soil solution, which improves ionic balance and enhances nutrient availability (Ara *et al*., 2013) [1].

Although the effect was statistically non-significant, higher organic carbon content was observed in amended plots. The maximum OC (15.62 g kg^{-1}) was recorded in T5, compared with the lowest (13.39 g kg^{-1}) in control. This improvement may be due to enhanced aggregation and stabilization of organic matter through Ca^{2+} and Mg^{2+} bridging (Higgins *et al*., 2012) [4]. Similar results were noted by Castro and Crusciol (2013) [3].

Effect on Primary nutrient uptake

Application of basic slag and dolomite significantly enhanced nutrient uptake by rice. The highest uptake of nitrogen (335.82 kg ha^{-1}), phosphorus (19.53 kg ha^{-1}) and potassium (354.76 kg ha^{-1}) was recorded in T5 (RDF + Basic slag @ 8 t ha^{-1}, 100% LR), followed closely by T8 (RDF + Dolomite @ 5.75 t ha^{-1}, 100% LR). The lowest uptake values were noted in control. The improvement in nutrient uptake may be attributed to amelioration of soil acidity, increased pH, and reduction of exchangeable Al^{3+} toxicity, which together created a favorable rhizosphere environment for better root proliferation and nutrient absorption. Moreover, higher P uptake can be linked to reduced P fixation and release of available phosphate ions from basic slag, while N and K uptake increased with improved soil fertility and ionic balance. These findings are in line with earlier reports by Tang *et al*. (2003), Chang and Sung (2004), and Mamatha *et al*. (2018) [10], who observed enhanced NPK uptake under limed acid soils.

Effect on Primary Nutrient status of soil

The available N, P and K contents of soil improved with application of basic slag and dolomite along with RDF. Maximum available N (335.82 kg ha^{-1}) and P_2O_5 (19.53 kg ha^{-1}) were observed in T5, while available K_2O (354.76 kg ha^{-1}) also recorded higher values but was statistically non-significant. The increase in P availability may be due to reduced fixation at higher pH and release of phosphate ions from slag. Similar improvements in NPK status of acid soils with slag amendments were reported by Kadrekar (1994) [6], Masud *et al*. (2014) [11] and Mamatha *et al*. (2019) [9].

Table 1: Initial properties of experimental soil

Sr. No.	Soil characteristics	Value
1.	pH(1:2.5)	5.04
2.	EC (dSm^{-1})	0.091
3.	Soil organic carbon (g kg^{-1})	13.61
4.	Available N($kgha^{-1}$)	313.28
5.	Available P_2O_5($kgha^{-1}$)	11.27
6.	Available K_2O ($kgha^{-1}$)	323.68

Table 2: Effect of basic slag and dolomite on grain and straw yield of rice.

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1- Absolute control (No fertilizers)	19.61	29.95
T_2- RDF	40.26	51.48
T_3- RDF + Basic slag @ 4 t ha^{-1} (50% LR)	45.06	58.17
T_4- RDF + Basic slag @ 6 t ha^{-1} (75% LR)	48.49	60.61
T_5- RDF + Basic slag @ 8 t ha^{-1} (100% LR)	52.15	62.92
T_6- RDF + Dolomite @ 2.87 t ha^{-1} (50% LR)	44.83	56.92
T_7- RDF + Dolomite @ 4.31 t ha^{-1} (75% LR)	47.71	59.56
T_8- RDF + Dolomite @ 5.75 t ha^{-1} (100% LR)	50.31	62.16
Mean	43.55	55.22
SE (m) ±	3.00	2.79
CD at 5%	9.10	8.47
% CV	11.92	8.76

(LR- lime requirement)

Table 3: Effect of basic slag and dolomite on nitrogen content and uptake of rice

Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total Uptake
T_1- Absolute control (No fertilizers)	1.14	0.13	22.17	3.78	25.94
T_2- RDF	1.31	0.24	52.52	12.33	64.85
T_3- RDF + Basic slag @ 4 t ha^{-1} (50% LR)	1.53	0.43	68.72	24.88	93.60
T_4- RDF + Basic slag @ 6 t ha^{-1} (75% LR)	1.66	0.86	80.40	51.78	132.18
T_5- RDF + Basic slag @ 8 t ha^{-1} (100% LR)	1.85	1.01	96.19	63.16	159.35
T_6- RDF + Dolomite @ 2.87 t ha^{-1} (50% LR)	1.34	0.50	60.50	28.57	89.07
T_7- RDF + Dolomite @ 4.31 t ha^{-1} (75% LR)	1.47	0.45	70.48	26.47	96.96
T_8- RDF + Dolomite @ 5.75 t ha^{-1} (100% LR)	1.66	0.90	83.83	55.56	139.39
Mean	1.50	0.56	66.85	33.32	100.17
SE (m) ±	0.05	0.04	4.83	1.90	5.33
CD at 5%	0.15	0.12	14.64	5.77	16.17

(LR- lime requirement)

Table 4: Effect of basic slag and dolomite on phosphorus content and uptake of rice

Treatments	Phosphorus content (%)		Phosphorus uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total Uptake
T_1- Absolute control (No fertilizers)	0.13	0.021	2.59	0.63	3.22
T_2- RDF	0.18	0.037	7.25	1.91	9.15
T_3- RDF + Basic slag @ 4 t ha^{-1} (50% LR)	0.20	0.057	9.01	3.34	12.35
T_4- RDF + Basic slag @ 6 t ha^{-1} (75% LR)	0.21	0.066	10.35	3.99	14.33
T_5- RDF + Basic slag @ 8 t ha^{-1} (100% LR)	0.23	0.078	11.99	4.91	16.90
T_6- RDF + Dolomite @ 2.87 t ha^{-1} (50% LR)	0.19	0.056	8.52	3.16	11.68
T_7- RDF + Dolomite @ 4.31 t ha^{-1} (75% LR)	0.21	0.064	10.02	3.78	13.80
T_8- RDF + Dolomite @ 5.75 t ha^{-1} (100% LR)	0.22	0.074	11.25	4.60	15.85
Mean	0.20	0.057	8.87	3.29	12.16
SE (m) ±	0.0035	0.0016	0.61	0.19	0.59
CD at 5%	0.0106	0.0049	1.86	0.56	1.80

(LR- lime requirement)

Table 5: Effect of basic slag and dolomite on potassium content and uptake of rice

Treatments	Potassium content (%)		Potassium uptake (kg ha^{-1})		
	Grain	Straw	Grain	Straw	Total Uptake
T_1- Absolute control (No fertilizers)	0.54	0.21	10.49	6.29	16.78
T_2- RDF	0.63	0.25	25.36	12.87	38.23
T_3- RDF + Basic slag @ 4 t ha^{-1} (50% LR)	0.67	0.28	30.19	16.29	46.48
T_4- RDF + Basic slag @ 6 t ha^{-1} (75% LR)	0.71	0.32	34.43	19.40	53.83
T_5- RDF + Basic slag @ 8 t ha^{-1} (100% LR)	0.78	0.36	40.68	22.85	63.52
T_6- RDF + Dolomite @ 2.87 t ha^{-1} (50% LR)	0.66	0.27	29.59	15.20	44.79
T_7- RDF + Dolomite @ 4.31 t ha^{-1} (75% LR)	0.69	0.31	33.08	18.63	51.71
T_8- RDF + Dolomite @ 5.75 t ha^{-1} (100% LR)	0.76	0.35	38.24	21.75	59.99
Mean	0.68	0.29	30.26	16.66	46.92
SE (m) ±	0.0042	0.003	2.03	0.84	1.98
CD at 5%	0.0127	0.0091	6.16	2.55	6.02

(LR- lime requirement)

Table 6: Effect of basic slag and dolomite on soil chemical properties (at harvest)

Treatments	pH (1: 2.5)	EC (dSm^{-1})	OC ($g\ kg^{-1}$)
T_1- Absolute control (No fertilizers)	5.01	0.083	13.39
T_2- RDF	5.19	0.102	14.24
T_3- RDF + Basic slag @ 4 t ha^{-1} (50% LR)	5.68	0.163	14.59
T_4- RDF + Basic slag @ 6 t ha^{-1} (75% LR)	6.08	0.234	14.84
T_5- RDF + Basic slag @ 8 t ha^{-1} (100% LR)	6.42	0.328	15.62
T_6- RDF + Dolomite @ 2.87 t ha^{-1} (50% LR)	5.40	0.159	14.54
T_7- RDF + Dolomite @ 4.31 t ha^{-1} (75% LR)	5.92	0.224	14.69
T_8- RDF + Dolomite @ 5.75 t ha^{-1} (100% LR)	6.40	0.315	15.31
Mean	5.76	0.201	14.65
SE (m) ±	0.04	0.004	0.82
CD at 5%	0.11	0.011	NS
% CV	1.12	3.140	-
Initial	5.04	0.091	13.61

(LR- lime requirement)

Table 7: Effect of basic slag and dolomite on primary nutrient content of soil (at harvest)

Treatments	Avai. N ($kg\ ha^{-1}$)	Avai. P_2O_5 ($kg\ ha^{-1}$)	Avai. K_2O ($kg\ ha^{-1}$)
T_1- Absolute control (No fertilizers)	311.37	10.59	322.43
T_2- RDF	320.62	13.23	330.37
T_3- RDF + Basic slag @ 4 t ha^{-1} (50% LR)	325.55	16.42	336.18
T_4- RDF + Basic slag @ 6 t ha^{-1} (75% LR)	327.57	17.61	342.28
T_5- RDF + Basic slag @ 8 t ha^{-1} (100% LR)	335.82	19.53	354.76
T_6- RDF + Dolomite @ 2.87 t ha^{-1} (50% LR)	323.25	16.29	334.71
T_7- RDF + Dolomite @ 4.31 t ha^{-1} (75% LR)	325.73	17.27	338.65
T_8- RDF + Dolomite @ 5.75 t ha^{-1} (100% LR)	334.72	19.41	352.53
Mean	325.58	16.29	338.99
SE (m) ±	2.68	0.12	6.78
CD at 5%	8.12	0.35	NS
% CV	1.42	1.22	3.46
Initial	313.28	11.27	323.68

(LR- lime requirement)

Conclusion

The application of basic slag or dolomite in combination with recommended fertilizers significantly improved rice yield and soil health in lateritic acid soils. The amendments enhanced nutrient uptake of nitrogen, phosphorus and potassium, while also improving soil pH by neutralizing acidity. Electrical conductivity increased due to greater availability of basic cations, and organic carbon showed a positive improvement with better soil aggregation. Overall, the integration of these amendments with fertilizers effectively enhanced crop productivity and sustained soil fertility through balanced nutrient availability and improved soil properties.

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