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Research Article

Effect of basic slag and lime on chemical properties of acid soil

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Abstract

A field experiment was conducted at Alasulige village located in Sakleshpur taluk, Karnataka to study the influence of application of basic slag and lime along with different doses of chemical fertilizer on soil chemical properties using paddy as a test crop in an acidic soil. The experiment was laid out in RCBD pattern with ten treatments and three replicates. In general, the results revealed that the application of basic slag and lime at the rate of 2 t ha^{-1} increased the soil pH, available P_2O_5 content, decreased the DTPA extractable Fe and Mn content, exchangeable aluminium content and exchangeable acidity of soil. The study clearly indicated that in acidic soils, basic slag can be used as an alternative to lime for the amelioration of acidic soil and it can also be utilized as a nutrient source in acidic soil.

Keywords basic slag, nutrient uptake, paddy, soil properties

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Introduction

Soil acidity is an important constraint in agriculture production. It affects crops; mainly by its influence on chemical factors include deficiency of nutrients (Ca, P and Mg) and toxicity of Al, Fe and Mn. Optimum nutrient uptake by most crops occurs at a soil pH near 7.0. The availability of nutrients such as nitrogen, phosphorus and potassium is generally reduced with the decrease in the soil pH. Phosphorus is particularly sensitive to pH and can become a limiting nutrient in strongly acidic soils. The practice of correcting soil acidity reduces the available Al, Fe, Mn, Zn, and Cu content, but increases the availability of other essential nutrients. The soil acidity and the associated nutrient availability problems of crops can be reclaimed by the use of lime as an integral part of liming activity in the crop production process, using limestone, stromatolitic limestone and dolomite. Some industrial byproducts such as slags from iron and steel industries, lime sludge from paper mills, cement kiln wastes etc. are also being used as liming agent.

Basic slag containing CaO, MgO, SiO_2 and micronutrients, such as copper, zinc, manganese and iron is a byproduct obtained from steel industry. Calcium and magnesium compounds, because of their basicity, improve soil pH and also serve as plant nutrients. Application of basic slag of steel industry is cost effective in reducing soil acidity [5]. In addition, silicon of basic slag has the potential to decrease Mn toxicity, suppress lodging, and improve insect and disease resistance power as well as increase the water use capability in line with the efficiency of phosphorous utilization in low pH oxisols. The present investigation was carried out to study the amelioration capacity of basic slag and agricultural lime in acidic soil and its influence on the performance of paddy crop.

Methodology

Site and experimental details

A field experiment was conducted during *Kharif*, 2014 at Alasulige village using paddy as test crop in hilly zone of Karnataka (Sakleshpurataluk) to study the effect of basic slag and lime on soil properties and growth performance of paddy (*Oryza sativa* L.) crop. The basic slag was obtained from Horsco Company, Hyderabad. It was alkaline in nature (pH 9.2) and contained about 24.8 per cent Ca, 10.08 per cent Mg, 0.62 per cent phosphorus and 8.2 percent silicon. The chemical properties of the soil of the experimental site are presented in Table 1.

Table 1. Chemical properties of the experimental site soil

Soil properties	
pH (1:2.5)	4.92
EC (dSm^{-1})(1:2.5)	0.09
CEC [$cmol(p^+)kg^{-1}$]	12.0
Available P_2O_5 (kg ha^{-1})	28.5
DTPA extractable Fe (mg kg^{-1})	125
DTPA extractable Mn (mg kg^{-1})	9.40
DTPA extractable Zn (mg kg^{-1})	3.10
DTPA extractable Cu (mg kg^{-1})	0.84
Exchangeable acidity [$cmol(p^+)kg^{-1}$]	1.0
Exchangeable Al [$cmol(p^+)kg^{-1}$]	0.50
Total potential acidity [$cmol(p^+)kg^{-1}$]	6.0
pH dependent acidity [$cmol(p^+)kg^{-1}$]	5.0
Total acidity [$cmol(p^+)kg^{-1}$]	2.1

The experiment was laid out in a randomized complete block design with ten treatments and three replicates. The treatment combination included,T1: Farmer's practice (Only DAP), T_2: T_1 + basic slag at the rate of 2 t ha^{-1}, T_3: T_1 + lime at the rate of 2 t ha^{-1}, T_4: Recommended doses of NPK (RDF), T_5 : 50 % RDF + basic slag at the rate of 2 t ha^{-1}, T_6: 50 % RDF + lime at the rate of 2 t ha^{-1}, T_7: 75 % RDF + basic slag at the rate of 2 t ha^{-1}, T_8: 75 % RDF + lime at the rate of 2 t ha^{-1}, T_9: 100 % RDF + basic slag at the rate of 2 t ha^{-1}, T_{10}: 100 % RDF + lime at the rate of 2 t ha^{-1}. Basic slag and lime were applied to the soil fifteen days prior to transplanting paddy seedlings and mixed thoroughly.

Soil analysis

The post-harvest soil samples were analyzed for pH [7], phosphorus [3], DTPA extractable Fe, Mn, Cu and Zn [8], exchangeable acidity [12], total potential acidity and total acidity [4] by using standard procedures. Fisher's method of analysis of variances was adopted for statistical analysis and interpretation of the data.

Results and Discussion

Soil properties

Soil pH

There was a slight increase in soil pH due to liming (Table 2). The increase in the pH of soil with the addition of basic slag and lime can be ascribed to the release of the alkaline elements such as calcium ions, which neutralize soil acidity by displacing the aluminum, hydrogen and iron ions, which are prevalent in acidic soils. These results were in agreement with Bhat et al., [2] who found that the application of calcium silicate causes an increase in soil pH by decreasing the different forms of soil acidity.

Table 2. Effect of basic slag and lime on chemical properties of soil

Treatments	pH	Avail. P_2O_5 (kg ha^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Cu (mg kg^{-1})	Zn (mg kg^{-1})
T1 : Farmer's practice (Only DAP)	4.85	27.4	127.3	11.2	3.32	0.87
T2 : T1 + basic slag at 2 t ha^{-1}	5.03	29.9	115.6	10.9	3.52	0.94
T3 : T1 + lime at 2 t ha^{-1}	5.11	26.7	110.1	8.9	3.28	0.90
T4 : Recommended dose of NPK (RDF)	4.81	30.0	137.3	15.7	3.45	0.92
T5 : 50 % RDF+ basic slag at 2 t ha^{-1}	5.05	27.6	118.3	10.5	3.52	0.95
T6 : 50 % RDF+ lime at 2t ha^{-1}	5.17	29.7	117.4	9.2	3.26	1.00
T7 : 75 % RDF+ basic slag at 2 t ha^{-1}	5.32	31.0	119.8	10.4	3.53	0.97
T8 : 75 % RDF+ lime at 2 t ha^{-1}	5.35	29.9	114.1	9.0	3.36	0.93
T9 : 100 % RDF+ basic slag at 2 t ha^{-1}	5.36	33.8	109.5	10.4	3.31	1.02
T10 : 100 % RDF+ lime at 2t ha^{-1}	5.42	30.5	104.3	9.4	3.28	0.97
SE.m±	**0.2**	**1.1**	**4.6**	**0.7**	**0.2**	**0.04**
CD (0.05)	**NS**	**3.2**	**13.6**	**2.0**	**NS**	**NS**

Available phosphorus

The available P content of soil varied significantly due to the application of basic slag and lime. The treatment with 100 % RDF+ basic slag at the rate of 2 t ha^{-1} (36.1 kg ha^{-1}) recorded higher P content followed by the treatment which received 100 % RDF+ lime at the rate of 2 t ha^{-1}(33.8 kg ha^{-1}) (Table 2). This result was in agreement with the result of Ali and Shahram [1] who used converter slag as a liming agent in the amelioration of acidic soils and reported that it proportionately enhances the P availability in soil. Increase in the available P content of the soil might be due to the increased soil pH upon liming. This culminated in an increased microbial activity which has accelerated the decomposition of organic matter and could have enhanced the labile P in the soil [10].

DTPA extractable micronutrients

Significant decrease in the DTPA extractable Fe and Mn content was noticed with the basic slag and lime application (Table 2). This result was supported by Takac et al., [11] who reported that liming result in a strong decrease in the content of DTPA extractable forms of iron and manganese, because the level of bioavailable forms of many metals are negatively correlated with pH value.

Effect of basic slag and lime on forms of soil acidity

The soil acidity parameters such as exchangeable acidity, exchangeable aluminum, total potential acidity, total acidity, and pH dependent acidity varied significantly due to the application of basic slag and lime (Table 3). Among the treatments, significantly higher exchangeable aluminium content, exchangeable acidity and total acidity in soil (0.47, 1.2 and 2.3 cmol [p$^+$] kg^{-1} respectively) was recorded in T_4 followed by T_1which received only DAP (0.43, 0.7 and 1.9 cmol [p$^+$] kg^{-1} respectively) and significantly lower exchangeable aluminium content, exchangeable acidity and total acidity in soil was recorded in all other treatments. This decrease in exchangeable acidity could be due to the neutralization effect of lime on Al^{+3}, H^+ and other hydrolysable acid producing ions in soil. The added Si reacts with Al^{3+} resulting in the formation of insoluble hydroxo-aluminosilicate and as a result the availability of aluminium was reduced in soil [6]. Ma and Takahashi [9] reported a decrease in the concentration of Al^{3+} as the concentration of silicic acid increased in the soil solution and attributed to the formation of non-toxic Al-Si complexes.

Conclusion

From the present study, it can be concluded that application of basic slag and lime at the rate of 2 t ha^{-1} were efficient in amending acidic soil. Thus, basic slag can be used as an alternative to lime for the

Table 3. Effect of basic slag and lime on different forms of soil acidity

Treatments	Exch. Al^{3+}	Exch. acidity	pH dependent acidity	Total potential acidity	Total acidity
	(cmol (p^+) kg^{-1})				
T1 : Farmer's practice (Only DAP)	0.43	0.7	5.4	6.1	1.9
T2 : T1 + basic slag At 2 t ha^{-1}	0.25	0.5	4.5	5.0	1.4
T3 : T1 + lime at 2 t ha^{-1}	0.33	0.6	4.7	5.3	1.5
T4 : Recommended dose of NPK (RDF)	0.47	1.2	5.3	6.5	2.3
T5 : 50 % RDF+ basic slag at 2 t ha^{-1}	0.25	0.5	4.1	4.7	1.5
T6 : 50 % RDF+ lime at 2t ha^{-1}	0.33	0.5	4.5	5.0	1.4
T7 : 75 % RDF+ basic slag at 2 t ha^{-1}	0.25	0.5	4.2	4.7	1.4
T8 : 75 % RDF+ lime at 2 t ha^{-1}	0.33	0.5	4.8	5.3	1.4
T9 : 100 % RDF+ basic slag at 2 t ha^{-1}	0.25	0.4	4.2	4.7	1.4
T10 : 100 % RDF+ lime at 2t ha^{-1}	0.25	0.4	4.6	5.0	1.4
SE.m±	**0.03**	**0.03**	**0.23**	**0.4**	**0.12**
CD (0.05)	**0.08**	**0.09**	**0.70**	**1.1**	**0.35**

amelioration of acidic soil and it also can be utilized as a nutrient source in acidic soil.

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