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## Effect of different sources of calcium on amelioration of soil acidity and its influence on availability of nutrients

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### Abstract

Soil acidity is one of the limiting factor affecting growth and development of various crops. A field experiment was carried out during *Kharif* 2016 at Bio Fuel Park, Madenur, Hassan district in acid soil to ameliorate both surface and subsurface soil acidity using different calcium sources *viz.*, lime, dolomite and gypsum and to study their effect on availability of nutrients. The treatment combination includes application of lime and dolomite @ 50 percent lime requirement with and without elemental sulphur @ 100 kg ha<sup>-1</sup> and was compared with gypsum levels and control. The results revealed that the application of lime and dolomite increased the soil pH, organic carbon content, available nitrogen content and dehydrogenase activity in both surface and subsurface soil. Exchangeable calcium and available sulphur contents were increased in gypsum treated plots compared to control. Low Exch. acidity and Exch. Al and high Exch. Mg content were observed with dolomite and elemental sulphur application.

**Keywords:** Soil acidity, lime, dolomite, gypsum and lime requirement.

### 1. Introduction

The acid soils occupy about 90 million hectares distributed across the country and more than 12 lakh hectares in Karnataka. Acid soil limit crop production to an extent of 30-40 per cent of the world's arable land (Haug, 1983) <sup>[11]</sup> and are characterized by poor fertility due to combination of mineral toxicities of Fe and Al coupled with deficiencies of nutrients *viz.*, phosphorus, calcium, magnesium and zinc and also affects activity of beneficial microorganisms. Soil acidification can greatly affect the potential production of crops and pastures. Subsoil acidity (>20 cm depth) is becoming an alarming problem and is widespread and its amelioration is costly and often practically not feasible.

Due to excess cation uptake by plant roots lead to the development of subsoil acidity. Both surface and subsurface acidity are characterized by low Ca<sup>2+</sup> and high H<sup>+</sup> and Al<sup>3+</sup> at depths below the plough layer restricting crop growth and production especially in humid tropics. Root growth and activity are impaired by high Al and low Ca which affect water and nutrient availability to the crop.

Conventionally, liming of acidic soil is common practice in ameliorating surface acidity more effectively, but this will have little effect on subsoil acidity because the downward movement of lime is very slow. That is due to low solubility of lime, the consumption of OH<sup>-</sup> ions released from lime by exchangeable H<sup>+</sup> and Al<sup>3+</sup>, the reactions of OH<sup>-</sup> ions with Fe and Al oxide minerals, which are abundant in most highly weathered soils, resulting in new adsorption sites, and lack of an accompanying anion. On the other hand, deep incorporation of lime by physical means is costly, and often undesirable, due to the exposure of the infertile subsoil.

Thus specialized management strategies which include surface incorporation of gypsum, phosphogypsum or organic manures have been proposed to overcome this problem. Keeping this in view, a study was conducted to know the Effect of different sources of Calcium on amelioration of soil acidity and its influence on availability of nutrients. Give importance of sulphur in subsoil acidity correction

### 2. Material and Methods

The study was conducted at Bio Fuel Park, Madenur, Hassan district, during *kharif* season of 2016-17. The experimental site was texturally classified as sandy loam, physiography of the

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land was fairly uniform with a gentle gradient towards southern side depicting Midland. It is located in the Southern Dry Zone of Karnataka. The Soil pH was 5.48 and 5.30 with an EC of 0.10 and 0.09 d Sm<sup>-1</sup> and organic carbon content of 3.35 and 3.23 g kg<sup>-1</sup> in surface and subsurface soil, respectively. The soil nitrogen was 232.80 and 265.20 kg ha<sup>-1</sup>, phosphorous 88.43 and 27.64 kg ha<sup>-1</sup> and potassium 245.35 and 186.24 kg ha<sup>-1</sup> in surface and subsurface soil, respectively. Exchangeable acidity of soil was 1.63 and 2.76 meq.100 g<sup>-1</sup> and exchangeable aluminium of soil was 1.36 and 2.34 cmol (p<sup>+</sup>) kg<sup>-1</sup> in surface and subsurface soil, respectively.

Maize was used as test crop. The experiment was laid out in randomised block design (RCBD) with nine treatment combinations and three replications. After lay out of the experiment, T<sub>2</sub> and T<sub>3</sub> plots received agricultural lime as calcium carbonate @ 50% of lime requirement (LR) calculated based on SMP abbreviate buffer method with desired pH level of 6.8 (~500 kg ha<sup>-1</sup>). Similarly, treatments T<sub>4</sub> and T<sub>5</sub> received dolomitic lime @ 50% lime requirement (~500 kg ha<sup>-1</sup>). Elemental sulphur @ 100 kg ha<sup>-1</sup> (equivalent to sulphur content in 500 kg gypsum) was applied to treatment T<sub>3</sub> and T<sub>5</sub>. All the ameliorants and elemental sulphur were broadcasted 20 days before sowing (DAS) plot wise, thoroughly mixed with soil and moisture was maintained by irrigating periodically. Basal dose of recommended fertilizers (50 per cent N and 100 per cent P and K) were applied treatment wise to each plot and mixed with soil at the base of seed row. Urea, Di Ammonium Phosphate (DAP) and Muriate of potash (MOP) were used as sources of NPK. The furrows were opened at 60 cm interval with the help of hand hoe and maize seeds were dibbled in each hill at 30 cm spacing and finally covered with soil. Remaining 50% N was top dressed in two equal splits at 25 and 50 DAS. The soil samples were collected at two depths (0-15 cm) and (15-30 cm) before and after the harvest of maize crop and analysed acidity parameters and nutrient availability by adopting standard protocol as outlined by Jackson (1973). The results were subjected to statistical analysis for the effectiveness of the ameliorants.

### 3. Results and Discussion

The results of soil pH when is it after harvest mention the stage revealed that the application of different calcium sources had significant influence on soil pH at both depths. In general the pH of surface soil was higher as compared to subsurface soil.

At 0-15 cm depth, the application of lime @ 50% LR (T<sub>2</sub>) recorded significantly highest soil pH (6.55) followed by application of lime @ 50% LR + Elemental S (6.32) (T<sub>3</sub>) compared to control (RDF alone furnish value). Whereas At 15-30 cm depth, application of lime @ 50% LR (T<sub>2</sub>) recorded significantly highest soil pH (5.83) followed by T<sub>3</sub> treatment with lime @ 50% LR + Elemental S (5.63) and the lowest soil pH (5.13) was recorded in T<sub>8</sub> treatment (RDF + Gypsum 750 kg ha<sup>-1</sup>). Cross reference of table no is missing kindly furnish. Among the different calcium sources, application of lime @ 50% LR (T<sub>2</sub>) had more impact in ameliorating the soil acidity. That is due to liming source has increased the base saturation and hence pH increased. As pH rise by addition of lime there was a decline in Al<sup>+3</sup> activities. Ameliorants neutralized the active acidity by removing free hydrogen ions from the bulk solution, thereby increasing pH. The calcium ions present in the ameliorants can be readily adsorbed to soil particles and organic matter. However, the carbonates in turn react with

hydrogen ions in solution (which act to keep the pH low), thus causing an increase in soil pH. The result of the present study is in agreement with the studies of Sudhir *et al.* (1987) [24], Legendre *et al.* (2004) [16], Castro *et al.* (2010) [2, 3], and Lee *et al.* (2011) [15].

The exchangeable acidity was significantly influenced due to application of different calcium sources at both depths. In general the exchangeable acidity of surface soil recorded lower compared to subsurface soil. At both 0-15 cm and 15-30 cm depth, the application of dolomite @ 50% LR and elemental sulphur @ 100 kg ha<sup>-1</sup>(T<sub>5</sub>) recorded significantly lower exchangeable acidity (0.59 and 1.74 m eq. 100 g<sup>-1</sup>, respectively) followed by T<sub>3</sub> treatment with lime @ 50% LR + Elemental S (0.75 and 1.90 m eq. 100 g<sup>-1</sup>, respectively) compared to control (RDF alone). The highest exchangeable acidity (1.59 and 2.74 m eq. 100 g<sup>-1</sup>, respectively) was recorded in treatment T<sub>1</sub> with RDF alone. At both 0-15 cm and 15-30 cm depth, the application of lime @ 50% LR (T<sub>5</sub>) recorded significantly lower exchangeable aluminium (0.50 and 1.48 m eq. 100 g<sup>-1</sup>, respectively) followed by T<sub>3</sub> treatment with lime @ 50% LR + Elemental S (0.67 and 1.64 m eq. 100 g<sup>-1</sup>, respectively) compared to control (RDF alone). The highest exchangeable aluminium (1.34 and 2.32 m eq. 100 g<sup>-1</sup>, respectively) was recorded in treatment T<sub>1</sub> with RDF alone. Decrease in soil acidity components upon liming may be ascribed to depressed activity of Al<sup>+3</sup> and H<sup>+</sup> due to neutralization upon liming. These findings are in confirmation with the findings of Mclean (1973) [17]; Prasad *et al.* (1983) [20]; Patil and Ananthanarayana (1989) [19] and Adane (2014) [1].

At 0-15 cm depth, the application of dolomite @ 50% LR (T<sub>4</sub>) recorded significantly highest soil organic carbon content (6.69 g kg<sup>-1</sup>) followed by T<sub>2</sub> treatment with lime @ 50% LR (6.43 g kg<sup>-1</sup>) and the lowest soil organic carbon content (3.10 g kg<sup>-1</sup>) was recorded in treatment T<sub>8</sub> with RDF + gypsum @ 750 kg ha<sup>-1</sup>. At 15-30 cm depth, the soil organic carbon content ranged from 3.10 to 3.60 gkg<sup>-1</sup>. Soil organic carbon content in subsurface soil was found to be non significant among the different treatments over control.

Increase in organic matter content in soil due to application of different calcium sources may be due to higher root biomass production which in turn added higher organic residues into the soil after harvest of the crop. This result are in agreement with finding of Sarkar *et al.*, 2002, Kadao *et al.*, 2003, Ghosh *et al.* (2005) [23, 12, 9] and Gangopadhyay *et al.*, 2008 [7].

The enzyme activity was significantly influenced by application of different calcium sources in both surface and subsurface soil. In general enzyme activity of surface soil is more compared to subsurface soil.

At both 0-15 cm and 15-30 cm depth, the application of dolomite @ 50% LR (T<sub>4</sub>) recorded significantly highest enzyme activity (60.38 and 66.68 µg TPF g<sup>-1</sup> per 24 hours, respectively) followed by (59.64 and 57.29 µg TPF g<sup>-1</sup> per 24 hours, respectively) with lime @ 50% LR (T<sub>2</sub>) over control (53.43 and 48.17 µg TPF g<sup>-1</sup> per 24 hours, respectively). Significant decrease in enzyme activity with increase in gypsum dosage was noticed up to 1000 kg ha<sup>-1</sup> as compared to control. The increase in dehydrogenase activity in treated plots with lime and dolomite was due to buffering action of ameliorants. Current findings are in agreement with earlier reports of Ghaly and Mahmoud (2006) [8]; Fernandez *et al.* (2010) [6] and Taylor *et al.*, (2001) [25].

At 0-15 cm depth, the application of dolomite @ 50% LR (T<sub>4</sub>) recorded significantly highest soil available nitrogen content (299.12 kg ha<sup>-1</sup>) followed by T<sub>2</sub> with lime @ 50% LR (277.46

kg ha<sup>-1</sup>). The lowest soil available nitrogen content (220.50 kg ha<sup>-1</sup>) was recorded in treatment T1 with RDF alone and in T<sub>9</sub> with gypsum @ 1000 kg ha<sup>-1</sup>. At 15-30 cm depth, no-significant variation was observed with respect to soil available nitrogen content in subsurface soil among the different treatments over control. Increase in nitrogen with lime application could be due to enhanced microbial activities in the soils which increased the soil pH, the rate of decomposition of organic matter and accelerated the process of mineralization of nitrogen (Ranjit *et al.*, 2007) [21]. The result obtained in the present study is in agreement with the results of Halder and Mandal (1985) [10]; Richard *et al.* (2010) [22] and Dixit and Sharma (2003) [5].

No significant variation was observed with respect to soil available phosphorous and potassium content among surface and subsurface soils.

Exchangeable calcium was significantly influenced due to application of different calcium sources at both depths. In general, the exchangeable calcium content of surface soil recorded lower compared to subsurface soil. At 0-15 cm depth, application of lime @ 50% LR + elemental sulphur (T<sub>3</sub>) recorded significantly highest exchangeable calcium (2.42 m eq. 100 g<sup>-1</sup>) followed by T<sub>9</sub> treatment with gypsum 1000 kg ha<sup>-1</sup> (2.82 cmol (p<sup>+</sup>) kg<sup>-1</sup>). The lowest soil exchangeable calcium (0.75 cmol (p<sup>+</sup>) kg<sup>-1</sup>) was recorded in treatment T1 with RDF alone. In 15-30 cm depth, the application of dolomite @ 50% LR + elemental S (T<sub>5</sub>) recorded significantly highest exchangeable calcium content (3.86 cmol (p<sup>+</sup>) kg<sup>-1</sup>) followed by T<sub>9</sub> treatment with gypsum 1000 kg ha<sup>-1</sup> (3.50 cmol (p<sup>+</sup>) kg<sup>-1</sup>). The lowest exchangeable calcium content (1.36 m cmol (p<sup>+</sup>) kg<sup>-1</sup>) was recorded in treatment T1 with RDF alone. This is due to increased base saturation of acid soils on liming and higher amount of calcium moved from lime particle to the exchange sites of soil particle. This is due to increase in charge density and greater affinity for higher valent ions. The calcium being divalent cation and its higher solution concentration due to liming increased its concentration on exchange complex. Similar observations were reported by Vishwanath, *et al.* (2012) [26];

Nagaraja *et al.* (2012) [18]; Patil and Ananthanarayana (1989) [19].

At 0-15 cm depth, application of dolomite @ 50% LR + elemental sulphur (T<sub>5</sub>) recorded significantly highest exchangeable magnesium (1.46 cmol (p<sup>+</sup>) kg<sup>-1</sup>) followed by T<sub>4</sub> treatment with dolomite @ 50% LR (1.31 cmol (p<sup>+</sup>) kg<sup>-1</sup>). The lowest soil exchangeable magnesium (0.71 cmol (p<sup>+</sup>) kg<sup>-1</sup>) was recorded in treatment T1 with RDF alone. At 15-30 cm depth, the application of dolomite @ 50% LR + elemental S (T<sub>5</sub>) recorded significantly highest exchangeable magnesium content (1.72 cmol (p<sup>+</sup>) kg<sup>-1</sup>) followed by T<sub>4</sub> treatment with dolomite @ 50% LR (1.55 cmol (p<sup>+</sup>) kg<sup>-1</sup>). This is because liming with dolomite increased the base saturation index and reduces Al saturation and increases the magnesium concentration in soil solution. Application of lime increased magnesium adequately. Similar observations were reported by Vishwanath *et al.* (2012) [26]; Patil and Ananthanarayana (1989) [19]; Curtin and Smillie (1995) [4]; and Castro *et al.* (2010) [2, 3].

At both 0-15 cm and 15-30 cm depth, the application of dolomite @ 50% LR + elemental S (T<sub>5</sub>) recorded significantly highest sulphur content (17.05 and 16.63 mg kg<sup>-1</sup>, respectively) followed by T<sub>2</sub> with lime @ 50% LR (16.28 and 15.74 mg kg<sup>-1</sup>, respectively). The lowest sulphur content (9.45 and 11.58 mg kg<sup>-1</sup>, respectively) was recorded in treatment T1 with RDF alone. Higher sulphur content in these treatments is due to addition of sulphur through gypsum or elemental sulphur. Further the application of lime and other calcium sources to an acid soil could increase solution levels of sulphur. It is because of most of the hydroxyl ions released in calcium carbonate dissolution reacted with protons produced during oxidation of reduced sulphur or reacted with adsorbed sulphate rather than reacting with exchangeable Al and also observed accelerated rate of decomposition and mineralization of organic matter due to increased biological activity of soil. The present results are in agreement with the findings of Helyar and Anderson (1974) [13], Kalluraya (1990) [14] and Crusciol *et al.* (2010) [3].

**Table 1:** Effect of different calcium sources on soil chemical properties

Treatments	pH		OC (g kg <sup>-1</sup> )		Exch. Acidity (m eq. 100 g <sup>-1</sup> )		Exch. Al (m eq. 100 g <sup>-1</sup> )	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T <sub>1</sub> : RDF (Control)	5.47	5.34	3.30	3.17	1.59	2.74	1.34	2.32
T <sub>2</sub> : RDF + Lime @ 50% LR	6.55	5.83	6.43	3.39	0.89	2.04	0.59	1.56
T <sub>3</sub> : RDF + Lime @ 50% LR + Elemental S @100 kg	6.32	5.63	4.65	3.15	0.75	1.90	0.67	1.64
T <sub>4</sub> : RDF + Dolomite @ 50% LR	6.28	5.72	6.69	3.20	1.02	2.17	0.84	1.81
T <sub>5</sub> : RDF + Dolomite @ 50% LR + Elemental S @ 100 kg ha <sup>-1</sup>	6.18	5.39	5.37	3.41	0.59	1.74	0.50	1.48
T <sub>6</sub> : RDF + Gypsum @ 250 kg ha <sup>-1</sup>	5.46	5.33	3.96	3.60	1.09	2.24	1.00	1.97
T <sub>7</sub> : RDF + Gypsum @ 500 kg ha <sup>-1</sup>	5.45	5.30	3.77	3.40	1.01	2.16	1.00	1.97
T <sub>8</sub> : RDF + Gypsum @ 750 kg ha <sup>-1</sup>	5.41	5.13	3.69	3.10	0.78	1.93	0.94	1.91
T <sub>9</sub> : RDF + Gypsum @ 1000 kg ha <sup>-1</sup>	5.26	5.21	3.36	3.25	1.10	2.25	1.05	2.06
<b>S. Em±</b>	<b>0.04</b>	<b>0.05</b>	<b>0.32</b>	<b>0.12</b>	<b>0.062</b>	<b>0.173</b>	<b>0.055</b>	<b>0.073</b>
<b>CD (P = 0.05)</b>	<b>0.13</b>	<b>0.14</b>	<b>0.95</b>	<b>NS</b>	<b>0.186</b>	<b>0.519</b>	<b>0.165</b>	<b>0.219</b>

**Table 2:** Effect of different calcium sources on soil dehydrogenase activity, available nitrogen, phosphorus and potassium

Treatments	Dehydrogenase activity ( $\mu\text{g TPF g}^{-1}$ per day)		Avail. Nitrogen ( $\text{kg ha}^{-1}$ )		Avail. Phosphorous ( $\text{kg ha}^{-1}$ )		Avail. Potassium ( $\text{kg ha}^{-1}$ )	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T <sub>1</sub> : RDF (Control)	53.43	48.17	220.50	256.41	85.49	25.65	234.92	184.28
T <sub>2</sub> : RDF + Lime @ 50% LR	59.64	57.29	277.46	280.86	128.24	42.75	297.64	212.96
T <sub>3</sub> : RDF + Lime @ 50% LR + Elemental S @100 kg	54.50	53.73	265.60	299.10	153.89	51.30	303.88	225.44
T <sub>4</sub> : RDF + Dolomite @ 50% LR	60.38	66.68	299.12	305.24	119.69	34.20	279.6	200.16
T <sub>5</sub> : RDF + Dolomite @ 50% LR + Elemental S @ 100 $\text{kg ha}^{-1}$	58.07	55.71	275.30	276.70	205.18	85.49	314.72	242.84
T <sub>6</sub> : RDF + Gypsum @ 250 $\text{kg ha}^{-1}$	48.92	54.79	248.23	280.83	94.04	34.20	236.32	187.36
T <sub>7</sub> : RDF + Gypsum @ 500 $\text{kg ha}^{-1}$	47.79	51.96	240.43	284.97	111.14	34.20	254.68	199.08
T <sub>8</sub> : RDF + Gypsum @ 750 $\text{kg ha}^{-1}$	37.08	42.62	228.10	284.83	119.69	34.20	263.88	207.84
T <sub>9</sub> : RDF + Gypsum @ 1000 $\text{kg ha}^{-1}$	26.91	36.78	220.62	291.01	94.04	34.20	253.6	197.12
<b>S. Em<math>\pm</math></b>	<b>0.74</b>	<b>0.67</b>	<b>11.2</b>	<b>13.5</b>	<b>43.62</b>	<b>12.05</b>	<b>39.90</b>	<b>21.80</b>
<b>CD (P = 0.05)</b>	<b>2.22</b>	<b>2.01</b>	<b>33.6</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>	<b>NS</b>

**Table 3:** Effect of different calcium sources on exchangeable Calcium, Magnesium and available Sulphur

Treatments	Ca ( $\text{cmol (p}^+) \text{ kg}^{-1}$ )		Mg ( $\text{cmol (p}^+) \text{ kg}^{-1}$ )		Avail. S ( $\text{mg kg}^{-1}$ )	
	0-15 cm	15-30 cm	0-15 cm	15-30 cm	0-15 cm	15-30 cm
T <sub>1</sub> : RDF (Control)	0.75	1.36	0.71	0.81	9.45	11.58
T <sub>2</sub> : RDF + Lime @ 50% LR	1.52	2.84	0.76	0.76	12.87	13.01
T <sub>3</sub> : RDF + Lime @ 50% LR + Elemental S @100 kg	2.42	3.17	0.80	0.70	16.28	15.74
T <sub>4</sub> : RDF + Dolomite @ 50% LR	2.10	3.30	1.31	1.55	14.71	13.81
T <sub>5</sub> : RDF + Dolomite @ 50% LR + Elemental S @ 100 $\text{kg ha}^{-1}$	1.90	3.86	1.46	1.72	17.05	16.63
T <sub>6</sub> : RDF + Gypsum @ 250 $\text{kg ha}^{-1}$	1.92	2.3	0.86	0.83	13.03	17.67
T <sub>7</sub> : RDF + Gypsum @ 500 $\text{kg ha}^{-1}$	2.07	2.84	0.74	0.76	14.57	18.44
T <sub>8</sub> : RDF + Gypsum @ 750 $\text{kg ha}^{-1}$	2.30	3.10	0.71	0.66	18.05	19.63
T <sub>9</sub> : RDF + Gypsum @ 1000 $\text{kg ha}^{-1}$	2.82	3.50	0.74	0.82	19.55	21.38
<b>S. Em<math>\pm</math></b>	<b>0.067</b>	<b>0.085</b>	<b>0.055</b>	<b>0.074</b>	<b>0.2</b>	<b>0.35</b>
<b>CD (P = 0.05)</b>	<b>0.20</b>	<b>0.253</b>	<b>0.165</b>	<b>0.222</b>	<b>0.59</b>	<b>1.03</b>

#### 4. Conclusion

Application of liming materials with and without sulphur has reduced soil exchangeable Hydrogen and Aluminum levels, which are responsible for causing potential soil acidity. The availability of major nutrients, exchangeable Calcium and sulphate levels are increased due to improvement in soil microbial activity couple with optimum soil reaction.

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