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Effect of Granulated Liming Material on Soil Properties and Yield of Paddy in Acid Soil of Bramhavara

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A B S T R A C T

A field experiment was conducted during kharif 2017-18 at ZAHRS, Bramhavara to study the effect of granulated liming material on soil properties and yield of paddy. Treatments included lime application as granulated lime and agricultural lime at different combinations along with FYM and RDF were studied in this experiment. The results revealed that the treatment receiving RDF (60:30:60 Kg N, P_2O_5, K_2O/ha) + FYM (10 t/ha) + 50 percent lime requirement through granulated lime based on 45 per-cent Ca saturation (1.14 tonnes/ha) recorded significantly higher growth parameters, yield, B:C ratio, soil pH, available N, P_2O_5, K_2O and S.

Introduction

Liming materials are commonly applied to reduce the acidity and to increase productivity of soils. Correction of soil pH is the cornerstone of a successful crop nutrient management program. Soil pH affects nutrient solubility and influences the sorption or precipitation of nutrients like Al, Mn, and Fe. Liming increase the pH of acidic soils and improves macronutrients availability of soil while reducing the solubility of Al and Mn. Pelletized lime is finely ground limestone, which is made into small pellets for broadcasting with fertilizer. In pelletized form the lime is protected from wind drift, and the uniform texture eliminates any larger, nonreactive particles that can take years to fully break down within the soil (Alvarez *et al.*, 2009). Clay or synthetic binders, such as lignosulfonates hold the pellets together and dissolve in contact with rainfall or soil solution, breaking down by solubilization or microbial action. The pellets are durable enough to withstand transport, and minimal dust is created on spreading. Finer liming materials dissolve and react more rapidly. Scott *et al.,* (1992) investigated the most effective particle size (between 0.005 and 3 mm) of liming material in an acid soil in Australia and concluded that the finest limestone particles produced greatest increases of pH, exchangeable Ca and wheat (*Triticum aestivum* L.) production. For crop production, however, soil acidity is a complex of numerous factors involving nutrient/element deficiencies and toxicities, low activity of beneficial microorganisms and reduced plant root growth that limit nutrient and water uptake (Fageria and Baligar, 2003). The situation is further complicated by various interactions among these factors (Foy, 1992). The practice of correcting soil acidity reduces the available contents of Al, Fe, Mn, Zn, and Cu, but increases the availability of other essential nutrients. Liming is an effective and dominant practice to raise soil pH and reduce acidity-related constraints to improve crop yields (Fageria & Baligar, 2008). The objectives of the present study was to determine the finely grounded granulated limestone on chemical properties in soil and yield of paddy.

Materials and Methods

The field experiment conducted during kharif 2017-18 at ZAHRS, Bramhavara. The paddy variety MO_4 was selected as test variety. The soil of the experimental site was having pH 4.86. The available N (191 kg ha^{-1}) and P_2O_5 (19.9 kg ha^{-1}) content was low while that of K_2O (225.0 kg ha^{-1}) was found medium. The exchangeable Ca and Mg content were 2.90 and 1.40 cmol (p+) kg^{-1}, respectively and the available S was15 mg kg^{-1} (Table 1).

The testing trial was carried out in RCBD design with 13 treatments and replicated three times. Gross plot size of the experiment was $4m^2$. Liming materials were applied 15 days before transplanting as per the treatments. Soil samples were collected before and after treatment imposition and analyzed for soil chemical properties as per standard procedure. Growth and yield attributes were recorded. Soil pH was determined 1:2.5 soil to water suspension by potentiometric method (Jackson, 1973). Available nitrogen in the soil was determined by alkaline potassium permanganate method as described by Subbiah and Asija (1956). Available phosphorus were extracted using Olsen's extractant for neutal and alkaline soils and Bray's extractant for acid soils and was determined by spectrophotometer (Jackson, 1973). Available potassium extracted using neutral normal ammonium acetate was determined by using flame photometer (Jackson, 1973). The exchangeable calcium and magnesium were determined by Versenate titration method (Jackson, 1973). Available sulphur was extracted from soil using 0.15 per cent calcium chloride solution and determined turbidimetrically as described by Black (1965). Fertilizer and manure applied as per package of practices (POP).RDF: 60:30:60 kg NPK/ha and FYM: 10t/ha.

Results and Discussion

Effect of liming materials on soil chemical properties and available nutrient status

pH

The treatment which received granulated lime recorded significantly higher soil pH in all the treatments studied as compared to powdered agriculture lime applied plots (Table 2). Granules of liming materials hold longer duration in the soil to react fully. Granulated lime holds the soil pH values higher for longer duration due to higher neutralization power and reduction of loss in leaching. As limestone is a source of Ca and Mg and in the presence of water the carbonates dissolve and the OH^- and HCO_3^- ions are released, reducing soil acidity (Havlin *et al.*, 1999).

Available Nitrogen, P_2O_5 and K_2O

Granulated lime applied plots recorded significantly higher available N, P_2O_5, K_2O compared to plots receiving powdered agriculture lime in all the growth stages of crop. This was due to higher neutralization, less loss in soil, more reactivity and quality of granulated lime. Increase in soil pH from acidic condition by application of liming material leads to increase in availability of nutrients. Liming increases the beneficial microbial activity of the soil with increase in pH of acidic soil thus enhancing the net mineralization of organic N which in turn led to the increase in availability of nitrogen in soil (Edmeades and Ridley, 2003). Lime application increased the soil pH which helped the release of fixed P from the oxides and hydroxides of Fe and Al thus increased the P availability in soils (Haynes, 1982) (Table 3). The ultimate effects of reasonable application of lime are generally considered to promote soil K availability as well as the efficiency of K fertilizer on acid soils (Pearson, 1958).

Exchangeable Ca and Mg and available sulphur

The treatments which received granulated lime recorded significantly higher Ca, Mg and S compared to plots receiving powdered agriculture lime in all growth stages of crop. This was due to higher neutralization, quality and reactivity of granulated lime. The liming material which on dissolution released a large amount of Ca & Mg and thus the available of Ca increased in post harvest soils. Addition of lime to soil results in increased Ca availability and, usually, greater Mg availability as well. This occurs not only because the direct addition of these elements increases their relative percentages on the soil exchange complex, but also because of the reduced inhibitory effects on plant uptake by H and A1 (Coleman *et al.,* 1958). Adams and Pearson (1967) infer from reviewed experiments showing increased adsorption of sulfate-S with decreasing pH that liming probably increases S availability (Table 6–8).

Effect of liming material on growth and yield of paddy

Among the treatments studied the higher number of tillers per hill (28.25) and plant height at harvest (106.11cm) were recorded in treatment which received RDF(Kg N, P_2O_5, K_2O/ha)+ FYM (10t/ha)+ 50 % lime requirement through granulated lime based on 45% Ca saturation as compared to other treatments (Table 4). The liming treatments recorded significantly higher yield and related attributes as compared to without liming treatments (Table 9).

Table.1 Chemical properties of granulated and powdered liming materials used in experiment

Sl. No.	Properties	Granulated lime ($CaCO_3$)	Powdered agricultural lime ($CaCO_3$)
1	Size	2-3 mm(100mesh)	100 mesh
2	Ca (%)	23.30	23.0
3	CaCO3 (%)	58.25	57.5
4	Mg (%)	9.20	8.50
5	MgCO3 (%)	31.57	29.14
6	CCE (%)	89.82	86.64
7	Residue (%)	20.0	40.0

*CCE: Calcium Carbonate Equivalent

Table.2 Effect of liming material on soil pH

Treatments	15DAP	30 DAP	60 DAP	At harvest
T_1: RDF + FYM (Control)	4.91	4.96	4.88	5.13
T_2:RDF + FYM+ 100 % LR through granulated lime based on 45% Ca saturation (2.29 tonnes/ha)	5.07	5.11	5.38	5.96
T_3 :RDF + FYM + 100% LR through ($CaCO_3$) powdered Agri. lime based on 45% Ca saturation (2.29 tonnes/ha)	4.93	5.19	5.35	5.51
T_4 :RDF + FYM + 75% LR through Granulated lime based on 45% Ca saturation (1.72 tonnes/ha)	5.18	5.13	5.28	6.05
T_5 :RDF + FYM + 75 % LR through powdered Agri. Lime ($CaCO_3$) based on 45% Ca saturation(1.72 tonnes/ha)	4.80	4.92	5.19	5.41
T_6 :RDF + FYM + 50 % LR through Granulated lime based on 45% Ca saturation (1.14 tonnes/ha)	5.18	5.27	5.49	5.94
T_7 :RDF + FYM + 50 % LR through powdered Agri.lime ($CaCO_3$) based on 45% Ca saturation(1.14 tonnes/ha)	5.00	5.08	5.47	5.73
T_8:RDF + FYM + 100 % LR through powdered Agri.lime ($CaCO_3$) based on shoemaker method (2.8 tonnes/ha)	5.10	5.37	5.83	6.11
T_9:RDF + FYM + 100 % LR through granulated lime based on shoemaker method (2.8 tonnes/ha)	5.30	5.46	5.87	6.17
T_{10}:RDF + FYM + 50 % LR through granulated lime based on shoemaker method(1.4 tonnes/ha)	5.05	5.08	5.14	5.97
T_{11}: Powdered Agri. lime ($CaCO_3$) @ 500 kg/ha	4.76	4.96	4.95	5.83
T_{12}: Granulated lime ($CaCO_3$) @ 500 kg/ha	4.98	5.06	5.04	5.18
T_{13}:Granulated lime @250 kg/ha	4.76	4.91	4.95	5.06
SEM +_	0.22	0.25	0.22	0.25
CD@5%	0.63	0.74	0.63	0.74
CV (%)	7.51	8.57	7.09	7.42

*DAP-Days After Planting

Table.3 Effect of liming materials on soil available nitrogen status (Kg ha^{-1})

Treatments	15DAP	30 DAP	60 DAP	At harvest
T1	192.36	198.27	196.27	194.38
T2	222.36	236.12	242.36	249.24
T3	210.26	218.64	222.36	227.29
T4	241.69	246.29	259.34	271.29
T5	213.28	222.36	238.26	243.29
T6	246.39	269.24	271.26	278.19
T7	236.29	246.29	253.61	262.31
T8	227.29	232.14	241.37	249.27
T9	258.29	260.19	270.19	276.19
T10	241.26	259.24	271.29	275.29
T11	203.65	210.26	219.27	221.63
T12	212.29	221.36	223.54	226.19
T13	209.25	216.29	219.29	221.35
SEm±	**5.63**	**6.95**	**6.84**	**7.40**
CD@5%	**16.43**	**20.30**	**19.95**	**21.61**
CV(%)	**8.36**	**8.16**	**8.91**	**8.88**

Table.4 Effect of liming materials on soil available P_2O_5 (Kg ha^{-1})

Treatments	15DAP	30 DAP	60 DAP	At harvest
T1	20.14	21.35	20.16	19.16
T2	24.15	26.19	26.28	32.15
T3	23.25	24.26	26.15	31.26
T4	27.15	28.16	29.14	31.26
T5	25.61	26.14	24.26	29.16
T6	28.15	28.16	29.24	34.26
T7	24.26	25.62	28.43	29.16
T8	26.19	24.19	27.16	28.15
T9	28.16	29.16	31.26	31.94
T10	27.16	27.19	31.26	31.69
T11	24.26	26.16	28.21	28.94
T12	21.26	23.14	24.15	26.21
T13	20.31	22.14	23.14	24.38
SEm±	**1.05**	**0.99**	**0.95**	**1.04**
CD@5%	**3.08**	**2.88**	**2.78**	**3.03**
CV(%)	**7.37**	**8.10**	**8.19**	**8.15**

Table.5 Effect of liming materials on soil available K_2O (Kg ha^{-1})

Treatments	15DAP	30 DAP	60 DAP	At harvest
T1	226.34	228.32	241.36	230.21
T2	230.98	228.36	241.36	243.21
T3	228.31	221.25	230.16	238.16
T4	249.21	246.23	256.14	261.26
T5	234.36	238.16	249.26	246.39
T6	261.22	268.24	271.46	279.31
T7	238.16	241.26	243.15	249.34
T8	248.62	249.24	261.26	268.61
T9	246.16	256.31	289.24	292.16
T10	251.23	258.31	259.26	272.16
T11	238.19	248.19	249.321	251.29
T12	236.15	241.26	241.29	250.31
T13	231.26	238.16	239.16	239.29
SEm±	**7.58**	**6.81**	**7.64**	**7.83**
CD@5%	**22.12**	**19.87**	**22.31**	**22.86**
CV(%)	**8.47**	**8.85**	**9.23**	**8.25**

Table.6 Effect of liming materials on soil exchangeable calcium (cmol(p+)Kg^{-1})

Treatments	15DAP	30 DAP	60 DAP	At harvest
T1	3.1	3.3	3.1	3.2
T2	4.4	4.7	4.9	5.6
T3	4.1	4.3	4.6	4.8
T4	4.3	4.8	4.9	5.1
T5	4.1	4.3	4.3	4.3
T6	4.5	4.6	4.8	4.7
T7	4.1	4.4	4.5	4.7
T8	4.1	4.2	4.6	4.4
T9	4.1	3.8	4.2	4.4
T10	4.3	4.6	4.2	4.4
T11	3.6	3.8	3.4	3.4
T12	3.4	3.6	3.7	3.8
T13	3.1	3.5	3.5	3.6
SEm±	**0.14**	**0.13**	**0.13**	**0.13**
CD@5%	**0.40**	**0.37**	**0.37**	**0.38**
CV(%)	**7.08**	**8.34**	**9.17**	**8.18**

Table.7 Effect of liming materials on soil exchangeable magnesium (cmol(p+)Kg^{-1})

Treatments	15DAP	30 DAP	60 DAP	At harvest
T1	15.26	18.26	14.25	17.60
T2	21.26	25.36	24.26	29.31
T3	19.24	19.25	21.36	24.15
T4	24.16	25.16	27.36	29.34
T5	23.24	25.16	24.36	27.26
T6	24.23	26.15	25.49	28.15
T7	23.14	25.34	24.16	28.25
T8	25.16	28.31	29.16	31.32
T9	24.36	24.63	28.34	29.19
T10	25.31	25.34	26.38	29.92
T11	18.16	21.36	23.31	24.21
T12	19.26	19.15	21.36	24.36
T13	18.35	18.29	19.26	21.31
SEM	**0.68**	**0.85**	**0.92**	**0.93**
CD	**1.99**	**2.47**	**2.68**	**2.72**
CV(%)	**8.45**	**8.26**	**8.64**	**8.02**

Table.8 Effect of liming materials on soil available sulphur status (mg Kg^{-1})

Treatments	15DAP	30 DAP	60 DAP	At harvest
T1	15.26	18.26	14.25	17.60
T2	21.26	25.36	24.26	29.31
T3	19.24	19.25	21.36	24.15
T4	24.16	25.16	27.36	29.34
T5	23.24	25.16	24.36	27.26
T6	24.23	26.15	25.49	28.15
T7	23.14	25.34	24.16	28.25
T8	25.16	28.31	29.16	31.32
T9	24.36	24.63	28.34	29.19
T10	25.31	25.34	26.38	29.92
T11	18.16	21.36	23.31	24.21
T12	19.26	19.15	21.36	24.36
T13	18.35	18.29	19.26	21.31
SEM	**0.68**	**0.85**	**0.92**	**0.93**
CD	**1.99**	**2.47**	**2.68**	**2.72**
CV(%)	**8.45**	**8.26**	**8.64**	**8.02**

Table.9 Effect of liming materials on growth and yield of transplanted paddy

Treatments	Yield (kg ha^{-1})		No. of tillers/hill	Plant height at harvest (cm)	Percent increase in yield over control (%)
	Grain	Straw			
T1	5766	850	19.00	85	-
T2	6900	10810	25.20	102	19.65
T3	6600	10029	21.00	93	14.45
T4	6966	10537	24.50	102	20.80
T5	6533	9672	22.50	95	13.81
T6	7400	9358	28.25	106	28.32
T7	6600	9690	23.50	98	14.45
T8	6400	11365	20.00	93	10.98
T9	6821	10299	23.70	90	18.29
T10	7009	11214	26.20	102	11.62
T11	6666	8652	24.10	98	15.60
T12	7016	9220	27.20	104	21.67
T13	6033	8650	23.3	97	04.62
SEm±	**504.11**	**847.13**	**0.47**	**1.9**	
CD@5%	**1501.16**	**2474.35**	**1.37**	**5.62**	
CV (%)	**13.29**	**15.21**	**14.03**	**17.23**	

Table.10 Economics of granulated liming material in transplanted paddy

Treatments	COC	GR	NR	B:C Ratio
T1	35,000.00	52,319	17,319.00	1.49
T2	41,693.30	67,505.17	25,811.86	1.62
T3	37,500.00	64,414.67	26,914.67	1.72
T4	38,600.00	67,968.67	29,368.67	1.76
T5	36,350.00	63,636.33	27,286.33	1.75
T6	36,653.00	69,945.73	33,292.73	1.90
T7	35,625.00	64,245.00	28,620.00	1.80
T8	40,350.00	63,282.67	22,932.67	1.57
T9	49,133.00	66,538.50	17,405.50	1.35
T10	38,466.60	68,688.00	30,221.40	1.78
T11	35,500.00	64,326.00	28,826.00	1.81
T12	36,333.30	67,760.34	31,427.04	1.86
T13	35,666.66	58,617.00	22951.00	1.69

*COC: Cost of cultivation GR: Gross return NR: Net return B: C: Benefit cost ratio
Grains @Rs. 900/quintal
Straw @RS: 0.5/kg

Among the different treatments studied revealed that higher grain (7400kg/ha) and straw yield (9358kg/ha) was recorded in the treatment which received RDF + FYM +50% LR through granulated lime based on 45% Ca saturation (1.14 tonne/ha) as compared to remaining treatments. Among the granulated and powdered agriculture lime there was a higher yield was recorded in granulated lime (Table 4). It appears that liming increased soil pH and availability of nutrients which increased the yield components of paddy finally higher yields of paddy. Similarly liming had positive effects on the yield as reported by Lalljee and Facknath (2001). Application of calcium silicate @ 45 per cent calcium saturation level increased the both grain (69.75 q ha^{-1}) and stover yield (64.15 q ha^{-1}) of maize as reported by Shetty *et al.*, (2012). The treatment which received RDF + FYM + 50 % lime requirement through granulated lime based on 45% Ca saturation recorded higher gross returns (Rs 69,945.75), Net returns (Rs 33,292.73) and B: C ratio (1:90) followed by granulated lime ($CaCO_3$) @ 500 kg/ha as been recorded gross returns (Rs 67760.67) net returns (Rs 31427.04) and B: C (1.86) (Table 10).

In conclusion, liming to soil significantly increased soil pH, available nutrient status and crop yield. Granulated liming material recorded higher level of soil pH, available nutrient status and crop yield.

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