Effect of Calcium, Magnesium and Boron on Rice and their residual effects on Groundnut

Abstract

The study was carried out at Zonal Agricultural Research Station (ZARS) Brahmavar, Udupi district. To know the effect of Calcium, Magnesium (Mg) and Boron (B) on yield and yield components of rice and also their residual effect on groundnut. The geographical position of the area is between 74^0 45' to 74^0 46' East longitude and 13^0 24' 45'' to 13^0 25' 30'' North latitude and is at an altitude of 10 meters above mean sea level. Field experiments were established using three levels of Ca (0, 400 & 800 kg ha^{-1}), two levels of Mg (0 & 120 kg ha^{-1}) and foliar spray of boron at two levels (0 & 0.5 %) combined to give 12 treatments. Groundnut crop was grown as a residual crop in the same plots in which rice has been raised in the previous season, for this recommended dose of fertilizer was applied along with that borax was sprayed on the 45^{th} day after sowing. Results showed that the different combinations of Ca-Mg-B significantly influenced the yield and yield components of rice. The highest were recorded from Ca, Mg and B at 800 kg, 120 kg and 550 g ha^{-1} respectively. The lowest was recorded in control plot (Ca_0-Mg_0-B_0). In case of groundnut the highest was found from Ca, Mg and B at 800 kg, 120 kg and 550 g ha-1 respectively this treatment was limed in previously cultivated rice crop and the lowest was recorded from control plot.

Keywords: Rice, Residual Effect, Groundnut, Calcium, Magnesium and Boron

Introduction

Soil acidity is a major reason for low productivity in most of cultivated soils. In India, more than 45 million hectares of land is acidic and Karnataka is one among the several states where the acidic soils are spread over a large area (Sarkar, 2002). Out of total cultivated area of 104 lakh hectares in Karnataka, 12.3 lakh hectares of land is acidic (Ananthanarayana, 1996). Most of the acid soils have several limiting factors for plant growth, including toxic levels of Al, Mn, and iron (Fe), as well as deficiencies of some essential elements, such as phosphorus (P), nitrogen (N), potassium (K), calcium (Ca), Mg, and some micronutrients such as Mo and B (Kochian *et al.*, 2004), low microbial activity, poor fertility, and low crop yields. To meet the demands of calcium and magnesium, as well as to create favorable conditions for better uptake of other essential nutrients, liming is an important management practice in the acid soils helping in raising the pH and base saturation of the soil and inactivation of iron, aluminium and manganese in the soil solution and minimizing phosphate fixation by iron.

In coastal Karnataka, where soils are acidic and base unsaturated (Anil Kumar *et al.*, 2012), rice is the major cereal crop accounting to more than 90 per cent of the field crops grown in the cultivable land. Even though rice –pulse is the conventional cropping system of the coastal zone in Karnataka, of late, groundnut has replaced pulses in many taluks of the coastal districts of the state. The yield levels of both rice and groundnut in the coastal zones are low mainly because of low base saturation of the soils causing poor availability of essential nutrients to crops. These soils may differ in terms of their response to the amelioration measures taken up to rejuvenate them. Hence it is not only important to know the quantity of liming materials that has to be added to the soils originating under different agro-climatic situations, but to understand the changes some of the ameliorating practices may bring about in the quality of the acid soils that originate due to different reasons and their effect on yield of crops. The present study was undertaken to study the effect by applying different levels calcium and magnesium salts to low pH soil of coastal zone in Karnataka, along with foliar applied boron on yield and yield components of rice and their residual effects on proceeding ground nut crop.

Materials and Methods

The study was carried out in Kharif and Rabi seasons of 2011-2012 at Zonal Agricultural Research Station (ZARS) Brahmavar, in Udupi district, selecting rice – ground nut cropping sequence. The geographical position of the area is 74^0 45' to 74^0 46' East longitude and 13^0 24' 45'' to 13^0 25' 30'' North latitude and is at an altitude of 10 meters above mean sea level and comes under the Agro Climatic Zone 10 (Coastal Zone) of Karnataka with mean annual rain fall of 3500 mm. The soil of the experimental plot was sandy loan, acidic in reaction and low in available boron content.

Experimental procedures for Rice

The experiment was laid out in Randomized Complete Block Design with 3 replications. Experiment were established using three levels of Ca (0, 400 & 800 kg ha^{-1}), two levels of Mg (0 & 120 kg ha^{-1}) and foliar spray of boron at two levels (0 & 0.5 %) combined to give 12 treatments. The treatments were- T1:Ca_0 – Mg_0 – B_0, T2:Ca_0 – Mg_0 – B_1, T3:Ca_0 – Mg_1 – B_0, T4:Ca_0 – Mg_1 – B_1, T5:Ca_1 – Mg_0 – B_0, T6:Ca_1 – Mg_0 – B_1, T7:Ca_1 – Mg_1 –B_0, T8:Ca_1 – Mg_1 – B_1, T9:Ca_2 – Mg_0 – B_0, T10:Ca_2 – Mg_0 – B_1,T11:Ca_2 – Mg_1 – B_0 & T12:Ca_2 – Mg_1 – B_1.Unit plot size was 4×3.5 m. Calcium carbonate and magnesium carbonate was used as sources of the Ca & Mg elements respectively. Foliar spray of boron was tried with Borax. For rice variety **MO-4** was used**.** Recommended fertilizer dose for rice was 100-50-50 kg ha^{-1} N-P-K respectively Farmyard manure (10 t ha^{-1}) and liming materials (calcium carbonate and magnesium carbonate) were incorporated into the soil fifteen and ten days in advance of transplanting of the seedlings respectively. On the day of planting, the soil was once again puddled and levelled using spade. Fifty per cent of nitrogen and 100 per cent of phosphorus and potassium were applied and mixed well with the soil. Twenty five days old seedlings raised in a wet nursery were transplanted in the plots maintaining 20cm between rows and 10cm between hills. Since there was no rain on the day of transplanting, the plots were irrigated soon after planting of the seedlings maintaining 1cm height above ground level. The crop was not irrigated afterwards because of regular rainfall till harvest of the crop. Excess water was drained out 10 days before harvest of the crop. Weeds were removed by hand weeding on the 30^{th} day and 55^{th} day of transplanting and top dressing of the crop with remaining 50 percent nitrogen was done after the first weeding. Borax was sprayed to the crop after first weeding. Plant protection measures were undertaken as and when pests and diseases were noticed. The crop was harvested at maturity. The panicles and straw were harvested separately from each plot and were sun dried before taking the weight. Data on plants height at harvest (cm), tillers m^{-2} (no.), 1000-grain weight (g), straw yield (t ha^{-1}), grain yield (t ha^{-1}) were recorded.

Experimental procedures for groundnut

Groundnut crop was grown as a residual crop in the same plots in which rice had been raised the previous season. The soil in each plot was dug manually using spade and then levelled. The bunds were strengthened and the irrigation channels were repaired. it was assumed that the effect of liming would continue at least for the next crop. For this reason liming and Mg was not applied before groundnut. Entire quantity of recommended dose of N P K (25-75-38 kg ha^{-1}) fertilizers was applied and mixed well. Variety **TMV-2** was used. Seeds which were treated with fungicides were dibbled with a spacing of 30cm between rows and 15 cm between seeds and the plots were watered soon after sowing. Since there was enough residual moisture, the crop was irrigated only twice afterwards. Weeds were removed on the 15th, 30th and 45th day of sowing by hand weeding. Borax was sprayed on the 45th day after sowing of seeds. Crop was harvested at maturity; the pods were separated from the haulm and both of them were sun dried before taking the final weight. Data on plants height at harvest (cm), primary branches (no.), pods per plant (no.), unfilled pods per plant(no.), haulm yield (t ha^{-1}), grain yield (t ha^{-1}) were recorded. Shelling percentage of pods was determined using the formula

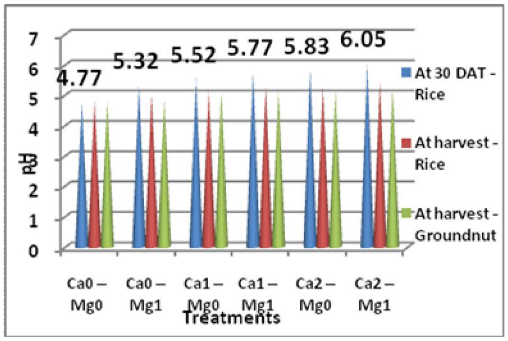
$$\text{Shelling percentage} = \frac{\text{Weight of kernels}}{\text{Weight of pods}} \times 100$$

Results and Discussion

The results of pre-seeding soil analysis indicated that the soil of the experimental site at ZARS, Brahmavar belonging to the order Oxisol is sandy loam in texture. The pH was 4.77 and organic carbon content was 1.48 per cent. Available N, P_2O_5, K_2O and S of soil were 276, 15.4, 82.9 kg ha^{-1} and 10.4 mg kg^{-1} respectively. The cation exchange capacity (CEC), exchangeable calcium, exchangeable magnesium, exchangeable potassium and exchangeable sodium content were 4.22, 1.12, 0.40, 0.093 and 0.055 cmol(p+)kg^{-1} respectively. The base saturation of soil was 39.5 per cent. Available B content was 0.45 mg kg^{-1}.

Soil pH was increased from 4.77 to 6.05 and Base saturation of the soil was increased from 40.6 per cent to 69.8 per cent indicating an increase by 29.2 per cent with the application of calcium and magnesium at different levels up to 30 days after transplanting there after the values showing decreasing trend but not less than the initial value (Fig.1 & 2). The positive effect of adding the two basic elements on pH of soil is evident from the fact that there was significant increase in exch.Ca and Mg contents of the soil after their application (Jena and Kabi, 2012) (Fig.3 & 4) and calcium has greater displacement ability of adsorbed H^+ and Al^{3+} ions from the exchange complex. Several workers have reported about an increase in soil pH by the application of Ca (Sudhir *et al.*, 1987 and Nagaraja *et al.*, 2012) and magnesium (Sudhir *et al.*, 1987 and Rensburg *et al*., 2009).

The reason for further decline in the pH and base saturation in the soil during the period from harvest of rice to harvest of groundnut could be attributed to absorption of bases by the crop and leaching of them from the soil which is coarse textured. This is in accordance with the report of Ananthanaryana (1969) and Vishwanatha shetty *et al*. (2012).



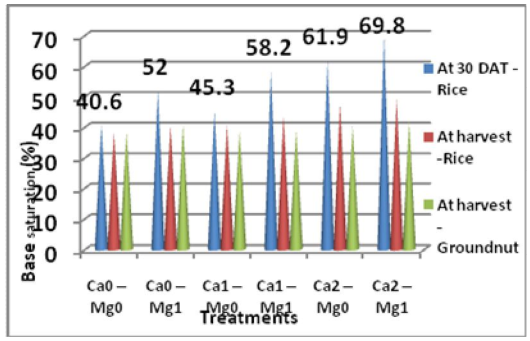
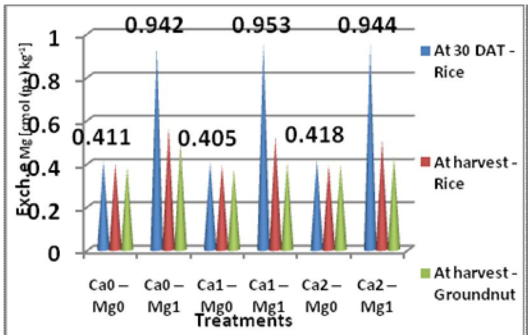


Fig1: Effect of different combinations of Ca-Mg levels on pH of soil

Fig2: Effect of different combinations of Ca-Mg levels on base saturation of soil



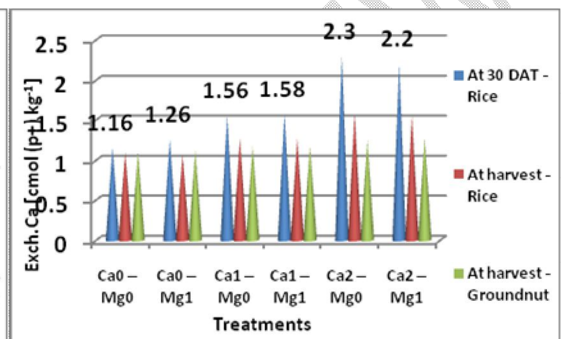


Fig3: Effect of different combinations of Ca-Mg levels on exchangeable Ca of soil

Fig4: Effect of different combinations of Ca-Mg levels on exchangeable Mg of soil

Effect of application of calcium and magnesium on growth and yield parameters of rice

Effect of treatment (Ca-Mg-B) was significant on all the growth and yield parameters i.e. number of tillers per hill, number of productive tillers per hill, plant height at harvest, grain yield, straw yield and 1000 grain weight of rice.

The fact that the number of tillers per hill, number of productive tillers per hill and plant height at harvest were increased by increasing the levels of application of the three nutrient elements indicated synergistic effects not only when only two of them were applied together but also when all the three of them were applied together. These results are in accordance with that of Rajasree and Pillai (2001). Saleem *et al.* (2011) have reported significant increase in the tiller numbers of rice due to the application of B (Table 1).

Application of Ca and Mg at their increased levels significantly increased the grain yield as well as straw yield of rice. The highest yield was obtained at Ca_2-Mg_1-B_1 levels of the three nutrients. There are several reports regarding the beneficial effect of Ca and Mg on grain yield of rice (Sudharmaidevi *et al*., 2012). Liming gradually raised soil pH, decreased exch. Al and H+ and increased CEC and in turn the nutrient availability and an increase in grain and straw yield (Manoj kumar *et al*., 2012). Application of B alone or in combination with Ca and Mg increased the grain yield significantly. The yield increase was due to the increased chlorophyll content, photosynthetic activity of the leaves, dry matter accumulation, advanced flowering and stimulation of the reproductive organs, there by significantly improving the growth and yield of the crop (Duyingqiong *et al.*, 2002). Dharmendra (2012) reported that boron application at critical stages like anthesis enhanced seed set and grain filling in rice. Boron nutrition played an important role in rice productivity due to its role in the development of panicles in rice in acid soils (Hossain *et al.*, 2011& Arporn *et al.* 2013).

Table 1: Effect of different combinations of calcium, magnesium and boron on plant growth and yield parameters of rice crop

Treatments	Plant height at harvest (cm)	No. tillers hill^{-1}	No. productive tillers hill^{-1}	1000 grain weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
$Ca_0 - Mg_0 - B_0$	61.6	12.3	9.30	24.1	40.9	54.8
$Ca_0 - Mg_0 - B_1$	64.7	13.5	10.6	24.9	43.5	58.7
$Ca_0 - Mg_1 - B_0$	63.7	13.2	10.0	24.5	43.4	59.0
$Ca_0 - Mg_1 - B_1$	68.4	14.0	11.6	25.2	46.5	60.9
$Ca_1 - Mg_0 - B_0$	65.6	13.5	10.0	25.1	45.7	60.7
$Ca_1 - Mg_0 - B_1$	69.4	14.7	12.3	26.3	48.0	61.1
$Ca_1 - Mg_1 - B_0$	71.3	14.7	12.6	25.7	48.4	61.4
$Ca_1 - Mg_1 - B_1$	75.0	15.3	13.3	26.8	52.5	66.6
$Ca_2 - Mg_0 - B_0$	70.1	14.0	11.3	26.2	47.0	60.4
$Ca_2 - Mg_0 - B_1$	72.0	14.3	12.0	28.3	49.7	60.4
$Ca_2 - Mg_1 - B_0$	71.7	14.8	12.8	27.9	50.7	63.4
$Ca_2 - Mg_1 - B_1$	75.6	15.0	13.7	29.2	53.5	68.6
SEm±	1.90	0.48	0.33	0.72	1.36	1.96
CD (5%)	5.68	1.45	0.98	2.10	4.10	5.90

Effect of application of calcium, magnesium and boron on growth and yield parameters of groundnut crop

Plant height, number of primary branches per plant, number of pods per plant, pod and haulm yield and shelling percentage were increased with increasing levels of application of the three nutrient elements either individually or in Ca - Mg – B. On the contrary, number of unfilled pods per plant was decreased by an increase in the levels of the three elements. The reason for positive effect of treatments on growth parameters of the crop might be attributed to enhanced synthesis of carbohydrates, fats and proteins constituting the kernels under the influence of high fertility level in the soils (Table 2).

Calcium is directly related to protein synthesis by its enhancement of the uptake of nitrate nitrogen and also due to its association with the activity of certain enzyme systems and magnesium has a role in protein synthesis, chlorophyll formation as it is an essential constituent of polyribosome (Agarwal and sharma 1976). The reports of Sudhir *et al.* (1987) are in conformity as regards the beneficial effect of Ca and Mg on the growth and yield parameters of groundnut. Increased yield of groundnut due to liming has also been reported by Bheemaiah and Ananthanarayana (1984). Duyingqiong *et al.* (2002) & Nalini and Bhavana, 2013, reported that application of B significantly increased chlorophyll content, photosynthetic activity of the leaves, dry matter accumulation, advanced flowering and promoted the reproductive organs This might be the reason for increase in the number of pods and decrease in number of unfilled pods per plant at the same time.

Table 2: Effect of different combinations of calcium, magnesium and boron levels on plant growth and yield parameters of groundnut crop

Treatments	Plant height at harvest (cm)	No. primary branches plant^{-1}	No. pods plant^{-1}	No. unfilled pods plant^{-1}	Pod yield (q ha^{-1})	Haulm yield (q ha^{-1})	Shelling percentage (%)
$Ca_0 – Mg_0 – B_0$	34.0	5.00	20.0	6.33	12.5	14.4	60.3
$Ca_0 – Mg_0 – B_1$	35.3	5.20	24.7	4.50	14.7	16.6	61.4
$Ca_0 – Mg_1 – B_0$	34.3	5.30	22.3	5.07	12.8	14.7	61.3
$Ca_0 – Mg_1 – B_1$	37.7	5.33	26.0	4.54	15.0	16.3	62.3
$Ca_1 – Mg_0 – B_0$	36.7	5.55	24.7	4.83	13.8	15.5	61.7
$Ca_1 – Mg_0 – B_1$	37.3	5.63	27.7	4.00	15.8	17.8	63.0
$Ca_1 – Mg_1 – B_0$	36.0	5.67	25.3	4.65	14.9	16.8	64.3
$Ca_1 – Mg_1 – B_1$	39.0	5.80	28.7	3.50	17.0	18.2	65.3
$Ca_2 – Mg_0 – B_0$	37.0	6.00	26.3	4.55	16.3	18.9	62.0
$Ca_2 – Mg_0 – B_1$	38.7	5.75	28.0	3.62	16.8	19.0	62.3
$Ca_2 – Mg_1 – B_0$	38.7	5.83	25.3	4.33	16.4	18.4	64.7
$Ca_2 – Mg_1 – B_1$	41.7	6.00	30.7	3.00	17.3	20.5	65.7
SEm±	0.58	0.164	0.52	0.17	0.37	0.34	-
CD (5%)	1.69	0.492	1.53	0.49	1.13	0.99	NS

Conclusion

The application of basic cations to soil before sowing/ planting of crops brought about an increase in the contents of exchangeable Ca and exchangeable Mg contents of soils and hence an increase in base saturation of soils with consequent increase in pH of soils. The yields of crops were increased with increasing levels of application of calcium and magnesium. Perusal of the results indicated that Ca and Mg applied to the main crop of rice could still have its positive effect on the groundnut crop raised subsequently in the same field. This would imply that the quantities of calcium and magnesium tried in this experiment are sufficient to improve the soil properties and hence crop yields. But, the results indicated that there was certainly a need for fresh application of the two elements to the soil in order to achieve good yields in the next crop cycle. Application of boron resulted in increased yield when applied alone or along with calcium and magnesium. Calcium and magnesium also played direct positive roles as nutrient elements in improving yields of crops.

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