Effect of dolomite on growth, productivity, economics of groundnut and soil properties in *alfisols*

ABSTRACT

A field experiment was conducted to study the effect of dolomite on the growth, and productivity of groundnut and soil properties at the Main Agricultural Research Station, UAS, Dharwad, Karnataka during *kharif* 2019. The experiment was laid out in a randomized complete block design consisting eight treatments (Control, Gypsum @ 500 kg ha^{-1}, Dolomite @ 250, 500, and 750 kg ha^{-1}, Cured dolomite with FYM @ 250, 500 and 750kg ha^{-1}) with three replications. Results of the study showed that higher growth parameters *viz.,* plant height (48.3 cm), number of branches per plant (8.5), leaf area (19.6 dm^2 plant^{-1}), leaf area index (6.53) and dry matter production per plant (40.48 g plant^{-1}) at harvest were recorded with the application of cured dolomite with FYM @ 750 kg ha^{-1}. Significantly higher kernel yield (19.8 q ha^{-1}) and net returns (₹ 66,240 ha^{-1}) were recorded with the application of cured dolomite with FYM @ 750 kg ha^{-1} which was found on par with application of cured dolomite with FYM @ 500 kg ha^{-1}, dolomite @ 750 kg ha^{-1} and dolomite @ 500 kg ha^{-1}. The same trend was observed in case of soil chemical properties *viz.,* calcium and magnesium content in the soil after harvest of groundnut. Thus, it was found that application of dolomite @ 500 kg ha^{-1} was found better either with curing or without curing by using FYM.

Key words: Groundnut, dolomite, calcium, oil yield, soil properties.

1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop of India and it plays a major role in bridging the vegetable oil deficit in the country and also an important agricultural export commodity. It is a leguminous crop plant that is widely cultivated in the tropics and sub-tropics between 40^0 N and 40^0 S latitudes valued for its high-oil edible seeds and such it is the fourth most important source of vegetable protein in the world. Groundnut is an important protein crop in India mostly grown under rainfed conditions. In India, though groundnut is cultivated in one or more seasons (*kharif, rabi,* summer) nearly 80 percent of the annual acreage and production comes from the *kharif* crop (June- October). India is the second largest producer of groundnuts in the world Anon., [1].

Almost every part of groundnut has commercial value, 80 per cent of its production is used for oil extraction, 12 per cent for seed, 6 per cent for edible purpose and 2 per cent for export purpose. Groundnut kernels contain 42 to 50 per cent oil, 26 per cent protein, 18 per cent carbohydrates, 11.5 per cent starch, 4.5 per cent soluble sugar, 2.1 per cent crude fiber and is also rich source of riboflavin, thiamine, nicotinic acid and vitamin E [2]. It's a dietary source of calcium, iron, zinc, magnesium, phosphorus and potash. Its high protein, unsaturated fats, carbohydrates, vitamins and mineral contents makes it an important dietary component in many countries. Groundnut cake contains on an average 7 to 8 per cent N, 1.5 per cent P, 1.2 per cent K, 22 to 30 per cent carbohydrates, 45 to 60 per cent proteins, 4.0 to 5.7 per cent minerals and 3.8 to 7.5 per cent crude fibre [3].

Globally, the crop is cultivated in an area of 32.7 million hectares with a total production of 53.9 m t and the average productivity is 1,776 kg ha^{-1}. The annual global export of groundnut is 2 m t, with an annual all-season coverage of about 70 lakh hectares. China and India are the world's leading groundnut producers, together accounting for nearly 60 per cent of the production and 52 per cent area [1]. In India groundnut is grown in an area of 5.42 m ha with a total production of 10.1 m t and productivity of 1,663 kg ha^{-1} [1]. Gujarat tops with 27.87 per cent of total production followed by Andhra Pradesh at 24.19 per cent, Tamil Nadu 14.84 per cent and Karnataka 10.95 per cent. Maharashtra, Madhya Pradesh, Rajasthan, Odisha, Uttar Pradesh and West Bengal are other groundnut-producing states.

Although groundnut is a self-fertilizing crop on the other hand it is very exhaustive as compared to other legumes. The balanced application of nutrients is the key to optimizing the production of groundnut [4]. Groundnut seed development is unique from other plants. Once flowers are pollinated, a peg is formed which moves downward as a geotropic movement and then moves horizontally called dia-geotropic movement. Calcium is the most critical element in the growth and development of groundnut pegs, pods and seeds and is the main limiting factor of groundnut production in many parts of the country [5]. For groundnut about 1 milli equivalent of exchangeable Ca 100 g^{-1} of soil in the root zone and three times this much in the pod formation zone are considered as threshold levels. So, it is very important that adequate levels of calcium should be present in the top 10-15 cm of soil, or pegging zone [6] because that is the zone where developing pods must acquire calcium.

Calcium deficiency leads to higher percentage of aborted seeds (empty pods) and unfilled or partially filled pods called pops [7]. It also leads to shriveled fruit, including darkened plumules and production of pods without seed. The presence of enough calcium content in the soil prevents the formation of black hallow and cracked pods, decreases aflatoxin production and consequently decreases decayed pod of groundnut [8].

Dolomite ($CaCO_3$. $MgCO_3$) is a double carbonate salt, having an alternate structural arrangement of calcium and magnesium ions. It has 21.73 per cent calcium, 13.18 per cent magnesium. Dolomite is widely used superior high calcium lime that increase soil pH and soil calcium levels [9, 10, 11]. It improves the physical, chemical and biological conditions of the soil, neutralizes the soil acidity and cuts fertilizer cost through improved fertilizer use efficiency. Dolomitic lime addition is needed to increase the availability of calcium and magnesium as well as to increase the concentration of basic cations like potassium, calcium and magnesium [12].

Groundnut is the most widely grown oilseed crop in peninsular India and some areas under coastal ecosystem shows formation of acidic soils particularly, in coastal Tamil Nadu, Kerala, Karnataka and Goa [13]. Nearly, one lakh hectares in the sea coast of India (east and west coast) represents such groundnut area. Keeping all the above points in view the present study was conducted in acidic soils to investigate the effect of dolomite on growth, productivity of groundnut and soil properties in *Alfisols*.

2. MATERIAL AND METHODS

A Field experiment entitled “Effect of dolomite on growth, productivity and economics of groundnut and soil properties in *alfisols”* was conducted at Main Agricultural Research Station, UAS, Dharwad, Karnataka, under rainfed conditions during *kharif* 2019 on red sandy loam soils having low organic carbon (4.5 mg kg^{-1}), pH (6.34), Electrical conductivity (0.21 dS m^{-1}), exchangeable calcium (1.31cmol (p^{+}) kg^{-1}), exchangeable magnesium (0.87cmol (p^{+}) kg^{-1}), available nitrogen (276.5 kg ha^{-1}) and medium available phosphorus (18.6 kg ha^{-1}) and potassium (196.2 kg ha^{-1}) and acidic in reaction.

2.1 Impact of weather parameters on crop performance

Growth and crop performance mainly depend on climatic and environmental conditions. Variations in weather conditions significantly influence the crop growth and development which in turn influences yielding ability. In the study area, 80 per cent of the groundnut crop is grown under rainfed. The crop is usually planted between 1st June and 15th July based on the usual onset of the monsoon. The unpredictable advent of monsoon and the beginning of sowing rainfall, however, often causes the farmers to sow the crop late in the season. Yield variation in rainfed groundnut can be attributed to rainfall variability *i.e.*, intensity and distribution of rainfall. The efficacy of rainfall in crop production depends primarily on start of sowing rain and the amount and distribution of rainfall during the season, as water deficit is a major constraint in groundnut production, especially during the critical flowering and pod set, resulting in a reduced pegging [14, 15]. Groundnut crop could be successively grown in area which receives 400 to 500 mm of well-distributed normal rainfall during crop growth period. The study area receives normal annual rainfall (1950 to 2018) of 735.1 mm. The total amount of rainfall received during the year of experiment was 1316.2 mm from January to December which was 424 mm higher than the average of the past 69 years. The crop was sown on 17th July with the onset of monsoon and uprooted on 6th November. The rainfall received during the experimental period was 1,133 mm. It is 2.35 times higher than the normal. Since the experiment was laid out with 3 percent gentle slope in red sandy loam soil, the crop never encountered the waterlogging situation until its maturity. Further, due to the effective drainage condition of the experimental site, the rainfall received during flowering (230.8 mm in 17 rainy days), pegging (451.2 mm in 17 rainy days) and pod formation stage (106.8 mm in 10 rainy days) turned as a boon to the crop and provided congenial soil moisture level resulting an average yield of >2000 kg per ha. The rainfall received at the time of maturity helped in the efficient uprooting of the crop.

Temperature also affects groundnut production. Warm and humid weather is more favorable than cold and humid atmosphere, resulting in slow germination and seedling emergence increasing the risk of seed and seedling diseases. During the cropping season highest maximum temperature was noticed in October (27.9 ºC) and the lowest maximum temperature in August (26.4 ºC) while the highest minimum temperature was noticed in August (20.4 ºC) and the lowest minimum temperature in October (19.0 ºC). This clearly indicated that crop experienced warm and moist conditions. Temperature is also a major environmental factor that determines the rate of growth of crops. Temperature > 35 ºC inhibits the growth of groundnut. In the present study, in none of the crop stages, the temperature exceeded 35 ºC. The lowest relative humidity of 79.8 per cent in October and highest relative humidity of 87.6 per cent were noticed in August.

The experiment was laid out in randomized complete block design with eight treatments: T_1: Control, T_2: Gypsum @ 500 kg ha^{-1}, T_3: Dolomite @ 250 kg ha^{-1}, T_4: Dolomite @ 500 kg ha^{-1}, T_5: Dolomite @ 750 kg ha^{-1}, T_6: Cured dolomite with FYM @ 250 kg ha^{-1}, T_7: Cured dolomite with FYM @ 500 kg ha^{-1}, T_8: Cured dolomite with FYM @ 750 kg ha^{-1} replicated thrice. Groundnut variety G2-52 was sown on 17^{th} July 2019 with a spacing of 30 cm × 10 cm. The recommended dose of N: P_2O_5: K_2O (18:46:25 kg ha^{-1}) and FYM @ 7.50 t ha^{-1} was applied uniformly to all the treatments at the time of sowing as a basal dose.

2.2 Curing:

Curing of dolomite with FYM in 1:2 proportion (Dolomite: FYM) was done before application and incubated for 15 days in air tight bag. At the pegging stage (45 DAS) cured dolomite, dolomite and gypsum were applied to the crop according to the treatments. The FYM required for curing dolomite in T_6, T_7, T_8 was compensated in the basal dose of FYM. Harvesting of crop was done on 6^{th} November 2019.

Growth parameters, yield parameters and yield of the crop was recorded at harvest and chemical properties of soil were analyzed after harvest of the crop. Oil content was estimated after air drying of the kernels.

2.3 Statistical analysis:

Interpretation of the data was carried out in accordance with Gomez and Gomez [16]. The level of significance used in the 'F' and 't' test was p=0.05. The critical difference values were calculated wherever the 'F' test values were significant. The treatment means were compared by applying Duncan's Multiple Range Test (DMRT) by using the statistical software MSTAT-C.

3. Results and discussion

3.1 Effect of dolomite on growth parameters of groundnut

The growth components of groundnut like plant height, branches $plant^{-1}$, leaf area, leaf area index and total dry matter production per plant did not varied significantly with dolomite application as shown in table (1). Nevertheless, with increasing the cured dolomite dosage to 750 kg ha^{-1} all the growth parameters *viz.,* plant height (48.3 cm), number of branches per plant (8.5), leaf area (19.6 $dm^2 plant^{-1}$), leaf area index (6.53) and total dry matter production per plant (40.48 g) increased numerically. This could be due to the fact that calcium maintains the cell integrity and cell membrane permeability, activates number of enzymes for cell division leading to enhanced growth of the crop. It also helps in the vascular bundle development which could have indirect effect on crop growth. Increased growth parameters in the dolomite application treatments over the gypsum application treatment might be ascribed to the dolomite's liming effect, which improves the soil structure and would have led to better nutrient uptake by the crop due to congenial soil conditions. Use of dolomite instead of gypsum will provide not only calcium and magnesium for the crop but also improves the availability of other nutrients. Similar conclusions are published by Ghosh et al. and Mandal et al. [17, 18].

3.2 Effect of dolomite application of yield and economics of groundnut

Kernel yield varied significantly with dolomite application even though pod yield was found non-significant. Significantly higher kernel yield was recorded with the application of cured dolomite with FYM @ 750 kg ha^{-1} (19.8 q ha^{-1}) and it was found on par with application of cured dolomite with FYM @ 500 kg ha^{-1} (19.6 q ha^{-1}), dolomite 500 kg ha^{-1} (19.3 q ha^{-1}) and dolomite @ 750 kg ha^{-1} (19.2 q ha^{-1}). Gypsum application @ 500kg ha^{-1}, Dolomite 250 kg ha^{-1} and Cured dolomite with FYM @ 250 kg ha^{-1} were found on par with each other whereas lowest kernel yield (15.1 q ha^{-1}) was observed in control in which gypsum and dolomite were not applied. Kernel yield increased by 31.7 percent over control with application of cured dolomite with FYM @ 750 kg ha^{-1} and 6.5 percent compared to gypsum @ 500 kg ha^{-1}. Variation existed between application of dolomite @ 500 kg ha^{-1} to cured dolomite 500 kg ha^{-1} was 1.3 percent and the difference between application of dolomite @ 500 kg ha^{-1} and cured dolomite @ 750 kg ha^{-1} was 2.6 percent. The increased kernel yield could be due to increased shelling percentage, 100 kernel weight and reduced pops percentage and the lower kernel yield might be due to lower shelling percentage, 100 kernel weight and higher pops percentage. 4.6 percent reduction in pops percentage was noticed due to application of cured dolomite with FYM @ 750 kg ha^{-1} over control and 1.6 percent reduction in pops percent over gypsum @ 500 kg ha^{-1}. Dolomite is an ameliorant that supplies calcium and magnesium nutrients to the crop which are important for gynophore formation and filling of pods. The increased kernel yield in the cured dolomite application treatment could be due to the availability of sufficient amount of calcium in the pod zone of the crop at critical period of calcium requirement which resulted in reduced pops percentage (4.6 % reduction as compared to control). Besides supplying calcium and magnesium, the application of dolomite also increased the pH of soil. With increasing the soil pH, availability of nutrients increases especially phosphorus which is fixed in the soil as aluminium phosphate and iron phosphate and hence better performance of the crop Seopardi [19]. The additional effect noticed due to curing of dolomite with FYM was the better release and availability of nutrients and reduced losses of nutrients by different mechanisms from the dolomite as compared to the treatment in which dolomite was applied without curing. The results of present study are consistent with documentation of Sutriadi and Setyorini [20] who reported that due to application of dolomite plus, dry weight of peanut seed increases twice as compared to application of NPK fertilizer application alone.

Pod yield of groundnut was found non-significant due to application of dolomite. Non significantly higher pod yield (26.9 q ha^{-1}) was recorded with application of cured dolomite with FYM @ 750 kg ha^{-1} which was followed by application of cured dolomite with FYM @ 500 kg ha^{-1} (26.5 q ha^{-1}), dolomite @ 750 kg ha^{-1} (26.3 q ha^{-1}) and dolomite 500 kg ha^{-1} (26.1 q ha^{-1}) whereas lowest pod yield was recorded in control (22.4 q ha^{-1}) in which dolomite and gypsum were not applied. The volume of progressive increase was much between dolomite application @ 250 to 500 kg ha^{-1} than that between 500 to 750 kg ha^{-1}. The pod yield of groundnut increased to the extent of 20.2 percent with cured dolomite with FYM @ 750 kg ha^{-1} over control and 4.46 percent gypsum application @ 500 kg ha^{-1}. 18.5 percent increased yield was observed due to application of cured dolomite with FYM @ 500 kg ha^{-1} over control and 2.9 percent increased pod yield was noticed over gypsum application @ 500 kg ha^{-1}. Similar findings were reported in which filled pods $plant^{-1}$ of groundnut increased and pops $plant^{-1}$ decreased due to increasing levels of calcium application and hence resulted in higher pod yield of groundnut Kumar et al. [21]. The lowest pod yield was recorded in control (22.4 q ha^{-1}) in which dolomite and gypsum were not applied. The decreased pod yield could be due to the fact that calcium was not available to the crop during the flowering stage which lead to decreased percent of filled pods and increased pops percent. The results are in line with the findings of Kamara et al. and Agasimani and Hosmani [22], [23] who stated that pod yield of groundnut reduced when calcium was not applied to the crop due to reduced sound mature kernel percent.

The economic returns indicate the sustainability and profitability of crop production. Farmers' adoption of new technologies depends on net returns of the system which is an important indicator of monetary efficiency. In the present investigation, application of dolomite has significant influence on the net returns of groundnut. Significantly higher net return were recorded with the application of cured dolomite with FYM 750 kg ha^{-1} (₹ 66,240 ha^{-1}) whereas lower net return were recorded in the control (₹ 44,390 ha^{-1}). Gross return and B:C ratio did not vary statistically with dolomite application. However, higher gross return (₹ 1,43,141 ha^{-1}) and B:C ratio (1.86) were documented with application of cured dolomite with FYM @ 750 kg ha^{-1} whereas lower gross return (₹ 1,19,018 ha^{-1}) and B:C ratio (1.59) were recorded in the control.

3.3 Effect of dolomite application on the chemical properties of soil after harvest of groundnut

Soil chemical properties like pH, EC and OC status did not varied statistically with dolomite application after groundnut harvest but the improvement was noticed from the initial values (pH 6.34 and EC 0.21 dS m^{-1}). Higher pH and EC (6.41 and 0.237 dS m^{-1}) were noticed with application of dolomite @ 750 kg ha^{-1} followed by cured dolomite with FYM @ 750 kg ha^{-1} (6.39 and 0.230 dS m^{-1}) respectively. This could be due to the fact that a sudden increase in the chemical properties of soil is not possible within a single season and it requires long-term application to get a change in the chemical properties to a desirable level. With increasing the dose of dolomite, calcium and magnesium bases addition will increase in the soil furthermore they substitute aluminum in the soil leading to an increase in the pH in the dolomite application treatments over the gypsum applied treatment. These results are consistent with the findings of Sutriadi and Setyorini [20] who reported that with increasing dolomite plus application rate up to 3200 kg ha^{-1}, pH increased from 4.3 to 6.2.

Organic carbon status of soil did not varied significantly due to dolomite application. The initial organic carbon status was 4.5 g kg^{-1}. However, numerically higher organic carbon (5.6 g kg^{-1}) was recorded with the application of cured dolomite with FYM @ 750 kg ha^{-1} followed by the application of cured dolomite with FYM @ 500 kg ha^{-1} (5.3 g kg^{-1}), dolomite @ 750 kg ha^{-1} (5.2 g kg^{-1}) and dolomite @ 500 kg ha^{-1} (5.1 g kg^{-1}). Higher organic carbon content with curing of dolomite might be because of the better availability and release of nutrients from dolomite and hence increasing the fertility of the soil by increased organic carbon content.

The exchangeable calcium and magnesium content of soil varied significantly with dolomite application. Significantly higher calcium and magnesium content in the soil after groundnut harvest was observed with cured dolomite with FYM @ 750 kg ha^{-1} (1.61, 1.17 cmol (p^{+}) kg^{-1}) respectively. This could be due to the higher doses of dolomite application over other treatments. Results of present investigation are consistent with the conclusion of Murata [24] who observed that with increasing dolomite dose upto 4000 kg ha^{-1}, calcium and magnesium content in the soil increased from 106 to 236 mg kg^{-1} and 26 to 42 mg kg^{-1} accordingly in the year 2000-2001 in Zimbabwe.

4. CONCLUSION

As the calcium composition in dolomite (21.73 % Ca) and gypsum (23.3 % Ca) is almost similar, dolomite application @ 500 kg ha^{-1} was found on par with application of gypsum @ 500 kg ha^{-1} with respect to most of the growth and yield parameters of groundnut. The progressive increase in yield observed with dolomite application between 500 to 750 kg ha^{-1} was tiny as compared to the progressive increase observed between 250 to 500 kg ha^{-1}. It clearly indicated that in the present study groundnut responded up to 500 kg ha^{-1} either with or without curing of dolomite and thereafter law of diminishing marginal returns has been observed *i.e.*, adding an additional factor of production (dolomite) would actually result in smaller increases in output (yield) and similar difference existed between cured and uncured treatments. In addition, looking to the bulky nature of the dolomite for transport, application of dolomite @ 500 kg ha^{-1} can be recommended to obtain higher yield and higher net returns along with improvement in soil chemical properties namely pH and EC.

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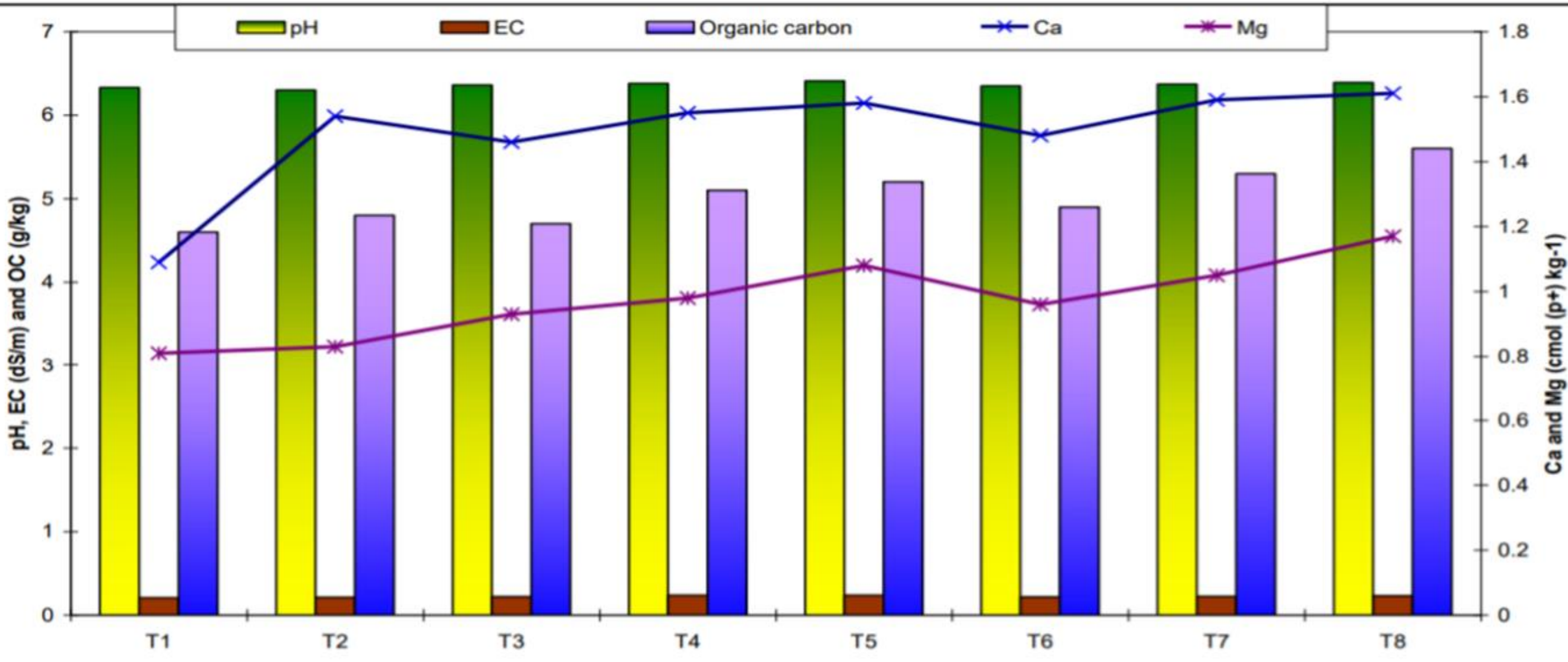
Table 1: Growth parameters of groundnut at harvest as influenced by application of dolomite

Treatment	Plant height (cm)	Branches per plant	Leaf area ($dm^2 plant^{-1}$)	Leaf area index	Dry matter production (g $plant^{-1}$)
T_1: Control (No gypsum and dolomite)	34.9^b	7.9^a	17.44^a	5.81^a	33.16^a
T_2: Gypsum @ 500 kg ha^{-1}	44.3^a	8.2^a	18.66^a	6.22^a	37.17^a
T_3: Dolomite @ 250 kg ha^{-1}	43.8^a	8.1^a	18.38^a	6.13^a	36.71^a
T_4: Dolomite @ 500 kg ha^{-1}	46.9^a	8.3^a	18.81^a	6.27^a	38.70^a
T_5: Dolomite @ 750 kg ha^{-1}	47.7^a	8.4^a	19.15^a	6.38^a	39.10^a
T_6: Cured dolomite with FYM @ 250 kg ha^{-1}	44.9^a	8.0^a	18.58^a	6.19^a	36.68^a
T_7: Cured dolomite with FYM @ 500 kg ha^{-1}	47.4^a	8.4^a	19.28^a	6.43^a	39.28^a
T_8: Cured dolomite with FYM @ 750 kg ha^{-1}	48.3^a	8.5^a	19.60^a	6.53^a	40.48^a
S.Em. ±	3.41	0.58	1.69	0.56	3.32
CV (%)	9.36	8.75	11.05	11.05	10.81

Table 2: Yield and economics of groundnut as influenced by application of dolomite

Treatment	Dry pod yield (q ha^{-1})	Kernel yield (q ha^{-1})	Cost of cultivation (₹ ha^{-1})	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	B:C Ratio
T_1: Control (No gypsum and dolomite)	22.4^a	15.1^b	74624	1,19,018^a	44,390^b	1.59^a
T_2: Gypsum @ 500 kg ha^{-1}	25.7^a	18.6^{ab}	75124	1,37,034^a	61,910^a	1.82^a
T_3: Dolomite @ 250 kg ha^{-1}	24.3^a	17.1^{ab}	74949	1,29,272^a	54,320^{ab}	1.72^a
T_4: Dolomite @ 500 kg ha^{-1}	26.1^a	19.3^a	75274	1,39,218^a	63,940^a	1.85^a
T_5: Dolomite @ 750 kg ha^{-1}	26.3^a	19.2^a	75599	1,40,277^a	64,680^a	1.86^a
T_6: Cured dolomite with FYM @ 250 kg ha^{-1}	25.7^a	18.5^{ab}	76249	1,36,518^a	60,270^a	1.79^a
T_7: Cured dolomite with FYM @ 500 kg ha^{-1}	26.5^a	19.6^a	76574	1,41,129^a	64,560^a	1.84^a
T_8: Cured dolomite with FYM @ 750 kg ha^{-1}	26.9^a	19.8^a	76899	1,43,141^a	66,240^a	1.86^a
S.Em. ±	2.03	1.45	-	10502	10502	0.13
CV (%)	9.77	9.67	-	9.47	10.86	9.45



T_1: Control (No gypsum and dolomite)
T_2: Gypsum at the rate of 500 kg ha^{-1}
T_3: Dolomite at the rate of 250 kg ha^{-1}
T_4: Dolomite at the rate of 500 kg ha^{-1}
T_5: Dolomite at the rate of 750 kg ha^{-1}
T_6: Cured dolomite with FYM at the rate of 250 kg ha^{-1}
T_7: Cured dolomite with FYM at the rate of 500 kg ha^{-1}
T_8: Cured dolomite with FYM at the rate of 750 kg ha^{-1}

Fig. 1: Chemical properties of soil after harvest of groundnut as influenced by application of dolomite