Effect of LD slag application on yield attributes, yield and protein content of groundnut kernel in acid soil of Bhubaneswar, Odisha

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ABSTRACT

A field experiment was carried out at the Central Horticultural Research Station, OUAT, Bhubaneswar, Odisha to explore the possibility of using low cost liming material like LD (Linz-Donawitz) slag to ameliorate acid soil and its impact on productivity of groundnut and its protein and oil content. Soil amelioration with LD slag @ 30 per cent lime requirement (LR) in conjunction with inorganics and vermicompost improved the growth, nutrient concentration and yield of the crop. The LD slag used in this study contained 32.5 per cent calcium carbonate which was applied at 30 per cent of LR along with organic and inorganic fertilizers in different treatments. The yield attributes viz plant height (37.98 cm) , stover yield (4.69 tonnes/ha), biological yield (8.2 tonnes/ha), number of pods per plant (22.33), pod yield (2.46 tonnes/ha), 1000-kernel weight (288.21 g), shelling percentage (77.36) and oil content (48.60%) were recorded highest in the treatment receiving LD slag, 100 per cent recommended dose as inorganic fertilizer and vermicompost. Highest crude protein content (26.19%) was also recorded in the above treatment. LD slag was found to be useful in enhancing biomass, protein content, yield and oil content of kernel. However no significant differences were observed when LD slag was applied without organic fertilizer.

Keywords: Acid soil; groundnut; LD slag; lime requirement; yield; protein

INTRODUCTION

Groundnut *(Arachis hypogaea* L) is an important oilseed crop of tropical and subtropical regions of the world. Although India is the second largest groundnut producing country but the groundnut productivity is quite low as compared to other countries. The main cause for the low production of groundnut is that though it is an energy-rich crop it is generally grown under energy-starved conditions such as acid soils. Under acidic conditions beneficial nutrients such as nitrogen, phosphorus, sulphur and calcium are in deficient concentration. The low yields of groundnut are owing to poor pod filling in acid soils which is because of poor calcium supplying power of soil. Hence efforts are often made to meet the calcium demands as well as to create favourable conditions for better uptake of other essential nutrients particularly phosphorus maintaining soil biological health for improving the yield of this crop.

The management of acid soil is thus most important to obtain higher productivity of the crop on sustainable basis (Caires et al 2008). Limestone is the most common liming material for ameliorating acid soil but small and marginal farmers of eastern India could not afford to purchase lime in the form of pure $CaCO_3$ or $MgCO_3$ because of their higher cost. Alternative cheap sources of liming material like LD (Linz-Donawitz) slag from by-products of steel industry that contain $CaCO_3$ can be used to ameliorate acid soil. Despite sporadic work carried out on soil amelioration using LD slag and its impact on crop growth, productivity and nutrients uptake in different parts of the world (He et al 2009) there is a paucity of information on appropiate application rates of LD slag and its effects on crop productivity of groundnut under high rainfall (about 1500 mm annual rainfall) tropical monsoon climate of eastern India. Keeping all these facts under consideration the present investigation was conducted.

MATERIAL and METHODS

The field experiment was conducted in Rabi season of 2014-15 at the Central Horticultural Research Station, OUAT, Bhubaneswar, Odisha with groundnut (TAG-24) as test crop. The site is located at 25°15'N latitude and 80°52'E longitude and altitude of 30 m above mean sea level. The experimental site experiences a high temperature in summer and mild during winter and a medium rainfall. The annual rainfall is about 1505 mm out of which more than 85 per cent is received between the months of July to October. The mean annual temperature is 27.4°C. The study comprised seven treatments replicated thrice. The treatments were T_1 (Control), T_2 (0.3 LR as LD slag), T_3 (0.3 LR as LD slag + vermicompost), T_4 (RDF 100%), T_5 (RDF 100% + 0.3 LR as LD slag), T_6 (RDF 100% + 0.3 LR as LD slag + vermicompost), T_7 (RDF 75% + 0.3 LR as LD slag + vermicompost). The soil of the site was strongly acidic (4.9) with low organic carbon (0.47%) and low available N (186.33 kg/ha), P (13.48 kg/ha) and K (102.80 kg/ha).

The test crop groundnut was harvested at maturity of 105 days. Ten plants from each plot were measured with respect to height of the plant and average height from ground level to tip of the leaf. The total number of pods of five sample plants were counted and the average was taken as the number of pods per plant. The sampled plants as well as pods were sun-dried for 2-3 days and then weighed. Shelling percentage was calculated by the following formula:

$$\text{Shelling percentage} = \frac{\text{Kernel weight}}{\text{Total weight of pods}} \times 100$$

Oil content was estimated by solvent extraction method using Soxhlet apparatus as described by Anon (1990).

The biometric data such as pod and stover yield were recorded and compiled in appropriate tables and analyzed statistically as per the procedure prescribed for randomised block design. The analysis of variance and standard error of means were determined in all the cases while critical difference was estimated only in cases where F-test was found significant.

RESULTS and DISCUSSION

Effect of LD slag application on yield attributing characters (Table 1)

A significant variation in number of pods per plant was observed due to sole and combined application of LD slag and vermicompost (VC) which varied from 11.33 to 22.33. Lowest pod number per plant (11.33) was recorded in the control plot (T_1). Maximum number of pods (22.33) per plant was recorded in the treatment T_6 which was significantly superior to all other treatments followed by T_7 (20.63). This may due to more availability of phosphorus due to liming effect and addition of recommended dose of phosphorus. Similar results were also found by Rath et al (2000).

Variation in plant height was observed due to sole and combined application of LD slag with recommended dose and VC which varied from 19.60 to 37.98 cm. Control plot recorded the lowest plant height (19.60 cm) and was significantly inferior to all other treatments. Highest plant height (37.98 cm) was recorded in treatment T_6 which was significantly superior to T_5 (35.37 cm) and T_7 (34.06 cm). Limed and un-limed plots showed significant differences in plant height however integrated application of 100 per cent NPK along with LD slag and vermicompost improved the plant height significantly over sole application of LD slag. From this finding it can be concluded that LD slag along with vermicompost increased the availability of nutrients specially nitrogen which resulted in higher plant growth in groundnut. Present results are in conformity with the findings of Dey and Nath (2015).

Stover yield varied from 3.05 to 4.69 tonnes/ha. Control plots recorded lowest stover yield (3.05 tonnes/ha) and highest (4.69 tonnes/ha) was recorded in treatment T_6 which was significantly superior to all other treatments followed by T_7 (4.51 tonnes/ha). Stover and biological yields were highest with combined application of LD slag, 100 per cent recommended dose and vermicompost. This could be due to the solubilization effect of phosphate solublizing bacteria (PSB) and mineralization effect of other beneficial bacteria which make available the required major nutrients (N, P, K and S). Further liming of the soil

Table 1. Effect of LD slag application on yield attributes and yield of groundnut

Treatment	Number of pods/plant	1000-kernel weight (g)	Plant height (cm)	Stover yield (tonnes/ha)	Biological yield (tonnes/ha)
T_1 (Control)	11.33	183.81	19.60	3.05	4.92
T_2 (0.3 LR as LD slag)	13.67	221.49	22.65	3.70	6.72
T_3 (0.3 LR as LD slag + VC)	15.33	242.63	25.61	3.88	7.00
T_4 (RDF 100%)	16.67	258.53	27.85	4.10	7.29
T_5 (RDF 100% + 0.3 LR as LD slag)	18.14	278.93	35.37	4.36	7.50
T_6 (RDF 100% + 0.3 LR as LD slag + VC)	22.33	288.21	37.98	4.69	8.20
T_7 (RDF 75% + 0.3 LR as LD slag + VC)	20.63	272.59	34.06	4.51	7.88
$CD_{0.05}$	1.26	8.68	2.06	0.17	0.24

LR= Lime requirement, LD= Linz-Donawitz, RDF= Recommended dose of fertilizer, VC= Vermicompost

increased exchangeable Ca and Mg values which became readily available to the crop.

Plots receiving treatment combination of LD slag, recommended doses (100%) and VC (T_6) recorded maximum biological yield (8.20 tonnes/ha) which was significantly superior to T_7 (7.88 tonnes/ha) and T_5 (7.50 tonnes/ha) as compared to lowest yield in control plots (4.92 tonnes/ha). This may be due to increase in nutrient availability specially nitrogen resulted from both liming and nitrogenous fertilizer. According to Satapathy et al (2005) nitrogen fertilization at optimum level is helpful for the development of the source system and also increases its efficiency for enhanced photosynthesis leading to higher dry matter production.

The lowest (183.81 g) 1000-kernel weight was recorded in the control plots. Plots imposed with LD slag, recommended doses of fertilizers (100%) and VC (T_6) recorded maximum 1000-kernel weight (288.21 g) which was significantly superior to T_5 (278.93 g) and T_7 (272.59 g) .

Yield attributes of groundnut were significantly higher in the treatments receiving LD slag, recommended fertilizer doses and vermicompost over sole application of chemical fertilizers. This might be attributed to the favourable rhizospheric environment created by the application of organic matter and lime which might have directly improved the beneficial microflora. The beneficial rhizobacteria have the ability to mineralize and supply both macro and micronutrients (Berg 2009). Collectively improved soil pH and enhanced microbial activities through application of lime and organic matter are the key factors of nutrient availability to crops resulting in higher yield.

Effect of LD slag application on yield, shelling percentage, oil and crude protein content (Table 2)

Pod yield ranged from 1.60 to 2.46 tonnes/ha. Control plots recorded lowest (1.60 tonnes/ha) pod yield. Highest pod yield (2.46 tonnes/ha) was recorded in treatment T_6 which was significantly superior to other treatments followed by T_7 (2.37 tonnes/ha). Pod yield increased significantly with addition of LD slag alone as well as in combination with vermicompost and RDF. Present results are in conformity with the findings of Sharma et al (2006).

Treatment T_6 (77.36%) was at par with treatment T_5 (74.84%) and T_7 (72.78%) in shelling percentage and minimum was found in control (T_1).

Maximum oil content in groundnut kernel was recorded in the treatment T_6 (48.60%) which was at par with T_7 (47.50%) and T_5 (47.35%) as compared to lowest in control (43.56%). Significantly higher oil content and crude protein were recorded in treatments with combined application of LD slag, 100 per cent RDF and vermicompost over sole application of inorganics. This may be attributed to the increased concentration of P, Ca and S in kernels (Basu et al 2008).

The crude protein of kernel was highest (26.19%) in the treatment T_7 which was statistically higher than all other treatments. Control plots recorded lowest (19.56%) crude protein content in kernel which

Table 2. Effect of LD slag application on oil and crude protein content of kernel

Treatment	Oil content (%)	Crude protein (%)	Pod yield (tonnes/ha)	% increase in pod yield over control (tonnes/ha)	Shelling (%)
T_1 (Control)	43.56	19.56	1.60	0	51.40
T_2 (0.3 LR as LD slag)	44.20	21.56	1.94	21	58.34
T_3 (0.3 LR as LD slag + VC)	44.60	22.25	2.03	23	63.32
T_4 (RDF 100%)	45.00	23.19	2.15	34	67.62
T_5 (RDF 100% + 0.3 LR as LD slag)	47.35	24.50	2.29	43	74.84
T_6 (RDF 100% + 0.3 LR as LD slag + VC)	48.60	25.75	2.46	53	77.36
T_7 (RDF 75% + 0.3 LR as LD slag + VC)	47.50	26.19	2.37	48	72.78
$CD_{0.05}$	2.12	0.58	0.11		6.64

LR= Lime requirement, LD= Linz-Donawitz, RDF= Recommended dose of fertilizer, VC= Vermicompost

was statistically inferior to all the limed plots. Since N is an integral part of protein and P is structural element of certain coenzymes involved in protein synthesis, higher concentration of N and P in kernels in lime, organic and inorganic fertilizer treated plots resulted in higher protein content (Kachot et al 2001).

CONCLUSION

The yield attributes viz plant height, stover yield, biological yield, number of pods per plant, pod yield, 1000-kernel weight and shelling percentage were recorded highest in treatment receiving LD slag, 100 per cent recommended dose of fertilizers and vermicompost. Highest oil content and crude protein were also recorded under combined application of LD slag, 100 per cent recommended dose of fertilizers and vermicompost. Soil amelioration with LD slag @ 30 per cent lime requirement (LR) in conjunction with inorganics and vermicompost improved the growth, nutrient concentration and yield of the crop.

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