The Andhra Agric. J 70 (1): 121-125, 2023
10.61657/aaj.2023.19

Effect of Nanoscale Gypsum on Nutrient Uptake of Groundnut Grown in Sodic Soils of Chittor District in Andhra Pradesh

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ABSTRACT

A pot culture experiment was conducted during *rabi* season, 2021-22 in the Department of Soil Science and Agricultural Chemistry, ANGRAU, Tirupati to evaluate the efficacy of nano-gypsum (NG) on growth and productivity of groundnut crop grown in sodic soils. Nano-gypsum used in the study was prepared manually by using bentonite nano clay through physical methods. The synthesized nano-gypsum was characterized for its physical, chemical and high resolution microscopic and spectroscopic properties (SEM and TEM). The soil used under this study was sandy clay loam in texture with a pH of 8.79, EC of 2.01 dS m^{-1} and ESP of 35.05. Nano-gypsum was applied at different levels (*i.e.*, 25%, 50%, 75% and 100%) along with 100% Gypsum requirement (GR) as conventional gypsum in completely randomized block deign and replicated four times. The results of this study revealed that the application nano-gypsum @ 100% GR shows significantly highest nutrient uptake at flowering and harvesting stages over application of conventional gypsum @ 100% GR and which is on par with application of nano-gypsum @ 75% GR.

Keywords: *Nano-gypsum, Nano clays, Gypsum requirement and Conventional gypsum.*

Soil is a biogeo-chemical and hydrological domain of the biosphere that faces a number of problems. Among the issues soil salinization and sodification are the most extensive problems, which reduces crop yields and as well as cultivated area. Alkali soils are found to be highly problematic for crop production because of very poor physical and chemical environment. The typical sodic soils are characterized by high pH (>8.5), excess of exchangeable sodium (ESP>15), lower EC (<4.0 dS m^{-1}) and possess predominant salts *viz.,* sodium bicarbonate, sodium carbonate and sodium silicate (Pagaria and Totawat, 2011).

To maintain productivity of sodic-affected soils, it is important to restore and sustain their physico chemical properties and fertility. Various reclamation techniques such as, application of gypsum, sulfur and acids may be used for amelioration of these soils (Amezketa *et al.*, 2005; Day *et al.*, 2019; Abdul *et al.*, 2022). During the reclamation process, Na in the exchangeable clay complex is replaced by Ca which was derived from the gypsum.

Groundnut (*Arachis hypogaea* L.) is an important oil seed crop. It requires approximately 200 kg ha^{-1} gypsum at flowering stage. Gypsum ($CaSO_4.2H_2O$) contains primary nutrients calcium (23.3 %) and sulfur (18.5%) which plays important role in pod filling and oil synthesis of groundnut respectively (Yadav *et al.,* 2015). Gypsum is widely used as a source of Ca for groundnut worldwide. The dissolution of gypsum is fairly rapid and therefore readily adds Ca to the podding zone. However, the disadvantage of gypsum is its vulnerability to leaching. Further, the ability of gypsum to reclaim the soil depends on the quality (fineness and solubility) and quantity of gypsum used. Nanotechnology deals with the materials, systems and objects whose size falls in the range of 1-100 nm (one billionth of a meter) in at least one dimension. These particles have high surface to volume ratio with quantum confinement (Moraru *et al.*, 2007; Subramanian and Tarafdar, 2011). Therefore, the present study was conducted to study the effects of nano-gypsum on the growth and productivity of groundnut crop grown in sodic soils.

MATERIAL AND METHODS

A pot culture experiment was conducted during *rabi*, 2021-22 in the Department of Soil Science and Agricultural Chemistry, ANGRAU, Tirupati to evaluate the efficacy of nano-gypsum (NG) on growth and productivity of groundnut grown in highly sodic soil. The nano gypsum was prepared by physical method and synthesized nano-gypsum (Bentonite loaded with the nanogypsum) characterized for its spectroscopic properties (SEM and TEM). Treatments imposed in the study includes control, 100% RDF, 100% RDF + conventional gypsum @ 100% GR and nano-gypsum at four levels of Gypsum Requirement (GR) @ 25, 50, 75 and 100 % along with 100% RDF and replicated 4 times by using completely randomized design. The sodic soils collected from Kukkambakam village of B.N Kandriga mandal, Chittor District was non calcareous, non saline sodic with a pH of 8.79 and ESP of 35.05. Plant samples were collected both at flowering and post harvest stages. The collected plant samples were thoroughly washed with double distilled water, dried in shade and then oven dried at 60ºC. The oven dried plant samples were weighed and chopped with stainless steel scissors and grounded by stainless steel jars and were stored for chemical analysis and a well a calculation of uptake values.

RESULTS AND DISCUSSION

The features of nano-gypsum examined using high resolution microscopes, such as SEM and TEM, made it clearly evident that the synthesis of nano-gypsum had been a success. In compared to conventional gypsum, which is dispersed and sparse, nano-gypsum was clustered and consolidated in the SEM image (Figure 1). The TEM images indicated that the conventional gypsum was crystalline and uniform with an average diameter about 500 nm and nano-gypsum showed the diameter of 50-100 nm with an average of 50 nm (Figure 2). The agglomeration of the particles has been observed and it may be due to the absence of protecting ligands on the surface. Similar results were reported by Kumar and Thiyageshwari (2018).

The treatments showed significant effect on macro and secondary nutrients (N, P, K, Ca^{+2}, Mg^{+2} and S) uptake at all stages of crop growth. Gradual increase in nutrient uptake was observed from flowering to harvest.

At flowering and harvesting stages, significantly the highest macronutrient uptake by groundnut was observed with the application of RDF + 100% GR as nano-gypsum (T_7) followed by RDF + 75% GR as nano-gypsum (Table 1) which is on par with RDF + 100% GR as conventional gypsum (T_3). The next best treatment observed with the application of RDF + 50% GR as nano-gypsum (T_5). The lowest uptake by crop was noticed in control (T_1).

The highest secondary nutrient uptake by groundnut was observed with the application of RDF + 100% GR as nano-gypsum (T_7) followed by RDF + 75% GR as nano-gypsum (Table 2) which is on par with RDF + 100% GR as conventional gypsum (T_3).

It is understandable that nano-gypsum had higher surface area than conventional gypsum and the exchange of Na^+ has increased correspondingly (Kumar and Thiyageshwari, 2018). The adsorption of Ca^{2+} facilitates soil aggregation and other physical conditions of the soil there by improving the availability and uptake of nutrients by plant. Similar results were found by Anthati (2011) with the application of gypsum in groundnut crop. The increase in soil fertility after soil reclamation with 100% GR as nano-gypsum which profoundly influenced the uptake of nutrients (Sharma *et al.*, 2008) at flowering and harvesting. Application of 250 kg of gypsum along with RDF recorded significantly higher nutrient uptake by haulm of groundnut (Parvathi *et al.*, 2015).

The results of this study proved that application of nano-gypsum is effective in reclamation of sodic soils and also on growth and productivity of groundnut crop compared to application of conventional gypsum. The higher levels of both the amendments were effective in reclamation of the sodic soil. The application of 100% GR as nano-gypsum conspicuously reclaimed the sodic soil and improve the uptake of nutrients. However, 75% GR as nano-gypsum was comparable to 100% GR as conventional gypsum.

It could be concluded that, nano-gypsum can be thought of as a viable alternative to conventional gypsum either at 100% or 75 % GR.

Table 1: Effect of application of nano-gypsum on N, P and K uptake at different stages of groundnut crop

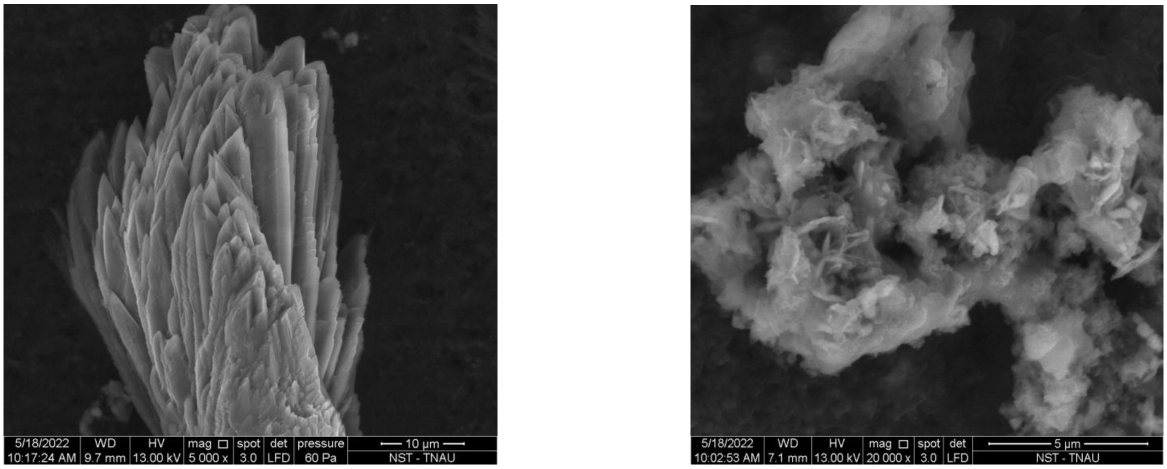
Treatments	N Uptake (g pot^{-1})		P Uptake (g pot^{-1})		K Uptake (g pot^{-1})	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: Control	0.28^{f}	0.41^{f}	0.06^{f}	0.08^{e}	0.12^{g}	0.15^{f}
T_2: RDF (30:40:50 $N:P_2O_5:K_2O$ kg ha^{-1})	0.32^{e}	0.47^{e}	0.07^{e}	0.10^{e}	0.14^{f}	0.17^{e}
T_3: RDF + 100% GR as conventional gypsum	0.57^{b}	0.74^{b}	0.12^{b}	0.17^{ab}	0.23^{c}	0.26^{b}
T_4: RDF + 25% GR as nano-gypsum	0.42^{d}	0.56^{d}	0.09^{d}	0.12^{d}	0.18^{e}	0.20^{d}
T_5: RDF + 50% GR as nano-gypsum	0.49^{c}	0.64^{c}	0.11^{c}	0.14^{c}	0.22^{d}	0.23^{c}
T_6: RDF + 75% GR as nano-gypsum	0.58^{b}	0.75^{b}	0.12^{b}	0.16^{b}	0.24^{b}	0.27^{b}
T_7: RDF + 100% GR as nano-gypsum	0.63^{a}	0.84^{a}	0.14^{a}	0.18^{a}	0.25^{a}	0.30^{a}
F-value	261.36^{**}	111.64^{**}	111.43^{**}	46.24^{**}	219.15^{**}	94.11^{**}
p-value	0.000	0.000	0.000	0.000	0.000	0.000
SE(d)	0.012	0.021	0.004	0.007	0.005	0.008

**Significant at p?0.01 level
Note: Same set of alphabets indicates no significant difference or at par with each other (DMRT)

Table 2: Effect of application of nano-gypsum on Ca, Mg and S uptake at different stages of groundnut crop

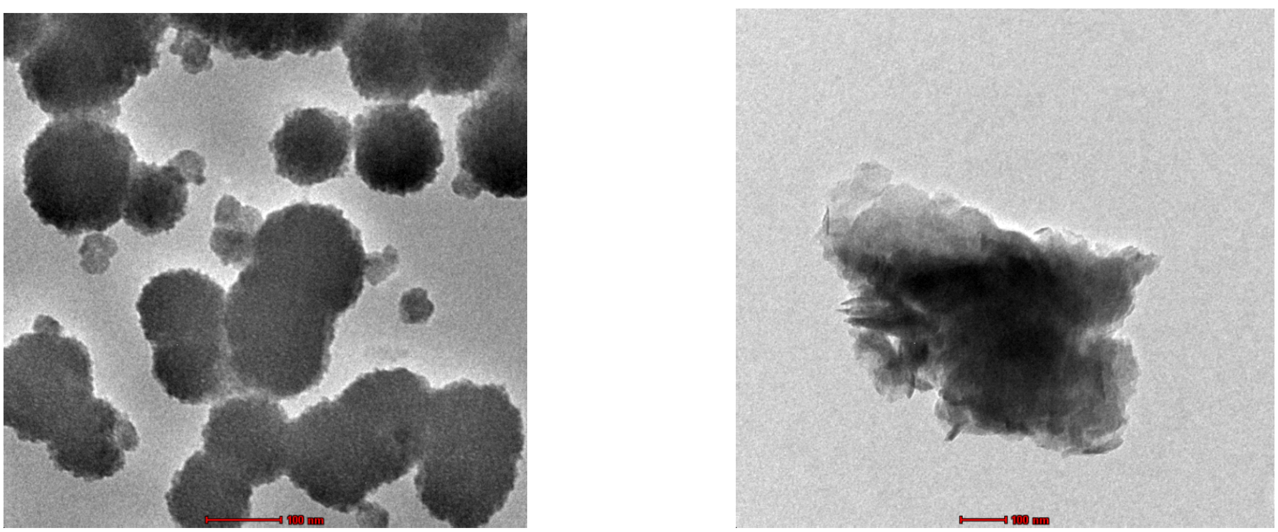
Treatments	Ca Uptake (g pot^{-1})		Mg Uptake (g pot^{-1})		S Uptake (g pot^{-1})	
	Flowering	Harvesting	Flowering	Harvesting	Flowering	Harvesting
T_1: Control	0.08^{e}	0.09^{e}	0.04^{f}	0.06^{e}	0.04^{g}	0.05^{f}
T_2: RDF (30:40:50 $N:P_2O_5:K_2O$ kg ha^{-1})	0.09^{e}	0.11^{de}	0.05^{e}	0.07^{e}	0.05^{f}	0.06^{e}
T_3: RDF + 100% GR as conventional gypsum	0.16^{bc}	0.20^{b}	0.09^{b}	0.11^{bc}	0.10^{e}	0.14^{b}
T_4: RDF + 25% GR as nano gypsum	0.11^{de}	0.14^{d}	0.07^{d}	0.08^{d}	0.07^{d}	0.09^{d}
T_5: RDF + 50% GR as nano gypsum	0.14^{cd}	0.18^{c}	0.08^{c}	0.10^{c}	0.09^{c}	0.11^{e}
T_6: RDF + 75% GR as nano gypsum	0.18^{ab}	0.22^{b}	0.10^{a}	0.12^{b}	0.12^{b}	0.14^{b}
T_7: RDF + 100% GR as nano gypsum	0.21^{a}	0.25^{a}	0.10^{a}	0.13^{a}	0.14^{a}	0.18^{a}
F-value	17.01^{**}	33.85^{**}	106.28^{**}	42.90^{**}	303.43^{**}	221.55^{**}
p-value	0.000	0.000	0.000	0.000	0.000	0.000
SE(d)	0.004	0.006	0.003	0.006	0.003	0.004

**Significant at p?0.01 level
Note: Same set of alphabets indicates no significant difference or at par with each other (DMRT)



(a) **(b)**

Figure 1: Scanning Electron Microscopic (SEM) images of (a) Conventional gypsum and (b) Nano-gypsum



(a) **(b)**

Figure 2: Transmission Electron Microscopic (TEM) images of (a) Conventional gypsum and b) Nano-gypaum

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Received on 03.08.2022 and Accepted on 09.01.2023