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# Efficacy of gypsum application on soil physical properties of groundnut (*Arachis hypogaea* L.) in typic ustifluvents

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## Abstract
The field experiment was conducted at the experimental farm of Udai Pratap Autonomous College, Varanasi (U.P.) to evaluate the response of applied major nutrient with gypsum on physical properties in test crop field. The study was carried out with five treatments and four replications in randomized design. The results revealed that combined application of NPK @ 25:50:20 kg ha$^{-1}$and $T_4G_{400}$ kg ha$^{-1}$ of gypsum in the soils significantly reduced soil dry bulk density by about 6.93% when compared to the control. The significantly highest soil particle density in 4.57 g cc$^{-1}$, pore space 11.47%, hydraulic conductivity 8.46, infiltration rate 17.37 and water stable aggregates were found in plots with a combination of NPK and gypsum at @ 25:50:20 kg ha$^{-1}$ and $T_4G_{400}$ kg ha$^{-1}$ respectively. The significant treatment differences on soil mechanical and physical properties of the study soil due to effect of the treatments could be attributed to the ability of Ca and S applied via gypsum to flocculate soil particles. Thereby, creating an enabling to better soil physical properties, infiltration and aeration for proper growth and quality of groundnut.

**Keywords:** gypsum, groundnut, physical properties of soil

## 1. Introduction
Groundnut (*Arachis hypogaea* L.) is a very important crop in the tropics and subtropics. It has a high content of edible oil, which ranges from 50 to 65% Taira (1985) [57] Boye-Goni *et al.* (1990) [8] and protein content ranging from 25 to 35% De Waele and Swanevelder (2001) [12] making it a very popular human food and source of cheap protein. In recent days there is mounting interest in diversified agricultural production systems to obtain improved crop protection, increased productivity and profitability offered by many cropping systems. This may be due to some of the established and speculated advantages for intercropping systems such as higher yields, greater land-use efficiency and improvement of soil fertility through the applications of gypsum (Ofori and Stern, 1987) [39] Groundnut is traditional crops, like pearl millet, maize and sorghum, and also with pigeon pea in groundnut-growing areas of India by marginal and sub-marginal farmers during rainy season (Reddy *et al.*, 1980) [44]. Groundnut is grown mostly on light-textured soils ranging from coarse and fine sands to sandy clay loams with moderately low amounts of organic matter (1 – 2%) and good drainage (Henning *et al.*, 1982). The well-drained soils provide good aeration for the roots and nitrifying bacteria. Groundnut does not grow well in soils with a high-water retention capacity (Stalker, 1997), and grows best in slightly acidic soils with optimum pH ranging from 5.5 to 6.2 Gibbons (1980) [20]. Gypsum is a soluble source of the essential plant nutrients, calcium and sulfur, and can improve overall plant growth. Gypsum amendments can also improve the physical properties of some soils (especially heavy clay soils). Such amendments promote soil aggregation and can help prevent dispersion of soil particles, reduce surface crust formation, and promote seedling emergence, and increase water infiltration rates and movement through the soil profile. It can also reduce erosion losses of soils and nutrients and reduce concentrations of soluble phosphorus in surface water runoff. Application of gypsum can reduce dispersion and promote flocculation of soils. Flocculation is a necessary condition for the formation and stabilization of soil structure. This increases water infiltration and percolation Norton (2008) [8] thus reducing soil erosion and improving water quality. Gypsum helps reduce the dispersion of the clay that leads to surface crust formation and also slows the rate of surface drying (Norton and Rhoton, 2007; Rao and Shaktawat, 2001) [7, 43].

Clay dispersion is caused by the mutual repulsion between the clay particles, which results from the presence of extensive negative electric fields surrounding those Dontsova *et al.* (2004) [14]. Flocculation is a necessary condition for the formation and stabilization of soil structure. This increases water infiltration and percolation Norton (2008) [8] thus reducing soil pH and improving water infiltration rate of soil. Other ions especially potassium in soil can effect on absorption of the calcium thus are effective in quality and quantity of the crop. Applying of potassium alone decreases the growth of aerial parts while the application of potassium along with calcium increases the growth aerial parts of groundnut. Therefore, a balanced and suitable fertility, soil physical properties to program with special emphasis on applicable contents of phosphorus, potassium, and nitrogen seems necessary for achieving notable yield and quality of groundnut (Naseri, 1996; Fathi, 1999; Safarzadeh, 1999; Ahmadi *et al.*, 2004) [35, 16, 46, 3]. Hence, the present study was under-taken to find out effect of sulphur and calcium through gypsum application in soil to promote the physical properties and enhances the nutrient availability in groundnut.

## 2. Materials and Methods

### 2.1 Experimental site characteristics

#### 2.1.1 Location

The field experiment was conducted at the experimental farm of Udai Pratap Autonomous College (UPAC); Varanasi is situated in the Middle Gangetic Plain region of Agro-climatic Zone (IV) located at25˚317″ N latitude, 82˚973″E longitude and an altitude of 80.71 meter above mean sea level. The soil of the experimental plot was alluvial deposited by river Ganga predominant of illite, quartz and feldspar mineral. The *illite* mineral is partly inherent from micas which are pre dominant in the sand and silt fractions. For details investigation, groundnut selected as test crop, and Randomized Complete Block Design (RCBD) selected for the check the efficacy level with different levels of added gypsum (0, 100, 200, 300 and 400 kg ha$^{-1}$) with RDF (NPK @ 25:50:20 kg ha$^{-1}$). NPK and gypsum as selected as treatments at the rate of (0, 100, 200, 300 and 400 kg ha$^{-1}$) with RDF (NPK @ 25:50:20 kg ha$^{-1}$). The initial soils samples were randomly collected from five different sites and make the composite samples prior to tillage operation from a depth of 0-15 cm. The post-harvest soil samples were collected by using screw auger from surface layers which was selected from each plot from randomly selected three spots. The size of the soil sample reduces by conning and quartering the composites soil sample after air dry, and its pass through a 2 mm sieve by way of preparing the sample for physical and chemical analysis. The composite soil samples were collected from each plot after field preparation and from each plot during the crop growing period at pegging and after the harvest of crop, during the years.

### 2.2 Climatic condition and weather

Varanasi has a tropical climate with hot desiccating summers cold winters and moderate rainfall. The climate is very hot in the month of May with the average temperature varying from 26 °C to 41 °C. January is the coldest month with mean minimum temperature varying between 9 °C to 23 °C. The means annual precipitation is 982 mm with most of the precipitation falling during middle of June to middle of October. The weekly weather condition of the experimental site during the crop growth period which is depicted in figure 2. The daily maximum and minimum temperature during the crop growth period varied from 35- 24.8ºC and 28.5 – 11.6 º C, respectively, and crop received a total rainfall of 461.11 mm during their crop growth periods, and R.H (relative humidity) value varied from 72% to 86% (7:00 AM) and 36% to 81% (2:00 PM), respectively. The statical analysis was done through SPSS 16 and methodology followed by Gomez and Gomez (1984) [29].

### 2.3 Determination of soil physical parameters

The exchangeable cations and cation exchange capacity (CEC) were determined by the method described by Thomas (1982) [58]. Particle size distribution was determined by hydrometer method (Gee and Orr, 2002) [19]. Dry bulk density was determined by the core method (Grossman and Reinsch, 2002) [21]. Total pore space values were derived from bulk density data. Saturated hydraulic conductivity (Ksat) was determined by the method of Klute and Dirksen (1986) [28].

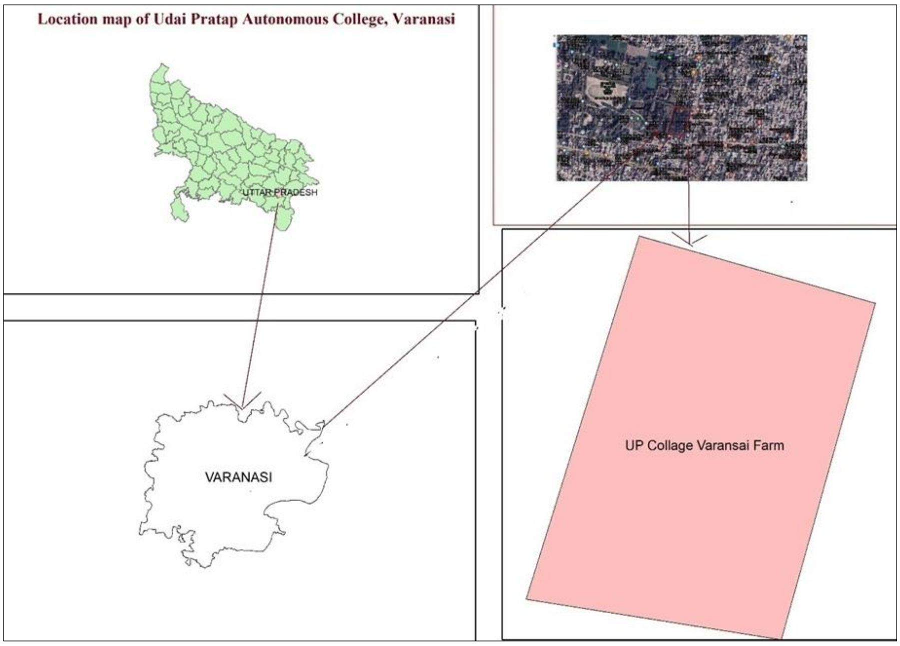


**Fig 1:** Location map of Udai Pratap Autonomous College, Varanasi Farm (Uttar Pradesh)

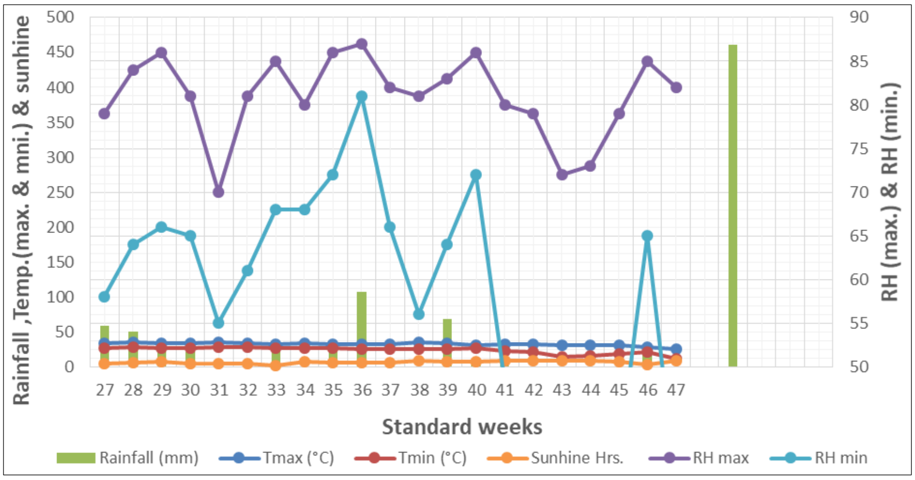


**Fig 2:** Meteorological data during crop growth period

## 3. Results and Discussion

### 3.1 Physico-chemical properties of post-harvest soil samples (0-15 cm depth)

The data pertaining to physical properties were depicted in table (1), and results revealed that mechanical analysis of sand silt and clay was found to be non-significant. Physical properties change only slightly in long term experiments. In general, during the one-year experiments, no changes the soil physical characteristics like sand silt and clay were observed. Continuous cultivation of crops has resulted in increase in soil organic carbon and reclamation of soil physical properties (Bhattacharya *et al.* 2007) [7]. Decline in soil pH with the application of gypsum and organic manures may be attributed to the production of organic and inorganic acids (amino acid, glycine, cysteine and humic acid) during decomposition (Singh *et al.*, 2014) [51]. Observed that the long-term application of gypsum and NPK fertilizer led to a change in soil physical properties. Application of gypsum in groundnut field, the bulk density was found to be significantly lower in control ($T_0G_0$) in comparison to other treatments, which were statistically at par with each other. NPK and gypsum application in treatment ($T_4G_{400}$ kg ha$^{-1}$) increased the bulk density by 6.48 per cent over no gypsum application control ($T_0G_0$). Similar results were reported by various scientist (Sheinberg *et al.*, 1989; Summer, 1993; Summer *et al.*, 1992) [48], and they noted that significant improvement in soil physical conditions have been observed because of advocation of various treatment, and meanwhile, pore space have also been brought the enrichment of calcium and sulphur content in soils which enable to flocculate soil particles under alkaline soils (Sheinberg *et al.*, 1989; Summer, 1993; Summer *et al.*, 1992) [48]. NPK and gypsum application in treatment ($T_2G_{200}$ kg ha$^{-1}$) increased the particle density by 4.37 per cent over no gypsum application control ($T_0G_0$). And NPK and gypsum application in treatment ($T_4G_{400}$ kg ha$^{-1}$) increased the pore space by 10.29 per cent over no gypsum application control ($T_0G_0$). In case of hydraulic conductivity, the maximum hydraulic conductivity 10.36 was recorded with ($T_4G_{400}$) treatment combination followed by 10.26, 10.16 and 10.08 with ($T_3G_{300}$), ($T_2G_{200}$) and ($T_1G_{100}$) treatment combination whereas the minimum 9.80 hydraulic conductivity was recorded with control ($T_0G_0$) treatment. The hydraulic conductivity data indicates that there was non-significant difference in hydraulic conductivity interaction between N P K and Gypsum. The maximum infiltration rate3.53 was recorded with ($T_3G_{300}$) treatment combination followed by 3.48 and 3.43 with ($T_4G_{400}$) and ($T_2G_{200}$) treatment combination whereas the minimum 3.28 and 3.28 infiltration rate was recorded with control ($T_1G_{100}$) and ($T_0G_0$) treatment. The infiltration rate data indicates that there was non-significant difference in infiltration rate interaction between N P K and Gypsum. The maximum water stable aggregates26.10 was recorded with ($T_4G_{400}$) treatment combination followed by 25.93, 25.63 and 25.53 with ($T_3G_{300}$), ($T_2G_{200}$) and ($T_1G_{100}$) treatment combination whereas the minimum 25.40 water stable aggregates were recorded with control ($T_0G_0$) treatment. The statistical analysis of water stable aggregates data indicates that there was non-significant difference in water stable aggregates interaction between N P K and Gypsum. Ismail *et al.* (1998) [25] reported that the @ of 0, 200, 400 and 600 kg ha$^{-1}$application of gypsum in soil no any change in physical properties of soil like, pH, EC, OC, Hydraulic conductivity, infiltration rate and water stable aggregates. But long-term experiment applications of gypsum change the pH and EC in problem soils.

## 4. Conclusion

The results of this study can be concluded that gypsum application in soils significantly improved the physical properties of soil. The significant variation was observed towards physical properties in soils after advocation of various treatment of gypsum which could be governed the ability of Sulphur and Calcium Supplied via gypsum to flocculate soil particles. Thereby, soil physical condition act as halts for their better nutrient availability, proper infiltration and aeration, and enormous increased the major nutrient availability because of their favorable pH for the maximizing the ideal crop growth and its quality attributes in groundnut. Despite being gypsum offers calcium and sulphur which is needed to flocculate soil particles in alkaline soils, and enhance favorable soil structure for root growth, air and water movement. It is, therefore, concluded that Ca and S primarily from gypsum acted as a catalyst for improved proper physical conditions of soil. We, therefore, recommend a combination of NPK and gypsum at the rate of 25:50:20 kg ha$^{-1}$and 400 kg ha$^{-1}$gypsum play pivotal role for significant contribution in physico-chemical properties and quality improvement in groundnut. Experimental findings of the present study indicated that graded levels of gypsum improved the physical conditions of soil in terms of BD, PD, pore space hydraulic conductivity infiltration rate and size of soil aggregates were significantly increased by the application of gypsum at various levels of soil application.

The farmers may be advised to follow intermittent groundnut cultivation practices to increase the concentration of nitrogen, through rhizobium bacteria in the solum of the soils. The result of this study may be helpful for the decision makers in framing the standard cultivation measures for enhancing the productivity of groundnut soils of this region.

**Table 1:** Effect of different treatments on physical properties with influence in test crops

| Treatments | Mechanical analysis (%) | | | Bulk density ($g\ cc^{-1}$) | Particle density (g cc-1) | Pore space (%) | Hydraulic conductivity ($ms^{-1} \times 10^{-6}$) | Infiltration rate ($cm\ hr^{-1}$) | % Water stable Aggregates (> 0.25 mm) |
|---|---|---|---|---|---|---|---|---|---|
| | Sand | Silt | Clay | | | | | | |
| $T_0G_0$ | 51.10 | 33.98 | 14.92 | 1.01 | 2.19 | 0.61 | 9.80 | 3.28 | 25.40 |
| $T_1G_{100}$ | 51.53 | 33.83 | 14.64 | 1.07 | 2.27 | 0.67 | 10.08 | 3.45 | 25.53 |
| $T_2G_{200}$ | 51.48 | 33.85 | 14.67 | 1.07 | 2.29 | 0.68 | 10.16 | 3.53 | 25.63 |
| $T_3G_{300}$ | 51.72 | 33.85 | 14.43 | 1.08 | 2.27 | 0.67 | 10.26 | 3.65 | 25.93 |
| $T_4G_{400}$ | 51.82 | 34.00 | 14.18 | 1.08 | 2.28 | 0.68 | 10.63 | 3.85 | 26.65 |
| S.Em± | 0.59 | 0.32 | 0.49 | 0.009 | 0.019 | 0.008 | 0.20 | 0.14 | 0.23 |
| C.D. P= (0.05%) | NS | NS | NS | 0.026 | 0.056 | 0.023 | 0.59 | 0.41 | 0.68 |

$T_0G_0$ = Control plot, $T_1G_{100}$ = NPK (25-50-20) + Gypsum @100 kg $ha^{-1}$, $T_2G_{200}$ = NPK (25-50-20) + Gypsum @200 kg $ha^{-1}$, $T_3G_{300}$ = NPK (25-50-20) + Gypsum @300 kg $ha^{-1}$ $T_4G_{40}$ = NPK (25-50-20) + Gypsum @400 kg $ha^{-1}$

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