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# Effect of the Magnetic Treatment of Urea and Groundnut Seeds before Sowing on Its Yield and Quality under Sandy Soil Conditions

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Authors AEAS and MIM designed the study and followed up the field-work. Author MAA managed the laboratory analyses of the study and performed the statistical analysis. Author KAHS arranged the literature survey and wrote the first draft of the manuscript. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** It is to study the effect of the magnetic treatment (MT) for 30 min of urea as nitrogen (N) fertilizer as well as the groundnut (*Arachis hypogaea* L.) seeds before sowing on the crop yield and quality under sandy soil conditions. This is to increase the crop productivity in the reclaimed sandy soils.
**Study Design:** A Randomized Complete Block Design with three replicates.
**Place and Duration of Study:** A field study have been carried out during the summer seasons of 2020 and 2021.

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**Methodology:** The control has received the recommended dose RD of the urea fertilizer while other treatments received the rates 50%, 75%, and 100% of the RD as magnetized urea applied to the surface soil. The groundnut grains were exposed to a magnetic field (MF) 1.4 T intensity before sowing. Representative samples from soil and plant were taken after harvesting.
**Results:** At the 30-min time and 100% N-fertilization, the yield (kg $ha^{-1}$) has increased relatively by 13.3% for pods and by 16.8% for the seeds. It has increased the chlorophyll a, b and the total chlorophyll (mg $g^{-1}$ f.w) by 29.4%, 37%, and 32.2%, respectively. It has increased the soil available N by 33.7%, the P by 13.2%, and Mn by 11.8%. It also increased the K by 4.1%, Fe by 5.1%, and Zn by 9.7%. The nitrogen use efficiency (NUE) and the agronomic efficiency (AE) were 5.76 and 2.75, respectively, being the highest value for the 100% rate compared to the 50% and 75% rates.
**Conclusion:** Magnetic treatment (MT) of urea as a nitrogen fertilizer and/or groundnut seeds for 30 min before cultivation can be recommended to enhance the N use efficiency under the sandy soil conditions. This can be attributed to the induction effect of the magnetic force on the chemical and biological reactions that enhance the nutrients availability and uptake in the soil-plant system.

*Keywords: Groundnut; magnetized seeds; magnetized urea; sandy soil.*

## 1. INTRODUCTION

Reclamation of sandy soils usually necessitate the continuous application of both mineral and organic fertilizers to improve its nutrients content and crop productivity [1-3].

The magnetic treatment (MT) technology is widely applied agriculturally to enhance the use efficiency of saline and low quality irrigation water [4,5], stimulate seeds before planting [6,7] and to increase the effect of the applied fertilizers [8-10]. The magnetic field (MF) induces the contents of the material magnetically resulting in some temporary changes. This magnetic induction does not change the atomic/molecular structure of a matter but may perhaps affect polarization. The exposure of water to a MF influences some properties. It depends on the magnetization time, the MF intensity and the temperature of medium [11,12]. The hydrogen bonds networks along with the Van der Waal's forces between the molecules forming the water structure when present become weaker [11-13]. The physicochemical properties of the magnetized water were affected due to the changed size of water clusters and facilitate nutrients uptake by plants. It dissolves minerals and increases the available nutrients for the plant [14,15].

Seed treatment was practiced for seed germination enhancement. The pre-sowing MT of seeds was extensively studied for many types of plants such as tomato, onion, wheat, sunflower, etc [6,16,17]. It has been accelerated the germination percentage, root and shoot length, leaf area, improved yield, and yield parameters due to the improved plant nutrition. It may be resulted from biochemical variations in the enzymes activities that affect the plant processes like photosynthesis, nutrients uptake, and growth [18].

The uptake of nutrients was studied in hydroponic systems using magnetized solutions of nutrients, which enhanced the uptake of nutrients including $N^+$, $P^+$, $K^+$, $Ca^{2+}$, $Fe^{2+}$, and $Zn^{2+}$, the chlorophyll and carbohydrates content and biomass accumulation [19].

The magnetism ($\chi_m$, $m^3$ $mol^{-1}$) of chemical elements and compounds may play a role in their response to the MF and their effect. Some available values for example compounds used as fertilizers [1], $\chi_m$ for aqueous ammonia $NH_3$ is –18.3 $m^3$ $mol^{-1}$, Ammonium nitrate NH4NO3 –33 $m^3$ $mol^{-1}$, ammonium sulfate $(NH_4)_2SO_4$ –67 $m^3$ $mol^{-1}$. The aim of study to evaluate the effect of the magnetic treatment MT of the urea as a nitrogen fertilizer and the groundnut (*Arachis hypogaea* L.) seeds before sowing on the yield under the sandy soil conditions.

## 2. METHODOLOGY

The field experiment has been carried out at the Ismailia Agricultural Research Station, during the

*[1] Landolt-B.rnstein, Numerical Data and Functional Relationships in Science and Technology, New Series, II/16, Diamagnetic Susceptibility, Springer-Verlag, Heidelberg, 1986. Landolt-B.rnstein, Numerical Data and Functional Relationships in Science and Technology, New Series, III/19, Subvolumes a to i2, Magnetic Properties of Metals, Springer-Verlag, Heidelberg, 1986-1992. Landolt-B.rnstein, Numerical Data and Functional Relationships in Science and Technology, New Series, II/2, II/8, II/10, II/11,and II/12a, Coordination and Organometallic Transition Metal Compounds, Springer-Verlag, Heidelberg, 1966-1984. Tables de Constantes et Donn.es Num.rique, Volume 7, Relaxation Paramagnetique, Masson, Paris, 1957.*

summer seasons of 2020 and 2021. Table 1 shows some properties of the studied sandy soil before planting. Super calcium phosphate was mixed with soil (476.19 kg $ha^{-1}$ RD), while 119 kg $ha^{-1}$ of $K_2SO_4$ (48% $K_2O$) was applied in two equal doses after planting.

The used urea 46% N was spread on soil surface without magnetization in three equal doses 30, 45, and 60 days after sowing to gain the total recommended dose RD as 142.86 N units per hectare for the control plots. Magnetized urea in the solid form was obtained by placing the required amount in a magnetic field MF of intensity 1.4 Tesla inside a magnetic tube for 30 min. Application rates 50%, 75%, and 100% of the N RD were applied to the surface soil in three equal doses 30, 45, and 60 days after sowing.

The groundnut seeds (*Arachis hypogaea* L., cv. Giza 5) were placed in a MF of intensity 1.4 Tesla inside a magnetic tube (70 cm × 1.5-inch) for 30 min before planting. Magnetically treated groundnut seeds were sown for all plots (except the control) in 20-cm apart holes in lines (50-cm apart) on 15 May 2020 and/or 2021. Treatments were in a Randomized Complete Block design with three replicates and plot area 10.5 $m^2$ (3.0 m × 3.5 m). The recommendations for groundnut planted in sandy soil were followed.

Representing samples from soil and plants after the crop harvesting were selected and air-dried for analysis [20]. The yield (t $ha^{-1}$) and some yield components have been calculated based on the seed yield per plot area and the mean of the two seasons was recorded.

Groundnut seeds and straw were dried in oven for 48 h at 70 ºC and ground. A half gram of the powdered seeds and/or straw was acid digested using the mixed $H_2SO_4/HClO_4$ (1:1) [21]. The N, P, and K concentrations available in soil were extracted by 1% $K_2SO_4$, 0.5 N $NaHCO_3$, and 1 N $NH_4OAc$ (pH 7.0), respectively [22]. The extracted concentrations were estimated using Kjeldahl apparatus, the UV-Vis. Spectrophotometer and the flame photometer, respectively. All results were average values of the two seasons.

The Nitrogen Use Efficiency (NUE) and agronomic Efficiency (AE) was calculated according to Roozbeh et al., [23] as follows:

Nitrogen Use Efficiency (NUE) =

$$\frac{(Pn_f - Pn_0)}{Fertilizer\ rate\ (N,\ kg\ ha^{-1})} \times 100$$

$P_{nf}$ = seed N in fertilized plots as (g $kg^{-1}$), $P_{n0}$ = seed N in non fertilized plots as (g $kg^{-1}$)

Agronomic Efficiency (AE) =

$$\frac{Y_f - Y_0}{Fertilizer\ rate\ (N\ ,\ kg\ ha-1\ )}$$

Y = seed yield (kg $ha^{-1}$)

The one-way analysis of variance (ANOVA) was carried out to calculate the treatments statistical significance (LSD) at $P \le .05$ using the Co-State software Package (Ver. 6.311) [24].

## 3. RESULTS AND DISCUSSION

### 3.1 Effect of the Studied Treatments on Some of the Experimental Soil Properties

The estimated soil available nutrients (mg $kg^{-1}$) have increased with increasing the rate of the N-fertilizer from 50% to 100% RD compared to the control as mentioned by Table 2. The differences between treatments were non-significant except for the available Mn (mg $kg^{-1}$) based on the LSD values at $p \le .05$. However, the 100% RD of magnetized urea ($CO(NH_2)_2$) applied to soil along with the magnetized groundnut seeds have significantly increased the soil available N by 33.68%, the P by 13.18%, and Mn by 11.8%. It also increased the K by 4.1%, Fe by 5.1%, and Zn by 9.7% but non- significantly compared to the control.

### 3.2 Effect of the Studied Treatments on the Groundnut Yield (kg $ha^{-1}$) and Some Yield Parameters

Although the differences between treatments in Table 3 were not significant based on the LSD, the magnetized 100% RD urea has resulted in a significant increase of the plant height (cm) by 33.87%, plant weight (g) by 52.51%, and the number of pods/plant by 55.32% compared to the control. The MT of groundnut seeds and urea at the 100% RD have also increased the weight of pods/plant by 36.32% and the weight of seeds/plant 47.23%, but decreased the 100 seed weight (g) by 11.11%. The relative increase in the yield (kg $ha^{-1}$) of the pods and seeds was by 13.29% and 16.75%, respectively [25].

### 3.3 Effect of the Studied Treatments on the Total Concentration (g kg$^{-1}$) of the N, P, and K in the Seeds and Straw

The relative increase in total concentrations of N-P-K (g kg$^{-1}$) in the groundnut seeds presented in Table 4 was by 33.1%, 16.9%, and 7.6%, respectively at the 100% rate. They were varied significantly in the straw as the N (g kg$^{-1}$) was increased by 14.5% for the 30 min. The total P was increased by 5.2% while the K was decreased by 13.3%.

### 3.4 The Effect of the Studied Treatments on the Chlorophyll Content (mg g$^{-1}$ f.w) in the Groundnut Leaves

The magnetically treated N-fertilizer at 100% RD has increased chlorophyll a, b and the total chlorophyll (mg g$^{-1}$ f.w) presented in Table 5 by 29.4%, 37%, and 32.2%, respectively. However, the chlorophyll a/b ratio has decreased by 5.8% for the mentioned treatment. There is no significant difference in the characterised chlorophyll.

## 4. DISCUSSION

The study indicates that the magnetically treated urea fertilizer applied on soil planted by magnetically treated groundnut seeds increased the N-P-K and micronutrients availability in soil. In addition, it affected the equilibrium concentrations of P and K nutrients in the seeds and straw. The balanced content of chlorophyll a and b in the leaves was disturbed. It may be due to the structural difference between the two chemical forms being chlorophyll b containing an aldehyde moiety (– CHO) of higher susceptibility $\chi_m$ compared to the methyl moiety (– $CH_3$). This may be due to some abnormal changes and disturbed equilibrium of the nutrients absorption by plant resulted from the MT. At the 30-min time and 100% N-fertilization, the yield (kg ha$^{-1}$) has increased relatively by 13.3% for pods and by 16.8% for the seeds. The nitrogen use efficiency (NUE) and the agronomic efficiency (AE) were 5.76 and 2.75, respectively, being the highest value for the 100% rate compared to the 50% and 75% rates (Fig. 1).

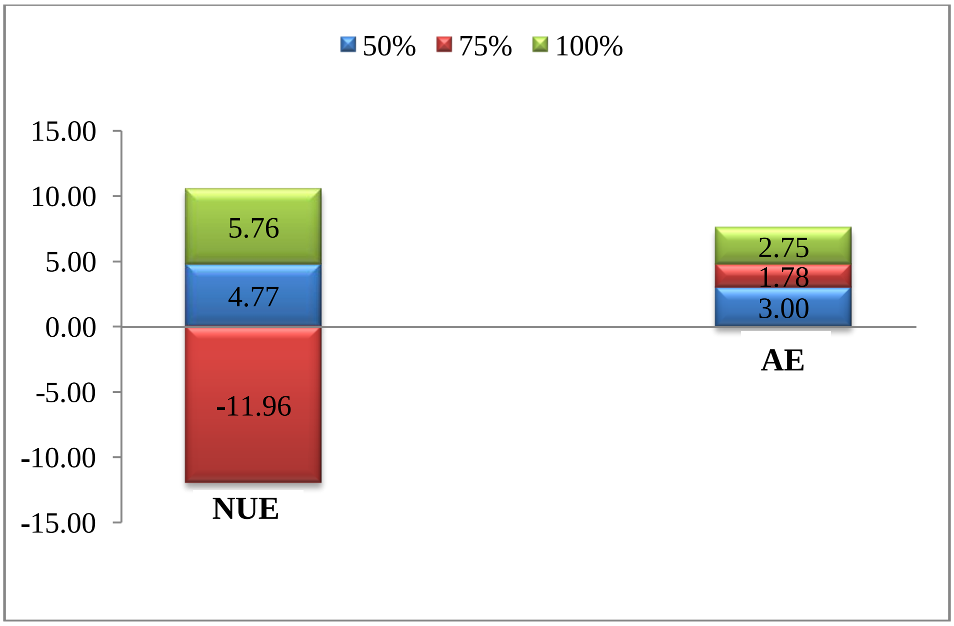


**Fig. 1. Nitrogen Use Efficiency (NUE) and Agronomic Effeciency (AE) as affected by the Magnetic Treatment (MT) of seeds and N-fertilizer**

**Table 1. Some properties of the experimental soil before planting**

| Coarse sand (%) | Fine sand (%) | Silt (%) | Clay (%) | Texture | | |
|---|---|---|---|---|---|---|
| 68.14 | 21.86 | 6.36 | 3.64 | Sand | | |
| **pH (1: 2.5)** | **EC (dS/m)** | **OM (%)** | **$CaCO_3$ (%)** | **Macronutrients (mg kg$^{-1}$)** | | |
| | | | | **N** | **P** | **K** |
| 7.92 | 1.10 | 0.35 | 0.50 | 24 | 3.22 | 120 |

**Table 2. Effect of the studied treatments on the soil available nutrients (mg kg$^{-1}$)**

| The N-fertilization rate | Available concentration (mg kg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | N | P | K | Fe | Mn | Zn |
| Control | 40.32 | 4.40 | 171.0 | 1.95 | 1.10 | 0.62 |
| 50% | 43.87 | 4.98 | 175.3 | 1.97 | 1.09 | 0.59 |
| 75% | 47.29 | 4.98 | 177.0 | 1.98 | 1.18 | 0.63 |
| 100% | 53.90 | 4.98 | 178.0 | 2.05 | 1.23 | 0.68 |
| LSD $_{5\%}$ | 12.65 | 0.52 | 18.94 | 0.52 | 0.01 | 0.52 |
| SL | ns | ns | ns | ns | *** | ns |

*LSD: Least Significant Difference at p ≤ .05, SL: Significance of Level, ns: non-significant*

**Table 3. Effect of the studied treatments on some groundnut pods and seeds yield (kg ha$^{-1}$) and some yield parameters**

| The N-fertilization rate | Plant height (cm) | Plant wt. (g) | No. of pods/ Plant | Wt. pods/ Plant (g) | Wt. seeds/ Plant (g) | 100 seed wt. (g) | Pods Yield (kg ha$^{-1}$) | Seeds Yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| Control | 49.6 | 120.5 | 24.4 | 45.7 | 27.1 | 74.74 | 3761.9 | 2345.2 |
| 50% | 55.4 | 113.3 | 30.2 | 53.1 | 30.1 | 56.39 | 3785.7 | 2333.3 |
| 75% | 62.9 | 107.3 | 37.3 | 57.9 | 32.1 | 75.29 | 4023.8 | 2500.0 |
| 100% | 66.4 | 183.8 | 37.9 | 62.3 | 39.9 | 66.43 | 4261.9 | 2738.1 |
| LSD $_{5\%}$ | 15.01 | 56.57 | 12.75 | 14.84 | 11.99 | 11.62 | 446.9 | 394.0 |
| SL | ns | ns | ns | ns | ns | * | ns | ns |

*LSD: Least Significant Difference at p ≤ .05, SL: Significance of Level, ns: non-significant*

**Table 4. Effect of the studied treatments on the total concentration (g kg$^{-1}$) of N, P, and K in the seeds and straw**

| The N-fertilization rate | Total concentration (g kg$^{-1}$) | | | | | |
|---|---|---|---|---|---|---|
| | Seeds | | | Straw | | |
| | N | P | K | N | P | K |
| Control | 24.85 | 4.37 | 5.13 | 18.48 | 1.35 | 6.77 |
| 50% | 40.27 | 4.16 | 5.52 | 22.40 | 1.30 | 6.56 |
| 75% | 34.97 | 4.08 | 5.69 | 11.76 | 1.13 | 7.61 |
| 100% | 33.08 | 5.11 | 5.52 | 21.16 | 1.42 | 5.87 |
| LSD $_{5\%}$ | 9.88 | 2.08 | 0.96 | 1.00 | 0.25 | 0.81 |
| | ns | ns | ns | *** | * | *** |

*LSD: Least Significant Difference at p ≤ .05, SL: Significance of Level, ns: non-significant*

**Table 5. Effect of the studied treatments on the chlorophyll content (mg g$^{-1}$ f.w) in the groundnut leaves**

| The N-fertilization rate | Chl a (mg g$^{-1}$ f.w) | Chl b (mg g$^{-1}$ f.w) | Total Chl (mg g$^{-1}$ f.w) | Chl a/b |
|---|---|---|---|---|
| Control | 1.26 | 0.81 | 2.08 | 1.56 |
| 50% | 1.23 | 0.69 | 1.93 | 1.78 |
| 75% | 1.30 | 0.91 | 2.21 | 1.43 |
| 100% | 1.63 | 1.11 | 2.75 | 1.47 |
| LSD $_{5\%}$ | 0.69 | 0.80 | 1.45 | 0.43 |
| SL | ns | ns | ns | ns |

*LSD: Least Significant Difference at p ≤ .05, SL: Significance of Level, ns: non-significant*

The magnetism $\chi_m$ ($10^{-6}$ $cm^3$ $mol^{-1}$) of different elements can be responsible for the behaviour of a material when it is induced by a MF. It is difficult to predict the magnetic response of the fertilizer or the nutrients within the soil or plant matrix because of the complex chemical and biological processes in the soil solution and plant cells [26,11,12]. Ions of potassium (K), iron (Fe), manganese (Mn), and perhaps the nitrate ($NO_3^-$) and phosphate ($PO_4^{-3}$) may possess positive susceptibility $\chi_m$. This can control the equilibria of chemical and biological reactions in the soil and plant and affects the balanced uptake of nutrients by plant. Magnetic fertilizers were believed to manage the molecular structure of soils [27,28,10].

## 5. CONCLUSION

Magnetic treatment (MT) of urea as a nitrogen fertilizer and/or groundnut seeds for 30 min before cultivation can be recommended to enhance the N use efficiency under the sandy soil conditions. This can be attributed to the induction effect of the magnetic force on the chemical and biological reactions that enhance the nutrients availability and uptake in the soil-plant system. The MT has increased the weight of pods/plant by 36.3% and the weight of seeds/plant 47.2%, but decreased the 100 seed weight (g) by 11.1%. The relative increase in the yield (kg ha$^{-1}$) of the pods and seeds was by 13.3% and 16.8%, respectively. The relative increase in total concentrations of N-P-K (g kg$^{-1}$) in the groundnut seeds was by 33.1%, 16.9%, and 7.6%, respectively at the 100% rate.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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