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# Groundnut Physiological and Chemical Response to Molybdenum

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**Abstract:** Two field experiments were carried out to evaluate the effect of different levels of molybdenum on nodules efficiency, growth, yield quantity and quality of groundnut plants. The experiments were conducted at Research and Production Station, National Research Centre, EL- Nobaria site, Beheara Governorate, Delta Egypt, under drip irrigation system during 2011 and 2010 seasons.

The obtained results are summarized in the following:

- Molybdenum enhances groundnut nodules efficiency, growth, minerals composition, yield quantity and quality compared with control plants.
- Molybdenum at 12 ppm resulted in maximum growth, nodules number and weight, nitrogenase activity, pods and seeds yield as well as nutritional and chemical content.
- Increasing molybdenum levels more than 12 ppm decreased the molybdenum promotive effect on groundnut.

**Key words:** Groundnut · Molybdenum · Yield · Nodutation

## INTRODUCTION

Groundnut is one of most important leguminous crops in Egypt as well as in many parts of the world. It is used for human consumption, oil production, food industries and animal feeding. Molybdenum is a trace element found in the soil and is required for growth of most biological organisms including plants and animals. The availability of molybdenum for plant growth is strongly dependent on the soil pH, concentration of adsorbing oxides (e.g. Fe oxides), extent of water drainage and organic compounds found in the soil colloids [1]. Vargas and Ramirez [2] showed that molybdenum increased nodules dry weight in both groundnut and soybean plants under different levels of nitrogen and phosphorous fertilizers, [3] stated that Mo application resulted in enhanced nitrogenase and nitrate reductase activities in groundnut.

Molybdenum is an essential element; it is constituent of the nitrogenase enzyme and every bacteria which fixes nitrogen needs molybdenum during the fixation processes. Molybdenum has a positive effect on yield quality and nodules forming in legume crops. The functions of molybdenum in leguminous plants include nitrate reduction nodulation, nitrogen fixation and general metabolism [4]. Molybdenum was required for normal plant growth, reduction supply with molybdenum to the growth media decreased the activities of nitrate reductase and glutamine synthetase involved at initial steps of nitrate assimilation [5].

Jingli *et al*. [6] found that Mo promoted the symbiotic nitrogen fixation and the competitive ability of peanut. Bhagiya *et al*. [7] showed that Mo increased pods and seeds yield in groundnuts, chickpeas and mungbean as well as increase N, P and K content of pods compared with control. Tripathy *et al*. [8] pointed that Mo significantly increased groundnut seeds oil yield as well as nutrients uptake.

The present study was throwing light on physiological and chemical effect on molybdenum in groundnut.

## MATERIALS AND METHODS

**Soil Analysis:** Physical and chemical properties of Nubaria Soil were determined and particle size distributions along with soil moisture were determined as described by authors [9]. Soil pH, EC, cations and anions,

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Table 1: Some physical and chemical properties of Nubaria soil

| Physical properties | | | | | | | |
|---|---|---|---|---|---|---|---|
| Particle size distribution % | | | | Soil moisture constant % | | | |
| Sand | Silt | Clay | Soil texture | Saturation | FC | WP | AW |
| 70.8 | 25.6 | 3.6 | Sandy loam | 32.0 | 19.2 | 6.1 | 13.1 |

| Chemical properties | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Soluble cations ($meq^{l}L$) | | | | Soluble anions ($meq^{-l}L$) | | | |
| pH 1:2.5 | EC($dS\ m^{-1}$) | $CaCO_3$ % | OM % | $Ca^{++}$ | $Mg^{++}$ | $K^{+}$ | $Na^{+}$ | $HCO_3^{-}$ | $CO_3$ | $Cl^{-}$ | $SO_4^{=}$ |
| 8.49 | 1.74 | 3.4 | 0.20 | 0.8 | 0.5 | 1.6 | 1.80 | 0.3 | - | 1.9 | 0.5 |

| Cobalt | | | Total | Available | Available micronutrients | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ppm | | | mg 100 $g^{-1}$ soil | Ppm | | | | | |
| Soluble | Available | Total | N | P | K | Fe | Mn | Zn | Cu |
| 0.35 | 4.88 | 9.88 | 15.1 | 13.3 | 4.49 | 4.46 | 2.71 | 4.52 | 5.2 |

FC (Field capacity), WP (Welting point), AW (Available Water)

Table 2: Some properties of chicken manure

| | | | | | Total available nutrievits (%) | | DTPA-extractable | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| O.M % | C/N Ratio | PFI (1:25) | EC $dSm^{-1}$ | Total N (%) | P | K | Te | Mn | Zn | Cu |
| 36.0 | 7.07 | 6.40 | 8.85 | 2.96 | 0.72 | 0.93 | 566 | 36.8 | 28.2 | 34.7 |

organic matter, $CaCO_3$, total nitrogen and available P, K, Fe, Mn, Zn, Cu were run according to authors [10]. Determination of soluble, available and total cobalt was determined according to method described by authors [11]. Some physical and chemical properties of Nobaria soil are shown in Table (1).

**Experimental Works:** A preliminary pot experiment was conducted to evaluate the molybdenum on the groundnut growth during 2010 season. This experiment was carried out at Wire house of National Research Centre to define molybdenum concentrations range which gave growth and yield response of groundnut plants. Seedlings of groundnut treated with molybdenum concentrations: 0.0, 2,4,6,8,10,12,14,16,18 and 20 ppm.

According to the preliminary experiment results, the concentrations range of molybdenum which gave the groundnut response to growth and yield were 8,10,12,14 and 16 ppm. Molybdenum at 12 ppm gave the best growth and yield parameters of groundnut.

Two Field experiments were carried out to evaluate groundnut physiological and chemical response to cobalt nutrition. The sandy loam soil with plot area consists of five ridges, 3.5 meter in length and 60 cm width ($10.5m^2$= 1/400 fed). Calcium super phosphate (15.5 %) at the rate of 200 kg $P_2O_5$/fed, chicken manure at the rate of 15 $m^3$/fed (Table 2) and potassium sulphate (48% $K_2O$) at the rate of 100 kg /fed were added during soil preparation. A seed of groundnut (*Arachis hypogaea mill, cv. Giza- 6*) was inoculated prior to sowing with a specific strain of rhizobium (*bradyrhizobium sp*.). Seeds were sown on April, 2011 and 2012 summer seasons.

The seedlings (at the third true leaves) were treated with six concentrations of molybdenum i.e. Control, 8,10,12,14 and 16 ppm as a foliar. All required agricultural managements for plants growth and production were carried out as recommended by Ministry of Agriculture.

**Measurements of Vegetative Growth:** After 80 days from sowing, all growth parameters of groundnut plants such as plant height root length, number of branches and leaves as well shoot and root fresh and dry weights were recorded according to authors [12].

**Nodulation and Nitrogenase Activity:** Nodules number and weight were recorded after 50 days from sowing. Nitrogenase activity was determined according to authors

[13]. Groundnut plants were gently uprooted then the root nodules were placed in 500 ml serum bottles and were sealed with suba-seal rubbers and 10 % of the gas phase was replaced by $C_2H_2$ then bottles were incubated in dark at room temperature for 2hr. production of $C_2H_4$ was measured by injecting one ml gas sample into (GC). Nitrogenase activity values were recorded as µmol $C_2H_4$ /g/h.

**Measurements of Plant Yield:** After 120 days from sowing groundnut yield parameters such as pods number/plant, weight of pods/plant, weight of seeds/plant, 100 seeds weight, total pods yield (kg/fed), total pods yield (ardab/fed) were recorded according to authors [14]. Ardab = 75 Kg.

**Nutritional Status:** Groundnut, seeds sampled either from the intact plant for each treatment of both seasons was oven dried at 70°C for 48 hr ground and kept to chemical determinations. For extraction a weight of 0.2 g finely powdered dry sample and digested using a mixture of sulfuric acid ($H_2SO_4$) with hydrogen peroxide ($H_2O_2$). Macronutrients (N, P and K) as well as micronutrients such as Fe, Mn, Zn, Cu and Mo (Colorimetric method) were determined according to the method described by authors [11].

**Chemical Constituents:** The percent of total carbohydrates, total soluble sugars, total soluble solids, of groundnut seeds were determined according to authors [15]. Also total phouds aqueous acetone (70%) was determined according to authors [16].

**Statistical Analysis:** All data were subjected to statistical analysis according to procedure outlined by [17] computer program and means were compared by LSD method according to [18].

## RESULTS AND DISCUSSION

**Vegetative Growth:** Data in Table (3) represented the vegetative growth of groundnut as affected by molybdenum. Data revealed that molybdenum had a significant beneficial effect on all vegetative growth parameters such as plant height, number of branches and leaves per plant, leaf area, root length of groundnut plants after 80 days from sowing compared with untreated plants. Molybdenum at 12 ppm gave the highest growth parameters. Increasing molybdenum above 12 ppm decreased the beneficial effect. These results are in harmony with those obtained by [19] who found that Mo at 10 Kg/ ha soil increased the vegetative growth of blackgram compared with the control.

Table 3: Groundnut growth parameters as affected by molybdenum levels after 80 days from sowing (mean of two seasons)

| | | Number/plant | | | | Dry weight (g) | |
|---|---|---|---|---|---|---|---|
| MO treatments (ppm) | Plant height (cm) | Branches | Leaves | Leaf area ($cm^2$) | Root length (cm) | Shoot | Root |
| Control | 22.2 | 6.2 | 59.6 | 1337 | 14.1 | 26.3 | 2.66 |
| 8 | 24.6 | 7.0 | 61.2 | 1373 | 14.5 | 27.6 | 3.78 |
| 10 | 26.3 | 9.9 | 65.0 | 1955 | 16.3 | 28.5 | 3.98 |
| 12 | 29.8 | 10.5 | 68.6 | 2189 | 18.8 | 32.9 | 4.48 |
| 14 | 27.5 | 10.2 | 67.0 | 2122 | 17.2 | 31.2 | 3.67 |
| 16 | 25.2 | 9.6 | 65.9 | 1814 | 16.0 | 29.9 | 3.18 |
| LSD 5% | 0.6 | 0.3 | 1.5 | 35 | 0.3 | 1.1 | 0.1 |

Table 4: Groundnut nodulation parameters as affected by molybdenum levels after 80 days from sowing (mean of two seasons)

| MO treatments (ppm) | Nodules No./plant nodule | Nodules fresh weight/plant (g) | Nodules dry weight/plant (g) | N- ase activity µ mol C2H2/g/h |
|---|---|---|---|---|
| Control | 72.5 | 7.96 | 1.66 | 13.1 |
| 8 | 86.4 | 9.51 | 2.72 | 15.5 |
| 10 | 111 | 11.3 | 4.59 | 16.8 |
| 12 | 139.1 | 12.7 | 4.98 | 17.9 |
| 14 | 135.5 | 11.8 | 4.78 | 17.2 |
| 16 | 133 | 10.6 | 4.54 | 16.6 |
| LSD 5% | 2.2 | 0.5 | 0.18 | 0.5 |

Table 5: Groundnut yield parameters as affected by molybdenum levels after 120 days from sowing (mean of two seasons)

| MO treatments (ppm) | Pods number/plant (pod) | Pods weight/plant (g) | 100 seeds weight (g) | Pods yield ardab/fed | Oil % | Oil yield (Kg/fed) |
|---|---|---|---|---|---|---|
| Control | 25.8 | 31.6 | 50.2 | 17.8 | 40.1 | 394.4 |
| 8 | 27.5 | 33.8 | 52.0 | 19.0 | 40.8 | 401.13 |
| 10 | 31.6 | 37.3 | 53.7 | 21.2 | 40.9 | 402.28 |
| 12 | 34.5 | 44.9 | 54.5 | 22.6 | 41.6 | 409.19 |
| 14 | 33.9 | 40.2 | 53.2 | 21.5 | 41.5 | 408.12 |
| 16 | 34.2 | 44.3 | 52.9 | 19.5 | 41.0 | 395.8 |
| LSD 5% | 0.3 | 0.5 | 0.14 | 0.6 | 0.5 | 1.1 |

Confirm, Niranjana *et al*. [20] stated that Mo at 2.0 g/Kg seed recorded the highest growth parameters and pods yield in groundnut compared with control.

Data in Table (3) also indicate that shoot and root dry weight of groundnut increased with different levels of molybdenum compared with control. Molybdenum at 12 ppm gave the highest biomass. Increasing Mo dose above 12 ppm reduced the promotive effect. These results are agree with those obtained by [22] who found that molybdenum improved plant growth such as root and shoot biomass in pea plants.

**Nodulation and Nitrogen Fixation:** Data in Table (4) obviously showed that molybdenum had a significant promotive effect on groundnut root nodules number per plant, fresh and dry weights of nodules with all Mo levels compared with control. Molybdenum at 12 ppm gave the best figures of both number and weights of groundnut root nodule. When Mo dose increased more than 12 ppm the promotive effect reduced. These results are in harmony with those obtained by [21] who stated that molybdenum at 25 ppm/Kg groundnut seeds significantly increased the number of nodules per plant by 46.00 and 50.42 during 45 and 60 days after sowing. Bhuiyan *et al*. [22] added that Mo application can play a vital role in increasing the nitrogen fixation and gave better nodulation in mungbean.

Data in Table (4) also indicated that all molybdenum concentrations gave the maximum nodules formation and enhanced nitrogenase activity compared with untreated plants. Molybdenum at 12 ppm gave the highest activity of nitrogenase enzyme. Increasing Mo above than 12 ppm reduced the one. These results are agree with those reported by [7] who found that root nodules parameters and nitrogenase activity gave the indication for nitrogen fixing activity in groundnuts nodules as affected by molybdenum application.

**Yield Characteristics:** The present data in Table (5) outline the effect of molybdenum on groundnut yield. Data indicated that all yield parameters such as pods number and weight per plant, weight of 100 seeds and pods yield per feddan significantly increased as affected by different Mo doses compared with control plants. Molybdenum at 12 ppm gave the maximum yield parameters. Molybdenum at 12 ppm increased pods yield about by 27% compared with control. Molybdenum is more than 12 ppm reduction the beneficial effect. These data are agree with those reported by [20] who pointed that molybdenum recorded the highest pods yield in groundnut compared with control.

Confirm, Bhagiya *et al*. [7] showed that molybdenum significantly increased pods and seeds yield in chickpeas, mungbean and groundnuts.

Data in Table (5) also indicate that molybdenum significantly improved the percentage of oil and oil-yield per feddan of groundnut seeds. Molybdenum at 12 ppm increased oil yield about 103%. All molybdenum doses enhanced groundnut oil seed compared with untreated plants. These results are in good agreement with those obtained by [8, 23] who stated that molybdenum significantly increased groundnut seed oil yield and nutrients uptake.

**Seeds Nutritional Status:** Data in table (6) exhibits the effect of molybdenum on groundnut seed nutrients content. Data clearly indicate that all molybdenum concentrations significantly increased minerals composition of groundnut seeds. Nitrogen, potassium, phoshphorus as macronutrients are significantly promotive effect as affected by Mo treatments compared with control plants. Also micronutrients i.e. Fe, Mn, Zn and Cu resulted better content in groundnut seeds treated with Mo. Molybdenum at 12 ppm gave the highest values of both macro and micro nutrient content. This means that increasing molybdenum levels more than 12 ppm in plant media decreased the promotive effect. This may be explained on the basis of the obtained results by [22] who found that molybdenum at 4.0 Kg per ha increased groundnut seeds N, P and K content. Tripathy *et al*. [8] added that molybdenum increased nutrients concentration of groundnut shoots and pods.

Table 6: Mineral composition in groundnut seeds as affected by molybdenum levels (mean of two seasons)

| MO | Macronutrients (%) | | | Micronutrients (ppm) | | | | |
|---|---|---|---|---|---|---|---|---|
| treatments (ppm) | N | P | K | Mn | Zn | Cu | Fe | Mo |
| Control | 1.33 | 0.35 | 0.81 | 12.6 | 19.0 | 15.9 | 36.6 | 0.69 |
| 8 | 1.76 | 0.39 | 0.84 | 12.9 | 20.3 | 16.3 | 37.2 | 1.16 |
| 10 | 1.83 | 0.45 | 0.9 | 13.4 | 20.7 | 16.9 | 39.0 | 2.85 |
| 12 | 2.03 | 0.68 | 1.08 | 14.5 | 22.8 | 18.0 | 42.8 | 4.16 |
| 14 | 1.98 | 0.68 | 1.01 | 14.2 | 22.2 | 17.8 | 42.2 | 6.56 |
| 16 | 1.95 | 0.64 | 0.97 | 13.8 | 21.0 | 17.0 | 41.0 | 7.85 |
| LSD 5% | 0.03 | 0.04 | 0.03 | 0.3 | 0.4 | 0.5 | 0.6 | 0.45 |

Table 7: Chemical content of groundnut seeds as affected by molybdenum levels (mean of two seasons)

| MO treatments (ppm) | Protein | Total carbohydrates | Total soluble Sugars | Total soluble Solids | Oil | Total phenols |
|---|---|---|---|---|---|---|
| | (%) | | | | | |
| Control | 8.31 | 21.6 | 8.41 | 31.6 | 40.1 | 1.11 |
| 8 | 11.0 | 22.9 | 8.72 | 32.8 | 40.8 | 1.19 |
| 10 | 11.44 | 25.2 | 9.02 | 34.0 | 40.9 | 1.26 |
| 12 | 12.69 | 24.0 | 9.54 | 35.6 | 41.6 | 1.54 |
| 14 | 12.38 | 23.2 | 9.11 | 35.2 | 41.5 | 1.49 |
| 16 | 12.19 | 22.5 | 9.02 | 34.5 | 41.0 | 1.45 |
| LSD 5% | 0.6 | 0.4 | 0.08 | 0.4 | 0.1 | 0.04 |

Data in Table (6) also indicate that increasing molybdenum levels in plant media increased Mo content in groundnut seeds.

**Seed Chemical Constituents:** Data in Table (7) show that molybdenum application significantly increase groundnut seeds chemical content such as protein, total carbohydrates, total soluble sugars, total soluble solids, oil and total phenols percentages as compared with untreated plants. Molybdenum at 12 ppm had a superior chemical content. The results in Table (6) show also the relative calculated values as percentage from control. It is evident that molybdenum rate at 12 ppm increased the content of: protein 52.7%, total carbohydrates 11.1%, total soluble sugars 13.4%, total soluble solids 12.7%, oil 2.5% and total phenols 38.7% respectively. These results are in harmony with those obtained by [23] who reported that molybdenum at 2.0 Kg/ha increased groundnut seeds oil content compared with control. Also authors [24] stated that molybdenum application resulted in enhanced total nitrogen accumulation in shoots, pods and seeds as well as seeds protein content of phaselus volgaris cv. Ouro Negro compared with the control. Data in Table (6) also show that the percentage of total phenoles content (1.54% with optimum level of Mo) less 2.0 % safety human health. This result is good agreement with those obtained by authors [16, 25].

## CONCLUSION

Groundnut plants needs 12 ppm molybdenum for its normal growth, molybdenum constituent of the nitrogenase enzyme and every bacteria which fixes nitrogen during the fixation processes. Also, Mo enhances plant growth, seeds and oil groundnut yields.

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