World Journal of Chemistry 7 (2): 64-70, 2012
ISSN 1817-3128

DOI: 10.5829/idosi.wjc.2012.7.2.1105

Influence of Molybdenum on Groundnut Production Under Different Nitrogen Levels

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Abstract: Two field experiments were carried out to evaluate of molybdenum, with different levels of nitrogen on physiological and chemical effects on nodules efficiency and the characteristics of plants. The experiments were conducted at Research and Production Station, National Research Centre, El-Nobaria, Behera Governorat, Delta Egypt, under drip irrigation system.
The obtained results are summarized in the following:

- Ammonium sulphate (20.5% N) recommended dose was the basic amount (100% N) as control gave the best groundnut growth parameters ,nodules number and weight, pods and seeds yield quantity and quality along with mineral composition compared with other nitrogen levels in the two seasons.
- Molybdenum at 12 ppm resulted in maximum growth, nodules number and weight, pods and seeds yield as well as nutritional and chemical contents especially with 100 and 75 % nitrogen compared with the control (100% N alone).
- With 50 %N, molybdenum was not significant while with 25 % N gave the lowest figures of growth and yield parameters in the two growth seasons.
- Molybdenum is more than 12 ppm reduction the beneficial effect.

Key words: Groundnut · Molybdenum · Nitrogen fertilizer

INTRODUCTION

The plant needs some macronutrients and micronutrients for its normal growth. Some of these elements play an important role in the process of Rhizobium symbiosis: for example, molybdenum is a constituent of the nitrogenase enzyme and every bacterium, which fixes nitrogen, needs molybdenum during the fixation process. Molybdenum is an essential element; it is a constituent of the nitrogenase enzyme and every bacterium, 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 [1]. Molybdenum was required for normal plant growth, reduction supply with molybdenum to the growth medium decreased activities of nitrate reductase and glutamine synthetase involved at initial steps of nitrate assimilation [2].

Cobalt is considered to be a beneficial element for higher plants in spite of the absence of evidence for direct role in their metabolism. This is true in spite of essentiality for photosynthetic activities of lower plants such as euglena gracilis; it was frequently reported to be localized in various sub-cellular fractions as in chloroplasts [3].

The present study was throwing light on groundnut growth; yield quantity and quality as affected by molybdenum.

MATERIALS AND METHODS

Soil Analysis: Physical and chemical properties of Nubaria soil, Research and Production Station, National Research Center, are shown in Table (1) and Table (2). Particle size distribution along with soil moisture of soil sample was determined as described by authors [4]. Soil organic matter, $CaCO_3$, Ec, pH, cations and anions were determined according to authors [5]. Soluble and available micronutrients, total N and available P and K as well as

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Table 1: Physical and chemical properties as well as nutrient content of Soil us

Properties	Particle size distribution %			
Physical	Sand	Silt	Clay	Texture
	13.40	25.00	61.60	clay loam
	Moisture content %wb at			
	Saturation	Field capacity	Wilting point	Available water
	75.30	42.60	12.30	3030
Chemical	pH (1:2.5)	EC dSm^{-1} soil paste	$CaCO_3$%	OM %
	8.40	3.10	3.27	0.87
	Soluble cations (meq/l)			
	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
	65.40	32.10	95.60	3.90
	Soluble anions (meq/l)			
	$CO_3^{=}$	HCO_3^{-}	Cl^{-}	$SO_4^{=}$
	0.00	2.70	121.40	63.90
Cobalt	Cobalt (ppm)			
	Soluble	Available	Total	
	0.23	2.19	9.50	

	N	P	K	Fe	Mn	Zn	Cu
Nutrients content	%			Ppm			
	13.20	3.80	0.48	45.40	22.82	19.46	13.60

Table 2: Some properties of chicken manure

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

total Cobalt was determined in aqua rejia extract, the water soluble Cobalt and available Cobalt (DTPA extractable) were determined according to authors [6].

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 16ppm. Molybdenum at 12ppm 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.

A number of 16 treatments were concluded:-

- $(NH_4)_2SO_4$ 100% recommended dose as control
- $(NH_4)_2SO_4$ 75%
- $(NH_4)_2SO_4$ 50%
- $(NH_4)_2SO_4$ 25%
- $(NH_4)_2SO_4$ 100% + Mo at 12 ppm
- $(NH_4)_2SO_4$ 75% + Mo at 12 ppm
- $(NH_4)_2SO_4$ 50% + Mo at 12 ppm
- $(NH_4)_2SO_4$ 25% + Mo at 12 ppm

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 [7].

Nodulation and Nitrogenase Activity: Nodules number and weight were recorded after 50 days from sowing. Nitrogenase activity was determined according to authors [8]. 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 [9]. 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 [6].

Chemical Constituents: The percent of total carbohydrates, total soluble sugars, total soluble solids, of groundnut seeds were determined according to authors [10]. Also total phouds Aqueous acetone (70%) was determined according to authors [11].

Statistical Analysis: All data were subjected to statistical analysis according to procedure outlined by authors[12] computer program and means were compared by LSD method according to authors [13].

RESULTS AND DISCUSSION

Vegetative Growth: Data in Table (3) represented the vegetative growth parameters of groundnut as affected by molybdenum and different nitrogen levels. Data revealed that molybdenum at 12 ppm had a significant beneficial effect on all vegetative growth parameters such as plant height, root length, number of branches and leaves especially with 100% and 75% nitrogen at all growth stages (50, 70, 90 days from sowing) in both 2011 and 2012 seasons. Growth parameters in groundnut plants treated with molybdenum and 50% nitrogen was not significant while molybdenum with 25% nitrogen gave the lowest figures. Molybdenum addition enhanced all growth parameters of groundnut plants in the two seasons. These results are in harmony with [14] who found that molybdenum at 10 kg/ha increased the vegetative growth of blackgram compared with the control (100% nitrogen alone) at intervals of 50, 70 and 90 days from sowing in both two seasons.

Data in Table (3) also indicated that the shoots and roots biomass of groundnut increased with different levels of nitrogen fertilizer combined with molybdenum application significantly increased shoot biomass about 25.4, 23.2, 16.3 and 18.0 %, respectively and for roots 19.8, 16.4, 14.1 and 13.4 %, respectively. These results are in harmony with those obtained by [2] who stated that molybdenum improved plant growth such as root and shoot biomass in pea plants.

This increment didn't reach the significant levels except for 75% and 100% nitrogen fertilizer (19.55, 20.26, 107.50, 108.32, 155.30, 160.33 for fresh weight and 2.78, 2.83, 20.33, 20.60, 26.70, 27.31 for dry weight, respectively) at intervals of 50, 70 and 90 days from sowing. These results were agreed with those of [15] who found that the plants need molybdenum for its normal growth.

Nodulation and Nitrogen Fixation: The present data in Table (4) obviously showed that molybdenum had a significant promotive effect on groundnut root total nodules number / plant, fresh and dry weights of nodules under all nitrogen percentages compared with the untreated plants. Molybdenum gave the highest nodules parameters with 100 % nitrogen followed by 75% nitrogen after 50 days from sowing for 2011 and 2012 seasons, compared with the control (100% N alone). Molybdenum with 50 % nitrogen was not significant while with 25% nitrogen gave the lowest figures. These data are agree with those obtained by [16] those indicated that nodules number and dry weight of groundnut were increased by applied molybdenum and its enhanced the rate of nitrogen fixation.

Data in Table (4) clearly indicated that molybdenum treatment significantly increased the nitrogenase activity of groundnut root nodules under different nitrogen levels

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

		Number/plant				Dry weight (gm)	
Nitrogen treatments (%)	Plant height (cm)	Branches	Leaves	Leaf area (cm^2)	Root length (cm)	Shoot	Root
		Without molybdenum					
100	22.5	6.3	59.5	1334	14.5	26.0	2.63
75	20.6	6.0	56.0	1256	12.7	23.7	2.15
50	18.5	5.5	52.6	1181	10.2	21.5	1.89
25	16.0	5.1	50.2	1128	9.3	18.9	1.64
		With molybdenum (12 ppm)					
100	29.5	10.2	68.0	2186	18.5	32.6	3.15
75	26.0	9.8	66.2	2101	16.5	29.2	2.62
50	23.0	7.0	60.0	1371	14.6	25.0	2.26
25	20.8	6.1	56.0	1314	12.0	22.3	1.86
LSD 5%	0.2	0.3	0.5	55	0.6	0.8	0.28

Table 4: Groundnut nodulation parameters as affected by molybdenum under different nitrogen levels after 50 days from sowing (means of two seasons)

	Nodules Number / plant			
Nitrogen treatments (%)	Nodules	Nodules fresh weight per plant (g)	Nodules dry weight per plant (g)	N-ase activity mol C_2H_2/g/h
	Without molybdenum			
100	130.2	11.8	4.45	15.9
75	126.9	11.1	4.16	15.0
50	119.0	10.3	3.83	13.6
25	116.2	9.96	3.67	12.7
	With molybdenum (12ppm)			
100	140.2	12.8	4.88	17.6
75	135.6	11.7	4.74	17.2
50	126.5	10.8	4.39	15.7
25	11.01	9.49	3.81	13.4
LSD 5%	0.3	0.34	0.16	0.4

Table 5: Groundnut yield parameters as affected by molybdenum under different nitrogen levels after 120 Days from sowing (means of two seasons)

Nitrogen treatments Ppm	Pods number / plant	Pods weight/ plant (gm)	Weight 100 seeds (gm)	Pods yield (ardab/fed)	Oil %	Oil yield (kg/fed)
	Without molybdenum					
100	25.9	31.7	50.1	17.7	38.0	393.5
75	21.2	28.9	49.6	16.9	37.8	384.6
50	16.5	27.2	39.0	16.1	37.3	379.5
25	14.0	26.7	38.5	15.3	37.0	371.8
	With molybdenum (12 ppm)					
100	35.0	45.1	55.0	22.8	40.7	416.9
75	30.8	41.0	52.2	19.5	38.9	408.1
50	26.0	39.3	51.0	18.1	38.5	403.9
25	24.2	36.0	49.2	17.0	38.0	398.7
LSD 5%	1.8	0.5	0.5	0.7	0.3	1.0

after 50 and 70 days from sowing for both two seasons compared with the untreated plants. Molybdenum had a significant promotive effect on nitrogenase activity of groundnut root nodules with both 100% and 75% nitrogen compared especially with the control (100% N alone) after 50 days from sowing for 2011 and 2012 seasons. These results are in harmony with those obtained by [17] who found that molybdenum requirement for nitrogen fixation of groundnut and to lesser extent to higher specific nitrogenase activity per unit nodule dry weight. Finally, root nodules parameters and nitrogenase activity gave the indication for nitrogen fixing activity in nodules of groundnut was significantly influenced by molybdenum [18].

Molybdenum saved about 25% of the recommended nitrogen fertilizer dose.

Yield Characteristics: Tables (5) exhibit the effect of molybdenum on groundnut yield under nitrogen levels. Data show that, molybdenum had a significant increased on number and weight of pods /plant, weight of seeds/ plant and total pods yield at both seasons with 100% and

Table 6: Minerals composition in groundnut seeds as affected by molybdenum under different nitrogen levels (mean of two seasons)

	Macronutrients (%)			Micronutrients (ppm)				
Nitrogen treatments (%)	N	P	K	Mn	Zn	Cu	Fe	Cobalt (ppm)
	Without							
100	1.34	0.32	0.71	12.4	18.0	15.5	35.2	0.68
75	1.27	0.30	0.69	11.9	17.8	15.1	33.5	0.68
50	1.24	0.27	0.66	11.7	17.5	14.8	30.9	0.67
25	1.20	0.25	0.64	11.7	17.1	14.5	30.5	0.66
	With (12 ppm)							
100	2.03	0.36	1.05	14.0	21.9	17.8	42.5	4.18
75	1.75	0.38	0.86	12.7	19.7	16.5	40.6	4.15
50	1.69	0.35	0.82	12.4	19.0	16.1	39.3	4.13
25	1.64	0.31	0.79	12.0	18.8	15.8	38.5	4.13
LSD 5%	0.3	0.2	0.3	0.2	0.3	0.3	0.4	0.1

Table 7: Chemical content of groundnut seeds as affected by molybdenum under different nitrogen levels (means of two seasons)

	Protein	Total Carbohydrates	Total soluble sugar	Total soluble solids	Oil	Total phenols
Nitrogen Treatments (%)	(%)					
	Without molybdenum					
100	8.19	21.3	8.39	31.4	38.0	1.19
75	7.94	20.7	8.11	29.9	37.8	1.08
50	7.75	20.2	9.97	29.3	37.3	0.99
25	7.50	19.8	9.69	28.8	37.0	0.88
	With molybdenum (12 ppm)					
100	12.7	24.0	9.49	35.5	40.7	1.66
75	10.9	23.3	9.18	34.9	38.9	1.59
50	10.5	22.9	8.89	34.6	36.5	1.52
25	10.3	22.4	8.52	34.0	36.0	1.45
LSD 5%	0.2	0.5	0.28	0.3	0.2	0.11

75% nitrogen compared with 100% nitrogen alone (control). Molybdenum addition as a foliar increased total pods yield about 28.8 % and 15.4 %, respectively under 100 % and 75% nitrogen. Molybdenum increased oil yield about 5.95 and 6.11 %, respectively. These results were agree with those obtained by [19] who found that molybdenum increased pods yield over control with 34.8 and 38.9 % respectively in groundnuts. Regarding 50% nitrogen, molybdenum was not significant. While with 25% nitrogen gave the lowest yield quantity. Data also indicate that molybdenum significantly increased other yield parameters as weight of pods/plant, weight of seeds/plant and 100 seeds weight in two seasons. These data were agreed with [20] who showed that molybdenum increased pods yield, seeds yield in chickpeas. Data also indicated that, molybdenum saved 25% from the recommended dose (100 % N alone). These data are in harmony with those of [21] who found that molybdenum recorded the highest growth parameters and pods yield in groundnut compared with the control.

Nutrition Status: Data presented in Table (6) reveal the promotive effect of molybdenum on mineral composition (N, P, K, Fe, Zn, Cu and Mn) of groundnut seeds. Data indicate that the superiority of molybdenum with 100% nitrogen and the favorable effect with 75% nitrogen. Molybdenum less than 50 % nitrogen was not significant, while less than 25% nitrogen gave the lowest nutritional composition in groundnut seeds. These results are in harmony with [22] who stated that molybdenum increased the content of (N, P and K) of groundnut seeds.

Seed Chemical Constituents: Data in Table (7) also indicated that molybdenum under 100% and 75% nitrogen increased protein percentage in seeds of groundnuts compared with the control. These results are in good agreement with those found by [1] who found that molybdenum increased protein and phosphorus content in lentil seeds.

Data in Tables (7) outline the response of groundnut nutritional content. Data showed that molybdenum with the complete dose of nitrogen fertilizer (100%) had a better status of macronutrients (N, P and K) and micronutrients (Fe, Zn and Mn). with 75% nitrogen molybdenum had a significant synergistic effect on the status of the studied minerals in seeds of groundnut compared with the control. While Under 50 % nitrogen molybdenum was not significant. While with 25% nitrogen molybdenum gave

the lowest nutrients composition compared with the untreated plants. This may go along with the finding of [22], they found that molybdenum at 4.0 kg/ha increased oil content of groundnut seeds by 12.1 % and N, P and K content of pods by 24.0, 20.2 and 27.9 % respectively compared with the control. Also, results [23] showed that molybdenum application enhanced total N accumulation in shoots and increased total nitrogen in both pods and seeds of phaseolous. Tripathy *et al*. [19] added that molybdenum increased nutrients concentration of groundnut shoots and pods.

CONCLUSION

Results showed that the addition of molybdenum led to increase in groundnut growth as well as the yields quantity and quality at the usual amount of fertilizer. The result showed also that the addition of these elements with 75% of the recommended amount of nitrogen fertilizer led to good results and often convergent with the results of full fertilization. These results lead to the conclusion that the addition of molybdenum saved about 25% of recommended nitrogen fertilizer dose and enhanced groundnut yield quantity and quality. Therefore, it could be reduced the agricultural cost for more money to farmers.

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