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THE IMPACT OF BIOFERTILIZERS AND CHEMICAL FERTILIZERS ON TWO GROUNDNUT CULTIVARS PRODUCTIVITY UNDER THE SEMI-ARID TROPICS OF SUDAN

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ABSTRACT

Two groundnut cultivars treated with *Rhizobium* strain with two concentrations and isolated local Mycorrhiza fungi chosen for this study compared with chemical fertilizers. The strains were screened in pots at the College of Agricultural Studies, Sudan University of Science and Technology.The study was performed to investigate the effects of *Rhizobium* strains and isolated local Mycorrhizal fungi from sorghum rhizosphere on groundnut plant in terms of (plant height, top dry weight, colour rating, nodulation, yield and tissue content of nitrogen, potassium and phosphorus). The performance of the combination between Mycorrhiza fungi and *Rhizobium* strain enhanced and developed the growth of groundnut plants. The performance of the Mycorrhiza fungi alone enhanced the groundnut plant on nutrient uptake and plant and over the inoculated plants and control. *Rhizobium* positively affected groundnut the plant growth traits and nutrient uptake; The performance of urea fertilizer enhanced the plant weight of groundnut M383 cultivar, also affected by the addition of *Rhizobium* bacteria as a single treatment and the Mycorrhiza fungi in all measurements. The Ahmadi cultivar was also affected by the treatment of *Rhizobium* bacteria in the yield, number and weight of root nodules.

Keywords: Biofrtilizer, Chemical fertilizer, Groundnut, Rhizobium, Mycorrhiza.

INTRODUCTION

Groundnuts (*Arachis hypogaea*) family leguminaceae, also known as peanuts or monkey nuts, are the edible seeds of a legume plant that grow to maturity in the ground. The crop is cultivated

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in nearly 100 countries, over 90% of developing countries; the groundnut is a food staple and valuable cash crop for millions of households (Ahmed et al., 2020). It is the 13th most essential food crop and the 4th most crucial oilseed crop (Taru et al., 2010). Due to the Sudanese soil problem, which is represented in the deficiency of macro element (Nitrogen, Phosphorus and Potassium) and some of the microelements, the immediate solution is to use organic and biofertilizers that can repair and fix the problems and in the same way do not deplete of natural resources.(Osman and Abd Elaziz, 2010). Biofertilizers are means of fixing and availability the nutrients in the soil. Involved microorganisms could readily and safely convert complex organic material into simple components, so that they are easily taken up by the plants. Microorganism function is continuous in long duration, causing improvement of the soil fertility. It maintains the natural habitat of the soil. Crops versus control groups (Htwe et al., 2019). Biofertilizers increase crop yield by 20-30%, replaces chemical nitrogen and phosphorus by 30%, and stimulates plant growth. It can also provide protection against drought and some soil-borne diseases. It has also been shown that produce a larger quantity of crops, biofertilizers with the ability of nitrogen fixation and phosphorus solubilizing would lead to the greatest possible effect in plant growth. (Schütz *et al.,* 2018). Nitrogen is the most important element in the growth and development of plants (Albareda et al., 2009). Ecofriendly N_2 fixing microorganisms inhabitant to Sudanese soils; Biological nitrogen fixation is anessential process that promotes plant growth and increases its productivity could be symbiotic or non-symbiotic according to the relationship between plant and bacteria. (Kızılkaya, 2008). Phosphorus is basically necessary for healthy growth with the effectual root system and profuse nodulation which can then impact the N_2 fixation potential (Amba et al., 2013). Research work by (Mmbaga et al., 2014) reveals that legumes inoculated with Rhizobium in addition to phosphorus fertilizer respond differently in terms of growth, yield and nitrogen fixation. Also (Ahiabor et al., 2014) observed that combined application of phosphorus at 45 kg P ha−1 plus *Rhizobium* inoculants increased nodulation by 56% and recorded significant groundnut grain yields. Adding mycorrhiza inoculums to the Sudanese soils, which are helpful to solve Phosphorus deficiency, also the availability of indigenous Mycorrhiza in the rhizosphere of most crops of economic importance such as sorghum and groundnuts needs thorough investigations. The degree of damage caused by the weeds has been a function of their leaf area index (LAI) compared to their competing crop.(El Naim and Ahmed, 2010), (M.M., A., Hadad, M. A., & Elhassan, 2016). Investigations in Sudan showed that plant inoculated with mycorrhizal fungi increased dry matter, phosphorus and nitrogen content, and in case of legumes better nodulation and nitrogen fixation (Howieson and Ballard, 2004). Experment was conducted in Sudan AM fungi and *Rhizobium* positively affected groundnuts plant growth traits and nutrient. The performance of the AMF alone or in combinations with Rhizobium strains was significantly better than that of the bacteria alone in terms of plant height, top dry weight and

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root dry weight (M.M., A., Hadad, M. A., & Elhassan, 2016). Therefore, this work was conducted to achieve the following objectives:

- To increase groundnut yield by adding different kinds of fertilizers. And Rhizobium added as a biofertilizer.
- To isolate local Mycorrhiza fungi from the rhizosphere of sorghum plant and add them as a biofertilizer. and to measure the response of the growth of two cultivars of groundnut to biofertilizers and chemical fertilizers.

MATERIALS AND METHODS

In vitro study:

Isolation of Mycorrhiza spores:

The spores were isolated by wet sieving and transferring method (Gerdemann and Nicolson, 1963) with the following modifications; Fifty grams of demonstrative soil sample were drawn from each site and suspended in 1000 ml of tap water and stirred thoroughly. The suspension was allowed to stand for 15 minutes and then passed complete a series of sieves 1 mm size, 500µm, 250µm, 125µm, 53 µm and 45 µm arranged in descending order of their mesh size. The spores on the six sieves were transferred to a 250 ml conical flask.

Rhizobium strains:

The *Rhizobium* strain was isolated from groundnut nodules in the Northern State of Sudan. Erlenmeyer flasks containing 200 ml of sterile medium yeast extract mannitol agar (YEMA) were inoculated with the *Rhizobium* strain under aseptic conditions. The flasks were placed on an orbital shaker at 200 rpm at ambient temperature for seven days. (Howieson and Ballard, 2004). Serial dilutions were made to count the *Rhizobium* cells/ml.

In vivo study:

General description of the experimental site:

The experiment was done in a rainy season in July 2019 at the experimental field, the College of Agricultural Studies, Sudan University of Science and Technology, in shambat, Khartoum, North.

Samples collection:

Soil and root samples from plants (groundnut and sorghum) were collected from the rhizosphere from 0-30cm depth of two different sites of Sudan; Northern State and Khartoum state.

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Treatments:

The treatments applied as follows: control, nitrogen mineral fertilizer (Urea), *Rhizobium* inoculums (10^4), *Rhizobium* inoculum (10^8), phosphorus mineral fertilizer (Superphosphate), the mixture of nitrogen mineral fertilizer(Urea)+ phosphorus mineral fertilizer (Superphosphate), the mixture of mycorrhizal spores +*Rhizobium* inoculum (10^4), mycorrhizal spores +*Rhizobium* inoculum (10^8) and mycorrhizal spores.

Seeds:

The seeds of groundnut, Ahmadi variety, and M383 variety used in this work were obtained from The Agricultural Research Corporation (Shambat Station). The seeds were sterilized with H_2O_2 (3%) for 15 minutes.

Seeds inoculation:

The seeds were mixed with the inoculum after germinating them in the incubator before putting them in the pots.

Plant samples:

The samples from each pot were taken randomly after one month, two months and four months.

Tissue analysis:

Nitrogen content determined using the Kjeldahl method; Phosphorus was determined using a Spectrophotometer, and potassium determined using a Flame photometer (Ryan et al., 1996).

Statistical analysis:

A completely randomized design was used with 9 replicates. Statistical analysis was conducted using (MSTAT) program. Mean separation was done using Duncan multiple range tests (Harter, 1960).

RESULTS AND DISCUSSIONS

In Vivo Study (Pot experiment):

Ahmadi cultivar:

Effect of treatments on plant height and colour rating.

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Table (1) showed that AM fungi and *Rhizobium* positively affected groundnuts plant height in the pots. Furthermore, the fungi in combinations with *Rhizobium* strains were significantly better than that of the bacteria alone in plant height, matching with (M.M., A., Hadad, M. A., & Elhassan, 2016) and (Mmbaga et al., 2014). The highest value of colour rating was observed with plants inoculated with a combination between Mycorrhiza and *Rhizobium* 10^4. The combination between Mycorrhiza and *Rhizobium* 10^8 and minerals added and treatment of superphosphate recommended dose.

Table 1: Effect of treatments on plant height and colour rating

Ahmadi Treatments	Plant height cm/plant			Colour rating		
	(1) Month	(2) Month	(3) Month	(1) Month	(2) Month	(3) Month
Urea	**17.83^{b}**	**24.73^{c}**	**29.00^{bc}**	**3.000^{abc}**	**2.000^{b}**	**2.000^{b}**
***Rhizobium*10^4**	**19.93^{ab}**	**25.67^{c}**	**33.20^{ab}**	**3.667^{a}**	**2.333^{ab}**	**2.000^{b}**
***Rhizobium*10^8**	**20.17^{ab}**	**31.33^{ab}**	**35.33^{a}**	**3.000^{abc}**	**2.333^{ab}**	**2.667^{a}**
Superphosphate	**20.23^{ab}**	**27.77^{bc}**	**30.33^{abc}**	**2.667^{bc}**	**2.667^{ab}**	**3.000^{a}**
Mycorrhiza	**19.97^{ab}**	**33.30^{a}**	**30.97^{abc}**	**2.333^{c}**	**2.333^{ab}**	**2.000^{b}**
Mycorrhiza + *Rhizobium*10^4	**20.33^{ab}**	**24.53^{c}**	**27.17^{c}**	**3.333^{ab}**	**2.333^{ab}**	**2.667^{a}**
Mycorrhiza + *Rhizobium*10^8	**21.17^{a}**	**26.03^{c}**	**31.47^{abc}**	**3.333^{ab}**	**3.000^{a}**	**2.667^{a}**
Urea + Superphosphate	**18.93^{ab}**	**28.77^{abc}**	**29.43^{bc}**	**3.000^{abc}**	**2.667^{ab}**	**2.000^{b}**
Control	**19.63^{ab}**	**28.93^{abc}**	**29.67^{bc}**	**3.000^{abc}**	**2.000^{b}**	**3.000^{a}**
LSD	**3.088**	**5.174**	**5.401**	**0.9496**	**0.8319**	**0.5767**

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of treatments on groundnut plant wet and dry weight at different sampling intervals (g/plant)

The results in table (2) clearly showed the effect of adding biological fertilizers; Mycorrhiza and *Rhizobium* positively affected the groundnut plant in terms of wet and dry weight, which matched with the findings of (Howieson and Ballard, 2004) and (M.M., A., Hadad, M. A., & Elhassan, 2016).

Table 2: Effect of treatments on groundnut plant wet and dry weight at different sampling intervals (g/plant).

Ahmadi Treatments	Plant wet weight cm/plant			Plant dry weight cm/plant		
	(1) Month	(2) Month	(3) Month	(1) Month	(2) Month	(3) Month
Urea	**5.833^{b}**	**41.13^{ab}**	**78.77^{ab}**	**1.333^{b}**	**10.67^{abc}**	**25.43^{a}**
***Rhizobium*10^4**	**10.90^{a}**	**22.20^{b}**	**94.33^{ab}**	**2.633^{a}**	**8.100^{c}**	**31.83^{a}**
***Rhizobium*10^8**	**11.03^{a}**	**32.17^{ab}**	**146.7^{a}**	**2.503^{ab}**	**19.90^{ab}**	**29.57^{a}**
Superphosphate	**8.733^{ab}**	**28.70^{b}**	**26.63^{b}**	**1.933^{ab}**	**9.767^{bc}**	**24.63^{a}**
Mycorrhiza	**8.067^{ab}**	**59.67^{a}**	**67.13^{ab}**	**1.967^{ab}**	**22.27^{a}**	**31.60^{a}**
Mycorrhiza + *Rhizobium*10^4	**6.400^{ab}**	**27.93^{b}**	**52.00^{b}**	**1.600^{ab}**	**8.300^{bc}**	**20.03^{a}**
Mycorrhiza + *Rhizobium*10^8	**10.77^{a}**	**36.23^{ab}**	**105.4^{ab}**	**2.533^{ab}**	**9.867^{bc}**	**26.20^{a}**
Urea + Superphosphate	**6.900^{ab}**	**23.23^{b}**	**64.37^{ab}**	**1.733^{ab}**	**7.200^{c}**	**21.73^{a}**
Control	**8.200^{ab}**	**36.03^{ab}**	**88.23^{ab}**	**1.967^{ab}**	**11.03^{abc}**	**28.17^{a}**
LSD	**4.879**	**28.05**	**84.20**	**1.219**	**11.65**	**21.73**

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of treatments on groundnuts number and weight of nodules in the primary roots

In the data presented in table (3), the nodulation was improved with the combination between Mycorrhiza and *Rhizobium* (10^8) inoculum. The number and weight of nodules each plant improved with inoculation compared with the uninoculated pots and control, which agreed with the findings of (Howieson and Ballard, 2004), (Mmbaga et al., 2014) and (Ahiabor et al., 2014).

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Table 3: Effect of treatments on groundnuts number and weight of nodules in primary roots

Ahmadi treatments in primary root	Second month		Third month	
	Number of nodules	Weight of nodules	Number of nodules	Weight of nodules
Urea	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Rhizobium10^4	38.67[d]	0.1380[de]	59.67[bcd]	0.1449[d]
Rhizobium10^8	47.67[bcd]	0.05490[e]	81.67[bc]	0.5228[bcd]
Superphosphate	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Mycorrhiza	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Mycorrhiza + *Rhizobium*10^4	59.33[ab]	0.4185[b]	34.67[cd]	0.1143[d]
Mycorrhiza + *Rhizobium*10^8	58.33[ab]	0.6083[a]	95.00[abc]	0.9298[abc]
Urea + Superphosphate	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Control	0.6667[e]	0.0004000[e]	0.0000[d]	0.0000[d]
LSD	10.18	0.1341	25.45	0.2189

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of treatment on groundnut number and weight of nodules in lateral roots

The results attached to table (4) showed that the formation of root nodules in the groundnut plant was significantly affected by the addition of the biological fertilizer, Mycorrhiza and *Rhizobium* in number and weight. This matched with (Howieson and Ballard, 2004) and (Mmbaga et al., 2014).

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Table 4: Effect of treatment on groundnut number and weight of nodules in lateral roots

Ahmadi treatments in lateral root	Second month		Third month	
	Number of nodules	Weight of nodules	Number of nodules	Weight of nodules
Urea	19.67 bcd	0.02630 c	0.0000 c	0.0000 d
Rhizobium 10^4	62.67 a	0.1211 bc	54.00 bc	0.1131 d
Rhizobium 10^8	60.33 ab	0.1809 bc	100.7 ab	0.3674 cd
Superphosphate	0.0000 d	0.0000 c	0.0000 c	0.0000 d
Mycorrhiza	19.33 bcd	0.05300 c	0.0000 c	0.0000 d
Mycorrhiza + *Rhizobium* 10^4	49.33 ab	0.1757 bc	63.33 bc	0.7258 bc
Mycorrhiza + *Rhizobium* 10^8	60.00 ab	0.3260 b	105.3 ab	1.078 ab
Urea + Superphosphate	0.0000 d	0.0000 c	0.0000 c	0.0000 d
Control	2.000 cd	0.0012 c	0.0000 c	0.0000 d
LSD	56.73	0.2896	38.62	0.3238

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of local isolated Mycorrhiza, *Rhizobium* strains and fertilization on Ahmadi cultivar yield

The data in table (5) was erratic. A combination of factors may have influenced the effect of the treatment on the appearance of groundnut nodules. Despite that, the applied *Rhizobium*strain 10^8 and the combination between Mycorrhiza and *Rhizobium* strain 10^8 increased the yield of specific groundnut cultivars in the third month. This was described by (Ahiabor et al., 2014) and (Schütz et al., 2018).

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Table 5: Effect of local isolated Mycorrhiza, *Rhizobium* strains and fertilization on Ahmadi cultivar yield

Ahmadi treatments	Second month		Third month	
	Grain No.	Grain weight	Grain No.	Grain weight
Urea	**6.333[ab]**	**3.333[b]**	**19.67[b]**	**25.63[b]**
Rhizobium **10^4**	**15.67[ab]**	**17.80[a]**	**32.33[ab]**	**37.57[ab]**
Rhizobium **10^8**	**8.333[ab]**	**5.100[ab]**	**47.33[a]**	**61.57[a]**
Superphosphate	**18.67[a]**	**13.63[ab]**	**26.00[ab]**	**17.27[b]**
Mycorrhiza	**7.667[ab]**	**3.433[b]**	**29.00[ab]**	**22.53[b]**
Mycorrhiza + *Rhizobium* **10^4**	**6.000[ab]**	**5.833[ab]**	**18.67[b]**	**20.03[b]**
Mycorrhiza + *Rhizobium* **10^8**	**5.667[b]**	**4.167[b]**	**31.67[ab]**	**37.30[ab]**
Urea + Superphosphate	**4.229[b]**	**4.444[b]**	**19.00[b]**	**18.40[b]**
Control	**5.333[b]**	**3.600[b]**	**28.33[ab]**	**24.07[b]**
LSD	**12.68**	**13.32**	**26.26**	**34.36**

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Effect of isolated Mycorrhiza, *Rhizobium* strains and fertilization on Ahmadi cultivar content of N, P and K

Table (6) showed that treatment of *Rhizobium* 10^4, 10^8, urea and combination between *Rhizobium* 10^4+ Mycorrhiza and *Rhizobium* 10^8+ Mycorrhiza significantly improved uptake of macroelements (N, K) compared with the uninoculated controls and other treatments. These results could be recognized as a Mycorrhizal positive infection that agreed with the findings of (M.M., A., Hadad, M. A., & Elhassan, 2016). No significant differences were observed between treatments among the potassium content in groundnut plants. This agrees with the findings of (Howieson and Ballard, 2004) and (Osman and Abd Elaziz, 2010).

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Table 6: Effect of isolated Mycorrhiza, *Rhizobium* strains and fertilization on Ahmadi cultivar content of N, P and K

Treatments	N%	P%	K%
Urea	3.533^{ab}	0.2333^{e}	0.2333^{ab}
Rhizobium10^4	3.567^{a}	0.2667^{e}	0.2667^{ab}
Rhizobium10^8	3.533^{ab}	0.2000^{ef}	0.1333^{cd}
Superphosphate	1.733^{d}	0.4333^{cd}	0.1333^{cd}
Mycorrhiza	1.500^{e}	0.3667^{d}	0.2000^{bc}
Mycorrhiza + *Rhizobium*10^4	3.333^{b}	0.7333^{b}	0.3000^{a}
Mycorrhiza + *Rhizobium*10^8	3.400^{ab}	0.8333^{a}	0.2000^{bc}
Urea + Superphosphate	2.600^{c}	0.5000^{c}	0.1000d^{e}
Control	1.100^{f}	0.1333^{f}	0.02422^{e}
LSD	0.2048	0.07741	0.07741

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

M383 cultivar:

Effect of treatments on plant height and colour rating

The results in table (7) showed no significant differences in terms of colour rating. As for the height of the plant, it was found that the addition of mineral fertilizers, especially superphosphate and the addition of *Rhizobium* and Mycorrhiza, had a significant effect on the height of the plant, which agreed with the findings of (Mmbaga et al., 2014), (Ahiabor et al., 2014) and (M.M., A., Hadad, M. A., & Elhassan, 2016).

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Table 7: Effect of treatments on plant height and colour rating

M383 Treatments	Plant height cm/plant			Colour rating		
	(1) Month	(2) Month	(3) Month	(1) Month	(2) Month	(3) Month
Urea	**19.10^{b}**	**29.00^{bc}**	**33.43^{a}**	**4.000^{a}**	**4.000^{a}**	**3.000^{c}**
***Rhizobium*10^{4}**	**22.30^{a}**	**33.20^{ab}**	**34.13^{a}**	**3.333^{ab}**	**4.000^{a}**	**3.333^{bc}**
***Rhizobium*10^{8}**	**20.00^{ab}**	**35.33^{a}**	**30.10^{ab}**	**3.667^{ab}**	**4.000^{a}**	**3.000^{c}**
Superphosphate	**22.37^{a}**	**30.33^{abc}**	**35.57^{a}**	**4.000^{a}**	**4.000^{a}**	**3.333^{bc}**
Mycorrhiza	**18.67^{b}**	**30.97^{abc}**	**32.00^{a}**	**4.000^{a}**	**4.000^{a}**	**3.667^{ab}**
Mycorrhiza + *Rhizobium*10^{4}	**18.27^{b}**	**27.17^{c}**	**34.87^{a}**	**3.000^{b}**	**4.000^{a}**	**3.333^{bc}**
Mycorrhiza + *Rhizobium*10^{8}	**20.80^{ab}**	**31.47^{abc}**	**29.33^{ab}**	**3.667^{ab}**	**3.667^{ab}**	**3.000^{c}**
Urea + Superphosphate	**19.17^{b}**	**29.43^{bc}**	**25.00^{b}**	**3.333^{ab}**	**3.667^{ab}**	**3.000^{c}**
Control	**18.57^{b}**	**29.67^{bc}**	**31.93^{a}**	**3.333^{ab}**	**3.333^{b}**	**4.000^{a}**
LSD	**3.103**	**5.401**	**6.271**	**0.7262**	**0.5635**	**0.6659**

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of the treatments on groundnut plant wet and dry weight at different sampling intervals (g/plant)

The results in table (8) showed that the addition of mineral fertilizers and biofertilizers, *Rhizobium*, and Mycorrhiza, led to a remarkable increase in the wet weight of the plant. The results also showed that the addition of mineral fertilizers, urea and superphosphate, had a more significant effect than the biofertilizers. Concerning the dry weight of the plant, this matched with the findings of Mahdi *et al*., (2004) and Alsamowal *et al*., (2016).

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Table 8: Effect of the treatments on groundnut plant wet and dry weight

M383 Treatments	Plant wet weight cm/plant			Plant dry weight cm/plant		
	(1) Month	(2) Month	(3) Month	(1) Month	(2) Month	(3) Month
Urea	**6.933^{bc}**	**71.80^{a}**	**96.03^{ab}**	**1.933^{b}**	**15.37^{ab}**	**34.30^{a}**
***Rhizobium*10^4**	**11.47^{a}**	**28.70^{b}**	**100.9^{ab}**	**3.033^{a}**	**6.733^{b}**	**34.13^{a}**
***Rhizobium*10^8**	**7.700^{bc}**	**43.07^{ab}**	**80.17^{ab}**	**2.067^{ab}**	**10.80^{ab}**	**25.90^{ab}**
Superphosphate	**6.400^{bc}**	**29.93^{b}**	**39.97^{ab}**	**1.800^{bc}**	**8.900^{ab}**	**37.83^{a}**
Mycorrhiza	**6.800^{bc}**	**74.97^{a}**	**32.03^{b}**	**1.833^{bc}**	**22.17^{a}**	**31.83^{a}**
Mycorrhiza + *Rhizobium*10^4	**7.500^{bc}**	**42.20^{ab}**	**109.2^{a}**	**1.933^{b}**	**12.30^{ab}**	**31.50^{ab}**
Mycorrhiza + *Rhizobium*10^8	**9.600^{ab}**	**35.27^{ab}**	**92.33^{ab}**	**1.900^{b}**	**10.90^{ab}**	**28.13^{ab}**
Urea + Superphosphate	**4.833^{c}**	**18.87^{b}**	**35.30^{b}**	**1.333^{bc}**	**6.167^{b}**	**13.17^{b}**
Control	**5.133^{c}**	**19.20^{b}**	**77.00^{ab}**	**0.8000^{c}**	**10.73^{ab}**	**24.93^{ab}**
LSD	**3.634**	**40.01**	**69.32**	**1.085**	**13.29**	**18.47**

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of treatment on groundnuts number and weight of nodules in primary roots in M383 cultivar

The data in the table (9) showed that adding *Rhizobium* strains 10^4,10^8 as a single fertilizer and combination between *Rhizobium* and Mycorrhiza significantly improved both the number and mass of nodulation in both primary and lateral roots, also observed no significant differences between other treatments. This agreed with the findings of Mahdi *et al*., (2004), Ahiabor *et al*., (2014) and Schütz *et al*., (2018).

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Table 9: Effect of treatment on groundnuts number and weight of nodules in primary roots

M383 Treatments primary root	Second month		Third month	
	Number of nodules	Weight of nodules	Number of nodules	Weight of nodules
Urea	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
*Rhizobium*10^4	55.00[abc]	0.03627[e]	111.7[ab]	1.088[ab]
*Rhizobium*10^8	45.67[cd]	0.03383[e]	85.67[bc]	0.3727[cd]
Superphosphate	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Mycorrhiza	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Mycorrhiza + *Rhizobium*10^4	66.33[a]	0.2500[cd]	156.0[a]	1.233[a]
Mycorrhiza + *Rhizobium*10^8	56.00[abc]	0.3607[bc]	102.0[ab]	0.1132[d]
Urea + Superphosphate	0.0000[e]	0.0000[e]	0.0000[d]	0.0000[d]
Control	0.3333[e]	0.0000[e]	0.0000[d]	0.0000[d]
LSD	10.67	0.1224	80.26	0.8860

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of treatment on groundnuts number and weight of nodules in lateral roots in M383 cultivar

The results in the table (10) showed that the addition of the mixture of *Rhizobium* and Mycorrhiza had a positive effect on the groundnut plant M383 cultivar, in agreement with Mahdi *et al.*, (2004) and Alsamowal *et al.*, (2016).

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Table 10: Effect of treatment on groundnuts number and weight of nodules in lateral roots

M383 treatments lateral root	Second month		Third month	
	Number of nodules	Weight of nodules	Number of nodules	Weight of nodules
Urea	0.0000^{d}	0.0000^{c}	0.0000^{d}	25.00^{abc}
Rhizobium10^4	44.33^{abc}	0.03543^{c}	0.3134^{cd}	41.67^{ab}
Rhizobium10^8	42.00^{abcd}	0.02810^{c}	0.5608^{bcd}	26.33^{abc}
Superphosphate	0.0000^{d}	0.0000^{c}	0.0000^{d}	36.00^{abc}
Mycorrhiza	0.0000^{d}	0.0000^{c}	0.0000^{d}	35.00^{abc}
Mycorrhiza + *Rhizobium*10^4	52.33^{ab}	0.09050^{c}	1.484^{a}	27.00^{abc}
Mycorrhiza + *Rhizobium*10^8	75.33^{a}	0.7640^{a}	0.7427^{bc}	28.33^{abc}
Urea + Superphosphate	2.000^{cd}	0.0000^{c}	0.0000^{d}	14.33^{c}
Control	0.0000^{d}	0.0000^{c}	0.0000^{c}	0.0000^{d}
LSD	14.89	0.05474	87.01	0.7116

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of local isolated Mycorrhiza, *Rhizobium* strains and fertilization on M383 cultivar yield

Table (11) showed no response to adding the different fertilizers in the first month. The plant response to added fertilizers was evident in the third month, which was affected by yield increase when the combination of rhizobium and Mycorrhiza treatment matching with Alsamowal *et al.*, (2016) and Schütz *et al.*, (2018).

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Table 11: Effect of local isolated Mycorrhiza, *Rhizobium* strains and fertilization on M383 cultivar yield

M383 Treatments	Second month		Third month	
	Grain No.	Grain weight	Grain No.	Grain weight
Urea	11.40^{a}	1.000^{ab}	25.00^{abc}	29.87^{abc}
Rhizobium10^4	4.400^{a}	1.667^{a}	41.67^{ab}	44.40^{ab}
Rhizobium10^8	5.033^{a}	1.333^{ab}	26.33^{abc}	27.87^{abc}
Superphosphate	6.000^{a}	1.000^{ab}	36.00^{abc}	20.43^{bc}
Mycorrhiza	17.97^{a}	1.000^{ab}	35.00^{abc}	23.23^{bc}
Mycorrhiza + *Rhizobium*10^4	8.633^{a}	1.333^{ab}	27.00^{abc}	35.33^{abc}
Mycorrhiza + *Rhizobium*10^8	7.800^{a}	1.333^{ab}	28.33^{abc}	32.53^{abc}
Urea + Superphosphate	3.367^{a}	1.000^{ab}	14.33^{c}	8.567^{c}
Control	11.33^{abc}	9.667^{a}	16.00^{c}	19.73^{bc}
LSD	12.26	14.86	15.77	23.44

- The same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test.

Effect of isolated Mycorrhiza, *Rhizobium* strains and fertilization on M383 cultivar content of N, P and K

The results represented in table (12), Addition of *Rhizobium* and Mycorrhiza separately in combination between *Rhizobium* 10^4+ Mycorrhiza and *Rhizobium* 10^8+ Mycorrhiza treatments improved the capacity of the plant to acquire nutrientsand significantly improved uptake of macro elements (N, P, K) compared to the control and other treatments. These results could be attributed to Mycorrhiza positive infection which was matching with Elhassan *et al.*, (2010).

Table 12: Effect of isolated Mycorrhiza, *Rhizobium* strains and fertilization on M383 cultivar content of N, P and K

Treatments	N%	P%	K%
Urea	**2.467[bc]**	**0.2333[c]**	**0.3333[a]**
***Rhizobium*10[4]**	**2.400[c]**	**0.1667[cd]**	**0.3000[ab]**
***Rhizobium*10[8]**	**1.667[d]**	**0.4667[d]**	**0.2333[bc]**
Superphosphate	**1.400[e]**	**0.4000[b]**	**0.1667[cd]**
Mycorrhiza	**3.400[a]**	**0.7333[a]**	**0.1333[d]**
Mycorrhiza + *Rhizobium*10[4]	**3.400[a]**	**0.6667[a]**	**0.2333[bc]**
Mycorrhiza + *Rhizobium*10[8]	**2.667[b]**	**0.4667[b]**	**0.2667[ab]**
Urea + Superphosphate	**1.033[f]**	**0.1000[cd]**	**0.1333[d]**
Control	**0.07876[g]**	**0.04953[d]**	**0.1000[d]**
LSD	**0.2386**	**0.1448**	**0.094810**

- Means with the same letters within each column are not significantly different at the 0.05 level of probability by the Duncan Multiple Range Test

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