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Peanut (*Arachis hypogaea* L.) yield and its components as affected by N-fertilization and diazotroph inoculation in Toshka desert soil-South Valley-Egypt.

Awadalla AO[1], Mohammed T Abbas[2]

[1]Department of Agronomy, Aswan University, Aswan, Egypt
[2]Department of Agricultural Microbiology, Aswan University, Aswan, Egypt

Abstract

To study the effects of N-fertilization and diazotroph inoculation on yield and its` components of Peanut (*Arachis hypogaea* L.) cv Giza 5 in new land soil at toshka project south valley region, tow field experiments were carried out in the farm of Toshka Research Station, Agriculture Research Center. During 2015 and 2016 seasons. Results showed that increasing N fertilization levels from 20 to 60 kgN/feddan and use of rhizobia + enterobacter inoculation, significantly increased No. pods/plant, Wt.pods/plant(g), Wt.seeds/plant(g), seed index, Wt.pods/fed.(ton) and Wt.seeds/fed.(ton). Oil and protein % in seeds compared to control treatment. The studied characters of yield and its attributes were significantly affected by the interaction between N fertilizer levels and diazotroph inoculation. Peanut fertilized with 60 kg N/fed. With rhizobium+enterobacter treatment recorded the highest significant values of most studied characters than the other treatments.

Keywords: Peanut (*Arachis hypogaea* L.), *Bradyrhizobium* spp., *Enterobacter coleace*, Nodulation, Nitrogen level, yield components, Toshka.

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Introduction

Peanut is one of the most important and economical oilseeds in tropical and subtropical regions which is mostly grown due to its oil, protein and carbohydrates [1]. It is an important cash crop for peasants in poor tropical countries [2]. Recently, this crop has been given great attention due to its suitability for growth in the newly reclaimed sandy areas in Egypt. New reclaimed areas in Egypt are mostly sandy soils and usually deficient in organic matter and poor in plant nutrients.

Toshka project is one of the giant projects to cultivate a large area of the desert in the South Valley of Egypt. To make the country self-sufficient in edible oil, it is extremely necessary to increase the total production of oilseed crops including peanut either by increasing their yield per feddan or by increasing their acreage of cultivation or by a combination of both.

Nitrogen is an important element for effective production of peanut, adequate supply of nitrogen fertilizer is essential for growth and yield. Usually, nitrogen shortage is observed when plant nutrition is not managed properly and this element is not provided in adequate amounts, which could result in the older leaves to turn yellow and eventually, the plant's growth stops. In other cases, when too much nitrogen is provided for the plant, it normally leads to watering of protoplasm and brittleness of the plant itself which would result in becoming vulnerable to diseases and pests.

Due to the intensive farming, Egypt is known as a heavy consumer of chemical fertilizer. The application of bio fertilizer is frequently recommended to get high and clean agricultural product.

Inoculation of peanut with efficient rhizobia is considered as a beneficial practice since the native rhizobia are not able to supply the total nitrogen requirements of peanut [3]. Nitrogen from Rhizobium-legumes symbiosis may be the only renewable soil fertility input that the farmer can acquire without significant investment. By maximizing biological nitrogen fixation through bio fertilization, a farmer can raise his yield and income. Co-inoculation with plant growth promoting rhizobacteria (PGPR) and rhizobia improved nitrogen availability and consequently plant yield [4,5]. Bai *et al.* and Abdel-Wahab *et al.* [6,7] reported that enhancement of nodulation and nitrogen availability were improved by co-inoculation in sustainable agriculture.

The aim of his study was to investigate, the effects of integrated inoculation and chemical nitrogen fertilization on yield, yield components and some chemical trails of peanut cultivated in newly reclaimed land in Toshka region.

Materials and Methods

Microorganisms

Bradyrhizobium spp. (Okadeen) was kindly obtained from the Biofertilizers Production Unit, Agricultural Microbiology Department, Soil, Water and Environment Research Institute (SWERI), Agricultural Research Center, Giza, Egypt. *Enterobacter coleace*, was isolated from *Salsola volkensii* behind Faculty of Energy Engineering, Airport Road, Sahari city, Aswan, Egypt.

Inoculation

Okadeen bag was mixed well with sugar solution and added to seeds of peanut which spreading on a clean plastic sheet under shading. *Enterobacter* inocula as a N_2-fixing bacterium and PGPR was grown in a CCM medium [8]. Seeds of peanut were soaked in liquid inocula after diluted 1:1 with well water for 30 min. before sowing.

Field experiments

Two field experiments were conducted at South Valley Farm Research Station, Toshka region, Agricultural Research Center during the two successive summer seasons of 2015 and 2016 under drip irrigation system. The experimental site located in Toshka region, it is laying out in the part of South Valley of Egypt, about 1300 and 280 km south from Cairo and Aswan, respectively on latitude 22°25 north, 31°5-longitude east and elevation 181 m above the sea level.

Soil samples were collected from 0 to 60 cm depth and analyzed for some physical, chemical and biological properties, soil characteristics are shown in Table 1.

Experimental design and treatments

This investigation aimed to identify the suitable N- levels (0, 20, 40 and 60) Kg N/fed. and bio fertilizers (rhizobia, and rhizobia + *Enterobacter*). Seeds of peanut, cv. Giza 5 were obtained from Oil Crops Department, Field crops Institute, Agricultural Research Center, Egypt. The experimental design was split plot design in a randomized complete blocks arrangement with four replications. Nitrogen fertilization was allocated to main plots, while bio fertilizers were distributed at random in the sub plots, the plot size was 20 m^2. Each sub-plot consisted of four ridges; each was 5 m in length and 1 m width.

Agricultural practices

The previous crop was wheat in both seasons. During soil preparation, 8 m^3 of chicken manure mixed with 37.5 kg P_2O_5 and 48 kg K_2O/fed. were applied. Peanut seeds were sown on the last week of April in each season. The field experiments were conducted under drip irrigation with 30 cm distance between drippers (2 L/hour) with one row of plants on both sides of dripper, in both seasons. Peanut seeds were inoculated with rhizobia and *Enterobacter* before planting. Nitrogen fertilizer (NH_4NO_3 33.5%) was applied in two equal doses, at 15 and 40 days after planting date as a solution with irrigation.

Data Recorded

Three samples were taken at 4, 6 and 8 weeks after sowing and three plants were taken from each plot randomly. Nodule numbers were counted also the fresh weight of shoot total plant fresh weight and nodules dry weight were measured after 100 days after sowing (DAS). At harvest, on November 20, 2015, and 2016 seasons, random samples of ten plants were taken from each plot to determine number of pods/plant, weight of pods/plant(g), weight of seeds/plant(g), and seed index. Plants on the middle two rows in each plot were harvested separately and dried in order to estimate weight of pods yield/fed. and weight of seeds/fed. 50 g. Seed samples were grinded into fine powder and stored in brown glass bottles for chemical analysis.

Methods of analysis

Soil were analyzed according to Piper [9] and Page et al. [10]. Oil% and NPK in seeds were determined according to methods described by A.O.A.C. [11]. And the seed protein content was calculated by multiplying total nitrogen concentration by 6.25.

Statistical analysis

Data were statistically analyzed and means were compared by least significant differences (LSD) at 5% level of probability test according to procedures outlined by Steel and Torrie [12] using MSTAT-C computer program.

Results and discussion

Nodulation status

Irrespective of inoculation treatment, ON treatment secured 127 nodules $plant^{-1}$ and 0.860 dry weight (g $plant^{-1}$) (Table 2). This indicates that native rhizobia persist in soil. On the other hand, irrespective of nitrogen fertilization, inoculation treatments revealed significant differences among them where *Bradyrhizobium* + *Enterobacter* give 126 nodule of 0.851 dry weight (g $plant^{-1}$).

Table 3 shows the interaction between nitrogen fertilizer and bio fertilizer application on nodulation status. Inoculation with effective Bradyrhizobium spp. increased number of nodules. Significant increase was gained when Bradyrhizobium co-inoculated with Enterobacter (252 nodules $plant^{-1}$) with 0 n. Significant increases were obtained (27.97, 1.70, 593.4, 629.38 gm plant-1) for nodule fresh and dry weights as well as shoot fresh and total plant fresh weights respectively. Dual inoculation gained significant numbers of 100 and 110 nodules with 20 and

Table 1. *Soil particle size distribution and chemical characteristics of the experimental sites at Toshka region in 2015 and 2016 seasons.*

Soil Analysis		2015		2016		Soil analysis		2015		2016	
		Soil depth (cm.)		Soil depth (cm.)				Soil depth (cm.)		Soil depth (cm.)	
		0 -30	30-60	0-30	30-60			0-30	30-60	0-30	30-60
Mechanical analysis	Sand (%)	65	51.5	65.8	51.9	Available nutrients (ppm)	N	15	14	20	19
	Clay (%)	4.3	9.5	3.2	9.6		P	2.3	1.8	2.5	2
	Silt (%)	29.7	39	31	38.5		K	84	83.8	92	87
	Soil Texture	Sandy loam	Loam	Sandy loam	Loam		Fe	4.17	5	3.8	4
							Zn	0.88	0.79	0.83	0.91
Chemical analysis	PH	8.13	8.17	8.11	8.2		Mn	0.55	0.64	0.6	0.44
	EC(%)	0.53	0.33	0.44	0.43		Cu	0.1	0.2	0.15	0.18
	CEC(mg/100g)	14.8	15	15	16		B	0.8	0.9	0.8	0.8
	$CaCo_3$ (%)	12.8	13.8	11.9	12.1	O.M (%)		0.48	0.35	0.43	0.31

Table 2. *Effect of nitrogen fertilizer and bio fertilizer application on nodulation status and total fresh weight of peanut in 2016 season.*

Treatment	Character				
	Nodules No.	Nodules F. W. (g plant^{-1})	Nodules D. W. (g plant^{-1})	Shoot F. W. (gm)	Total plant F. W. (gm)
N- levels (KgN/fed.) (A)					
0	127	10.36	0.860	368.5	369.43
20	50	0.74	0.334	337.22	353.01
40	67	1.79	0.455	468.5	463.04
60	36	0.90	0.242	199.80	222.5
LSD (0.05)	8.08	0.70	0.06	68.41	71.09
Biofertilizer (B)					
0	26	1.26	0.172	324.42	307.10
Rhizobia	59	1.50	0.395	317.45	339.85
Rhizobia+Enter	126	7.59	0.851	388.64	407.53
LSD (0.05)	7.0	0.61	0.05	59.25	61.57
CV%	9.09	16.08	9.06	15.67	15.92

Table 3. *Effect of interaction between nitrogen fertilizer and bio fertilizer application on nodulation status and total fresh weight of peanut in 2016 season.*

Treatments		Characters				
N-levels (Kg N/fed(	Biofertlizer	Nodules No.	Nodules F. W. (gm)	Nodules D. W. (gm)	Shoot F. W. (gm)	Total plant F. W. (gm)
0	Cont.	25	2.54	0.169	257.96	196.9
	Rhiz.	105	0.58	0.709	254.15	281.99
	Rhiz. + Enterobacter	252	27.97	1.701	593.4	629.38
20	Cont.	11	0.09	0.074	381.90	408.47
	Rhiz.	38	1.10	0.253	232.47	238.74
	Rhiz. + Enterobacter	100	1.01	0.675	397.3	411.81
40	Cont.	35	1.46	0.236	459.86	409.35
	Rhiz.	57	3.29	0.385	662.4	688.98
	Rhiz.+ Enterobacter	110	0.61	0.743	283.24	290.78
60	Cont.	31	0.94	0.209	197.98	213.67
	Rhiz.	35	1.01	0.233	120.8	149.68
	Rhiz.+ Enterobacter	42	0.76	0.284	280.62	298.15
LSD (0.05)		14.0	1.22	0.098	118.5	123.1
CV%		9.09	16.08	9.06	15.67	15.92

40 kg N fed-1 respectively. Dry weights of nodules were 0.675 and 0.743 gm plant^{-1}. Treatment with Bradyrhizobium with 40 N level secured significant increases in shoot fresh and total plant fresh weights (662.40 and 688.98 gm plant^{-1}) respectively.

Peanut yield and yield component

Results in Table 4 revealed that there were significant effect by nitrogen treatments on all studied traits of yield and yield components in both seasons. All studied yield characters increased gradually by increasing N-levels from 0 to 60 kg / fed. and the differences between N-levels were significance for all traits at most differences between N-levels in the two seasons. Nitrogen at 60 Kg /fed. produced the maximum values of number of pods/plant (43.20 and 42.34), weight of pods/plant (53.00 and 52.92 gm), weight of seeds/plant (34.29 and 32.77 gm), seed index (52.65 and 53.38 gm), weight of pods/fed. (1.774 and 1.801 ton) and weight of seeds/fed. (0.980 and 0.987 ton), in 2015 and 2016 growing seasons, respectively. Nitrogen fertilizer is an important factor in achieving better growth and development of vegetative and reproductive organs of groundnut and with increases of photosynthesis rate and photosynthetic matter production and sequently the yield components and seed yield of peanut. Similar results were obtained by Gomaa et al., Tiwari and Dhakar and Barik et al. [13-15], seed yield and yield components of peanut increased [16,17].

Bio-fertilizer treatment significantly affected all studied characters in both seasons, except seed index in 2016 (Table 4). Using Rhizobia + Enterobacter gave significant increase in all studied traits, except seed index in 2016 season. Rhizobia + Enterobacter produced the highest values of number of pods/plant (39.56 and 39.00), weight of pods/plant (47.96 and 48.81gm), weight of seeds/plant (29.39 and 29.41gm), seed index (50.31 and 49.36gm), weight of pods/fed. (1.553 and 1.592 ton) and weight of seeds/fed. (0.825 and 0.832 ton) in 2015 and 2016 growing seasons, respectively [3] and Abdel-Wahab et al. [7] came to similar results.

Such superiority in yield and yield components from treating seeds of peanut by Rhizobacterin inoculation may be attributed to N2 –fixation, which had marked influence on the growth of peanut plants and reflects to increase yield and yield components. Adding to this N2-fixation reduce the soil pH especially in the rhizosphere, thereby increase the availability of most essential macro and micro-nutrients.

Results in Table 5 revealed that interactions between nitrogen fertilizer and bio fertilizer were significant in all traits. The highest values of No. pods/plant (49.10 and 46.67), Wt. pods/ plant (57.50 and 56.35 g), Wt. seeds/plant (38.62 and 37.10 g), seed index (53.87 and 53.38 g), Wt. pods/fed. (1.788 and 1.802 ton) and Wt. seeds/fed. (0.987 and 0.992 ton) resulted from treatment of 60 kg N/fed. with rhizobia + Enterobacter application in both seasons respectively. While less values of all parameters were given by untreated. These results may be due to the symbiotic relationship of *Rhizobium* with roots of peanut crop, which fix the atmospheric nitrogen into the roots of peanut and thus the yield was increased [18]. It may also due to more leaves, more carbohydrates were produced due to the number of leaves, sank into the root zone and hence more production. These results are in harmony with those obtained by Moradi et al., Gholami et al., Lugtenberg et al., and Verma et al. [19-23,5].

Chemical traits of peanut

Data presented in Table 6 showed that oil % in seeds, seed protein% and N content in seeds significantly affected by nitrogen fertilizer levels. Neither P nor K content in seeds significantly affected by nitrogen fertilizer treatments. The highest values of oil% (46.26 and 46.06) were obtained by control treatment received no nitrogen fertilizer, while seed protein (26.23 and 24.62%) and N content in seeds (4.20 and 4.26%) resulted from treatment of 60 kg.N/fed. in 2015 and 2016 respectively. Higher levels of nitrogen fertility affected seed quality by increasing protein and decreasing oil concentrations. The oil content appears to be less negatively impacted by nitrogen rates. These results are in harmony with those obtained by Abdel-Wahab et al. [20]; Thorave and Dhonde [24].

Bio fertilizer application significantly affected oil%, seed protein% and N content in seeds in 2015 season only. While P% and K% were insignificant in the two growing seasons. Rhizobia + *Enterobacter* application gave the highest values of oil% (45.6), seed protein% (23.47) and N content (3.76) in 2015 season. These results are in harmony with those obtained by Bogino et al. and Nasr-Alla et al. [25,26].

Data presented in Table 7 indicate significant differences by the interaction between the two studied factors among treatments in respect to chemical characters except in both seasons P% and K% in 2015 season only. Control treatment (zero kg N/f without inoculation) gave the greatest oil%. (46.40%) in 2015 season. 60 kg.N/f with inoculation by rhizobia and Enterobacter

Table 4. *Effect of nitrogen fertilizer and biofertilizer application on yield and yield components of peanut in 2015 and 2016 seasons.*

Treatment	**Character**											
	No.pods/plant		**Wt.pods/plant (g)**		**Wt.seeds/plant (g)**		**Seed index**		**Wt.pods/ Fed.(ton)**		**Wt.seeds/ Fed.(ton)**	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
N- levels (KgN/fed.): (A)												
0	24.74	25.77	35.41	35.27	15.12	16.63	44.77	44.27	1.195	1.251	0.568	0.583
20	32.63	32.93	42.77	43.57	22.51	23.12	48.37	48.10	1.356	1.443	0.712	0.726
40	38.80	40.17	47.80	50.79	29.37	30.38	50.22	50.69	1.636	1.662	0.872	0.858
60	43.20	42.34	53.00	52.92	34.29	32.77	52.65	53.38	1.774	1.801	0.980	0.987
LSD (0.05)	0.90	3.44	2.32	3.43	1.58	3.43	0.87	1.43	0.12	0.148	0.05	0.03
Biofertilizer (B)												
0	30.58	31.27	41.22	41.68	21.05	21.73	46.98	48.78	1.410	1.437	0.717	0.716
Rhizobia	34.38	35.67	45.06	46.42	25.52	26.04	49.72	49.20	1.509	1.588	0.806	0.818
Rhizobia+Enter	39.56	39.00	47.96	48.81	29.39	29.41	50.31	49.36	1.553	1.592	0.825	0.832
LSD (0.05)	2.09	2.03	3.17	2.79	1.67	2.10	1.54	ns	0.07	0.096	0.04	0.03
CV%	4.77	7.77	6.16	6.88	9,97	12.23	3.39	2.84	6.99	4.73	5.72	3.43

Table 5. *Effect of interaction between nitrogen fertilizer and biofertilizer application on yield and yield components of peanut in2015 and 2016 seasons.*

N-levels (Kg N/fed)	***Biofertlizer***	**characters**											
		No.pods/plant		**Wt.pods/plant(g)**		**Wt.seeds/plant(g)**		**Seed index**		**Wt.pods/Fed. (ton)**		**Wt.seeds/Fed.(ton)**	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
0	Cont.	22.87	23.72	32.97	33.05	13.52	15.15	42.70	43.50	1.153	1.175	0.490	0.505
	Rhiz.	24.42	26.22	35.07	35.53	15.00	16.65	45.65	44.53	1.212	1.285	0.580	0.612
	Rhiz.+Enterobacter	26.92	27.37	38.17	37.22	16.82	18.10	45.95	44.78	1.220	1.292	0.633	0.632
20	Cont.	28.67	28.00	39.72	38.50	19.07	17.42	46.45	46.78	1.242	1.287	0.632	0.617
	Rhiz.	32.45	32.92	43.52	44.60	22.65	24.38	48.52	48.90	1.408	1.509	0.758	0.772
	Rhiz.+ Enterobacter	36.75	37.87	45.07	47.63	25.80	27.58	50.15	48.63	1.419	1.533	0.745	0.787
40	Cont.	32.60	34.47	43.87	45.25	23.05	24.65	48.07	50.83	1.476	1.491	0.772	0.760
	Rhiz.	38.32	41.95	48.42	53.10	28.72	31.63	51.35	50.60	1.647	1.753	0.907	0.897
	Rhiz.+ Enterobacter	45.47	44.07	51.10	54.03	36.32	34.88	51.25	50.65	1.785	1.743	0.935	0.915
60	Cont.	38.17	38.90	48.30	49.92	28.55	29.70	50.70	54.00	1.767	1.796	0.975	0.980
	Rhiz.	42.32	41.45	53.20	52.47	35.70	31.50	53.37	52.78	1.768	1.806	0.977	0.987
	Rhiz.+ Enterobacter	49.10	46.67	57.50	56.35	38.62	37.10	53.87	53.38	1.788	1.802	0.987	0.992
LSD (0.05)		2.47	4.07	4.08	4.66	3.75	4.67	2.47	2.07	0.18	0.122	0.07	0.047

Table 6. *Effect of nitrogen fertilizer and biofertilizer application on some chemical traits of peanut in 2015 and 2016 seasons.*

Treatment	***Character***									
	Oil %		**Seed protein %**		**N.P.K content in seeds %**					
					N		**P**		**K**	
	2015	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**	**2015**	**2016**
N-levels (KgN/fed.): (A)										
0	46.26	46.06	20.81	20.69	3.33	3.31	0.789	0.842	0.691	0.732
20	45.86	45.78	22.62	22.73	3.62	3.64	0.826	0.879	0.713	0.785
40	45.52	45.37	23.83	24.26	3.81	3.88	0.833	0.843	0.747	0.748
60	44.68	44.57	26.23	24.62	4.20	4.26	0.826	0.830	0.737	0.738
LSD (0.05)	0.62	0.26	0.63	0.41	0.14	0.09	ns	ns	ns	ns
Biofertilizer (B)										
0(control)	45.54	45.39	23.21	23.49	3.71	3.76	0.806	0.849	0.715	0.754
Rhizobia	45.60	45.32	23.42	23.56	3.75	3.77	0.828	0.842	0.734	0.739
Rhizobia+Enter	45.60	45.62	23.47	23.68	3.76	3.79	0.821	0.853	0.717	0.759
LSD (0.05)	0.29	ns	0.70	ns	0.20	ns	ns	ns	ns	ns
CV%	0.82	0.51	2.60	1.50	2.60	1.50	12.20	7.72	14.22	8.04

Table 7. *Effect of interaction between nitrogen fertilizer and biofertilizer application on some chemical traits of peanut in 2015 and 2016 seasons.*

N-levels (Kg N/fed)	**Biofertlizr**	**characters**									
		Oil (%)		**Seed protein (%)**		**N.P.K content in seeds (%)**					
						N		**P**		**K**	
		2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
0	Cont.	46.40	45.95	20.97	20.70	3.356	3.312	0.800	0.812	0.728	0.700
	Rhiz.	46.17	45.88	20.75	20.67	3.320	3.308	0.807	0.862	0.675	0.752
	Rhiz.+ Enterobacter	46.20	46.35	20.70	20.70	3.312	3.312	0.760	0.850	0.670	0.743
20	Cont.	45.67	45.83	22.47	22.70	3.596	3.632	0.810	0.853	0.702	0.760
	Rhiz.	45.92	45.63	22.52	22.73	3.604	3.636	0.825	0.870	0.723	0.778
	Rhiz.+ Enterobacter	45.97	45.90	22.85	22.77	3.656	3.644	0.843	0.837	0.805	0.817
40	Cont.	45.55	45.30	23.12	24.13	3.700	3.860	0.835	0.877	0.742	0.770
	Rhiz.	45.47	45.42	24.62	24.15	3.940	3.864	0.870	0.840	0.715	0.752
	Rhiz.+ Enterobacter	45.55	45.38	23.75	24.50	3.800	3.920	0.793	0.812	0.693	0.723
60	Cont.	44.55	44.47	26.30	26.42	4.208	4.228	0.778	0.855	0.688	0.785
	Rhiz.	44.82	44.38	25.80	26.67	4.128	4.268	0.810	0.797	0.732	0.675
	Rhiz.+ Enterobacter	44.67	44.85	26.60	26.75	4.256	4.280	0.890	0.915	0.792	0.752
LSD (0.05)		0.557	0.348	0.901	0.525	0.164	0.948	ns	0.109	ns	0.109

treatment gave the highest seed protein (26.60 and 26,75%), N content in seeds (4.256 and 4.280%) and P (0.890 and 0.915%) in 2015 and 2016 seasons, respectively . while 20 kg.N/f with the application of rhizobia+ Eenterobacter gave the highest value of K (0.805 and 0.817%) in 2015 and 2016 respectively. This means that nitrogen fertilizer levels and inoculation with rhizobia and Eenterobacter not only increased peanut yield and its components but also improved its nutritive value. These results may be due to the beneficial effect of N on metabolic processes and growth which in turn reflected

positively on the chemical content of peanut seed. These results are in harmony with those obtained by Purushotham and Hosmani [27]. All growth parameters were improved when peanut plants received the dual inoculation Bradyrhizobium and some rhizoorganisms under sandy loam soil [28]. Moreover, inoculation with phosphate solubilizing rhizobacteria such as *Enterobacter asbiriae* enhancement N2 fixation [29]. A great potential of peanut growth was resulted by co-inoculation with phosphate solubilizing *rhizobacteria Pantoea* sp. and Bradyrhizobium sp. [30]. Continued application of PGPR enhanced nodule formation and reduced the need to chemical fertilizer and pesticide ultimate, conserved environment and braving sustainability [31-37].

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***Correspondence to:**

Moniem Awadalla Omar
Department of Agronomy
Aswan University
Aswan, 81528
Egypt
Tel: +201117350144
E-mail: abdelmoniemomr@yahoo.com