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EFFECT OF MINERAL NITROGEN AND BIOFERTILIZER APPLICATION ON NODULATION EFFICIENCY AND GROWTH OF PEANUT PLANTS GROWN ON A SANDY SOIL TREATED WITH ORGANIC FERTILIZERS

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ABSTRACT: ***A field experiment was carried out on a sandy soil of Experimental Farm, Ismailia Research Station, Soils, Water and Environment Research Institute, Agricultural Research Center (ARC), Egypt, during two successive growth summer seasons, i.e. 2016 and 2017 on peanut (Arachis hypogaea L.) Giza 5 cv., to study the individual and combined effect of applications of mineral N fertilization levels (25 and 40 kg N / fed., ammonium sulphate, 20.3 % N).Four resources of organic fertilizers (farmyard manure "FYM" , solid plant compost "SPC" , enriched compost tea "ECT" and FYM+ECT) and two different mixtures of biofertilizers (B_1 and B_2) on nodulation efficiency and growth of peanut plants. B_1 consists of Azospirillum braselinse (local strain) + Bacillus megatherium (local strain) + Azotobacter chroococcum (local strain); while B_2 consists of Bradyrhizobium.sp (strain (USDA 3456)) + Serratia marcescens (strain MH6) + Psuedomonas fluorescens (strain IFO 2034). Application rate of SPC, FYM were 5 ton / fed., while ECT was 75 L/fed (fed is 0.42 ha). The treatment of FYM+ECT was carried out at a rate of 2.5 ton FYM / fed. + 37.5 L ECT/ fed. The layout of the experiment was a split-split-plot design, with the main plots arranged in a randomized complete blocks design, with three replicates.***

The results showed that, a marked significant increases in both nodules (number and dry matter) formed on the roots of peanut plants as well as the dry matter of shoots of peanut plants owing to the used fertilization treatments as compared to the control. The highest values of nodulation (number and weight) and shoots dry weights were found in the plants fertilized by triple combinations of mineral N, organic and biofertilizers followed by those found duo to the dual combinations. Data also showed a superior increase of applied B_2 and addition of ECT than that obtained for B_1 and either of than other organic fertilizers on nodules number as shoots dry weight of peanut plants at growth period of 45 days. Generally, data showed an importance role of mineral N and bio-fertilizers application on sandy soil fertility of sandy soil treated with organic fertilizers and its productivity of peanut plants.

Key words: ***Peanut, Sandy soil, Mineral nitrogen, Organic and Biofertilizers, Nodulation and Soil Fertility.***

INTRODUCTION

Peanut or Groundnut (*Arachis hypogaea L.*) is best grown in semi-arid eco-systems where rainfall is low (Hamidou *et al.,* 2012) Sandy and sandy loam soils are of poor fertility and low water holding capacity (Latif *et al*., 2014); low soil organic matter (Samuel, 2013) and thus poor fertilizer use efficiency.

The nutrient and water holding capacity of such soils can be improved through adding organic materials (Latif *et al.,* 2014). Thus combined use of mineral and organic fertilizers like manures, compost and vermicompost (VC) is becoming increasingly important (Chouichom and Yamao, 2011). Peanut is considered the main oil crop grown in Egypt. It is an important oil duo to its high nutritive value. It contains about 50 % oil, 25-30 % protein, 20 % carbohydrate and 5 % fiber and ash, which make a substantial contribution to human nutrition (Fageria *et al.,* 1997). Peanut offers ecosystem services such as renewable inputs of nitrogen into crops and soil via biological ambient N_2 fixation. Increasing peanut productivity largely depends on improving the cultural practices such as soil fertility by utilization of organic fertilization, which may help to solve soil problem (Siam *et al*., 2015).

Sandy soils cover vast areas in Egypt. Therefore, reclamation of these soils is the main target for the horizontal expansion of our cultivable land. Unfortunately, sandy soils have very poor hydrophysical and nutritional values. Thus, the use of soil amendments is of vital importance to improve physical, chemical and nutritional characteristics of these soils. So, fertilization with different elements and also application of gypsum as a source of Ca and S elements to these soils enhance the vegetative growth of crops where, Ca and S nutrients are often a yield limiting factor for peanut and are necessary for pod growth and increasing peg strength.

Nitrogen (N) is an element required for plant growth where it is an important component of proteins, enzymes and vitamins in plant. It is a central part of the chlorophyll and essential photosynthetic molecule. The excessive application of mineral fertilizers increases production cost. The residual of mineral fertilizers seriously and ngatively affect the quality of agricultural products, people’s health and causs environmental pollution. Therefore a great interest has been generated to apply bioorganic and inorganic fertilizers to establish a good ecoenvironment for plant growth (Basak, 2006). Nitrogen fertilizers are economically an expensive input. In many instances less than 60 % of the added N is recovered by the crop and soil with the remainder being lost by processes such as volatilization, leaching, immobilization and denitrification. Thus, it is necessary to develop fertilizer management practices that can reduce losses and increase the nitrogen use efficiency (Yusron and Phillips, 1997).

Organic fertilization deficiency limits the production of many crops especially grain legumes in many soils. Nowadays there is a high demand on the organic products. Organic agriculture (application of organic matter soil and no use of mineral compounds) is a production management system that aims to promote and enhance ecosystem health, including biological cycles and soil biological activity and minimize the use of external inputs (Rasul and Thapa, 2003 and Ghaly *et al.,* 2018).

The use of biofertilizers is important for sustainable agriculture, and the use of nodule bacteria and endophytic actinomycetes is an attractive way to enhance plant growth and yield. Biofertilizers are alternatives of mineral fertilizers to increase soil productivity and plant growth in a sustainable agriculture regime. (El-Noamany, 2013 and Htwe *et al.,* 2019). The legume-*Rhizobium* symbiotic relationship is a very important practice, particularly under the intensive cropping system, in order to decrease the chemical inputs and to raise soil quality and

sustainability. *Rhizobium*-legume symbiosis is thus considered as the most efficient and necessary process in crop production. Leguminous plants in a partnership with members of the bacterial genera *Rhizobium* and *Bradyrhizobium* have the ability to convert the atmospheric nitrogen into usable forms. The inoculation with either micro – symbiont meets 50-70% of the crop nitrogen requirement and increases legumes productivity (Amarger, 2001 ; Ndakidemi *et al.,* 2006 and Tena *et al.,* 2016).

The aim of the present study is to develop a suitable fertilization management system, that use three types of fertilization (mineral nitrogen, bio and organic fertilizers), as integrated regime of fertilization "IRF", for peanut plants (*Arochis hypogaea L.*) "variety Giza 5" cultivated in a sandy soil. Also, This study aimes at investigating the effect of the studied treatments on nodulation (number and dry weight) and growth of peanut plants. Finally, the rationalization use of mineral – N fertilization is one of the important aims of this study.

MATERIALS AND METHODS

A field experiment was carried out on a sandy soil of the Experimental Farm, Ismailia Research Station, Soils, Water and Environment Research Institute , Agricultural Research Center (ARC), Egypt, during two successive growth summer seasons, i.e. 2016 and 2017 on peanut (*Arachis hypogaea L.*) Giza 5 cv., to study the individual and combined effect of applications of mineral N fertilizer levels{ (25 and 40 kg N / fed., ammonium sulphate, 20.3 % N) = (N1 and N2) }, four resources of organic fertilizers (farmyard manure "FYM " , solid plant compost "SPC" , enriched compost tea "ECT" and FYM +ECT), plus control (O_0) and two different mixtures of biofertilizer (B_1 and B_2), plus control (B_0) on nodulation efficiency and growth of peanut plants. B_1 consists of *Azospirillum braselinse* (local strain) + *Bacillus megatherium* (local strain) + *Azotobacter chroococcum*(local strain) ; while B_2 consists of *Bradyrhizobium.sp* (strain (USDA 3456)) + *Serratia marcescens* (strain MH6) + *Psuedomonas fluorescens* (strain IFO 2034). Application rate of SPC, FYM were 5 ton / fed., while that of ECT was 75 L/fed. The treatment FYM +ECT was carried out at a rate of 2.5 ton FYM / fed. + 37.5 L ECT/ fed. All agricultural practices beginning from preparation of soil to planting until harvesting were carried out as recommended by Egyptian Ministry of Agriculture.

Before planting, surface soil samples (0-20 cm) were taken from the experimental soil, air-dried, ground, mixed throughtly, sieved through a 2 mm sieve, kept and there after were analyzed for some physical as well as chemical properties and its content (total and available) of N, P and K according to the methods described by Cottenie *et al*. (1982) ; Page *et al*. (1982) and Kim (1996). The obtained data were recorded in Table (1).

Sources of the organic fertilizers

The used organic fertilizers were :-

1- **Enriched compost tea "ECT", prepared from a well mature compost and enriched with humic. ECT preparation and purification processes were carried out according to the methods described by Abdel-Wahab *et al.* (2007).**
2- **Solid plant compost "SPC" prepared from plant residues at Agricultural Microbiology Research Department, Soils, Water and Environment Research Institute**

Table (1): Some physical and chemical properties and some nutrients content of the studied soil.

a. Physical properties			
Particles size distribution (%)			
Sand	Silt	Clay	Textural class
90.6	4.6	4.8	Sandy

b. Chemical properties											
Organic matter g kg $^{-1}$	$CaCO_3$ g kg $^{-1}$	pH (1:2.5) soil:water suspension	EC(dSm^{-1}) Saturated Soil paste	Soluble ions (m mole L^{-1})							
				Cation				Anion			
				Ca^{2+}	Mg^{2+}	K^{+}	Na^{+}	CO_3^{2-}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
4.0	16	7.6	0.31	0.7	0.6	0.3	1.5	0.0	1.6	0.7	0.8

c. Nutrient contents (mg kg^{-1})					
N		P		K	
Total	Available was extracted with 1 N KCL	Total	Availablewas extracted with0.5N $NaHCO_3$	Total	Availablewas extracted with 1N ammonium acetate
221.0	31.00	62.30	5.3	489.60	57.50

Research, Agricultural Research Center (ARC), Egypt. Compost used was prepared from rice straw and farmyard manure provided with bentonite, rock phosphate, elemental sulphur and urea, which were composted for three months, according to the methods described by Abdel-Wahab *et al.* (2008) were added.

3- Farmyard manure "FYM" which was taken from Private Animal Farm Breading.

4- Mixture of farmyard manure and enriched compost tea "FYM" + "ECT".

All samples of organic fertilizers were analyzed for their chemical composition according to the methods described by Cottenie *et al*. (1982). The obtained data are recorded in Table (2).

Preparation of biofertilizers

Bio-fertilizers preparation was done by using two different mixtures (B_1 and B_2) (blends) of bacterial agents supplied by Agricultural Microbiology Research Department, Soils, Water and Environment Research Institute, Agricultural Research Center (ARC), Egypt. All the bacterial agents were used as plant growth promoting rhizobacteria (PGPR) and are represented by the following mixtures:-

- B_1 consists of *Azospirillum braselinse* (local strain) + *Bacillus megatherium* (local strain) + *Azotobacter chroococcum* (local strain).
- B_2 consists of *Bradyrhizobium.sp* (strain (USDA 3456)) + *Serratia marcescens* (strain MH6) + *Psuedomonas fluorescens* (strain IFO 2034).

Table (2): Some chemical properties of the used three organic fertilizers.

Sources of organic fertilizers (OF)	Organic C	Organic matter	Total N	C/N ratio	pH (1:10) OF: water suspension	EC (dSm^{-1}) (1:10) OF : water extract	Total P	Total K
	(%)						(%)	
Enriched compost tea “ECT”	5.80	9.99	0.41	14.15	6.85	3.89	0.57	0.82
Solid plant compost “SPC”	18.00	31.03	1.42	12.68	7.79	3.53	0.46	1.60
Farmyard manure “FYM”	22.05	38.01	1.20	18.37	8.38	3.80	0.70	1.90

The layout of the experiment was a split-split-plot design, with the main plots arranged in a randomized complete blocks design, with three replicates. The experimental plots were 90 units including 2 levels of mineral N fertilization × four resources of organic fertilizers, plus control × two different mixtures of biofertilizer, plus control × three replicates. The area of each plot was 21 m² (7 m length × 3 m width), including 5 rows. The experimental plots were divided into two main groups (45 plots / main group), each of which was treated with either of the mineral N fertilization levels (25 or 40 kg N / fed., ammonium sulphate, 20.3 % N). It was added in two equal doses, after 20 and 30 days of planting. The sub main plots were represented by the biofertilizer, where peanut seeds were inoculated with gamma irradiated vermiculite based inoculums at a rate of 300 g/50 kg seeds using 16% Arabic gum solution as a sticking agent. Moreover, the sub-sub main plots were treated with either of the used organic fertilizers (ECT, SPC, FYM or FYM+ECT). Before planting, SPC and FYM were added at a rate of 5 ton/fed , while, ECT was added at a rate of 75 L/ fed., after 20 and 30 days of planting. The treatment of FYM+ECT was carried out at a rate of 2.5 ton FYM / fed. + 37.5 L ECT/ fed. Also, before planting, during the final soil preparation, all plots were fertilized by ordinary super phosphate (15.5 % P_2O_5) at a rate of 200 kg / fed. beside of agricultural gypsum at a rate of 500 kg / fed. At the same time of mineral N fertilization, all plots received potassium fertilizer in the form of potassium sulphate (48 % K_2O) at rate of 100 kg/ fed., in both two seasons.

Directly after inoculation, peanut (Giza 5 cv.; kindly provided from Field Crop Research Institute, Agriculture Research Center, Giza, Egypt) seeds were planted on 10 th and 15 th of May 2016 and 2017 in the two seasons, respectively at a seeding rate of 50 kg seeds / fed., thus 2 seeds for each hole at 2 cm depth at distance of 20 cm between holes. After 15 days of planting, the plants of each hole were thinned to one plant.

In both the two seasons, after 45 days of planting, the plants of one length meter of each replicate were taken separately counted and separated into roots and shoots. Shoots of the plants of each sample were air-dried, oven-dried at 70 ^{o}C for 48 h, to determine the following parameters: -

1- Number of nodules/plant (formed on the roots of peanut plant).
2- Weight of nodules roots (g/plant).
3- Weight of dry matter shoots (g/plants/m).
4- Finally, the relative change (%) of the obtained data were calculated,

where: the relative change (%) =
{ (Parameter value duo to the treatment – Parameter value in the control) / Parameter value in control } × 100.

All the data obtained from this study were analyzed using analysis of variance as described by Snedecor and Cochran (1980). The statistical analysis was done using costat package program, version 6.4 (Cohort software, USA). The differences among the means of different treatments were tested using the least significant differences (L.S.D.) at probability level of 5%.

RESULTS AND DISCUSSION

Effect of mineral N fertilization levels, biofertilizer and organic fertilizers on:

1- Nodules number:

The data presented in Tables (3, 4 and 5) show that, the number of nodules formed on the roots of peanut plants grown on the sandy soil after 45 days of planting and their relative changes duo to the different treatments under study. The of nodules number increased from 23.00 nodules/plant duo to the treatment N1+ B_0 + O_0 to 27.67 nodules/plant duo to the treatment N2+ B_0 + O_0 , thus relative change (%) owing to the mineral N fertilization levels (RCM) was 20.30 %. This result also show the important effect of the added rate of mineral N on nodules number under sandy soil conditions. In this respect, Gad (2006) ; Bekele *et al.* (2019) and Tantawy *et al*. (2019) obtained similar results with pea ; groundnut and common bean plants, respectively.

All observation emphasize the beneficial effect of biofertilizers (B_1 and B_2) on nodules number. where Tables (3 and 4) reveal that inoculation with biofertilizers resulted in a significant increases in the nodules number formed on the roots of peanut grown under the sandy soil conditions. This positive effect was found duo to individual applications of the biofertilizers as well as duo to their combined treatments with mineral N and organic fertilizers. Duo to the individual application of B_1+N1+O_0, the relative change (%) owing to biofertilization (RCB) was value 13.04 % (Table,4), where the nodules number increased from 23.00 to 26.00 nodule/plant duo to the treatments N1+B_0+O_0 and N1+B_1+O_0, respectively. Under the same treatment of mineral N and/or organic fertilizers, nodules number formed on the roots of peanut plants biofertilized by B_2 were higher than the corresponding ones formed on the rate of the plants fertilized by B_1. For example, nodules number resulted from the treatment N1+B_1+O_0 was 26.00 no/plant increased to 32.00 no/plant with the treatment N1+B_2+O_0 by RCB value of 13.04 and 39.13% compared to the corresponding ones resulted duo to the treatment N1+B_0+O_0 . These findings show the high efficiency of nodulation process as a result of biofertilization especially with the treatment B_2. Abbas *et al.* (2011); El-Noamany (2013) and Mbah and Dakora (2018) found augments positive effect of biofertilization on nodules formation on soybean ; faba bean and some legumes plants (soybean ; Bambara groundnut ; and Kersting's groundnut) , respectively.

More of nodules formed on the roots of peanut plants were found in the plants grown on the soil treated with combined application of the mineral N and biofertilizers (B_1 and B_2) as compared with those found duo to either of the individual applications (Table, 3). So, RCB (%) of nodules number duo to these

Table (3): Effect of mineral nitrogen , biofertilizer and organic fertilizers application on number of nodules/plant formed on the roots of peanut plants grown on the sandy soil and its relative changes as affected by additives of mineral N (RCM,%) under different treatments of bio-and organic fertilizers (mean values of two growing seasons, 2016 and 2017).

Mineral -N (M)	Biofertilizer (B)	Fertilizers application: Organic fertilizer (O): O_0 No./plant	O_0 RCM (%)	FYM No./plant	FYM RCM (%)	SPC No./plant	SPC RCM (%)	FYM+ ECT No./plant	FYM+ ECT RCM (%)	RCT No./plant	RCT RCM (%)	Mean number of nodules
N1	B_0	23.00	--------	35.00	--------	47.00	--------	65.00	--------	87.00	--------	51.40
	B_1	26.00	--------	48.67	--------	56.00	--------	75.67	--------	93.67	--------	60.00
	B_2	32.00	--------	55.67	--------	69.00	--------	105.00	--------	130.00	--------	78.33
	Mean	27.00	--------	46.45	--------	57.33	--------	81.89	--------	103.56	--------	63.24
N2	B_0	27.67	20.30	43.33	23.80	48.33	2.83	69.00	6.15	92.67	6.52	56.20
	B_1	31.67	21.81	51.67	6.16	60.00	7.14	81.33	7.48	98.00	4.62	64.53
	B_2	38.00	18.75	59.33	6.57	70.00	1.45	118.33	12.70	139.67	7.44	85.07
	Mean	32.45	--	51.44	--	59.44	--	89.55	--	110.11	--	68.60
General mean		29.72	--	48.94	--	58.38	--	85.72	--	106.83	--	65.92

LSD at 0.05: Mineral-N = 1.906; Biofertilizer = 2.334; Organic fertilizer = 3.013
Mineral-N = ***; Biofertilizer = ***; Organic fertilizer = ****
M×B = ns; M×O = ns; B×O = ***; M×B×O = ns

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium sp.* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM=farmyard manure, SPC=solid plant compost and ECT=enriched compost tea.

Table (4): Relative changes of nodules number /plant formed on the roots of peanut plants grown on the sandy soil as affected by bio-fertilizer applications (RCB , %) under different treatments of mineral and organic fertilizers (mean values of two growing seasons, 2016 and 2017).

Fertilizers application						
Mineral -N (M)	Biofertilizer (B)	Organic fertilizer (O)				
		O_0	FYM	SPC	FYM+ ECT	ECT
N1	B_0	--	--	--	--	--
	B_1	13.04	48.57	19.15	16.41	7.67
	B_2	39.13	59.06	46.81	61.54	49.42
N2	B_0	--	--	--	--	--
	B_1	14.46	19.25	24.14	17.87	5.75
	B_2	37.33	36.92	37.95	71.50	50.72

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

Table (5): Relative changes of nodules number /plant formed on the roots of peanut plants grown on the sandy soil as affected by organic fertilizer applications, (RCO%) under different treatments of mineral and biofertilizers (mean values of two growing seasons, 2016 and 2017).

Fertilizers application					
Mineral-N (M)	Biofertilizer (B)	Organic fertilizer (O)			
		FYM	SPC	FYM+ ECT	ECT
N1	B_0	52.17	104.35	182.61	278.26
	B_1	87.19	115.38	191.04	260.27
	B_2	73.97	115.62	228.12	306.25
N2	B_0	56.59	74.66	149.37	234.91
	B_1	63.15	89.45	156.80	209.44
	B_2	56.13	84.21	211.39	267.55

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

combined applications were higher than those formed duo to their individual application (Tables, 3 and 5). This findings show the high importance of both mineral N and biofertilization on nodules formation. Dikand *et al.* (2012) showed that nodulation and nitrogen fixation in N-fertilized soybean were low compared to any *bradyrhizobium* inoculations.

The nodules number formed on the roots of peanut plants planted in the sandy soil treated with the organic fertilizers whereas applied individually or in combination with mineral N and/or bio fertilizers resulted in a wide variations depending mainly on the added organic fertilizers (Tables, 3 and 5). All applications of organic fertilizers resulted in an increases of nodules number per plant of peanut. According to the formed nodules number, the efficiency of the tested organic fertilizers may be arranged in the following order: ECT > FYM + ECT > SPC > FYM > O_0 (control treatment). For example, with the treatment N1+B_0 +O_0, the number of nodules increased from 23.00 to 35.00, 47.00, 65.00 and 87.00 no/plant with relative changes, of organic fertilizers (RCO) of 52.17%, 104.35%, 182.61%, 278.26 % duo to application of FYM, SPC, FYM+ECT, and ECT as compared to the treatment of O_0, respectively. Similar trends were attained with all combined applications of organic fertilizers with both mineral N and biofertilization. This trend was in harmony with the chemical compositions of these manures especially their C/ N ratios and their contents of the essential plant nutrients as well as to their effects on improving soil physical and chemical properties. Abbas *et al.* (2011) found that farmyard manure (FYM) treatment has increased nodulation root (numbers and dry weight).

More significant increases of nodules number formed on the roots of peanut plants grown in sandy soil were found in the plants treated by dual applications of mineral –N + organic fertilizers (Tables, 3, 4 and 5). The values of RCM, RCB and RCO reveal such an effect. Vessey and Buss (2002) and Sulfab *et al*. (2011), showed that organic manure either alone or with Rhizobium inoculation plus 20 kg N ha^{-1} significantly increased groundnuts nodulation. The triple applications of mineral N, biofertilizers (B_1 or B_2) and either of FYM, SPC, FYM+ECT or ECT were of more pronounced effects on nodulation probably duo to improving fertility as a result of these applications. The highest nodules number was found in the plants grown in the sandy soil treated with triple application of N2+B_2+ECT followed by the treatment N2+B_2+FYM with ECT while the lowest effect of the triple combinations was recorded with the treatment N1+B_1+FYM.

2- Nodules weight:

The data presented in Tables (6, 7 and 8) showed nodules weight (g/plants/m) formed on the roots of peanut grown in sandy soil and their relative changes as affected by both individual and combined applications mineral N, biofertilizers (B_1 and B_2) and organic fertilizers (FYM, SPC, ECT and FYM + ECT. All these applications resulted in significant increases in nodules weight as g/plants/m. So all RCM, RCB and RCO (%) were positive. The lowest value of nodules weight (0.20 g/plants/m) was found on the roots of peanut plants treated by N1+B_0+O_0, whereas the highest (0.74g/plants/m) one was found in the plants grown in the sandy soil fertilized by N2+B_2+ECT.

Increasing rate of the added mineral N to the sandy soil from 25 kg/fed. (N1) to 40 kg/fed. (N2) resulted in significant increases in nodules weight from 0.20 g/plants/m, with the treatment of

Table (6): Effect of mineral nitrogen , biofertilizer and organic fertilizers application on root nodules weight (g / plant) formed on the roots of peanut plants grown on the sandy soil and its relative changes as affected by additives of mineral N (RCM,%) under different treatments of bio-and organic fertilizers (mean values of two growing seasons, 2016 and 2017).

Mineral- N (M)	Biofertilizer (B)	Fertilizers application										Mean of weight (g / plant)
		Organic fertilizer (O)										
		O_0		FYM		SPC		FYM+ ECT		ECT		
		g/plant	RCM (%)	g/plant	RCM (%)	g/plant	RCM (%)	g/plant	RCM (%)	g/plant	RCM (%)	
N1	B_0	0.20	-------	0.28	--------	0.29	--------	0.32	-------	0.37	-------	0.29
	B_1	0.27	-------	0.29	--------	0.33	--------	0.34	-------	0.41	-------	0.33
	B_2	0.32	-------	0.39	--------	0.45	--------	0.50	-------	0.55	-------	0.44
	Mean	0.26	-------	0.32	--------	0.36	--------	0.39	-------	0.44	-------	0.35
N2	B_0	0.26	30.00	0.30	7.14	0.37	27.59	0.42	31.25	0.47	27.03	0.36
	B_1	0.31	14.81	0.39	34.48	0.45	36.36	0.49	44.12	0.59	43.90	0.45
	B_2	0.36	12.50	0.48	23.08	0.55	22.22	0.67	34.00	0.74	34.54	0.56
	Mean	0.31	-------	0.39	--------	0.46	--------	0.53	-------	0.60	-------	0.46
General mean		0.28	-------	0.35	--------	0.41	--------	0.46	-------	0.52	-------	0.40

LSD at 0.05 Mineral-N = 0.053 Biofertilizer= 0.065 Organic fertilizer= 0.084
Mineral-N = *** Biofertilizer = *** Organic fertilizer =****
M×B=ns M×O= ns B×O= ns M×B×O= ns

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

Table (7): Relative changes of root nodules weight formed on the roots of peanut plants grown on the sandy soil as affected by bio-fertilizer applications (RCB, %) under different treatments of mineral and organic fertilizers (mean values of two growing seasons, 2016 and 2017).

Fertilizers application						
Mineral- N (M)	Biofertilizer (B)	Organic fertilizer (O)				
		O_0	FYM	SPC	FYM+ ECT	ECT
N1	B_0	--	--	--	--	--
	B_1	35.00	3.57	13.97	6.25	10.81
	B_2	60.00	39.28	55.17	56.25	48.65
N2	B_0	-	-	-	-	-
	B_1	19.23	30.00	21.62	17.46	25.53
	B_2	38.46	60.00	48.65	59.52	57.45

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

Table (8): Relative changes of root nodules weight formed on the roots of peanut plants grown on the sandy soil as affected by organic fertilizer applications (RCO, %) under different treatments of mineral and biofertilizers (mean values of two growing seasons, 2016 and 2017).

Fertilizers application					
Mineral- N (M)	Biofertilizer (B)	Organic fertilizer (O)			
		FYM	SPC	FYM+ ECT	ECT
N1	B_0	40.00	45.00	60.00	85.00
	B_1	7.40	22.22	25.92	51.85
	B_2	21.87	40.62	56.23	71.87
N2	B_0	15.87	42.31	61.54	80.77
	B_1	25.81	45.16	58.06	90.32
	B_2	33.33	52.77	86.11	105.55

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

$N1+B_0+O_0$ to 0.26 g/plants/m with the treatment of $N2+B_0+O_0$, consequently RCM of 30.00% occurred in the nodules weights of root plants grown in the sandy soil (Table, 6). These increases are in harmony with the nodules number formed as a result of these treatments. These increases were duo to enhanced effect of mineral N fertilizer on plant growth as well as its enhanced effect on microbial and enzymes activities as reported by Gad (2006) and Bekele *et al.* (2019) who obtained similar results with pea and groundnut plants .

Similar increases nodules weight (g/plants/m) were found as a result of biofertilizations, where these increases were significant compared with those attained duo to the treatment free from biofertilization (Table, 6 and 7). At the same treatment of mineral N and organic fertilizers, biofertilization by B_2 resulted in higher nodules weights formed on the roots of peanut plants compared with those found on the plants biofertilized by B_1. For example, values of nodules weight resulted duo to the treatment $N1+B_1+O_0$ was 0.27 g/plants/m increased to 0.32 g/plants/m duo to the treatment $N1+B_2+O_0$. The effects of biofertilizer types on microbial and enzyme activities as well as nitrogen fixation were reported by El-Noamany (2013) and El-Zemrany *et al.* (2019). In this respect, the obtained results are in agreement with those reported by Tantawy *et al.* (2019) .

Data in Tables (6 and 7) showed high and significant increases in nodules weights (g/plants/m) duo to the combined applications of mineral-N and biofertilization i.e. B_1 and B_2 as compared with those found duo to their individual applications. These findings may be supported and cleared from the high values of RCM and RCB. For example, the nodules weight resulted duo to the treatment $N2+B_0+O_0$ was 0.26 g/plant increased to 0.31 and 0.36 g/plants/m duo to the treatment $N2+B_1+O_0$ and $N2+B_2+O_0$, respectively corresponding to RCB values of 19.23 and 38.46 %. These findings mean that, the efficiency of the combined applications of mineral-N and biofertilizers were higher than those resulted duo to their individual applications. In contrast, Dikand *et al.* (2012) showed that nodulation and nitrogen fixation in N-fertilized soybean were lower as compared to the corresponding ones resulted duo to *bradyrhizobium* inoculations. Nitrogen fertilization at a rate of 50 mg N kg^{-1} soil was deleterious to soybean, while combined application of 10 mg N kg^{-1} soil as N starter with any *bradyrhizobium* strain inoculation improved significantly nodulation.

Individual as well as combined applications of the tested N, and biofertilizers with organic fertilizers, i.e., FYM (farmyard manure), SPC (solid plant compost), FYM (farmyard manure) + ECT (enriched compost tea) and ECT resulted in significant increases in nodules weight (g/plants/m). The increases were higher with duo to the combined applications of these organic fertilizers with mineral-N or / and bio (B_1 and B_2) fertilizers as compared with the individual applications (Table, 6). So, all RCO (%) were positive (Table, 8). Also, the rate of these increases varied widely from an organic fertilizer to another depending on its chemical composition, nutrients content and C/N ratio, (Hammad, 2019). According to the general means of nodules weight (g/plants/m) formed on the roots of peanut plants grown in sandy soil, the used organic fertilizers took the order: ECT (0.52) > FYM + ECT (0.46) > SPC (0.41) > FYM(0.35). This trend may be cleared from RCO value (%) recorded in Table (8), where the highest RCO values of nodules weight were found with the plants fertilized by ECT followed by these found in the plants grown on the soil treated with FYM+ECT. These results are in agreement with those obtained by Abedel-Wahab *et al.* (2006) who found that application of compost to

sandy soil has led to increase in plant growth of peanut crop and the nodulation status after 45 and 75 days. Recently, Hammad (2019) pointed out that with different applications rates of vinase and molase the nodules weight formed on the roots of common bean plants significantly increased as compared to the control treatment.

More significant increases in nodules weight formed on the roots of peanut plants grown in the sandy soil were found duo to dual applications of organic fertilizers with mineral and/ or N bio (B_1 and B_2) fertilizers. The combined applications of mineral N and organic fertilizers with biofertilizers showed greater increase in nodules weight as compared with these resulted duo to the combined applications of organic fertilizers and mineral-N (Table, 6). It is also shown more increase in nodules weights in the plants treated with the three types of fertilizers together, where these treatments gave the highest values of RCM, RCB and RCO (Tables, 6, 7 and 8). So, the highest values of nodules weights were associated with the treatment N2+B_2+ECT followed by the treatment N2+B_2+FYM-ECT , while the lowest one were found in the plants treated with N1+B_0+O_0. Sulfab *et al.* (2011) they showed that either organic manure alone or with *Rhizobium* inoculation plus 20 kg N ha^{-1} has significantly increased groundnuts nodulation.

3- Dry matter of plant shoots plants:

Value of dry matter of shoots (g/plants/m)of peanut plants grown on the sandy soil after 45 days of planting and its relative changes (%) in relation with the studied individual and combined applications of mineral N (N1 and N2), bio ["B_1" *Azospirillum braselinse* (local strain), *Bacillus megatherium,* (local strain) and *Azotobacter chroococcum* (local strain) and "B_2" *Bradyrhizobium.sp (*strain (USDA 3456))*, Serratia marcescens* (strain MH6) and *Psuedomonas fluorescens*(strain IFO 2034) and organic fertilizers {FYM (farmyard manure), SPC(solid plant compost), FYM (farmyard manure) + ECT (enriched compost tea) and ECT (enriched compost tea) } are presented in Tables (9, 10 and 11). Increasing application rate of mineral N from 25 kg/fed (N1) to 40 kg/fed (N2) whereas individually or in combinations with bio- and / or organic fertilizers resulted in significant increases in the dry weights of peanut shoots. Therefore, all RCM values were positive. For example, shoots dry weights increased from 8.39 g/plants/m duo to the treatment N1+B_0+O_0 to 25.56 g/plants/m duo to the treatment N2+B_0+O_0, with RCM value of 204.65 %. Gogoi *et al.* (2000) compared the response of groundnut to different levels of N *viz.,* 0, 20, 40, 60 and 80 kg ha^{-1} and found that increased level of nitrogen application up to 80 kg ha^{-1} has increased the number of branches and pegs. Munda *et al.* (2004) observed increase in number of branches per plant (10.1) and number of pods per plant (12.3) in groundnut as compared to the control (9.9 and 9.2) when 20:60:40 kg N, P_2O_5, K_2O ha^{-1} were applied. Also, Ali and Seyyed (2010) reported that use of 60 kg ha^{-1} nitrogen fertilizer resulted in the highest pod yield and kernel yield of 2314 kg ha^{-1} and 1378 kg ha^{-1}, respectively. Ali and Ebrahim (2011) stated that nitrogen fertilizerat a rate of (60 kg ha^{-1}) had significant effects on kernel yield,100 kernel weight, the number of seeds $plant^{-1}$, width and length of seed. Also, the maximum kernel yield of 1796 kg ha^{-1}

Table (9): Effect of mineral nitrogen , biofertilizer and organic fertilizers application on dry matter shoots (g/plants/m) and its relative changes as affected by additives of mineral N (RCM,%) under different treatments of bio-and organic fertilizers (mean values of two growing seasons, 2016 and 2017).

Mineral- N (M)	Biofertilizer (B)	Fertilizers application: Organic fertilizers (O): O_0 g/plant s/m	O_0 RCM (%)	FYM g/plant s/m	FYM RCM (%)	SPC g/plant s/m	SPC RCM (%)	FYM+ ECT g/plan ts/m	FYM+ ECT RCM (%)	ECT g/plant s/m	ECT RCM (%)	Mean of dry matter shoots (g/plant s/m)
N1	B_0	8.39	--------	15.24	--------	16.32	--------	17.95	--------	19.11	--------	15.40
	B_1	13.01	--------	17.62	--------	18.53	--------	19.62	--------	22.20	--------	18.20
	B_2	16.15	--------	18.14	--------	19.12	--------	21.77	--------	24.98	--------	20.03
	Mean	12.52	--------	17.00	--------	17.99	--------	19.78	--------	22.10	--------	17.88
N2	B_0	25.56	204.65	33.91	122.51	34.59	111.95	36.57	103.73	39.52	106.80	34.03
	B_1	30.39	133.59	36.56	107.49	37.62	103.03	40.88	108.36	48.74	119.55	38.84
	B_2	33.81	109.35	38.30	111.13	42.71	123.38	48.00	120.49	51.16	104.80	42.80
	Mean	29.92	--------	36.26	--------	38.31	--------	41.82	--------	46.47	--------	38.56
General mean		21.22	--------	26.63	--------	28.15	--------	30.80	--------	34.28	--------	28.22

LSD at 0.05 Mineral-N = 0.723 Biofertilizer = 0.885 Organic fertilizers = 1.143

Mineral-N = *** Biofertilizer = *** Organic fertilizers = ****

M×B = *** M×O = *** B×O = ** M×B×O = ns

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM=farmyard manure , SPC=solid plant compost and ECT=enriched compost tea.

Table (10): Relative changes of dry matter shoots of peanut plants grown on the sandy soil as affected by bio-fertilizer applications (RCB, %) under different treatments of mineral and organic fertilizers (mean values of two growing seasons, 2016 and 2017).

Fertilizers application						
Mineral- N (M)	Biofertilizer (B)	Organic fertilizer (O)				
		O_0	FYM	SPC	FYM+ ECT	ECT
N1	B_0	--	--	--	--	--
	B_1	55.06	15.62	13.54	9.30	16.17
	B_2	92.49	19.03	17.16	21.28	30.72
N2	B_0	--	--	--	--	--
	B_1	18.90	7.81	8.76	11.78	23.33
	B_2	32.28	12.95	23.47	31.25	29.45

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

Table (11): Relative changes of dry matter shoots of peanut plants grown on the sandy soil as affected by organic fertilizer applications (RCO, %) under different treatments of mineral and biofertilizers (mean values of two growing seasons, 2016 and 2017).

Fertilizers application					
Mineral- N (M)	Biofertilizer (B)	Organic fertilizer (O)			
		FYM	SPC	FYM+ ECT	ECT
N1	B_0	81.64	94.52	113.94	127.77
	B_1	35.54	42.54	50.92	70.77
	B_2	12.32	18.39	34.80	54.67
N2	B_0	32.67	35.33	43.07	54.62
	B_1	20.30	23.79	34.52	60.38
	B_2	13.28	26.32	41.97	51.32

N1 and N2=25 and 40 kg N / fed., ; B_0= non biofertilizer , B_1= *Azospirillum braselinse* + local strain+ *Bacillus megatherium* + local strain + *Azotobacter chroococcum* + local strain , B_2= *Bradyrhizobium.sp* + strain (USDA 3456) + *Serratia marcescens* + strain MH6 + *Psuedomonas fluorescens* + strain IFO 2034 ; O_0=non organic fertilizers, FYM= farmyard manure , SPC= solid plant compost and ECT=enriched compost tea.

was obtained duo to the application of nitrogen at a rate of (60 kg ha^{-1}). Recently, Bekele *et al.* (2019) has obtained similar results with groundnut plant.

Biofertilizers (B_1 and B_2) in combination with mineral N (N1 and N2) and/or organic (FYM, SPC, FYM + ECT and ECT) fertilizers caused a significant increases in shoots dry weights (g/plants/m) where its relative changes (RCB,%) were recorded in Tables (9 and 10). At the same treatment of mineral N and organic fertilizers, values of shoots dry weight of peanut plants biofertilized by B_2 were higher than those resulted duo to the treatment B_1. For example, value of the shoots dry weight resulted duo to the treatment N1+B_1+O_0 was 13.01 g/plants/m and increased up to 16.15 g/plants/m duo to the treatment N1+B_2+O_0, with RCB values of 55.06 % and 92.49 %, respectively. Mohammad and Muhammad (2002) and Meghvansi *et al.* (2008) confirmed that co-inoculation of *Rhizobium* and PSB increased shoot dry weight and nitrogen and phosphorus content in shoot and phosphorus use efficiency compared to uninoculated control. Oad *et al*. (2002) showed that *Rhizobium japonicum* exhibited positive changes terms of enhanced growth and seed yield. Bai *et al.* (2003) found that co-inoculation with *Bacillus sp* (strains NEB17) showed most consistent increases in shoot weight, root weight, total biomass, total nitrogen, and grain yield. *B. thuringiensis* NEB17 would be suitable for use as a plant growth promoting bacteria strain in soybean production systems in short growing season. Similar results were found by El-Tahlawy (2018) on wheat plants grown on sandy soil ; El-Zemrany *et al.* (2019) on peanut plants grown in sandy soil and Tantawy *et al*. (2019) on common bean plants grown on sandy and clay soils.

Organic fertilizers applications from different sources (FYM, SPC, FYM +ECT and ECT) either alone or together with mineral N(N1 and N2) or/and bio(B_1 and B_2) fertilizers resulted in significant increases in shoots dry weights (g/plants/m) and consequently values of RCM, RCB and RCO (%) as shown in Tables (9,10 and 11). Shoots dry weight of peanut plants varied widely from on organic fertilizers to another, where at the same treatment of mineral N and biofertilizers. The used organic fertilizers could be warged according to their effects on increasing shoots dry weights (g/plants/m) takes the following order: FYM (26.63) < SPC (28.15) < FYM +ECT (30.80) < ECT (34.28).Therefore, all RCO (%) of shoots dry weights as affected by the applied organic fertilizers were positive as listed in Table (11). These variations reflect the improving effect of the added organic fertilizers on soil properties and its fertility as well as thier enhanced effect on microbial and enzymes activity (Abdel Aal, 2018 and Hessin, 2019).

Different combined applications of mineral N (N1 and N2), bio (B_1 and B_2) and organic (FYM, SPC, FYM + ECT and ECT) in dual or in triple applications resulted in high significant increases in shoots dry weight as compared with their individual treatments as shown in Table (9). Therefore, the treatments are characterized by high values of RCM, RCB and RCO (%) as listed in Tables (9,10 and 11). These findings show the higher efficiency of the studied fertilizers when added together. The highest value of shoots dry weight were recorded duo to the treatment N2+B_2+ECT followed by that resulted duo to the treatment N2+B_2+FYM-ECT which gave shoots dry weights of 51.16 and 48.00 g/plants/m,

respectively. Sulfab *et al*. (2011) showed that nitrogen application at the rate of 20 kg N ha^{-1} *via* inoculation with rhizobia coupled with either manures resulted in significant increments in shoot and root dry weights as compared to the control. These treatments also influenced groundnuts shoot N and P accumulation and resulted in a significantly highest pod and straw yields over all other treatments under irrigated and rain fed conditions. Rizk *et al.* (2012) has found a response of peanut to inoculation with *Bradyrhizobium* either individually or in combination with PGPR (*Pseudomonas fluorescens*) under different levels of organic compost. Recently, El-Tahlawy (2018) and Ghaly *et al.* (2018) obtained similar results with wheat and common bean plants, respectively.

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تأثير إضافة النيتروجين المعدنى والسماد الحيوي على كفاءة التعقد والنمو لنباتات الفول السوداني النامية علي الأرض الرملية المُعاملة بالأسمدة العضوية

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الملخص العربي

أُجريت تجربة حقلية علي الأرض الرملية في المزرعة البحثية – محطة بحوث الإسماعيلية – معهد بحوث الأراضي و المياه و البيئة – مركز البحوث الزراعية – مصر ؛ خلال موسمي نمو صيف متتاليين لعامي ٢٠١٦ و ٢٠١٧ م علي نبات الفول السوداني صنف جيزة ٥ ، لدراسة التأثير المنفرد و المشترك لإضافة مستويات مختلفة من التسميد النيتروجيني المعدني (٢٥ و ٤٠ كجم نيتروجين / فدان ، في صورة كبريتات أمونيوم ٢٠,٣ ٪ نيتروجين) و أربعة مصادر من الأسمدة العضوية (السماد البلدي ، كمبوست المخلفات النباتية الصلبة ، شاي الكمبوست المخصب و السماد البلدي + شاي الكمبوست المخصب) و خليطين مختلفين من الأسمدة الحيوية علي كفاءة التعقد (عدد العقد الجذرية و وزنها الجاف) و نمو نباتات الفول السوداني. و يتكون الخليط الأول للسماد الحيوي من الأزوسبيريللم براسيلينس وباسيلليس ميجاتيريم والأزوتوباكتركروكوكم ، بينما يتكون الخليط الثاني للسماد الحيوي من برادى رايزوبيم وسيريتيا مارسينيس وسيدوموناس فلوريسينس. و قد تم إضافة كلٍ من السماد البلدي و كمبوست المخلفات النباتية الصلبة بمعدل إضافة ٥ طن / فدان بينما تم إضافة شاي الكمبوست المخصب بمعدل ٧٥ لتر / فدان. في حين كانت المُعاملة السماد البلدي + شاي الكمبوست المخصب بمعدل إضافة ٢,٥ طن / فدان بالنسبة للسماد البلدي + ٣٧,٥ لتر / فدان بالنسبة لشاي الكمبوست المخصب. و تم إجراء التجربة في تصميم منشقة مرتين في ثلاث مكررات.

وقد أوضحت النتائج المُتحصل عليها وجود زيادة معنوية واضحة لكلٍ من تكوين العقد الجذرية علي نباتات الفول السوداني (عدداً و وزن مادتها الجافة) و كذلك وزن المادة الجافة للمجموع الخضري لنباتات الفول السوداني المُعاملة بالمعاملات التسميدية بالمقارنة بالكنترول. وقد صاحب الإضافات الثلاثة المشتركة للتسميد النيتروجيني المعدني و الأسمدة العضوية والحيوية معاً أعلى القيم لكل من عدد العقد الجذرية و وزنها الجاف وكذلك الوزن الجاف للمجموع الخضري يتبعها في ذلك الإضافات الثنائية. وأيضاً أوضحت النتائج تفوق الخليط الحيوي الثاني عن الخليط الحيوي الأول و بالمثل تفوق شاي الكمبوست المخصب عن بقية الأسمدة العضوية في التأثير الإيجابي علي التعقد (عدد و وزن المادة الجافة للعقد الجذرية) وكذلك وزن المادة الجافة للمجموع الخضري لنباتات الفول السوداني و ذلك بعد فترة نمو ٤٥ يوماً. وبناءا على ذلك فقد أوضحت نتائج الدراسة الأهمية الكبرى لإضافات النيتروجين المعدني وكذلك الأسمدة العضوية والحيوية على زيادة خصوبة الأراضي الرملية و رفع إنتاجيتها من الفول السوداني.

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