American-Eurasian J. Agric. & Environ. Sci., 15 (5): 903-912, 2015
ISSN 1818-6769

DOI: 10.5829/idosi.aejaes.2015.15.5.12660

Enhancement of Growth and Yield Productivity of Sesame Plants by Application of Some Biological Treatments

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Abstract: Two field experiments were conducted during the successive summer seasons of 2011 and 2012, at the Agricultural Experiment and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. The study included 16 (2 cultivars * 8 fertilizer treatments) including two sesame cultivars, viz: Toushki-1 and Shandaweel-3 besides eight different mineral and biological fertilizers (100% NPK, biological fertilizers, 50% mineral NPK, 100% NPK+ biological fertilizers, 100%NPK+ biofertilizer + bio agent, 50% NPK + biofertilizer, 50% NPK + biofertilizer+ bio agent and control (without fertilizer)). The biofertilizer and bio agent were adopted as soil inoculants. Their effects on growth and yield of sesame plant were studied. Data obtained exhibited significant differences among the applied treatments for most of the studied characters. The cultivar Shandaweel-3 surpassed Toushka-1 in total bacterial counts, plant height, seed weight per plant, 1000-seed weight and seed yield per feddan as well as oil and protein percentages. Application of both plant growth promoting and bio agent bacteria with different rates of NPK fertilizers scored significant effects on total bacterial counts compared to initial counts and recorded percentage increases ranged from 20 to 175%, 125 to 525%, 150 to 317 and 94 to 483% for *Bacillus megaterium* (BM), *Bacillus cerculans* (BC), *Bacillus polymexa* (BP) and *Pseudomonas florosences* (PF), respectively. Treatment 100% recommended chemical fertilizer + biofertilizer came in the first order for sesame attributes (plant height, seed weight per plant and 1000-seed weight). While treatment 100%NPK +biological +bio agents came in the second order with seed yield per feddan and oil and protein percentages. The lowest treatment was by using control in comparison with the other experimental treatments for all characters studied. The effect of the interaction between the two commercial cultivars and fertilization treatments on seed yield per plant, seed yield per feddan, oil and/or protein percentages was significant in the two seasons except oil percentage had no significant in the second season. The results showed the importance of applying biofertilizers and bio agent chemical fertilizers to protect the environment from harmful chemical pollution.

Key words: Sesame · Mineral fertilizers · Bio-fertilizers · *Fusarium* Fungi · Yield characters · Seed oil percentage

INTRODUCTION

Sesame (*Sesame indicum* L.) is widely grown in tropical and sub-tropical regions of Asia, Africa, South and North America [1]. Sesame is a versatile crop having diversified usage and contains 42-45% oil, 20% protein, 14-20% carbohydrate and 2-3% fiber. Besides, it is rich in minerals (Ca, P, K..etc) as well as vitamin E. Also, its oil has a very high percentage of unsaturated fatty acids (about 80%). In Egypt, sesame is considered as a food crop rather than oil seed crop because most of its production is used for snacks, confectionery, bakery products, tehena and halawa purposes [2]. The local production of sesame is very low and does not cover the national requirements, so, increasing the productivity could be achieved via breeding for high yielding cultivars as well as application of the suitable cultural practices such as fertilization, irrigation, weed control and fungal disease control [3]. Concerning differences among sesame genotypes, Shabana and Abu- Hagaza [4] reported a wide

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range of variation among genotypes from Egypt and the Sudan for yield contributing traits such as number of capsule/ plant, seed weight/ plant and seed yield / faddan. Also, Shabana *et al.* [5] tested thirty eliete sesame entries of sesame for their reaction against infection with either *Macrophomina phaseolina* or *Fusarium oxysporium* or their combination. They concluded that best lines in yield were resistant to charcoal rot diseases and others were resistant to wilt disease. Thus high yield of sesame could be achieved via ones high yielding cultivars plus the optimum agronomic treatments and resistance against biotic and abiotic stresses.

In Egypt, expanding area under sesame should be done in newly reclaimed sandy soils, which were facing many problems like low fertility, poverty and high loss of nutrients by leaching.

Nitrogen is the most important essential nutrient for plant nutrition. Adequate supply of nitrogen is beneficial for carbohydrate and protein metabolism, promoting cell division and cell enlargement. Similarly, good supply of P is usually associated with increased root density and proliferation, which aid in extensive exploration and supply of nutrients and water to the growing plant, resulting in increased growth and yield traits, thereby ensuring more seed and dry matter yield. It is well known that the uses of mineral fertilizers are important factors for vigorous growth and consequently higher yield of different plant species. However, repeated application of mineral fertilizers may cause environmental pollution [6].

Recently, under Egyptian conditions, a great attention is being devoted to reduce the high rates of mineral fertilizers, the cost of production and decrease environmental pollution via reducing doses of chemical fertilizers by using organo-and bio farming systems [3,7].

Using plant growth promotingrhizobacteria (PGPR) as bio fertilizers for non- legume crops (a symbiotic N_2 fixing bacteria, phosphate dissolving bacteria, potassium realizing bacteria and bio control diseases bacteria) had a marked influence and had a positive effect on seed yield and recorded significant increases in all growth and yield tested parameters compared to untreated plants [8-11]. They also reported that PGPR did support sesame plants and gave higher yields of both seed yield and oil content (%) compared mineral NPK fertilizer application.

On the other hand, wilt disease of sesame caused by *Fusarium oxysporium* F. sp, *sesami*, is the most serious diseases causing considerable losses in seed yield in Egypt [4,5,11,12]. Application of abiotic and biotic agents with sesame transplanting as root dipping before cultivation will protect sesame plants from wilt disease for a long time and significantly increased sesame yield. Several bio control agents were able to control root diseases of sesame in the field caused by *Tricoderma* spp., *Bacillus subtilis* and AM as well as *Bacillus megaterium* [10,11,13].

The present investigation aimed to evaluate the effects of some biofertilizers and bio agents (PGPR) in combination with different rates of mineral N, P and K fertilizers on growth and yield productivity of sesame plants.

MATERIALS AND METHODS

Two field experiments were conducted during the successive seasons of 2011 and 2012 at the Agricultural Research and Experiment Station, Faculty of Agriculture, Cairo University, Giza, Egypt.

The mechanical and chemical analysis of the experimental soil was done according to the method described by Jackson [14] are shown in Table (1).

Seeds of both cultivars were grown on 18 May in the first season and 22 May in the second one. Seeds of sesame were grown in ridges 50 cm apart and 3.5 cm long. Distance between each hills was 20 cm. Plants were thinned to 2 plants / hill. Each plot included 6 ridges. The plot size was $10.5m^2$ (3.5*3.0m). The experimental layout companied 8 treatments for each sesame cultivars, as follows:

- T_1: 100% mineral NPK (60kg N, 30kg P_2O_5 and 50kg K_2O/fad.)
- T_2: Biological fertilization with *Bacillus megaterium* (BM), as a phosphate dissolving bacterium, *Bacillus cerculans* (BC) , as a potassium realizing bacterium and *Bacillus polymexa* (BP), as a N_2- fixing bacterium.
- T_3: 50% mineral NPK (30kgN, 15kg $P_2O_5$and 25kg K_2O/fad.).
- T_4: 100% NPK+ Biological fertilization (BM, BC, BP).
- T_5: 100% mineral NPK +Biological fertilization (BM, BC, BP) *Pseudomonas florosences* (PF) as a biological control bacterium against wilt disease.
- T_6: 50% mineral NPK + Biological fertilization (BM,BC,BP).
- T_7: 50% mineral NPK + Bio-fert. (BM, BC,BP) + (PF).
- T_8: Without fertilization (control).

Table 1: Mechanical and chemical characteristics of soils of the experimental sites

	Experimental sites	
Soil properties	2011	2012
Mechanical properties		
Sand %	32.70	31.30
Silt %	29.40	30.10
Clay %	37.90	38.60
Texture	Clay loam	Clay loam
Chemical properties		
Soil (pH)	7.82	7.79
Ec dsm^{-1}	1.30	1.36
Organic Matter (%)	1.78	1.70
Total CaCo3 (%)	0.94	0.78
N %	0.21	0.23
P%	0.050	0.051
K%	0.297	0.262
Available N ppm	41.15	42.47
P	6.21	6.56
K	698	701
Soluble anions (meq/L) (meq/100g soil)		
Cl^-	3.84	4.80
HCO_3^-	5.09	4.95
SO_4^{--}	4.14	3.90
Soluble cations (meq/L) (meq/100g soil)		
Na^+	6.08	6.96
K^+	0.27	0.39
Ca^{++}	3.31	2.94
Mg^{++}	3.41	3.36

The N, P and K fertilizers were added in the forms of ammonium sulphate (20%N), single super-phosphate (15.5%P_2O_5) and potassium sulphate (48%K_2O), respectively. N-fertilizer was added at two equal doses (21 and 35 days after planting). P and K fertilizers were added before sowing seeds during preparation of soil.

Strains of bacteria were kindly obtained from Dept. of Agric. Microbiol., Agric. Res. Center, Giza inoculation technique. Strains were applied as seed inoculation at planting time at a rate of (4g/100g) of seeds. Harvest was made on 2th October in the first season and on 8 th October in the second one.

The Experimental design used was a split plot arranged in randomized complete block with three replications. The main plots were devoted to sesame cultivars and sub plots to mineral and biological fertilizers.

Obtained data were subjected to analysis of variance suggested by Steel and Torrie [15]. Differences among the various means for different characters were compared causing least significant difference (LSD) test at 0.05 levels.

Samples of ten guarded plants were taken from each plot to measure the following characters:

Plant height, (cm), 1000-seed weight, (g/plant) (seed index), seed weight/plant, (g), seed yield, (kg/fad), oil percentage, protein percentage.

Microbial Determinations:

- Total counts of various bacterial groups used as biofertilizers and bio agent at 70 and 140 day after planting (DAP).
- Various hormone activities and promoting substances produced by bacteria used.
- The effect of PGPR (BM, BC, BP and PF) on *Fusarium* disease on sesame (*in vitro*). The two sesame varieties were germinated on wetted filter paper in a Patridishs for two days then each bacterial suspension was soaked for 15 minutes and set on fungal mycelium growth 7days old. Plats were incubated at 27°C for 5days. Ten plates were used as replicates for the two cultivars and each plate has ten sesame seedlings. Disease incidences were determined 7 day after incubation according to Ziedan [16].
- The availability of various PGPR strains with or without PF to biological control effect on wilt disease *in vivo* by marked and account the infected plants (at field 75 days after planting).

RESULTS AND DISCUSSION

Microbial Studies

Total Bacterial Counts: Soil microbial status was estimated before cultivation, 60 (DAP) and after cultivation as shown in Table (2). Data indicated that the initial numbers before sowing of total bacteria were 20,10,15 and 9□10^5 $cfug^{-1}$soil for BM, BC, BP and BF in averages of the two seasons, respectively and recorded the lower values as compared to treated treatments with PGPR bacteria. Application of both PGPR and biocontrol bacteria with different rates of NPK mineral fertilizers to supported bacterial growth compared to initial counts and recorded percentage increases ranged from 20 to 175%, 125 to 525%, 150 to 317 and 94 to 483% for BM, BC, BP and PF, respectively.

Irrespective of sesame varieties the treatment which received 50% of mineral NPK fertilizers and both biofertilizers (PGPR) and bio agent bacteria scored the highest total bacterial counts being 55, 62.5, 62.5 and 52.5□10^5cfu g^{-1} soil for BM, BC, BP and PF, respectively. Variety (V2) Shandweel-3 scored higher total bacterial counts compared to those scored by Toshkay-1as in averages of the two seasons. These increases of (12, 27, 6 and 11% for BM, BC, BP and PF), respectively.

Table 2: Total counts of biofertilizer and bio agent bacteria as affected by application of PGPR and mineral NPK fertilizers to sesame varieties (average the two seasons)

	Numbers (X^{-} 10^5cfug^{-1} soil)											
	Bacillus megatherium (BM)			*Bacillus cericulans* (BC)			*Bacillus Ploymexa* (BP)			*Pseudomonas florosences* (PF)		
Treatments	V1	V2	X^{-}	V1	V2	X^{-}	V1	V2	X^{-}	V1	V2	X^{-}
Before	20			10			15			9		
NPK	19.0	15.0	17.0	18.0	25.0	21.5	30.0	40.0	35.0	14.0	17.0	15.5
Biolog	18.0	30.0	24.0	20.0	25.0	22.5	25.0	50.0	37.5	15.0	20.0	17.5
1/2NK	30.0	25.0	27.5	21.0	30.0	25.5	45.0	30.0	37.5	15.0	20.0	17.5
1/2 NPK +biolog	26.0	40.0	33.0	30.0	35.0	32.5	35.0	50.0	42.5	25.0	27.0	26.0
Biolog+1/2NPK+bioc	30.0	35.0	37.5	40.0	45.0	42.5	50.0	60.0	55.0	34.0	35.0	35.0
Biolog+1/2NPK+bioc	30.0	40.0	35.0	40.0	50.0	45.0	55.0	50.0	52.5	40.0	45.0	42.5
1/2NPK + biolog+bioc	45.0	65.0	55.0	55.0	70.0	62.5	70.0	55.0	62.5	50.0	55.0	52.5
Without (control)	25.0	30.0	22.5	21.0	30.0	25.5	20.0	15.0	17.5	15.0	12.0	13.5
X^{-}	29.1	32.5	30.8	30.6	38.8	34.7	41.3	43.8	42.6	26.0	28.9	27.5
After	25			15			20			12		

Table 3: Production of indole acetic acid (IAA), gibberellins (G), siderophores and cyanide (HCN) by PGPR bacteria isolated from experimental sites of sesame plant (means of two seasons)

Bacteria used	IAA ug 100ml^{-1}	G ug 100ml^{-1}	Siderophores plat test (mm)	Siderophores mgl^{-1}	HCN color intensity
Bacillus megatherium	35.60	41.70	4.90	0.51	+++
Bacillus cericulans	29.70	44.50	6.90	0.72	-
Bacillus ploymexa	29.50	38.50	5.30	0.67	++

Total bacterial numbers after they were cultivated were higher compared to values scored before planting. Those increases were 25, 50, 33and 23% for BM, BC, BP and PF, respectively. These finding are in harmony with Pandey *et al.* [17], Ragab *et al.*[18]and El-Mehrat [19] who found that application of PGPR bacteria had stimulation effect on the population of rhizospher microorganisms (ROM) and increased their numbers significantly compared to untreated treatments.

Production of Plant Growth Promoting Substances: Data in Table (3) indicate that variations were recorded among the bacterial strains used on production of indol acetic acid (IAA), gibberellins (G), siderophores and cyanide (HCN) and their amounts being 35.6 mg 100 ml^{-1}, 44.5mg 100ml^{-1}and 0.72 mg l^{-1}. These data are in agreement with Glick [20] who reported that some bacteria called plant growth promoting rhizobacteria (PGPR), stimulate plant growth. The stimulatory effects of microorganisms may result from either direct or indirect action. Direct effects include production of phytohormones enhancement of availability of some minerals. Indirect effects arise from (PGPR) altering the root environment and ecology

Effect of Bacterial Used as Biofertilizers and Bio Agent on *F.oxysporum* (*in vitro*): Data in Table (4) indicated that all treatments highly reduced sesame seedling infection by *F. oxysporium* F. sp. The BM and BF, were the best individual bacteria reduced disease incidence of sesame seedling followed by BM+ BC and BM+PF. Combined treatments of PGPR in presence of bio agent bacteria (BM, BC, BP+BF) were the best treatments in this respect. These data are in agreement with El-Bramawy *et al*. [21], Sahab *et al.* [12], Elewa *et al*. [10] and Ziedan *et al*. [11] who reported that transplanting of sesame gave a good opportunity with biotic agents to protect plants for a long time to soil borne diseases by suitable agents than in case of seed treatment which may be effective for a short time after sowing.

Effect of PGPR and Bio Agent Bacteria on Fusarium Disease of Sesame Plants under Field Conditions (*In vivo*): Data in Table (5) indicated that application of PGPR biofertilizers and bio agents with two different NPK minerals fertilizer doses resulted in plant growth promotion and disease reduction compared to single NPK treatments for both seasons and sesame varieties used. These data are in harmony with this obtained by El-Fiki *et al*. [22] and Zarrin *et al.* [23] who reported that the enhancement of plant growth characters, resistance to fungal diseases and yield components may be due to ability of PGPR agents to provide plant by nutritional requirements, plant growth regulates.

Table 4: Reducing percentage (%) of sesame seedling infection as affected by application various PGPR bacteria tested with *Fusarium oxysporium* F.sp, *in vitro*

Treatments	V1	V2
Control	92	88
BM	27	22
BC	68	61
BP	72	67
PF	28	25
BM+BC	31	25
BM+PF	18	15
BM+BP	48	37
BC+BF	45	40
BC+BP	48	39
BP+PF	37	25
BM+BC+BP	21	19
BM+BC+PF	7	5
BM+BC+BP+PF	5	3

Table 5: Disease of percentages sesame plant as affected by various treatments

Cultivars						
Treatments	V1		X^-	V2		X^-
Seasons	S1	S2		S1	S2	
Mineral NPK	5.0	3.0	4.0	3.0	2.0	2.5
Biolog. NPK	0.0	0.0	0.0	0.0	0.0	0.0
1/2 Mineral NPK	9.0	7.0	8.0	7.0	6.0	6.5
Biolog + NPK	0.0	0.0	0.0	0.0	0.0	0.0
Biolog + NPK+ bioc	0.0	0.0	0.0	0.0	0.0	0.0
1/2 Mineral NPK+biog	4.0	4.0	4.0	0.0	0.0	0.0
1/2 Mineral NPK+biog+bioc	0.0	0.0	0.0	0.0	0.0	0.0
Without (Control)	15.0	17.0	16.0	9.0	8.0	8.5

Agronomic Parameters

Plant Height

Effect of Cultivars: Data in Table (6) cleared that there was significant difference between the two varieties in plant height. Shandawel-3 plants were the tallest (188.8cm) only in the first season as compared to Toushka-1 cultivar (179.3 cm). In the second season, there were no significant differences between the two cultivars. These results are in agreement with those obtained by Kassab *et al*. [24] and Sawsan Abou- Taleb [25]. They found insignificant differences between two sesame cultivars concerning all characters; except plant height of plants received different combinations between organic and inorganic fertilizations.

Effect of Fertilizer Treatments: Data in Table (7) revealed that plant height was significantly affected by fertilizer treatments in both seasons. T2 (biofertilizer) produced the tallest plants (192.2cm), followed by T5 (NPK+ biofertilizer+ bio agent) gave 191.4cm. The shortest plants (165.7cm) were recorded in T8 (control) in the first season. Difference between T2 and T5 was not significant. But in the second season, T1 (100% NPK mineral fertilizer) produced the tallest plants (222.9cm) followed by T4 (100% NPK+ biofertilizer) which recorded219.9 cm. The shortest plants (191.5cm) were recorded in T8 when received no fertilizers. Also, the difference between T1 and T4 was not significant. This may be due to a good supply of N, P and K which leads to increase photosynthesis rate, which is actively concerned in the process of sugar formation and translocation of starch as well as photosynthates. These results are in concert with those obtained by El-Kramany *et al*.[26], Malik *et al*.[27] and El-Habbasha *et al*.[3], who reported also that plant height increased with increasing nitrogenlevels.

1000- Seed Weight

Effect of Cultivars: The 1000-seed weight is an important yield parameter which represents the magnitude of seed development and reflects the final yield of a crop. Table (6) shows the effect of the different treatments on 1000- seed weight in the two growing seasons. The1000-seed weight was cultivar-dependent only in the second growing season. Shandawel-3 had the highest 1000-seed weight (4.52 g).

Effect of Fertilizer Treatments: Data presented in Table (7) revealed that the effect of fertilizer treatments on 1000-seed weight was significant. Significant differences among the treatments were found in the two seasons where treatment No.5 (100% NPK+ biofertilizer+ bio agent) recorded the highest value (4.45g) followed by T1 (100%NPK) and T6 (50% NPK + biofertilizer) without significant differences between the three treatments in the first season. While in the second season, the highest value of 1000-seed weight (4.51g) recorded by T1 (100%NPK) followed by T4 (100%NPK+ biofertilizer) which gave 4.47g without significant differences between them.

Seeds Weight per Plant

Effect of Cultivars: Data presented in Table (6) showed significant varietal differences between the two varieties of sesame in seed yield per plant in the two seasons. Shandawel3 cultivar recorded the highest seeds weight per plant (123.9 and 132.2g) compared to Toushka1 cultivar (121.5 and 120.7g) in both seasons, respectively. These results may be due to the differences in genetic background between the two studied cultivars.

Table 6: Effect of varietal differences on growth and yield attributes of sesame plants (2011 and 2012 seasons).

Cultivars	Plant height (cm)	Seed yield /plant (g)	1000- Seed weight (g)	Seed yield /fed. (Kg)	Oil %	Protein %
	2011					
Toushka-1	179.3	121.5	4.25	488.2	45.4	18.96
Shandawel-3	188.8	123.9	4.39	513.9	50.8	19.26
x^{-}	184.1	122.7	4.32	501.1	48.1	19.11
LSD 5%	0.82	1.71	NS	18.41	1.69	NS
	2012					
Toushka- 1	220.4	120.6	4.05	536.1	49.04	19.08
Shandawel-3	199.0	132.2	4.52	607.4	48.01	19.53
x^{-}	209.7	126.4	4.29	571.8	48.53	19.31
LSD (5%)	NS	4.02	0.4	51.72	0.73	0.39

Table 7: Effect of fertilization treatments on growth and attributes of sesame plants (2011 and 2012 seasons).

Treatments	Plant height (cm)	Seed yield /plant (g)	1000- seed weight (g)	Seed yield /fed. (Kg)	Oil percentage	Protein percentage
	2011					
T 1	188.2	125.2	4.39	567.6	46.3	18.37
T2	192.2	132.3	4.29	573.9	48.7	18.82
T3	186.9	98.7	4.18	419.8	50.2	19.32
T4	181.5	67.0	4.31	579.7	48.8	18.60
T5	191.4	138.0	4.45	584.1	48.9	19.62
T6	181.9	115.2	4.39	504.7	48.5	19.42
T7	184.5	127.3	4.34	456.1	46.2	19.20
T8	165.7	78.0	4.20	339.4	46.9	19.53
x^{-}	184.0	110.2	4.32	503.2	48.06	19.11
LSD (5%)	8.18	5.81	0.29	46.52	2.12	0.39
	2012					
T 1	222.9	131.8	4.51	588.9	48.97	19.13
T2	206.3	128.5	4.33	580.1	47.73	19.30
T3	201.6	112.0	4.28	517.4	46.55	20.10
T4	219.9	138.3	4.47	662.3	50.22	18.83
T5	217.1	133.5	4.32	599.9	51.28	18.97
T6	208.9	122.7	4.19	558.1	47.88	19.10
T7	209.8	127.5	4.14	572.2	49.38	19.83
T8	191.5	116.8	4.03	495.0	46.17	19.17
x^{-}	209.8	126.4	4.28	571.7	48.52	19.30
LSD (5%)	26.21	8.01	0.49	78.81	3.16	0.64

Effect of Fertilizer Treatments: Table (7) exhibits that different fertilizer treatments significantly affected seed weight per plant in both seasons. Also, the application of 100% NPK with biofertilizer (T4) produced the highest seed weight per plant (167.0g), followed by T5 (100%NPK+ biofertilizer+ bio agent) which gave 138.0g. On the other hand, minimum seed weight /plant (78.0g) was in case of T8 (control). Similar results were noticed in the second season. The superiority of seed weight resulting from T4 and T5 may be due to the increases in 1000- seed weight. These results are in harmony with those reported by Muhamman *et al*. [28] who found that seed weight per plant was increased by increasing plant nutrient especially N.

Effect of Interactions Between Sesame Cultivars and Fertilizer Treatments: Data presented in Table (8) showed the interaction between sesame varieties and fertilizer treatments on seed weight plant^{-1}. Interaction between varieties and fertilizer treatment had a significant effect on seed weight /plant in both seasons. The application of 100% NPK+ biofertilizers (T4) with shandawel-3 gave the highest values of seed weight plant^{-1} in both seasons (169 and 139g, respectively). On the other hand, Toushka-1 received no fertilizers or received 50% NPK mineral fertilizer (T3) recorded the lowest seed weight per plant in the first season. On the other hand Shandawel-3 with control treatment or Toushka-1 with T4 recorded low seed weight per plant in the second growing season.

Table 8: The interaction effect between sesame varieties and fertilizer treatments during 2011 and 2012 seasons

Treatments	T1	T2	T3	T4	T5	T6	T7	T8	x¯
	Seed yield /plant (g)								
	2011								
Toushka-1	130.3	137.7	88.0	165.0	141.7	107.0	125.7	76.7	121.5
Shandawel-3	120.0	127.0	109.3	169.0	134.3	123.3	129.0	79.3	123.9
x¯	125.2	132.4	98.7	167.0	138.0	115.2	127.4	78.0	122.7
LSD (5%)=	4.87								
	2012								
Toushka-1	127.0	122.0	96.9	137.3	131.3	112.9	120.3	117.2	120.6
Shandawel-3	136.5	135.0	127.1	139.3	135.8	132.6	134.8	116.4	132.2
x¯	131.8	128.5	112.0	138.3	133.6	122.8	127.6	116.8	126.4
LSD (5%)=	6.89								
	Seed yield/fed. (Kg)								
	2011								
Toushka-1	562.8	497.1	470.8	537.0	564.9	502.3	448.1	355.5	492.3
Shandawel-3	557.2	582.8	368.7	622.3	671.0	507.1	464.1	323.3	591.8
x¯	567.7	573.9	419.8	579.7	584.1	504.7	456.1	339.4	542.1
LSD(5%)=	39.45								
	2012								
Toushka-1	571.9	564.9	483.8	548.9	578.2	532.7	547.9	460.3	536.1
Shandawel-3	605.9	595.3	550.9	675.7	621.7	583.5	596.3	529.7	594.9
x¯	588.9	580.1	517.4	612.3	599.9	558.1	572.1	495.0	565.5
LSD(5%)=	69.85								
	Oil %								
	2011								
Toushka-1	45.77	45.57	46.67	47.67	45.10	44.80	43.20	44.07	45.46
Shandawel-3	46.83	51.57	53.77	50.00	52.70	52.20	49.20	49.90	50.77
x¯	46.30	48.57	50.22	48.84	48.90	48.50	46.20	46.54	48.12
LSD(5%)=				1.95					
	Protein %								
	2011								
Toushka-1	18.30	17.93	19.20	17.90	19.93	19.33	19.50	19.57	18.96
Shandawel-3	18.43	19.70	19.43	19.30	19.30	19.50	18.90	19.50	19.26
x¯	18.37	18.82	19.32	18.60	19.62	19.42	19.20	19.54	19.11
LSD(5%)=	0.73								
	2012								
Toushka-1	18.97	18.77	20.03	18.63	19.50	18.63	19.70	18.43	19.08
Shandawel-3	19.30	19.83	20.17	19.03	18.43	19.57	19.97	19.90	19.53
x¯	19.14	19.30	20.10	18.83	18.97	19.10	19.84	19.17	19.31
LSD(5%)=	0.87								

Seed Yield (kg/fed)

Effect of Cultivars: Data in Table (6) indicated that cultivars had a significant effect on seed yield /faddan in both seasons. Shandaweel-3 produced higher yield in both seasons, which differed significantly with Toushka-1. The superiority of Shandweel-3 may be due to the increase in 1000-seed weight and seed weight plant.

Effect of Fertilizer Treatments: Data in table (7) revealed that application of fertilizers had significant effects on seed yield/faddan in both seasons. The highest seed yield was obtained from T5 (100% NPK+ biofertilizer+ bio agent) followed by T4 (100%NPK +biofertilizer) and T2 (biofertilizer). Differences among these treatments were not significant. T5 and T4 produced higher seed yield more than that of T1 (fertilization with NPK alone). These results refer to the importance of the dual application of mineral and biological fertilizers for increasing seed yield. The BP has an important role as a N fixing organism. PM and BC has important effect on the availability of P and K, respectively.

Similar results were recorded in the second season, where T4 followed by T5 produced higher seed yields without significant differences. The lowest seed yield was obtained by control plants (T8). These results refer to the importance of the bio agent *Pseudomonas florosences* (PF). This bacterium reduced the percentage of diseased plants with *Fusarium* wilt (Table 5). The increase in seed yield of plants T4 and T5 may be due to the increase in 1000- seed weight and seed weight /plant.

. These results are in accordance with Kumar *et al*. [8], Rifat *et al*. [9], Elewa *et al*. [10] and Ziedan *et al*. [11], who reported that biological fertilizers recorded a higher seed yields compared to NPK fertilizer only. Elewa *et al.* [10] and Ziedan *et al*. [11] concluded that several bio agent bacteria were able to control root diseases of sesame in the field.

In addition, high relatively seed yield, in the first season (Table 7) was recorded by fertilization with biological fertilization only. This may reduce the soil pollution of mineral NPK. These results are in agreement with those obtained by Duhboon *et al*. [29] who reported that the excessive usage of NPK may increase pollution of NPK, decrease soil productivity and leads to nutrient imbalance.

Effect of Interactions Between Sesame Cultivars and Fertilizer Treatments: Data presented in Table (8) indicated that the effect of interactions between sesame cultivars and fertilizer treatments on seed yield/ fad was significant in both seasons. Shandawel-3 fertilized with 100%NPK+biofertilizer +bio agent (T5) gave the highest seed yield /fad, followed by T4 (100% NPK+ biofertilizer) in the first season. Fertilization with 100% NPK+ bio agent (T4) followed by T5 in the second one gave the highest seed yield. By contrast the lowest seed yield/fad was produced by Shandaweel-3 and Toushka-1 with no fertilizer in the first and second season, respectively.

Oil Percentage

Effect of Cultivars: Table (6) shows the effect of sesame cultivars on oil % in the two growing seasons. Sesame cultivars affected significantly seed oil percentage in both seasons. Shandawel-3 had the highest oil percentage (50.8%) compared to Toushka-1 (45.4%) in 2011; while in 2012, Toushka1 had the highest oil percentage (49.03%). Similar results have been reported by Sinharoy *et al*. [30] who found that two sesame cultivars significantly differed from each other in oil content. Saeidi [31] also found that sesame cultivars (Mobarakeh and Ardestan) showed significant differences in oil yield and oil percentage.

Effect of Fertilizer Treatments: Table (7) cleared that the effects of fertilizer treatments on oil percentage were significant in both seasons. Results in the first season showed that the application of50% NPK(T3) recorded the highest values of oil percentage (50.2%) followed by the application of T5(100%NPK +biofertilizer + bio agent) T4,T2 and T6 without significant differences among them. While T1, T7 and T8 recorded the lowest values of oil percentage. In the second season, the treatment (T5) recorded the highest seed oil percentage (51.28%) followed by (T4) without any significant differences between them, while T8(control) recorded the lowest value of oil percentage followed by (T3) and (T2) and was no significant differences between the three treatments. Papari Moghaddamfard and Bohrani [32], Sharar *et al*. [33] reported that application of fertilizer had significant effect on influenced the oil content and the maximum content was at high NP level. Malik *et al*. [27] reported that there was increase in seed oil percentage with increasing rate of nitrogen. In contrast, Cheema *et al.* [34] and El-Habbasha *et al*. [3] reported decreased seed oil percentage resulted from increasing nitrogen level. These differences might have been due to differences in the response of cultivars to N application or differences in climatic conditions [33]. In addition, the use of biofertilizer showed no significant effect on oil percentage Hasanpour *et al.* [35]. El-Habbasha *et al*. [3] recorded that sesame oil percentage was not affected significantly by biofertilizer.

Effect of Interactions Between Sesame Cultivars and Fertilizer Treatments: Data presented in Table (8) show that the interaction between two sesame cultivars and fertilizer treatments had significant effects on oil percentages in the first season only. Shandaweel-3 fertilized with 50% NPK (treatment No.3) recorded the highest value of oil percentage followed by the treatments (T5) and (T6) with the same variety. While interaction between Toushka-1 and treatment T7(50% NPK+ biofertilizer+ bio agent) recorded the lowest value of oil percentage.

Protein Percentage

Effect of Cultivars: Table (6) shows that the effect of sesame cultivars on protein percentage was significant in the second season only. Shandawel-3 surpassed Toushka-1 in protein percentage; they recorded 19.26 and 19.08%, respectively. In general, data cleared that Shandawel-3 variety surpassedToushka-1 in protein percentage.

Effect of Fertilizer Treatments: Table (7) illustrates that fertilizer treatments had significant effects on sesame protein percentage. Where, significant differences between the treatments were found in both seasons.

On the first season, the treatment T5 (100% NPK+ biofertilizer +bio agent) recorded the highest protein percentage (19.62%) followed by T8(19.53%) and T6, 50% NPK +biofertilizer (19.42%). There were no significant differences among the three treatments. The treatment (T1) of 100%NPK recorded the lowest value of protein percentage (18.37%). In the second season, the treatment No.3 (50% NPK) recorded the highest protein percentage (20.10%) followed by T7 (50% NPK +biofertilizer +bio agent) giving 19.83% and there were no significant differences between these two treatments. While, the treatment 4 (100%NPK+ biofertilizer) recorded the lowest value of 18.83%.

Effect of Interactions Between Sesame Cultivars and Fertilizer Treatments: Table (8) indicates that the interaction between the two sesame cultivars and among fertilizer treatments on protein percentage had significant effect. Results in the first season showed that Shandaweel-3 variety of T5(100% NPK+ biofertilizer+ bio agent)gave the highest protein percentage (19.93%), while the lowest (17.90%) was recorded by Toushka-1 of treatment No.4 (100%NPK+ biofertilizer). In the second season, Shandaweel-3 of treatment 3 (50% NPK) gave the highest protein percentage (20.17%) followed by T7 (50% NPK +biofertilizer +bio agent) (19.97%) with no significant difference among these treatments. Meanwhile, Toushka-1 received no fertilizer (T8) or fertilized with T5(100% NPK + biofertilizer+ bio agent)recorded the lowest value of protein percentage(18.43%).

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