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RESEARCH ARTICLE

Influence of bio and mineral fertilization on some sesame varieties grown in Upper Egypt

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Abstract

Nowadays, there is a call for the reduction of the environmental pollution resulted from over application of chemical fertilizers. Therefore, study has been done to investigate the possibility and efficiency of using bio-fertilizers. Two field experiments were carried out during the two successive summer growing seasons of 2016 and 2017 at El-Mattana, Agriculture Research Station (latitude of 25 º 17′ N and longitude 32 º 33′ E), Luxor Governorate, Egypt to evaluate the influence of two sesame varieties (Sohag 1 and Shandaweel-3) and eight different fertilizers treatments: 0, 50, 75, 100% of recommended nitrogen, phosphorus and potassium (NPK), bio-fertilizers, 50% NPK + bio, 75% NPK+ bio and 100% NPK + bio on sesame yield. Treatments were carried out as Split Plot Design with three replicates, varieties in the main plots and fertilization treatments in the sub plots. The results could be summarized as follows: Shandaweel-3 variety surpassed Sohag-1 variety in all studied characters. Except umber of capsules/plants, length of fruiting area, harvest index, oil yield, K uptake in seed and NK uptake in straw. The addition of 100% mineral recommended dose of NPK + Bio fertilizer resulted in a significant increment in sesame yield and its components in both seasons. The highest oil yield and content of N and P were obtained from Shandaweel-3 with fertilization at 75% NPK+ Bio-fertilization treatment. The results showed the importance of using bio-fertilizers to protect the soil and the environment from harmful chemical pollution.

Keywords: Sesame varieties yield; Upper Egypt; Nitrogen; Phosphorus, Potassium and bio fertilizer.

Introduction

Sesame being an important oilseed crop as it has its own merits like its fast growth rate, short duration, less water requirement, and wide adaptability under varying soil type. Sesame is an important oilseed crop with great commercial attributes by virtue of its oil having an edible quality and medicinal value. It yields 50-60% oil and the oil is highly stable against rancidity due to the presence of the natural antioxidants sesamin and sesamolin (Weiss, 2000 and El-Khier *et al.*, 2008).

In Egypt, sesame is considered as a food crop rather than oilseed crop because most of its seeds production is used for snacks, confectionery, bakery products, tehena and halawa purposes. The cultivated area increased markedly during the last few years, while the productivity was not increased by the same relative. However,

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the local production of sesame did not cover the national requirements, thus a lot of amount of sesame seeds was imported every year. So increasing the productivity could be achieved through generate a new cultivars with high yield potentiality as well as application of suitable agricultural practices such as fertilization, irrigation and weed control etc. (El-Habbasha *et al.*, 2007 and Abdo and Anton, 2009).

Sesame needs more nitrogen than any other nutrient to increase plant height, leaf area, dry matter and seed production (Purushottam, 2005). Studies have indicated that nitrogen, phosphorus and even potassium are the major nutrient elements influencing the growth and yield of sesame (Shehu, 2014).

One of the main bases in sustainable agriculture is application of biologic fertilizers in agronomical ecosystems to reduce consumption of chemical inputs so that they can guarantee production sustainability of agriculture systems in some cases as a substitution and as a supplement in majority of cases for chemical fertilizers (Antoun, H. 2005).

Biologic fertilizers consist of some beneficial microorganisms that are produced for specific purposes such as nitrogen fixation and releasing phosphate and potassium. These microorganisms usually are placed around the root helping the plant to nutrient uptake through cohabitation (Elkholy *et al.*, 2005). These bacteria have more than one role so that they not only help to uptake a specific element but also can absorb other elements, reduce illnesses, improve soil structure, more promote plant growth, increase quantity and quality of product and increase plant tolerance against environmental stresses (Elkramany et al., 2007).

El-Samanody *et al.*, (2010) and Amal *et al.*, (2015) indicated that Shandaweel-3 gave the best results in all studied characters as well as the highest values of N, P and K of the seed content. Bio-fertilizer led to a significant increase in yield components and yield, also N, P and K of sesame seeds. Shandaweel3 was superior in seed yield by 10.30 and 5.90 % as compared with Sohag1 in two seasons, respectively. Hamza and Abd El-Salam (2015) found that sesame variety Shandaweel-3 surpassed significantly on the Sohag-1 in number of fruiting nodes/ plant, number of capsules /plant, capsule length, number of seeds /capsule, 1000-seed weight, seed weight/ plant, seed and oil yields /ha, as well as, harvest index.

Mahrous *et al.*, (2015) showed that the cultivar Shandaweel-3 surpassed Toushka-1 in plant height, seed weight per plant, 1000-seed weight and seed yield per feddan as well as oil and protein percentages. Treatment 100% recommended chemical fertilizer + biofertilizer came in the first order for sesame attributes (plant height, seed weight per plant and 1000-seedweight). 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.

Boghdady *et al.* (2012) revealed that increasing level of the used mineral

fertilizers induced significant increases in all investigated morphological and yield characters as well as in seed oil percentage of sesame cv. Shandaweel-3. It is realized that raising the level of the used mineral fertilizers from 25 to 100% of the recommended dose induced prominent increases plant height, number of capsules/plant, weight of 1000 seeds, yield of seeds/plant and seed oil percentage; respectively. Data also indicated that sesame plants obtained from biofertilized seeds and grown in biofertilized soil showed prominent increases in all investigated morphological and yield characters as well as in seed oil percentage when compared with control plants which were obtained from uninoculated seeds and grown in uninoculated soil. Abdel-Rahman (2014) indicated the seed inoculation with bio fertilizer significantly affected the sesame yield and its contents of the studied nutritive elements.

Asl (2017) found that a significant effect of nitrogen and phosphate as biofertilizer, on plant height, No. of branches/plant, No. of capsules/plant, seed in capsules, oil percent, seed yield and harvest index. Consumption of chemical fertilizer of triple super phosphate was reduced equal to 50% using phosphate biofertilizer and consumption of chemical fertilizer of urea was reduced equal to 25% using nitrogen biofertilizer. Elizabeth *et al.,* (2017) indicated inoculated seeds with Phosphate Solubilizing Microorganisms (PSM) are a promising strategy to improve world food production without causing any environmental hazard. Heba et al., (2018) found that the soil treated with different sources and rates of potassium fertilizers with potassium solubilizing bacteria (KSB) led to decrease both soil pH and increased available N, P and K in soil solutions. Heba *et al.*, 2018. Hassaan, M. A. and A. M. Bughdady (2018) showed that Shandaweel 3 cultivar with bio-fertilizer produced the highest seed yield than Sohag1 cultivar under conditions of the Toshka, South Egypt

Materials and Methods

Two field experiments were carried out during the two successive summer growing seasons of 2016 and 2017 at El-Mattana Agricultural Research Station, (latitude of 25.17o N and longitude 32.33o E), Luxor Governorate (Upper Egypt), to evaluate the effect of NPK fertilization (mineral and bio-fertilizers) and two varieties of sesame: Sohag 1 and Shandaweel-3. Samples of soil were randomly taken from the field experiments and then analyzed for some soil physical and chemical characteristics according to the methods outlined by Black (1965) and Ryan *et al.* (1996) Table (1).

Table 1. some physical and chemical properties of the experiment soil before sowing.

Properties	Particle size distribution				OM	CaCO3	pH	EC
	Sand %	Silt %	Clay %	Texture class	%	%		dSm^{-1}
Values	40.0	30.6	29.4	Clay loam	0.73	2.5	8.02	2.5

	Soluble Cations and anions (meq/L)								Available Nutrients ($mg\ kg^{-1}$)		
Properties	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	$CO3^{--}$	$HCO3^{-}$	Cl^{-}	$SO4^{--}$	N	P	K
Values	7.1	4.8	12.1	1.0	-	1.0	19.4	4.6	40	7.3	232

pH in 1:2.5 soil: water suspension, EC_e in soil paste extract.

Experimental Design and Treatments: Split Plot Design with three replicates was utilized. Each experiment included 16 treatments, and the plot area was 10.5 m^2 (five lines * 3.5 m length * 60 cm width). The main plots were arranged for two varieties of sesame: Sohag 1 and Shandaweel-3, and the sub plots were divided into eight treatments of NPK fertilization (mineral and bio fertilizers) as follows: without fertilization (control), NPK1 30kg N, 15kg P_2O_5 and 24kg K_2O/fed^{-1} (50% NPK), NPK2 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} (75% NPK), NPK3 60kg N, 30kg P_2O_5 and 48kg K_2O fed^{-1} (100 % NPK), Bio fertilization only, NPK1+ Bio fertilization, NPK2+ Bio fertilization and NPK3+ Bio fertilization.

Sesame seeds were sown on May 15th and 11th in the first and second seasons, respectively. The seeds of two varieties of sesame: Sohag 1 and Shandaweel-3 were coated just before sowing with bio fertilizers, using Arabic gum as an adhesive agent, and were sown at hills per 10 cm. The seeds rate amounted 3 kg /fed. Soil application of nitrogen and potassium fertilizers as ammonium nitrate fertilizer (33.5% N) and potassium sulfate (48 % K_2O), were applied at two equal doses for all N and K fertilization treatments at 21 and 45 days after sowing, while phosphorus was added as calcium super phosphate (15.5 % P_2O_5) with soil preparation. The bio-fertilizers used contain nitrogen fixer's bacteria *Azotobacter or Azospirillum brasilense*, phosphate dissolving bacteria (*Bacillus megatherium*) and potassium dissolving bacteria (*Bacillus circulans*) at the concentration of 9^{10} colony forming unit /g for each was used. The bio-fertilizers provided by the Unit of Bio-fertilizers Production- Microbiology Research Department- Soils, Water and Environment Res. Institute- Agric. Res. Center, Giza, Egypt.

The yield was harvested on September 10th in 2016 and on September 15th in 2017. Samples of 10 guarded plants were randomly taken from inner ridges in each sub plot to estimate plant height (cm), number of capsules/plant, 1000 seed weight (g), first capsule height (cm), length of fruiting area (cm), biological yield (kg/fed.), seed yield (kg/fed.), straw yield (kg/fed.), harvest index%. Oil yield (kg/fed), oil (%), seed protein % were determined according to A.O.A.C. (1990). Protein content was calculated as follows: (Protein % = N % in grain × 5.30). Nitrogen was determined by Kjeldahl method, phosphorus was determined spectrophotometrically and potassium was determined using flame photometer.

Results and Discussions:

Growth characters and yield attributes

Data presented in Table (2) show differences between the two varieties of sesame (Sohag-1 and Shandaweel-3) in plant height, number of capsules/ plant, 1000-seed weight, first capsule height, first capsule height, length of fruiting area (cm) and Biological yield (kg/fed.). The data illustrate significant differences between the two varieties in all the above studied characters, variety Shandawel-3 tended to have high plant height, 1000-seed weight, first capsule height and biological yield/fad at harvest compared with Sohag-1 variety in two seasons. These results are in concert with those obtained by El-Habbasha, *et al.* (2007), El-Samanody *et al.*, (2010), Amal *et al.*, (2015) and Hamza and Abd El-Salam (2015). Shandaweel-3

surpassed significantly on the Sohag-1 in number of fruiting nodes/ plant, number of capsules /plant, capsule length, number of seeds /capsule, 1000-seed weight, seed weight/ plant, seed and oil yields /ha, as well as, harvest index in both seasons.

Furthermore, data in Table 2 focus that the effect of mineral and bio- fertilization on plant height, number of capsules/ plant, number of branches / plant, length of the fruiting area and biological yield/fad. The treatment 100 % of recommended mineral NPK3 (60kg N, 30kg P_2O_5 and 48kg K_2O / fed^{-1}) + Bio fertilization records the highest values of plant height (186.6 and 165.6 cm), number of capsules/ plant (131.0 and 134.9 capsules/ plant), 1000-seed weight (5.31 and 5.46 gm.), length of the fruiting area (104.83 and 115.83 cm) and biological yield/fad (2496.6 and 2287.0). While, first capsule height recorded highest values (82.37 and 55.83 cm) followed by the control without fertilization treatment in both seasons. The present results cleared that dual application of mineral fertilization and biofertilizers were better than addition of mineral fertilization alone. These results agreed with those obtained by Purushottam, (2005), El-Habbasha, *et al.* (2007) and Shehu, (2014). Bio-fertilizer strengths plant growth through increasing free phosphorus of soil so that more photosynthetic materials are produced in plant, the growth of vegetative buds is promoted and the number of branches in plant is increased.

Here too the interaction between two sesame varieties (Sohag-1 and Shandaweel-3) and chemical and bio-fertilization treatments on plant height, number of capsules/ plant, 1000-seed weight, first capsule height, length of the fruiting area and biological yield/fad. The use of 100 % of recommended mineral NPK3 (60kg N, 30kg P2O5 and 48kg K2O / fed-1) + Bio fertilization with Shandaweel-3 gave the highest values of plant height (206.0 and 181.6 cm), 1000-seed weight (5.45 and 5.60 gm) and biological yield/fad (2499.5and2347.1kg/fed.) in both seasons. Where, the highest values of number of capsules/ plant was (144.6 and 156.4 capsules/ plant) and length of the fruiting area was (108.66 and 121.66 cm) the use of 100 % of recommended mineral NPK (60kg N, 30kg P2O5 and 48kg K2O / fed-1) with Sohag 1. But the highest value of first capsule height was (108.0 and 78.66 cm) with Sohag-1 and control (without fertilization treatment) in both seasons. These results agreed with those obtained by El-Samanody et al., (2010), Amal et al., (2015) and Hassaan, and Bughdady (2018).

Yield and yield component

Data in Table 3 reveal that the tested sesame genotypes varied in seed yield kg/fed, straw yield kg/fed, harvest index %, oil yield/ fed, oil % and seed protein % in the 1st and 2nd seasons. Shandaweel-3 produced higher seeds yield, straw yield, and oil yield kg/fad., oil % and seed protein % than sohag-1. The superiority of Shandweel-3 may be due to the increase in 1000-seed weight and seed weight plant. El-Samanody et al. (2010) found that the Shandaweel 3 was superior in seed yield during two seasons compared with sohag1. These results agreed with those obtained by Subrahmaniyan et al. (1999), El Karamany et al. (2000), El Naim et al. (2010), Abd El-Lattief (2015) and Fakhry (2016).

It is clearly from the results in same Table that the effect of mineral and bio-fertilization treatments on seed yield /fed, straw yield /fed, harvest index %, oil yield/fed, oil % and seed protein % Significant differences between the treatments. The maximum seeds yield and oil yield /fed in the first season were 628.5 and 291.8 kg/fed, respectively, which was fertilized by NPK3 (60kg N, 30kg P_2O_5 and 48kg K_2O / fed^{-1}) + Bio fertilization. In the second season, the corresponding mean values (614.2 and 289.1 kg/fed.) were gained at NPK2 (45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1}) + Bio fertilization. Also, NPK2 + Bio fertilization records the highest values in harvest index % (35.07 and 40.15 %) and protein % (22.47 and 22.66 %) in both seasons. Straw yield /fed (1868.2 and 1678.1 kg/fed.) was the highest with NPK3 (60kg N, 30kg P_2O_5 and 48kg K_2O / fed^{-1}) + Bio fertilization. Asl (2017) found that a significant effect of nitrogen and phosphate as biofertilizer on seed yield and harvest index. The highest values on oil % was treatment Bio fertilization only (48.24 and 48.91) in both season. Boghdady et al. (2012) indicated that sesame plants obtained from biofertilized seeds increases in seed oil percentage when compared with control plants which were obtained from uninoculated seeds and the treatment 50% NPK+biofertilizer recorded the highest protein percentage. However, oil percentage decreased with increasing levels of nitrogen, due to with higher application of N there was greater accumulation of protein that hinders the availability of carbohydrates for polymerization into fatty acids and thus leading to lower oil content into seed. Hasanpour, *et al.* (2012) showed that application of biofertilizer caused an increase in oil yield.

Concerning the interactions effect, data in Table 3 reveal that the interaction had a significant effect on seed yield /fed, straw yield /fed, harvest index %, oil yield/ fed and seed protein %. In general, maximum seed yield /fed (653.6 and 673.8 kg fed^{-1}), Harvest index% (37.88 and 41.55 %), oil yield/fed (306.2 and 313.8 kg/fed.) and seeds protein percentage (23.96 and 23.06 %) were obtained from Shandaweel-3 variety supplying with NPK2 (45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1}) + Bio fertilization treatment in the first and second season. While the highest mean of straw yield/fad (1871.6 and 1749.0 kg fed^{-1}) was obtained at the interaction of Shandaweel-3 variety with the treatment of 100 % recommended mineral NPK3 (60kg N, 30kg P_2O_5 and 48kg K_2O / fed^{-1}) + Bio fertilization. Also, the highest mean of the highest percent of oil were obtained at the interaction of Shandaweel-3and Bio fertilization only (49.08 and 49.87 %) in the both seasons.

Boghdady *et al.* (2012) reported that Shandaweel-3 fertilized with 50% NPK recorded the highest value of oil percentage and seed protein %. Result of Mahrous *et al.*, (2015) showed that the application of 100% NPK+ biofertilizers (BM, BC, BP) with shandawel-3 gave maximum seed weight $plant^{-1}$ during both seasons. The highest seed yield was obtained from T5 (100% NPK+ biofertilizer+ bioagent) followed by T4 (100%NPK +biofertilizer). These findings are in close conformity with the results of El Habbasha *et al.* (2007)

Table 2. Effect of varieties, fertilization treatments and interaction between varieties and fertilization treatments on growth attributes of sesame plants in 2016 and 2017 seasons.

Characters		Plant height (cm)		Number of capsules/plant		1000 seed weight (g)		First capsule height(cm)		Length of fruiting area (cm)		Biological yield (kg/fed.)	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Varieties													
Sohag 1		157.2	140.5	107.7	106.6	4.29	4.45	53.08	29.41	102.95	110.75	1873.2	1678.0
Shandawel 3		188.0	166.8	90.0	82.6	4.52	4.70	97.37	68.50	89.25	97.83	1966.2	1878.8
F test		*	*	*	*	*	*	*	*	*	*	*	*
Fertilization treatments													
(Control)		164.5	143.6	62.1	58.4	3.82	3.99	82.37	55.83	82.33	87.16	1210.2	967.8
NPK1		173.6	155.0	95.0	86.4	4.00	4.17	77.50	50.50	98.00	103.66	1734.8	1753.3
NPK2		171.8	153.1	99.6	95.5	4.46	4.61	72.16	45.33	99.66	107.50	2150.6	1873.9
NPK3		180.0	162.6	113.6	113.8	4.88	5.10	76.83	53.50	98.83	108.83	2286.2	2010.0
Bio. Only		163.8	145.3	75.0	71.4	3.70	3.87	70.00	47.00	93.16	97.83	1139.2	1340.2
NPK1+ Bio		168.8	150.6	100.8	86.6	4.06	4.22	71.83	44.00	97.00	106.50	2018.7	1845.2
NPK2+ Bio		172.1	153.5	113.8	109.6	4.99	5.16	73.50	46.16	94.66	107.00	2321.1	2149.7
NPK3+ Bio		186.6	165.6	131.0	134.9	5.31	5.46	77.83	49.33	105.16	115.83	2496.6	2287.0
LSD at 0.05%		**5.9**	**6.68**	**8.7**	**7.4**	**0.20**	**0.06**	**6.62**	**4.02**	**9.11**	**7.92**	**252.7**	**151.7**
Interaction of varieties * fertilization													
Sohag 1	(Control)	149.3	127.3	76.0	71.0	3.70	3.86	56.33	33.00	93.00	94.00	1172.1	950.9
	NPK1	161.3	144.6	94.3	85.7	3.88	4.05	57.00	34.66	108.00	109.33	1721.0	1752.5
	NPK2	156.3	140.3	106.6	104.5	4.56	4.74	48.00	25.66	108.33	114.00	2069.1	1825.6
	NPK3	166.0	153.6	122.3	122.3	4.70	4.90	57.00	38.66	102.00	114.66	2280.3	1973.8
	Bio. Only	150.0	132.3	80.0	79.0	3.60	3.75	47.33	25.33	101.33	106.66	1032.2	1023.0
	NPK1+ Bio	149.6	134.6	106.0	105.5	3.93	4.07	48.00	23.00	101.66	111.66	1958.7	1675.1
	NPK2+ Bio	158.3	142.0	131.6	128.4	4.75	4.89	55.00	27.66	100.66	114.00	2258.7	1995.9
	NPK3+ Bio	167.3	149.6	144.6	156.4	5.18	5.32	56.00	27.33	108.66	121.66	2493.8	2227.0
Shandawel 3	(Control)	179.6	160.0	48.3	45.8	3.95	4.12	108.00	78.66	71.66	80.00	1248.3	984.8
	NPK1	186.0	165.3	95.6	87.2	4.13	4.30	98.00	66.33	88.00	98.00	1748.7	1754.1
	NPK2	187.3	166.0	92.6	86.5	4.36	4.48	96.33	65.00	91.00	101.00	2232.2	1922.2
	NPK3	194.0	171.6	105.0	105.4	5.07	5.31	96.33	68.33	95.66	103.00	2292.0	2046.2
	Bio. Only	177.6	158.3	70.0	63.9	3.80	3.99	92.66	68.66	85.00	89.00	1246.3	1657.4
	NPK1+ Bio	188.0	166.6	95.6	67.8	4.20	4.38	95.66	65.00	92.33	101.33	2078.7	2015.4
	NPK2+ Bio	186.0	165.0	96.0	90.8	5.24	5.43	92.00	64.66	88.66	100.00	2383.9	2303.5
	NPK3+ Bio	206.0	181.6	117.3	113.3	5.45	5.60	99.66	71.33	101.66	110.00	2499.5	2347.1
LSD at 0.05 %		8.4	9.45	12.1	10.4	0.29	0.09	9.36	5.68	12.89	11.21	357.3	214.5

Table 3. Means of Yield (kg/fed.) and Some seeds chemical attributes as affected by genotypes, mineral and bio fertilization as well as their interactions in the sesame plants in 2016 and 2017 seasons.

Characters		Seed yield (kg/fed.)		Straw yield (kg/fed.)		Harvest index%'		Oil yield (kg/fed.)		Oil (%)		Seed protein %	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Varieties													
Sohag 1		449.4	440.4	1423.7	1237.6	32.22	35.86	205.6	201.9	45.74	45.84	20.88	20.97
Shandawel 3		473.2	485.3	1492.9	1393.5	31.75	34.67	217.3	223.5	46.10	46.02	22.08	21.57
F test		**ns**	*	*	*	*	*	*	*	**ns**	*	*	*
Fertilization treatments													
(Control)		231.5	227.2	978.7	740.6	24.19	31.10	105.7	101.5	45.65	44.67	22.39	21.73
NPK1		397.3	388.8	1337.6	1364.5	29.57	28.60	180.4	177.0	45.44	44.58	22.29	21.62
NPK2		486.1	477.7	1664.5	1396.2	29.32	34.47	217.9	214.5	44.82	44.90	22.37	21.86
NPK3		572.2	565.0	1714.0	1445.0	35.69	39.30	247.5	244.9	43.25	43.35	19.77	20.14
Bio. Only		310.3	373.9	828.9	966.3	38.11	39.87	149.7	183.5	48.24	48.91	21.33	20.94
NPK1+ Bio		462.6	447.0	1556.0	1398.2	29.98	32.15	215.6	207.8	46.60	46.35	20.94	19.74
NPK2+ Bio		602.3	614.2	1718.2	1535.5	35.07	40.15	282.8	289.1	46.97	47.13	22.47	22.66
NPK3+ Bio		628.5	608.9	1868.2	1678.1	33.82	36.51	291.8	283.4	46.44	46.53	19.56	21.47
LSD at 0.05%		**33.82**	**36.74**	**255.8**	**145.1**	**6.43**	**4.56**	**17.38**	**16.52**	**1.00**	**0.84**	1.30	0.99
Interaction of varieties * fertilization													
Sohag 1	(Control)	237.3	223.3	934.7	727.6	25.71	30.97	107.5	100.3	45.31	44.96	22.53	21.73
	NPK1	411.8	377.0	1309.2	1375.6	31.47	27.35	183.4	173.2	44.52	45.95	21.73	20.94
	NPK2	433.3	462.9	1635.8	1362.8	26.56	34.40	196.5	203.1	45.30	43.92	22.79	21.20
	NPK3	577.7	573.2	1702.6	1400.7	35.84	41.09	252.6	251.6	43.73	43.91	20.46	19.88
	Bio. Only	299.3	306.3	732.8	716.7	41.47	43.49	141.8	146.9	47.40	47.96	21.20	21.47
	NPK1+ Bio	455.8	406.1	1502.9	1268.9	30.57	32.25	208.0	183.0	45.67	45.04	18.82	19.08
	NPK2+ Bio	551.1	554.6	1707.2	1441.3	32.27	38.75	259.5	264.4	47.10	47.68	20.99	22.26
	NPK3+ Bio	629.0	619.7	1864.7	1607.3	33.90	38.66	295.4	293.1	46.96	47.29	18.02	21.20
Shandawel 3	(Control)	225.6	231.1	1022.6	753.7	22.66	31.22	103.8	102.6	45.99	44.37	22.26	21.73
	NPK1	382.7	400.6	1366.0	1353.5	28.02	29.85	177.3	180.9	46.35	45.21	22.84	22.31
	NPK2	538.9	492.5	1693.3	1429.7	32.08	34.55	239.3	226.0	44.34	45.88	22.68	22.53
	NPK3	566.7	556.8	1725.3	1489.4	35.55	37.52	242.5	238.3	42.87	42.80	19.08	20.41
	Bio. only	321.3	441.4	925.0	1215.9	34.74	36.24	157.6	220.1	49.08	49.87	21.47	20.41
	NPK1+ Bio	469.5	487.9	1609.1	1527.5	29.39	32.06	223.3	232.5	47.54	47.66	23.06	20.41
	NPK2+ Bio	653.6	673.8	1730.3	1629.7	37.88	41.55	306.2	313.8	46.84	46.57	23.96	23.06
	NPK3+ Bio	627.9	598.0	1871.6	1749.0	33.47	34.35	288.3	273.7	45.91	45.76	21.09	21.73
LSD at 0.05 %		**47.83**	**51.96**	**361.7**	**205.2**	**9.09**	**6.45**	**24.58**	**23.36**	**1.42**	**1.19**	1.85	1.40

NPK-Uptake (Kg fed^{-1}) in seeds and straw

Data presented in Table (4) show that the varietal differences between two varieties of sesame (Sohag-1and Shandaweel 3) in NPK uptakes in seed and straw. Where, significant differences were observed between the two varieties in the studied characters except P and K % in seed is no significant differences. However, Shandaweel 3 surpassed in NPK uptakes in

seed and straw. El-Samanody et al., (2010) and Amal et al., (2015) indicated that Shandaweel-3 gave the best results in all studied characters as well as the highest values of N, P and K of the seed content. Basavaraj *et al., (2000)* found that the concentration of N and K in seed did not differ significantly due to varieties.

According to the data presented in Table (4), average seeds and straw uptakes of the NPK were significantly differed between treatments fertilization. The superiority for the seeds and straw yield uptake of NPK was recorded for the treatment of 75 % of recommended mineral (NPK2) 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} + Bio fertilization. It increased by 12.55, 5.34, 6.01, 31.24, 45.04 and 13.46 % compared treatment 100 % of recommended mineral NPK (60kg N, 30kg P2O5 and 48kg K2O / fed-1) for the average of the two seasons.

El-Samanody et al., (2010) and Amal et al., (2015) indicated that bio-fertilizer led to a significant increase in yield components and yield, also N, P and K of the seeds of sesame in both seasons. The strength of relationship between seed yield and N, P and K uptake was very strong. These results agreed with those obtained by Khaled *et al.,* (2012), where the highest values of N, P and K contents in seeds were 3.46, 0.62 and 1.07 %, respectively achieved by soil application of bio-fertilizer and organic materials could be used as an integrated plant nutrition with 20, 30 or 40 kg $fed^{-1}$of mineral N. Moreover, application of such materials conserves the environment from chemical pollution hazards.

Concerning the interactions effects in this respect, data illustrated in Table 4 reveal that the interactions had a significant influence on NPK uptakes in seeds and straw. Thus, the highest average value of the seeds NPK uptake and P uptake of straw (29.55, 4.51 and 3.80 kg fed^{-1} in the first season), (25.05, 5.08 and 4.20 kg fed^{-1} in second seasons) and (7.54 and 5.75 kg fed^{-1} in both seasons) were detected by Shandaweel-3 variety which was fertilized by 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} + Bio fertilization .While the corresponding mean value in K uptake of straw (27.89 and 22.63 kg/fed. in both seasons) was recorded from Shandaweel-3 variety which was fertilized by 60kg N, 30kg P_2O_5 and 48kg K_2O /fed^{-1} + Bio fertilization. However, the highest mean of the N uptakes in straw (51.30 Kg fed^{-1}) were obtained at Sohag-1 variety which was fertilized by 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} + Bio fertilization in the first season. Also, as for the highest mean of the N uptakes in straw (44,61 Kg fed^{-1}) were obtained at Shandaweel-3 variety which was fertilized by (60kg N, 30kg P_2O_5 and 48kg K_2O / fed^{-1}) + Bio fertilization in the second season. El-Habbasha, *et al.,* (2007) found that the interaction between two sesame varieties (Giza 32 and Shandawel 3) and partial replacement of chemical fertilizers by bio-organic fertilization treatments on NPK in seed. No significant differences were observed between treatments on the studied characters. The use of 75 % chem. + 25 % organic + biofertilizers with Shandaweel 3 gave the highest values of P % in seed. However, the use of recommended chemical fertilization with Shandawel 3 and Giza 32 gave the highest values of N % in seed in each variety, while the highest K % in seed recorded by Shandawel 3 with the treatment 25 % chem.+ 75 % organic + biofertilizers.

Table 4. Effect of varieties, fertilization treatments and interaction between varieties on NPK-uptakes in seeds and straw yield (Kg fed-1) of sesame plants in 2016 and 2017 seasons.

		Uptake NPK in seed						Uptake NPK in Straw					
Characters		N		P		K		N		P		K	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Varieties													
	Sohag 1	17.53	17.41	3.04	3.17	2.95	2.52	35.20	30.28	4.32	3.85	16.33	16.56
	Shandawel 3	19.70	19.71	3.10	3.18	2.85	2.89	34.66	31.91	4.51	4.27	20.87	17.42
	F test	*	*	n.s	n.s	n.s	*	*	*	*	*	*	*
Fertilization treatments													
	(Control)	9.78	9.31	1.42	1.28	1.42	1.34	21.05	15.85	1.77	1.24	9.57	8.51
	NPK1	16.68	15.83	2.66	2.74	2.44	2.38	32.13	32.13	3.51	3.59	17.50	18.44
	NPK2	21.19	19.38	3.25	3.52	2.82	2.76	41.38	33.93	5.66	5.05	21.91	17.45
	NPK3	21.37	22.86	3.86	4.24	3.64	3.27	37.34	31.44	4.99	4.64	21.44	19.34
	Bio. Only	13.70	14.71	2.08	2.44	2.07	2.23	18.39	21.50	2.15	2.21	9.59	9.59
	NPK1+ Bio	18.34	16.70	2.76	3.04	2.89	2.35	37.82	33.00	4.95	4.80	19.97	18.09
	NPK2+ Bio	24.68	25.06	4.20	4.32	3.80	3.52	47.82	42.24	7.41	6.57	23.40	22.78
	NPK3+ Bio	23.15	24.65	4.13	3.84	4.14	3.79	47.20	42.10	6.32	5.95	25.41	25.08
	LSD at 0.05%	**1.70**	**1.55**	**0.29**	**0.29**	**0.23**	**0.23**	**7.25**	**3.40**	**0.76**	**0.42**	**3.39**	**1.66**
Interaction of varieties * fertilization													
Sohag 1	(Control)	10.09	9.15	1.45	1.39	1.59	1.34	21.03	16.59	1.82	1.20	8.60	7.79
	NPK1	16.88	14.90	2.85	2.55	2.66	2.43	34.74	33.02	3.37	3.51	14.92	19.63
	NPK2	19.12	17.81	2.93	4.20	2.51	2.78	41.75	32.04	5.12	4.09	20.45	18.85
	NPK3	22.32	21.49	4.05	3.84	3.49	3.32	36.73	30.83	5.17	4.74	18.56	17.81
	Bio. Only	14.37	12.41	2.06	2.24	2.07	1.91	16.88	17.20	1.75	1.66	7.62	7.51
	NPK1+ Bio	16.24	14.62	2.58	2.94	3.05	1.99	34.69	32.61	5.44	4.79	17.73	15.29
	NPK2+ Bio	19.82	24.16	3.90	3.56	3.80	2.84	51.30	41.82	7.28	6.30	19.80	23.15
	NPK3+ Bio	21.39	24.79	4.17	4.65	4.49	3.59	47.56	39.65	6.19	6.12	22.94	27.24
Shandawel 3	(Control)	9.48	9.47	1.39	1.16	1.26	1.34	20.99	15.07	1.72	1.29	10.53	9.25
	NPK1	16.49	16.76	2.47	2.92	2.22	2.33	29.38	31.25	3.67	3.67	20.08	17.27
	NPK2	23.27	20.95	3.57	2.84	3.12	2.74	40.98	35.89	6.21	6.05	23.37	15.96
	NPK3	20.42	24.24	3.67	2.63	3.79	3.23	37.96	32.03	4.81	4.52	24.33	20.93
	Bio. only	13.03	17.00	2.10	2.64	2.08	2.56	19.74	24.93	2.60	2.75	11.56	11.39
	NPK1+ Bio	20.43	18.79	2.93	3.13	2.72	2.72	41.09	32.84	4.41	4.73	22.21	21.12
	NPK2+ Bio	29.55	25.05	4.51	5.08	3.80	4.20	44.31	42.39	7.54	6.83	26.99	22.18
	NPK3+ Bio	24.91	24.52	4.08	3.02	3.79	4.00	46.84	44.61	6.44	5.75	27.89	22.63
	LSD at 0.05 %	**2.41**	**2.19**	**0.41**	**0.41**	**0.33**	**0.32**	**11.78**	**5.55**	**1.24**	**0.69**	**5.54**	**2.71**

NPK percentage in seeds and straw

Data exhibited in Table 4 reveal that the tested varieties of sesame varied significantly in seeds and straw content of N and P elements in both seasons. Thus, the maximum average values of seeds N content (4.17 and 4.07 % in the two respective seasons) were recorded from Shandaweel 3 variety in both seasons. While, the maximum average values of seeds p content (0.672 and 0.666 % in the two respective seasons) were recorded from Sohag-1 variety in both seasons. Also, the maximum average values of

straw N content (2.47 and 2.29 % in the two respective seasons) were recorded from Sohag-1 variety in both seasons. Here too, the obtained data in the same table revel that the K content of seeds and straw failed to be significant in this respect in both seasons. These results may be due to the differences among the examined varieties in their gene structure. These results are in harmony with those obtained by El-Habbasha, *et al.* (2007).

Also, the obtained data in the same table focus that N&P content in sesame seeds and straw was reacted significantly to the tested NPK fertilization treatments in both seasons. The highest leaves mean values content of N (4.36 and 4.55 %) and in the first and second seasons, respectively) were obtained from sesame plants which were fertilized by NPK2 (45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1}. While, the highest leaves mean values content of P (0.700 and 0.707 %) in the first and second seasons, respectively) were obtained from sesame plants which were fertilized by NPK2 (45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1})+ Bio fertilization in both seasons. Similar observations were detected by El-Samanody *et al.,* (2010) and Amal *et al.,* (2015) who indicated that Bio-fertilizer led to a significant increase in N, P and K of the seeds of sesame. Shehu et al., (2010) found the N fertilization enhanced N, P and K shoot uptake by 260, 43 and 46%, respectively. These results agreed with those obtained by Khaled *et al.* (2012), where the highest values of N, P and K contents in seeds were 3.46, 0.62 and 1.07 %, respectively achieved by soil application of bio-fertilizer and organic materials could be used as an integrated plant nutrition with 20, 30 or 40 kg $fed^{-1}$of mineral N.

Regarding the interaction effects in this respect, data illustrated in Table 5 reveal that order interactions involved had a significant influence on NPK content of sesame seeds and straw trait in two seasons. Thus, Sohag-1 variety which was fertilized by 45kg N, 22.5kg P_2O5 and 36kg K_2O fed^{-1} + Bio fertilization gave the highest average values of P percentage in seeds (0.711 and 0.712 %) and N percentage in straw (3.01 and 2.90 %) in the two respective seasons).

Soil fertility

Data in Table 6 showed that Inoculated plants of sesame at sowing with bio-NPK fertilizer had positive effect on soil fertility, where it increased soil content of available N, P and K that increasing the application rate of mineral NPK fertilizer significantly enhanced soil content of available N, P and K as compared with control (without addition). No significant differences were observed between the two sesame varieties ((Sohag-1 and Shandaweel-3)) in soil content of available N, P and K that increasing the application rate of mineral NPK fertilizer.

At the time of sowing N level in soil was 40 mg kg^{-1}, P level was 7.3 mg kg^{-1} and K level was 232 mg kg^{-1}. NPK levels in soil at time of harvesting was 66.3 mg kg^{-1}, P level was 8.8 mg kg-1and K level was 263 mg kg^{-1}, when maximum in treatment NPK3 60kg N, 30kg P_2O_5 and 48kg K_2O fed^{-1} (100 % NPK) +bio fertilizer. NPK + Biofertilizers improved the NPK status of the soil due to N fixation by Azotobacter and Azospirillum. Thus, improved the nitrogen availability in the soil improved the phosphorus status in the soil. Phosphorus soluble bacteria (PSB) solubilize the unavailable form of

phosphorus into available form; also potassium soluble bacteria (KSB) solubilize the unavailable form of potassium into available form. Biofertilization had moderately enhanced the fertility level of the soil after sesame harvest.

Table 5. Effect of varieties, fertilization treatments and interaction between varieties on NPK% in seeds and straw yield (Kg fed-1) of sesame plants in 2016 and 2017 seasons.

		NPK in seed						NPK in Straw					
Characters		N		P		K		N		P		K	
		1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Varieties													
Sohag 1		3.99	3.96	0.672	0.666	0.65	0.58	2.47	2.45	0.303	0.311	1.13	1.34
Shandawel 3		4.17	4.07	0.650	0.655	0.60	0.59	2.32	2.29	0.302	0.307	1.37	1.25
F test		*	*****	*****	*****	**n.s**	**n.s**	*****	*****	**n.s**	**n.s**	**n.s**	**n.s**
Fertilization treatments													
(Control)		4.23	4.10	0.616	0.614	0.61	0.59	2.15	2.14	0.181	0.168	0.98	1.15
NPK1		4.21	4.08	0.670	0.678	0.61	0.61	2.40	2.35	0.263	0.263	1.31	1.35
NPK2		4.36	4.55	0.672	0.679	0.58	0.58	2.49	2.43	0.340	0.362	1.32	1.25
NPK3		3.73	4.05	0.675	0.689	0.64	0.58	2.18	2.18	0.291	0.321	1.25	1.34
Bio. only		4.42	3.95	0.672	0.633	0.67	0.60	2.22	2.23	0.260	0.229	1.15	0.99
NPK1+ Bio		3.95	3.73	0.627	0.634	0.63	0.52	2.43	2.36	0.318	0.344	1.28	1.29
NPK2+ Bio		4.07	4.10	0.700	0.707	0.64	0.57	2.78	2.75	0.431	0.428	1.36	1.48
NPK3+ Bio		3.69	4.05	0.658	0.648	0.66	0.62	2.53	2.51	0.338	0.355	1.36	1.49
LSD at 0.05%		0.24	0.18	0.03	0.032	0.03	0.01	0.21	0.09	0.030	0.030	0.07	0.03
Interaction of varieties * fertilization													
Sohag 1	(Control)	4.25	4.10	0.614	0.622	0.67	0.60	2.25	2.28	0.195	0.164	0.92	1.07
	NPK1	4.10	3.95	0.693	0.677	0.65	0.65	2.65	2.40	0.257	0.256	1.14	1.43
	NPK2	4.40	3.85	0.677	0.710	0.58	0.60	2.55	2.35	0.313	0.300	1.25	1.38
	NPK3	3.86	3.75	0.701	0.706	0.60	0.58	2.16	2.20	0.303	0.339	1.09	1.27
	Bio. Only	4.80	4.05	0.691	0.632	0.69	0.62	2.30	2.40	0.239	0.232	1.04	1.05
	NPK1+ Bio	3.55	3.60	0.627	0.626	0.67	0.50	2.31	2.57	0.362	0.377	1.18	1.20
	NPK2+ Bio	3.61	4.35	0.711	0.712	0.69	0.51	3.01	2.90	0.426	0.437	1.16	1.61
	NPK3+ Bio	3.40	4.00	0.664	0.642	0.71	0.57	2.55	2.47	0.332	0.381	1.23	1.69
Shandawel 3	(Control)	4.20	4.10	0.617	0.607	0.56	0.58	2.05	2.00	0.168	0.172	1.03	1.23
	NPK1	4.31	4.21	0.646	0.678	0.58	0.58	2.15	2.31	0.268	0.271	1.47	1.28
	NPK2	4.32	4.25	0.667	0.648	0.58	0.56	2.42	2.51	0.367	0.423	1.38	1.12
	NPK3	3.60	4.35	0.648	0.671	0.67	0.58	2.20	2.15	0.279	0.303	1.41	1.41
	Bio. only	4.05	3.85	0.654	0.634	0.65	0.58	2.13	2.05	0.281	0.226	1.25	0.94
	NPK1+ Bio	4.35	3.85	0.626	0.642	0.58	0.55	2.55	2.15	0.274	0.310	1.38	1.38
	NPK2+ Bio	4.52	3.85	0.690	0.701	0.58	0.62	2.56	2.60	0.435	0.419	1.56	1.36
	NPK3+ Bio	3.98	4.10	0.652	0.655	0.60	0.67	2.50	2.55	0.344	0.329	1.49	1.29
LSD at 0.05 %		**0.34**	**0.26**	**0.05**	**0.05**	**0.05**	**0.01**	**0.30**	**0.12**	**0.05**	**0.05**	**0.10**	**0.05**

Table 6. Effect of applied mineral and bio fertilizers on the availability of some macronutrient contents in soils (mg kg^{-1}) after sesame varieties (combined data of 2016 and 2017 seasons.

		Available macronutrients (NPK) in soil (mg kg^{-1})		
Characters		**N**	**P**	**K**
		Varieties		
Sohag 1		50.16	7.83	247.16
Shandawel 3		51.20	7.97	248.41
F test		**n.s**	**n.s**	**n.s**
		Fertilization treatments		
(Control)		28.33	6.55	216.66
NPK1		41.66	7.44	226.50
NPK2		47.50	7.76	243.00
NPK3		46.00	7.64	258.00
Bio. Only		52.50	8.00	245.00
NPK1+ Bio		59.66	8.31	264.5
NPK2+ Bio		63.50	8.62	265.66
NPK3+ Bio		66.33	8.87	263.00
LSD at 0.05%		**20.91**	**1.83**	**28.51**
		Interaction of varieties * fertilization		
Sohag 1	(Control)	28.33	6.55	216.66
	NPK1	44.33	7.44	234.00
	NPK2	46.00	7.63	248.00
	NPK3	45.00	7.76	255.00
	Bio. Only	50.66	7.88	239.00
	NPK1+ Bio	58.66	8.17	261.66
	NPK2+ Bio	62.66	8.45	261.66
	NPK3+ Bio	65.66	8.72	261.33
Shandawel 3	(Control)	28.33	6.55	216.33
	NPK1	39.00	7.44	219.00
	NPK2	49.00	7.90	238.00
	NPK3	47.00	7.53	261.00
	Bio. Only	54.33	8.12	251.00
	NPK1+ Bio	60.66	8.44	267.33
	NPK2+ Bio	64.33	8.79	269.66
	NPK3+ Bio	67.00	9.02	264.66
LSD at 0.05 %		29.5	n.s	40.3

Economical evaluation

Data in Table 7 show the economical evaluation of sesame yields (grain and straw) as affected by NPK fertilization treatments. The inputs were 200 L.E/50 kg ammonium nitrate fertilizer, 500 L.E/50 kg potassium sulfate (48 % K_2O), 80 L.E/50 kg calcium super phosphate (15.5 % P_2O_5), 30 L.E/biofertilizer and. The outputs were 22 L.E/kg grain (2728 L.E/ardab) and 500 L.E/1000 kg straw. Data illustrate that treatment of NPK3 +bio had the highest cost (2066 L.E), while the treatment of control had the lowest cost (0 L.E). For the total gross return per feddan, NPK3 +bio recorded the highest value (14498 L.E) of grain and straw yields. However, for the net return (total gross return - total cost), NPK2 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} (75% NPK) + Bio fertilization recorded the highest net return (12638 L.E). These results illustrate that NPK2 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} (75% NPK) + inoculation with biofertilizer was maximized grain and straw yields and the net return per feddan as compared with mineral fertilization at NPK3 60kg N, 30kg P_2O_5 and 48kg K_2O fed^{-1} (100 % NPK), (11263 L.E) and other treatments.

Table 7. Economical evaluation of sesame yield as affected by NPK fertilization treatments (average of two seasons).

Treatments	Total cost of fertilization (L.E)	sesame yield (kg fed^{-1})		Gross Return (L.E)			Net return (L.E)
		Grain	Straw	Grain yield	Straw Yield	Total	
(Control)	0	229.4	859.7	5046	430	5476	5476
NPK1	358+160+500)=1018	393.1	1351.1	8647	676	9323	8305
NPK2	(537+240+750)=1527	481.9	1530.4	10602	765	11367	9840
NPK3	(716+320+1000)=2036	568.6	1579.5	12509	790	13299	11263
Bio. Only	30	342.1	897.6	7526	449	7975	7945
NPK1+ Bio	358+160+500+30)=1048	454.8	1477.1	10006	739	10744	9696
NPK2+ Bio	(537+240+750+30)=1557	608.3	1626.9	13382	813	14195	12638
NPK3+ Bio	(716+320+1000+30)=2066	618.7	1773.2	13611	887	14498	12432

Conclusion

From previous results, it can conclude to maximize yield of sesame varieties plant grown in Luxor governorate (Upper Egypt): fertilize plants with mineral fertilizers at rate of 45kg N, 22.5kg P_2O_5 and 36kg K_2O fed^{-1} (75% NPK) with bio-fertilization and sowing sesame variety Shandaweel-3.

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