Efficiency Replacement of Mineral Fertilization by Biofertilization and Foliar Spraying on Yield, Its Attributes and Seed Quality of Sesame

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ABSTRACT

Modern intensive agricultural practices face numerous challenges that pose major threats to global food security. In order to address the nutritional requirements of the ever-increasing world population, chemical fertilizers and pesticides are applied on large scale to increase crop production. Nowadays, there is a call for the reduction of the environmental pollution resulted from over application of chemical fertilizers and fertilizers cost. Therefore, study has been done to investigate the possibility and efficiency of using partial NPK chemical fertilizers:SF1; 100% of the recommended NPK fertilizers (142.9kg N, 71.4kg P_2O_5 and 119.1kg K_2Oha^{-1}), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers by foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: 0 kg as foliar application, FF2: 3.57 kg as foliar application and FF3: 7.14 $kgha^{-1}$ as foliar application) and different types of bio fertilizers (Uninoc.; 0 Bacterial strain and Inoc.; Mix Bio *ex. Bacillus polymexa*, *Bacillus megaterium* and *Bacillus cerculans*) for improving the characteristics of sesame yield and oil yield, also contributing to decrease environmental pollution. Two field experiments were carried out during the two successive summer growing seasons of 2016 and 2017 at the Agricultural Experimental and Research Station, Faculty of Agriculture, Cairo University, Giza, Egypt. Experimental design was split-split plot arrangements in randomized complete block design, repeated three times. The results could be summarized as follows: The recommended NPK fertilizers gave the maximum value for plant height (172 and 175 cm), number of capsule plant^{-1} (186 and 188), 1000-seeds weight (4.69 and 4.79 g), seed yield plant^{-1} (140 and 145 g), seed yield ha^{-1} (2.729 and 2.848 ton), oil % (46.95 and 47.48) and protein % (21.0 and 21.2) in both seasons, respectively. The maximum values of plant height (162 and 167 cm), number of capsule plant^{-1}(177 and 179), 1000-seeds weight (4.68 and 4.61 g), seed yield plant^{-1}(134 and 140 g), seed yield ha^{-1}(2.586 and 2.710 ton), oil % (47.10 and 47.48) and protein % (20.7 and 20.3) were produced by the inoculation by bacterial strains in both seasons, respectively. The study showed that all interactions of the first order have significant effects on all studied traits during the two seasons of study. The highest values for plant height (185 and 187 cm), number of capsule plant^{-1}(194 and 195), 1000-seeds weight (5.73 and 5.25 g), seed yield plant^{-1}(145 and 151 g), seed yield ha^{-1}(3.139 and 3.295 ton), oil % (48.11 and 48.03) and protein % (22.7) in both seasons, respectively resulted from combination of applied 100% of the recommended NPK fertilizers with inoculated by bacterial strains and applied 7.14 kg NPK ha^{-1} as foliar applicationin both seasons, respectively. the treatment of 75% of the recommended NPK fertilizers with 7.14 kg NPK ha^{-1} as foliar application and bacterial inoculation led to a significant increase than the recommended rate of 100 % NPK in the soil application only for seed yield ha^{-1} by 17.8 and 25.2 % in both seasons, respectively, as well as, There are no significant differences between 75% and 50% of the recommended NPK soil fertilizers.Therefore, the same seed yield per hectare can be obtained by saving 50% of the amount of NPK soil fertilizer.The content of sesame seeds from oil and protein increased significantly, estimated in oil (3.1 and 0.1%) and protein (7.7 and 3.1 %), when 50% of the recommended NPK soil fertilizers with 7.14 kg NPK ha^{-1} as foliar application and bacterial inoculation compared by 100% of the recommended NPK soil fertilizers only during the two seasons, respectively.

Keywords: Sesame, yield, quality, NPK, Biofertilization, foliar application

INTRODUCTION

Sesame is an important oilseed crop with great commercial attributes by virtue of its oil having an edible quality and medicinal value. Sesame is known queen of oilseeds crop because of its high oil content 50-60% oil and the oil is highly stable against rancidity due to the presence of the natural antioxidants sesamin and sesamolin, its high protein content (19-25%) and high content of unsaturated fatty acids, especially oleic acid and linoleic acid, Sesame is growing fast, short duration , less water consumption and wide adaptability under different soil type (Weiss, 2000; El-Khier*et al*., 2008 and Bekele*et al.*, 2017).

Sustainable agriculture has become very popular in recent years and it refers to the plant production without relying on toxic chemical pesticides or herbicides, synthetic fertilizers, genetically modified grains or agricultural practices that pollute soil, water, or other natural resources.

In Egypt, sesame is known 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, the local production of sesame is low and did not cover the national requirements, thus a lot of sesame seeds amount was imported every year.Previous research showed that seed nutrition qualities were influenced by complex genetic and environmental factors and their interactions. So increasing the productivity could be achieved through application of suitable agricultural practices as fertilization, irrigation and weed control etc. also generate a new cultivars with high yield potentiality (El-Habbasha *et al*., 2007).Supplying nitrogen is beneficial for carbohydrates and protein metabolism, promoting cell division and cell enlargement. Similarly, good supplying of Phosphorus is usually associated with increased root density, which aid in extensive exploration and supply of nutrients and water to the growing plant parts, resulting in increased growth and yield traits (Shehu*etal.,* 2010).

Using bio-fertilizers for non-legume crops (a symbiotic N-fixing bacteria, phosphate dissolving bacteria and bio-control) had a marked influence and had a positive effect on seed yield and recorded significant increases in all growth and yield tested parameter compared to uninoculation plants (Kumar *et al.,* 2009, Ziedan *et al.,* 2011 and Mahrous *et al.,* 2015).

Foliar nutrition encourages increasing chlorophyll production in leaves, cellular activity and controls respiration. It also triggers plant response to increased water and nutrient uptake from soil. The purpose of applying fertilizers through foliar spray during the seed filling period is to keep the leaves viable longer by re-supplying nutrients that are being rapidly translocated to developing seeds .

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, 2005). 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) 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.

To increase their yield farmers use higher doses of chemical fertilizer which affect the soil and environment adversely. 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 organic-and bio farming systems (El-Habbasha *et al*., 2007 and Labib*et al*.,2019). One such approach could be the use of integrated nutrient management, which can save soil, environment and farmer's limited resources (Reddy *et al*., 2005). Abdel-Rahman (2014) indicated the seed inoculation with bio fertilizer significantly affected the sesame yield and its contents of the studied nutritive elements. Attia and Abd-El-Saber (2021) indicated that 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. The objectives of the present research were to possibility and efficiency of using partial NPK chemical fertilizers by foliar application and different types of bio fertilizers for improving the characteristics of sesame yield and quality also contributing to decrease environmental pollution.

MATERIAL AND METHODS

Experimental site

Two field experiments conducted at the Agricultural Experiment and Research Station of the Faculty of Agriculture, Cairo University, Giza, Egypt (30°02' N and 31°13' E, with an altitude of 22.5 meter) during the two summer seasons of 2016 and 2017. The preceding winter crop was faba bean (*Viciafaba*) during the two seasons.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 (1982) and Clark *et al.* (1998) Table (1).

Table 1. Some physical and chemical properties of the experiment soil before sowing average two seasons.

Properties	Particle size distribution	Sand %	Silt %	Clay %	Texture class	OM %	CaCO3 %	pH	EC dSm^{-1}
Values		32.0	29.75	38.25	Clay loam	1.74	0.86	7.81	1.33
Properties	Soluble Cations and anions (meq/L)						Available Nutrients ($mg\ kg^{-1}$)		
	Ca^{++}	Mg^{++}	Na^{+}	$CO3^{--}$	$HCO3^{-}$	Cl^{-}	$SO4^{--}$	N	P	K
Values	3.14	3.36	6.53	--	5.0	4.3	4.0	41.5	4.8	84.0

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

Meteorological variables in the 2016 and 2017 growing seasons of sesame were obtained from the Central Laboratory for Agriculture Climate (CLAC), ARC, and Egypt (Table 2).

Table 2.Climatic factors of studied region during crop growth period average 2015 and 2016 at Giza Governorate.*

Month	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%)	Sunshine duration (hr)	Average wind speed ($m\ sec^{-1}$)

March	26.5	15.9	52.4	11.8	1.5
April	35.0	19.8	41.0	12.7	1.4
May	32.9	20.5	42.3	13.5	1.4
June	36.0	22.4	53.0	13.9	1.4
July	35.2	22.4	60.0	13.8	1.3
August	37.2	23.7	61.0	13.1	1.0
September	34.8	21.9	59.9	12.2	1.1
October	30.1	17.3	59.0	11.3	1.1

* Data obtained by the Central Laboratory for Agriculture Climate (CLAC), Agricultural Research Center, Egypt

Treatments and experimental design

The main objectives of this article were to; investigate the possibility and efficiency of using partial NPK chemical fertilizers by foliar application (NPK) and different types of bio fertilizers for improving the characteristics of sesame variety shandaweel-3 yield and oil yield, also contributing to decrease environmental pollution. Each experiment included 18 treatments, which were the combinations of three chemical fertilizers;SF1: 100% of the recommended NPK fertilizers (142.9kg N, 71.4kg P_2O_5 and 119.1kg K_2Oha^{-1}), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers, foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: 0 kg as foliar application, FF2: 3.57 kg as foliar application and FF3: 7.14 kg ha^{-1} as foliar application) and different types of bio fertilizers (Uninoc.; 0 Bacterial strain and Inoc.; Mix Bio *ex. Bacillus polymexa* ,*Bacillus megaterium* and *Bacillus cerculans*). Experimental design was split-split plot arrangements in randomized complete block design, repeated three times. The main plots were devoted to the three NPK soil applications. The sub-plots were allotted to the biofertilizer (Bacterial strains), while the foliar treatmentswill be in sub-sub plot. Each sub-sub plot consisted of 5 rows of 5 m length and 0.60 m width with an area of 15 m^2.

Agricultural practices

Shandaweel-3 this variety were kindly obtained from Oil Crop Department, Field Crop Research Institute, Agriculture Research Center, Ministry of Agriculture and land reclamation, Egypt. Sesame seeded by hand on May 15 in both seasons and thinned to one plant per hill 30 days after planting. 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 N, P and K mineral fertilizers will add in the in three rates (100%, 75% and 50% of the recommended). NPK recommended fertilizers at the rate of 142.9kg N, 71.4kg P_2 O_5 and 119.1kg K_2O/ hectare. Nutrition with NPK fertilizer 100% water soluble 19:19:19 as foliar application in three doses (0, 3.57 and 7.14 kg/ha) sprayed twice at 21-day intervals as a foliar application. The bio-fertilizers used compositinculam contain mixture of 3 different strains (*Bacillus polymexa*, as N – fixing bacteria (BP) + *Bacillus megaterium* as phosphate dissolving bacteria (BM) and *Bacillus cerculans* (BC), as a potassium realizing bacteria. These bacteria were kindly obtained from biofertilizer production unit (BPU) Soil, Water and Environment Research Institute, Agriculture Research Center, Ministry of Agriculture and land Reclamation, Egypt. They were used as seed coating inoculation method for each inoculated treatment at a rate of 4g/100g seed with seed 1>104 cell per seed.

Irrigation was applied by flooding system after three weeks for the first irrigation and every two weeks for subsequent ones. Weed control was performed manually by hoeing twice, the first before the first irrigation and the second before the second irrigation. The normal cultural practices for sesame production adopted according to recommended package deal of ARC, ministry of Agriculture, Egypt.

Studied traits

Ten plants from each sub-plot were taken at random where the following traits were recorded at harvest; plant height (cm), number of capsules plant^{-1}, thousand-seed weight (g) and seed weight plant^{-1} (g). Seed-oil and protein percentage were determined according to A.O.A.C. (2000). Protein content was calculated as follows: (Protein % = N % in grain × 5.30). Nitrogen was determined by Kjeldahl method. Seed yield (kg ha^{-1}) was calculated from all harvested plants of each sub-plot and adjusted to yields per hectare.

Statistical analysis

All obtained data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the split- split plot design according to Gomez & Gomez (1984). Significant F-test and Least Significant Difference (LSD) method was used to test the differences between treatment means at 5% level of probability.

RESULTS AND DISCUSSION

1. *Effect of NPK soil applications (SF), Biofertilizer and NPK foliar applications (FF)*

Statistical analysis of the data indicated in Table 3 that NPK soil application had significanteffect on plant height, number of capsule plant^{-1}, 1000-seeds weight, seed yield plant^{-1}, seed yield ha^{-1}, oil % and protein % in both seasons. The recommended NPK fertilizers (SF1) gave the maximum value forplant height (172 and 175 cm), number of capsule plant^{-1} (186 and 188), 1000-seeds weight (4.69 and 4.79 g), seed yield plant^{-1} (140 and 145 g), seed yield ha^{-1} (2.729 and 2.848 ton), oil % (46.95 and 47.48) and protein % (21.0 and 21.2) in both seasons, respectively. The results showed that the less the amount of NPK fertilizer added than recommended, the lower the value of the previous traits in both seasons. The results showed that the gradual decrease in the amount of fertilizer added from 100 % (SF1) to 75% (SF2) from recommended of NPK sesame led to a decrease in the sesame yield ha^{-1}, estimated at 6.12% and 6.04% during the two seasons, respectively. As well as, when the gradual decrease in the amount of fertilizer added from 75 % (SF2) to 50% (SF3) from recommended of NPK sesame led to a decrease in the sesame yield ha^{-1}, estimated at 18.03% and 19.92% during the two seasons, respectively. The increased seed yield caused by application of nitrogen could be due to enhanced vegetative growth and other yield attributes, e.g. more branches and capsules per plant. These would therefore be the ideal fertilizer application rates for sesame production under conditions of Egypt. Furthermore, these findings agree with those of Ghosh and Patra (1994), Kafiriti and Deckers (2001), Mujaya and Yerokum (2003), Amanullah *et al*. (2014) and Iorlamen *et al*. (2014).The lowest values of previous traits when were used the lower doses of NPK rate (SF3) in both seasons. These results are in agreement with El-Mahdi (2008) who found the highest and least seed yields were produced in plots treated with 44 and 0 kg N ha^{-1}, respectively.Ashfaq *et al*. (2001) found that the highest seed yield and yield components were obtained with 20 and 40 kg ha^{-1} nitrogen and phosphorous rates, respectively.

With regarded to the effect of bio-fertilization on sesame yield and its components, the results were given in Tables 3. These results reveal generally showed that all characters under this study were significantly affected by inoculation of sesame seeds with bacterial strains when compared with uninocultion (control treatment) in both seasons. The maximum values of plant height (162 and 167 cm), number of capsule plant^{-1}(177 and 179), 1000-seeds weight (4.68 and 4.61 g), seed yield plant^{-1}(134 and 140 g), seed yield ha^{-1}(2.586 and 2.710 ton), oil % (47.10 and 47.48) and protein % (20.7 and 20.3)were produced by the inoculation by bacterial strainsin both seasons, respectively. The significantly lowest of previous traitswere recorded with treatment Control (Uninoculation by bacterial strains) in both seasons. The obtained results might be attributed to better development of inoculted plants compared to uninoculated ones creating a more favorable environment in terms of natural and concentration of root exudates for cell growth and metabolic activities of rhizospheric microorganisms.

Table 3.Yield and quality of sesame as influenced by applications of NPK soil & foliar andbio-fertilization during 2016 and 2017 seasons.

Treatments	**Plant height (cm)**	**No. capsules plant^{-1}**	**1000-seeds weight (g)**	**Seed yield plant^{-1} (g)**	**Seed yield ha^{-1} (ton)**	**Oil %**	**Protein %**
First season							
NPK soil applications (SF)							
SF1	172	186	4.69	140	2.729	46.95	21.0
SF2	156	178	4.38	133	2.562	46.59	19.4
SF3	150	155	4.20	127	2.100	46.08	19.1
$LSD_{0.05}$	**5.72**	**8.56**	**0.31**	**7.73**	**0.531**	**0.46**	**0.23**
Biofertilizer (Inoculation by Bacterial strains)							
Inoc.	162	177	4.68	134	2.586	47.01	20.7
Uninoc.	157	169	4.16	131	2.341	46.06	19.0
F- test	*	**	*	*	**	*	*
NPK foliar applications (FF)							

FF1	146	163	3.93	130	2.348	45.88	19.3
FF2	164	174	4.56	131	2.454	46.60	19.7
FF3	169	181	4.77	137	2.589	47.14	20.6
$LSD_{0.05}$	**3.2**	**3.6**	**0.43**	**3.4**	**0.097**	**0.57**	**0.3**
Second season							
NPK soil applications (SF)							
SF1	175	188	4.79	145	2.848	47.48	21.2
SF2	161	180	4.63	135	2.676	46.79	20.1
SF3	156	164	4.13	130	2.143	45.69	19.6
$LSD_{0.05}$	**5.81**	**9.72**	**0.36**	**5.82**	**0.371**	**0.51**	**0.24**
Biofertilizer (Inoculation by Bacterial strains)							
Inoc.	167	179	4.61	140	2.710	47.05	20.3
Uninoc.	161	175	4.42	133	2.402	46.36	19.5
F- test	*	*	*	**	**	*	*
NPK foliar applications (FF)							
FF1	149	170	4.00	129	2.043	46.11	19.8
FF2	169	179	4.73	137	2.566	46.83	20.5
FF3	174	183	4.81	144	2.699	47.19	20.7
$LSD_{0.05}$	**4.4**	**2.1**	**0.49**	**6.1**	**0.126**	**0.59**	**0.3**

**** Significance at a 1% level of probability ($p < 0.01$),* Significance at a 5% level of probability ($0.01 = <p < 0.05$) N.S. non-significant ($p > = 0.05$)**

SF1: 100% of the recommended NPK fertilizers (142.9kg N, 71.43kg P_2O_5 and 119.1kg K_2O/ha), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers - foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: 0 kg ha^{-1} as foliar application, FF2: 3.75 kg ha^{-1} as foliar application and FF3: 7.14 kg ha^{-1} as foliar application.

This result is in accordance with those obtained by Debnath *et al.* (2007) found that the inoculation by Azotobacter attained the highest significant value of 1000-seed weight. Additionally, Maheshwari *et al*. (2012) mentioned that the inoculated seeds via *Azotobacter chroococcum* (TRA2) significantly increased seed yield ha^{-1} and oil yield ha^{-1} in a sandy loam soil. On the other hand, Jadhav *et al*. (2015) found that the inoculation via 600g *Azotobacter chroococcum* and *Pseudomonas striata* 3kg^{-1} of seeds gave the highest value of seed yield plant^{-1} in a clay soil. Furthermore, Subash and Rafath (2016) noticed that the bacterial inoculum of Azospirillum gave a maximum value of plant height, number of capsules plant^{-1} and seed yield plant^{-1} followed by the bacterial inoculum of Azotobacter.

Results in Table 3 clear that the plant height, number of capsule plant^{-1}, 1000-seeds weight, seed yield plant^{-1}, seed yield ha^{-1}, oil % and protein % in both seasons as affected by different NPK foliar applications (FF) are presented in Table 3. The significantly highest plant height (169 and 174 cm), number of capsule plant^{-1}(181 and 183), 1000-seeds weight (4.77 and 4.81 g), seed yield plant^{-1}(137 and 144 g), seed yield ha^{-1}(2.589 and 2.699 g), oil % (47.14 and 47.19) and protein % (20.6 and 20.7) were produced by the FF3 application (7.14 kg ha^{-1} as foliar application; NPK fertilizer 100% water soluble 19:19:19) in both seasons, respectively andfound significantly superior over rest of the treatments.

The significantly lowest previous traits were recorded with treatment Control FF1. It was noticeable from the results in Table 3 that the NPK foliar application led to a gradually increased in the values of the previous traits compared to no foliar application of elements in both seasons. The obtained results are in agreement with Deepthi1*et al.* (2020).

2. Effect of the interaction between NPK soil applications and Biofertilizer (Inoculation by Bacterial strains)

Moreover, agriculture soils are continuously losing their quality and physical properties as well as their chemical (imbalance of nutrients) and biological health.Regarding the interaction effect between NPK soil applications and Biofertilizer, the results clearly showed significant and highly significant differences for all studied traits in both seasons (Table 4).According to means comparison of interaction between NPK soil applications and biofertilizer, the results were obtained from SF1 (100% of the recommended NPK fertilizers) with inoculated by bacterial strains gave the highest means for all studies traits in both seasons. On the other hand, the lowest values of all studies traits were recorded due to the interaction between SF3 (50% of the recommended NPK fertilizers) and un-inoculated by bacterial strains in both seasons. It could be recommended that to maximize sesame yields SF1 (100% of the recommended NPK fertilizers) with inoculated by bacterial strainsshould be applied (Table 4).

Also, it was indicated that the yield of sesame seeds per hectare there were differencesare not great between the addition of SF1 (100% of the recommended NPK fertilizers) and the addition of SF2 (75% of the recommended NPK fertilizers) with inoculated by bacterial strains, where the difference was 306 kg ha^{-1} in the first season and 291 kg ha^{-1} in the second season. Also, we did not great differences in SF1 (100% of the recommended NPK fertilizers) without un-inoculated by bacterial strains andSF2 (75% of the recommended NPK fertilizers) with inoculated by bacterial strains, where the difference was 159 kg ha^{-1}in the first season than SF2 with inoculated, but in the second season SF2 (75% of the recommended NPK fertilizers) with inoculated by bacterial strains, it was 187 kg more than SF1 (100% of the recommended NPK fertilizers) without un-inoculated (Table 4).

Table 4.Yield and quality of sesame as influenced by applications ofNPK soil and bio-fertilization interaction during 2016 and 2017 seasons.

NPK soil applications (SF)	Biofertilizer (Inoculation by Bacterial strains)	Plant height (cm)	No. capsules $plant^{-1}$	1000-seeds weight (g)	Seed yield $plant^{-1}$ (g)	Seed yield ha^{-1} (ton)	Oil %	Protein %
First season								
SF1	**Inoc.**	176	190	5.02	143	2.942	47.42	22.1
	Uninoc.	168	182	4.36	137	2.477	46.49	19.8
SF2	**Inoc**	158	180	4.59	135	2.636	47.12	20.1
	Uninoc	154	175	4.16	131	2.488	46.05	18.6
SF3	**Inoc**	151	159	4.44	129	2.141	46.48	19.7
	Uninoc	148	149	3.95	124	2.058	45.66	18.4
$LSD_{0.05}$		**2.72**	**2.63**	**0.32**	**3.88**	0.190	**0.48**	**0.29**
Second season								

SF1	**Inoc**	180	190	4.89	148	3.087	47.80	22.4
	Uninoc	171	185	4.69	142	2.609	47.16	19.9
SF2	**Inoc**	163	181	4.72	138	2.796	47.02	20.9
	Uninoc	158	178	4.53	133	2.538	46.56	19.4
SF3	**Inoc**	157	166	4.21	134	2.227	46.01	19.9
	Uninoc	154	163	4.05	125	2.058	45.37	19.3
$LSD_{0.05}$		**2.11**	**3.25**	**0.37**	**3.22**	0.098	**0.25**	**0.37**

SF1: 100% of the recommended NPK fertilizers (142.9kg N, 71.43kg P_2 O_5 and 119.1kg K_2O/ha), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers.

This may be due to the role of phosphorus dissolving and nitrogen fixation bacteria on increasing the endogenous phytohormonas (IAA, GAs and CKs), which play an important role in formation a big active root system, increasing the nutrient uptake and photosynthesis and translocation, as well as, accumulation within different plant parts (El-Khawas, 1990). These results are in agreement with those obtained by El-Habbasha *et al*. (2007), Hasonpour *et al*. (2012), Abdullahi *et al*. (2013) and Labib *et al*. (2019).

3.Effect of the interaction between NPK soil applications and NPK foliar applications

Results in Table 5 showed that highly significant differences existed among interaction between NPK soil applications and NPK foliar applications for all studies traits in both seasons. The treatment 100 % of recommended mineral NPK ((142.9kg N, 71.43kg P_2 O_5 and 119.1kg K_2O/ha) soil + foliar applications records the highest values ofplant height (183 and 185 cm), number of capsule plant^{-1}(193 and 194), 1000-seeds weight (5.18 and 5.19 g), seed yield plant^{-1}(143 and 149 g), seed yield ha^{-1}(2.857 and 3.067 ton), oil % (47.62 and 47.79) and protein % (21.5) in both seasons, respectively. The present results cleared that dual application of mineral fertilization soils and foliar application were better than addition of NPK soil fertilization alone.

Significantly lower values for all the yield attributes were observed with the lowest level of (50% of the recommended NPK fertilizers) NPK applied to soil (SF3) and FF1 (0 kg ha^{-1} as foliar application) in both seasons (Table 5).It could be recommended that to maximize sesame yields 142.9kg N, 71.43kg P_2 O_5 and 119.1kg K_2O/ha NPK applied to soil together with 7.14 kg NPK ha^{-1} as foliar application should be applied. This may be due to the provision of nutrients at latter stages which might have enhanced accumulation of assimilate of the seeds and thus resulting in hover seeds of sesame. Such findings is in agreements with those of El-Nkhlawy and Shaheen (2009), Shehu *et al.* (2010), Ulmar *et al.* (2012) and Kashani *et al.* (2015). Also, data illustrated that in Table (5) indicated that all studied traits there were differencesare not great between the addition of SF1 (100% of the recommended NPK fertilizers) and the addition of SF2 (75% of the recommended NPK fertilizers) with 7.14 kg NPK ha^{-1} as foliar application in both seasons.

Table 5.Yield and quality of sesame as influenced by applications ofNPK soil and foliar and their interaction during 2016 and 2017 seasons.

NPK soil applications (SF)	NPK foliar applications (FF)	Plant height (cm)	No. capsules plant^{-1}	1000-seeds weight (g)	Seed yield plant^{-1} (g)	Seed yield ha^{-1} (ton)	Oil %	Protein %
First season								
SF1	**FF1**	154	177	4.18	137	2.611	46.32	20.5
	FF2	180	189	4.71	141	2.719	46.92	20.9
	FF3	183	193	5.18	143	2.857	47.62	21.5
SF2	**FF1**	142	169	3.84	130	2.445	45.88	18.8
	FF2	158	181	4.59	135	2.552	46.55	19.1
	FF3	168	183	4.70	135	2.690	47.33	20.2
SF3	**FF1**	140	144	3.77	122	1.987	45.44	18.5
	FF2	153	152	4.4	125	2.091	46.32	18.9
	FF3	157	168	4.42	133	2.220	46.47	19.8
$LSD_{0.05}$		**2.7**	**2.63**	**0.32**	**3.88**	**0.190**	**0.48**	**0.29**
Second season								
SF1	**FF1**	158	181	4.11	141	2.638	47.19	20.7
	FF2	183	188	5.08	144	2.840	47.47	21.3
	FF3	185	194	5.19	149	3.067	47.79	21.5
SF2	**FF1**	147	173	3.98	128	2.511	46.08	19.4

	FF2	163	182	4.89	134	2.696	46.99	20.1
	FF3	173	185	5.02	144	2.822	47.29	20.9
SF3	**FF1**	143	155	3.93	119	2.059	45.05	19.2
	FF2	161	168	4.25	132	2.163	45.53	19.9
	FF3	**163**	**170**	**4.22**	**138**	**2.206**	**46.49**	**19.8**
$LSD_{0.05}$		**2.11**	**2.25**	**0.37**	**3.22**	**0.098**	**0.25**	**0.37**

SF1: 100% of the recommended NPK fertilizers (142.9kg N, 71.43kg P_2O_5 and 119.1kg K_2O/ha), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers - foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: 0 kg ha^{-1} as foliar application, FF2: 3.75 kg ha^{-1} as foliar application and FF3: 7.14 kg ha^{-1} as foliar application.

3. Effect of the interaction between biofertilization and NPK foliar applications

Regarding the interaction effect between biofertilizationand NPK foliar applications, the results clearly showed significant and highly significant differences for all studied traits in both seasons (Table 6). According to means comparison of interaction between biofertilizer and NPK foliar applications, the results were obtained from FF3 (7.14 kg NPK ha^{-1} as foliar application) with inoculated by bacterial strains gave the highest means for all studies traits in both seasons. On the other hand, the lowest values of all studies traits were recorded due to the interaction between FF1 (0 kg NPK ha^{-1} as foliar application) and un-inoculated by bacterial strains in both seasons. It could be recommended that to maximize sesame yields FF3 (7.14 kg NPK ha^{-1} as foliar application) with inoculated by bacterial strains should be applied (Table 6).

Table 6. Yield and quality of sesame as influenced by bio-fertilization and applications of NPK foliar interaction during 2016 and 2017 seasons

NPK foliar applications (FF)	Biofertilizer(Inoculation by Bacterial strains)	Plant height (cm)	No. capsules plant^{-1}	1000-seeds weight (g)	Seed yield plant^{-1} (g)	Seed yield ha^{-1} (ton)	Oil %	Protein %
First season								

Inoc.	**FF1**	149	168	4.29	133	2.461	46.45	19.8
	FF2	165	177	4.69	130	2.567	46.99	205
	FF3	171	185	5.06	139	2.730	47.59	21.7
Uninoc.	**FF1**	142	158	3.57	126	2.235	45.31	18.7
	FF2	162	171	4.43	131	2.340	46.20	18.8
	FF3	167	177	4.47	135	2.448	46.68	19.4
$LSD_{0.05}$		**1.11**	**3.11**	**0.50**	**3.11**	**0.090**	**0.73**	**0.22**
Second season								
Inoc.	**FF1**	153	173	4.07	134	2.538	46.31	20.6
	FF2	171	180	4.87	139	2.737	47.31	21.1
	FF3	176	184	4.88	146	2.855	47.53	21.5
Uninoc.	**FF1**	145	166	3.93	124	2.268	45.90	18.9
	FF2	167	178	4.59	134	2.396	46.34	198
	FF3	171	182	4.74	141	2.542	46.85	19.9
$LSD_{0.05}$		**1.09**	**3.72**	**0.58**	**5.97**	**0.140**	**0.81**	**0.25**

N.S. non-significant (*p* > = 0.05), Foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: 0 kg ha^{-1} as foliar application, FF2: 3.75 kg ha^{-1} as foliar application and FF3: 7.14 kg ha^{-1} as foliar application.

5. Effect of the interaction between NPK soil applications, biofertilization and NPK foliar applications

Data presented in Table 7 and 8 showed that the interaction of NPK soil applications, biofertilization and NPK foliar applications had significant effects on all studied traits in both seasons. The highest values for plant height (185 and 187 cm), number of capsule plant^{-1}(194 and 195), 1000-seeds weight (5.73 and 5.25 g), seed yield plant^{-1}(145 and 151 g), seed yield ha^{-1}(3.139 and 3.295 ton), oil % (48.11 and 48.03) and protein % (22.7) in both seasons, respectively resulted from combination of applied 100% of the recommended NPK fertilizers (SF1) with inoculated by bacterial strainsand applied 7.14 kg NPK ha^{-1} as foliar application (FF3) in both seasons, respectively.These findings are in line with those reported by several earlier researchers (Attia and Abd-El-Saber, 2021).Moreover, Labib *et al.* (2019) found that the mineral fertilizer was completely replaced via 100% compost and partially replaced by 100% bioformulations with 50% mineral recorded the best results in both seasons.On the other hand, the lowest values of all studies traits were recorded due to the interaction between SF3 (50% of the recommended NPK fertilizers) withFF1 (0 kg NPK ha^{-1} as foliar application) and un-inoculated by bacterial strains in both seasons.

From the data in the two Tables (7 and 8), it is clear that NPK foliar fertilization with bacterial inoculation led to a significant increase in all studied traits during the two growing seasons compared to only the recommended soil application.The increase was when adding the rate by 7.14 kg NPK ha^{-1} as foliar application (FF3) and bacterial inoculation with the 100% of the recommended NPK fertilizers (SF1) as soil applied compared to the addition to the 100% of the recommended NPK fertilizers (SF1) as soil application only, where it was recorded in plant height (27.6 and 25.5 %), number of capsule $plant^{-1}$(14.1 and 11.4 %), 1000-seeds weight (48.4 and 30.9 %), seed yield $plant^{-1}$(9.8 and 10.2 %), seed yield ha^{-1}(32.8 and 38.5 %), oil % (5.3 and 2.5 %) and protein % (17.4 and 16.4 %) in both seasons, respectively.

Besides, the results indicated that the soil application of NPK at a lower rate with NPK foliar fertilization and bacterial inoculation led to a significant increase than the recommended rate of NPK in the soil application only.Possibilities of partial substitution of mineral fertilizer via bio and foliar fertilizers were evaluated for improving the characteristics of sesame seed yield and quality, also contributing to decrease environmental pollution; this is the main objective of the study. Results in Table 8 clear that the treatment of SF2; 75% of the recommended NPK fertilizers with 7.14 kg NPK ha^{-1} as foliar application (FF3) and bacterial inoculation led to a significant increase than the recommended rate of 100 % NPK (SF1) in the soil application only for seed yield ha^{-1} by 17.8 and 25.2 % in both seasons, respectively, as well as, There are no significant differences between 75% and 50% of the recommended NPK soil fertilizers.Therefore, the same seed yield per hectare can be obtained by saving 50% of the amount of NPK soil fertilizer.The results in Table 8 showed that the content of sesame seeds from oil and protein increased significantly, estimated in oil (3.1 and 0.1%) and protein (7.7 and 3.1 %), when 50% of the recommended NPK soil fertilizers with 7.14 kg NPK ha^{-1} as foliar application (FF3) and bacterial inoculation compared by 100% of the recommended NPK soil fertilizers only during the two seasons, respectively.

Table 7.Yield and attributes of sesame as influenced by applications of NPK soil and foliar, bio-fertilization and their interactions during 2016 and 2017 seasons.

NPK soil applications (SF)	Biofertilizer(Inoculation by Bacterial strains)	Plant height (cm)			No. capsules plant^{-1}			1000-seeds weight (g)			Seed yield plant^{-1} (g)		
		FF1	FF2	FF3	FF1	FF2	FF3	FF1	FF2	FF3	FF1	FF2	FF3
First season													
SF1	**Inoc.**	163	180	185	183	193	194	4.49	4.83	5.73	142	143	145
	Uninoc.	145	179	181	170	185	191	3.86	4.59	4.63	132	139	140
SF2	**Inoc.**	143	160	170	173	183	185	4.22	4.71	4.83	132	137	137
	Uninoc.	141	156	166	165	179	181	3.45	4.46	4.56	127	132	133
SF3	**Inoc.**	141	155	158	147	154	176	4.15	4.55	4.61	125	128	134
	Uninoc.	139	151	155	140	148	159	3.39	4.25	4.22	119	121	131
$LSD_{0.05}$		**3.12**			**1.47**			**0.41**			**5.6**		
Second season													
SF1	**Inoc.**	16	1	1	187	189	19	4.21	5.2	5.2	1	147	1

		7	85	87			5		2	5	45		51
	Uninoc.	149	181	183	175	187	193	4.01	4.93	5.12	137	141	147
SF2	**Inoc.**	148	166	175	175	182	185	4.03	5.03	5.11	131	135	147
	Uninoc.	145	160	170	170	181	184	3.92	4.75	4.92	125	132	141
SF3	**Inoc.**	144	163	165	157	169	171	3.98	4.37	4.27	126	134	141
	Uninoc.	141	159	161	153	166	169	3.87	4.11	4.17	111	130	135
$LSD_{0.05}$		**3.01**		**1.88**				**0.48**			**4.8**		

SF1: 100% of the recommended NPK fertilizers (142.9kg N, 71.43kg P_2O_5 and 119.1kg K_2O/ha), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers - foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: FF1: 0 kg ha^{-1} as foliar application, FF2: 3.75 kg ha^{-1} as foliar application and FF3: 7.14 kg ha^{-1} as foliar application.

Table 8.Yield and attributes of sesame as influenced by applications of NPK soil and foliar, bio-fertilization and their interactions during 2016 and 2017 seasons.

NPK soil applicatio	Biofertilizer(Inoculation by Bacterial	Seed yield ha^{-1} (ton)	Oil %	Protein %

ns (SF)	strains)	FF1	FF2	FF3	FF1	FF2	FF3	FF1	FF2	FF3
First season										
SF1	**Inoc.**	2.743	2.943	3.139	46.93	47.21	48.11	21.5	22.1	22.7
	Uninoc.	2.362	2.494	2.575	45.71	46.63	47.12	19.4	19.8	20.3
SF2	**Inoc.**	2.517	2.609	2.782	46.43	47.11	47.83	19.2	20.0	21.1
	Uninoc.	2.373	2.494	2.598	45.32	46.01	46.82	18.4	18.1	19.2
SF3	**Inoc**	2.004	2.148	2.269	45.98	46.65	46.82	18.8	19.3	20.9
	Uninoc.	1.970	2.033	2.172	44.9	45.98	46.11	18.2	18.4	18.7
$LSD_{0.05}$		**0.074**			**0.54**			**0.24**		
Second season										
SF1	**Inoc.**	2.897	3.070	3.295	47.53	47.83	48.03	21.8	22.7	22.7
	Uninoc.	2.379	2.609	2.840	46.84	47.11	47.54	19.5	19.9	20.2
SF2	**Inoc.**	2.59	2.74	2.97	46.1	47.2	47.66	20.	2	21.

		8	8	8	7	2		1	0.8	7
	Uninoc.	2.425	2.523	2.667	45.99	46.75	46.93	18.7	19.4	20.0
SF3	**Inoc**	2.120	2.269	2.292	45.22	45.89	46.91	19.8	19.8	20.1
	Uninoc.	1.999	2.056	2.120	44.87	45.17	46.07	18.6	20	19.4
$LSD_{0.05}$		**0.161**			**0.63**			**0.28**		

SF1: 100% of the recommended NPK fertilizers (142.9kg N, 71.43kg P_2 O_5 and 119.1kg K_2O/ha), SF2: 75% of the recommended NPK fertilizers and SF3: 50% of the recommended NPK fertilizers - foliar application (NPK fertilizer 100% water soluble 19:19:19 in three doses; FF1: 0 kg ha^{-1} as foliar application, FF2: 3.75 kg ha^{-1} as foliar application and FF3: 7.14 kg ha^{-1} as foliar application.

Conclusion

Nowadays, there is a call for the reduction of the environmental pollution resulted from over application of chemical fertilizers. Nitrogen is a critical element having significant roles in crop production. Therefore, it requires proper management in the modern crop production in order to alleviate its high level of volatilization and leaching losses from farmlands, particularly in the tropics where rainfall is torrential and solar radiation is very high. From previous results, it can conclude to maximize yield of sesame varieties plant grown in Egypt fertilize plants with mineral fertilizers at rate of 107.2 kg N, 53.6 kg P_2O_5 and 89.3 kg K_2O ha^{-1} (75% NPK soil application) with biofertilization and 7.14 kg ha^{-1} as foliar application. It can be concluded that the mineral fertilizer was partial replaced via 7.14 kg NPK ha^{-1} as foliar application and bioformulations with 75% NPK solil application recorded the best results and follow 50% in both seasons compared 100% NPK soli application.

REFERANCES

1. **Abdel-Rahman, A.H. (2014)** 'Effect of mineral potassium, compost and bio-fertilizers on soil physio-chemical properties and productivity of sesame grown on salt affected soil' *J. Soil Sci. and Agric. Eng., Mansoura Univ*., 5 (6), pp. 791– 805.
2. **Abdullahi, R.;Sheriff,H. H. and Lihan,S. (2013).** Combine effect of biofertilizer and poultry manure on growth, nutrients uptake and microbial population associated with sesame (*Sesamum indicum*, L) in Northeastern Nigeria. IOSR J. of Environ. Sci., Toxicology and Food Technology (IOSR-JESTFT) 5(5): 60-65.
3. **Amanullah, J. S. A. and Ahmad, M. (2014).** Influence of sowing time and nitrogen fertilization on Alternaria leaf blight and oil yield of Sesame cultivars. Pure Appl. Bio., 3(4): 160-166.
4. **Antoun, H. (2005) '**Field and greenhouse trials performed with phosphate solubilizing bacteria and fungi. department of soil and agrifood engineering' Faculty of Agriculture and Food. Science, Canada, 8 p.
5. **A.O.A.C. (2000)** 'Official methods of analysis of the association of official analytical chemists' 15th (edition, published by Association of Official Analytical Chemists Arlington, Virginia U.S.A.).
6. **Ashfaq, A; Mahboob, A.; Abid, H., Ehsanullah,L. and Muaddigue, M.(2001).** Genotypic response of sesame to nitrogen and phosphorous application. Pakistan J. Agric. Sci., 38:12- 15.
7. **Attia, A.M. and Abd-El-Saber, A. (2021)**. Influence of bio and mineral fertilization on some sesame varieties grown in Upper. SVU-Inter. J. Agric. Sci., 3(2):72-88.
8. **Bekele, A.; Besufekad, Y.; Adugna, S. and Yinur, D. (2017)**. Screening of selected accessions of Ethiopian sesame (*Sesame indicum* L.) for salt tolerance. Bioc. and Agric. Biot., 9: 82-94.
9. **Black, C.A. (1982).** "Methods of Soil Analysis. Part 1, physical and mineralogical properties" Second (ed). Agronomy series no.9, SSSA, Madison, Wis., USA.
10. **Clark, M.S.; Horwath, H.R.; Shennan,C. and Scow, K.M.(1998).** Changes in soil chemical properties resulting fromorganic and low-input farming practices.Agron, Sci., 90:662-671.

11. **Debnath, S., Moharana, R.L. and Basu, A.K. (2007).** Evaluation of sesame (*Sesamum indicum* L.) genotypes for its seed production potential as influenced by bio-fertilizer. J. Crop and Weed, 3(2): 33-36.
12. **Deepthi1, Ch.; Ramana, A.V.; Upendra Rao, A. and Guru Murthy, P. (2020).** Effect of NPK and foliar nutrients on dry matter and nutrient uptake of rabi sesame. Inter. J. Agric., 10 (3):67-72.
13. **El-Habbasha, S.F.; Abd El Salam,M.S. and Kabesh,M.O. (2007).** Response of Two Sesame Varieties (*Sesamum indicum* L.) to Partial Replacement of Chemical Fertilizers by Bio-organic Fertilizers. Rese. J. Agric. and Biol. Sci., 3(6): 563-571.
14. **El-Khawas, M. A. (1990).** Effect of Azotobacter chroococum and Azospirllium brasiliance inoculation under graded levels of nitrogen growth and yield of wheat. Plant and Soil, 69:61-67.
15. **El-Khier, M.K.S.; Ishag, K.E.A. and Yagoub, A.E.A. (2008).** 'Chemical composition and oil characteristics of sesame seed cultivars grown in Sudan' Res. J. Agric. and Biol. Sci., 4(6):761-766.
16. **Elkholy, M.A.; Ashly, S.E. and Gomaa, A.M. (2005) '**Biofertilizer of maize crop and its impact on yield and grain nutrient under low rates of mineral fertilizers'. J. Applied Sci. Res., 2: 117-121.
17. **El-Kramany.M.F.; BahrAmany A.; Manal, F. Mohamed and Kabesh.M.O. (2007).** Utilization of Bio-Fertilizers in Field Crops Production 16-Groundnut Yield,its Components and Seeds Content as Affected by Partial Replacement of ChemicalFertilizers by Bio-Organic Fertilizers. J. Applied Sci.s Res., 3(1): 25-29.
18. **El-Mahdi, A. A. (2008).** Response of sesame to nitrogen and phosphorus fertilization in Northern Sudan. J. Applied Bio., 8(2): 304 - 308
19. **El-Nakhlawy, F.S. and Shaheen,M.A. (2009).** Response of seed yield, yield components and oil content to the sesame cultivar and nitrogen fertilizer rate diversity. Electronic J. of Environ. Agric. & Food Chem., 8 (4): 287-293.
20. **El-Samanody, M. K. M.; El-Marsafawy, S. M., and Rehab, H.K.A. (2010)** 'Impact of deficit irrigation at different growth stages on some sesame varieties in Upper Egypt'. J. Plant Prod. Mansoura Univ., 1 (7), pp. 857 – 871.

21. **Ghosh, DC. and Patra, A.K.(1994).** Effect of plant density and fertility levels on productivity and economics of summer sesame (*Sesamum indicum* L.) India J. Agron., 39: 71-75.
22. **Gomez, K. A. and Gomez, A. A. (1984) "**Statistical Procedures for Agriculture Research". 2nd ed. John Wiley and Sons. New York, USA. 680pp.
23. **Hasanpour, R.;Pirdashti,H.;Esmaeili,M.A. and Abbasian,A. (2012).** Effect of plant growth promoting rhizobacteria (PGPR) and nitrogen on qualitative characteristics of sesame
24. **Iorlamen, T.; Ayam, F. M. and Akombo, R. A. (2014).** Growth and yield response of sesame (*Sesamum indicum* L.) to foliar and soil applied fertilizer in Makurdi, Benue State. International Journal of Scientific Research and Management, 2(2), 528-541.
25. **Jadhav, S.R.; Naiknaware, M.D. and Pawar, G.R. (2015).** Effect of nitrogen, phosphorus and biofertilizers on growth, yield and quality of summer Sesamum (*Sesamum indicum* L.). Int. J. Tropical Agric. 33(2), 475-480.
26. **Kafiriti, E.M. and Deckers, J.(2001).** Sesame (*Sesamum indicum* L.). In R. H. Raemaekers (ed); Cropproduction in Tropical Africa. Directorate General for international Co- operation, Belgium. pp 797- 804.
27. **Kashani, S.;Buriro,M.;Nadeem,A.;Ahmed,N.;Saeed,Z.;Mohammad,F. and Ahmed,S. (2015)**. Response of various sesame varieties under the influence of nitrogen and phosphorus doses. Am. J. of Plant Sci., 6:405-412.
28. **Kumar, S.;Pandey,P. and Maheshwari,D.K. (2009).** Reduction in dose of chemical fertilizers and growth enhancement of sesame (*Sesamum indicum* L.) with application of rhizospheric competent Pseudomonas aerugionsa LES4. Eur. J. Soil Biol., 45: 334-340.
29. **Labib, H. A.; Hamza, M.; Abbas, M. S. and Fayed, S. A. (2019**). Bio and Organic Fertilizers as an Alternative to Conventional Mineral Source on Sesame (*Sesamum indicum* L.) Production and Oil Quality in Egypt. Egypt. J. Agron., 41 (2): 133 – 147.
30. **Maheshwari, D.K.; Dubey, R.C.; Aeron, A.; Kumar, B.; Kumar, S.; Tewari, S. and Arora, N.K. (2012)**. Integrated approach for disease management and growth enhancement of *Sesamum indicum* L. utilizing Azotobacter chroococcum TRA2 and chemical fertilizer. World J. Micr. Biot., 28(10): 3015-3024.

31. **Mahrous, N. M.;Abu-Hagaza,N. M.;Abotaleb,H. H. and Fakhry,S. M. K. (2015).** Enhancement of Growth and Yield Productivity of Sesame Plants by Application of Some Biological Treatments American-Eurasian J. Agric. & Environ. Sci., 15 (5): 903-912.
32. **Mujaya, IM. and Yerokum, O.A.(2003).** Response of sesame (*Sesamum indicum* L.) to plant population and nitrogen fertilizer in North-Central Zimbabwe. Sesame and Safflower Newsletter 18: 64 – 69.
33. **Purushottam, G. (2005)** Integrated nutrient management in sesame (*Sesamum indicum* L.) and its residual effect in succeeding chickpea (*Cicer arietinum* L.). M.Sc Thesis, University of Agricultural Sciences, Dharwad, India, 100 pp.
34. **Reddy, S.S.; Shivaraj, B.; Reddy, V.C. and Ananda, M.G. (2005).**Direct effect of fertilizers and residual effect of organic manures on yield and economics of maize (*Zea Mays* L.) in groundnut-maize cropping system. Crop Res. (Hisar). 31:1-5.
35. **Shehu, H.E. (2014) '**Effect of manganese and zinc fertilizers on shoot content and uptake of N, P and K in sesame (*Sesamum indicum* L.) on Lithosols' International Research Journal of Agric. Sci. and soil Science, 4(8), pp. 159-166.
36. **Shehu, H.E.; Kwari, J.D. and Sandabe, M.K. (2010).** Effects of N, P and K fertilizers on yield, content and uptake of N, P and K by sesame (*Sesamum indicum*)', Int. J. Agric. Biol., 12, pp. 845-850.
37. **Subash, M. and Rafath, H. (2016).** Effect of plant growth promoters and biofertilizers on yield and yield components of sesame (*Sesamum indicum* L.). Life Sci. Archives (LSA), 2(4), 622-627.
38. **Ulmar, U.A.;Mahmud,M.;Abubakar,I. U.;Babaji,B. A. and UIdris, D. (2012).** Effect of nitrogen fertilizer level and intra row spacing on growth and yield of sesame (*Sesamum indicun*, L) varieties. Tech. J. Eng. & Appl. Sci., J., (2-1):22-27.
39. **Weiss, E.A. (2000).** 'Oil seed Crops. 2nd Edit' Blackwell Science, London, United Kingdom, pp: 364.
40. **Ziedan, E.H.;Elewa,I.S.;Mostafa,M.H. and Sahab,A.F. (2011).** Application of mycorrhizae for controlling root diseases of sesame. Plant Protec. Res. J., 51(4): 355-367.