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Original Research

Effect of urea, compost, manure and bio-fertilizers on yield, percentage and composition of fatty acids of sesame seed oil (*Sesamum indicum* L.)

Esmaeil Ganjineh[1], Farzad Babaii[1*], Afshin Mozafari[1], Mohammad Heydari[1], Rahim Naseri[2]

[1] Department of Agronomy and Plant Breeding, College of Agriculture and Natural Resources, Islamic Azad University, Ilam Branch, Ilam, Iran
[2] Department of Agronomy and Plant Breeding, Faculty of Agriculture, Ilam University, Ilam, Iran

*Correspondence to: babaeiifarzad@gmail.com

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Abstract: This study was carried out in Iran during two growing seasons 2016-2017. Sesame is one of the earliest oilseed plants, high oil percentage and high content of unsaturated fatty acids, especially oleic acid and linoleic acid, have led to an increase in the nutritional quality of sesame oil. Accordingly, a two-year experiment was conducted as factorial based on randomized complete block design with three replications. The evaluated factors included four levels of urea as nitrogen fertilizer (0, 33, 66 and 100% of plant requirement), three kinds of organic fertilizer (manure, vermicompost and control) and four kinds of biofertilizers (Azosperillum, Azotobacter, Azosperillum +Azotobacter and control). At the end of the growing season, seed yield, percentage and yield of seed oil and fatty acids composition (oleic acid, linolenic acid, linoleic acid, stearic acid and palmitic acid) were measured. The results showed that the effect of different levels of nitrogen, organic and biological fertilizers on all studied traits was significant in two years of experiment and in all three environments (control, manure and compost). Vermicompost fertilizer and Azosperillum + Azotobacter have a more favorable effect on traits than other levels of each of these fertilizers, but nitrogen fertilizer levels have different effects on different traits. The highest seed yield (1298 kg ha^{-1}) was obtained for control environment in 100% nitrogen application, for manure environment in 33% nitrogen application (1565 kg ha^{-1}) and for compost environment in 66% nitrogen application (1799 kg ha^{-1}).

Key words: Azospirillum; Azotobacter; Compost; Seed oil; Sesame; Yield; Urea.

Introduction

Oilseed crops are economically important and valuable plants for human nutrition (1, 2). Sesame is one of the oldest oilseed crops and its high protein content (19-25%) and high content of unsaturated fatty acids, especially oleic acid and linoleic acid, have led to an increase in the nutritional quality of sesame oil (3). Due to the high quality of its oil, protein and anti-oxidant, sesame is in use in the production of food, medicine and also in industry. In addition, due to its deep roots, sesame is a tolerant crop and can be cultivated in dry and semi-dry regions (4) thus has a great potential to be cultivated in Iran.

There are so many factors involved to achieve the optimum yield of sesame and among them, nutrients are very important ones (5, 6). Among all nutrients, nitrogen (N) is the most important one so N management and its use efficiency is quite vital (7-9). Currently, farmers apply chemical fertilizers to achieve the highest production. However, in addition to higher yield, higher quality should be considered too (10). N is among nutrients that plants need it during their life cycle. Nitrogen fertilizers increase the green areas through expanding the shoots, chlorophyll and amino acids content and thus play an important role in increasing crops yield (11).

Few studies have found that sesame has not responded to chemical fertilizer application. This might be due to this fact that local varieties of this crop have adapted to low soil fertility while new cultivars positively respond to fertilizers (12). Studies of fertilizer effects on oil yield showed that 44 kg ha^{-1} nitrogen significantly increased the final oil yield compared to control (13). Garg *et al.* (14) showed that applying nitrogen increased the photosynthesis efficiency of sesame and resulted in higher growth and yield. In contrast, some of the studies indicated that seed oil production did not respond to nitrogen and manure (15). Sharma (16) reported that application of nitrogen fertilizer had a significant negative effect on oil percentage however as seed yield increased thus final oil production was increased too.

In recent decades application of chemical resources in agricultural fields has resulted in many environmental problems including groundwater resources contamination, lower agricultural production quality and reduction of lands fertility (17). Using bio-fertilizers can be considered as an alternative to avoid environmental pollution. These bio-resources are considered as an important component of sustainable agriculture (18, 19). Bio-fertilizers contain preservative materials which include soil microorganism or their derivative metabolites which are able to fertilize the land in any given sustainable system (20). Azospirillum and azotobacter in root environment are able to produce active biological materials like vitamin B, nicotinic acid, pentatonic acid, biotin, auxin, gibberellin and others which play important role in root growth (21). Positive effects of mycorrhiza in cropping systems due to its role in enhancing phosphate uptake (22) and interaction with useful soil microorganisms which reduce the pathogens, has been extensively reported (23). In spite of the positive roles of these bio-fertilizers on crop yield, their nitrogen-fixing species and mycorrhiza would be affected by the organic matter in growth media (24). Low levels of organic matters will reduce or delete the effects of bio-fertilizers on crop yield so in arid and semi-arid environments that character low content of organic materials, increasing yield may be possible by adding organic fertilizers. A few studies have shown that applying organic fertilizers (chicken manure and cow manure) for sesame have increased yield and yield components (5, 24).

The goal of this study is to evaluate the percentage seed oil, yield and composition of fatty acids in sesame in response to urea, bio and organic fertilizers under Kermanshah climate condition.

Materials and Methods

This study was performed for two years (2016 and 2017) in Agricultural Research Station of Kermanshah, Islamabad Garb located in 46.9E latitude and 34.8N longitude with 1260 a.s.l (m). Soil analysis for physicochemical properties was performed from the experimental field from a soil depth of 0-30 cm. Soil analysis showed (Table 1) that the soil texture is loamy. The experiment was conducted as factorial based on complete random block design with three replications. Treatments consisted of nitrogen fertilizer, seed inoculation by organic and bio-fertilizer. Urea fertilizer consisted of 4 levels (0.0, 33, 66 and 100% nitrogen requirement) in the form of urea, divided (50% each time) and applied at two times. First application time was at planting and the second application was at first weeding when plants height was 20 cm. Seed inoculation with fertilizers was also at four levels as no inoculation, inoculation with azotobacter, inoculation with azospirillum and inoculation with both bacteria. Third treatment included organic fertilizer at three levels as 0.0 application, 10 t ha^{-1} manure application and 10 t ha^{-1} compost application. Applied compost properties are shown in (Table 2). To perform this study, after the experiment land was disked, furrower was used to form the ridges and furrows.

Field preparation was performed based on local practices. Seeds were grown in ridges 50 cm apart and in each plot of 75 cm length. Distance between plots was 150 cm and between blocks was 300 cm. Manure and compost were added to soil 14 days before planting and mixed with soils to 30 cm depth. Planting was performed in mid of April and plants were thinned at two leaf stages to achieve 20 plants per square unit of ground. Half of the determined nitrogen fertilizer was applied as a band along with one side of ridges. The rest of the fertilizer (50%) was applied when the plants height was about 20 cm. During the main crop growth, weeds were manually removed. Irrigation was applied based on crop requirement, temperature and climate condition at every 7 to 12 days.

Weeds were removed by hands and irrigation was applied every 7 to 12 days based on plants requirement and climate conditions. When 50% of the capsules were brown, plants were harvested. A separate 3 m^2 of each plot was considered for final yield measurement. The harvested plants were oven dried at 72 °C and seed yield was measured. Random samples were obtained to measure the oil yield, percentage and amount of fatty acids (Oleic, linoleic, linolenic, stearic and palmitic acids) by GC. Final harvest for all treatments was performed when 50% of pods in each plot became brown. After removing the border lines of each plot, bout 3 m^2 was selected for a final yield of each plot. All crops in the selected area were cut from the crown and transferred to the lab. All samples were dried in an oven at 70°C and seed yield was measured. In order to measure the oil, the samples were chosen in random and transferred to the lab.

To measure the oil percentage, 10 g seeds from each treatment were chosen and ground, then the ground samples was placed in Whatman papers. Then the papers and seed powders were placed in Soxhlet to extract the oil (25). About 300 ml of Petroleum ether (40-60 °C) was used as a solvent. Extraction was performed for 4-4.5 hours then the samples were removed from chiller and oil was separated from the solvent. Finally, the seed oil percentage was calculated according to the below equation:

Oil percentage= ((Initial seed weight – Seed weight after oil extraction)/Initial seed weight) ×100

Extraction of the oil should not be under high temperature (avoid its fatty acids composition change). From each treatment about 50 g ground seed was also chosen for fatty acid determination with mixing ratio of 1-4 was mixed with hexane and for 48 hours were placed on a shaker (160 rpm) (26).

After the separation of the solvent from the solution, 15 drops of oil from each sample were placed in a tube and 7 ml potassium methoxide 2-molar was added. After shaking, the solution was transferred to a smaller tube and placed under a bain-marie temperature for 3 minutes. After removing the upper layer from the solution and pass it through the potassium sulfate for removing the moisture and purification, each sample was injected to Gas chromatography-mass (Dil Wcot Fused Silica type) with a column of 100 m, the internal diameter of 0.25mm and thickness of 0.2. Injection to

Table 1. Physico-chemical properties of field study soil.

Depth (cm)	Sat (%)	EC (dS/m)	pH	Organic carbon (%)	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Clay (%)	Silt (%)	Sand (%)
(0-30)	43	0.92	7.58	0.85	0.085	4.6	280	44.4	45	10.6

Table 2. Applied compost properties.

EC (dS/m)	pH	Nitrogen (%)	Phosphorus (%)	Potassium (%)	Iron (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})
18.85	7.4	3.19	0.41	0.086	473	69	10	10

gas chromatography performed as Split 100:1. Injection temperature was 250°C, detector temperature was 280 °C, helium makes up gas rate was 30 ml/min and the injection amount was 0.5 microlitre. By comparison of samples peak with reference one according to RRT (relative retention time), the fatty acids were identified. After collecting all the data, they were analyzed by SPSS (Version 22). The mean comparison was based on Duncan at the 5% probability level.

Results and discussion

Nitrogen and organic fertilizers showed a significant effect (P≤0.01) on both seed and oil yield in both experiment years under all three environments (control, manure and compost) (Table 3). Each level of treatments imposed a significant change in seed yield compared to control. Year effect was also showed significant (P≤0.01) across all experiment environments (Table 3). The highest seed yield (1298 kg ha^{-1}) was obtained from a control plot under 100% nitrogen requirement supply. Under manure environment and supplying 33% nitrogen requirement, seed yield was 1565 (kg ha^{-1}) and under compost environment, 66% supply of nitrogen requirement seed yield was 1799 (kg ha^{-1}) (Table 4). The bio-fertilizers of azotobacter and azospirillum were applied under environment control. Manure and organic fertilizers, compared to no fertilizer application resulted in higher seed yield by 24%, 22% and 20%, respectively (Table 4). Inoculation of seeds with bacteria resulted in a higher potential for plants to use nitrogen and other nutrients. Such inoculations help plants to expand their root system, improved water uptake and producing growth stimulators and vitamins, which enhance the crop growth and development.

In this study, the oil yield of 483 kg ha^{-1} was obtained from the control plots when 100% nitrogen requirement was supplied. Under manure environment and 33% nitrogen supply, oil yield was 667 (kg ha^{-1}), and for compost environment with 66% nitrogen requirement supply oil yield was 720 kg ha^{-1} (Table 4). The highest oil yield across all three environments was obtained under a compost environment. Application of nitrogen showed a significant and negative relation on oil yield but as higher N increased the seed yield thus oil yield was increased too. Bio-fertilizers also showed a positive effect on oil yield and the maximum was obtained by applying the combination of azotobacter and azospirillum and lowest oil yield obtained when no boo-fertilizer was applied. These results were similar in all three envi-

Table 3. ANOVA results of applying chemical, organic and bio-fertilizers on seed and oil yield of sesame in 2 years experiment.

		Mean Square								
		Seed yield			Oil yield			Oil %		
Source of variation	df	Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost
Year (Y)	1	818443**	640430**	619691**	122337**	107401**	29646**	0.602^{ns}	2.57^{ns}	69.0*
Block in year	4	11818	14175	15932	910	473	1329	1.72	3.47	7.26
Nitrogen (A)	3	552452**	594561**	1440374**	31784**	174728**	173461**	143**	332**	105**
Y*A	3	21342^{ns}	35233^{ns}	54010^{ns}	1675^{ns}	4034^{ns}	2991^{ns}	5.13^{ns}	11.5^{ns}	4.00^{ns}
Error a	12	10923	10601	17257	1642	2723	2706	3.57	3.30	2.955
Organic fertilizer (B)	3	250436**	306027**	326653**	60449**	93520**	61500**	71.4**	36.1**	1.81^{ns}
Y*B	3	14565^{ns}	3393^{ns}	3059^{ns}	3319^{ns}	440^{ns}	1328^{ns}	0.487^{ns}	0.506^{ns}	0.568^{ns}
A*B	9	8869^{ns}	13353^{ns}	326653^{ns}	1618^{ns}	5146^{ns}	3773^{ns}	1.21^{ns}	1.85^{ns}	2.40^{ns}
Y*A*B	9	2230^{ns}	2676^{ns}	5756^{ns}	764^{ns}	556^{ns}	1004^{ns}	1.52^{ns}	0.369^{ns}	0.298^{ns}
Error b	48	6231	27323	33305	1442	4337	5682	3.42	4.24	2.16
CV	-	7.04	11.9	11.7	8.43	12.1	12.1	4.58	5.23	3.66

**, * and ns: are significant at 1 and 5% probability levels and non-significant, respectively.

Table 4. Mean comparison of the effects of chemical, organic and bio-fertilizers on seed and oil yield of sesame in two years.

		Oil Percentage (%)			Oil yield (kg ha^{-1})			Oil yield (kg ha^{-1})		
Fertilizer	**Fertilizer Level**	**Control**	**Manure**	**Compost**	**Control**	**Manure**	**Compost**	**Control**	**Manure**	**Compost**
Nitrogen Fertilizer	N0	931^{c}	1185^{c}	1219^{c}	398^{b}	501^{c}	515^{d}	42.7^{a}	42.2^{a}	42.2^{a}
	N33	1099^{b}	1565^{a}	1576^{b}	460^{a}	667^{a}	644^{b}	41.8^{a}	42.5^{a}	40.9^{b}
	N66	1156^{b}	1426^{b}	1799^{a}	460^{a}	543^{b}	720^{a}	39.8^{b}	38.0^{b}	40.1^{c}
	N100	1298^{a}	1366^{b}	1641^{b}	483^{a}	474^{c}	610^{c}	37.2^{c}	34.7^{c}	37.3^{d}
Bio fertilizer	Control (C)	993^{c}	1248^{c}	1403^{c}	387^{c}	470^{c}	556^{c}	39.3^{b}	37.8^{c}	39.8^{a}
	Azotobacter (A)	1109^{b}	1377^{b}	1565^{b}	446^{b}	543^{b}	625^{b}	40.5^{a}	39.4^{b}	40.1^{a}
	Azospirillum (B)	1142^{b}	1393^{b}	1582^{ab}	459^{b}	550^{b}	629^{b}	40.5^{a}	39.5^{b}	40.0^{a}
	A+B	1240^{a}	1524^{a}	1685^{a}	510^{a}	622^{a}	679^{a}	41.3^{a}	40.8^{a}	40.5^{a}

Similar letters in each column indicate as no significant difference at 5% level.

ronments however the percentage increase or decrease was different (Table 4). Interactive effect of urea fertilizers and organic fertilizers were significant too at 5% probability (Table 5). Interaction of organic fertilizer and nitrogen indicated that the pattern of different levels of nitrogen effect on morphological traits and final yield would be different based on using or not using the organic fertilizer and its type.

Organic compost resulted in significantly highest seed yield (1478 kg ha^{-1}) and manure application resulted in 1304 kg ha^{-1} seed yield however at no application of organic fertilizer, 1029 kg ha^{-1} seed yield was harvested. Compost and manure application showed 43.6% and 26.7% higher seed yield compared to control, respectively. Many studies have shown that nitrogen fertilizer has improved the plant growth and enhanced various physiological processes to increase the assimilates and finally resulted in higher sesame seed yield (27). Compost contains many enzymes, growth regulators and nutrients available to crops and has a positive impact on final yield (27). High application of nitrogen increases the sesame final grain yield through increasing yield components (13). Sharma (16) reported that nitrogen application has a significantly negative effect on sesame oil percentage but through positive effects on yield components it resulted in higher seed oil. Studies on the effect of chicken manure on sesame seed yield have found that there is a positive interaction effect of chicken manure and nitrogen which increased both crop yield and soil fertility (28, 29).

Application of nitrogen significantly increased the seed yield and lowest yield the average of 1074 kg ha^{-1} was obtained when no nitrogen was applied (Table 6). No significant difference was shown among the three levels of nitrogen application, however at 66% per ha, nitrogen resulted in highest yield (1354 kg ha^{-1}) and in comparison to no nitrogen application, the yield was increased by 26.07%. Shehu *et al.* (30) reported that there was no significant difference for yield between using 75 and 112.5 kg ha^{-1} nitrogen and their conclusion was consistent with this study results. Applying bio-fertilizer showed a significant effect on seed yield and highest yield (1386 kg ha^{-1}) was obtained when a combination of azotobacter and azospirillum was applied (Table 6).

Highest oil yield (604.7 kg ha^{-1}) was obtained in response to organic and compost and was significantly ($P \leq 0.05$) different than control (Table 6). In comparison to no application of organic fertilizer, using compost resulted in a 45.7% increase in oil yield and manure increased it by 19.05%. It seems that compost has an effective role in oil yield increase. Among various nitrogen levels, the highest oil yield was associated with 33% nitrogen level with an average production of 556.4 kg ha^{-1} and it was not significantly different than 66% nitrogen level (Table 6). Among bio-fertilizers levels combined the application of azotobacter and azospirillum resulted in the highest oil yield (568.5 kg ha^{-1}) which was significantly different than other levels (Table 6).

Table 5. ANOVA analysis results for seed and oil yield.

		Mean Square		
Source of variation	**df**	**Seed yield (kg ha^{-1})**	**Oil yield (kg ha^{-1})**	**Oil percentage**
Replication	2	23342^{ns}	2742^{ns}	74.7^{ns}
Organic fertilizer	2	2467144**	431890**	39.99**
Chemical fertilizer	3	627421**	78716**	181.03**
Bio-fertilizer	3	423090**	102058**	22.13**
Organic*Chemical	6	156665**	40779**	10.10**
Organic*Bio	6	4072^{ns}	1173^{ns}	2.90^{ns}
Bio*Chemical	9	4945^{ns}	1068^{ns}	0.92^{ns}
Organic* Chemical*Bio	18	7135^{ns}	2045^{ns}	0.80^{ns}
Error	94	16010	3061	3.11
CV (%)		9.96%	10.83%	4.39%

**, * and ns: are significant at 1 and 5% probability levels and non-significant, respectively.

Table 6. Mean comparison at 5% level for main effects of organic, nitrogen and bio-fertilizer effects on seed and oil yield.

Fertilizer	Fertilizer level	Seed yield (kg ha^{-1})		Oil yield (kg ha^{-1})	
Organic	Compost	1478	a	604.7	a
	Control	1029	c	415.0	c
	Manure	1304	b	512.7	b
Chemical	Control	1074	b	454.5	c
	33%	1339	a	556.4	a
	66%	1354	a	541.2	a
	100%	1315	a	491.1	b
Bio-fertilizer	Control	1124	c	439.5	c
	Azotobacter	1284	b	517.7	b
	Azospirillum	1288	b	517.4	b
	Both bacteria	1386	a	568.5	a

Means with same letters in each column showed no significant difference (P<=0.05).

Table 7. Mean comparison of various fertilizer effects on seed and oil yield using Duncan at 5% level.

Treatment	Seed yield (kg ha^{-1})		Oil yield (kg ha^{-1})		Treatment	Seed yield (kg ha^{-1})		Oil yield (kg ha^{-1})	
Compost	993	o-r	424.1	n-t	N66	931	p-r	361.3	s-t
Azotobacter	1244	h-o	535.3	e-m	Azotobacter+N66	1106	k-q	442.7	l-s
Azospirillum	1241	h-o	530.5	f-n	Azospirillum+N66	1083	l-q	435.7	l-s
Azospirillum+Azotobacter	1304	e-m	561.8	d-k	Azospirillum+Azotobacter+N66	1194	i-o	489.5	i-q
N33	1418	c-j	580.9	c-j	N100	993	o-r	362.6	s-t
Azotobacter+N33	1509	b-g	634.1	c-f	Azotobacter+N100	1163	k-p	442.5	l-s
Azospirillum+N33	1529	b-f	626.7	c-g	Azospirillum+N100	1172	j-p	446.0	l-s
Azospirillum+Azotobacter+N33	1613	abc	662.4	bcd	Azospirillum+Azotobacter+N100	1342	d-k	522.6	g-o
N66	1560	bcd	630.0	c-g	Manure	1014	n-r	411.8	o-t
Azotobacter+N66	1678	ab	687.1	bc	Azotobacter+Manure	1170	j-p	491.3	i-q
Azospirillum+N66	1661	abc	680.9	bc	Azospirillum+Manure	1169	j-p	479.4	j-r
Azospirillum+Azotobacter+N66	1837	a	791.4	a	Azospirillum+Azotobacter+ Manure	1272	g-m	543.5	e-l
N100	1264	g-n	478.2	j-r	Manure+N33	1305	e-m	515.9	h-o
Azotobacter+N100	1542	b-e	595.1	c-i	Azotobacter+Manure+N33	1482	b-h	616.6	c-h
Azospirillum+N100	1612	abc	629.0	c-g	Azospirillum+Manure+N33	1529	b-f	642.3	b-e
Azospirillum+Azotobacter+N100	1651	abc	627.7	c-g	Azospirillum+ Azospirillum+Manure+N33	1681	ab	737.4	ab
Control	780	r	323.6	t	Manure+N66	1158	k-p	416.8	o-t
Azotobacter	911	q-r	388.8	q-t	Azotobacter+Manure+N66	1324	d-l	503.0	i-p
Azospirillum	891	q-r	380.6	q-t	Azospirillum+Manure+N66	1284	f-m	489.1	i-q
Azospirillum+Azotobacter	897	q-r	383.5	q-t	Azospirillum+Azotobacter+Manure+N66	1431	c-i	566.6	d-j
N33	911	q-r	370.3	rst	Manure+N100	1159	k-p	398.9	p-t
Azotobacter+N33	1021	n-r	428.0	m-t	Azotobacter+Manure+N100	1263	g-n	448.4	l-s
Azospirillum+N33	1000	o-r	415.1	o-t	Azospirillum+Manure+N100	1281	g-m	453.3	k-s
Azospirillum+Azotobacter+N33	1065	m-q	447.4	l-s	Azospirillum+Azotobacter+Manure+N100	1340	d-k	488.6	i-q

This study results showed that mean of all fertilizers treatments or in other words triple effect interaction for all four yield traits using Duncan approach for seed yield indicated (Table 7) that treatment as vermi-azospirillum+azotobacter+N66 resulted in highest seed yield (1837 kg ha^{-1}) and oil yield of 791.4 (kg ha^{-1}) which in comparison with control was 2.35 times more seed yield. This triple treatment did not show significant difference with manure treatments of azospirillum + azotobacter + N66, vermin-azotobacter + N66, vermi-azospirillum + N66, vermi-azospirillum + azotobacter + N100, vermi-azospirillum + azotobacter + N33, vermi-azospirillum + N100, for seed yield (Table 7). However, oil yield showed significant difference with all treatments except with vermi-azospirillum + N100. Control treatment resulted in lowest seed yield (780 kg ha^{-1}) and oil yield (323.6 kg ha^{-1}) and did not show any significant difference with N66, N100, N33, azospirillum, azospirillum + azotobacter, azotobacter, manure + N100, azospirillum + N33, manure + N66, vermin and azotobacter + N33 (Table 7).

Our results are consistent with other studies that found for sesame fertilization management, a combination of chemical, organic and bio-fertilizers can increase the crop yield and same time reduce the negative effects on the environment (31). Babajide and Fagbola (32) showed that azospirillum has an effective role in oil yield production under nitrogen limitation. Haruna and Aliyu (15) on studying the effect of nitrogen on sesame seed yield, showed that by increasing the fertilizer level, vegetative growth of plants increased but seed yield did not show a significant increase. Boghdady *et al.* (31) indicated that seed yield increase due to chemical fertilizer application was about the same as when bio-fertilizers were used so concluded that instead of using 100 fertilizers from chemical ones, it is better to use combined chemical and bio-fertilizers which can reduce the application of chemical fertilizers by 50%.

The effect of chemical, organic, and bio-fertilizer on oil percentage

Nitrogen levels significantly (P≤0.01%) affected the sesame oil percentage under all types of fertilizer environment (control, manure, and compost) for both years of the experiment (Table 3). Bio-fertilizer levels were effective (P≤0.01%) only under control and manure environments. The main effect of year was significant only under compost environment (Table 3). Increasing nitrogen application decreased the oil percentages and highest percentage was obtained at no nitrogen application and even under control condition oil percentage was higher than manure or compost environments which were due to nitrogen in soil under these two environments (Table 4). Oil percentage under bio-fertilizer showed that under control environments were at least amount and other three treatments did not show any significant difference but under manure environments, the maximum was associated with combined fertilizers of azospirillum + azotobacter (Table 4). In general, by increasing nitrogen, oil percentage reduced which indicates the negative relation between applied nitrogen and oil percentage.

The effect of chemical, organic and bio-fertilizer on oleic acid

According to Table 8, the effect of nitrogen levels on the oleic acid percentage of sesame across control, manure and compost environments were significant (P≤0.01). This study results showed that oleic acid increased at any level of nitrogen application compared to control (Table 9). Other studies also reported that linolenic and oleic fatty acids were the highest among other fatty acids in sesame seeds (33, 34). High oleic acid indicates a high quality of oil for frying and high linolenic acid indicates high-quality oil for salad (34). The effect of nitrogen on linolenic acid was significant in both years of the experiment (Table 9).

The effect of chemical, organic and bio-fertilizer on linoleic acid

Nitrogen levels effects on linoleic acid of sesame oil in both years of the experiment under all three environments (control, manure, and compost) was significant (P≤0.01) (Table 8). Nitrogen application compared to control, manure and compost environments reduced the linoleic acid by 29%, 39%, and 30% respectively compared to when no nitrogen was applied. Bio-fertilizer showed no effect on linoleic acid and the highest amount of linoleic acid was when no bio-fertilizer was applied. Azotobacter and azospirillum are able to produce biomaterials like vitamin B, pantothenic acid, nicotinic acid, auxin and gibberellin and are able to increase organic matter available to plants (20).

The effect of chemical, organic and bio-fertilizer on linolenic acid

Nitrogen levels effects on linolenic acid of sesame oil in both years of the experiment under all three environments (control, manure, and compost) was significant (P≤0.01) (Table 8). Bio-fertilizer was only effective only under manure, and compost environments. The main effect of year of study was only effective on linolenic only under manure environment (Table 8). Nitrogen application showed a negative association with linolenic acid content of sesame oil and the highest amount was obtained when no nitrogen was applied (Table 9).

Under control environment, bio-fertilizer did not show any significant difference with control on linolenic acid but under manure and compost environments, the least amount was associated with combined application of azospirillum + azotobacter (Table 9). Saturated and non-saturated fatty acids of sesame oil respond differently to fertilizer treatments. By increasing the linolenic acid in plants oil, oxidation rate will increase to reduce the oil stability and higher unnatural tastes will decrease the oil consumption value. Based on this study, availability of soil nutrient increases the oil yield, and through reduction of the linolenic acid and increasing, oleic acid will increase oil quality.

The effect of chemical, organic and bio-fertilizer on palmitic acid

The effects of nitrogen on palmitic acid were significant under all three control, compost and manure environments (Table 8). The bio-fertilizer effect was significant under manure and compost environments (Table 8). Based on (Table 9), palmitic acid in sesame oil was

Table 8. ANOVA results for effects of nitrogen and bio-fertilizer on oleic and linolenic fatty acids in sesame.

Source of variation		Mean Square														
		Oleic			linoleic			linolenic			Palmetic			Stearic		
	df	Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost
Year (Y)	1	22.9**	73.5**	4.29^{ns}	32.3*	60.3**	29.0*	0.0013^{ns}	0.0049*	0.0006^{ns}	0.0037^{ns}	0.440^{ns}	3.19^{ns}	0.655^{ns}	0.088^{ns}	2.62^{ns}
Block	4	0.769	2.13	2.01	1.98	0.692	1.48	0.0015	0.0005	0.0008	0.1027	0.325	0.54	0.221	0.436	0.487
Nitrogen (A)	3	23.6**	3.55*	46.5**	61.1**	12.5**	67.3**	0.218**	0.114**	0.237**	3.81**	2.81**	1.38**	2.64**	3.02**	0.703^{ns}
Y*A	3	9.43**	1.29^{ns}	6.96**	2.57^{ns}	7.67**	9.04**	0.0044**	0.0046**	0.003**	0.769^{ns}	0.753^{ns}	0.483**	0.506^{ns}	0.882*	0.175^{ns}
Error a	12	1.015	0.815	1.08	1.17	0.879	1.17	0.0002	0.0003	0.0003	0.244	0.257	0.077	0.173	0.247	0.238
Biofertilizer (B)	3	8.00^{ns}	5.79^{ns}	1.39^{ns}	6.12^{ns}	27.4**	5.25*	0.0031^{ns}	0.028**	0.018**	0.217^{ns}	2.46**	0.760**	0.528^{ns}	1.60**	0.262^{ns}
Y*B	3	1.83^{ns}	1.30^{ns}	3.62^{ns}	0.664^{ns}	1.62^{ns}	1.58^{ns}	0.0008^{ns}	0.0002^{ns}	0.0007^{ns}	0.231^{ns}	0.119^{ns}	0.220^{ns}	0.188^{ns}	0.146^{ns}	0.119^{ns}
A*B	9	0.666^{ns}	0.969^{ns}	0.808^{ns}	1.23^{ns}	0.776^{ns}	0.896^{ns}	0.00007^{ns}	0.004**	0.0006^{ns}	0.029^{ns}	0.0048^{ns}	0.264^{ns}	0.085^{ns}	0.043^{ns}	0.212^{ns}
Y*A*B	9	2.44^{ns}	1.11^{ns}	1.06^{ns}	1.45^{ns}	0.722^{ns}	1.42^{ns}	0.0009^{ns}	0.0006^{ns}	0.0005^{ns}	0.142^{ns}	0.066^{ns}	0.140^{ns}	0.049^{ns}	0.051^{ns}	0.039^{ns}
Error b	48	4.52	3.47	2.14	3.50	2.75	1.40	0.0013	0.0008	0.0013	0.235	0.335	0.168	0.288	0.372	0.381
CV (%)	-	4.68	3.95	3.12	5.98	5.72	3.97	6.80	5.90	6.59	4.52	5.23	3.81	6.28	6.89	7.20

Table 9. Mean comparison of nitrogen, and bio-fertilizer o fatty acids in sesame seeds.

Fertilizer	Fertilizer level	Mean Square														
		Oleic			linoleic			linolenic			Palmetic			Stearic		
		Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost	Control	Manure	Compost
Nitrogen	N0	44.1^{c}	47.2^{ab}	45.7^{c}	33.4^{a}	29.9^{a}	31.1^{a}	0.638^{a}	0.564^{a}	0.658^{a}	10.3^{c}	10.6^{b}	10.7^{b}	8.13^{c}	8.35^{b}	8.47^{a}
	N33	45.4^{b}	47.0^{b}	45.9^{c}	31.2^{b}	29.1^{b}	31.1^{a}	0.577^{b}	0.524^{b}	0.604^{b}	10.8^{b}	11.1^{a}	10.5^{c}	8.58^{b}	8.83^{a}	8.42^{a}
	N66	45.9^{ab}	46.7^{b}	47.2^{b}	30.9^{b}	28.9^{b}	29.4^{b}	0.494^{c}	0.465^{c}	0.523^{c}	10.6^{b}	11.3^{a}	10.8^{b}	8.51^{b}	9.10^{a}	8.62^{a}
	N100	46.4^{a}	47.6^{a}	48.7^{a}	29.6^{c}	28.1^{c}	27.6^{c}	0.420^{d}	0.406^{d}	0.430^{d}	11.3^{a}	11.3^{a}	11.1^{a}	8.94^{a}	9.10^{a}	8.80^{a}
Bio-fertlizer	Control (C)	45.6^{a}	46.5^{a}	46.7^{a}	31.4^{a}	30.2^{a}	30.3^{a}	0.543^{a}	0.533^{a}	0.592^{a}	10.6^{a}	10.7^{c}	10.5^{b}	8.33^{a}	8.53^{c}	8.43^{a}
	Azetobacter (A)	46.0^{a}	47.1^{a}	46.6^{a}	30.7^{a}	29.2^{b}	30.0^{a}	0.524^{a}	0.492^{b}	0.553^{b}	10.8^{a}	11.0^{bc}	10.8^{a}	8.55^{a}	8.80^{bc}	8.58^{a}
	Azospirillum (B)	45.5^{a}	47.2^{a}	46.8^{a}	31.1^{a}	28.9^{b}	29.7^{ab}	0.521^{a}	0.483^{b}	0.537^{bc}	10.8^{a}	11.1^{b}	10.9^{a}	8.60^{a}	8.90^{ab}	8.64^{a}
	A x B	44.6^{a}	47.7^{a}	47.2^{a}	31.9^{a}	27.6^{c}	29.2^{b}	0.542^{a}	0.450^{c}	0.532^{c}	10.8^{a}	11.5^{a}	10.9^{a}	8.68^{a}	9.16^{a}	8.66^{a}

Means with similar letters show no significant difference at 5% level of probability.

higher when nitrogen was applied compared to when nitrogen was not applied. For bio-fertilizer the there was no different effects under control environment but under manure and compost environments the highest amount was obtained with combined azotobacter and azospirillum treatment (Table 9).

The effect of chemical, organic and bio-fertilizer on stearic acid

The effect of nitrogen and bio-fertilizer on stearic acid content was significant as for nitrogen was under control, manure and bio-fertilizer was under manure environment effective (Table 8). Application of nitrogen under control and manure environments would increase 10 and 8% Stearic acid of sesame oil in comparison when no nitrogen was applied. The highest amount of Stearic acid was obtained at 100% nitrogen requirement application (Table 9). Comparison of the average production of Stearic acid across different levels of bio-fertilizers showed that azotobacter and azospirillum under manure environment increased Stearic acid (Table 9).

Highest seed yield was different and was depending to study environment across different nitrogen, bio and organic fertilizer. Highest seed yield under control environment at 100% nitrogen application was 1298 kg ha^{-1}, under manure environment at 33% nitrogen application was 1565 kg ha^{-1} and under compost environment at 66% nitrogen application was 1799 kg ha^{-1}. The mixture of bio-fertilizer azotobacter and azospirillum at the three environments (control, manure a compost) increased the seed yield by 24, 22, and 20% compared to no fertilizer application. Bio-fertilizer effect was significant on oil percentage and see protein percent across all three environments (control, manure, and compost). Increasing the nitrogen application showed a negative effect on seed oil percentage and higher oil percentage was obtained at no nitrogen application. Under the control environment of bio-fertilizer, lowest oil percentage was obtained when no bio-fertilizer applied but under manure environment, highest seed yield was obtained by a mixture of azotobacter and azospirillum fertilizers.

In general, this study results showed that application of organic and bio-fertilizers resulted in more nutrient availability in soil, higher seed and oil yield, increased oleic, stearic, and palmitic acids and low linolenic, and linoleic acids which increased the seed oil quality.

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