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Effect of manure sources and rates on nitrogen replacement value, sesame yield and nutrient content under drip irrigation system

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Abstract

Background: This work was conducted to investigate the effect of different manure types (compost, chicken manure and FYM) at 12, 24 and 48 m^3 ha^{-1} with or without reduced N rate (72 kg ha^{-1}) compared with N fertilizer levels: 0, 36, 72 and 108 kg ha^{-1} under drip irrigation system. Therefore, field trials were established in the summer seasons of 2018 and 2019 on a private farm, Belbais District, Sharkia Governorate, in a newly reclaimed soil (loomy calcareous). Sesame seed yield, oil content and macro- and micronutrients were determined.

Results: Highly significant effects due to organic sources applied were apparent on seed yield and yield components. Yield response to FYM at the lowest rate compared to the other two sources and rates was evident. Correlation analysis of the various yield characteristics with N fertilizer application was reported. Fertilizer replacement value in manure sources ranged between 30 and 62%. The chemical analysis of sesame seeds indicated that chemical composition of sesame seed was insensitive to the type of soil amendment.

Conclusion: It could be concluded from this study that the predictable benefits from manure application to sesame will increase farmer confidence in organic fertilizers reducing the reliance up on inorganic fertilizers for crop nutrition and improving the sesame seed nutrient content.

Keywords: Sesame, Organic manure, Yield, Oil, Protein, N equivalency, Macro- and micronutrient status

Background

Sesame (*Sesamum indicum* L.) is an important oil seed crop grown in tropical and subtropical areas with high nutritive value (Ashri 1989; NCRI 2005). The main important world producers are India, China, Sudan, Myanmar, Ethiopia, Uganda and Nigeria (Wikipedia 2009).

The demand on sesame is increasing for its multiple uses, but there is a wide gap between production and consumption of sesame in Egypt. Sesame cultivation is sensitive to unsuitable soil conditions such as low fertility, salinity and poor moisture retention. Due to the shortage of animal manures, it is important to substitute other materials as organic wastes and composts to fulfill the organic matter requirement of these soils (Abd El Lateef et al. 2019a). Soil amendments such as farmyard and chicken manures are handled by many investigators as soil conditioners and fertilizers for increasing growth and yield of many field crops and vegetables (Abd El Lateef et al. 2019b). Organic materials are a major source of organic matter and plant nutrients resulting in improved soil physical and chemical attributes, especially nutrient content (Craswell and Lefroy 2001; Murphy 2015). Application of organic manures to sesame improves its seed

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yield and quality (Mbagwu and Ekwealor 1990; Anyanga and Obong 2001; Bedigian 2003; Morris 2002).

Slow and gradual lasting release of a wide range of nutrient elements to the soil could be achieved by organic matter (Ogbonna and Umar-Shaba 2012; Abd El-Lateef et al. 2019a).

Both macro- and micronutrients integrated with organic amendments like farmyard manures should be saved to sesame (Singh et al. 2018). Abdel Sabour and Abo El Soud (1996) indicated that all compost treatments have beneficial effects to sesame.

Integration of organic and inorganic fertilizer could save better nutrient management in sesame with advantages of maintaining higher productivity and providing stability in crop production, balanced proportion for sustainable production of sesame besides improving soil physical conditions (Teshome 2016; Sahu et al. 2018). Higher seed yield of sesame can be obtained by integrated use of fertilizer along with FYM (Purushottam 2005; Sahu et al. 2017). Haruna and Abimiku (2012) found that application of 2.5 t ha^{-1} of poultry manure produced the highest value for all the yield attributes measured.

These trials aimed to manage the use of different manure sources and rates, for a new crop for this type of land under drip irrigation. Another objective was to determine nitrogen fertilizer replacement value of different manure sources and to monitor the nutritional status of macro- and micronutrients in sesame seeds.

Methods

Two field trials were carried out in the summer of 2018 and 2019 seasons on a private farm, 8 km east of Bilbeis, south of Ismailia Canal, Sharkia Governorate, in a newly reclaimed sandy calcareous soil (EC 6.3 ds m^{-1}), $CaCO_3$ (5.6–19%). The objective of the trials was to manage different soil ameliorating nutrients through manure application types (Compost, chicken manure and FYM) at rate of 12, 24 and 48 m^3 $h^{-1}$with or without reduced N rate (72 kg ha^{-1}) as well as N fertilizer levels: 0, 36, 72 and 108 kg ha^{-1} on sesame yield and nitrogen fertilizer equivalency under drip irrigation system. Another objective of this work was to monitor the nutritional status of macro- and micronutrients in sesame seeds. The soil was newly reclaimed desert soil (loomy calcareous), and the physical and chemical analyses of the soil are listed in Table 1. Each experiment included 22 treatments as listed in Tables 6 and 8. The experimental design in the trials was complete randomized block design (CRBD) with four replicates. Manures were delivered to the site, and the chemical analysis of the manures applied is given in Table 2. The experimental soil was plowed twice with fixed-tine harrow and divided to experimental units each of 21 m^2 area. Thereafter, the manures were calibrated on a volumetric basis and applied to the assigned plots. Manure application was carried out manually according to common farmyard manure application in the district. In order to ensure homogenous incorporation with the soil surface layer, a rotary cultivator was used. Sesame (*Sesamum indicum* L.), Mutation 48, was sown on June 25, 2018, and June 15, 2019 seasons, respectively. Sowing was carried out by hand at 15 cm distance in the wetting area of the drippers line. Irrigation was applied every two-day intervals.

The agronomic practices for sesame followed the normal farmer practice in the district. During seed-bed preparation, the phosphatic fertilizer was applied as calcium superphosphate (15.5% P_2O_5) was applied at 76 kg P_2O_5 ha^{-1}. Nitrogen was applied as ammonium sulfate (20.6% N) in split applications through fertigation, while the potassium was applied as potassium sulfate (48–52% K_2O) at 57 kg K_2O ha^{-1}. Harvesting of the sesame was carried out on 20 and 15 September in first and second seasons, respectively.

Data collected

Sesame plant height, number of branches and capsules $plant^{-1}$ were determined. All plants from each plot were harvested left in the field until full drying to determine seed yield ha^{-1}, harvest index, seed oil yield ha^{-1} and seed protein yield ha^{-1}.

Chemical analysis

Seeds of harvested sesame were analyzed for their contents of nutrients. Chemical analysis was carried out on dried and ground samples. Nitrogen was determined by micro-Kjeldahl according to the AOAC (2005). After wet digestion of the samples, according to Chapman and Pratt (1978), P was determined by spectrophotometry, K was determined by flame photometer (Jackson 1967) and Fe, Mn, Cu and Zn were determined by atomic absorption spectrophotometry. Other analyses were according to the methods described by Jackson (1967). Seed oil content (%) was determined by using Soxhlet extraction apparatus using petroleum as a solvent according to AOAC (2005).

Oil yield and seed protein yield ha^{-1} were calculated by multiplying seed yield × seed oil percentage and seed protein%, respectively.

To define the optimum dressings of manure sources for crop production, a dynamic modeling approach was used to describe yield effects and quantitative numerical descriptions of the relationships between crop yield and the amount of a particular input applied to the soil.

The model used to describe the crop yield takes the numerical form (Cooke 1982) as follows:

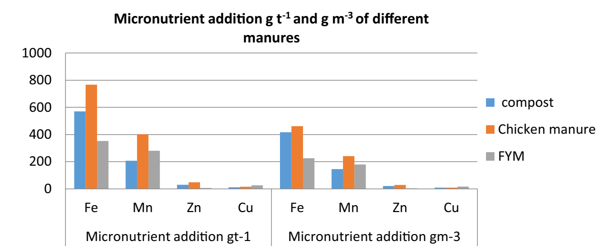

Fig. 1 Micronutrient addition in the different manures applied

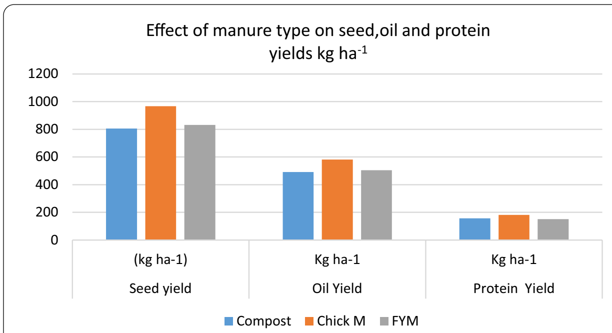

Fig. 3 Effect of manure type on seed, oil and protein yields kg ha^{-1}

Linear model: $y = a + b_1 x$

where y is the measured yield variable (units: t ha^{-1} or kg ha^{-1}); b_1 is the regression coefficient representing the linear gradient (or slope) of the incremental yield response to increasing application rate; x (units: kg ha^{-1}, m^3 ha^{-1}) of the fertilizer or manure; and a is a constant value (intercept) representing the yield obtained without fertilizer or manure. The N fertilizer equivalency is calculated by dividing the regression coefficient for the manure, on the basis of its rate of total N application, with the coefficient obtained for the yield response to applied mineral N. The units quantifying the rate of N supplied to the soil are the same, kg N ha^{-1}, in both cases for both manures and inorganic fertilizer.

The N equivalency value was estimated by the following equation according to Colwell (1994):

$$\text{N equivalency (\%)} = \frac{1/b(y-a)}{\text{N}} \times 100$$

where a is the regression intercept value), b is the regression 4 coefficient, y is the mean root yield recorded for the plots supplied with compost or FYM at a rate of 24 m^3 ha^{-1} and N is the rate of N application at 24 m^3 ha^{-1} of farmyard manure or compost.

Statistical analysis

The data were subjected to the proper statistical analysis using (MSTAT-C Software package 1988). Since the data in both seasons took similar trends, Bartlett's test was applied and the combined analysis of the data was done. For means comparison, least significant difference (LSD) at 5% level was applied.

Results

The chemical analysis of manure applied to the field trials is reported in Table 2. The manures contained more than 71.9, 73.1 and 91.4% dry solids for FYM, plant compost and chicken manure, respectively, indicating that they were generally similar. Therefore, the plant compost and chicken manure have comparable soil conditioning properties as the conventional bulky organic manure at equivalent rates of application to soil. Chicken manure contained 44% more N compared with the average content in FYM and fivefold increase compared to the plant compost (Table 3). Plant compost and FYM supplied similar amounts of total P in the dry solids. K excreted in the wastes of domestic livestock is largely retained in the bedding material that forms the main bulk matrix of FYM.

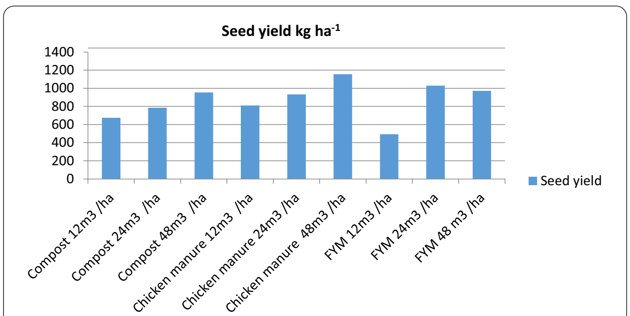

Fig. 2 Effect of manure types and rates on sesame yield

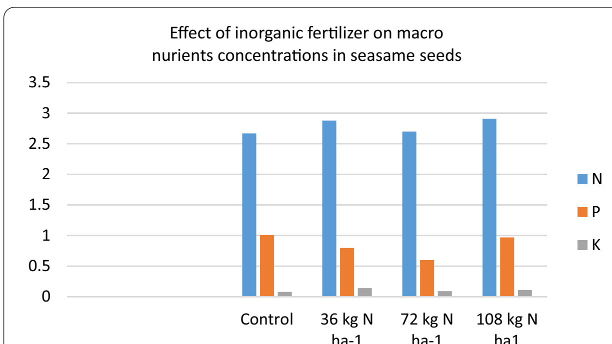

Fig. 4 Effect of inorganic fertilizer on macronutrients concentrations in sesame seeds %

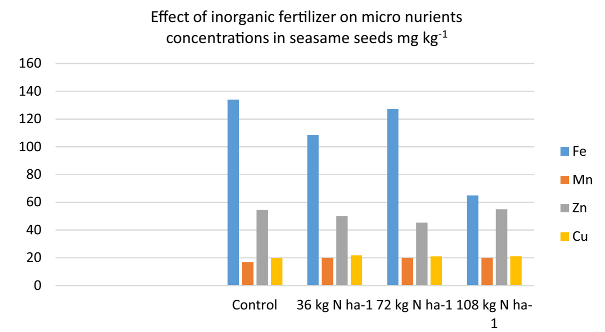

Fig. 5 Effect of inorganic fertilizer on micronutrients concentrations in sesame seeds

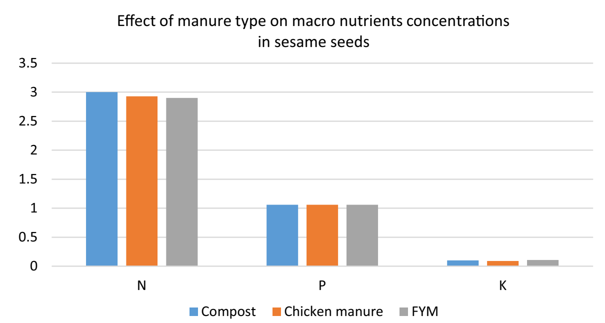

Fig. 6 Effect of manure type on macronutrients concentrations in sesame seeds

Micronutrient addition in the different manures applied

As expected, the concentrations of trace elements in the plant compost are larger than for FYM. Data presented in Table 4 and Fig. 1 show the four key micronutrients Fe, Mn, Zn and Cu loading rates when applied by the different manures.

Sesame yield and yield components

Three-way ANOVA showed there were significant main effects of manure type and rate, and inorganic N fertilizer application on seed yield and yield components of sesame (Table 5). A significant interaction ($P=0.002$) was also apparent between the type of manure and the rate of application.

Data presented in Table 6 show significant differences among different manure types on sesame number of branches plant^{-1}, 1000-seed weight, seed yield ha^{-1}, oil and protein yields ha^{-1}. Application of chicken manure resulted in the highest significant increase in seed, protein and oil yields ha^{-1}.

Data in Table 7 show gradual increases in sesame yield characters as N level increases over the control treatment. Seed, protein and oil yields reached their maximum values per hectare when sesame plants were fertilized with 108 kg N ha^{-1} as compared with the other N levels or the control treatment. It is clear from the same table that application of moderate N levels (72 kg N ha^{-1}) alone resulted in reasonable yields but could not achieve the greatest seed, oil and protein yields reported by the higher N level 108 kg N ha^{-1}.

The measured yield characteristics of sesame are listed in Table 8, and the analysis of variance indicated highly significant effects of the interaction among experimental treatments on number of branches plant^{-1}, 1000-seed weight (g) seed, oil and protein yields (kg ha^{-1}). Data presented in Table 8 show significant interaction effects among fertilizer treatments on No of branches plant^{-1}, 1000-seed weight and seed yield kg ha^{-1}. However, plant height and number of capsules plant^{-1} did not significantly affect. The highest seed yield ha^{-1} was achieved when chicken manure was applied at 48 m^3 ha^{-1}, 24 m^3 FYM combined with 72 kg N which mounted 15.9% and 9.7% increase over the recommended dose applied

Table 1 Physicochemical properties of soil samples from profile inspection pits at the field trial site

Depth (cm)	Gravels (% > 2 mm)	$CaCO_3$ (%)	Gypsum (%)	pH	EC (dS m^{-1})	Cation concentration (me l^{-1})				Anion concentration (me l^{-1})		
						Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{2-}
0–20	25.6	5.6	0.23	8.81	6.3	30.2	11.1	25.1	1.2	2.4	29.3	35.9
25–80	28.8	18.0	0.09	8.66	7.1	35.6	12.1	30.4	1.7	3.6	28.1	48.1
80–150	19.2	19.2	0.14	8.83	7.5	40.1	9.3	33.6	1.3	3.8	35.1	45.4

Table 2 Chemical analysis of bio-solids (units: ds, VS, N, P, K and Fe as %; other elements as mg kg^{-1})

Manure	ds	VS	N	P	K	Fe	Mn	Zn	Cu
Plant compost	73.1	59.8	0.37	0.72	0.14	0.78	283	40.3	16.0
Chicken manure	91.4	66.0	1.73	1.23	0.14	0.84	440	52.4	16.0
FYM	71.9	68.0	1.20	0.55	0.62	0.49	390	8.0	35

Table 3 Nitrogen additions in bio-solids applied

Manure applied		Plant compost kg N ha^{-1}	Chicken manure kg N ha^{-1}	FYM kg N ha^{-1}
t ha^{-1}	m^3 ha^{-1}			
7.2	12	33.60	73.68	54.24
14.4	24	66.96	147.36	108.48
28.8	48	133.92	294.72	216.96

(108 kg N), respectively (Fig. 2). Seed oil and protein contents % were not significantly affected by treatments. The highest seed oil content % was determined when the plants were fertilized with the lower rate of N applied or the compost with or without the adjusted N rate (72 kg N ha^{-1}), while the highest protein% was achieved by compost application at 12 m^3 and chicken manure at 24 m^3 ha^{-1} alone (Fig. 3).

From the same table, it is clear that there were significant effects due to fertilizer treatments on oil and protein yields ha^{-1}. Sesame fertilization with 48 m^3 or farm yard manure at 24 m^3 combined with 72 kg N ha^{-1} gave 15.1 and 6.8% increase over the recommended N rate (108 kg N ha^{-1}), respectively. Meanwhile, the same treatments produced 25 and 6.4% increase in protein yields over the recommended N rate applied. Such results could be attributed to the high N content in chicken manure and K in the farm yard manure.

Correlation analysis

Correlation analysis of the various yield characteristics showed that seed yield, capsule number and plant stature were raised significantly with increasing rate of applied mineral N (Table 9). Crop response to applied compost, chicken manure, FYM and inorganic N fertilizer followed a linear pattern and was effectively summarized by these simple regression models (Table 9).

Nitrogen fertilizer equivalencies

The N equivalency values which express the N fertilizer replacement value of the applied organic manures were estimated from the regression coefficients of the linear models and in relation to inorganic N fertilizer and are presented in Table 10. The N equivalence of chicken manure was 50% of mineral N, and the yield response to compost at equivalent rates of N addition was 30% of that obtained with inorganic N fertilizer.

Table 5 Results of ANOVA to assess the effects of manure type and rate, and N fertilizer application on seed yield of sesame

Source of variation	F-ratio	Probability	Significance level
Blocks	0.163	0.691	ns
Main effects			
Fertilizer (Fert.)	49.5	< 0.001	***
Manure rate (Rate)	45.1	< 0.001	***
Manure type (type)	9.62	0.002	**
Interactions			
Fert. × rate	0.880	0.433	ns
Fert. × type	3.26	0.063	ns
Rate × type	6.44	0.002	**
Fert. × rate × Type	4.86	0.008	**

Total and available N supplied in organic manures

On the basis of the sesame seed yield response to the applied organic manures and N fertilizer equivalency, the available N content of the applied compost, chicken manure and FYM is estimated to be: 1.4 kg N m^{-3} (2.1 kg N t^{-1} ds), 3.1 kg N m^{-3} (5.1 kg N t^{-1} ds) and 1.7 kg N m^{-3} (1.7 kg N t^{-1} ds), respectively (Table 11).

Chemical composition of sesame seeds

Data presented in Table 12 show that only P, Fe, Mn and Cu concentrations in sesame seed were significantly affected by the experimental treatments (Figs. 4, 5, 6). The results showed that copper and P concentrations in sesame seed were significantly affected by organic manures and improved the seed contents of these elements compared to inorganic fertilizer.

Discussion

Due to the bedding used in preparing FYM which is a relatively rich source of K compared with compost and contained more than four times the amount of K (0.62% ds) compared with chicken manure (0.14% ds) or compost, compensation for the soil with this major plant nutrient

Table 4 micronutrients loading rates applied by the different manures

Manure	Micronutrient addition g t^{-1}				Micronutrient addition g m^{-3}			
	Fe	Mn	Zn	Cu	Fe	Mn	Zn	Cu
Plant compost	570.0	206.9	29.5	11.7	416.0	144.8	20.6	8.4
Chicken manure	767.0	402.2	47.9	14.6	461.0	241.3	28.7	8.8
FYM	352.0	280.4	5.8	25.2	225.0	179.5	3.7	16.1

Table 6 Effect of manure types on sesame yield components, oil and protein yields

Manure type	Plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	1000-seed weight (g)	Seed yield (kg ha^{-1})	Seed oil content	Protein content	Oil yield kg ha^{-1}	Protein yield kg ha^{-1}
Compost	115.8	6.2	86.4	3.1	804.6	61.1	19.6	490.8	157.4
Chicken manure	125.7	7.7	114.7	3.1	966.8	59.9	18.8	580.9	181.4
FYM	119.5	6.4	114.9	3.1	831.8	60.5	18.1	503.9	151.4
F probability	0.41	0.01	0.24	0.02	< 0.001	0.409	0.443	0.226	0.305
LSD at 0.05	ns	5.35	ns	ns	425	ns	ns	34	21
cv (%)	10.8	27.8	64.8	10.8	33.4	10.8	3.4	8.8	6.4

Table 7 Effect of N fertilizer rates on sesame yield components, oil and protein yields

N fertilizer rates	Plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	1000-seed weight (g)	Seed yield (kg ha^{-1})	Seed oil content%	Protein content%	Oil yield kg ha^{-1}	Protein yield kg ha^{-1}
Control	101.0	5.4	51.5	2.603	255.6	61.73	16.69	157.8	42.7
36 kg N ha^{-1}	111.7	4.7	52.4	2.418	544.8	63.15	18.0	344.0	98.1
72 kg N ha^{-1}	118.5	5.7	115.8	2.975	820.8	60.72	16.88	498.4	138.5
108 kg N ha^{-1}	129.0	7.5	122.6	2.848	1194.0	62.11	18.19	741.6	217.2
F probability	0.41	0.01	0.24	0.02	< 0.001	0.41	0.44	< 0.001	0.01
LSD at 0.05	ns	5.35	ns	0.509	425	ns	ns	54	36
cv (%)	10.8	27.8	64.8	10.8	33.4	10.8	3.4	12	22

is recommended to maintain crop productivity through supplying FYM or inorganic K fertilizer in the crop rotation. The estimated N application from plant compost ranged between 33.6 and 133.9, farmyard manure 54.2 and 216.7 and chicken manure 73.7 and 294.7 kg N ha^{-1} according to the rate of application. Similarly, chicken manure contained the greatest rates of Fe, Mn and Zn per ton or cubic meter. However, FYM contained the greatest Cu rates applied to the soil. This may be due to the high rates of Cu in animal diet. Abd El Lateef et al. (2018,2019b) reported substantial macro- and micronutrients applied to either cowpea or sugar peat through organic manures although the additions are rather small but on the long term will be significant under continues application and will be beneficial to the soil. Moreover, similar results were obtained by Sahu et al. (2017, 2018); they attributed the enhancing effect of manure to the gradual and slow release of nutrient to the soil as well as improving the soil physical properties to the benefit of the crop. The superiority of chicken manure than the other two sources was confirmed by Ogbonna and Umar-Shaba (2012). They showed that the application of poultry manure significantly promoted sesame growth and yield. Seed yield ha^{-1} was increased as manure rate was increased.

Regarding yield and yield components, it is clear that application of moderate N levels (72 kg N ha^{-1}) alone resulted in reasonable yields but could not achieve the greatest seed, oil and protein yields reported by the higher N level 108 kg N ha^{-1}. The efficiency of N fertilizer on sesame yield characters was reported by Malik et al. (2003), Noorka et al. (2011), Umar et al. (2012), Elamin Ibrahim et al. (2014) and Elamin and Madhavi (2015); they revealed that the application of nitrogen at 80 kg ha^{-1} produced significantly higher seed yield of sesame due to enhanced value of yield attributes, viz. number of capsules plant^{-1}, number of seeds capsule^{-1}, seed yield (g plant^{-1}) and harvest index as compared to other dose of nitrogen. It is emphasized, however, that the apparent increase in mean seed yield at the highest rate of chicken manure was explained by the inorganic N fertilizer treatment. Crop yield was not raised at the high rate of chicken manure without mineral N compared to the 24 m^3 ha^{-1}. This behavior also explains the basis to the significant third-order interaction ($P = 0.008$) detected by ANOVA (Table 5).

The results of the integration of organic and inorganic fertilizer indicate that it could save better nutrient management in sesame with advantages of maintaining higher productivity and providing stability in crop

Table 8 Effect of nitrogen fertilizers and manure types and rates on sesame yield components, oil and protein yields

Treatment	Plant height (cm)	Branches plant^{-1}	Capsules plant^{-1}	1000-seed weight (g)	Seed yield (kg ha^{-1})	% of the recommended N level	Seed oil content	Protein content	Oil yield kg ha^{-1}	% of the recommended N level	Protein yield kg ha^{-1}	% of the recommended N level
Control	101.0	5.4	51.5	2.60	256	21.4	61.73	16.7	157.8	21.3	42.7	19.7
Fert. 36 kg N ha^{-1}	111.7	4.7	52.4	2.42	545	45.6	63.15	18.0	344.0	46.4	98.1	45.2
Fert. 72 kg N ha^{-1}	118.5	5.7	115.8	2.98	821	68.7	60.72	16.9	498.4	67.3	138.5	63.8
Fert. 108 kg N ha^{-1}	129.0	7.5	122.6	2.85	1194	100.0	62.11	18.2	741.6	100.1	217.2	100.0
Compost 12 m^3	109.3	4.6	48.1	2.72	662	55.5	59.90	19.8	396.8	53.5	131.2	60.4
Compost 12 m^3 ha^{-1} + F	122.8	6.1	81.0	3.07	688	57.6	61.39	20.4	422.1	57.0	140.1	64.5
Compost 24 m^3	101.3	4.5	54.4	3.27	684	57.3	62.23	18.9	425.7	57.4	129.1	59.4
Compost 24 m^3 ha^{-1} + F	111.7	5.3	102.7	3.21	886	74.2	63.16	18.7	559.3	75.5	165.5	76.2
Compost 48 m^3 ha^{-1}	122.5	6.1	91.4	3.13	894	74.9	60.05	19.9	536.8	72.4	178.2	82.0
Compost 48 m^3 ha^{-1} + F	126.9	10.5	140.6	3.06	1014	84.9	59.60	19.8	604.3	81.6	200.3	92.2
Chicken manure12 m^3 ha^{-1}	122.0	5.5	84.0	3.28	701	58.7	58.24	20.1	408.1	55.1	140.6	64.7
Chicken manure 12 m^3 ha^{-1} + F	117.0	7.0	98.3	2.89	922	77.2	59.26	16.3	546.1	73.7	149.8	69.0
Chicken manure 24 m^3 ha^{-1}	130.5	8.2	103.0	3.26	890	74.6	60.50	20.3	538.7	72.7	180.9	83.3
Chicken manure 24 m^3 ha^{-1} + F	119.5	8.4	129.5	3.22	977	81.8	61.85	18.7	604.2	81.5	182.5	84.0
Chicken manure 48 m^3 ha^{-1}	131.0	7.6	112.1	2.65	928	77.7	57.68	17.6	535.0	72.2	162.9	75.0
Chicken manure 48 m^3 ha^{-1} + F	134.0	9.3	161.0	3.09	1384	115.9	61.65	19.6	853.0	115.1	271.5	125.0
FYM 12 m^3 ha^{-1}	112.9	5.5	277.0	3.37	349	29.2	59.34	18.3	207.2	28.0	63.7	29.3
FYM 12 m^3 ha^{-1} + F	112.4	5.9	55.8	2.78	640	53.6	61.74	15.3	394.9	53.3	97.9	45.1
FYM 24 m^3 ha^{-1}	114.5	5.6	67.0	3.41	749	62.7	60.24	18.5	451.1	60.9	138.5	63.8
FYM 24 m^3 ha^{-1} + F	126.5	6.2	82.5	3.03	1310	109.7	60.42	17.6	791.7	106.8	231.0	106.4
FYM 48 m^3 ha^{-1}	125.4	7.2	92.7	2.65	929	77.8	61.70	20.6	573.1	77.3	191.0	87.9

Table 8 (continued)

Treatment	Plant height (cm)	Branches $plant^{-1}$	Capsules $plant^{-1}$	1000-seed weight (g)	Seed yield (kg ha^{-1})	% of the recommended N level	Seed oil content	Protein content	Oil yield kg ha^{-1}	% of the recommended N level	Protein yield kg ha^{-1}	% of the recommended N level
FYM 48 m^3 ha^{-1} + F	125.5	7.7	114.4	3.10	1014	84.9	59.69	18.4	605.3	81.7	186.3	85.8
F probability	0.409	0.009	0.242	0.022	< 0.001	–	0.409	0.443	0.033	–	0.053	–
LSD at 0.05	ns	5.35	ns	0.509	425		ns	ns	89.2	–	54.8	–

Table 9 Linear regression models of relationships ($y = a + bx$) between sesame yield parameters and inorganic N fertilizer application

Yield component	Constant (a)	Regression coefficient (b)	r^2	Probability	Significance level
Seed yield (kg ha^{-1})	100.1	8.59	0.93	< 0.001	***
1000-seed weight (g)	No significant relationship				
Capsule no. plant^{-1}	44.1	1.84	0.71	0.009	**
Branch no. plant^{-1}	No significant relationship				
Plant height (cm)	101.4	0.605	0.89	< 0.001	***
Seed oil content (%)	No significant relationship				

Application rates of inorganic N were: 0, 36, 72 and 108 kg N ha^{-1}

Table 10 Nitrogen fertilizer equivalencies of different manure types estimated from linear regression coefficients of the relationships ($y = a + bx$) between seed yield (kg ha^{-1}) of sesame and the quantities of N applied (kg ha^{-1}) in the manures

N source	Regression coefficient (b)	Probability	r^2	*N* equivalence relative to inorganic *N* (%) ($b_{orgN} \div b_{inorgN} \times 100$)
Compost	2.61	0.003**	0.80	30
Chicken manure[a]	4.31	0.001**	0.94	50
FYM	5.35	< 0.001***	0.88	62
Inorganic N[b]	8.58	< 0.001***	0.93	

[a] 24 m^3 ha^{-1}

[b] The maximum rate of application used in estimating the regression coefficient for compost, chicken manure and FYM

Table 11 Total and available N supplied in organic manures and FYM

N source	Total N (ds)		Available N (ds)	
	kg t^{-1}	kg m^{-3}	kg t^{-1}	kg m^{-3}
Compost	7.06	4.52	2.15	1.38
Chicken manure	10.24	6.14	5.14	3.08
FYM	2.66	2.79	1.66	1.74

production, balanced proportion for sustainable production of sesame besides improving soil physical conditions (Teshome 2016; Sahu et al. 2017). Higher seed yield of sesame can be obtained by integrated use of fertilizer along with FYM Purushottam (2005). Chatterjee et al. (2017) and Sahu et al. (2017) came to similar conclusion.

Linear regression models formed on the basis of calculations of N fertilizer equivalency values for the manures showed that the crop response to applied compost, chicken manure, FYM and inorganic N fertilizer followed a linear pattern and were effectively summarized by these simple regression models. Binh and Lieu (2016) found that the correlation relationship between yield and yield attributes of sesame showed that seed yield strongly correlated with plant height ($r = 0.93$***), number of capsules plant^{-1} ($r = 0.88$***), number of seed (0.86***), capsule length ($r = 0.77$***) capsule ($r = 0.74$***), weight of 1000 seeds (0.64***) and weight of seeds/five capsules (0.61**).

The N equivalence of chicken manure was 50% of mineral N, and the yield response to compost at equivalent rates of N addition was 30% of that obtained with inorganic N fertilizer. The higher N equivalency (62%) apparent for FYM compared with compost is probably explained by reasons other than its N content. For example, FYM contained more than four times the amount of K compared with compost which is frequently limiting to agricultural production in Egyptian soils (Table 1). In this respect, Abd El Lateef et al. (2019b) reported that the N equivalencies estimated for FYM were less consistent than for sewage sludge, reflecting the more variable chemical composition of FYM, and were usually similar to, or lower than, the sludge products. However, the N equivalency value calculated for FYM was apparently much larger than for manure with soybean. Farmyard manure increased seed yield of soybean by 60% compared with inorganic fertilizer supplied at equivalent rates of N addition.

The results of seed content of macro- and micronutrients showed that the organic materials significantly improved the seed status of these elements compared to inorganic fertilizer which was confirmed by Ibrahim

Table 12 Chemical composition of sesame seed

Treatment	N	P	K	Fe	Mn	Zn	Cu	Ni	Cd	Pb	Co
Control	2.67	1.01	0.08	134.1	17	54.7	19.9	13.2	1.1	6.6	1.4
Fert. 36 kg N ha^{-1}	2.88	0.80	0.14	108.4	20	50.2	21.7	15.1	1.1	5.3	1.3
Fert. 72 kg N ha^{-1}	2.70	0.60	0.09	127.2	20	45.3	21.0	11.5	1.0	7.1	1.4
Fert. 108 kg N ha^{-1}	2.91	0.97	0.11	65.0	20	55.0	21.2	11.7	0.9	6.9	2.0
Compost 12 m^3	3.17	1.10	0.10	62.4	19	54.7	24.6	9.9	1.1	6.0	2.3
Compost 12 m^3 ha^{-1} + F	3.26	1.04	0.11	78.9	20	68.6	27.5	13.4	0.5	1.9	1.7
Compost 24 m^3	3.02	1.04	0.12	101.4	22	66.6	25.7	15.7	1.1	5.5	3.1
Compost 24 m^3 ha^{-1} + F	2.99	1.12	0.11	69.7	18	46.1	24.7	13.2	1.0	4.0	1.7
Compost 48 m^3 ha^{-1}	3.19	1.04	0.48	112.5	20	69.6	23.0	12.9	0.8	1.4	2.5
Compost 48 m^3 ha^{-1} + F	3.16	1.05	0.14	97.3	20	48.9	22.9	15.0	0.6	5.5	2.1
Chicken manure 12 m^3 ha^{-1}	3.21	1.02	0.08	89.1	19	105.0	22.7	15.3	1.1	4.7	1.7
Chicken manure12 m^3 ha^{-1} + F	2.60	1.14	0.12	70.9	18	54.2	22.8	10.2	1.0	3.5	2.0
Chicken manure 24 m^3 ha^{-1}	3.25	1.08	0.11	89.1	20	68.3	22.0	12.6	1.0	1.7	1.7
Chicken manure 24 m^3 ha^{-1} + F	2.99	1.05	0.08	83.9	17	110.1	25.0	17.4	1.3	3.7	2.6
Chicken manure 48 m^3 ha^{-1}	2.81	1.03	0.12	120.6	33	62.4	21.8	17.0	0.7	0.9	1.8
Chicken manure 48 m^3 ha^{-1} + F	3.14	1.02	0.07	73.3	16	42.7	23.7	14.4	0.6	5.7	2.2
FYM 12 m^3 ha^{-1}	2.92	1.12	0.10	97.8	21	101.4	22.8	13.6	1.1	5.7	1.4
FYM 12 m^3 ha^{-1} + F	2.45	1.05	0.07	162.2	14	43.1	22.0	10.3	0.7	2.9	1.5
FYM 24 m^3 ha^{-1}	2.96	1.00	0.10	79.9	20	45.0	21.5	10.7	1.2	1.6	2.5
FYM 24 m^3 ha^{-1} + F	2.82	1.05	0.12	105.0	19	52.3	22.2	14.4	1.1	3.2	2.0
FYM 48 m^3 ha^{-1}	3.29	1.07	0.14	105.3	24	71.0	23.4	13.0	0.9	3.5	2.5
FYM 48 m^3 ha^{-1} + F	2.94	1.05	0.13	112.9	18	53.0	24.4	13.4	1.0	4.0	2.0
F probability	0.22	0.02	0.37	0.05	0.03	0.29	0.01	0.97	0.65	0.27	0.44
LSD at 0.05	ns	0.41	ns	99.2	13	ns	5.5	ns	ns	ns	ns

et al. (2014). Ewulo et al. (2007), Khaled et al. (2012) and Anguria et al. (2017) reported that combined application of organic manures enhanced uptake of N, P and K by plants and the level of each on its initial concentration in organic manure.

The results presented here for sesame are entirely consistent with N equivalency values. This implies that organic manures are relatively consistent materials for use as fertilizers and soil amendments in agriculture. Moreover, manures apply significant macro- and micronutrients with agronomic and economic value to such poor soils.

Conclusion

It could be concluded from this study that organic manures application could provide further evidence of the significant N fertilizer replacement value of organic manures on reclaimed desert soils. Chicken manure was 50% as effective as N source compared with inorganic N and compost was 30% as effective. The results presented for sesame are entirely consistent with N equivalency values. This implies that organic manures are relatively consistent materials for use as fertilizers and soil amendments in agriculture.

Abbreviations

FYM: Farm yard manure; DS: Dry solids; VS: Volatile solids; C.V%: Coefficient of variation.

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Authors' contributions

EMA and MSA conceived and designed the experiments, MSA and AW performed the experiments and analyzed the data, and EMA, MSA and AW wrote the paper and reviewed the manuscript. All authors read and approved the final manuscript.

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Declarations

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Competing interests
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