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Effect of organic manure and tillage depths on sunflower (*Helianthus annuus* L.) production

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Effect of organic manure and tillage depths on sunflower (*Helianthus annuus* L.) production

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Abstract

One of the factors affecting the productivity of sunflower is poor management of soil service operations such as tillage depth. As choosing the depth of tillage helps in increasing the growth of the root system, which is reflected in the plant vegetative growth. Although the addition of animal manure can increase the activities of microorganisms in the soil and the soil contents of available nutrients, the effects on sunflowers were not tested under dry land conditions of Basrah province. Field experiment was carried out during the 2020 growing season, at two locations, to determine the effect of three tillage depths (10, 20 and 30 cm) and four organic manure levels (M0= without manure, M1= 6 t ha^{-1}, M2= 8 t ha^{-1}, M3= 10 t ha^{-1}) on sunflower performance, seed yield and selected soil properties. Results showed that, the maximum vegetative parameters, yield component and yield were recorded at 30 and 20 cm tillage depth treatments at the both growing locations without significant differences between them compared to 10 cm tillage depth. Number of seeds head^{-1} was not influenced by tillage depth treatments over the two locations. Tillage depth of 30 cm significantly improved seed yield as compared to 10 cm tillage depth. The maximum seed yield recorded by 30 cm tillage depth. The application of organic manure had a significant effect on sunflower seed yield, biomass yield, head diameter, 500 seed weight, seeds head^{-1}, leaf area, leaves plant^{-1}, plant height and stem girth at the both growing locations.

1. Introduction

One of the annual oleaginous crops is Sunflower (*Helianthus annuus* L.), that belongs to the class of dicotyledons. The crop was widely used in many countries for cooked oil production compared to alternative oilseeds [1]. In the recent years, sunflower consumption has increased. The local average of seed production of sunflower was 2333.2 kg ha^{-1} in 2019 [2]. The production is still, therefore, below current needs, consequently, improved productivity of this crop is essential to meet supply shortages. Sunflower crops have been poor productivity in some areas in southern Iraq, due to the use of low-capacity conventional cultivars and the lack of suitable practices such as mineral nutrition and sufficient depth of tillage. The poor content of nitrogen and phosphorus characterizes much of the soils in Iraq southern parts. The use of high doses of mineral fertilizers, usually offsets this deficiency [3] that considered an economically and environmentally unsatisfactory solution. For these reasons, there has been an increase in the search for alternate fertilizer sources, which are less environmentally damaging and economically effective.

Organic manure contains large macro-nutrient quantities (i.e., N, P and K) [4]. Organic manure contains other elements, including secondary nutrients and micro-nutrients, which are significantly responsible for increased crop yield [5]. It was also observed that after application of 15 t. ha^{-1} and 30 t. ha^{-1} cattle manure and 10 t. ha^{-1} and 20 t. ha^{-1} polymers, soils pH, organic matter, Nitrogen, available phosphorus, exchangeable potassium, calcium and magnesium were increased relative to control [6]. Several organic fertilizer sources are currently used in agriculture. However, little information is available about the amounts to be used in sunflower crops to achieve a better yield. The purpose of this study was therefore to evaluate the effects of depths of tillage and organic manure fertilization on yield components and yield of sunflower, cultivated at two growing locations.

2. Material and methods

Field experiment was conducted during 2020 growing season at Shatt Al-Arab (SL) 17 km east Basra province, and Al-Qurna (QL), 74 km northwest Basrah province, Iraq, to investigate the response of sunflower to tillage depths and organic manure.

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Prior to the experiment, soil characteristics were determined (Table 1). Disturbed and undisturbed soil samples from 0–10, 10–20 and 20–30 cm depth were taken at 5 random locations at cross-diagonal sampling points to better represent the field. Disturbed soil samples have been taken using the auger and analyzed using the hydrometer process for particle size distributions [7]. Undisturbed soil samples were collected using stainless steel cylinders to assess the bulk density of the soil from each depth [8]. The experimental design was a randomized complete block design in a split plot arrangement replicated three times. The main plots were three-tillage depths (10, 20 and 30 cm), the subplots, consisted of four organic manure levels (M0= without manure fertilizer (control), M1= organic manure 6 t ha^{-1}, M2= organic manure 8 t ha^{-1}, M3= organic manure 10 t ha^{-1}). Tillage depths were conducted using chisel ploughing followed by harrowing with disc harrowing. Organic manure was added and mixed thoroughly with soil, according to each tillage depth treatment, followed by watering 21 days before sowing [9]. Cattle manure was the source of organic manure. It was fetched from vicinity farmer. (Table 2).

Plot area was 4.5×2.5 m^2. Each plot consisted of 6 rows 75 cm apart, and 20 cm between hills. Three seeds were sown per hill at 3 cm depth, thinning down to one plants per hill at 21 days after sowing. The plots were separated by 1 m to avoid encroachment of manure. Sunflower (*Helianthus annuus* L. TARSAN-1018 hybrid) were sown after soil preparation. Seeding was carried out on June 15th, 2020. The weeds control was manually performed during the experiment. Phosphorus fertilizer was added before sowing at a rate of 70 kg P_2O_5 ha^{-1} as superphosphate (15.5% P_2O_5). Potassium sulfate (48%, K_2O) was applied at a rate of 60 kg K_2O ha^{-1} before sowing. Urea (46%, N) as a source of nitrogen, was added as stimulation dose at 60 kg ha^{-1} [10].

At physiological maturity, the observations of the parameters viz, plant height (cm), stem girth (cm), leaves $plant^{-1}$, head diameter (cm), seeds $head^{-1}$ and 500-seed weight, were recorded. Ten randomly selected sample plants were taken from each sub plot. These plants samples were averaged for data collected. For determination of seed yield, plants were harvested from one square meter area of each sub plot, seeds were separated, weighted and yield per hectare was determined. After harvesting, three undisturbed soil samples using core method from 0-10, 10-20 and 20-30 cm soil depths were taken for determination of bulk density. Meteorological data were recorded from local meteorological station (Table 3).

Table 1. Physical and chemical characterization of the soil at the two location.

Parameters	Soil Characteristic	
	SL location	QL location
Soil texture	Silty Clay	Silty Clay
Sand (%)	11.3	7.6
Silt (%)	47.9	46.1
Clay (%)	40.8	46.3
Ec_e (dS m^{-1})	8.32	10.31
pH	7.31	7.18
Available N mg/kg soil	39.01	41.1
Available P mg kg^{-1} soil	14.9	17.3
Available K mg kg^{-1} soil	184.32	196.2
Soluble K^+ mmoI L^{-1}	3.01	3.21
Soluble Na^+ mmoI L^{-1}	27.64	31.44
Soluble Ca_2^+ mmoI L^{-1}	12.71	19.41
Soluble Mg_2^+ mmoI L^{-1}	8.32	12.32
Cl^- (mEq L^{-1}) mmoI L^{-1}	24.15	36.52
HCO_3^- mmoI L^{-1}	4.2	3.6
O.M. (%) g kg^{-1} soil	9.13	6.23

Table 2. Chemical characteristics of the organic manure used.

pH	Total nitrogen %	P g kg^{-1}	K g kg^{-1}	Na g kg^{-1}	Ca g kg^{-1}	Mg g kg^{-1}
7.9	1.72	4.53	11.34	6.75	15.53	7.98

Table 3. Monthly meteorological data at the both growing locations.

	SL location				QL location			
	Temperature				Temperature			
Month	Maximum C°	Minimum C°	Humidity %	Rainfall mm	Maximum C°	Minimum C°	Humidity %	Rainfall mm
Jun	46.20	28.01	7.12		45.51	29.55	6.46	
Jul	46.33	29.45	7.39	-	46.87	30.00	5.79	-
Aug	45.08	27.95	7.60	-	45.46	26.51	9.00	-
Sep	43.23	25.91	9.55	-	42.34	25.91	11.80	-
Oct	37.9	20.16	4.26	-	37.76	21.44	5.9	-
Nov	31.24	12.58	25.91	13.2	30.96	12.19	24.87	58.0

Data were analyzed statistically with analysis of variance (ANOVA) procedures using Genstat version 12. Differences among treatments means were evaluated with the least significant difference (LSD) test accepted at 5% probability.

3. Results and discussion

3.1. Plant height (cm)

Height is an important for plant needs of sunlight to stimulate photosynthesis to increase growth rate. Data shown in Table 4 indicated that use of 30 and 20 cm helped in producing significantly taller plants with an average height of 112.08 and 110.42 cm in the SL location and 110.42 and 108.50 cm respectively in the QL location without significant differences between them. Meanwhile 10 cm tillage depth recorded 106.42 and 103.08 cm in the SL and QL location respectively. The increase in the depth of tillage led to loosening the soil in the root zone, which helped the root to spread well and deepen the root system that increased its utilization of water and nutrients, and this led to an increase in plant height.

Data illustrated in Table 4 showed that plant height at harvest in the SL and QL location was increased with the application of different OM levels compared to the control treatment. Plants were higher at the SL location after M3, M2 and M1 without significant differences among treatments (112.56, 111.33 and 108.33 cm respectively) compared with M0 that recording lower plants 106.33 cm. At the QL location, the highest plants were recorded for M3 and M2 without significant differences between them 109.67 and 108.44 cm respectively, while it was 104.44 cm for the control treatment without organic manure M0. This may be because organic matter is decomposed and nutrients are released in the available form. These results are consistent with [11], they stated that addition of 5 ton of poultry residues recorded the highest sorghum plants compared with control treatment without addition.The different combinations of tillage depths and organic manure levels treatments had no significant effect on seed plant height.

3.2. Stem girth

The data illustrated in Table 4 demonstrate that the use of different tillage depths significantly increased the stem girth. The individual effect of tillage depth showed an increases in the order of, 30 cm>20 cm>10 cm. This trend was probably due to better availability of moisture with increasing tillage depth that facilitate nutrient movement, as bulk density decreased with increasing tillage depth (Table 5). The results regarding stem girth of sunflower as influenced by use of different organic manure levels are given in Table 4. It is apparent from the results that stem girth was highest (2.24 and 1.92 cm in the SL location and 1.87 and 1.68 cm in the QL location) under M3 and M2 treatments respectively without significant differences between them. The stem girth decreased under M0 and M1 treatments without significant differences between them (1.49 and 1.72 cm respectively in the SL location and 1.45 and 1.55 cm respectively in the QL location). The enhanced stem girth could be due to the applied organic manure levels that might increase the available nutrient for plant, hence an improved sunflower stem girth. The addition of organic matter mends the physical and chemical properties of soil, which reflected on plant growth [12]. [13] indicated that the girth of sunflower stem was significantly influenced by application of different rates of chicken manure, as application of 10 t ha^{-1} of chicken manure produced highest stem girth (3.3 cm). Stem girth was not significantly altered by tillage depths and organic manure interaction (Table 4).

3.3. Leaves plant^{-1}

The effect of tillage depths on number of leaves per plant shown in Table 4. The tillage depths of 30 and 20 cm resulted in significant higher number of leaves per plant than 10 cm (21.33 and 14.67% respectively in the SL location and 17.91 and 9.02% respectively in the QL location). The increase in tillage depth reduced the bulk density of soil (Table 5) that might facilitate water and nutrient movement at the root zone. The increase in the availability of nutrient promotes apical branching consequently the total number of leaves that appear on a plant [14].

Table 4 shows changes in plant leaves number. The effect of organic manure levels on plant leaves number was significant at the both locations. Plant leaves number values at M3 and M2 organic manure levels were higher than those at control treatment without organic manure. The addition of organic manure might providing adequate amount of nutrient, in addition to increase moisture retaining in the soil that provide better condition for increase vegetative growth. [15] mentioned that application of manure had significant effect on the number of leaves for sunflower. The interaction between tillage depths and organic manure levels was not significant for number of leaves per plant value during the experiments at the both locations.

3.4. Leaf area cm^2 plant^{-1}
The leaf area recorded under different tillage depths and organic manure levels over the two locations shown in Table 4. The results indicated that, the leaf area per plant was affected by tillage depths at both locations. The maximum leaf area (3372.53 and 3088.90 cm^2 plant^{-1} in the SL and QL location respectively) was recorded under 30 cm, and it decreased under 20 cm (2847.11 and 2506.09 and cm^2 plant^{-1} in the SL and QL location respectively) and 10 cm (2606.38 and 1763.36 cm^2 plant^{-1} in the SL and QL location respectively). This could be ascribed to the lower bulk density (Table 5) in the root zone that may facilitate root growth and proliferation, which enhance nutrients absorption and supply adequate water requirements.

The amount of organic manure has significant effect on the leaf area (Table 4). M3 gave wider leaves (3689.55 and 2778.94 cm^2 plant^{-1} in the SL and QL location respectively) than that of control without organic manure (2049.94 and 1973.55 cm^2 plant^{-1} in the SL and QL location respectively). The addition of organic manure might increase nutrient in the soil, which has favored conditions for plant growth that might increase cell expansion and division, thus increasing the leaf area. [13] report similar results, where leaf area of sunflower plants was affected statistically by varying rates of chicken manure as it was (173.2 cm^2) in plots earlier augmented with chicken manure at 5 t ha^{-1}, while the leaf area was (117.5 cm^2) in the control plot. There were no significant differences in the interaction between tillage depth and organic manure in the leaf area (Table 4).

3.5. Head diameter (cm)
Maximizing tillage depth increased the head diameter of sunflower (Table 4). Head diameter was significantly lower in the 10 cm (by 13.29% and 13.65 in the SL and QL location respectively), and the 20 cm (by 5.57% and 5.68 in the SL and QL location respectively), compared with 30 cm tillage depth. The tillage depth of 30 cm reduced soil bulk density at deeper layers (Table 5), which might improve root growing and proliferation of sunflower as compared with 10 cm. Such improvement might provide favorable conditions for root growth that might improve plant performance. These results are similar to those of [16], who reported an increase in head diameter with increasing tillage intensity. The analysis of variance showed a significant effect of organic manure on head diameter of sunflower (Table 4). The greatest value was found in M3 at the two growing locations and was significantly on par with M2 and M1. Lower value of head diameter recorded for M0. As organic manure rate increased, the head diameter of sunflower plants increased, this effect might attributed to positive contribution of nutrient released by organic manure on plant growth. Positive responses for diameter of the head to organic fertilization were found by [17], when studying cattle manure effects on sunflower (Embrapa 122/V- 2000). There were no statistically significant differences in head diameter due to tillage depths and application of organic manure interaction (Table 4).

3.6. Seeds head^{-1}
According to results, seed per head was not significantly different between treatments for tillage depths at the both growing locations, although increasing tillage depth resulted in a slight increase in the seed number (Table 4). Meanwhile, there was significant difference between organic manure levels, on the number of seed per head in sunflower (Table 4). The maximum number of seed per head (1383.67 and 1379.33 seeds head^{-1} in the SL and QL location respectively) was recorded in the treatment of M3. Minimum seed per head (1331.78 and 1328.33 seeds head^{-1} in the SL and QL location respectively) was found in the treatment of M0. Improvement of agronomic management such as adding organic manure to soil might increase nutrient availability in soil, which provide better initiation for seed. As imbalances in nutrients, causes a stress on soil [18] that limits growth rate and will result in a reduced number of seeds [19]. The result of this study is consistent with [20] who stated that chicken manure had significantly affected number of seed per head of sunflower variety Hysun 33. It was also observed that there was no significant interaction between treatments on the number of seed per head in sunflower.

3.7. 500 seed weight (g)
Significant differences in 500-seed weight was found among the three tillage depths treatments. 500-seed weight increased significantly from 20.77 and 19.33 g in the SL and QL location respectively with 10 cm to 29.42 and 22.97 g in the both locations respectively with 30 cm (Table 4). The increase in tillage depth might have resulted in greater accumulation of nutrients in plants, due to reducing the bulk density at deeper layers (Table 5) that increase root ability to go deeper in the soil and increase the surface area of root exposed to nutrient absorption.

Application of the two higher levels of organic manure significantly increased the 500-seed weight without significant differences between them. Increase in 500-seed weight with M3 and M2 organic manure levels were 66.27 and 46.53% respectively over M0 in the SL location. In the same direction the increase were 32.04 and 25.50%, respectively over M0 in the QL location (Table 4). The addition of organic manure may enhance soil fertility, which may increase metabolic processes and leads to increases in vegetative and reproductive growth [21]. Similar increase in 1000- seed weight with application of organic manure levels was earlier reported by [22]. The interactions between tillage depths and organic manure levels were not significant for 500-seed weight (Table 4).

3.8. Seed yield kg h^{-1}

The results of analysis of variance showed that tillage depths have a significant effect on the amount of seed yield. The mean comparison of this variable, based on the LSD test, showed that the highest and lowest amount of seed yield exist in the 30 and 10 cm respectively at the two growing locations (30 cm resulted 18.19 and 21.61% increase over 10 cm in the SL and QL location respectively) (Table 4). The increase in the seed yield was a result of an improvement in the yield components i.e. number of seeds and seed weight. Using 30 cm tillage depth led to low soil bulk density in the deeper soil layers (Table 5) due to the impact of using plow shanks that convert soil to lower aggregates and decrease soil compression subsequently. This helps to ease of growth and elongation of the roots and water movement, in addition to the exchange of gases between soil air and atmosphere. [23] stated that sunflower yield increased significantly as tillage depth increased from 20 to 30 cm.

The different levels of organic manure treatments had significant effect on seed yield in the sunflower. The highest seed yield (2527.72 and 2361.06 kg ha^{-1} in the SL and QL location respectively) was obtained at M3 treatment which was statistically in par with M2 and M1 that both giving seed yields of 2433.10 and 2210.13 kg ha^{-1} in the SL location and 2324.43 and 2176.79 kg ha^{-1} in the QL location, respectively. The minimum seed yield (2070.89 and 1941.55 kg ha^{-1} in the SL and QL location respectively) were recorded in the M0 treatment that was statistically in par with M1 in the both growing location (Table 4). The addition of organic manure might increase the nutrients ready for absorption by the plant within the root zone, which reflected positively on improving the physical properties of the soil and increasing its ability to retain moisture at the root zone, and then increasing the effectiveness of absorption and transportation of water and nutrients upon this treatment, which led to an increase in the effectiveness and the efficiency of the food manufacturing process, which was reflected in an increase in the yield components and thus an increase in the total yield. Research elsewhere has shown that the application of 10 t ha^{-1} and 20 t ha^{-1} farmyard manure improved sunflower seed yield [24]. There were no significant interaction between tillage depths and organic manure treatments (Table 4).

3.9. Biomass yield kg h^{-1}

Table 4 shows changes in biomass yield values. The effect of tillage depths on biomass yield was significant at the two experimental locations. Biomass yield values in 30 cm (9811.98 and 9872.06 kg h^{-1} in the SL and QL location respectively) were higher than those in other tillage depths. The lower amount of biomass yield were 9279.78 and 9259.28 kg h^{-1} in the SL and QL location respectively has been obtained in the 10 cm. The highest biological yield for 30 cm could be attributed to an increasing in plant height by 5.31 and 6.34%, stem girth by 55.57 and 19.41%, leaf area by 29.40 and 75.17% and leaves per plants by 21.33 and 17.91% in the SL and QL location respectively. Increasing tillage depth led to a decrease in soil compaction due to increased spaces among aggregates, which led to facilitate water movement and transport of nutrients. In addition to accelerating the downward movement of excess water, preventing waterlogging and increasing ventilation. As well as facilitating the movement of roots and increasing their ability to reach greater depths, thus increasing the absorption of water and nutrients from the soil. The results revealed significant effect of organic manure levels on biomass yield (Table 4). Biomass yield increased by 9.52 and 9.49% [1] in the SL and QL location respectively when organic manure level increased from M0 to M3 treatment. The improvement in plant growth characteristics with the addition of organic manure may be due to an improvement in the physical properties of the soil as well as an increase in the ability of the soil to retain moisture within the area of roots spreading, which led to the provision of nutrients and water to other parts of the plant and increase the effectiveness of the photosynthesis process, which was positively reflected in the increase of plant height, the leaf area and in the yield components as a result of the increase in the amount of processed and stored nutrients in the flower disc, which pushed towards increasing the diameter of the disc and the number of filled seeds in it, and then increasing the biomass yield. Our results agree with those of [25] who found that application of farmyard manure (containing 119.0 kg N ha^{-1}) improved sunflower (Vidoc hybrid) biological yield significantly. The Biological yield value was 12224.3 kg ha^{-1} compared to 6802.811 kg ha^{-1} without application. According to results, there was no significant interaction between tillage depths and organic manure levels, on biomass yield of sunflower (Table 4).

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Table 4. Effect of tillage depths and organic manure levels on yield attributes, seed yield of sunflower.

Tillage	Plant height (cm)	Stem girth (cm)	Leaves plant^{-1}	Leaf area cm^2 plant^{-1}	Head diameter (cm)	Seeds head^{-1}	500 seed weight g	Seed yield kg h^{-1}	Biomass yield kg h^{-1}
					SL location				
10	106.42	1.41	18.75	2606.38	16.44	1355.25	20.77	2108.01	9279.78
20	110.42	1.92	21.50	2847.11	17.90	1368.92	23.63	2331.87	9555.59
30	112.08	2.20	22.75	3372.53	18.96	1369.67	29.42	2491.50	9811.98
LSD	3.951*	0.390*	2.935*	573.839*	1.871*	ns	6.399*	282.729*	375.560*
M0	106.33	1.49	19.33	2049.94	15.8	1331.78	18.35	2070.89	9082.45
M1	108.33	1.72	20.11	2721.2	17.86	1360.11	22.67	2210.13	9437.89
M2	111.33	1.92	22.56	3307.34	18.65	1382.89	26.89	2433.10	9728.81
M3	112.56	2.24	22.00	3689.55	18.76	1383.67	30.51	2527.72	9947.31
LSD	4.225*	0.390**	2.353*	1079.87*	2.1689*	18.707**	6.383**	324.507*	612.971*
10*M0	102.33	1.03	17.00	1525.49	14.6	1323.67	14.72	1843.13	8805.06
10*M1	104.00	1.15	17.33	2292.99	16.29	1348.33	19.05	2001.15	9252.77
10*M2	107.67	1.39	20.33	2976.30	17.46	1371.67	22.75	2246.34	9452.00
10*M3	111.67	2.08	20.33	3630.75	17.41	1377.33	26.53	2341.41	9609.29
20*M0	107.67	1.66	20.00	1770.55	15.42	1333.67	18.86	2033.39	9022.41
20*M1	109.67	1.77	21.00	2791.86	18.13	1366.67	21.83	2252.85	9457.05
20*M2	112.67	1.99	22.67	3250.36	18.88	1385.33	24.24	2459.45	9678.75
20*M3	111.67	2.26	22.33	3575.65	19.18	1390.00	29.58	2581.78	10064.15
30*M0	109.00	1.77	21.00	2853.78	17.37	1338.00	21.47	2336.15	9419.87
30*M1	111.33	2.23	22.00	3078.74	19.17	1365.33	27.12	2376.38	9603.86
30*M2	113.67	2.40	24.67	3695.36	19.61	1391.67	33.67	2593.50	10055.70
30*M3	114.33	2.39	23.33	3862.24	19.69	1383.67	35.42	2659.98	10168.50
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns
Tillage	Plant height (cm)	Stem girth (cm)	Leaves plant^{-1}	Leaf area cm^2 plant^{-1}	Head diameter (cm)	Seeds head^{-1}	500 seed weight g	Seed yield kg h^{-1}	Biomass yield kg h^{-1}
					QL location				
10	103.08	1.49	18.73	1763.36	14.15	1346.83	19.33	1974.01	9259.28
20	108.50	1.63	20.42	2506.09	15.46	1359.83	21.08	2228.37	9659.26
30	110.42	1.78	22.08	3088.90	16.39	1370.25	22.97	2400.50	9872.06
LSD	3.614*	0.144*	1.802*	887.123*	1.650*	ns	2.664*	274.921*	387.353*
M0	104.44	1.45	17.78	1973.55	11.92	1328.33	17.69	1941.55	9090.78
M1	106.78	1.55	19.30	2492.92	15.27	1358.22	21.26	2176.79	9541.67
M2	108.44	1.68	21.89	2565.74	16.40	1370.00	22.20	2324.43	9801.26
M3	109.67	1.87	22.67	2778.94	17.75	1379.33	23.36	2361.06	9953.76
LSD	2.628**	0.294*	3.777*	570.174*	2.728**	8.371**	3.831*	312.290*	627.640*
10*M0	99.00	1.40	16.33	1355.72	10.66	1310.00	16.47	1675.13	8759.72
10*	101.67	1.44	16.91	1778.85	15.13	1347.67	19.37	1943.15	9172.10

M1									
10* M2	104.67	1.53	20.00	1804.92	14.30	1359.33	20.04	2140.34	9488.66
10* M3	107.00	1.60	21.67	2113.97	16.52	1370.33	21.44	2137.41	9616.62
20* M0	106.33	1.44	17.33	2035.10	11.37	1334.00	17.06	1929.39	9066.41
20* M1	108.33	1.57	20.00	2420.03	15.03	1356.33	21.57	2208.85	9583.72
20* M2	109.33	1.66	22.67	2718.05	17.35	1368.33	22.73	2353.45	9930.08
20* M3	110.00	1.86	21.67	2851.19	18.08	1380.67	22.98	2421.78	10056.82
30* M0	108.00	1.50	19.67	2529.82	13.72	1341.00	19.54	2220.15	9446.20
30* M1	110.33	1.64	21.00	3279.87	15.65	1370.67	22.85	2378.38	9869.20
30* M2	111.33	1.85	23.00	3174.25	17.55	1382.33	23.83	2479.50	9985.03
30* M3	112	2.14	24.67	3371.66	18.64	1387.00	25.65	2523.98	10187.83
LSD	ns	ns	ns	ns	ns	ns	ns	ns	ns

Significant at 0,05 (*) and at 0,01 (**) of probability; (ns) not significant.

3.10. Effect of time of sampling on bulk density

Data shown in Table 5 represent bulk density of the experiment soil averaged across tillage depth. The analysis of variances showed that there was significant differences at the 20 and 30cm depths in the SL location among bulk density values during the experiment period. The highest bulk density recorded before tillage that was higher by 15.385%, 11.349% and 12.712% than after tillage, and was higher by 7.362%, 4.000% and 3.502% than after harvest at the 10, 20 and 30cm depths respectively. In the QL location, bulk density before tillage was higher by 16.481, 12.500 and 15.086% compared to after tillage, and was higher by 7.172, 3.012 and 5.743% than after harvest for the 10, 20 and 30cm depths respectively. The decrease in the bulk density after tillage is attributed to loosening the soil, crushing and smoothing the soil clods and increasing the pores between the soil particles. Also, the addition of manure reduces the bulk density of the soil, as it has a low density, which leads to a decrease in soil density. It was reported that applying 5 t ha^{-1} of cattle manure on a hard setting and crusting soil, improved aggregate stability, reduced soil strength and bulk density [26]. The increase in the bulk density after harvesting is due to breaking down the pores by irrigation water and washing small soil particles from the surface to the depth, as well as the microorganisms in the soil work to decompose the manure fertilizer during the period of plant growth; this was agreed with [27].

Table 5. Bulk density of the experiment soil at various times through tillage depths.

	SL location		
	10 cm	20 cm	30 cm
Before tillage	1.396	1.369	1.425
After tillage	1.198	1.217	1.238
After harvest	1.302	1.329	1.348
LSD	0.083**	0.096*	0.059**
	QL location		
	10 cm	20 cm	30 cm
Before tillage	1.403	1.387	1.420
After tillage	1.217	1.247	1.263
After harvest	1.307	1.337	1.373
LSD	ns	0.101*	0.087*

Significant at 0,05 (*) and at 0,01 (**) of probability; (ns) not significant.

Conclusions

Productivity of sunflower was lower under 10 cm tillage depth compared to 20 and 30 cm tillage depth. The highest seed yield was found in the 30 cm tillage depth. Application of organic manure provided a good source of organic amendments for improvement of plant nutrients. Application of organic manure showed a significant influence on all agronomic traits of sunflower. Based on the results of this study, organic manure is recommended as the choice for local smallholder farmers due to the response of plant to the increase in the amount of organic manure. M3 and M2 organic manure levels were superior in most studied traits compared to other levels of organic manure. Long-term studies are needed in order to decisively evaluate the effects of tillage depths and organic manure on soil properties. However, the results that mentioned from the current experiment are only useable for soil and climatic conditions previously determined.

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