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Effect of Irrigation Water Rates and Organic Sources on Soil Fertility, Productivity and Quality of Maize Crop

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ABSTRACT
In the summers of 2022 and 2023, two field experiments were held at the Ismailia Agricultural Research Station (30°35'30" N 32°14'50" E), Agricultural Research Center (ARC), Egypt. The goals of these work were to find out what happened to the soil's fertility and the quality and quantity of maize grown when different amounts of irrigation water were mixed with organic matter sources such as compost, organic farm waste, and trash from the town. Three replicates were used in the split-plot design of the experiment. According to the acquired data, increasing irrigation water at a rate of 3000 m^3 and organic matter sources, along with an increase in the soil's accessible macro-micronutrient contents, resulted in reducing pH and EC (dSm^1). The increase of maize component and quality with irrigated at a rate of 3000 m^3 combined by town refuse waste compared to other treatments. When town refuse waste and irrigation water were applied at a rate of 3000 m^3 flowing by 2500 m^3, the highest mean values of protein, oil, carbohydrate, and chlorophyll contents in maize plants were observed. In comparison to the control without organic matter sources, the relative increases in mean values for irrigation water of 3000 m^3, 2500 m^3, and 2000 m^3 that combined with various organic matter sources were 11.67%, 11.03%, and 8.51%, respectively. Finally, the use of composted town refuse waste mixed with irrigation water at different levels enhances the quality of sandy soil, water productivity, and soil fertility.

Keywords: *Zea mays* L. sandy soil, organic matter resources, soil fertility, irrigation water different rates, maize productivity and quality

1. Introduction
One of the most significant environmental factors influencing the decline in plant growth, development, and yield is drought stress. According to Jajarmi (2009), it is among the most destructive environmental stressors. By influencing a number of physiological and biochemical functions, including transpiration, translocation, ion uptake, and nutrient metabolism, drought stress inhibits plant growth (Farooq *et al*., 2009). One of the most harmful abiotic stresses in the world, drought significantly reduces crop yield. Despite being one of the most important cereal crops in the world, maize is drought-sensitive (Muhammad *et al*., 2015). One significant abiotic stressor that negatively impacts crops is drought. Water scarcity has emerged as a major obstacle to agricultural development in Egypt's new territories. (Ali *et al*.., 2019). Using organic fertilizers leads to an increase in the means of maize plant parameters. Also, the drought water leads to a decrease in maize parameters (Hussein *et al*., 2019). The rates of transpiration and photosynthesis were comparable across all treatments when there was an adequate supply of water. While applied compost increased water availability to plants and, consequently, the number of days until wilting, drought-stressed plants wilted quicker than control plants (Nguyen *et al*. 2012). Crop water needs and irrigation schedules are dependent on local weather conditions. Reference evapotranspiration (ETo) is calculated in conjunction with the amount of water

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applied to crops (Ouda *et al*., 2015). The decrease of parameters plants due to water stress may be attributed to the reduction in internode growth plants, because of the deficiency of soil moisture (Abd El-Aty *et al.,* 2024). Particularly in regions where water is a determining factor for crop growth and productivity, the increase in water unit productivity achieved through the application of various field technologies through fertilizer additions and irrigation scheduling is crucial (Hameedi *et al*., 2015). Corn irrigation treatments at 5- and 8-day irrigation intervals had the highest crop water productivity (water usage efficiency) on average. The treatment of mutual irrigation for terracing had the highest crop water use efficiency, with 2.33 and 2.42 kg m^{-3} at irrigation intervals of 5 and 8 days, respectively. The water productivity of agricultural water use varied (Alkarawi *et al*., 2022).

Low specific surface area, low water retention, low organic matter content, low fertility, and rapid infiltration rate are among the negative qualities of sandy soils. Particularly in dry and semi-arid areas, these unfavorable physical characteristics lead to inadequate water utilization (Aiad *et al*., 2018). Sandy soils have low organic content, soil moisture content, and nutrient retention due to high permeability, which limit crop yield and endanger global food security in arid and semi-arid countries (Misei *et al*., 2024).

Compost is one of the preferred choices of organic fertilizer for improving soil fertility. Compost application improved soil fertility with the increase of soil cation exchange capacity (Agegnehu *et al*., 2016). Although compost can improve soil water availability and plant uptake of nutrients, it is unclear if it can also help plants recover from drought stress. Compost made more water accessible overall. Under both drought-stressed and well-watered conditions, the addition of compost boosted shoot and root growth, with the impact of incorporated compost being larger (Nguyen *et al*. 2012). The number of lateral branches and leaves per plant, plant height, and dry weight of plants all increased when organic (compost) fertilizer was applied to the soil in response to the nutritional requirements of the plants. Drought stress and various fertilizers have an impact on the essential oil yield of aerial components (Mohammad and Majid 2011). When compost was added to soil, its pH and EC (dSm-1) decreased, but its levels of N, P, K, Fe, Mn, and Zn increased (Abo Hussin *et al*., 2019). Applying compost to soil has a major impact on its chemical characteristics, including organic matter, soil EC, pH, and macronutrient and micronutrient concentrations. It lowers the pH and EC of the soil while increasing the macro- and micronutrient content (Hakimi *et al*.,2024).

According to Rasoulzadeh and Yaghoubi (2010), organic farms have an impact on crop growth and yields either directly by providing nutrients or indirectly by altering the physical characteristics of the soil, such as aggregate stability, porosity, and available water capacity, which can enhance the root environment and promote plant growth. Egypt's agricultural industry is being revolutionized by organic farming. Since Egyptian consumers are still learning how to use organic products, organic production is quite profitable when aiming for foreign markets (Sadek and Shelaby 2011). Enhancing the physical, chemical, and biological characteristics of soils is facilitated by organic matter. The application of compost to soil was a very important nutrient that can help improve crop yield and growth and play a role in several important plant processes. Organic farm residual is improved water retention capacity ensuring adequate soil moisture availability for plant growth, supporting sustainable crop production, and minimizing the risk of yield losses due to water stress. Organic manure application enhances soil water retention capacity, primarily by increasing soil organic matter content and improving soil structure (Brown and Johnson 2018). The high nutrient content of the organic matter led to improved soil health and fertility (Moghith*et al*., 2024).The use of organic manure alone had the problem of not being able to release plant nutrients for plant uptake, especially during the period of growth, there is the need for organic fertilizers to be fortified to improve their nutrient release efficiency and plant uptake through integration with chemical fertilizer to diminish the leaching losses of running (Nweke and Nsoanya 2015). The complex interactions between organic manure and soil, and the impacts on soil structure, nutrient availability, microbial activity, and overall soil health. Additionally, the role of organic manure in mitigating soil degradation enhances crop productivity, and promotes sustainable agricultural practices (Sudhanshu *et al*., 2024).

An estimated 100 million tons of garbage (town rubbish) are produced in Egypt each year. According to Chemonics Egypt and Cleantech Arabia (2018), Egypt's primary waste streams are building waste (6%), industrial waste (5%), MSW (23%), canal and irrigation network cleaning (28%), and agricultural waste (34%).60–90% of municipal solid waste can be composted. According to Simeon and Ambah (2013), 50–70% of all municipal solid trash is composed of organic elements, with the remainder consisting of metal textiles, rock, food waste, plant debris, and soil chemicals. Non-liquid waste materials that can be broken down by bacteria or other natural creatures and do not contribute to pollution are known as biodegradable solid waste (BSW). Activities in homes, farms, businesses, and industries produce these wastes. Large-scale land and water pollution is caused by BSW, which comprises food waste, leaf yard waste, animal manure, etc., produced from agricultural lands and city areas (UNEP, 2018). The idea of recycling URW provides a way to guarantee long-term soil fertility without the need for outside inputs for smallholder farmers, many of whom have little or no access to conventional manures (Alhassa *et al*., 2019). According to Papafilippaki *et al*. (2015), town garbage compost enhanced the bioavailability of trace elements (Cu, Zn, Fe, Mn, Cr, Ni, Pb, and Cd) in soil and promoted Crop growth and yield. Maize is one of the main grain crops in Egypt because of its importance in the nutrition of humans, animals, and poultry It enters the manufacture of dry feed and bread, as it enters in some industries such as the extraction of glucose sugar, fructose, and oil. Development of the cultivated maize crop (in Egypt during the period 2000 to 2020) as it became clear that the cultivated area of the maize crop at about 658.1 million acres in 2003 and a maximum of about 337.2 million acres in 2018, with an annual average of about 975.1 million acres (Mekawy and Gmail 2022). Egypt's corn production in 2024/25 (October-September) at 7.6 MMT, up by approximately 5.5 % from the 2023/2024 production estimate of 7.2 MMT. The rise in production is due to an increase in the area harvested forecasted to reach 970,000 hectares in MY 2024/25, up some 20,000 hectares from the previous year (USDA 2024). Plant height (cm), seed number/cob, 100-seed weight (g), seed yield (ton/fed), and Stover yield (ton/fed) all rise when municipal organic waste is applied to the soil (Hossain *et al*., 2024).

The goal of the study is to determine how to improve soil fertility and maize productivity under irrigation at varying rates by adding organic matter sources to address the issues with sandy soil.

2. Materials and Methods

At the Ismailia Agricultural Research Station (30°35'30" N 32°14'50" E), Agricultural Research Center (ARC), Egypt, two field experiments were conducted in sandy clay soil. The impact of organic matter on soil chemical characteristics and the productivity and quality of maize (*Zea mays* L.) cultivar Triple hybrid 320 during drought conditions was investigated throughout two consecutive summer seasons in 2022 and 2023. Before planting, the primary physical and chemical characteristics of the soil were assessed using the techniques by Cottenie *et al*. (1982) and Page *et al*. (1982) as shown in Table (1). Chemical analysis of organic matter sources of study is shown in Table (2). The organic farm, compost, and town refuse waste were examined using the standard procedures by Brunner and Wasmer (1978).

Table 1: Mean values of physical and chemical properties in soil study before planting.

Coarse sand (%)	Fin sand (%)	Silt (%)	Clay (%)	Texture	O.M (%)	CaCO$_3$ (%)
6.88	75.22	10.30	7.60	Loamy sand	0.52	1.05

pH (1:2:5)	EC (dS/m)	Cations (meq/l)				Anions (meq/l)		
		Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO^{-}_{3}	Cl^{-}	SO^{--}_{4}
8.12	2.75	6.50	4.22	15.89	0.89	1.44	12.79	13.27

Available macronutrients (mg/kg)			Available micronutrients (mg/kg)		
N	P	K	Fe	Mn	Zn
30.60	4.32	165.00	1.75	0.85	0.50

Table 2: Chemical analysis of organic matter sources of study.

Organic matter sources	EC (dSm^{-1}) 1 :10	pH (1:2.5)	O.C	C/N ratio	O.M	N	P	K	Fe	Mn	Zn
			(%)						(mgkg^{-1})		
Compost	3.75	7.40	33.50	15.95	40.50	2.10	1.20	4.88	219.00	112.00	90.66
Organic farm	4.10	7.10	31.20	12.48	44.75	2.50	1.40	5.30	240.00	140.00	98.00
Town refuse	4.55	7.00	30.45	10.68	48.90	2.85	1.75	6.10	260.00	180.00	110.00

Table 3: Weather conditions at Ismailia, Egypt, during the two growing summer seasons of maize cultivation (2022 and 2023).

Month	Temperature (°C)			Relative Humidity %	Rainfall	ETo mm/day
	Min.	Max.	Aver.			
May	20.44	29.70	25.07	55.90	0.00	6.10
June	28.90	35.10	32.00	64.00	0.00	7.33
July	29.10	38.20	33.65	65.30	0.00	7.75
August	30.55	40.22	35.39	75.44	0.00	7.90
September	28.00	35.77	31.88	66.00	0.00	6.30
October	25.10	32.90	29.00	60.30	0.00	5.00
Average	27.01	35.32	31.17	64.49	0.00	6.73

Each experiment was conducted using a split-plot design with three replicates in both seasons, where the irrigation treatments were implemented in the main plot, and the organic fertilizers were randomly distributed in the subplot.

The area of each experimental unit (plot) was 5 x 10 m, which was divided into rows with 50 cm. Irrigation water rates (2000, 2500, and 3000 m^3). Organic matter sources (town refuse, compost, and organic farm at a rate of 5 tons/fed) were applied to the soil 25 days before planting. Super calcium phosphate (15.5 % P_2O_5) was applied at a rate of 200 kg /fed before planting during the tillage of the soil. Urea (46 % N) was applied at a rate of 100 kg/fed after 30, 45, and 65 days from planting. Potassium sulfate (48 % K_2O) was applied at a rate of 75 kg/fed after 30 and 45 days from planting.

Maize (*Zea mays* L) cultivar Triple hybrid 320) supplied by Maize Department, Filed Crop Res Inst. ARC. Sowing grains maize was the 15 May 2022 and 2023. The maize plants were harvested at full maturity; ten plants were randomly taken from each record with the average of the following traits: Plant length (cm), the weight of grains of the ear (g), the weight of 100 grains (g), the weight of grains yield (ton/fed) and weight of yield Stover (ton/fed).

2.2. Plant analysis.

Oven-dried ground maize (grains) was half a gram, digested in 4 ml of H_2SO_4 mixed with 2 ml $HCLO_4$ according to the methods described by Chapman and Pratt (1961). The plant content of N, P, K, Fe, Mn, and Zn concentrations in seeds was determined in plant digestion using the methods described by Cottenie *et al*. (1982) and Peage *et al*. (1982).
Protein content (%) = nitrogen% % of seed multiplied by 5.75 as outlined by the Association of Official Analytical Chemists.

2.3. Water productivity (WP).

WP = Grain yield (ton/fed)/Applied irrigation amount (m^3/ fed) (FAO 2003).

The collected data were subjected to statistical analysis using analysis of variance and at a 5% level with the MSTAT computer program according to, Gomez and Gomez (1984).

3. Results and Discussion

3.1. Effect of organic sources on soil properties under drought.

3.1.1. Soil pH.

One of the most crucial factors that represents the general shifts in the chemical characteristics of soil is its pH. In comparison to other treatments, soil treated with town garbage combined with a 3000 m3 irrigation water rate had the lowest pH value. Table 4 data indicates that the pH of the soil decreased after all organic sources under the examination of higher irrigation water rates. The pH values of the soil are consistently between 8.04 and 7.85, which is classified as mildly to moderately. The amount of water provided, however, had no discernible impact on the pH levels of the soil. Both the synthesis of organic acidic compounds and the release of H+ ions during the composting of the employed composts were blamed for the drop in soil pH. Acidic chemicals were produced as a result of the decrease in pH in soil treated by compost, organic farms, and local waste, as well as the rise in the amount of macro- and micronutrients accessible in the soil and biological activity. These findings concur with those of Assefa *et al*. (2015), who proposed that applying organic farms to soil enhanced some soil chemical characteristics (soil pH), since the lowest pH values in the soil dropped in comparison to the control. The presence of acidic compounds as a result of the sulphitation process nitrification and acidification processes stimulated by continuous fertilizer application as well as by H+ released by roots may be the cause of the higher reduction in soil pH observed with organic farm treatment (Sedeek *et al*. 2016). Increased porosity, decreased bulk density, high organic matter, which enhances the soil's nitrogen content, cation exchange capacity (CEC), and improved pH are all results of town refuse treatment (Amos-Tactual al., 2014). The remaining organic matter following various chemical and biological changes may be the cause of the dead pH of the soil. Applying compost to soil lowered its pH. The creation of some organic acids and carbon dioxide in the soil as a result of microorganisms oxidizing organic soil additions may be the cause of the pH drop caused by compost (Doaa, 2012). Furthermore, organic acid was produced as a result of microbial activity, which in turn fueled the activity of the bacteria (Abdel-Azeem 2020). When municipal solids (town trash) were applied to soil, the pH values decreased from 8.13 to 7.52, respectively, and were classified as neutral. (Asabe *et al*., 2024).

3.1.2. Soil salinity (EC dSm^{-1}).

Data presented in Table (4) revealed the minimum value of EC 1.03 (dSm^{-1}) as affected by compost combined with irrigation water at a rate of 3000 m^3 compared to all treatment studies. Depending on the variation of EC by increasing the rate of irrigation water combined with organic sources, especially compost. These changes in soil EC value are related to the movement of salt in the root zone. It was determined that this increase in irrigation water rate, which occurred depending on the application of organic matter sources reached the levels that would decrease salt stress for soil. The effects of organic matter sources and irrigation water different rates on soil salinity were not significant and the interaction between organic sources and irrigation at rates was not significant.

The relative decreases in mean values EC (dSm^{-1}) were 3.74 % for soil treated with compost, 0.93 % for soil treated with an organic farm, and 1.87 % for soil treated with town refuse respectively as irrigation water at rate 3000 compared to irrigation water at rate 3000 m^3 without organic matter (control).

Also, the relative decreases of mean values EC (dSm^{-1}) as affected by irrigation water at a rate of 2500 m^3 combined with compost, organic farm, and town refuse respectively were 10.92 %, 5.88 %, and 0.84 % respectively, compared to control (irrigation water 2500 m3 without organic matter sources). Additionally, when coupled with irrigation water at a rate of 2000 m3, the relative declines in mean values were 44.44 percent for compost, 32.37% for the organic farm, and 10.63 percent for town garbage, respectively, in comparison to the control (irrigation water 2500m^3withoutorganicmatter). However, when compared to control and organic matter sources, the percentage decreases in mean values (EC dSm^{-1}) were 0.93% for irrigation water of 3000 m3, 5.88% for irrigation water at a rate of 2500 m3, and 27.54% for irrigation water at a rate of 2000 m3. These outcomes concur with When compared to the control, Assefa *et al*. (2015) discovered that the use of organic farming (FYM) resulted in a minor drop in soil salinity (EC) during maize harvest. According to El-Nagar and AbuEl-Ezz (2021), compost treatment decreased the salinity of the soil. Compost outperforms control in terms of enhancing the chemical characteristics of the soil. Doaa (2012) discovered that adding compost to soil lowers its salinity and Na+ concentrations. Na+ salts' easy solubility in water may be the cause of this, as they can escape the soil system and seep into the lower depths.

3.1.3. Available macronutrient contents in soil.

Data presented in Table (4) indicated that the increase of (N, P, and K mg/kg soil) available contents in the soil was affected by the increase of irrigation water rates combined with organic matter sources. The maximum values of N, P, and K contents in soil were 58.30, 5.62, and 179.88 mg/kg respectively as affected by soil treated with town refuse and irrigation at a rate of 3000 m^3 than other treatments. Also, the irrigation water at different rates application led to significant increases of N and P while the K was not significant and the effect of organic matter on soil had no significant of available N, P, and K contents in soil, as well as the interaction between organic matter sources and irrigation water different rates on available N, P, and K contents in soil were no significant. Concerning, that the relative increases of mean values were 10.49 %, 21.21 %, and 20.31 % for N, 0.37, 1.87 %, and 5.98 % for P, and 3.00 %, 5.00 % and 3.65 % for K respectively, contents in soil treated with compost, organic farm and town refuse respectively, combined with irrigation water at rate 3000 m^3compared control without organic matter sources under irrigation water at 3000m^3. Additionally, when irrigation water was applied at a rate of 2500 m^3, the mean values of N, P, and K available contents in soil treated with compost, organic farm, and compost increased by 11.05%, 25.37%, and 38.56% for N; 3.75%, 5.34%, and 12.06% for P; and 2.47%, 3.81%, and 4.12% for K. Also, when comparing the contents of soil treated with compost, organic farm, and town refuse irrigation water at a rate of 2000 m^3 to that without organic matter sources, the relative increases of mean values were 7.35%, 23.57%, and 31.95% for N, 1.43%, 6.35%, and 9.22% for P, and 1.14%, 3.04%, and 3.87% for K. Because compost contains nutrients (N, P, and K) and organic matter because the soil is rich in functional groups, it increases the amount of available macronutrients in the soil (El-Nagar and AbuEl-Ezz 2021).

Table 4: Mean values of Soil pH, EC (dSm^{-1}) and macro-micronutrients contents in soil after harvest (mean two seasons)

Irrigation rate (m^3)	Organic fertilizer	pH (1:2.5)	EC (dSm^{-1})	Available macronutrients (mg kg^{-1})			Available micronutrients (mg kg^{-1})		
				N	**P**	**K**	**Fe**	**Mn**	**Zn**
3000	**Control**	8.00	1.07	44.80	5.35	170.00	1.88	1.02	0.58
	Compost	7.92	1.03	49.50	5.37	175.10	1.94	1.09	0.64
	Organic farm	7.88	1.06	54.30	5.45	178.50	1.97	1.29	0.68
	Town refuse	7.85	1.09	58.30	5.62	179.88	2.05	1.43	0.73
Mean		-----	1.06	51.73	5.54	175.87	1.96	1.21	0.66
2500	**Control**	8.01	1.19	38.90	5.06	169.22	1.81	0.93	0.55
	Compost	7.95	1.06	43.20	5.25	173.40	1.83	0.98	0.59
	Organic farm	7.90	1.12	48.77	5.33	175.66	1.90	1.23	0.62
	Town refuse	7.87	1.18	53.90	5.67	176.20	1.98	1.35	0.69
Mean		-----	1.14	46.19	5.33	173.62	1.88	1.12	0.61
2000	**Control**	8.04	2.07	35.77	4.88	167.40	1.67	0.88	0.53
	Compost	8.01	1.15	38.40	4.95	169.30	1.78	0.93	0.56
	Organic farm	7.98	1.40	44.20	5.19	172.49	1.85	1.14	0.59
	Town refuse	7.93	1.85	47.20	5.33	173.88	1.93	1.25	0.63
Mean		-----	1.62	41.39	5.09	170.77	1.81	1.05	0.58
LSD. 5% Irrigation rate		-----	ns	0.75	0.18	ns	0.55	ns	0.01
LSD. 5% Organic sources		-----	ns	0.88	ns	ns	ns	ns	0.02
Interaction		-----	ns	ns	ns	ns	ns	ns	ns

3.1.4. Available micronutrients in the soil.

According to the data in Table (4), soil treated with town trash under irrigation at a rate of 3000 m^3 had higher accessible levels of micronutrients (Fe, Mn, and Zn mg/kg soil) than other treatments. In every instance, the addition of organic matter was linked to an increase in the soil's micronutrient levels; this was mostly because of the rise in organic matter in the top layer when irrigation water rates were high. While Mn was not significantly increased, the availability of Fe and Zn concentrations in soil treated with irrigation at varying rates significantly increased. Zn increased significantly when organic matter was added to the soil, while Fe and Mn did not significantly increase. Furthermore, for Fe, Mn, and Zn, respectively, there was no significant interaction between the source of organic matter and the varying rates of irrigation water. However, when compared to a control without organic matter sources, the corresponding relative increases in micronutrient contents in soil were 3.19 percent for iron, 6.86 percent for manganese, and 10.34 percent for zinc in soil treated with compost; 4.79 percent for iron, 26.47 percent for manganese, and 17.24 percent for zinc in soil treated with organic farm; and 9.04 percent for iron, 40.20 percent for manganese, and 25.86 percent for zinc in soil treated with town refuse combined with irrigation water at a rate of 3000 m^3.Comparatively speaking, the values of available (Fe, Mn, and Zn) contents in soil increased 1.10 for Fe, 5.38 for Mn, and 7.27 for Zn, respectively, when compost was added; 4.97 for Fe, 32.26% for Mn, and 12.73 for Zn, respectively, when organic farm application was applied; and 9.39 for Fe, 45.16% for Mn, and 25.45% for Zn, respectively, when town refuse was mixed with irrigation water at a rate of 2500 m³ compared to the control. Additionally, when compost, organic farm waste, and town waste were combined with irrigated water at a rate of 2000 m³, the relative increases in values (Fe, Mn, and Zn) in the soil were 6.59% for Fe, 5.68% for Mn, and 5.66% for Zn; 10.78% for Fe, 29.55% for Mn, and 11.32% for Zn; and 15.57% for Fe, 42.05% for Mn, and 18.87% for Zn, respectively, when compared to the control. According to Amos-tautua*et al*. (2014), the town refuses to enhance the physicochemical characteristics of the soil and raise its nutrient status. Composting improved nitrogen availability and soil fertility (EL-Shaieny *et al*., 2022).

3.2. Yield and yield component.

Table 5, the analysis of the impact of organic matter sources on yield and yield components, showed that, in comparison to other treatments, increasing irrigation water rate in conjunction with town refuse increased the values of plant length (cm), weight of ear grains (g), weight of 100 grains (g), weight of grains yield (ton/fed), and weight of Stover yield (ton/fed), respectively. The weight of grain yield (ton/fed) was not significantly impacted by irrigation water rates or organic matter sources; however, there were notable increases in plant length (cm), weight of grain/ear (g), weight of 100 grains (g), and weight of stover yield (ton/fed). Plant length (cm), weight of grain/ear (g), and weight of stover (ton/fed) all significantly increased when organic matter sources and irrigation water rates interacted, but the weight of 100 grains and weight of grain yield (ton/fed) was no significant.

Table 5: Effect of irrigation water rates and organic sources on yield and yield component of maize plants.

Irrigation rate (m^3)	Organic fertilizer	Plant length (cm)	Weight of grains ear (g)	Weight of 100 grain (g)	Weight of grains yield (ton./fed)	Weight of yield Stover (ton./fed)
3000	Control	209.00	245.00	33.45	1.093	1.390
	Compost	220.00	256.00	37.50	1.173	1.395
	Organic farm	234.00	273.00	41.30	1.200	2.130
	Town refuse	245.00	282.00	45.22	1.250	2.230
Mean		227.00	264.00	39.37	1.18	1.79
2500	Control	195.00	232.00	26.40	0.975	1.150
	Compost	209.00	244.00	29.88	1.040	1.190
	Organic farm	220.00	249.00	34.58	1.095	1.220
	Town refuse	229.00	275.00	39.10	1.110	1.245
Mean		213.25	250.00	32.49	1.06	1.20
2000	Control	185.00	225.00	25.86	0.930	1.094
	Compost	194.00	238.00	30.64	0.986	1.140
	Organic farm	198.00	245.00	35.64	1.020	1.175
	Town refuse	207.00	256.00	38.66	1.050	1.189
Mean		196.00	241.00	32.70	1.00	1.15
LSD. 5% Irrigation rate		2.62	2.48	1.36	ns	0.39
LSD. 5% Organic sources		2.30	1.53	1.95	ns	0.26
Interaction		***	***	ns	ns	*

Corresponding, relative increases of values plant length (cm), the weight of grains of the ear (g), weight of 100 grains (g), weight of grains yield (ton/fed), and weight of Stover yield (ton/fed) were 5.26 %, 4.49 %, 12.11, 7.32 % and 0.36 % respectively as affected of compost combined with irrigation water at rate 3000 m^3;also, 11.96 %, 11.43 %, 23.47 %, 9.79 % and 53.24 % respectively as affected with organic farm combined with irrigation water at rate 3000 m^3;as well as, 17.22 %, 15.10 %, 35.19 %, 14.36 % and 60.43 % respectively as affected with town refuse combined with irrigation water at rate 3000 m3 compared with control irrigation water at rate 3000 m^3 without organic sources. Relative increases of values were 7.18 %, 12.82 %, and 17.44 % for plant length (cm), 5.17 %, 7.33 %, and 18.53 % for the weight of grains of the ear, 13.18 %, 30.98 %, and 48.11 % for the weight of 100 grains (g), 6.67 %, 12.31 % and 13.85 % for the weight of grains yield (ton/fed) and 3.48 %, 6.09 % and 8.26 % for weight of Stover yield (ton/fed) respectively, as affected with compost, organic farm and town refuse respectively plus irrigation water at rate 2500 m^3 compared with control irrigation water at rate 2500m^3 alone. On the other hand, the relative increases of plant length (cm), the weight of grains of the ear (g), the weight of 100 grains (g), the weight of grains yield (ton/fed), and weight of Stover yield (ton/fed) respectively values were 4.86 %, 7.03 %, and 11.89 %; 5.78 %,8.89 %, and 13.78 %; 18.48 %, 37.82 % and 49.50 %; 6.02 % 9.68 % and 12.90 % and 4.20 %, 7.40 % and 8.68 % respectively contents in plant treated with compost, organic farm and town refuse combined with irrigation water at rate 2000 m^3 compared with control irrigation water at rate 2000 m^3 alone.

These results are in agreement by El-Sabagh *et al*. (2017) found that the yield component values under well-irrigated conditions were increased significantly as compared with drought condition plant length, ear height, number of kernels row, grain weight, grain yield, biomass yield, and harvest index of maize were adversely affected by drought stress. Indagawa *et al*. (2024) indicated that the soil treated with town refuse led to a significant increase of the growth parameters and NPK compared to the control soil. This might be attributed to the nutrient status of the soils (especially N) due to the presence of organic waste (which serves as a nutrient reserve) in town refuse-treated soil and the effect of inorganic minerals in the NPK-treated soil. Using organic manure for maize plants were the highest mean values of vegetative growth (plant height, fresh, dry weight of flag), yield and its components (cob length, No. of grain/cob, 100-grain weight, grain yield ton/fed, straw yield ton/fed and cobs yield ton/fed of corn), (Baddour *et al*., 2017). The increase in irrigation water led to an increase in plant height, 100-grain weight, ear length, and grain yield component properties in both seasons (El-Henawy and El-Sayed (2018). Organic fertilizer sources indicated a significant increase effect on plant height, stem diameter, cob length, grain rows per cob, number of grains per row, and number of grains per cob in the maize hybrids under normal and drought stress (Nadeem *et al.,* 2023). The compost might save the amount of irrigation water and improve the production of black caraway plants without a significant reduction compared with wholly irrigated ones. The enhanced yield growth consequently leads to an increase in the absorption of nutrients and water (Rashwan *et al*., 2024). It is recommended to utilize town refuse as an alternative, enhancing soil fertility and subsequently boosting crop yield, given that these materials have undergone sorting, recycling, and treatment to eliminate detrimental elements.

3.3. Macronutrient concentrations in grains.

Data presented in table (6) show that the increase of macronutrient concentrations in grain values was maize plant treated with town refuse combined with irrigation water at a rate of 3000 m3 compared to other treatments. The significant increase of N and P concentrations in grains while the K concentration was not significant as affected by irrigation water rates and organic sources. The interaction between irrigation water rates combined with organic sources was not significant with N, P, and K concentrations in grains. On the other hand, the relative increases of values N, P, and K concentration in grains were 5.83 % for N; 13.33 % for P, and 4.19 % for K respectively as affected with compost; 9.71 % for N, 30.00 % for P and 9.30 % for K respectively as affected with organic farm and 14.56 % for N, 46.67 % for P and 11.16 % for K respectively as affected with town refuse combined with irrigation at rate 3000 m^3 compared by control without organic sources. Also, the relative increases of values were 5.15 % for N, 7.41 % for P, and 7.07 % for K concentrations in grains as affected by compost; 9.28 % for N, 22.22 % for P, and 9.60 % for K as affected by organic farm and 15.46 % for N, 40.74 % for P and 13.64 % for K respectively as affected with town refuse combined with irrigation water at rate 2500 m^3compared with control without organic sources. As well as, the relative increases of values N, P, and K concentrations in grains maize were 6.74 % for N; 12.00 % for P, and 4.86 % for K concentrations in grains treated with compost; 13.48 % for N, 28.00 % for P and 12.43 % for K concentrations in grains as affected with organic farm and 17.98 % for N, 44.00 % for P and 15.14 % for K concentrations in grains as affected with town refuse respectively, combined with irrigation water at rate 2000 m^3 compared with control irrigation water alone at rate 2000 m^3.

These results are in agreement with Farrell and Jones, (2009) found that the maize plants treated with town refuse had increased N, P, and K concentrations in the plant compared to the control because town refuse is rich in a wide range of plant nutrients namely N, P and K). Seddik *et al*. (2016)revealed that the organic farm application to soil increased N, P, and K uptake in plants.

Table 6: Effect of irrigation water rates and organic sources on Macro-micronutrients concentrations in grains of maize plants.

Irrigation rate (m^3)	Organic fertilizer	Macronutrients concentrations (%)			Micronutrients concentrations ($mgkg^{-1}$)		
		N	P	K	Fe	Mn	Zn
3000	Control	1.03	0.30	2.15	75.20	59.30	27.40
	Compost	1.09	0.34	2.24	83.90	64.50	33.89
	Organic farm	1.13	0.39	2.35	88.20	68.30	37.40
	Town refuse	1.18	0.44	2.39	93.10	75.22	42.11
Mean		1.11	0.37	2.28	85.10	66.83	35.20
2500	Control	0.97	0.27	1.98	68.50	56.44	24.65
	Compost	1.02	0.29	2.12	73.20	59.20	27.50
	Organic farm	1.06	0.33	2.17	77.90	63.30	32.98
	Town refuse	1.12	0.38	2.25	82.70	69.20	36.88
Mean		1.04	0.32	2.13	75.58	62.04	30.50
2000	Control	0.89	0.25	1.85	64.88	53.44	22.80
	Compost	0.95	0.28	1.94	68.40	57.20	24.77
	Organic farm	1.01	0.32	2.08	73.22	61.90	29.86
	Town refuse	1.05	0.36	2.13	79.40	66.40	33.40
Mean		0.98	0.30	2.00	71.48	59.74	27.71
LSD. 5% Irrigation rate		0.023	0.018	ns	3.261	4.753	1.822
LSD. 5% Organic sources		0.045	0.025	ns	2.334	2.236	1.939
Interaction		ns	ns	ns	ns	ns	ns

The beneficial effects of the applied treatments are more attributed to the improved status of the air-water balance of the studied sandy soil, consequently increasing nutrient availability and mobility towards plant roots as well as the mechanism of their uptake by plant roots. Compost is a good organic fertilizer because it contains nutrients (N, P, K, Ca, Mg, and S), micronutrients as well as organic matter and leads to increases in macro-micronutrient contents in plants (Agegnehu *et al*., 2014).

3.4. Micronutrient concentrations in grain maize.

Data presented in Table (6) indicated that the effect of organic sources and irrigation water at different rates on micronutrient concentrations in grains of maize were increased with organic matter and an increase of irrigation water at a rate of 3000 m^3. The irrigation water at different rates and organic matter sources applied to maize plants showed a significant increase in Fe, Mn, and Zn concentrations in grains. Also, the interaction between irrigation water at rates and organic matter sources was not significant for Fe, Mn, and Zn concentrations in grains. On the other hand, the relative increases of mean values were 17.55 % for Fe, 22.26 % for Mn, and 48.18 % for Zn concentrations in grain treated with organic matter sources combined with irrigation water at rate 3000 m^3 compared with control (irrigation water at rate 3000 m^3 without organic sources). Also, the relative increases of mean values Fe, Mn, and Zn concentrations in grains treated with organic matter sources and irrigation water at a rate of 2500 were 20.35 % for Fe, 24.70 % for Mn, and 57.89 5 for Zn respectively compared with control (irrigation water at rate 2500 m^3 alone). Concerning the relative increases of mean values were 13.69% for Fe, 15.89 % for Mn, and 28.68 % for Zn, respectively concentrations in grains treated with organic matter sources and irrigation water at a rate of 2000 m^3 compared with control irrigation water at a rate 2000 m^3 without organic sources. These results mean that the effect use of irrigation water at different rates combined with organic matter sources on micronutrient concentration in grains could be arranged in the following order: 2500 m^3> 3000 m^3> 2000 m^3 compared with control. These results are in agreement with Hu *et al*. (2007) reported that the effect of drought stress on nutrient uptake was reduced by the roots partially due to the reduction in soil moisture, which causes a decreased rate of nutrient diffusion from the soil matrix to the absorbing root surface. Papafilippaki *et al*. (2015) found that the town refused compost applied to soil increased the bioavailability of micronutrient concentration in plants. Compost application to soil increases soil water availability and nutrient uptake by plants, but it is not clear whether it can also improve the ability of plants to recover after drought stress (Nguyen *et al*., 2012). Compost plays a crucial role in various physiological processes in plants, including enzyme activation, photosynthesis, and increase of nutrient uptake (Cakmak *et al*., 2023).

3.5. Maize quality.

Data presented in Table (7) suggested that the effect of irrigation water at different rates and organic sources on protein (%), carbohydrate (%), and chlorophyll (mg/g.f.w) was significantly increased while the oil (%) was not significant. The oil (%), carbohydrate (%), and chlorophyll (mg/g.f.w) were significantly increased while the protein (%) content in the plant was not significant as an effect of organic matter sources. Also, the interaction between organic matter sources and irrigation water different rates were no significant for protein, oil, carbohydrate, and chlorophyll content in plants. Protein, oil, carbohydrates, and chlorophyll were important components of maize crops besides biomass and yield. The application of irrigation water in the town refuses increased protein. Carbohydrate, oil, and chlorophyll content in grain maize. The increase in protein content in grains as affected by combined with NPK and organic farm application is consistent compared with the control (Cai *et al.,* 2019).

Table 7: Effect of irrigation water rates and organic sources on quality of maize plants.

Irrigation rate (m^3)	Organic fertilizer	Protein (%)	Oil (%)	Carbohydrate (%)	Total Chlorophyll (mg/.g.f.w.)
3000	Control	5.92	3.22	70.10	6.40
	Compost	6.27	3.85	74.80	7.90
	Organic farm	6.50	4.20	77.10	8.33
	Town refuse	6.79	4.65	79.77	8.65
Mean		6.37	3.98	75.44	7.82
2500	Control	5.58	3.12	68.40	4.85
	Compost	5.87	3.65	73.20	4.99
	Organic farm	6.10	3.95	75.20	5.65
	Town refuse	6.44	4.12	77.10	6.30
Mean		6.00	3.71	73.48	5.45
2000	Control	5.12	2.95	65.40	4.10
	Compost	5.46	3.25	69.88	4.66
	Organic farm	5.81	3.76	73.90	4.80
	Town refuse	6.04	3.85	75.44	5.22
Mean		5.61	3.45	71.16	4.70
LSD. 5% Irrigation rate		0.36	ns	1.33	1.50
LSD. 5% Organic sources		ns	0.40	1.15	0.55
Interaction		ns	ns	ns	ns

The application of organic matter from different sources and irrigation water at 3000 m^3 and 2500 m^3 improved biomass, yield, and maize quality. On the other hand, the relative increases of mean values were 10.14 % for protein (%); 31.37 % for oil (%); 10.16 % for carbohydrate, and 29.53 % for chlorophyll contents in maize as affected by compost combined with irrigation water at rate 3000 m^3 compared with irrigation water at rate 3000 m^3 without organic matter sources. The corresponding relative increases of mean values protein, oil, carbohydrate, and chlorophyll contents in maize were 10.04 % for protein; 2.24 % for oil, 9.90 % for carbohydrate, and 16.49 % for chlorophyll respectively treated with organic farm and irrigation water at rate 2500 m^3 than control (irrigation water at a rate 2500 m^3) alone. As well as, the relative increases of mean values were 12.70 % for protein, 22.71 % for Oil, 11.67 % for carbohydrate, and 19.27 % for chlorophyll respectively contents in maize plants treated with town refuse combined with irrigation water at a rate of 2000 m^3 compared with control (irrigation water at rate 2000 m^3 alone. Therefore, it could be categorized the beneficial effects of the used irrigation water at different rates and organic sources on the studied crop maize into different orders according to the amounted of increases in protein. Oil, carbohydrate, and chlorophyll are as follows:

Town refuse > compost > organic farm > control for Protein and carbohydrate. Compost > town refuse > organic farm > control for Oil and chlorophyll. These results are in agreement with Nadeem *et al*. (2023) reported that the highest mean values of oil content; protein, and total chlorophyll contents were used with organic farms under normal irrigation rather than drought.

3.5. Water production (WP):

Water production (WP)is the standard for comparing the economy of agricultural water use units under different rates of irrigation water. Data presented in Table (8) indicated that irrigation at a rate (2000 $m^3 fad^{-1}$) exhibited the maximum (WP) value (5.30 kg m^3) combined with town refuse. This may be due to the lower applied irrigation water under (3000$m^3 fad^{-1}$) and (2500 $m^3 fad^{-1}$) resulting in lower (WP) mean values (3.93 and 4.23 kg m^{-3}). On the other hand, relative increases of mean values for Water production (WP) were 11.67 % for soil treated with organic sources and irrigation water different rate at 3000m^3 compared with control irrigation water at a rate of 3000 m^3 alone. The relative increases of mean values were 11.03 % for soil traded with organic sources combined with irrigation water at a rate of 2500 m^3 than control irrigation water at a rate of 2500 m^3 alone. Correspondingly, relative increases of mean values (WP) were 8.51 % for soil treated with organic matter sources combined with irrigation water at a rate of 2000 m^3 combined with control irrigation water at a rate of 2000 m^3 alone. These results are in agreement with Abd El-Halim *et al*. (2014) indicated that water productivity was significantly positively affected by irrigation water intervals 7 and 14

Table 8: Water productivity (W.P.).

Irrigation rate (m^3)	Organic fertilizer	Weight of yield (ton/fed)	WUE. (kg/m^3)
3000	Control	1.093	3.60
	Compost	1.173	3.90
	Organic farm	1.200	4.00
	Town refuse	1.250	4.20
Mean		1.18	3.93
2500	Control	0.975	3.90
	Compost	1.040	4.20
	Organic farm	1.095	4.40
	Town refuse	1.110	4.40
Mean		1.06	4.23
2000	Control	0.930	4.70
	Compost	0.986	4.90
	Organic farm	1.020	5.10
	Town refuse	1.050	5.30
Mean		1.00	5.00

Days in both seasons for maize production. The greater amount of water saving with higher production and hence higher water productivity, it seems that planting maize in double ridge-furrow, where the water was applied at 7- day intervals, permitted better and continuous distribution of irrigation water around the roots and maintained the soil moisture content closer to the optimum level. Ouda *et al*. (2010) found that water productivity was the highest when the irrigation schedule was changed under irrigation water amounts. Crop irrigation water requirement and irrigation water productivity were mainly influenced by soil texture and soil fertility. Soil management to improve water productivity should be addressed. In agricultural water management, reasonable irrigation water allocation based on soil conditions should be considered (Fang and Su, 2019).

4. Conclusion

The findings of both seasons' field trials showed that the growth, production, and quality characteristics of maize in a dry agroecosystem were significantly affected by the various additives added to town refuse and its combination with irrigation water treatments. Organic matter combined with irrigation water at different rates led to soil fertility and increased nutrient concentration in soil, concentrations in grains, and maize productivity and quality, especially irrigation water at rates of 3000 m^3 and 2500m^3.

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