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Measuring the use of urban waste and its economic impact on agricultural land productivity: an applied study on eggplant production

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Abstract

The problem of urban waste and how to dispose of it safely without affecting human health and the environment is one of the most important problems that Iraqi cities suffer from, especially the capital, Baghdad, due to population growth and high population density. Furthermore, proper disposal methods are not followed, despite the existence of four unused waste recycling plants. Instead, waste is burned or buried, which negatively impacts the health of residents in nearby areas, especially in the informal settlements that have recently proliferated, most of which are inhabited by the poor. In addition, we have high costs for vegetable production, and the most important cost component is chemical fertilizer, the repeated use of which in the soil leads to an increase in the percentage of some undesirable elements and a deterioration of soil properties. Therefore, the experiment was conducted in cooperation with the waste recycling plant in Al-Yusufiyah (20 km southwest of Baghdad). The organic material (compost) was prepared using poultry and buffalo waste, and the sludge (sewage waste) was obtained from the Al-Rustamiyah area (15 km southeast of Baghdad). The experiment was carried out on agricultural land in the Abu Ghraib area (33 km from Baghdad), where an area of (2) dunams was equipped with greenhouses using a completely randomized block design for eggplant cultivation.

Keywords: Urban waste. Yield. Eggplant crop.

Introduction

The issue of waste management and disposal is an important topic in both developing and developed countries, as it costs huge sums of money. Moreover, organic waste is a source of pollution if the way it is collected or disposed of is not handled properly **[1]**. Waste also includes animal waste, which humans first collected and used as fuel before the discovery of coal and oil. Some rural areas in developing countries still rely on it for heating **[2]**.

In Iraq, many cities, especially the capital Baghdad, suffer from the problem of waste and how to dispose of it. There are several methods, the most important of which is burning it. Neighborhoods near burning areas suffer from problems of smoke, foul odors, and incurable diseases as a result of air pollution. These neighborhoods are often the least poor in the cities. Moreover, the burning process is not useful because of its negative effects on soil organisms. When waste and other refuse are burned, it leads to the death of living organisms in it and the inability to cultivate it for years. In addition, some solid waste cannot be disposed of in this way and needs to be treated in a special way to prevent it from remaining in the soil.or burying them may be done in areas not far from the reach of the population, which causes many problems in the long term, since burying these wastes and the decomposition of some of them, while some of the solid waste remains, cannot decompose in the soil in the long term. This in turn affects the physical and chemical properties of the soil, as well as groundwater, and these lands may not be

able to be cultivated for many years if they are not treated [3].

The best way to get rid of city waste is by separating and sorting its components and converting the larger and more useful part of it into organic fertilizer that can be used in agriculture, since the sources of organic fertilizers in Iraq are limited and almost exclusively animal manure. In addition, the nature of the mineral composition of the soil, which reflects the nature of its various basic components, represented by clay minerals, carbonate minerals, its content of organic matter and oxides, the proportions of its separations, and its evolutionary path that it has reached over time, indicates that it is significantly affected by the external environment. This, in turn, requires good soil management and protection from any factors that lead to a change in its chemical and physical properties. One of the most important and prominent of these factors is the accumulation of waste in agricultural soils. It is also one of the most important causes of pollution of these soils in the short or long term, depending on the different types of waste [4].

The research aims to measure and assess each of the following points acomparative economic analysis of the use of chemical and organic fertilizers in eggplant production. In addition, the production of high-quality organic fertilizers (compost) as a complete or partial alternative to chemical fertilizers, which have a negative impact on the soil and pollute the environment. As well as measurement a study of the effect of these fertilizers on eggplant yields in greenhouses, providing a practical example of the feasibility of disseminating organic compost production technology from waste and municipal byproducts on a large commercial scale. This also leads to improved soil properties in the long term as a result of using organic fertilizers and reducing the use of chemical fertilizers, and this is reflected in the plant and increased production.

The research problem lies in the fact that frequent and intensive cultivation of the land leads to the depletion of soil elements and a decrease in its productivity. Furthermore, reliance on chemical fertilizers leads to a deterioration in the physical and chemical properties of the soil, as well as a decline in the quantity and quality of agricultural products. The high prices of chemical fertilizers lead to increased production costs, which in turn leads to higher prices that may prevent local products from competing with imported products. The importance of the research stems from the importance of the problem related to agriculture on the one hand, which is achieving the highest levels of productivity, and the deterioration of the soil when chemical fertilizers are used continuously, as well as the low productivity of these fertilizers due to adulteration, and on the other hand, what is related to the environment and the proper and beneficial disposal of city waste.

The research hypothesis can be explained in that producing eggplant crops in greenhouses grown in soil fertilized with organic fertilizer consisting of compost (prepared from city waste) mixed in certain proportions with other animal waste leads to improved soil properties and also gives better production than the same crop fertilized with chemical fertilizer, which in turn leads to maximizing profits while reducing costs.

Materials and Methods

Practical Aspect

Compost Preparation

The composting process was carried out at the solid waste recycling plant in the Yusufiyah area, located approximately 20 km south of Baghdad (the plant was normally closed but was restarted for this experiment). The compost was prepared using the Windrow method, and the materials bellow were used:

Organic fraction of municipal solid waste (OFMSW), collected from household and restaurant waste, primarily including food scraps, fruits, and vegetables, after manual sorting. Approximately 100 garbage trucks (compactors) arrive at the site from central Baghdad, each with an average load of 5 tons (meaning the plant receives 500 tons of waste daily). First, the sorting process begins, where each material is sorted separately (such as glass, plastic and iron, cardboard, construction material remnants, and food and fruit remnants, which is what concerns us). The food and fruit remnants are transferred to a special area and spread out in lines for the purpose of ventilation and fermentation. There are pipes that pump water and air onto these lines, and the humidity level rises until it reaches 80% in the first week. The temperature also rises from 20 degrees Celsius to 60 degrees Celsius as a result of the reactions in the organic material. It is stirred by a tractor, and this process continues for 6 weeks, as its temperature decreases until it reaches 20 degrees Celsius at the end of the sixth week. After that, it is stirred without pumping anything for another two weeks until it dries and its components are measured. It can be enriched with additives (such as adding poultry or buffalo waste or some elements if needed) and becomes ready for use as organic material for composting. Considering the nature of the Iraqi table and some inherited customs and traditions, we obtain 65% (Table 1)

organic material from the quantity of waste received (and this has a special study on the economics of disposing of city waste safely that will be completed) **[5,6]**.

Table 1. Shows the mixing ratios of organic waste used in compost.

Transactions	poultry waste	Sewage waste	Buffalo waste	OFMSW Municipal Waste	chemical fertilizer	Mixing ratios
C_1	-	-	-	-	-	-
C_2	-	-	-	-	1	100%
C_3	-	-	-	1	--	100%
C_4	-	-	1	3	--	1:3
C_5	-	1	-	3	--	1:3
C_6	1	1	1	2	---	1:1:1:2
C_7	1	-	-	3	---	1:3

Source: Prepared by the researchers based on the results of the experiment data.

Results and Discussion

The experiment was conducted on farmland in the Abu Ghraib area, covering an area of tow dunams (approximately 1.2 acres) covered with greenhouses. Eggplant was planted on November 12, 2022. The experiment was carried out by adding the standard quantities of fertilizer per dunam, as prescribed for vegetable crops, including eggplant. The amount of chemical fertilizer was 400 kg/dunam, while the amount of organic fertilizer was 10 tons/dunam of all types. These quantities were added according to the prescribed mixing ratios. The costs were calculated based on these ratios, using a completely randomized block design with four replicates for each mixing ratio. The results are shown in Table 2, which represents the total yield from January 10 to May 20, 2023, when the harvest rate began to decline.

Table 2. Shows the total yield of eggplant crop tons/dunum for the period (10/1 - 20/5/2023).

Mixing ratios	Sectors (repeators)				
	1	2	3	4	Total
C_1	9.8	6.7	11.2	8.2	35.9
C_2	14.7	13.5	18.9	17.8	64.9
C_3	31.9	27.4	29.9	29.7	118.9
C_4	39.9	45.7	35.6	38.4	159.6
C_5	38.1	40	36.4	38.9	153.4
C_6	41	37.7	38.9	37.8	155.4
C_7	47.4	45.9	43	46.9	183.2
Total	222.8	216.9	213.9	217.7	871.3

Source: Prepared by the researchers based on the results of the experiment data.

Estimates of the population mean (μ), the coefficient effect (ti), and the segment effect (ri) can be obtained using the least squares method by partially differentiating the sum of squared deviations of error for each of the variables (μ, ti, rj), **[7]**. and setting the results to zero. In this case, the sum of squared deviations we want to obtain is the smallest possible (the sum of squared deviations of error), **[8]**. which is:

$R = \sum_{ij} (y_{ij} - \mu - t_i - r_j)^2$

From this we obtain the following differential equations:

$\partial R/\partial \mu = -2(y_{ij} - \mu - t_i - r_j) = 0$

$\partial R/\partial t_i = -2(y_{ij} - \mu - t_i - r_j) = 0$

$\partial R/\partial r_i = -2(y_{ij} - \mu - t_i - r_j) = 0$

The sum of the differential equations leads to the following independent natural equations: The equation for the population mean (μ) is:

$Y = rt\mu + r\sum ti + t\sum rj$

Equations for the effect of the coefficient ti are:

$Y_i = r\mu + rt_i + \sum r_j$

The equations for the effects of the rj sectors are:

$Y_i = t\mu + \sum t_i + tr_j$

The analysis of variance table can also be calculated using the following steps: [9]

1- Calculating the correction factor:

$C = (\sum Y)^2 / rt$

2- Calculate the total squares:

$TSS = \sum y2ij - C$

3- Calculate the sum of the squares of the sectors:

$ESS = (\sum Y2j/r) - C$

4- Calculate the sum of the squares of the coefficients:

$TSS = (\sum Yi2/t) - C$

5- Calculate the sum of the squares of the error:

$RSS = TSS - ESS - tSS$

Next, we summarize the results of the analysis in the analysis of variance table, complete the table, and perform the F-test to test the effect of the treatments, as follows:[10]

Correction factor $C = (871)2 / 7*4 = 27094$

Total squares:

$TSS= [(9.8)^2 + (14.7)^2 + (31.9)^2 + (39.9)^2 + (38.1)^2 +$ ---------- $+ (46.9)^2] - 27094$

$TSS = 31709 - 27094 = 4615$

Sum of squared sectors (repeated):

$RSS = \{ (222.8)^2 + (216.9)^2 + (213.9)^2 + (217.7)^2 /t\} - 27094$

$RSS= 189832 /7 - 27094 = 27118.85 - 27094 = 24.85$

Sum of squared coefficients:

$tSS= [(35.9)^2+ (64.9)^2 + (118.9)^2 + (159.6)^2 + (153.4)^2 + (155.4)^2 + (183.2)^2]/r - 27094$

$tSS = 126353.2 /4 - 27094 = 31588.29 - 27094 = 4494.3$

The sum of the squares of the error: [11]

$RSS = TSS - ESS - tSS$

$RSS = 4615 - 4494.3 - 24.85 = 95.85$ (Table 3)

Table 3. Table of Variance Analysis.

Sources of difference	SS	d.f	MS	F
Sectors (repeators)	24.85	3	16.25	248.38 **
Transactions	4494.3	6	787.23	
Error	95.85	18	4.21	
Total	4615	27		

Source: Prepared by the researchers based on the results of the experiment data using a randomized block design.

The analysis of variance (ANOVA) Table 4 shows that the calculated F = 248.38 value is greater than the tabulated F value, with 6 degrees of freedom in the numerator and 27 in the denominator, and a significance level of 0.01, which equals F6.27.α = 2.771. This indicates significant differences between the treatments due to the use of organic fertilizer. These results were obtained manually. This is almost consistent with the results obtained using the SPSS statistical software, which also confirms significant differences between the treatments.

Table 4. Variance Analysis Table from SPSS program. (Anova Table).

Sig.	F	Mean Square	df	Sum of Squares	
.000	155.837	759.481	6	4556.884	Between Groups
		4.874	21	102.345	Within Groups
			27	4659.229	Total

Source: SPSS program results.

After it became clear that there were significant differences in production resulting from the use of organic fertilizers in different mixing ratios instead of chemical fertilizers, we needed to determine which ratio yielded the best production. To this end, we used several tests to measure which ratio produced the most yields. The most important of these tests is Tukey's B test, **[12]** as shown in Table 5. It is evident that Treatment 1 (Subset for alpha = 0.05) differs significantly from all other treatments, as none of the other treatments share the same field, yet it represents the lowest average production of 8.6049 tons/dunum. This also explains the differences between Treatments 2 and 3, as they differ from each other, from Treatment 1, and from the other treatments. The experiment shows a difference in their average production, which reached 15.6000 and 29.4700 tons/dunum. As for treatments 4, 5, and 6, there are no significant differences between them because they are in the same category, as it is observed that their averages are very close, as their average production reached 39.5800, 38.9000, and 38.2000 tons/dunum respectively. However, they differ significantly from treatments 1, 2, 3, and 7 because they are not present in any of the other experimental fields. Subset for alpha = 0.05, This means that the treatments of mixed organic fertilizers in different proportions are significantly superior to the control treatment represented by treatment number 1, and the chemical fertilizer treatment represented by treatment number 2. Likewise, treatment number 3, which represents the use of 100% organic fertilizer, while treatment 7 is significantly different from all the treatments in the experiment as none of the six treatments were involved with it, and it is distinguished by its high average production compared to the other treatments, which reached 46.5500 tons/dunum.

Table 5. Tukey test table, and Duncan test.

Subset for alpha = .05						VAR00006	
5	4	3	2	1	N		
				8.6049	4	1.00	Tukey HSD(a)
			15.6000		4	2.00	
		29.4700			4	3.00	
	38.2000				4	5.00	
	38.9000				4	6.00	
	39.5800				4	4.00	
46.5500					4	7.00	
1.000	.976	1.000	1.000	1.000		Sig.	
				7.5750	4	1.00	Duncan(a)
			14.4000		4	2.00	
		28.4500			4	3.00	
	38.2000				4	5.00	
	38.9000				4	6.00	
	39.5800				4	4.00	
46.5500					4	7.00	
1.000	.432	1.000	1.000	1.000		Sig.	

Means for groups in homogeneous subsets are displayed. (a) Uses Harmonic Mean Sample Size = 4.000. Source: SPSS program results.

Cost and Profit Calculations

As shown in Table 6, the total production costs, which only include fertilizer costs, are considered because all other costs are equal in all replicates, and the difference lies in the fertilizer costs, as follows:

Table 6. Shows the costs of fertilizers used in the experiment.

Treatment ratios for fertilizer use	Total production (kg)	Production value\dinar (TR)	Total costs\dinar (Tc)	Profits\ dinar (π=TR-Tc)
C_1	8775	8915400	0	8915400
C_2	18530	18826480	500000	18326480
C_3	29750	30226000	1100000	29126000
C_4	38778	39398448	900000	38498448
C_5	39360	39989760	790000	39199760
C_6	40570	41219120	750000	40469120
C_7	45600	46329600	1000000	45329600

Source: Prepared by the researchers based on experimental data.

Costs were calculated at prevailing market prices,

where the price of a ton of chemical fertilizer ranges from 950,000 to 1,100,000 dinars. The requirement for one dunam for vegetable crops, including eggplant, is 400 kg/dunam. The requirement for one dunam of organic fertilizer (compost), with its various mixing ratios including poultry and buffalo manure and sludge, is 10 tons/dunam (This is the quantity recommended by specialists for vegetable cultivation.) Costs were calculated based on a compost price of $100 per ton, buffalo manure and sludge prices ranging from 17,000 to 22,000 dinars per ton, and poultry manure prices of 80,000 dinars per ton (Table 7).

Table 7. Measures Profit Equations for Mixing Levels of Fertilizer Used in Eggplant Production.

Transaction	C_1	C_2	C_3	C_4	C_5	C_6	C_7
Fertilizer costs\Iraqi dinar	0	500000	1100000	900000	790000	750000	1000000

Source: Prepared by the researchers based on the profit equation and the results of Table 4.

By looking at the results of the table above, which includes estimating the profit equations for the levels of fertilizer use in eggplant crop production, it is clear that the seventh treatment for the levels of fertilizer mixing ratios was the highest in terms of the profits achieved (п), **[13]** as it amounted to a value of (45,329,600) dinars, followed by the sixth treatment, the fifth treatment, the fourth treatment, the third treatment, then the second treatment, and finally the first comparison treatment, respectively, which was the least profitable. This indicates that eggplant crops benefit significantly more when organic fertilizer (compost) is used instead of chemical fertilizer.

It is also clear that organic fertilizer, in its various formulations, offers distinct profit advantages over chemical fertilizer, in addition to other less obvious benefits, most notably the safe and cost-effective disposal of urban waste, improved soil texture, and the absence of any undesirable chemical or other contaminants on the fruit. Experts in each field can scientifically study these effects and establish the valid scientific findings. As is the case with the numerous studies that have been conducted on the importance of organic matter for the soil, it has been indicated that soils rich in organic matter are a factor of great importance in determining soil health and its relationship to increased crops. The addition of organic matter has led to plant growth and reduced the negative effects of soil salinity **[14]**. The use of organic fertilizer has also led to an improvement in the physical and chemical properties of the soil, as well as a reduction in soil salinity and an increase in the absorption of nutrients **[15]**.

Recommendations

1. Focus on, encourage, and support organic farming by providing sites for converting municipal waste into compost.
2. Guidelines for using a 3:1 ratio of compost to poultry waste.
3. The importance of the safe disposal of urban waste through composting to support agricultural production, environmental cleanliness, and soil improvement.
4. The necessity of conducting environmental studies on the safe disposal of urban waste and its conversion into a beneficial resource for society, soil, and the environment.

Conclusion

The study demonstrated that using organic fertilizer (compost) increased eggplant production, leading to higher profits. Furthermore, it helped save the Iraqi environment from urban waste by converting it into organic fertilizer for agriculture instead of burying or burning it. The study's hypothesis was confirmed, showing a significant difference in eggplant production and a substantial increase in profits when using organic fertilizer (compost prepared from urban waste) instead of chemical fertilizer. Increased eggplant yield from organic fertilizer at all ratios, resulting in higher profits. Treatment seven stood out from all other treatments in the experiment, showing significant differences in profits and substantial differences in yield according to the Tukey and Duncan statistical tests.

CrediT

Author contributions: Conceptualization, methodology, investigation, data collection, formal analysis, data interpretation, supervision, writing—original draft: All authors.

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Informed Consent

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Data Sharing Statement

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request, and all data is stored following privacy and ethical guidelines.

Conflict of Interest

The authors declare no competing interests.

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