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RESEARCH ARTICLE

The Effect of the Type of Organic Residues and the Level of Lead on the Growth of Yellow Corn *mays Zea L.*

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ABSTRACT

For the purpose of studying the behavior of lead in the two study soils in Basrah Governorate, southern Iraq, soil samples were collected from two sites in Basrah Governorate (Al-Zubair and Kutayban) with different chemical and physical soil properties, and their content was estimated. Of total lead, a pot experiment was carried out that included growing the yellow corn crop (*mays Zea L.*) in pots filled with three kg of air-dry soil from the two study soils, treated with organic waste (cow waste and wheat straw waste) at a level of 0.40 tons ha^{-1}. Then lead was added to the two study soils at a level of 0, 50, and 100 mg Pb kg^{-1} soil. The experiment continued for 60 days, after which plant growth measurements were taken, as well as the amount of total and ready lead remaining in the soil. The results of the study showed that adding lead at a level of 50 mg Pb kg^{-1} soil significantly increased the total lead concentration compared to the comparison treatment, and the Zubair soil was superior to the Kutayban soil in terms of dry weight and absorbed quantity. The levels of materials added from cow manure and wheat straw to the two soils of the study had a significant effect. In the concentration of lead compared to the comparison treatment, with the difference in the effect of the two substances, the cow manure 40 tons ha^{-1} outperformed the rest of the treatments and gave the highest growth characteristics, as the dry weight of the plant and the amount absorbed reached 8.806 mg pot^{-1} and 2.281 mg pot^{-1}, respectively.

Keywords: Cow waste, Lead, Organic residues, Wheat straw.

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1. Introduction

Pollution is an environmental phenomenon that has taken a large part of the attention of governments around the world since the second half of the twentieth century. The problem of pollution is considered one of the most pressing environmental problems that have begun to take on serious environmental, economic, and social dimensions, especially after the Industrial Revolution in Europe and the massive industrial expansion supported by modern technology. Recently, industries have taken dangerous trends, represented by great diversity and the emergence of some complex industries, which are often accompanied by serious pollution that usually leads to the deterioration of the biosphere and the elimination of global ecosystems [1]. The problem of environmental pollution is one of the most serious problems facing the world, especially in developing countries. The agricultural use of untreated wastewater, the use of agricultural fertilizers, and automobile exhaust are among the main sources of environmental pollution. These materials may contain heavy elements that may be toxic or that have a harmful effect on plants. It depends on the nature of the elements and their bioavailability [2].

Showed that the presence of heavy elements in the environment as pollutants is a serious problem that destroys the environment and is more harmful than organic pollutants, as most organic pollutants are degradable, and that the presence of heavy elements can reduce the rate of decomposition of organic pollutants and thus in fact double the problems environmental pollution [3]. Lead is one of the elements polluting the environment, and its source is industrial activities such as the manufacture of batteries, electrical wires, and pipes in which lead is used, in addition to foundries and from the decomposition of paint containing lead in the soil, as well as gasoline containing lead, motor oils, pesticides, and sources of combustion [4]. Indicated that organic matter is considered an important element in soil productivity as a result of its influence on physical, chemical, and biological properties, recycling nutrients, conserving water in the soil, regulating the degree of interaction and the exchange mechanism of positive ions, so organic waste is important from a standpoint [5], [6]. Agricultural as a result of its impact on crop production [7]. Therefore, organic matter reduces the readiness of heavy elements as a result of its association with carbonates, organic matter, and metal oxides [8]. It was pointed out by Singh *et al*. indicated a decrease in the readiness of heavy metals for the plant when fermented cow manure and rice straw were added compared to unfermented manure [9].

The yellow corn crop is considered one of the economically important cereal crops, as it is used in human and animal nutrition and comes in third place after wheat and rice in terms of cultivated area and production. Despite the environmental conditions being suitable for its cultivation in Iraq, its productivity is still low per unit area, and this is due to the lack of basic factors, including Water [10].

2. Methods

The agricultural experiment was conducted in the canopy of the Research Station of the College of Agriculture, University of Basrah, during the 2022–2023 agricultural season, where the yellow corn crop (*mays zea L.*) was planted for the purpose of testing the effectiveness of organic wastes in the adsorption and release of lead. Some preliminary chemical and physical properties of the soil and its content of lead were estimated total lead (Table I). The experiment was designed on the basis of a completely randomized design with a factorial experiment. The experiment included two types of soil × the best level of organic waste treatments × lead levels × replicates. Thus, the number of experimental units is 2 × 3 × 3 × 3 and is 54 experimental units soil × Organic waste treatments × Lead levels × Refineries. Plastic pots with a height of 15 cm and a diameter of 18 cm were used, containing 3 kg of soil (after drying them and sifting them with a 4 mm sieve).

All treatments were treated with a single level of nitrogen, 695.65 kg N ha^{-1}, in the form of urea fertilizer (46% N), equivalent to 1.04 g of potting urea in two batches, the first at planting mixed and the second after a month of planting with irrigation water. Phosphorous fertilizer was also added in the form of concentrated superphosphate fertilizer (20.21% P), amounting to 593.76 kg P ha^{-1}, equivalent to 0.89 g of potting. As for potassium, at a level of 186.05 kg K ha^{-1} in the form of potassium sulphate fertilizer (43% K), which is equivalent to 0.279 g K^{-1} in one batch before planting, mixed with the soil.

Yellow corn seeds were planted on April 1, 2023, after soaking the seeds in water for two days, with 10 seeds per pot, then irrigated with water equivalent to the field capacity. All pots were arranged for the different treatments in a random order. It is worth noting that the germination process was carried out before planting, and after the success of the germination process, they were placed 10 seeds in each pot after germination. They were reduced to 6 plants, and the pots were watered during the experiment period to the level of moisture level of the field capacity.

TABLE I: The Physical and Chemical Characteristics of the Two Study Soils

Units	Soils		Adjective
	Kutayban soil (T_2)	Zubair soil (T_1)	
—	7.45	7.60	Soil reaction pH1:1
ds m^{-1}	5.00	4.72	Electrical conductivity EC1:1
C $mole^{+}$ kg^{-1}	20.21	10.12	Ketone exchange capacity (CEC)
g kg^{-1}	5.62	3.75	Soil organic matter O.M
g kg^{-1}	372	291.51	Total solid carbonates
Dissolved positive ions			
mmoIL^{-1}	14.38	7.92	Ca^{2+}
	5.52	6.79	Mg^{2+}
	6.5	17.25	Na^{+}
	3.74	1.52	K^{+}
Dissolved negative ions			
mmoIL^{-1}	13.37	8.91	$SO_4{}^{2-}$
	20.5	30.72	Cl^{-}
	3.52	1.30	$HCO_3{}^{-}$
	0	0	$CO_3{}^{2-}$
mg kg^{-1}	29.40	13.30	Total lead
Soil separators			
g kg^{-1}	136	90.31	Clay
	419.2	50.48	Silt
	445	860	Sand
	Mixed greenery	Mixed sand	The tissue

After the moisture content decreased to half of the field capacity, watering was repeated for all the soil by weighing the pots from time to time. After 60 days had passed since the planting process, the plants were harvested at a height of 1.5 cm from the soil surface. The plants were washed with plain water, then with distilled water to remove the suspended dust, and then dried in the oven at a temperature of 65°C for 72 hours until the weight was constant, after which the dry weight of the plants was recorded, then they were cut, ground, and sieved with a sieve. The diameter of its holes was 1 mm, and it was stored in plastic containers until the required chemical analyzes were carried out.

2.1. Studied Characteristics of the Plant

2.1.1. Dry Weight of Shoots

After taking the shoots of the plants and all the pots, they were dried at a temperature of 65°C, and after the end of drying, their dry weight was recorded.

2.1.2. Plant Digestibility and Determination of Lead in Shoots

The plant was digested using dry plant samples (vegetative part) by taking 0.5 g of dried and ground plant samples and digesting them using the acid mixture (Nitric acid: Perchloric Acid) (HNO_3: $HClO_4$) in a ratio of 1:3 according to the method mentioned in Kalra [11]. The lead was then determined in the digestion solution using Atomic Absorption Spectroscopy (AAS).

TABLE II: Effect of Lead Levels, Cow Manure, and Wheat Straw on the Dry Weight (g of pot^{-1}) of Yellow Corn Plants in the Two Soils of the Study

Soil × coefficients	Lead levels (mg Pb kg^{-1})			Transactions (ton ha^{-1})	Soil
	100	50	0		
7.922	7.600	7.630	8.536	Comparison	
7.798	7.280	7.260	8.856	Cow waste 40	Al-Zubair
7.185	8.313	6.526	6.716	Wheat straw 40	
5.441	6.053	6.013	4.256	Comparison	
9.815	9.636	8.566	11.243	Cow waste 40	Kutayban
4.620	4.650	4.220	4.990	Wheat straw 40	
		Coefficients			
6.681	6.826	6.821	6.396	Comparison	
8.806	8.458	7.913	10.049	Cow waste 40	Coefficients × lead
5.902	6.481	5.373	5.853	Wheat straw 40	
		Soil			
7.301	7.731	7.138	7.036	Al-Zubair	
6.624	6.779	6.266	6.829	Kutayban	Soil × lead
7.129	7.255	6.702	7.432	Lead levels	

Soil × coefficients × lead	Soil × coefficients	Coefficients × lead	Soil × lead	Coefficients	Soil	Pb levels
N.S	1.701**	N.S	N.S	1.148**	0.673*	N.S

Note: * means significant at 0.05 probability level, ** means highly significant at 0.05 probability level, and N.S means Nonsignificant.

2.1.3. Calculate the Amount of Lead Absorbed

The absorbed amount of lead in the shoot was calculated by multiplying the concentration of the element in plant tissues with the weight of the dry matter of the plant.

$$\textit{Absorbed amount} = \textit{weight of dry matter (weight of plant after drying)} \times \textit{concentration (content of element in plant)}$$

3. Results and Discussion

3.1. Dry Weight of the Vegetative Part

The results of Table II show a highly significant effect of the treatments added to the two study soils on the dry matter of yellow corn plants, as the treatment added at a level of 40 tons ha^{-1} of cow manure gave the highest value for the dry matter rate of 8.806 g pot^{-1}, while the treatment added 40 tons ha^{-1} lowest values 5.902 g pot^{-1}.

The results of Table II showed that there were significant differences in the type of soil in the dry matter of yellow corn plants. Al-Zubair soil gave the highest value for dry matter, which amounted to 7.301 g pot^{-1}, while the Kutayban soil gave the lowest value, which amounted to 6.624 g pot^{-1}. The results of Table II showed that there was no significant effect when comparing the levels of lead added to the two soils of the study on the dry weight of yellow corn plants. The binary interaction between treatments, lead levels, soil type, and lead levels did not have a significant effect on the dry weight of yellow corn plants, while the interaction of soil type gave the added treatments a highly significant effect, as the results of Table II indicate the superiority of the Kutayban soil, which gave the highest value of 9.815 g pot^{-1} when treating the same soil with 40 tons ha^{-1}, and the lowest value reached 4.620 g pot^{-1} when treating the same soil. The reason for the increase in dry matter production of the yellow corn plant can be explained by the fact that adding cow manure to the soil causes an increase in the absorption of water and nutrients by the roots of the yellow corn plant due to improving the physical conditions of the soil and increasing the soil's water retention. These results are consistent with the findings of Varela Milla *et al*. [12] and Zamir *et al*. [13]. The triple interaction of experimental factors did not significantly affect the dry matter weight of yellow corn plants.

3.2. Lead Concentration in the Shoots of Yellow Corn

The results in Table III show that there are significant differences in the lead content in the vegetative parts of the yellow corn plant with increasing lead contents, where the level of 50 mg Pb kg^{-1} gave the highest lead content in the yellow corn plant, reaching 0.346 mg Pb kg^{-1}, while the comparison treatment gave less. The lead content in yellow corn plants is 0.276 mg Pb kg^{-1}, and this is consistent with SAEED who found that the biological accumulation of lead increases with an increase in the concentration of lead in the shoot of wheat plants, and it was 36.80, 40.92, 43.60, 55.41 mg Pb kg^{-1} [14]. Dry weight at concentrations of 0, 25, 50, 75 mg Pb kg^{-1} soil. We conclude from this that the biological accumulation of heavy elements in the shoots has been confirmed by many studies conducted. Sao *et al*. [15] found it when treating the soil with concentrations of 1 mmol. of the elements (Pb, Cd, and Zn) [15], it led to an increase in the accumulation of these elements in the vegetative system with increasing concentrations, and this is consistent with what was found by Khudair that the accumulation of the element lead in the vegetative system of the Indian mustard plant increases in a proportional manner with the increase in its concentration in the soil, as it exceeded

TABLE III: The Effect of Lead Levels, Cow Manure, and Wheat Straw on the Concentration of Lead (mg pb kg^{-1}) in Yellow Corn Plants in the Two Soils of the Study

Soil × coefficients	Lead levels (mg Pb kg^{-1})			Transactions (ton ha^{-1})	Soil
	100	50	0		
0.376	0.444	0.430	0.254	Comparison	Al-Zubair
0.303	0.357	0.269	0.283	Cow waste 40	
0.317	0.283	0.356	0.313	Wheat straw 40	
0.440	0.446	0.605	0.269	Comparison	Kutayban
0.220	0.196	0.181	0.284	Cow waste 40	
0.235	0.211	0.239	0.254	Wheat straw 40	
			Coefficients		
0.407	0.445	0.517	0.261	Comparison	Coefficients × lead
0.261	0.276	0.225	0.283	Cow waste 40	
0.275	0.247	0.297	0.283	Wheat straw 40	
			Soil		
0.331	0.361	0.351	0.283	Al-Zubair	Soil × lead
0.298	0.284	0.341	0.269	Kutayban	
0.314	0.322	0.346	0.276	Lead levels	

Soil × coefficients × lead	Soil × coefficients	Coefficients × lead	Soil × lead	Coefficients	Soil	Pb levels
N.S	0.069*	0.085**	N.S	0.043**	N.S	0.051*

Note: * means significant at 0.05 probability level, ** means highly significant at 0.05 probability level, and N.S is nonsignificant.

Treatments at concentrations of 100, 200, and 300 mg kg^{-1} were significantly significant, respectively, compared to the comparison treatment of 77.3 mg kg^{-1} [16].

The results in Table III indicated that the additives from cow waste and wheat straw waste had a highly significant effect on the plant's lead content, as the lead content of the shoots of yellow corn plants decreased from 0.407 mg Pb kg^{-1} in the control treatment to 0.261 mg Pb kg^{-1}. When treating the addition of cow waste at a level of 40 tons ha^{-1}.

The results of Table III showed that there were no significant differences in soil type in the plant lead content in the plant parts of yellow corn plants. The results of Table III indicate that there is a highly significant effect between the additives and lead levels on the lead concentration of the shoots of yellow corn plants, where the treatment with 50 mg Pb kg^{-1} soil and the control treatment gave the highest value for lead concentration, which amounted to 0.517 mg Pb kg^{-1} soil and cow manure 40 tons ha^{-1} is the lowest concentration of lead in the shoots of yellow corn plants.

As for the interaction of soil type and added treatments, the effect was significant on the concentration of lead in the foliage of yellow corn plants, as the soil of Kutayban with 40 tons ha^{-1} of cow manure recorded the lowest value for the concentration of lead in the foliage of yellow corn plants, amounting to 0.220 mg Pb kg^{-1} compared to the equation. The comparison for the soil of Kutayban amounted to 0.440 mg Pb kg^{-1}. The results of Table III indicate that there is no significant effect of the double interaction of soil type and lead levels on the lead content of yellow corn plants. The triple interaction of experimental factors did not significantly affect the lead concentration of the vegetative system of yellow corn plants.

3.3. The Amount of Lead Absorbed into the Plant

The results of Table IV showed that the type of soil and additives from cow manure and wheat straw had a significant effect at the probability level (0.05) on the amount of lead absorbed by the plant. The results of the study indicated a highly significant effect of the type of soil, as the Zubair soil gave the highest value. It amounted to 2.516 mg pot^{-1}, while the Kutayban soil gave a lower value of 1.929 mg pot^{-1}. This is attributed to the difference in the physical and chemical properties of the soil for both soils and their effect on plant growth parameters and the ability to absorb lead ready in the soil, which was reflected in the amount of lead absorbed by the plant. The results from Table IV show that the amount of lead absorbed by the plant differed significantly at the probability level (0.05) according to the materials added from cow waste and wheat straw, as all treatments significantly outperformed the control treatment, and the greatest effect is due to wheat straw waste compared to cow waste. The average absorbed amount of the two substances was 2.281 and 1.671 mg pot^{-1}, respectively, compared to the comparison treatment of 2.716 mg pot^{-1}.

The interaction of additive treatments with lead levels had a significant effect on the absorbed quantity, as it is noted that the highest absorbed quantity was at the level of 50 mg Pb kg^{-1}, and the lowest absorbed quantity amounted to 1.665 mg Pb^{-1} when treated with 50 mg Pb kg^{-1} and 40 tons kg^{-1} of waste—wheat straw. The results of the study showed that the effect of the binary interactions, as well as the triple interaction of the study factors, was not significant on the amount of lead absorbed by the plant.

3.4. Total Lead Concentration in Soil After Planting

It is noted from the results of the statistical analysis of Table V that there is a significant effect at the level of

TABLE IV: The Effect of Lead Levels, Cow Manure, and Straw Waste on the Amount Absorbed (mg P^{-1}) in Yellow Corn Plants in the Two Soils of the Study

Soil × coefficients	Lead levels (mg Pb kg^{-1})			Transactions (ton ha^{-1})	Soil
	100	50	0		
2.940	3.374	3.280	2.168	Comparison	Al-Zubair
2.352	2.598	1.952	2.506	Cow waste 40	
2.259	2.352	2.323	2.102	Wheat straw 40	
2.493	2.699	3.637	1.144	Comparison	Kutayban
2.210	1.888	1.550	3.193	Cow waste 40	
1.085	0.981	1.008	1.267	Wheat straw 40	
Coefficients					
2.716	3.036	3.458	1.656	Comparison	Coefficients × lead
2.281	2.243	1.751	2.849	Cow waste 40	
1.671	1.666	1.665	1.684	Wheat straw 40	
Soil					
2.516	2.774	2.518	2.258	Al-Zubair	Soil × lead
1.929	1.856	2.065	1.868	Kutayban	
2.223	2.315	2.291	2.063	Lead levels	

Soil × coefficients × lead	Soil × coefficients	Coefficients × lead	Soil × lead	Coefficients	Soil	Pb levels
N.S	N.S	1.184*	N.S	0.610**	0.498*	N.S

Note: * means significant at 0.05 probability level, ** means highly significant at 0.05 probability level, and N.S means nonsignificant.

TABLE V: Effect of Lead Levels, Cow Manure, and Wheat Straw on the Concentration of Total Lead (mg Pb kg^{-1}) Remaining in the Soil After Planting in the Two Study Soils

Soil × coefficients	Lead levels (mg Pb kg^{-1})			Transactions (ton ha^{-1})	Soil
	100	50	0		
2.925	3.970	2.990	1.815	Comparison	Al-Zubair
18.042	20.596	17.568	15.964	Cow waste 40	
12.446	16.006	11.207	10.127	Wheat straw 40	
4.555	4.874	4.861	3.931	Comparison	Kutayban
24.961	35.312	20.186	19.386	Cow waste 40	
24.983	30.307	25.952	18.691	Wheat straw 40	
Coefficients					
3.74	4.422	3.925	2.873	Comparison	Coefficients × lead
21.502	27.954	18.877	17.675	Cow waste 40	
18.714	23.156	18.579	14.409	Wheat straw 40	
Soil					
11.138	13.524	10.588	9.302	Al-Zubair	Soil × lead
14.164	23.497	16.999	13.996	Kutayban	
14.650	18.510	13.793	11.649	Lead levels	

Soil × coefficients × lead	Soil × coefficients	Coefficients × lead	Soil × lead	Coefficients	Soil	Pb levels
14.095**	7.310**	9.511**	7.764**	5.752**	3.000**	5.168**

Note: ** means highly significant at 0.05 probability level.

(0.05) when adding lead to the soil if the total lead rate after planting is 13.793, 18.510 mg kg^{-1} for the addition levels of 50 and 100 mg kg^{-1}, respectively, compared to the treatment. The comparison is 11.649 mg kg^{-1}, as the increase in total lead in the soil is a natural result of adding high concentrations of lead to the soil. Our results were consistent with Azeez, as the total lead rate was 226.47 and 468 mg kg^{-1} for the addition levels [17]. 468 and 234 mg Pb kg^{-1}, respectively, compared to the comparison treatment, whose value was 11.25 mg kg^{-1}. The results of Table V showed that there were significant differences in the type of soil at the level (0.05) in the concentration of total lead remaining after planting. The soil of Kutayban gave the highest value for the total lead concentration, amounting to 14.164 mg Pb kg^{-1}, compared to the soil of Zubair, 11.138 mg Pb kg^{-1}. Because clay soil has little permeability, it is difficult for the elements to wash away during the watering process.

The results of Table V showed that there was a highly significant increase at the probability level (0.05) in the concentration of total lead remaining in the soil after planting as a result of the use of cow manure and wheat

TABLE VI: Effect of Lead Levels, Cow Manure, and Wheat Straw on the Concentration of Residual Lead in the Two Study Soils (mg Pb kg^{-1}) After Planting

Soil × coefficients	Lead levels (mg Pb kg^{-1})			Transactions (ton ha^{-1})	Soil	
	100	50	0			
1.012	1.015	1.013	1.011	Comparison	Al-Zubair	
4.335	5.832	4.654	2.521	Cow waste 40		
5.485	5.971	5.834	4.651	Wheat straw 40		
2.168	2.873	1.981	1.652	Comparison	Kutayban	
5.936	9.324	7.833	5.651	Cow waste 40		
4.780	6.135	4.327	3.880	Wheat straw 40		
Coefficients						
1.590	1.944	1.497	1.331	Comparison	Coefficients × lead	
5.969	7.578	6.243	4.086	Cow waste 40		
5.132	6.053	5.080	4.265	Wheat straw 40		
Soil						
3.610	4.272	3.833	2.727	Al-Zubair	Soil × lead	
4.850	6.110	4.713	3.727	Kutayban		
4.230	5.191	4.273	3.227	Lead levels		
Soil × coefficients × lead	Soil × coefficients	Coefficients × lead	Soil × lead	Coefficients	Soil	Pb levels
N.S	0.744*	N.S	N.S	0.445**	0.413*	0.526*

Note: * means significant at 0.05 probability level, ** means highly significant at 0.05 probability level, and N.S means nonsignificant.

straw compared to the comparison treatment, as the total lead concentration increased from 3.74 mg Pb kg^{-1} when compared to the comparison treatment (Without addition) to 18,714 and 21,502 mg Pb kg^{-1} for the addition level of 40 tons ha^{-1} for both wheat straw waste and cow waste, respectively. The results of the binary interaction between soil type and lead levels showed a highly significant effect at the probability level (0.05) on the concentration of total lead remaining in the soil (Table V), as the soil of Kutayban gave the highest value at the level of 100 mg Pb kg^{-1} and amounted to 23.156 mg Pb kg^{-1} compared to the treatment. The comparison at Zubair soil amounted to 9.302 mg Pb kg^{-1}. The results of the binary interaction between lead levels and additive treatments showed a significant effect at the probability level (0.05) on the total lead concentration remaining after planting, as it appears from Table V that treating the soil with cow manure and wheat straw had a significant effect on the total concentration remaining in the soil after planting. The effect of cow waste was greater than that of wheat straw waste, especially at high levels of lead, with an increase in the total concentration of lead remaining in the soil after planting with an increase in all lead levels. The highest value of the total concentration of lead remaining in the soil after planting was 27.95 mg Pb kg^{-1} when treating the soil treated with cow manure at a level of 40 tons ha^{-1} with a lead level of 100 mg Pb kg^{-1}, and the lowest value when treating the comparison treatment reached 2.87 mg Pb kg^{-1}.

The effect of the interaction between soil type and additive treatments had a highly significant effect at the probability level (0.05) on the concentration of total lead remaining in the soil after planting (Table V), where the Kutayban soil treatment treated with wheat straw residue of 40 tons ha^{-1} recorded the highest value of 24.983 mg Pb kg^{-1}, while the lowest value was when treating Zubair soil with the comparison treatment and amounted to 2.925 mg Pb kg^{-1}. The effect of triple interaction of lead levels, soil type, and additive treatments had a significant effect at the probability level (0.05) on the total lead concentration remaining in the soil after planting (Table V), where the highest value reached 35.312 mg Pb kg^{-1} in the Kutayban soil treated with 40 tons ha^{-1} and the lowest value is 1.815 mg Pb kg^{-1} at Zubair soil not treated with organic waste (comparison treatment) and at the level of 0 mg Pb kg^{-1}.

3.5. *Ready Lead Remaining in the Soil After Planting*

The results of Table VI show the values of ready-made lead in the soil after planting. It is noted that there is a significant increase at the probability level (0.05) in the ready-made lead content of the soil with increasing levels of added lead, reaching 3.227, 4.273, and 5.191 mg kg^{-1} soil. For lead levels of 0, 50, and 100 mg Pb kg^{-1}, this result is consistent with an increase in total lead concentrations with increasing levels of addition. The results agree with Azeez [17], where the rates of ready lead concentrations in the soil increased with lead addition levels 234 and 468 mg Pb · kg^{-1}, whose value was 19.46 and 39.43 mg Pb kg^{-1}, and for the addition levels sequentially compared to the comparison treatment, which reached a value of 0.93 mg Pb kg^{-1}. The results in Table VI indicated that there was a significant increase at the probability level (0.05) in the amount of ready-made lead when treated with cow waste and wheat straw compared to the comparison treatment, as it gave the highest value of 5.969 mg Pb kg^{-1} soil when treated with cow waste and the lowest value when treated with the comparison, which amounted to 1.590 mg Pb kg^{-1} soil, as it was shown from Table VI that the soil texture had a significant effect at the probability level (0.05) on ready-made lead in the soil. The highest concentration of ready-made lead was reached in the soil of Kutayban (clay), which was 4.85 mg Pb kg^{-1}, while Al-Zubair soil (sandy) gave the lowest value, which amounted to 3.610 mg Pb kg^{-1}. The increase in ready lead in the soil of Kutayban (clay) may be due to the clay soil containing clay minerals, organic matter, and calcium carbonate, as these components work to retain the element and increase its readiness in Soil, which led to an increase in the concentration of the mixture in the soil. This is consistent with the percentage of ready-made lead in the soil varies according to its content of organic matter and its proximity to sources of pollution in Al-Halafi [18]. Jin *et al*. [19] found that ready-made lead in soil depths 0 cm–20 cm of seventeen sites in China was between 0.06–8.12 mg kg^{-1}. This was attributed to the total lead and organic matter content of these soils. Paul *et al*. [20] found that the ready-made lead extracted at the Buda site in Nigeria had a 79.23% of sand and a cation exchange capacity of 6.4 mEq. 100 g^{-1} soil, as the average concentration of ready-made lead reached 19.35 mg Pb kg^{-1}, while the average concentration of ready-extracted lead at the Bang Boy site was 22.58 mg Pb kg^{-1}, and the percentage of sand was 72% and the cation exchange capacity was 4.81 mEq/100 g of soil. The results of the binary interaction between soil and additives show a significant effect at the probability level (0.05), as it gave the highest value for the amount of ready-made lead in the treatment of 5.936 mg kg^{-1} soil when treating 40 tons kg^{-1} of cow waste with the Kutayban soil treatment, while the comparison treatment gave the lowest value for the amount of ready lead in Zubair soil. The increase in the ready concentration of lead in the soil with the addition of cow manure may be due to the production of organic acids after their decomposition, which leads to a reduction in the degree of interaction and increases the readiness of the element in the soil, and this is consistent with Araujo *et al*. [21]. As Oraibi [22] showed, when adding solid sewage waste (sludge) at levels 20, 40, and 80 tons ha^{-1}, it led to an increase in the rate of ready lead in the soil by 1.95%, 115%, and 145%, respectively, compared to the comparison treatment. The effect of the double interaction between soil, lead levels, additive levels, and lead levels, as well as the triple interaction of the study factors, did not give a significant effect on the amount of ready lead in the soil after planting.

4. Conclusions

The ability of the study soils to retain lead increased with increasing levels of additives from cow manure and wheat straw. Cow manure had the greatest effect on improving the growth parameters and absorption of lead in maize plants compared to wheat straw waste. Use available organic materials, such as cow manure and plant residues (wheat straw), and add them to the soil to absorb lead and reduce its harmful effect on plants. Given the importance of this topic, we recommend conducting more applied research due to the lack of studies related to the use of organic materials in the soils of central and southern Iraq. Do not plant agricultural crops, especially leafy ones, in areas close to crowded streets, taking into account conducting a study of the lead content in the soil before planting.

Conflict of Interest

The authors declare that they do not have any conflict of interest.

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