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Effect of the type and level of organic amendments and phosphogypsum of soil affected by salinity planted with sorghum on some chemical properties of the soil

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Abstract

At the Department of Agricultural Research's Salinity Research Station, a Factorial experience using an RCBD design was conducted. The Ministry of Science and Technology, southeast of Baghdad, in salt-affected land, conducted a combined experiment with three components: Conocarpus, palm frond compost, three levels of each, and two levels of phosphogypsum. There were twelve treatments, with three replicates, making a total of 36 experimental units. The plate area was 4 m^2 (2 m×2 m), with soil that had a silty clay texture and was planted with white corn (*Sorghum bicolor* L.), classified as 70 research class.

In August 2023, in two phases, soil samples were collected from each plate: once prior to planting on August 6, 2023, and again following the conclusion of the experiment, for three depths: 0-20, 20-40, and 40-60 cm, wherein the EC, organic matter (OM), and available elements (NPK) were calculated in order to compare the salt movement at every depth, after harvesting, and the outcomes show the impact of the organic amendments (M_1 and M_2) and its levels (L_0, L_1 and L_2) , following harvesting at depths 0–20, the average electrical conductivity of the soil significantly decreased due to the amount of phosphogypsum (G_0 and G_1). While it raised considerably and saw the biggest increase receiving the same care, with two increase rates of 37.01 and 36.28% at depths 20–40 and 40–60, respectively, the $M_2L_2G_1$ treatment experienced the highest decrease, with decrease rates reaching 36.62%. After harvest, the soil's surface layer contained ready-made elements of potassium, phosphorus, and nitrogen, and the average amount of organic matter increased significantly, with the $M_2L_2G_1$ treatment showing the largest increase at 46.27%. with corresponding growth rates of 46.27%, 14.13, and 33.65%, the $M_2L_2G_1$, M_1L2G_1, and $M_1L_2G_0$ treatments showed the largest increase.

Keywords: organic matter, organic reformers, mineral amendments.

Introduction

Saline soils include very large areas compared to the total area, and more than half of the lands suffer from the problem of salinization caused by the accumulation of salts resulting from successive irrigation operations over thousands of years, due to the lack of efficient drainage networks, high ground water levels, and the prevailing climatic conditions. [1] stated that in saline soils the sodium ion predominates over the rest of the positive ions, followed by calcium and then magnesium. Saline soils constitute about 7% of the cultivated land area in the world and are clearly spread in 100 countries of the world, especially in dry, semi-arid and desert areas. In most Arab countries, of which Iraq is one [2], in application of the concepts of modern precision and renewable [3]. [4] demonstrated that the chemical characteristics of the soil are impacted by the addition of organic fertilizers. transforming waste from fronts.

Palms are converted into an organic fertilizer that is added to the soil before planting, which increases soil fertility as it increases the number of humic acids [5]. The fertilization process represents the most effective method for exploiting these wastes, eliminating environmental pollution, and investing palm wastes instead of wasting them to improve the properties of the soil [6]. Recycling the pruning waste of the Conocarpus plant, which is widely planted along streets and public squares, is one of the major problems due to its large biomass. [7]) pointed out the possibility of using the pruning waste, leaves, and small stems of the Conocarpus plant, turning them into fertilizer and providing the appropriate conditions for their decomposition, as the organic fertilizer works Formed from the decaying remains of trees as soil fertilizer [8].

Phosphogypsum is a good calcium source found in its chemical makeup ($CaSO_4.2H_2O$). When calcium is added mixed with irrigation water or directly it replaces and displaces the monovalent sodium that is already present in the soil in the complex of exchange, causing a reduction in the sodium adsorption rate and improving Building the soil as well as lowering the pH by means of the existence of sulphates in its chemical makeup, so It is thought to be an effective chemical amendment [9]. [10] suggested that adding more phosphogypsum caused an increase in calcium in the soil. Sorghum is one of the crops that could withstand high levels of salinity, drought, and high temperatures compared to other crops. It is characterized by a fibrous root that can reach a depth of 90-120 cm and obtain the necessary moisture for growth. It is also characterized by its narrow leaves covered with a waxy layer, causing a decrease in moisture. Transpiration process, so it is one of the crops that can be grown in degraded lands. [11] stated that the different morphological and physiological characteristics of sorghum enable it to tolerate drought and heat stress by avoiding and tolerating their effects to maintain physiological and metabolic activities. The deep root system, thick leaf epidermis layers, and leaf system allow it to avoid drought. The aim of this study is to understand the combined impact of the kind and quantity of phosphogypsum and organic amendments of soil affected by salinity on a few soil chemical characteristics.

Material and methods

Using a randomized complete block design (RCBD), a worldwide experiment was conducted 20 Km southeast of Baghdad, at the Department of Agricultural Research/Salinity Research Station at the Tuwaitha site, on salt-affected land with an estimated area of 576 m^2 (48 m x 12 m), with three Factors: the first is the addition of organic conditioners (compost of Conocarpus and palm leaves, M1 and M_2, The amounts of organic amendments (0, 10, and 15 Mg ha^{-1}, L_0, L_1, and L_2) are listed in the second, and the third consists of the two successive levels of the mineral amendment phosphogypsum (0 and 9.75 Mg ha^{-1}, G_0 and G_1), with a total of 12 treatments and three replicates, or 36 experimental units.

The field was irrigated with heavy water from a well equipped with a submersible pump (located near the field and at a depth of 30 m and used for irrigation throughout the duration of the experiment) with a 3.2 dS m^{-1} EC. Perpendicular plowing operations and the smoothing, adjusting and leveling operations were carried out using the rotary Plow and the rotary disc plow. The field was divided longitudinally into three sectors, and each sector contained 12 experimental units with an area of 4 m^2 (2 m×2 m) and the separation between the two sectors 2 m, and between one plate and another, 1 m. Well water samples and soil samples were taken from each plate to estimate some physical and chemical characteristics before planting, as shown in Tables 1 and 3. The plots were numbered, and the treatments were distributed randomly. The organic amendments and mineral amendment\ were added to the plates according to the treatment. Tables 2 and 4 show the characteristics of the flora used in the experiment. The fertilizer suggestion was followed when fertilizing the plots. While the two nitrogen fertilizers (urea 46% N) amounted to 320 kg N ha^{-1} and two batches of potassium fertilizer (100 kg K_2O ha^{-1} in the form of potassium sulphate, K_2O% 50) were added: 45 days after planting, and at planting with phosphate fertilizer, Phosphate fertilizer (calcium super phosphate, 45% P_2O_5) was added in the quantity of 100 kg P_2O_5 ha^{-1} all at once during planting [12]. The seeds of white corn (*Sorghum bicolour* L.), variety of Bahouth 70, were planted in the fall season on August 8, 2023. The experiment continued until reaching final maturity and harvest on November 26, 2023. Following the conclusion of the experiment, soil samples were collected from every experimental unit in the rhizosphere. For conducting some analyses, the EC was evaluated using a 1:1 soil extract, the organic matter content was estimated, and the ready concentration of N, P, and K in the soil was estimated sequentially. The Genstat Discovery Edition 3 program was used to analyze the experiment data, and the averages were compared to LSD at the 0.05 level [13].

Table (1) Some chemical characteristics of the experiment's irrigation water

pH	EC	Ca^{2+}	Mg^{2+}	K^+	Na^+	Cl^-	HCO_3^-	SO_4^{2-}	SAR	Water class
-	dS m^{-1}	mmol L^{-1}							$(mmol\ l^{-1})^{0.5}$	C_3S_3
7.31	3.20	0.55	3.02	Nill	24.3	12.85	5.6	9.15	12.86	

Table (2) The experiment's phosphogypsum's chemical characteristics

F	P	SO_4^{2-}	Cl^-	Na^+	K^+	Mg^{2+}	Ca^{2+}	$EC_{1:1}$	$pH_{1:1}$
%	mmol kg^{-1}							dS m^{-1}	-
0.170	64.60	61.20	2.800	Nil	1.200	10.60	58.50	2.300	2.680

Table (3) The physical, chemical, and other properties of the soil prior to planting

Properties			value	unit
Soil pH ($pH_{1:1}$)			7.328	-
Electrical conductivity ($EC_{1:1}$)			17.31	$dS\ m^{-1}$
Organic matter			0.660	%
Organic Carbon (OC)			0.380	
Carbonate Minerals			21.28	
Gypsum			0.040	
CEC			18.08	$cmmole_{+}\ kg^{-1}$
Dissolved ions	Calcium (Ca^{2+})		26.00	$mmol\ L^{-1}$
	Magnesium (Mg^{2+})		18.21	
	Sodium (Na^{+})		138.5	
	Potassium(K^{+})		0.586	
	Bicarbonate (HCO_3^{-})		0.440	
	Chloride (Cl^{-})		134.9	
	Sulphates (SO_4^{2-})		75.01	
SAR			20.86	0.586
Available	Nitrogen	NH_4^{+}	25.60	$mg\ kg^{-1}$ soil.
		NO_3^{-}	21.60	
	Phosphorus		75.01	
	Potassium		20.86	
Field capacity			0.240	$cm^3\ cm^{-3}$
Bulk density			1.336	$Mg\ m^{-3}$
soil separates		Sand	61.00	$g\ kg^{-1}$ soil
		Silt	399.0	
		clay	540.0	
Texture			Clay	

Table (4) Some characteristics of organic amendments used in the study

The description	Palm fronds	Conocarpus	Unit
$pH_{1:5}$	6.780	6.640	-
$EC_{1:5}$	2.540	4.890	$dS\ m^{-1}$
Water holding capacity	183.0	168.0	%
Organic Matter	52.89	56.86	
Organic Carbon	30.68	32.98	
Total nitrogen	2.240	2.080	
Total phosphorus	0.280	0.210	
Total Potassium	1.870	1.280	
Carbon: Nitrogen	13.69	15.85	-

Results and Discussion

1. Electrical conductivity (EC) dS m^{-1} of soil after planting to depth 0-20 cm.

The results in Table 5 show how the average EC of the soil after harvesting to the extent of 0–20 cm is impacted by the kind of organic amendment (M_1 and M_2), its level (L_0, L_1, and L_2), and the amount of phosphogypsum (G_0 and G_1). The average values reached 4.916 and 4.959, respectively, with a rise of 0.87%, indicating that the organic amendment (M_2) had an impact on the soil's electrical conductivity values after harvest when compared to the organic fertilizer (M_1).

The average soil electrical conductivity values at the two levels of adding the two compounds, L_1 and L_2, also significantly decreased, reaching 4.952 and 4.369, respectively, with a decrease rate of 15.00 and 25.01%, in comparison to the comparison treatment (L_0) of 5.826.

The findings demonstrated that the addition of phosphogypsum G_1 significantly decreased the soil's electrical conductivity values following harvest; the average value was 4.768, which was 10.54% lower than the comparison treatment (G_0), which was 5.330. The data shown in Table 5 demonstrate that the average conductivity is significantly impacted by the binary exchange between the kind of organic amendment (M_1 and M_2) and its level (L_0, L_1, and L_2). Following harvesting to a depth of 0–20 cm, the soil electrical values fell. The M1L2 interference treatment had the largest decline, totaling 4.133, with a decrease rate of 28.80% in contrast to the comparison therapy (M_1L_0), which had a total of 5.805. When the double interference M_1G_1 hit 4.607, it dropped considerably, with a rate of 11.84% lower than that of the comparator treatment (M_1G_0).

It was also found that there was a significant decrease in the bilateral interaction between the level of organic fertilizer and phosphate gypsum in the soil's average electrical conductivity following harvest, since the L2G1 treatment showed the largest decline, amounting to 4.260, with a 33.45% reduction in comparison to the comparison treatment (L_0G_0), which amounted to 6.401. The preceding table also makes it evident that the average EC soil following harvesting for depths 0–20 is significantly impacted by the triple interaction of the type of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0 and G_1). The $M_1L_2G_1$ treatment showed the largest decrease in electrical conductivity. In comparison to the comparable transaction ($M_1L_0G_0$) of 6.390, it came to 4.050, a 36.62% drop.

Table (5) Effect of the type and level of some organic amendments and phosphogypsum on average EC (dS m^{-1}) for post-harvest soil for depth 0-20 cm

Organic Amendments M	Levels Organic Amendments L (Mg ha^{-1})	Gypsum Phosphate(G) (Mg ha^{-1}) G_0 (0)	G_1 (9.75)	Average M × L
M_1 Palm fronds	L_0 (0)	6.390	5.220	5.805
	L_1 (10)	5.070	4.550	4.810
	L_2 (20)	4.217	4.050	4.133
Average M × G		5.226	4.607	4.607
M_2 Conocarpus	L_0 (0)	6.411	5.280	5.846
	L_1 (10)	5.150	5.037	5.093
	L_2 (20)	4.740	4.470	4.605
Average M × G		5.434	4.929	4.929
		G_0	G_1	Average
L× G	L_0 (0)	6.401	5.250	5.826
	L_1 (10)	5.110	4.793	4.952
	L_2 (20)	4.478	4.260	4.369
Average		5.330	4.929	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
0.5907	0.4177	0.3410	0.4177	0.2411	0.2953	0.2411

2. Electrical conductivity (EC) dS m^{-1} of soil after planting to depth 20-40 cm

The results in Table 6 demonstrate how the type of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0 and G_1) on the average electrical conductivity of the soil after harvesting to a depth of 20-40 cm. The results show that there is an effect of the organic amendment (M_2) reduced the EC values of the soil following harvest in contrast to the organic fertilizer (M_1), as the average values reached 6.883 and 6.862, in turn, with a decline rate of 0.31%. Additionally, the findings revealed a notable rise in the average of EC values of the soil at the levels of adding the reformers L_1 and L_2, as the values reached 6.773 and 7.600, with an increase of 8.45 and 21.70%, in contrast to the comparison treatment, respectively (L_0) of 6.245. The results showed that adding phosphogypsum G_1 had a significant effect on the increase soil EC values following harvest, the mean value attaine 7.280, with an increase of 12.61% compared to the comparison treatment (G_0) of 6.465. It is clear from the results in Table 6 that there is a significant effect of the dual interaction of the type of organic reformer (M_1 and M_2) and its levels (L_0, L_1 and L_2) on the average electrical conductivity of the soil after harvesting to a depth of 20-40 cm, as the values increased, and the highest increase was when treated with the M_1L_2 interaction, which reached 7.630, with an increase percentage 22.47% compared to the comparison treatment (M_1L_0) amounting to 6.230, and it increased significantly when the binary interaction M_1G_1 amounted to 7.317, with a rate of growth of 13.44% in contrast to the comparison treatment (M_1G_0) amounting to 6.450. A significant increase was also found regarding the binary relationship between the organic amendment and phosphogypsum in the average EC of the soil after after harvesting to the depth of 20-40, The highest increase in harvest was found in the L_2G_1 treatment, amounting to 8.255, an increase of 37.01% compared to the comparison treatment (L_0G_0), which amounted to 6.025. It is also evident from the previous table that there is a significant effect of the triple interaction of the kind of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0) and G_1) on the average EC of the soil after harvesting to the depth of 20-40, as the highest increase occurred in the $M_2L_2G_1$ treatment. It reached 8.270, an increase of 36.24% compared to the comparison factor ($M_2L_0G_0$) of 6.070.

Table (6) Impact of certain organic reformers' level and type and phosphogypsum on the average EC (dS m^{-1}) for post-harvest soil for depth 20-40 cm

Organic Amendments M	Levels Organic Amendments L (Mg ha^{-1})	Gypsum Phosphate(G) (Mg ha^{-1})		Average M × L
		G_0 (0)	G_1 (9.75)	
M_1 Palm fronds	L_0 (0)	5.980	6.480	6.230
	L_1 (10)	6.350	7.230	6.790
	L_2 (20)	7.020	8.240	7.630
Average M × G		6.450	7.317	6.883
M_2 Conocarpus	L_0 (0)	6.070	6.450	6.260
	L_1 (10)	6.500	7.010	6.755
	L_2 (20)	6.870	8.270	7.570
Average M × G		6.480	7.243	6.862
		G_0	G_1	Average
L× G	L_0 (0)	6.025	6.465	6.245
	L_1 (10)	6.425	7.120	6.773
	L_2 (20)	6.945	8.255	7.600
Average		6.465	7.280	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
0.1219	0.0862	0.0704	0.0862	0.0497	0.0609	0.0497

3. Electrical conductivity (EC) dS m^{-1} of soil after planting to a depth of 40-60 cm

The results in Table 7 show how the amount of phosphogypsum (G_0 and G_1), the type of organic conditioner (M_1 and M_2), and its level (L_0, L_1, and L_2) affect the soil's average electrical conductivity after harvesting to a depth of 40–60 cm. The results show that there is an effect of the organic amendment (M_2) in lowering the soil's electrical conductivity values following harvest compared to the organic fertilizer (M_1), as the average values reached 7.065 and 7.045, respectively, with a decrease rate of 0.33%. Additionally, the findings revealed a significant increase on average EC values of the soil at the two levels of adding the compounds L_1 and L_2, as the values reached 6.950

and 7.805, with a rise in 8.42 and 21.76%, respectively, compared to the comparison treatment (L_0) of 6.410. The results showed that adding phosphogypsum G_1 had a noteworthy impact on increasing the soil's EC following harvest, which was calculated at 7.473, with an increase of 12.60% compared to the comparison treatment (G_0) of 6.637.

Table (7) Effect of the type and level of some organic reformers and phosphogypsum on the average EC (dS m^{-1}) for post-harvest soil for depth 40-60 cm

Organic Amendments M	Levels Organic Amendments L (Mg ha^{-1})	Gypsum Phosphate(G) (Mg ha^{-1})		Average M × L
		G_0 (0)	G_1 (9.75)	
M_1 Palm fronds	L_0 (0)	6.140	6.650	6.395
	L_1 (10)	6.510	7.420	6.965
	L_2 (20)	7.210	8.460	7.835
Average M × G		6.620	7.510	7.065
M_2 Conocarpus	L_0 (0)	6.230	6.620	6.425
	L_1 (10)	6.670	7.200	6.935
	L_2 (20)	7.060	8.490	7.775
Average M × G		6.653	7.437	7.045
		G_0	G_1	Average
L× G	L_0 (0)	6.185	6.635	6.410
	L_1 (10)	6.590	7.310	6.950
	L_2 (20)	7.135	8.475	7.805
Average		6.637	7.473	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
0.1315	0.0930	0.0759	0.0930	0.0537	0.0657	0.0537

It is clear from Table 7 that the double interaction has a substantial impact on the type of organic amendment ($M_1$and M_2) and its level (L_0, L_1 and L_2) on EC of the soil: after harvesting to a depth of 40-60 cm, as the values increased, and the highest increase was when treated with the M_1L_2 interaction, which reached 7.835, with a percentage increase 22.51% compared to the comparison treatment (M_1L_0) amounting to 6.395, and it increased significantly when the binary interaction M_1G_1 amounted to 7.510, with an increase rate of 13.44% compared to the comparison treatment (M_1G_0) amounting to 6.620. A significant increase was also found for the binary interaction between the level of organic reformer and phosphogypsum in the average EC of the soil after the highest increase in harvest was found in the L_2G_1 treatment, amounting to 8.475, an increase of 37.02% compared to the comparison treatment (L_0G_0), which amounted to 6.185.

It is also clear from the previous table that there is a significant effect of the organic amendment type's triple interaction (M_1 and M_2), its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0 and G_1) on the average EC after harvesting the soil down to the depth of 40-60, as the highest increase occurred in the $M_2L_2G_1$ treatment. It reached 8,490, a 36.28% increase over the comparison transaction ($M_2L_0G_0$) of 6,230.

The results of soil salinity indicators after harvest showed that adding the mineral conditioner phosphate gypsum to the soil led to a reduction in soil salinity at the surface layer, a depth of 0-20 cm, and increased and accumulated at subsurface depths of 20-40 and 40-60 cm, which indicates the effectiveness of the mineral conditioner in reducing Salinity in the root growth area and the movement of salt ions into the depths of the soil.

This may water inside the soil bed and increasing the efficiency of salt leaching. These results are consistent with the findings of [14, 15 and 16]. In addition, phosphate gypsum has an acidic effect because of it containing sulfuric and phosphoric acid residues that were added during the manufacturing process of phosphate fertilizers, which have a positive effect in improving soil properties and increasing the efficiency of salt leaching [17]. Because adding organic matter to the soil improves its physical, chemical, and biological qualities, the results also demonstrated a decrease in soil salinity when organic amendments were added, as well as their accumulation at subsurface depths [18], which increases the efficiency of washing salts and removing them from a growing area. Roots: This result is consistent with many researchers [19 and 20]. The results showed that the organic amendment palm frond peat moss was superior to conocarpus peat moss in lowering the salinity of soil, which could be explained by the fact that palm frond peat moss has a relatively low electrical conductivity compared to Conocarpus peat moss, in addition to the fact that palm frond peat moss has a relatively low carbon to nitrogen ratio compared to Conocarpus peat moss. It is shown in Table 4, which leads to the degree of decomposition and release of decomposition products of palm frond peat moss is relatively higher than that of Conocarpus peat moss, which in turn helps in improving soil characteristics and increasing the efficiency of washing salts and removing salt ions [21].

4. Available Nitrogen concentration (mg kg^{-1}) in the soil after harvest

The findings in Table 8 show how the mean values of the percentage of nitrogen in the soil following harvest are impacted by the kind of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the amount of phosphogypsum (G_0 and G_1). The findings indicate that the organic amendment (M_2) has a noteworthy impact. In raising the percentage of nitrogen values after harvest compared to the organic fertilizer (M_1), the average values reached 90.54 and 95.09, respectively, with an increase of 5.03%. Additionally, the findings revealed a notable rise in the average percentage values of nitrogen in the soil at the levels of adding the reformers L_1 and L_2, as the values reached 94.30 and 119.88, with an increase of 46.75 and 86.55%, in contrast to the comparison treatment, respectively (L_0) of 64.26. The results showed that adding phosphogypsum G_1 had an effect. The percentage of nitrogen in the soil increased significantly after harvest, as the average value reached 100.44, with a 17.90% increase over the comparison treatment (G_0) of 85.19. Table 8 makes it evident that the average percentage values of nitrogen in the soil following harvest significantly increase the binary interaction of the kind of organic fertilizer (M_1 and M_2) and its levels (L_0, L_1 and L_2). Comparing the M_2L_2 interaction therapy to the comparison treatment, the biggest increase was 120.67, representing an increase rate of 87.64%. M_2L_0) was 64.31, and it also substantially rose with the binary interaction M_2G_1, reaching 102.00, at a rate of 15.67% higher than the comparison treatment (M_2G_0), which was 88.18. The binary interaction for the level of phosphate gypsum and organic reformer also showed a considerable rise; the treatment L_2G_1 had the largest increase, reaching 125.50, with a rate of increase of 117.07% when compared to the 58.90 comparison factor (L_0G_0).

It is also It is clear from the preceding table that there was a notable rise in the triple interaction of the type of organic fertilizer (M_1 and M_2) and its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0 and G_1) in average values of percentage of nitrogen in the soil after harvest, as the highest increase took place in the $M_2L_2G_1$ treatment, amounting to 126.10, with a percentage an increase of 114.13% compared to the comparison transaction ($M_2L_0G_0$) of 58.89.The results show that

Table (8) The impact of phosphogypsum and the kind and quantity of certain organic amendments on the soil's available nitrogen concentration (mg kg^{-1}) following harvest.

Organic Amendments M	Levels Organic Amendments L ($Mg\,ha^{-1}$)	Gypsum Phosphate(G) ($Mg\,ha^{-1}$) G_0 (0)	G_1 (9.75)	Average M × L
M_1 Palm fronds	L_0 (0)	58.91	69.52	64.21
	L_1 (10)	74.40	102.2	88.30
	L_2 (20)	113.3	124.9	119.1
Average M × G		82.20	98.88	90.54
M_2 Conocarpus	L_0 (0)	58.89	69.73	64.31
	L_1 (10)	90.41	110.1	100.2
	L_2 (20)	115.2	126.1	120.6
Average M × G		88.18	102.0	95.09
		G_0	G_1	Average
L× G	L_0 (0)	58.90	69.62	64.26
	L_1 (10)	82.41	106.1	94.30
	L_2 (20)	114.2	125.5	119.8
Average		85.19	100.4	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
5.087	3.597	2.937	3.597	2.077	2.543	2.077

adding mineral amendments led to an increase in the average values of the percentage of ready soil nitrogen, which could be ascribed to the enhancement of the soil's chemical, physical or biological characteristics, as explained previously, which in turn increases the activities of soil revitalization and the process of mineralizing organic nitrogen and converting it to ready nitrogen, given the availability of the necessary aerobic conditions. To complete this process [22 and 23], in addition to reducing soil salinity, as previously explained, which encourages the activity of soil revival in the process of mineralizing soil nitrogen and fixing atmospheric nitrogen by means of azotobacterial. This result is consistent with much research that were indicated by [24]. And [25] who attributed this to improving soil physical properties, increasing aeration, and increasing nitrification rates. The results showed that adding organic amendments contributed to increasing the average percentage of nitrogen values, which may be attributed to the effective role played by the presence of organic materials in releasing mineral nitrogen into the soil during the organic materials' breakdown processes

The presence of organic materials also provides a suitable environment for the growth of soil organisms that work to transform Atmospheric nitrogen into mineral nitrogen [26]. The results also displayed a relative superiority in increasing the average percentage values of nitrogen when adding conocarpus peat moss compared to palm frond peat moss, which may be attributed to the relatively greater Conocarpus content of organic matter than palm frond peat moss, Table 4, as many researches have proven that there is a close positive correlation. Between the content of organic matter and ready-made nitrogen [27], as the presence of organic matter reduces the leaching of nitrogen from the soil and reduces the process of reversing nitrification, which provides the nitrogen element well in the soil. Organic fertilizers are the primary storehouse that contains most of the nitrogen, and in general, organic fertilizers. The used one contains good percentages of total nitrogen, which is converted into ready-made materials through the mineralization process [21, 28 and 29].

5. Available phosphorus concentration (mg kg^{-1}) in the soil after harvest

The findings in Table 9 show how the average values of the percentage of accessible phosphorus in the soil following harvest are influenced by the kind of organic amendment (M_1 and M_2), its level (L_0, L_1, and L_2), and the amount of phosphogypsum (G_0 and G_1).

There is a significant effect of the organic amendment (M_2) in reducing the values. The percentage of available phosphorus after harvest compared to the organic amendment (M_1), as the average values reached 14.97 and 13.71, respectively, with a decrease rate of 8.42%. The results also showed a significant increase in the average values of the percentage of ready-made phosphorus in the soil at the levels of adding the amendments L_1 and L_2, as the values reached 15.62 and 16.81 sequentially, with an increase rate of 47.50 and 58.73%, respectively, in contrast to the comparison treatment (L_0) of 10.59.

Table (9) The effect of the type and level of some organic amendments and phosphogypsum on the concentration of available phosphorus (mg kg^{-1}) in the soil after harvest

Organic Amendments M	Levels Organic Amendments L (Mg ha^{-1})	Gypsum Phosphate(G) (Mg ha^{-1})		Average M × L
		G_0 (0)	G_1 (9.75)	
M_1 Palm fronds	L_0 (0)	8.300	12.96	10.63
	L_1 (10)	13.84	18.65	16.25
	L_2 (20)	15.89	20.17	18.03
Average M × G		12.68	17.26	14.97
M_2 Conocarpus	L_0 (0)	8.250	12.86	10.55
	L_1 (10)	12.99	17.02	15.00
	L_2 (20)	13.20	17.97	15.58
Average M × G		11.48	15.95	13.71
		G_0	G_1	Average
L× G	L_0 (0)	8.270	12.91	10.59
	L_1 (10)	13.41	17.83	15.62
	L_2 (20)	14.54	19.07	16.81
Average		12.08	16.60	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
0.329	0.233	0.190	0.233	0.134	0.165	0.134

The results showed that adding phosphogypsum G_1 had a significant effect on increasing the values of the percentage of ready phosphorus in the soil after harvest, as the average value reached 16.60, with an increase rate of 37.42% compared to the comparison treatment (G_0) of 12.08. Table 9 makes it evident that the percentage of available phosphorus in the soil after harvest is significantly impacted by the dual interaction of the type of organic amendment (M_1 and M_2) and its levels (L_0, L_1 and L_2).

The highest increase in the M_1L_2 interaction treatment was 18.03, with a 69.61% rise in comparison to the comparison treatment. (M_1L_0) of 10.63, and it increased with the binary interaction (M_1G_1) of 17.26, with a 36.21% increase rate in contrast to the comparison treatment (M1G0), which had a 12.68 rate. Furthermore, in contrast to the comparison treatment (M_1G_0), a significant increase of 36.21% was seen for the interaction (M_1G_1) of 17.26, with a 69.61% rise in comparison to in comparison to the comparison treatment (M_1G_0) of 12.68, it increased by 36.21% with the binary interaction (M_1G_1) of 17.26 and the comparison treatment (M_1L_0) of 10.63.

Additionally, the interaction (M_1G_1) of 17.26 showed a substantial rise, with a rate of growth of 36.21% in contrast to the comparator treatment (M_1G_0) of 12.68. Also, a significant increase was found for the binary interaction between the level of organic reformer and phosphate gypsum in the percentage of phosphorus in the soil after harvest, as it was found The highest increase in transaction L_2G_1 was 19.07, an increase of 130.60% compared to the comparison transaction (L_0G_0) of 8.270. It is also clear from the previous table that there is an effect of the triple interaction of the type of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0 and G_1) on the average values of the percentage of available phosphorus in the soil following harvest, with the M1L2G1 treatment showing the most notable increase., amounting to 20.17, an increase of 143.01% compared to the comparison factor ($M_1L_0G_0$) of 8.300. all experimental treatments increased their phosphorus content.

This is due to the good phosphorus content of mineral and organic fertilizers, as well as the acids secreted by organic fertilizers that help in liberating unready phosphorus by lowering the pH [30]. According to what the researchers found, the increase in the soil content of materials Organic matter leads to a significant increase in phosphorus content, and over time, with the presence of mineral and organic fertilizers, the biomass of the soil increases, and the readiness of the phosphorus element increases with it [21, 23,31 and 32].

6. Available potassium concentration (mg kg^{-1}) in the soil after harvest

The findings in Table 10 show how the mean values of the percentage of potassium in the soil following harvest are impacted by the kind of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the amount of phosphogypsum (G_0 and G_1). The results show that the organic amendment (M_2) has a significant effect. After harvest, the average potassium percentage values decreased by 3.99% as compared to the organic fertilizer (M_1), reaching 77.82 and 74.71, respectively. The average percentage values of potassium in the soil when the reformers are added L_1 and L_2 also showed a considerable increase, reaching 78.78 and 86.39, respectively, with increases of 23.83 and 35.71% above the comparative treatment (L_0) of 63.62. The outcomes demonstrated the impact of adding phosphogypsum G_1. With an average value of 68.77 and a drop rate of 17.89% from the comparator treatment (G_0) of 83.76, it considerably decreased the percentage of accessible potassium in the soil following harvest. Table 10 makes it evident that the type of organic amendment (M_1 and M_2) and its levels (L_0, L_1, and L_2) have a major effect on the average soil potassium percentage values following harvest. The M1L2 interaction caused the largest increase in the values (87.94), which was 38.03% higher than the comparison treatment (M_1L_0), which was 63.71, it decreased with the binary interaction (M_1G_1) of 69.57, with a decrease rate of 19.17% compared to the comparison treatment (M_1G_0) of 86.07. Also, a significant increase was found for the binary interaction between the level of organic reformer and phosphate gypsum in the average values of the percentage of potassium in the soil after harvest.

The highest increase was found in the L_2G_0 treatment, which amounted to 94.39, an increase of 32.12% compared to the comparison treatment (L_0G_0), which amounted to 71.44. It is also evident from the previous table that there is an effect of the triple interaction of the type of organic amendment (M_1) and M_2) and its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0) and G_1) on the average values of the percentage of available potassium in the soil after harvest, as the highest significant increase took place in the $M_1L_2G_0$ treatment. It reached 96.08, an increase of 33.65% compared to the comparison factor ($M_1L_0G_0$) of 71.89.

Table (10) The impact of phosphogypsum and the kind and quantity of certain organic additions on the soil's available potassium concentration (mg kg^{-1}) upon planting

Organic Amendments M	Levels Organic Amendments L (Mg ha^{-1})	Gypsum Phosphate(G) (Mg ha^{-1})		Average M × L
		G_0 (0)	G_1 (9.75)	
M_1 Palm fronds	L_0 (0)	71.89	55.87	63.71
	L_1 (10)	89.65	73.98	81.81
	L_2 (20)	96.08	79.19	87.94
Average M × G		86.07	69.57	77.82
M_2 Conocarpus	L_0 (0)	70.98	56.08	63.53
	L_1 (10)	81.28	70.22	75.75
	L_2 (20)	92.09	77.60	84.84
Average M × G		81.45	67.97	74.71
		G_0	G_1	Average
L× G	L_0 (0)	71.44	55.81	63.62
	L_1 (10)	85.47	72.10	78.78
	L_2 (20)	94.39	78.39	86.39
Average		83.76	68.77	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
0.702	0.497	0.405	0.497	0.287	0.351	0.287

The reason for the increase is the decomposition of organic fertilizers, which produces various organic acids that could make potassium more readily available [34]. The organic conditioner, palm frond waste, contains a high percentage of potassium, according to the analysis table for the properties of reformers, Table 4, as the percentage is higher than the percentage of organic conditioners from Conocarpus waste, and the percentage increases with the increase in the level of addition of conditioners, agrees with [35], as they found that the increase in the available -made potassium content increases with the increase in the addition of organic fertilizers.

7. Organic matter (OM) of soil after harvest (%)

The findings in Table 11 show how the average amount of organic matter in the soil after harvest for the surface layer is affected by the kind of organic amendment (M_1 and M_2), its level (L_0,

L_1, and L_2), and the amount of phosphogypsum (G_0 and G_1). The findings indicate that there is a noteworthy impact of the organic amendment (M_2) in Raising the soil organic matter values after harvest compared to the organic fertilizer (M_1), as the average values reached 0.750 and 0.838, respectively, with an increase rate of 11.73%. The average values of soil organic matter at the levels of adding the reformers L_1 and L_2 also significantly increased, reaching 0.820 and 0.890, respectively, with a growth rate of 22.02 and 32.44%, in comparison to the comparative treatment (L_0) of 0.672.

The results showed that adding phosphogypsum G_1 had a noteworthy impact on increasing soil organic matter values following harvest; the average value was 0.828, representing an 8.95% increase over the comparison treatment (G_0) of 0.760.

It is clear from Table 11 that the dual interaction of the kind of organic material has a substantial impact amendment (M_1 and M_2) and its level (L_0, L_1 and L_2) on the average organic matter of the soil after harvesting to a depth of 0-20 cm, as the values increased, and the highest increase in the M_2L_2 interaction treatment was 0.960with a 41.17% rate of growth. In contrast to the comparison treatment (M_2L_0) of 0.680, it increased significantly with the binary interaction (M_2G_1) of 0.867, with an increase rate of 7.03% compared to the comparison treatment (M_2G_0) of 0.810. A significant increase was also found for the binary interaction between the level of organic amendment and phosphate gypsum in the average organic matter of the soil after harvest, as the highest increase was found in treatment L_2G_1, which amounted to 0.925, an increase of 39.09% compared to the comparison treatment (L_0G_1), which amounted to 0.665.

Table (11) The impact of phosphogypsum and the kind and quantity of certain organic amendments on the soil's average percentage of organic matter (OM) following harvest.

Organic Amendments M	Levels Organic Amendments L (Mg ha^{-1})	Gypsum Phosphate(G) (Mg ha^{-1}) G_0 (0)	G_1 (9.75)	Average M × L
M_1 Palm fronds	L_0 (0)	0.660	0.670	0.665
	L_1 (10)	0.700	0.830	0.765
	L_2 (20)	0.770	0.870	0.820
Average M × G		0.710	0.790	0.750
M_2 Conocarpus	L_0 (0)	0.670	0.690	0.680
	L_1 (10)	0.820	0.930	0.870
	L_2 (20)	0.940	0.980	0.960
Average M × G		0.810	0.867	0.838
		G_0	G_1	Average
L× G	L_0 (0)	0.665	0.680	0.762
	L_1 (10)	0.760	0.880	0.820
	L_2 (20)	0.855	0.925	0.890
Average		0.760	0.828	

LSD (0.05)						
G × L × M	G × L	G × M	L × M	G	L	M
0.0548	0.0388	0.0317	0.0388	0.0224	0.0274	0.0224

The previous table also makes it evident that the average amount of organic matter in the soil after harvesting for depths 0-2, which increased most in the $M_2L_2G_1$ treatment, is significantly impacted by the triple interaction of the type of organic amendment (M_1 and M_2), its level (L_0, L_1 and L_2), and the level of phosphogypsum (G_0 and G_1). When compared to the comparison factor ($M_2L_0G_0$) of 0.670, it increased by 46.27% to 0.980.

The findings indicated that adding the mineral conditioner phosphate gypsum increased the amount of organic matter, which could be explained by the mineral conditioner's ability to enhance the physical characteristics of the soil, water relations, and soil aeration, which increases the effectiveness of soil revitalization and increases its organic secretions. It also helps in plant growth and increases organic root secretions [24 and 36].

The findings demonstrated that the amount of organic matter in the soil rose as addition levels rose, with the best treatment of adding conocarpus residues over palm frond waste in raising the values of soil organic matter. This is because Conocarpus wastes contain a higher percentage of organic matter, as shown in Table 4 regarding the characteristics of the organic reformers. This is due to the reason Increasing the organic matter in the soil, as the percentage of organic matter increases with the increase in the rate of addition of organic amendments, and this agrees with [37, 38 and 39].

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