Effect of Source of Organic Matter Level and Phosphorous Level on Phosphorous Forms and Humic Acids Release in Gypsiferous Soil

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Abstract

A laboratory experiment was conducted in the Department of Soil Sciences and Water Resources, College of Agriculture / Tikrit University for the year 2019 for the purpose of studying the effect of the source and level of organic matter and the level of added phosphorous on the level of phosphorous forms and humic acids in gypsum soil. A factorial experiment was conducted with three factors: The first factor: the type of organic matter (sheep manure and compost), the second factor: the level of organic matter as follows (0.5, 1.0, 1.5)% of the weight of the soil, and the third factor: it included phosphorous levels (0, 40, 80, 120) mg kg⁻¹. The experiment was carried out in a complete randomization design (RCD) with three replications. To reach the field capacity to maintain the humidity of the experimental units, after the end of the incubation period (two months), the samples were air-dried, ground and passed through a sieve with holes (2) mm in diameter, then humic and fulvic acids, soluble, ready-made and organic acids were measured. With water and phosphorous prepared and organic by increasing the level of organic matter added, 1.5% was the best. It was also noted that the best level of phosphorous for the above indicators was the level (120) mg kg⁻¹ compared to the rest of the levels, and that sheep manure outperformed the organic fertilizer in all the studied traits. Interventional treatment of 1.5% of the residual organic matter at a level of (120) mg kg⁻¹ gave the highest significant effect, and the concentrations of humic and fulvic acid were (8.35 and 2.95) g kg⁻¹ respectively. The treatment gave 1.5% organic matter for sheep manure and (120) mg kg⁻¹ which is the highest value in the amount of water-soluble, ready-made and organic phosphorus with an average of (13.80, 71.35 and 167.44) mg kg⁻¹ respectively.

Keywords: Humic acids, Organic matter, Phosphorous, Gypsiferous soil.

1. Introduction

Iraqi soils are characterized by a low percentage of organic matter in them, a relatively high degree of soil interaction and a high percentage of carbonate minerals. These factors lead to a decrease in the availability of most of the plant nutrients originally present in the soil and to a lack of efficiency in the use of added fertilizers, especially phosphate fertilizers (even if added with a Soluble composition in water) due to its rapid interaction with the components of the soil (adsorption and sedimentation) and its transformation into low soluble compounds [1]. Phosphorous is one of the most important elements that Gypsiferous soils suffer from a deficiency, and this may be attributed to the lack of organic matter. To the soil and the use of good management helps to increase its readiness [2].

Organic waste is decomposed by soil microorganisms such as bacteria and fungi that exploit organic carbon as a source of energy and to build new cells. Organic matter plays an important role in preparing the soil with nutrients necessary for plant growth without causing any harm to the environment in application to improving it building soil, preserving soil moisture and increasing Trapping nutrients in the soil and preventing them from leaching [3]. The decomposition of organic residues in the soil results in the liberation of some organic functional groups and some anions such as citrates and oxalates that chelate calcium ions that combine with phosphorous to form low-soluble minerals and thus reduce the effectiveness of calcium in the soil and this leads to an increase in the solubility of phosphorous compounds with little solubility and the release of phosphorous. The decomposition of organic residues in the soil results in the release of organic acids such as humic and fulvic acid and others that lower the pH of the soil and increase the solubility of phosphorus [4]. The aim of this study Effect of source of organic matter level and phosphorous level on phosphorous forms and humic acids release in Gypsiferous soil.
2. Materials and Methods

2.1 Study soil analysis

Random samples were taken from the field soil before conducting the incubation process at a depth of 0-30 cm, then mixed homogeneously, air-dried and ground, then passed through a sieve with a diameter of 2 mm to estimate some of its physical and chemical properties in the laboratory of the Department of Soil Sciences and Water Resources of the College of Agriculture, Table 1. The volume ratios of soil separations of sand, silt and clay were estimated using the hydrometer method described by [5]. The bulk density of paraffin wax was estimated according to [6] method. The pH and electrical conductivity of the soil extract were measured (1:1) according to the method mentioned in [7] the positive ion exchange capacity (CEC) was estimated by the method of sodium acetate and ammonium acetate described in [23] while carbonate minerals (CaCO3) was estimated by the gravimetric method mentioned in [8]. Gypsum was estimated (CaSO4. 2H2O) by dilution method, as distilled water was used in the extraction in a solution containing acetic acid and acetone to precipitate gypsum and according to the method described in [9]. The organic matter was estimated by wet digestion with sulfuric and phosphoric acid with ammoniac ferrous sulfate. According to the method of (Walkely and Black) mentioned in [10], the Soluble positive and negative ions were estimated in a soil extract (1:1) as sodium and potassium were estimated using a flame photometer. Calcium and magnesium were determined by stroking method (0.01 N), while chloride was measured by scaling With silver nitrate solution (1.0 N). The sulfates were determined by precipitation method in the form of barium sulfate, while the carbonates and bicarbonates were estimated by scaling with sulfuric acid [11]. The prepared nitrogen was estimated by potassium chloride (2M KCl) in a steam distillation device (Mico-Kjeldal) according to Method [12].

2.2 Organic waste

Two types of organic waste were selected, which are animal waste (sheep), which were collected from one of the sheep fields in the Al-Alam district and were air-dried, then crushed and passed through a sieve with holes diameter of 2 mm. As for the residues of the corn cobs (the calcareous corn cob without grain) obtained from the Mesopotamian Company (the silo of corn in the Al-Alam area). The korean was air dried, and impurities, rock pieces and gravel were removed from it, then it was cut and crushed by an electric grinder and prepared for the decomposition process. 0.5% P of Triple le super phosphate fertilizer (20%P) with the application of decomposed poultry residues and fertile soil with a percentage of not more than 5%, after working in suspension, and continuously moistening and stirring every 3 to 4 days until a degree of decomposition is reached. Then, it is possible to diagnose the substance as to its severity, after which the decomposing organic waste is spread out to air-dry for a period of three days. The process lasted for 90 days, starting from 23/12/2018 to 23/4/2019. Then a sample of it was taken for the purpose of conducting some chemical analyzes on it as shown in Table (2), after which it was filled in plastic bags and kept until use.

2.3 The experiment included three factors

First factor: sheep residues at three levels of 1.5, 1, and 0.5% by weight of the soil, equivalent to (5, 10 and 15) gram of Kg soil1. Second factor: corn cob residues at three levels of 1.5, 1, and 0.5% by weight of the soil, which is equivalent to (5, 10 and 15) gram of Kg soil1. Third factor: four levels of phosphorus (0, 40, 80 and 120) mg P kg-1 (the source of phosphorus used : triple super phosphate TSP). The experiment was carried out in three replications with a complete randomization (CRD) design, so that the number of experimental units was 72 experimental units. The experiment was carried out under laboratory conditions. One kilogram of sieved soil was filled with a sieve with holes diameter of 2 mm after distributing the treatments on it in plastic pots. The soil was mixed with phosphorous and organic matter treatments. Irrigation was carried out using distilled water on the basis of field capacity by weighted method and moisture was maintained. Soil by weighing the pots with the soil daily and adding water to deliver moisture to the field capacity, and the experiment continued for two months from (1/5/2019) to ((1/7/2019). Its holes are 2 mm in diameter and placed in plastic containers for the purpose of conducting analyzes on them.

3. Experiment Measurements

3.1 Humic acids (humic and fulvic acid)

Humic acids (humic + fulvic) and humic were separated according to the method approved by [13] using 0.1 M potassium hydroxide solution KOH instead of sodium hydroxide in a ratio of 1: 10 (Soluble organic residues: KOH). The solutions were shaken in the vibrator for 24 hours, then filtered using filter paper and purified using a centrifuge at a speed of 4000 rpm. The precipitated part was humene, which was neglected. As for the filtrate, it was collected and divided into two parts,
the first part: it remained as an extract (humic acid + fulvic acid) and was preserved in large plastic containers, and the second part: the humic acid was separated from it, which was acidified using 2.0 molar hydrochloric acid (HCl). To reach the pH equal to 2.0 and left until the next day for the purpose of coagulation. The Soluble part (fulvic acid) was isolated and neglected, while the precipitated part (humic acid) was collected by centrifugation at a speed of 4000 rpm and kept in suitable containers in the refrigerator for analysis and completion of experiments.

3.2 Phosphorous fraction

The available phosphorous in the soil was estimated by extracting the soil with a solution of sodium bicarbonate (0.5M NaHCO3) at pH 8.5. The blue color was developed using a solution of M. The lipids of ammonium and ascorbic acid were measured using a spectrophotometer at a wavelength of 840 nm as mentioned in [14], the Soluble phosphorous was estimated by extracting it with distilled water at a ratio (1 soil: 10 water) using a Spectrophotometer, and the Available potassium extracted with ammonium acetate solution was estimated according to method [15]. The organic phosphorous was estimated after burning the soil at a temperature of 550 °C for one hour and then extracting the phosphorous with sulfuric acid (M 0.5) according to the method of Saunders et al., (1955). Then the blue color was developed using a solution of ammonium molybdate and ascorbic acid and it was measured using a spectrophotometer at a wavelength of 840 nm as mentioned in [16].

| Property               | Unit          | Value   |
|------------------------|---------------|---------|
| Sand                   | g kg⁻¹        | 451     |
| Silt                   | g kg⁻¹        | 313     |
| Clay                   |               | 236     |
| Texture                |               | Loamy   |
| Bulk density           | g m⁻³         | 1.353   |
| pH                     |               | 7.63    |
| EC                     | ds m⁻³        | 2.41    |
| CEC                    | Cmol kg⁻¹     | 17.07   |
| S.O.M                  | g Kg⁻¹        | 8.20    |
| CaSO₄.2H₂O             | g Kg⁻¹        | 123     |
| carbonate minerals     |               | 202.57  |
| Available N            |               | 23.50   |
| Available K            |               | 117     |
| Available P            | g Kg⁻¹        | 6.741   |
| Soluble P              |               | 0.161   |
| Total P                |               | 709.21  |
| Organic P              |               | 89.14   |
| Soluble ions           |               |         |
| Na⁺                    |               | 1.39    |
| K⁺                     |               | 0.55    |
| Ca²⁺                   |               | 11.03   |
| G²⁺                    |               | 6.22    |
| CL⁻                    | mmol L⁻¹      | 1.83    |
| CO₃²⁻                  |               | Nil     |
| HCO₃⁻                  |               | 1.76    |
| SO₄²⁻                  |               | 15.41   |
The decomposition of organic matter by the action of microorganisms leads to the release of organic acids, including fulvic acid (FA), which has a medium color between bright and dark and dissolves in the base and does not dissolve in acid. Its molecular weight is (1680) and its chemical symbol is C_{33}H_{37}N_{2}O_{11}(COOH)\_1(OH). 6(CO)\_1 [17]. The results of Table (3) show that the level of phosphorous in the soil has a significant effect on the release and release of fulvic acid, as the application level (120) g P kg\(^{-1}\) gave the highest rate for this trait amounted to (2.37) g kg\(^{-1}\), which did not differ from treatment P2, which gave an average It reached (2.37) g kg\(^{-1}\), and treatment P0 gave the lowest rate, which reached (1.31) g kg\(^{-1}\). The reason for liberating fulvic acid when adding phosphorous is attributed to the role of phosphorus in accelerating the process of decomposition of organic matter, as decomposing organisms need phosphorous to build their bodies and this led to an increase in their activity and density [18]. Table (3) indicates that the level of the organic matter has a significant effect on the amount of fulvic released, as the treatment M2 gave the highest rate for this trait amounted to (2.38) g kg\(^{-1}\), with a significant increase of (44.24 and 23.95) % compared to the treatments M0 and M1 which gave a rate of (1.65 and 1.81) g kg\(^{-1}\), and this is due to the increase in the amount of added organic matter leads to an increase in the amount of carbon in the middle of the soil and this carbon is used by microorganisms to obtain energy and thus increase its density and activity [19] which increases the decomposition of organic matter whose decomposition was reflected in the release of fulvic acid. It is noticed from Table (3) that the type of organic waste had an effect on the amount of fulvic acid released, as sheep manure gave a superior rate of (2.09) g kg\(^{-1}\), with a significant increase of 17.42% compared to the treatment of yellow corn kernels, which gave (1.78) g kg\(^{-1}\). This is due to the fact that sheep’s waste contains easy and quickly decomposing materials such as proteins and small amounts of lignin, which is believed to be the basic nucleus of fulvic acid [28] in contrast to corn cobs with a high content of lignin and cellulose. What he found [20]. Between the bilateral interaction between the levels of organic matter and phosphorous levels, the treatment M3P3 gave the highest rate for this trait amounted to (2.71) g kg\(^{-1}\), which significantly outperformed all treatments in this interaction with the exception of M3P2 treatment, while the treatment M1P0 gave the lowest rate of this interaction reached (0.91) g kg\(^{-1}\). As for the bilateral interaction between the type of organic fertilizer and phosphorous levels, treatment SP3 gave the highest average of the amount of fulvic acid liberated in this interaction amounted to (2.53) g kg\(^{-1}\), and treatment KP0 gave the lowest rate for this trait amounted to (1.21) g kg\(^{-1}\). As for the bilateral interaction between the type of organic matter and its levels, treatment SM3 gave the highest rate for this trait amounting to (2.58) g kg\(^{-1}\), outperforming with a significant increase of 72% compared to treatment KM1, which gave the lowest rate for this trait amounted to (1.50) g kg\(^{-1}\). The triple interaction was significant in some treatments, whereby SM3P3 treatment gave the highest rate in this interaction reached (2.95) g kg\(^{-1}\), and treatment KM1P0 gave the lowest rate in this interaction amounted to (0.85) g kg\(^{-1}\).

### 4.2 Humic acid (g kg\(^{-1}\))

The decomposition of organic matter by the action of microorganisms leads to the release of organic acids, including humic acid, which has a bright color and dissolves in acid and base and has a partial weight of (640) and its chemical symbol is C_{22}H_{22}(COOH)\_3(OH)\_3(CO)\_2. It is noted from Table (4) that the application of phosphorous significantly affected the amount of humic acid liberated from the soil, as the P3 level gave the highest rate of (6.23) g kg\(^{-1}\), possibly due to the fact that the application of phosphorus led to a decrease in the ratio (C:P) Which led to an increase in the density and activity of living things, leading to the decomposition of organic waste, which was reflected in the release of humic acid, and this is consistent with what was found by [21], who found that adding phosphorous to organic waste increased the process of its decomposition and the release of humic acid. It is clear from the table (4) The application of the organic matter, regardless of its source, significantly affected the amount of released humic acid. The application of the organic matter at a rate of 1.5% gave the highest rate of releasing humic acid amounted to (636) g kg\(^{-1}\), while the two treatments gave (0.5 and 1%).

### Table 2. Some characteristics of organic fertilizer

| Property | PH | EC\(_{ds \ m^{-1}}\) | N \(\%\) | P \(\%\) | K \(\%\) | C \(\%\) | C/N | C/P |
|----------|----|-----------------|--------|--------|--------|--------|-----|-----|
| Organic matter |    |                 |        |        |        |        |     |     |
| Sheep Manure | 7.69 | 8.37 | 3.42 | 0.620 | 0.85 | 44.05 | 12.88 | 71.05 |
| compost | 7.84 | 4.82 | 3.10 | 0.410 | 0.55 | 55.74 | 17.98 | 135.95 |

Estimate the pH and electrical conductivity at the dilution level 1:5

4. Results and Discussion

#### 4.1 Fulvic acid (g Kg\(^{-1}\))

The decomposition of organic matter by the action of microorganisms leads to the release of organic acids, including fulvic acid (FA), which has a medium color between bright and dark and dissolves in the base and does not dissolve in acid. Its molecular weight is (1680) and its chemical symbol is C_{33}H_{37}N_{2}O_{11}(COOH)\_1(OH). 6(CO)\_1. 6(CO)\_1 [17]. The results of Table (3) show that the level of phosphorous in the soil has a significant effect on the release and release of fulvic acid, as the application level (120) g P kg\(^{-1}\) gave the highest rate for this trait amounted to (2.37) g kg\(^{-1}\), which did not differ from treatment P2, which gave an average It reached (2.37) g kg\(^{-1}\), and treatment P0 gave the lowest rate, which reached (1.31) g kg\(^{-1}\). The reason for liberating fulvic acid when adding phosphorous is attributed to the role of phosphorus in accelerating the process of decomposition of organic matter, as decomposing organisms need phosphorous to build their bodies and this led to an increase in their activity and density [18]. Table (3) indicates that the level of the organic matter has a significant effect on the amount of fulvic released, as the treatment M2 gave the highest rate for this trait amounted to (2.38) g kg\(^{-1}\), with a significant increase of (44.24 and 23.95) % compared to the treatments M0 and M1 which gave a rate of (1.65 and 1.81) g kg\(^{-1}\), and this is due to the increase in the amount of added organic matter leads to an increase in the amount of carbon in the middle of the soil and this carbon is used by microorganisms to obtain energy and thus increase its density and activity [19] which increases the decomposition of organic matter whose decomposition was reflected in the release of fulvic acid. It is noticed from Table (3) that the type of organic waste had an effect on the amount of fulvic acid released, as sheep manure gave a superior rate of (2.09) g kg\(^{-1}\), with a significant increase of 17.42% compared to the treatment of yellow corn kernels, which gave (1.78) g kg\(^{-1}\). This is due to the fact that sheep’s waste contains easy and quickly decomposing materials such as proteins and small amounts of lignin, which is believed to be the basic nucleus of fulvic acid [28] in contrast to corn cobs with a high content of lignin and cellulose. What he found [20]. Between the bilateral interaction between the levels of organic matter and phosphorous levels, the treatment M3P3 gave the highest rate for this trait amounted to (2.71) g kg\(^{-1}\), which significantly outperformed all treatments in this interaction with the exception of M3P2 treatment, while the treatment M1P0 gave the lowest rate of this interaction reached (0.91) g kg\(^{-1}\). As for the bilateral interaction between the type of organic fertilizer and phosphorous levels, treatment SP3 gave the highest average of the amount of fulvic acid liberated in this interaction amounted to (2.53) g kg\(^{-1}\), and treatment KP0 gave the lowest rate for this trait amounted to (1.21) g kg\(^{-1}\). As for the bilateral interaction between the type of organic matter and its levels, treatment SM3 gave the highest rate for this trait amounting to (2.58) g kg\(^{-1}\), outperforming with a significant increase of 72% compared to treatment KM1, which gave the lowest rate for this trait amounted to (1.50) g kg\(^{-1}\). The triple interaction was significant in some treatments, whereby SM3P3 treatment gave the highest rate in this interaction reached (2.95) g kg\(^{-1}\), and treatment KM1P0 gave the lowest rate in this interaction amounted to (0.85) g kg\(^{-1}\).
Table 3. The effect of type, levels organic fertilizer and the level of phosphor applied in fulvic acid concentration of released after 60 day from incubation (g Kg\(^{-1}\)).

| Type organic fertilizer | Levels organic fertilizer | Phosphor rate (mg kg\(^{-1}\)) | MT |
|-------------------------|---------------------------|---------------------------------|----|
|                         |                           | \(P_0\) | \(P_1\) | \(P_2\) | \(P_3\) |
| T                      | M                         |        |        |        |        |        |
| S                      | M_1                        | 0.98 p | 1.42 m | 2.33 d | 2.40 cd |
|                        | M_2                        | 1.28 n | 1.92 ji| 2.18fe | 2.25 e  |
|                        | M_3                        | 1.97 ji| 2.50 b | 2.89 a | 2.95 a  |
|                        | M_1                        | 0.85 q | 1.21 n | 1.94 ji| 2.01li  |
|                        | M_2                        | 1.10 o | 1.53 l | 2.02hi | 2.14 fg |
|                        | M_3                        | 1.69 k | 2.09 hg| 2.44cb | 2.48 cb |
|                        |                             |        |        |        |        |        |
| K                      | M_1                        | 1.91 c | 2.25 e | 2.18fe | 2.13 d  |
|                        | M_2                        | 2.58 a | 2.95 a | 2.89 a | 2.50 b  |
|                        | M_3                        | 1.50 f | 2.01 h | 1.94 ji| 1.21 n  |
|                        |                             |        |        |        |        |        |
| Average T              | S                          | 1.41 g | 1.95 e | 2.47 b | 2.53 a  |
|                        | K                          | 1.21 h | 1.61 f | 2.13 d | 2.21 c  |
|                        |                             |        |        |        |        |        |
| Average M              | S                          | 1.91 c | 2.25 e | 2.18fe | 2.13 d  |
|                        | K                          | 2.58 a | 2.95 a | 2.89 a | 2.50 b  |
|                        |                             |        |        |        |        |        |
| Average P              | S                          | 1.91 c | 2.25 e | 2.18fe | 2.13 d  |
|                        | K                          | 2.58 a | 2.95 a | 2.89 a | 2.50 b  |
|                        |                             |        |        |        |        |        |
| M_1 : 0.5 % organic fertilizer | \(P_0\) : 0 mg P Kg\(^{-1}\) |
| M_2 : 1.0 % organic fertilizer | \(P_1\) : 40 mg P Kg\(^{-1}\) |
| M_3 : 1.5 % organic fertilizer | \(P_2\) : 80 mg P Kg\(^{-1}\) |
|                        | \(P_3\) : 120 mg P Kg\(^{-1}\) |

Average rates reached (3.17 and 4.92) g kg\(^{-1}\), respectively, and this is due to the fact that organic carbon is the source of energy that decomposers need to build their bodies and carry out their activities. Therefore, the increase in the percentage of organic matter in the soil affects the activity of these organisms, which greatly affects the secretions of these organisms. These acids, these results were in line with what he found [22]. It is clear From Table (4), the source of the organic matter had a significant impact on the amount of humic acid released, as the sheep treatment gave an average of (5.09) g kg\(^{-1}\), significantly superior to the compost treatment, which gave (4.54) g kg\(^{-1}\).

The main reason is in the composition of the residues Sheep manure contains easily and quickly decomposing substances such as proteins and small amounts of lignin (Vandachari and Gosh, 1984) in contrast to calcareous with a high content of lignin, and this is consistent with [23], who found that the amount of humic acids released from cow waste It was higher than vegetable compost. Between the bilateral interaction between the levels of organic matter and phosphorous levels, the treatment M3P3 gave the highest rate of (7.78) g kg\(^{-1}\), significantly superior to all treatments in this interaction, while the treatment M1P0 gave the lowest rate of this interaction reached (2.12) g kg\(^{-1}\). As for the bilateral interaction between the type of organic fertilizer and phosphorous levels, treatment SP3 gave the highest average of the amount of fulvic acid liberated in this interaction amounted to (6.69) g kg\(^{-1}\), and treatment KP0 gave the lowest rate for this trait amounted to (3.47) g kg\(^{-1}\). As for the binary interaction between the type and levels of organic matter, treatment SM3 gave the highest rate of this trait amounted to (6.74) g kg\(^{-1}\), significantly superior to all treatments in this interaction, and treatment KM1 gave the lowest rate of (3.00) g kg\(^{-1}\), while the triple interaction Its effect was significant in some treatments, as the SM3P3 treatment gave the highest rate in this interaction, reaching (8.35) g kg\(^{-1}\), and the KM1P0 treatment gave the lowest rate in this interaction, which amounted to (2.10) g kg\(^{-1}\).
Table 4. The effect of type, levels organic fertilizer and the level of phosphor applied in humic acid concentration of released after 60 day from incubation (g Kg^{-1}).

| Type organic fertilizer | Levels organic fertilizer | Phosphor rate (mg kg^{-1}) | MT |
|-------------------------|---------------------------|----------------------------|----|
|                         |                           | P0 | P1 | P2 | P3 |       |
| T                       |                           |    |    |    |    |       |
| S                      | M1                         | 2.13 t | 2.90 r | 3.31 p | 5.00 j | 3.34 e |
|                        | M2                         | 3.99 n | 4.47 l | 5.59 i | 6.71 d | 5.19 c |
|                        | M3                         | 5.72 h | 5.89 g | 7.00 c | 8.35 a | 6.74 a |
|                        | M4                         | 2.10 t | 2.62 s | 3.18 q | 4.11 m | 3.00 f |
| K                      | M2                         | 3.50 o | 4.00 n | 5.08 j | 5.97 f | 4.64 d |
|                        | M3                         | 4.81 k | 5.53 i | 6.33 e | 7.21 b | 5.97 b |
| Average P              |                            | 3.71 D | 4.24 C | 5.08 B | 6.23 A |       |

Phosphor rate (mg kg^{-1})

- P0: 0 mg P Kg^{-1}
- P1: 40 mg P Kg^{-1}
- P2: 80 mg P Kg^{-1}
- P3: 120 mg P Kg^{-1}

4.3 Soluble Phosphorous (mg kg^{-1})

Table 5 shows the effect of the source and level of the organic matter and the level of phosphorus on the amount of phosphorous Soluble in water. The results in the table show that the increase in the application of phosphorous levels led to a significant increase in the amount of soluble phosphorous in water, as the level (120) g Kg^{-1} gave the highest average reached (9.05) g P Kg^{-1} gave the highest value, and the application levels gave (80, 40, 0) g P Kg^{-1}, an average of (7.88, 6.55, 5.42) g P kg soil-1, respectively, and this is due to the fact that triple superphosphate fertilizer is a high fertilizer solubility in water and that its application leads to an increase in the Soluble amount of phosphorous in the soil solution. These results were in agreement with what was found by [24], who mentioned that with increasing levels of phosphorus application, the average precipitation increases with calcium, but the amount of Soluble phosphorous increases. With the increase in the level of application, Table 5 indicates that the application of organic matter with increasing levels significantly affected the amount of Soluble phosphorous in the soil, as the levels of application gave (0.5, 1, and 1.5) % of the soil weight, an average of (3.23, 8.23 and 10.21) g kg^{-1} for the three levels, respectively. This is attributed to the fact that the organic matter chelates calcium and reduces the precipitation of phosphorous in the form of calcium phosphate [25,26]. On the other hand, the decomposition of organic matter leads to the release of organic acids Table (3, 4), which increase the solubility of phosphate compounds with Low solubility, these results with what he found [27]. It is evident from Table 5 that the source of the organic waste significantly affected the amount of Soluble phosphorous, as sheep manure S gave an average of the amount of Soluble phosphorous amounted to (7.78) g Kg^{-1}, significantly superior to the residues of compost such as corn cobs S2, which gave a minimum average of (6.67) g Kg^{-1}. This is due to the fact that sheep manure released large amounts of humic and fulvic acid compared to corn cork residues, and thus these acids increased the solubility of phosphate compounds, and on the other hand, it was due to the concentration of phosphorous that was higher in sheep waste than compost like corn cork (Table 2). These results were in agreement with what was found [28].
The results of the bilateral interaction between the levels of organic matter and phosphorous levels showed significant differences, and the M3P3 treatment gave the highest average (12.82) g kg⁻¹, which significantly outperformed all treatments in this interaction, and the M1P0 treatment gave the lowest average for this interaction, which amounted to (1.3) g kg⁻¹. Between the twofold interaction between the type of organic fertilizer and the levels of significant differences between the treatments, as the treatment S1P3 gave the highest mean in this interaction amounted to (9.87) g kg⁻¹ and the interaction S2P0 gave the lowest average in this interaction amounted to (5.81) g kg⁻¹. The binary interaction between the type of organic matter and its levels showed significant differences between the treatments, as the treatments of sheep manure outperformed the compost, the treatment S1M3 gave the highest average (10.97) g kg⁻¹, and treatment S2M1 recorded the lowest average for this trait amounting to (2.73) g kg⁻¹. As for the triple interaction between the study factors, the differences were in favor of sheep manure, the level of phosphorus (120) g kg⁻¹ and the average application of organic matter (1.5%) of the soil weight. The treatment S1M3P3 recorded the highest average of (13.80) g kg⁻¹ and gave Treatment S2M1P0 had the lowest average of (1.19) g kg⁻¹.

4.4 Available phosphorous (mg kg⁻¹)

It is noted from Table (5) that the added phosphorous levels led to a significant increase in the concentration of Available phosphorous compared to the comparison treatment, with an average of (38.11, 45.67 and (54.36) mg kg⁻¹ for the levels of application (40, 80 and 120) mg P kg⁻¹, respectively, while The non-application of phosphorous treatment gave an average of (31.09) mg kg⁻¹, due to the fact that the added levels of phosphorous are high and that increasing the amount of phosphorus is one of the ways to increase the Available phosphorous, and increasing the application of phosphate fertilizer Soluble in water increases the level of Available phosphorus in the soil. Despite its exposure to sedimentation and adsorption processes, especially in limestone soils, and this was indicated by many researchers [29], these results were in agreement with [30]. The results of Table (5) showed the effect of the level of organic residues application in the average Available phosphorus in the soil, as the averages of Available phosphorous concentrations were (30.10, 42.03 and 54.80) mg kg⁻¹ at the levels of application (0.5, 1, and 1.5)% of the weight. The soil, respectively, and the reason for this is that the decomposition of organic waste results in organic and inorganic acids that contribute to lowering the pH, which increases the solubility of phosphate compounds and increases the release and readiness of phosphorous. In the equilibrium medium or on the surface of carbonate minerals, and this will reduce the chance of phosphorous bonding with Ca²⁺ and Mg²⁺ ions, which reduces the adsorption and precipitation processes of phosphorus in application to the content of these residues from this element and this is consistent with what was indicated by [16] and [7], who found that the application of organic manure to the soil led to an increase in the availability of phosphorus in the soil.

The results of Table (5) indicate the effect of the two types of organic fertilizers on the amount of Available phosphorus in the soil. It is noted that sheep manure gave the largest amount of Available phosphorous amounted to (45.28) mg kg⁻¹, while the treatment of adding compost like corn kernels gave an average of (39.34) mg kg⁻¹. The superiority of sheep manure treatment over compost such as corn cobs is due to its phosphorous content of 0.620%. On the other hand, sheep manure decomposes faster than compost residues such as corn cork, which produces organic acids. These acids increase the availability of phosphorous as a result of lowering the pH. These results are in line with what was found [19], who found that the amount of Available phosphorous in the soil was higher in the soil treated with poultry manure compared to the soil treated with rice residues.

The bilateral interactions between the levels of organic matter and phosphorous levels showed clear significant differences, and the M3P3 treatment recorded the highest mean of (67.18) mg kg⁻¹, which significantly outperformed all treatments in this interaction, while M1P2 gave the lowest average for this interaction, which amounted to (13.92) mg kg⁻¹. The results of Table (5) indicate that there are significant differences in the bilateral interaction between the type of organic fertilizer and levels, and the highest average in this interaction was in favor of the S1P3 treatment, which amounted to (57.75) mg kg⁻¹, and the S2P0 treatment recorded the lowest average in this interaction amounting to (28.95) mg kg⁻¹. The interaction between the type and levels of organic matter recorded significant differences between the treatments, as the treatments of sheep manure outperformed the compost treatments, as the treatment S1M3 gave the highest average of (58.49) mg kg⁻¹, and the treatment S2M1 recorded the lowest average for this trait amounting to (27.88) mg kg⁻¹. The three interactions showed differences in favor of sheep waste S, the level of phosphorous P3 (120) g kg⁻¹ and an average application of organic matter M3 (1.5%) of the soil weight, as the treatment S1M3P3 gave the highest average of (71.35) mg kg⁻¹, and the treatment gave S2M1P2 The lowest average was (13.03) g kg⁻¹.
Table 5. Effect of the type and level of organic fertilizer and the level of phosphorus added on the amount of Soluble phosphorus (mg kg⁻¹) after 60 days of incubation.

| Type organic fertilizer | Levels organic fertilizer | Phosphor rate (mg kg⁻¹) | MT          |
|-------------------------|---------------------------|-------------------------|-------------|
|                         | T                         |                         |             |
|                         | M                         |                         |             |
|                         | P₀ | P₁  | P₂  | P₃  |             |
| S                       | M₁ | q1.41| o 3.29| m  4.88| l  5.32 | 3.72 e      |
|                         | M₂ | j7.23| 17.71| f9.15  | c 10.48 | 8.64 c      |
| K                       | M₁ | g  8.80| e9.59| b 11.67| a  13.80| 10.97 a     |
|                         | M₂ | q  1.13| P 2.29| o  3.35| n  4.11| 2.73 f      |
|                         | M₃ | k  6.66| hi 7.81| h 8.03| g  8.73| 7.81 d      |
| TP                      | S  | 5.81| g 6.61| d 10.18| b 11.83| 9.46 b      |
|                         | K  | 5.02| h 6.24| f 7.19| d 8.22| 6.67 B      |
| MP                      | M₁ | 1.30| L 2.79| k 4.12| j 4.72| 3.23 C      |
|                         | M₂ | 6.95| h 7.76| g 8.59| e 9.61| 8.23 B      |
|                         | M₃ | 8.00| f 9.10| d 10.93| b 12.82| 10.21 A     |
| Average P               | S  | 5.42| D 6.55| C 7.88| B 9.05| 9.05 A      |

4.5 Organic phosphorus (mg kg⁻¹)

It is noticed from the data of Table (6) that the values of organic phosphorus increased by increasing the levels of phosphate fertilizer application, regardless of the level and source of the organic fertilizer followed (132.62 and 139.54) mg kg⁻¹, respectively, and this is due to the role of added phosphorus in the decomposition of existing or added organic residues to the soil, thus increasing organic phosphorus, which constitutes (20-80)% of the total amount of phosphorus and that this percentage depends on the organic matter and microbial activity [29]. These results agreed with [5] who found that the amount of organic phosphorus in soil increased when phosphorus levels increased after 240 days of incubation. It is noted from the data of Table (6) that the application of organic matter, regardless of its source, whether animal or vegetable, led to an increase in organic phosphorus in the soil. And (125.03 and 142.43) mg kg⁻¹ for the three levels, respectively. This is due to the fact that the application of organic fertilizers increases the percentage of organic matter in the soil, and this increases the amount of organic phosphorus in the soil, especially in gypsum soil, because this soil is low in organic matter, as it does not exceed 1% On the other hand, the application of organic fertilizers may have increased microbial diversity and activity, and then reflected on the organic phosphorus content. The amount of organic phosphorus in the soil after 16 weeks of incubation. Table (6) shows that the source of organic fertilizer has a significant effect on the amount of organic phosphorus in the soil after 60 days of incubation, as the fertilization treatment with sheep waste and gave a concentration of organic phosphorus amounted to (130.32) mg kg⁻¹ significantly superior to the treatment of compost as corn cobs. Which gave an average of (122.64) mg kg⁻¹. The superiority of the sheep treatment over calcarea is attributed to the fact that sheep manure contains a higher amount of phosphorus than fermented calcare (Table 2). On the other hand, sheep waste is more palatable by microorganisms because it contains more nitrogen than compost. These organisms may have formed colonies on these residues, so the bodies and secretions of these organisms are considered to be within the organic part, which is reflected in the amount of Organic phosphorus in soil, these results were consistent with what was found [27] that adding organic matter to 12 different soils increased the organic phosphorus concentration of these soils in gypsum soil. The results of Table (6) of the binary interactions between the levels of organic matter and phosphorus levels indicate that there are clear significant differences, and the M3P3 treatment recorded the highest average of (160.03) mg kg⁻¹, which significantly outperformed all
treatments in this interaction, and M1P0 gave the lowest average of this interaction amounted to (100.82) mg kg\(^{-1}\). The bilateral interaction between the type of organic fertilizer and phosphorous levels showed significant differences, and treatment S1P3 recorded the highest mean in this interaction with an average of (143.51) mg kg\(^{-1}\), and treatment S2P1 recorded the lowest average in this interaction amounted to (108.37) mg kg\(^{-1}\). The interaction between the type of organic matter And their levels were significant differences between the treatments, as the sheep manure treatments outperformed similar compost treatments, and the treatment S1M3 recorded the highest mean in this interaction with an average of (149.20) mg kg\(^{-1}\), with a significant difference from treatment S2M1, which gave the lowest average for this trait amounted to (110.20) mg kg\(^{-1}\), which did not differ. Significantly compared to treatment S1M1. The triple interactions showed significant differences in favor of sheep manure S, the level of phosphorous P3 (120) mg kg\(^{-1}\) and an average application of organic matter M3 1.5% of the soil weight, as the treatment S1M3P3 gave the highest average amounted to (167.44) mg kg\(^{-1}\). The treatment S2M1P0 gave a lower mean of (100.1) mg kg\(^{-1}\), which did not differ significantly from the treatment S1M1P0, whose value was (101.53) mg kg\(^{-1}\).

### Table 6. Effect of the type and level of organic fertilizer and the level of phosphorus added on the amount of organic phosphorous (mg kg\(^{-1}\)) after 60 days of incubation

| Type organic fertilizer | Levels organic fertilizer | Phosphor rate (mg kg\(^{-1}\)) | MT |
|-------------------------|---------------------------|-------------------------------|----|
|                         |                           | P0 | P1  | P2    | P3    |       |
| T                       | M1                        | 101.53 m | 111.10 k | 119.40 i | 123.13 hi | 113.79 e |
| S                       | M2                        | 112.1 k | 126.09 h | 133.77 fg | 139.96 e | 127.98 c |
|                         | M3                        | 129.03 g | 141.30 de | 159.00 b | 167.44 a | 149.20 a |
|                         | M1                        | 100.1 m | 107.27 f | 113.67 jk | 119.74 i | 110.20 e |
| K                       | M2                        | 108.99 l | 118.89 i | 126.05 f | 134.35 f | 122.07 d |
|                         | M3                        | 116.03 ij | 130.17 g | 143.81 d | 152.62 c | 135.66 b |
| TP                      | S                         | 114.22 d | 126.16 c | 137.39 b | 143.51 a | 130.32 A |
|                         | K                         | 108.37 e | 118.78 d | 127.84 c | 135.57 b | 122.64 B |
| MP                      | M1                        | 100.82 h | 109.19 g | 116.54 f | 121.44 ef | 112.00 C |
|                         | M2                        | 110.55 g | 122.49 e | 129.91 d | 137.16 c | 125.03 B |
|                         | M3                        | 122.53 e | 135.74 c | 151.41 b | 160.03 a | 142.43 A |
| Average P               |                           | 111.30 D | 122.47 C | 132.62 b | 139.54 A |       |

| Type of organic fertilizers | Phosphor rate (mg kg\(^{-1}\)) |
|-----------------------------|-------------------------------|
| M1 : 0.5 % organic fertilizer | P0 : 0 mg P Kg\(^{-1}\) |
| M2 : 1.0 % organic fertilizer | P1 : 40 mg P Kg\(^{-1}\) |
| M3 : 1.5 % organic fertilizer | P3 : 120 mg P Kg\(^{-1}\) |

**Conclusions**

- The addition of phosphorous levels gave a significant increase in the concentration of humic and fulvic acid, and the addition level (120) mg kg\(^{-1}\) gave the highest value. It also gave an increase in the concentration of phosphorous forms (Soluble P, Available P and organic P).
- The addition level of 1.5% of the organic matter gave the highest value for the amount of humic and fulvic acid, A significant increase in the concentration of soluble, Available and organic phosphorus liberated after 60 days of incubation.
- Sheep manure gave a significant superiority over compost in the amount of liberated humic acids, The soil content of soluble, available and organic phosphorus also increased.
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