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The Role of Organic and Inorganic Fertilization in Mineral Transformations in Zea Maize Rhizosphere

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Abstract: *To study the effect of organic fertilization (poultry manure) and mineral fertilization (potassium sulphate) in the mineral transformations of yellow maize rhizosphere, three plates were planted with Zea maize seeds in one of the private farmers' farms located in Al-Qadisiyah / Diwaniyah / Daghara / in a sedimentary soil with Silt Clay Loam and with three treatments, the first without fertilization and the second included the addition of mineral fertilizer (potassium sulphate) in the amount of 225 kg. K. ha^{-1} and the last included the addition of organic fertilizer (poultry manure) in the amount of 7.5 tons. ha^{-1}. For the purpose of X-ray analysis, soil samples were taken from the rhizosphere for the three samples after physiological maturity of the crop. X-ray analysis proved the presence of mineral transformations and changes. Mineral fertilization had a major role in the construction of minerals, especially Illite mineral, due to the supplying of clay minerals with potassium, while organic fertilization was not sufficient to meet the required quantities for plant growth, which led to the depletion of potassium mineral and caused a change in the mineral composition of the Illite mineral.*

Keywords*: Fertilization, Mineral transformations, Rhizosphere, X-ray.*

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I. Introduction

Organic fertilization is defined as plant or animal residues added to the soil to improve its physical, chemical and biological properties, and these substances are decomposed by microorganisms when appropriate conditions of heat, humidity and ventilation are produced, resulting in biochemical compounds such as sugars, carbohydrate, organic and amino acids, fats and pigments. In addition to gases, these compounds are called non-humus materials. While Humus materials are a mixture of dark color heterogeneous and non-amorphous materials, and these materials can be divided according to their molecular weight and properties to humine, humic acid and folic acid (1).Most organic matter in soil originates from plant residues containing 60-90% moisture. While the remaining dry matter is composed of carbon, oxygen, hydrogen, and a small amount of sulfur, nitrogen, phosphorus, potassium, calcium and magnesium, although these elements exist in small amounts but they are very important in soil fertility (2). The addition of organic manure to soil has a role in increasing potassium availability as a result of replacing the potassium ion K^+ on the exchange surfaces with hydrogen ion H^+ resulting from the decomposition of organic acids and thus reducing the fixation of potassium (3). While (4) stated that organic material plays a role in dissolving some minerals and compounds containing potassium through organic acids resulting from their decomposition. Organic material is also a direct source of potassium in soil.Mineral fertilizer is defined as inorganic materials that are mainly salts and contain one or more nutrients needed by the plant. A part of the mineral fertilizer added to the soil which contains potassium element increases the concentration of potassium in its dissolved form while the other part turns into other forms of potassium, including mineral potassium, which has an important role in influencing mineral transformations in soil (5).Rhizosphere is an effective area for plant and microorganism growth due to the presence of organic materials produced by the roots of the plant, as well as the different secretions, in addition to the different excretions of organisms that vary in size and types (6).These secretions, whether produced by roots or different organisms, play a large role in the mineral transformations that can occur as a result of this effect (7).(8) explained that the chemical weathering mechanism and its effect on the silica layers of the mica minerals as four chemical reactions:

1. Depotasication: means the displacement of potassium and its release from the layers of mica minerals as in the following reaction:

$AI_2O_3(OH)_2AlSi_3O_8K \rightarrow Al_2O_3(OH)_2AlSi_3O_8 + K^+$

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* Part of MSC thesis of the second author.

This interaction increases with the presence of water and some cations such as H^+, and to produce vermiculite and montmorillonite minerals should be accompanied by a decrease in the layer charge.

2. Dehidroxylation: Depending on weathering of mica as the removal of hydroxyl means the following:
   $(AlSi_3O_8)^{-1} + H^+ \rightarrow HOAlSi_3O_7$

(Tetrahedral)

And this reaction occurs as a result of charge equivalence

3. This reaction occurs in low hydroxyl components and is accompanied by a decrease in the charge of the layers as follows:
   $(AlSi_3O_8)^{-1} \rightarrow Si_3O_6 + (AlO_2)^{-1}$
   (tetrahedral)
4. Desilication indicates that the displacement of silicon from expanded silicate minerals (2:1) is accompanied by an increase in aluminum is suitable for the production of kaolinite and gypsum.

So the purpose of the research is study the role of organic and inorganic fertilization in mineral transformations in Zea Maize rhizosphere.

II. Materials and methods

An agricultural field was selected for the purpose of carrying out a field experiment in one of the private farmers' farms located in Al-Qadisiyah/ Diwaniyah/ Daghara/ Sadr al-Daghara in a sedimentary soil with Silt Clay Loam. A sample of soil from the field was randomly selected prior to planting from the surface layer (0-30 cm) and was air-dried and tested and passed from a 2 mm diameter sieve to perform some chemical and physical analysis as shown in Table (1).The soil of the field was prepared with the necessary tillage, softening and leveling. Three plates (3 mx3 m) were planted with seeds Zea mays L. research type (DKC 6120) on 20/7/2016 in the form of lines, as the distance between one line and the other was 75 cm between and 25 cm between on pit and another in the form of four lines in one plate.The three plates were treated with the treatments (first plate without fertilization, the second plate included the addition of mineral fertilizer (potassium sulphate) with 225 kg. k. ha^{-1} and the third plate included the addition of organic fertilizer (poultry waste) 7.5 tons. ha^{-1}. And table (2) shows some chemical properties of organic fertilizer, and the insect of corn stem borer (*Sesamiacailica*) has been controlled by using herbicide Diazinon pesticide 10% active material added to the growth peaks of the plants two times: the first one after 25 days from germination and the second after 10 days of the first control.

A soil sample from the rhizosphere was taken for each of the three plates after the physiological maturity of the crop. It was air-dried, grinded with a wooden hammer, and was sown with a 2 mm diameter sieve and mixed well for the purpose of examining the x-ray diffraction curves using (X-ray Diffraction-Phillips) device in the powder method. The potential of hydrogen, Electrical conductivity, carbonate, gypsum, calcium, magnesium, available phosphorus, soluble potassium, exchangeable potassium, and total phosphorus were measured according to (9), cations exchange capacity, organic matter, sulfate, available nitrogen, Bulk Density, soil texture, organic carbon and total nitrogen according to (10), sodium, carbonates, bicarbonate, chlorine and total potassium according to (11) and non-exchangeable and mineral potassium according to (12).

III. Results and Discussion

The results in figures 1,2 and 3 showed that there are many changes and transitions in x-ray diffraction of these soils. X-ray diffraction of a treatment without fertilization shown in the figure (1) showed the presence ofSmectite, which was diagnosed through the first diffraction (14.7) Ang. And its forth diffraction (4.37) Ang. And the presence of this metal may be due to the prevailing chemical conditions, which is characterized by its basic reaction with a total prevail to Calcium and Magnesium ions, as well as the nature and age of the parent materials well as the erosion and weathering processes that occurred during the transfer and re-sedimentation of these soils (13).As for the chlorite it could be identified through its diffraction (14.25, 7.12, 4.72, 3.52)Ang**.** representing its first, second, third and fourth diffractions respectively. While Kaolinite which could be identified through the diffraction (7.12, 2.37) Ang**.** representing its first and third diffractions and collaborated diffraction by its first diffraction with the second diffraction for chlorite. While the mineral of elites which could be identified through its first, second, third and fourth diffractions (10.28, 5.0, 3.30, 2.48) Ang. respectively. In addition, for the presence of palgorscaite mineral, which was identified through the diffraction (10.28, 6.4, 4.48) Ang. representing the first, second and third diffractions of this mineral and collaborated with elite by its first diffraction and what confirms the collaboration is the presence of its second and third diffraction. And the minerals above are the predominant clay minerals in these soils, which are the active part of the chemical reactions and mineral transformations that can occur in the soil.

Table (1) some of the chemical and physical properties of farm soil before planting.

property		value	unit
potential of hydrogen		7.85	----
Electrical conductivity		5.3	ds. m^{-1}
cations exchange capacity		21.2	Cmol. Kg^{-1}
carbonate		219	g. Kg^{-1}
gypsum		1.06	g. Kg^{-1}
organic matter		10.32	g. Kg^{-1}
Soluble cations	Ca^{+2}	1.54	Cmol. Kg^{-1}
	Mg^{+2}	0.93	
	Na^{+1}	3.15	
Soluble anions	SO_4^{-2}	1.97	Cmol. Kg^{-1}
	HCO_3^{-1}	0.38	
	CO_3^{-2}	Nill	
	Cl^{-1}	2.88	
available nitrogen		39.20	mg. kg^{-1}
available phosphorus		14.52	mg. kg^{-1}
soluble potassium		0.075	Cmol. Kg^{-1}
exchangeable potassium		0.599	Cmol. Kg^{-1}
Non- exchangeable and mineral potassium		35.615	Cmol. Kg^{-1}
Total potassium		36.289	Cmol. Kg^{-1}
Bulk Density		1.401	megg. m^{-1}
soil texture	sand	185	g. Kg^{-1}
	silt	435	
	clay	380	
Texture class		Silt Clay Loam	

Table (2) Some chemical properties of organic fertilizer (poultry residues)

property	Value	Unit
Potential of hydrogen	7.31	----
Electrical conductivity	4.01	ds. m^{-1}
C/N	10.32	----
Organic Carbon	263	g. Kg^{-1}
Total Nitrogen	25.5	g. Kg^{-1}
Total ph0sphorus	14.6	g. Kg^{-1}
Total potassium	16.9	g. Kg^{-1}

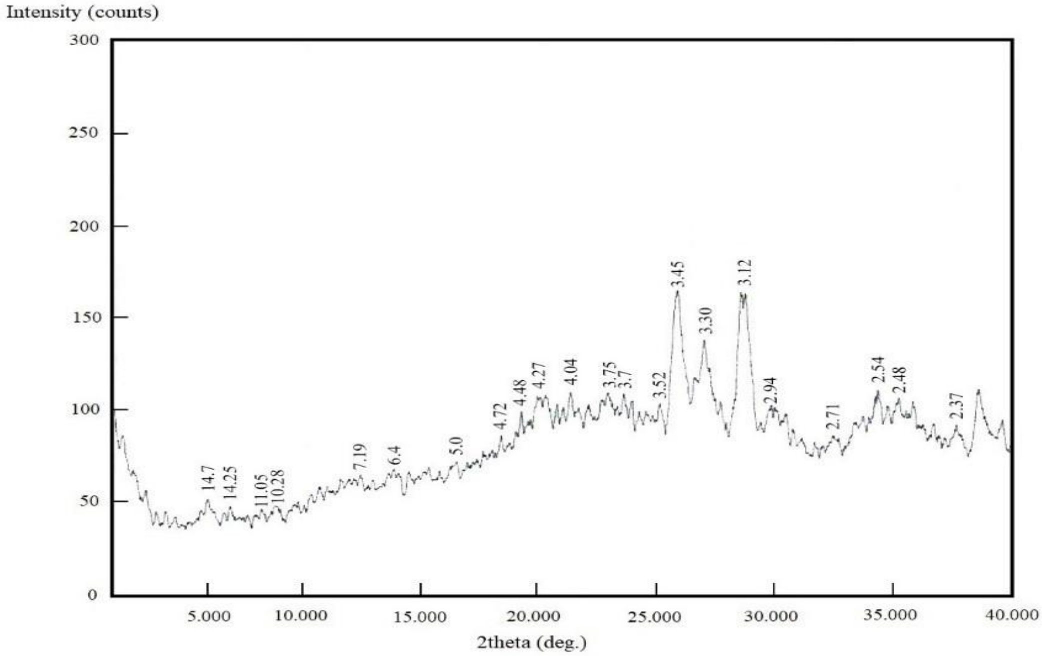

Figure (1) X-ray diffraction of control treatment after the physiological maturity of the crop

Figure (2) represents the X-ray diffraction of the treatment of mineral fertilization after maturation of the crop,which showed the presence of calcite through diffraction (14.7) Ang. and the disappearance of its third diffraction (4.37) Ang. indicating changes in this clay mineral and confirms the increase of intensity of diffraction (14.7) Ang.As for the mineral of Illite, it kept its diffraction (10.28, 5.0, 3.30, 2.48) Ang. with the increase of the intensity of all these X-ray diffractions, indicating an increase in the construction of this mineral due to increased presence of the potassium element on one hand and the result of the surplus of it because of the process of potassium fertilization on the other hand.Which led to an increase in its intensity and disappearance of the third diffraction of the Smectite mineral as a result of its formation.While the intensity of the Ballicorscite mineral didn't change through its second and third diffractions (6.4, 4.48) Ang**.** Respectively, confirming that the differences in the intensity of the first diffraction (10.28) Ang. were the result of changes in the Illitemineral.

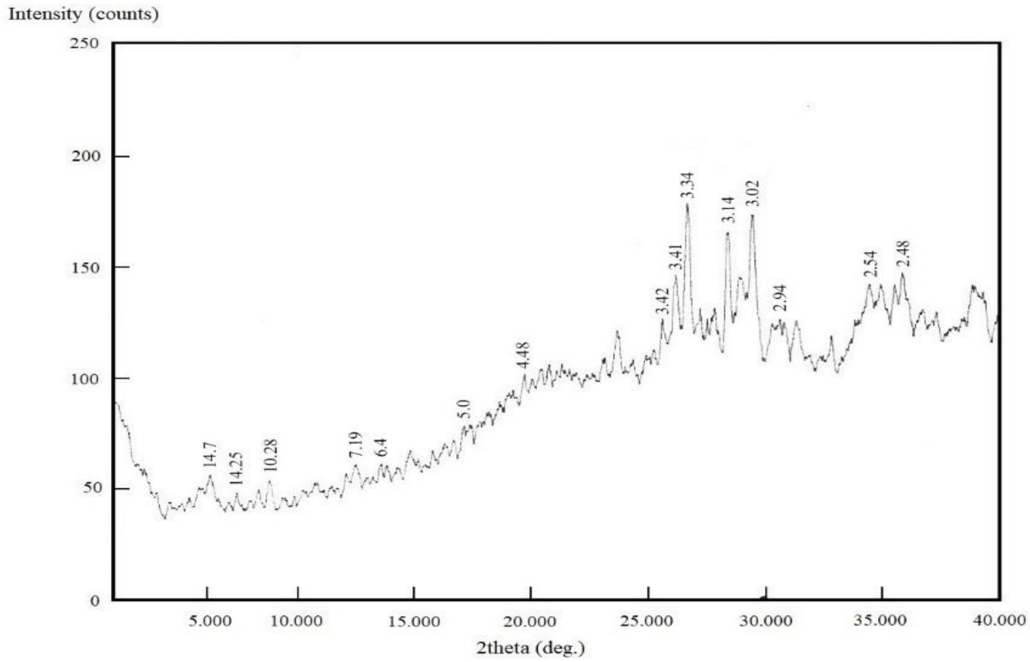

Figure (2) X-ray diffraction of potassium fertilization treatment (225 kg K. ha^{-1}) after the physiological maturity of the crop

While chlorite mineral was identified through the diffraction (14.25, 7.12) Ang. with no differences in intensity with the disappearance of the third and fourth diffractions (3.30, 2.48) Ang**.** indicating a change in this mineral may be due to the fact that it is of the type of low crystallized Swelling chlorite, whichLeads to mineral changes in it. Kaolinitemineral was identified through the diffraction (7.12, 3.34) Ang**.** with an increase in diffraction intensity (3.34) Ang. This may be due to soil content of it (14). Potassium fertilization treatment was characterized by an increase in x-ray diffraction intensity (sharp)compared with the control treatment.This agrees with what (15) found, that x-ray diffraction shows that Kaoliniteminerals in rhizosphere have stability or high thermal resistance compared with outside of the rhizosphere.

Figure (3) shows the X-ray diffraction of the organic fertilization treatment after maturity of the crop.Smectite mineral was identified by the diffraction (14.7) Ang**.** while the metal of the Illite through the diffraction (10.28, 5.0, 2.48) Ang. and the disappearance of the diffraction (3.30) Ang.instead of the diffraction (3.26) Ang**.** And with high intensity more than 250 after its intensity was 140 in the treatment without fertilization and that indicates that the first diffraction (10.28) Ang. which its intensity has decreased represents the first diffraction of palgorscaite and that the low intensity was the result of potassium depletion by the plant and its transformation into other minerals. While the second diffraction intensity of Illitemineral hasn't change (5.0) Ang. but its edge became sharper (Sharp) and the case is the same with its third diffraction (its diffraction presented as 3.26 instead of 3.30) Ang. And its intensity became high and this due to compression of its layers and this agrees with (16) which stated that the process of potassium depletion between the layers of clay minerals leads to a decrease in the process of potassium release. And this means that these minerals keep their high selective properties of potassium and the occupying of binding sites on the surface of minerals and edges as well as between the layers caused by the contraction of these metals and their shrinkage, which indicates the mineral transformations that occurred on this mineral through the depletion of potassium from its mineral layers by plant roots due to the fact that organic fertilization Does not cover the plant's need for potassium and what confirms that is the decrease in x-ray intensity. Palgorscaitewas also identified through its diffraction (10.28, 6.4, 4.48) Ang. which its intensity did not change with this fertilization, confirming that the changes that occurred in the first diffraction collaborated with the elites were the result of the change of the Illitemineral.While the chlorite was identified through the diffraction (14.25, 7.12) Ang. and kaolinite through the diffraction (7.12) Ang.

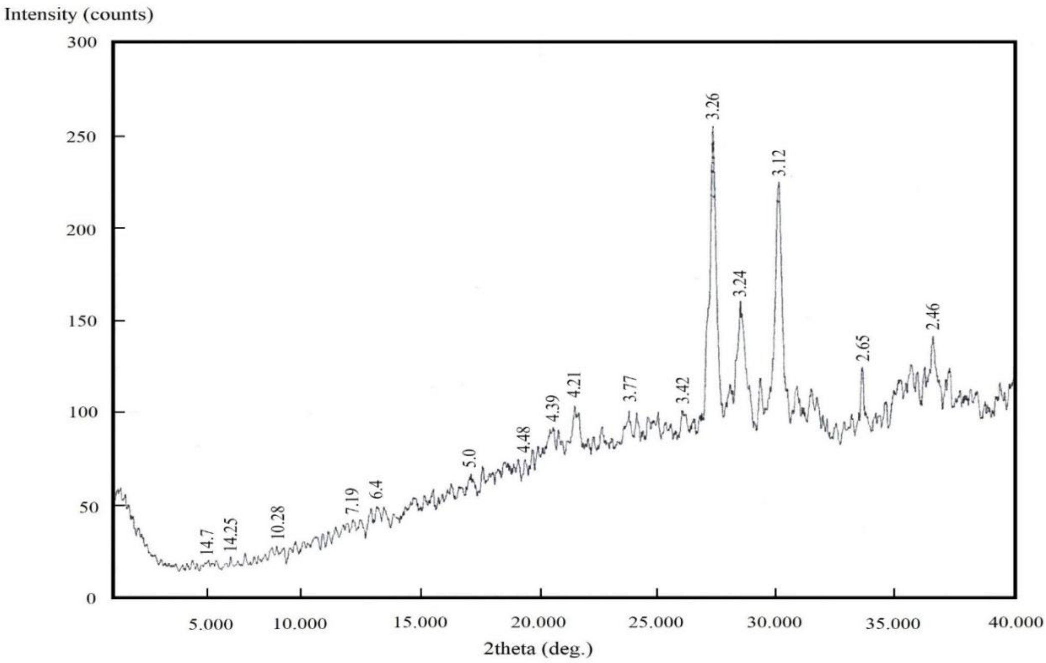

Figure (3) X-ray diffraction of the organic fertilization treatment (7.5 tons. ha^{-1}) after the physiological maturity of the crop

In general, we notice from Figure (3) the decrease in X-ray diffraction intensity for clay minerals, which confirms the effect of plant roots in these mineral transformations and the effect on the quality and quantities of clay minerals on one handand the organic fertilization not supplying the appropriate quantities of potassium to keep the minerals from the changes on the other hand and this agrees with (17) that differences in the mineral composition between the area of the rhizosphere and the soil outside it (bulk soil) are due to plant secretions.While (18) stated that organic acids play an important role in the mineralization of soil through at least three mechanics, the first one is the effect on the saturation state for mineral solutions and the second mechanism is to form complexes with positive ions on the surface of the mineral or to reduce the pH of the solution which changes the melting rate away from equilibrium, while the third mechanism is the effect of mineral melting rates due to the change in the behavior and efficiency of some ions in the solution such as aluminum.

Therefore, we find that mineral fertilization reduced the mineral changes, in contrast to organic fertilization, which led to mineral changes and transformations, especially Illite mineral, as a result of potassium depletion.

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