USE OF ORGANIC MATTER AND SAND IN IMPROVING PROPERTIES OF SOME SOILS OF HOLY KARBALA GOVERNORATE AFFECTED BY PHENOMENON OF CRACKING

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ABSTRACT

This study was conducted to show the effect of cows' manure, date palm residues, sand fraction and the interactions between them in treating the common cracking phenomenon in some soils of holy karbala governorate, and their role in improving some of the physical characteristics of those soils, represented in soil aggregates stability, modules of rupture, and linear expansion coefficient.Two agricultural sites were selected whose soils are characterized by heavy clay textures and widespread of cracking phenomenon within the holy Karbala governorate, the first was in Al-Kamaliya area and the second in Al-Khairat area. The results, showed a decrease in number of cracked masses, and their sizes in both studied soils. with an increase in levels of addition of animal manure, and plant residues and sand,and reached to lowest in treatments in which cracks disappeared while the highest values of mean weight diameter were reached in the treatments in which cracks disappeared for the soil of two study sites. Results showed that the decreased values of modules of rupture and linear expansion coefficient of soil with increasing the rates of addition and reaching to the lowest values in the treatments in which cracks disappeared compared to reference treatment.

Key words: soil cracking, palm residues, cows' manure, sand particales, morphological properties.
***Part of Ph.D. Dissevtation of the 1st author.**

استخدام الماده العضويه والرمل في تحسين خصائص بعض ترب كربلاء المقدسه المتأثره بظاهرة التشقق

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المستخلص

أجريت الدراسة لبيان تاثير مخلفات الابقار ومخلفات النخيل ودقائق مفصول الرمل وتداخلاتهما في معالجة حالة التشقق السائدة في بعض ترب كربلاء المقدسة ودورها في تحسين بعض الصفات الفيزيائية لتلك الترب والمتمثلة بثباتية التجمعات ومعامل الكسر ومعامل التمدد الخطي. تم إختيار موقعيين زراعيين تمتاز تربتيهما بنسجة طينية ثقيلة وبانتشار ظاهرة التشقق بشكل واسع ضمن محافظة كربلاء المقدسة، الاول في منطقة الكمالية والثاني في منطقة الخيرات. أظهرت النتائج فيما يخص الخصائص الشكلية للكتل المتشققة تناقص اعداد الكتل المتشققة وأحجامها لترب موقعي الدراسة بزيادة مستويات الاضافة للمخلفات الحيوانية والنباتية والرمل ووصلت الى اقلها في المعاملات التي اختفت فيها التشققات، واعلاها في معاملات عدم الاضافة (المقارنة) وكان هنالك تناسب عكسي بين أعداد الكتل واحجامها. وكذلك حصل تناقص في سمك الجزء الصلب من الكتل المتشققة وعرض الشقوق وعمقها والذي تناسب مع سمك الكتل المتشققة مع زيادة الاضافة وحصل الاختفاء التام للتشققات في مستويات الاضافة المتوسطة والعالية للمخلفات النباتية والحيوانية والرمل. وكان تاثير الاضافات بشكل عام اكبر في تربة موقع الخيرات مقارنة بتربة موقع الكمالية وعزي سبب ذلك لزيادة المحتوى الطيني فيها. وأشارت النتائج الى أرتفاع معدلات القطر الموزون لتربتي موقع الدراسة بزيادة الاضافات للمخلفات الحيوانية والنباتية والرمل مما يشيرالى زيادة ثباتية تجمعات التربة وتحسن بنائها، إذ يعد معدل القطر الموزون أحد أهم مؤشرات بناء التربة، وبلغت أعلى قيم لمعدل القطر الموزون عند المعاملات التي اختفت فيها التشققات لترب موقعي الدراسة. كماأظهرت النتائج إنخفاض قيم معامل الكسر ومعامل التمدد الخطي لتربتي موقعي الدراسة بزيادة معدلات الاضافة وبلغت أقل القيم لهما عند المعاملات التي اختفت فيها التشققات قياسا بمعاملة المقارنة.

الكلمات المفتاحية: تشقق التربة، مخلفات النخيل، مخلفات الابقار، دقائق الرمل، الخصائص الشكلية

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INTRODUCTION

Soil cracking phenomenon is one of the morphological phenomena prevalent in fine texture soils containing expanded clay minerals of a type 2: 1 such as smectite minerals, and it is considered an unwanted surface manifestation of agricultural soils and widespread in many soils of countries with semi-arid, tropical and temperate climates, including sedimentary plain soils. The formation and spread of cracks in the soil is a natural process resulting from droughts resulting from seasonal environmental changes, with alternating periods of drying and wetting. During dry periods, the soil shrinks and forms cracks. The presence of cracks in the soil affects its mechanical and hydraulic properties, reduces soil resistance and increases the rate water infiltration in soil (17).This phenomenon prevails in expanded clay soils developed from the parent material rich in Calcium and Magnesium, with an active and expanding clay content, and low drainage of water in the soil, as the high content of expanded clay minerals of the type 2: 1 leads to an increase in the volume of the soil when moistering, due to the entry of water inside the structures. The crystallinity of minerals, which makes the soil plastic and sticky, shrinks strongly when dry, causing surface cracks (13). Therefore, tillage and the lack of vegetation cover or residues expose the soil to more drought and increase the problem, and cause major problems for proper water management in practices Agricultural (23) One of the most important means to improve the properties of these soils is to add organic wastes. Waste leads to change or improvement of some physical or chemical properties of the soil, and at the same time it may be a source of compost that adds some important nutrients to the plant. The products of decomposition of these wastes lead to linking the initial soil particles together, improving its construction, increasing its porosity and its aeration, so the importance of adding these residues in soils affected by cracks is to increase the soil's ability to retain water for a longer period and thus reduce soil shrinkage when drought (reducing the formation of cracks).Adding organic residues to soil increases the stability of the aggregates, given the great role of organic matter in the formation of carnivorous materials due to microbial decomposition and its decomposition products from polysaccharides and various organic acids, which work side by side with cations with multiple charges such as Ca^{2+} and Mg^{2+}, which work to aggregate soil by sticking the particles together and increasing the stability of the clusters (10 ، 2). As well as the role of gelatin-like glues by binding the clay sheets together and with the particles of clay and silts, in addition to the role of organic matter in coating soil particles and reducing the speed of their wetting (7). Research has found that mixing an inert, non-expanding material, such as sand, with expanded soil is one of the ways to physically alter these soils and reduce the damage caused by their expansion (27). The sand reduces the fracture coefficient and reduces the expansion coefficient of the soil, thus reducing the hardness of the surface crust and facilitating seedling emergence. In view of the urgent need to address the common cracking problem in some of the holy Karbala soils and its negative effects on the growth and production of crops, so the current study came to know the effect of adding plant, animal residues, sand and the interaction between them in addressing this problem. This study aimed to improve the physical properties of studied soils by adding plant, animal residues and sand to improve soil structure and reduce its expansion and contraction to address the cracking phenomenon in the soil.

MATERIALS AND METHODS

Two agriculturial sites were selected for this study their soils characterized by a heavy clay texture and a widespread of cracking phenomenon. Sites were located in holy province of Karbala. The first site was located in Al-Kamaliya area - Al-Hur district, and the second site was in Al-Khairat area - Al-Hindiya district. Soils of two sites were classified as Typic-Torrifluvent soils (30) Soil mass samples were taken from both sites, at different depths, according to the thickness of masses. The surface crust (Hard part) of cracking masses has taken first, then the lower part (Fragile part) of soil masses. Soil samples were stored in polyethylene bags to preparation for subsequent laboratory analysis.The collected soil samples were transferred to the laboratory, air dried, crashed, and passed through a sieve of 2mm. Then, chemical, physical and mineralogical analyzes were performed on them. (Tables 1 and 2).

Table 1. Some chemical properties of the two studied soils

Measured adjective	Measuring unit	Sample site			
		Al-Kamaliya		Al-Khairat	
		hard	fragile	hard	fragile
EC 1:1	dS m^{-1}	6.26	4.11	6.77	6.18
pH 1:1		7.34	7.51	7.44	7.58
Ca^{+2}		1.40	1.17	1.46	1.49
Mg^{+2}		1.12	0.60	1.37	1.20
K^{+}	Cmol L^{-1}	0.41	0.23	0.21	0.25
Na^{+}		0.82	0.37	0.41	0.39
HCO_3^{-}		0.12	0.1	0.11	0.1
$SO4^{-2}$		0.68	0.60	0.62	0.60
Cl^{-}		5.28	2.63	1.83	1.52
CEC	Cmol + kg^{-1}	22.3	20.5	23.7	21.6
Total carbonate	gm kg^{-1}	350.0	335.2	355.0	340.3
Active carbonate	$gmkg^{-1}$	130.4	102.2	133.3	109.8
Total iron oxides	$gmkg^{-1}$	7.18	7.18	7.18	7.18
OM	$gmkg^{-1}$	0.78	0.76	0.74	0.81
SAR	$(mmolL^{-1})^{1/2}$	1.15	0.62	0.54	0.53

Table 2. Some physical properties of the two studied soils

Sample site	$gmkg^{-1}$			Texture	pw	Bulk density Mg m^{-3}	Hydraulic Conductivity cmh^{1-}
	sand	silt	clay				
Al-Kamaliya - hard	270	380	450	Clay loam	30.4	1.58	0.146
Al-Kamaliya - Fragile	150	440	438	Silty clay	33.6	1.47	4.210
Al-Khairat- hard	200	200	600	clay	41.8	1.67	0.135
Al-Khairat- Fragile	170	290	540	clay	45.2	1.60	3.126

Two field experiments were carried out at the two aforementioned sites. The start of their implementation was early November of 2019 until the beginning of May 2020, to see the effect of three levels of animal waste (Cows' manure), and three levels of plant residues (palm residue) at levels of (0%, 2%, 4%), and three levels of sand fraction are (0%, 5%,10%) with their interactions in the morphological, physical, chemical, and mineralolgical characteristics of cracks and causing the cracking phenomenon in those soils, and to determine the effectiveness of these treatments in treating this phenomenon, the field experiment was designed statistically according to the randomized complete block design, each field was divided into three blocks and the distance between one block and another was 2 m. Each block included 27 transactions, thus the number of experimental units became 81 experimental units for each experiment. The area of the pilot unit was 6 m^2 (2 x 3m) with 2m left for the irrigation canal. The were three experiment factors, included the first (A) adding animal wastes(Cows' manure) at three levels (0%,2%, 4%), and the second factor (B) adding plant wastes (palm residues) with a medium degree of decomposition at three levels (0%, 2%,4%),while the third factor (C)was included adding of sand fraction, with three level as well (0%,5%,10%).Thus, the experiment treatments are as listed in the table3. Eeah treatment was mix well with soil to the depth of 15-20 cm, The method of tourist irrigation with river water was adopted, moisture close to the field capacity was maintained throughout the duration of the experiment, by using the moisture tension curve for both soils and left for 6 months.After the end of the experiment, some measurements were made. Morphology of cracked masses and an area of square meters. Measurements were included (width of cracks, depth of cracks, number of cracked units, thickness of cracked masses, thickness of hard part, weight of cracked masses, perimeter of cracked masses, shape of cracked masses).The square meter wooden was used to determine selected areas for the aforementioned measurements, and the use of a metal ruler to determine the depth of cracks,

and a metal tape measure to limit. Some physical characteristics were measured, including: stability of soil aggregates, linear expansion coefficient, and modules of rupture, in order to determine the effect of animal, plant residues and sand with their interactions on treating the phenomenon of cracking and determine the best treatments used for processing. After carefully crushing the soil samples by hand at an appropriate moisture content to maintain the natural order of the assemblies, the crushed samples were sieved using two sieves, the first with holes diameter of 9 mm, and the second with holes diameter of 4 mm. The granules with diameters 4-9 mm were dried under laboratory conditions. 25 g of these granules were taken and placed on top of a group of sieves with aperture diameters of 4.75, 2.36, 1.00, 0.50 and 0.25 mm and moistened from the bottom by capillary action for six minutes and the sieving process was carried out using Yoder device for another six minutes at a speed of 30 revolutions per minute . Then the contents of each of the aforementioned sieves were transferred to a moisture tray and dried in an oven at a temperature of 105°C. Mean weight diameter was calculated according to method proposed by (34). Modulus of rupture for the rectangular soil briquette was calculated according to (29)by Eqution:

$S=\frac{3FL}{2bd2}$ where:

S = modulus of rupture (kPa),

F = breaking force applied at center of briquette beam span (kN),

L = distance between the two briquette supports (m),

b = width of briquette (m), and

d = depth or thickness of briquette (m)

Coefficient Liner Expantion: Estimated according to the method given in (18) Using Law:

COLE = (Lm-Ld)/Ld

Since:

Lm: The length of the wet form at 1/3 bar tension

Ld: is the length of the dry form at 105°C

Table 3. Field experiments treatments

Treatment	A Cows' manure%	B Palm residues%	C Sand%
T1	**0**	**0**	**0**
T2	**2**	**2**	**0**
T3	**4**	**4**	**0**
T4	**0**	**0**	**5**
T5	**2**	**2**	**5**
T6	**4**	**4**	**5**
T7	**0**	**0**	**10**
T8	**2**	**2**	**10**
T9	**4**	**4**	**10**
T10	**2**	**0**	**5**
T11	**4**	**0**	**10**
T12	**0**	**2**	**0**
T13	**4**	**2**	**10**
T14	**0**	**4**	**0**
T15	**2**	**4**	**5**
T16	**0**	**2**	**5**
T17	**0**	**4**	**10**
T18	**2**	**0**	**0**
T19	**2**	**4**	**10**
T20	**4**	**0**	**0**
T21	**4**	**2**	**5**
T22	**4**	**2**	**0**
T23	**2**	**4**	**0**
T24	**4**	**0**	**5**
T25	**0**	**4**	**5**
T26	**2**	**0**	**10**
T27	**0**	**2**	**10**

RESULTS AND DISCUSSION

Morphological Features of cracked masses:

Number of cracked masses

Cows' manure and interaction between palm residues and sand had a clear effect in reducing number of cracked masses per square meter, also number of masses decreased by increasing added amount of cows' manure, palm and sand, in both soils, where highest number of masses reached (35-75) per square meter in comparison treatment for Al-Khairat and Al-Kamaliya soils respectively, and number of masses decreased until reached (0) for the treatments (T8, T13, T17, T19, T21, T26) (Fig. 2) within soil of Al-Khairat site, and the treatments (T13, T19, T21) within soil of Al-Kamaliya site,(Fig.1) which were the best treatments, As the cracks disappeared completely.This effect was more pronounced within the soils of Al-Khairat site compared to the soil of Al-Kamaliya site, although their numbers within soil of Al-Khairat in general were higher, This variation in the numbers of cracked masses within the soil of the two sites may be due to the small perimeter of the cracked masses formed within soil of Al-Khairat site compared to soil of Al-Kamaliya site , as there is an inverse proportion between perimeter of the masses and their number for same measured area (6). The reason for the decrease in the number of masses may also be due to the high content of clay particles in the soil of Al- Khairat site compared to the soil of Al-Kemaliya site. The clay and the presence of organic matter increases the binding of soil particles the formation of aggregates, thus reducing the size and number of cracked masses, as the organic matter works to bind the particles physically and chemically. These results are consistent with results of (21) that the addition of organic waste to cracked clay soils reduced the number of cracked masses. The effect of sand here comes through reducing the percentage of clay particles in the soil and reducing the expansion properties on the one hand.(32) concluded that reducing the content of clay particles led to a reduction in the plasticity coefficient of soil after an increasing number of wetting and drying cycles, on an other hand, adding more sand fraction will lead to increased porosity, provision of air conditions and increased activity of soil microorganisms, which in turn is reflected in increased decomposition of organic matter, thus increasing the binding of soil particles and the formation of fixed aggregates that contribute to reducing cracking, as many studies have shown (12,31), that increasing the percentage of clay in the soil reduces the porosity, which leads to the predominance of anaerobic conditions, and this will inevitably be reflected in the types and numbers of microorganisms prevailing in them on one hand, on an other hand, increasing the content of clay in soil causes adsorption of many organic materials, and thus decomposition of the organic matter added to soil decreases, in addition to the adsorption of enzymes secreted by the organisms on the surfaces of clay minerals and colloids, thus reducing the speed of biological activities.

Perimeter of cracked masses

The results of tables 4 and 5 showed the existence of an inverse relationship between the number of cracked masses and their perimeter also, results showed that the perimeter of the cracked masses within Al-Kemaliya soil site exceeded the perimeter of the masses in the soil of Al-Khairat site, so the increasing of clay content leads to an increase volumetric shrinkage, plasticity index, and thus a reduction in the size of masses (3). Also, increasing content of clay particles with a large surface area and high exchange capacity can adsorbed humic materials on their surfaces and increase stability of the aggregates to a greater degree comparing to the soils have low content of these minerals (16, 24). The results also showed that increase in width and depth of cracks is accompanied by an increase in size of masses, and this was evident in the soil of AL- Kemaliya site Al-Khairat site, so increasing of clay content leads to an increase volumetric shrinkage, plasticity index, and thus a reduction in the size of masses (3). Also, increasing content of clay particles with a large surface area and high exchange capacity can adsorbed humic materials on their surfaces and increase stability of the aggregates to a greater degree comparing to the soils have low content of these minerals (16, 24). The results also showed that increase in width and depth of cracks is accompanied by an increase in size of masses, and this was evident in the soil of AL- Kemaliya site.Also the increased levels of addition of cows' manure, palm residues and sand

caused to decreased the perimeter of masses in the study soils. This is due to the role of waste in increasing the organic matter, which works to increase the binding of soil particles, as well as the role of sand in reducing the bulk density and forming weak areas between masses that facilitate the separation and thus reduce the perimeter of masses, where the highest of perimeter reached (78 and 47 cm) in soil of AL- Kemaliya and Al-Khairat respectively, at treatment of (T1) and lowest perimeter of masses reached (0) with same treatments that disappeared of cracks mentioned previously. The reason for this may be due to the significant effect of the decomposition of the added organic waste, and its role in improving the soil structure and formation of soil aggregates, through its act as binders for the clay particles through their functional groups such as hydroxyl, carboxylic groups, which work to increase the stability of aggregates and formation of new soil aggregates, As their degradation results in viscous gels that work on bonding soil particles to each other, and this is consistent with findings of many studies (1 8) that adding natural and synthetic enhancers is one of means used to reduce cracking,and improves the physical and chemical properties of soils, as soil conditioners from different sources to improving the soil structure.

Table.4 Morphological characteristics of masses for the field experiment after incubation of Al-Khairat Soils

Treatment	Average number of masses (m^2)	The average width of the cracks (cm)	The average depth of the cracks (cm)	The average thickness of the masses (cm)	The average thickness of the hard part	Average weight of masses (kg)	The average circumference of the masses (cm)
T1	**75**	**1.20**	**5.25**	**8.00**	**4.5**	**4.49**	**49.00**
T2	**50**	**1.00**	**4.50**	**6.00**	**1.50**	**1.14**	**30.00**
T3	**38**	**0.90**	**1.60**	**2.00**	**0.65**	**0.11**	**18.00**
T4	**35**	**0.80**	**2.83**	**1.75**	**2.55**	**1.26**	**27.00**
T5	**70**	**1.05**	**4.00**	**5.50**	**1.00**	**0.93**	**41.00**
T6	**22**	**1.25**	**2.90**	**3.75**	**0.50**	**0.42**	**40.00**
T7	**41**	**1.05**	**5.53**	**5.00**	**2.30**	**0.80**	**36.00**
T8	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T9	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T10	**26**	**0.70**	**0.60**	**2.00**	**2.05**	**0.02**	**20.00**
T11	**60**	**0.70**	**1.65**	**5.50**	**0.81**	**0.48**	**36.00**
T12	**40**	**1.15**	**1.20**	**4.20**	**2.20**	**0.92**	**36.00**
T13	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T14	**50**	**0.60**	**1.10**	**4.00**	**1.40**	**0.15**	**17.00**
T15	**22**	**0.90**	**2.00**	**4.50**	**0.85**	**0.05**	**47.00**
T16	**52**	**0.75**	**1.60**	**2.50**	**2.00**	**0.06**	**19.00**
T17	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T18	**38**	**0.85**	**1.05**	**6.50**	**2.25**	**0.87**	**31.00**
T19	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T20	**65**	**0.95**	**2.25**	**4.50**	**1.12**	**0.31**	**28.00**
T21	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T22	**42**	**1.20**	**5.00**	**4.00**	**1.30**	**0.70**	**17.00**
T23	**50**	**1.20**	**7.00**	**6.00**	**1.20**	**1.15**	**30.67**
T24	**35**	**0.55**	**0.55**	**2.00**	**0.50**	**0.02**	**19.00**
T25	**45**	**0.65**	**1.50**	**2.00**	**1.02**	**0.04**	**31.00**
T26	**0**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
T27	**68**	**1.25**	**2.40**	**1.50**	**1.37**	**1.30**	**32.00**
$LSD_{0.05}$	**9.94**	**0.72**	**2.74**	**2.20**	**0.45**	**0.43**	**6.93**

Table.5 Morphological characteristics of masses for the field experiment after incubation of Al-Kemalia Soil

Treatment	Average number of masses (m^2)	The average width of the cracks (cm)	The average depth of the cracks (cm)	The average thickness of the masses(cm)	The average thickness of the hard part(cm)	Average weight of masses (kg)	The average circumference of the masses (cm)
T1	35	1.30	10.00	9.00	5.00	9.60	80.00
T2	28	0.85	6.00	8.50	2.00	4.65	72.00
T3	24	0.95	4.00	9.00	2.50	2.53	76.00
T4	20	0.90	5.00	4.50	1.00	8.19	64.00
T5	28	0.60	1.00	7.50	2.50	4.45	60.00
T6	20	0.55	1.60	7.50	1.50	1.27	53.00
T7	28	0.70	4.10	6.50	1.33	4.11	51.00
T8	27	0.40	2.50	5.50	2.00	2.20	64.00
T9	26	0.45	2.33	3.50	1.50	1.16	50.00
T10	23	0.80	3.35	8.00	3.00	4.85	45.00
T11	21	0.80	2.00	5.50	1.25	2.80	77.00
T12	20	1.00	1.80	7.50	0.50	6.79	64.00
T13	0	0	0.00	0.00	0.00	0.00	0.00
T14	17	0.90	1.90	6.50	2.40	3.66	78.00
T15	20	1.00	2.10	7.50	2.50	1.10	77.00
T16	21	0.60	4.50	7.50	0.00	4.56	58.00
T17	24	0.60	3.00	8.50	2.00	4.59	55.00
T18	20	1.00	4.80	9.00	1.50	5.78	70.00
T19	0	0.00	0.00	0.00	0.00	0.00	0.00
T20	20	0.65	2.10	8.00	1.50	3.28	65.00
T21	0	0.00	0.00	0.00	0.00	0.00	0.00
T22	26	0.90	5.50	9.00	2.50	3.55	52.00
T23	25	0.80	2.10	7.00	2.25	3.21	65.00
T24	20	0.60	3.00	6.50	2.00	2.63	45.00
T25	19	0.30	2.75	7.00	1.75	5.39	62.00
T26	25	0.90	3.00	8.50	2.50	2.25	60.00
T27	27	1.05	2.50	9.00	2.75	2.56	46.00
$LSD_{0.05}$	6.21	0.49	2.08	3.36	0.99	1.85	10.09

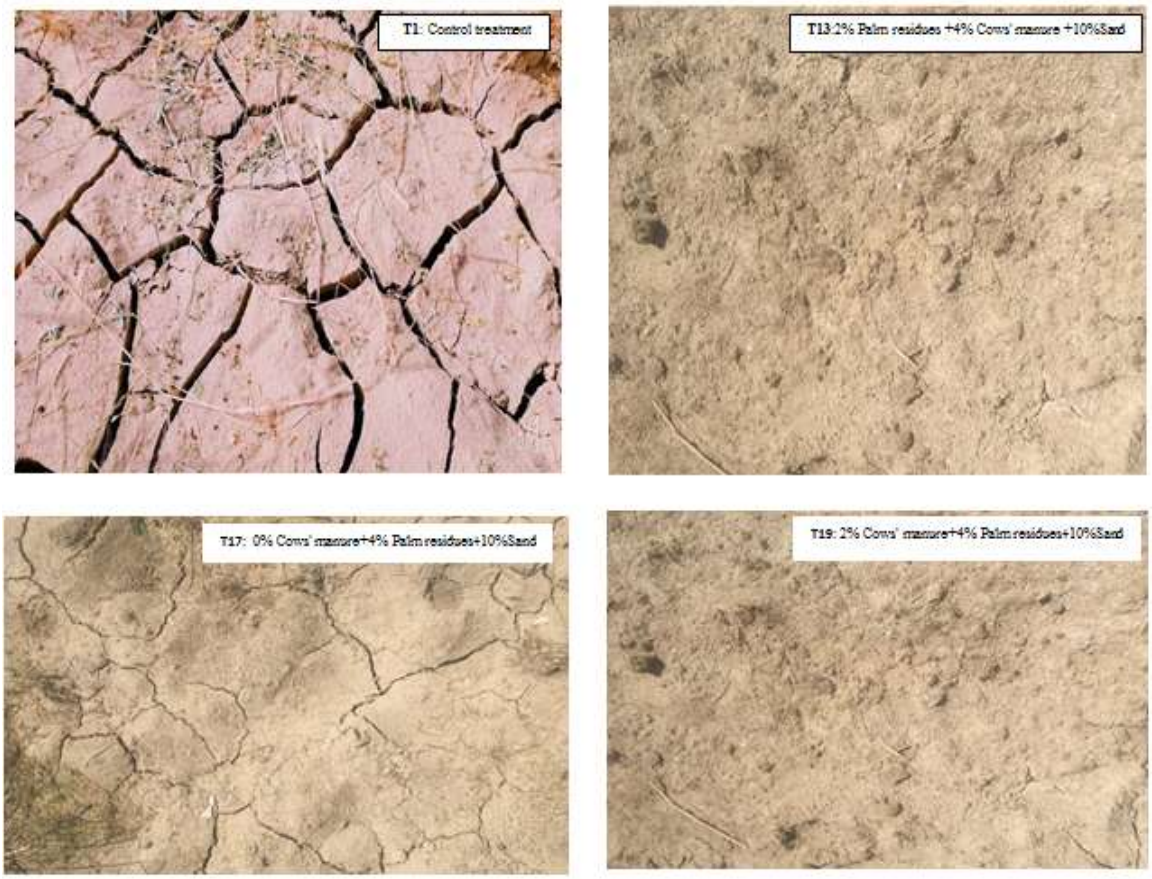

Fig 1. Some pictures of Al- Kemalia treatments

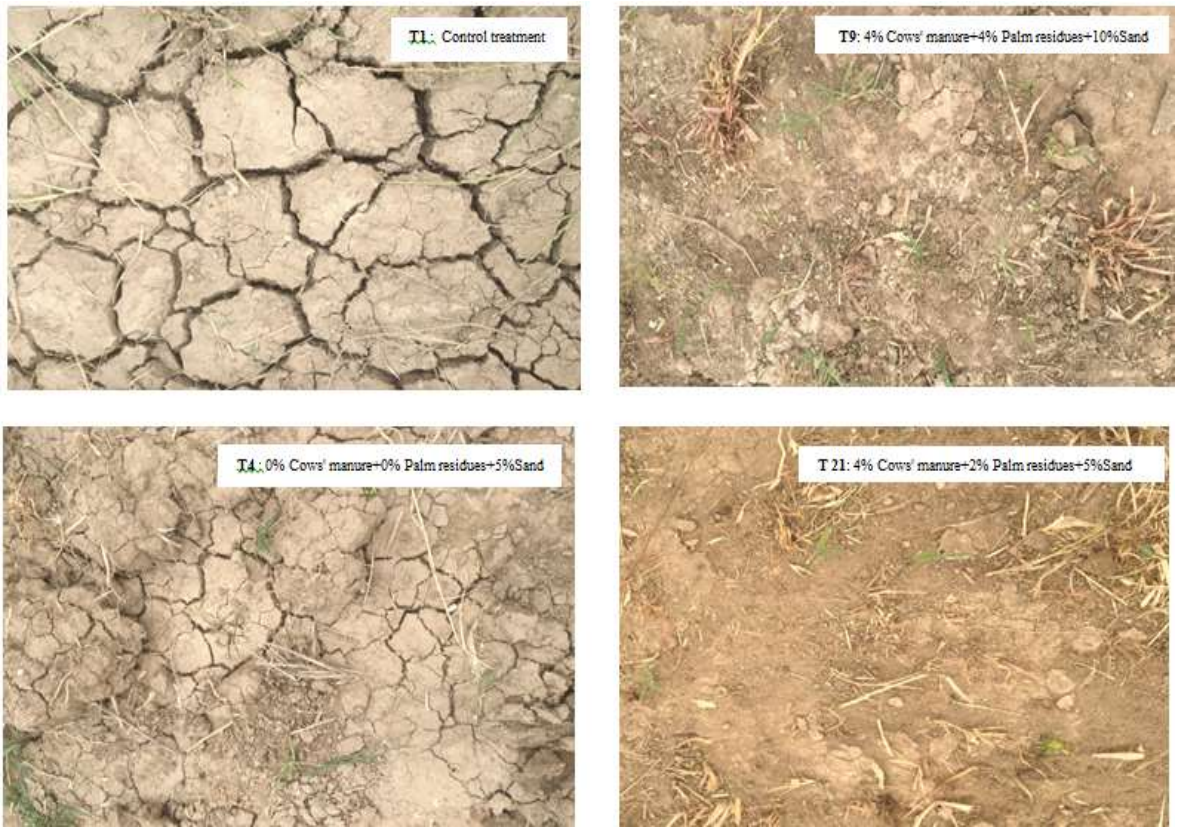

Fig 2. Some pictures of Al-Kl-Kairat treatments

Weight of the cracked masses

The results of tables 4 and 5 showed that there is a clear effect of sand fraction, cows' manure and palm residues in reducing the weight of the cracked masses while the effect of sand was higher, as well as the duo interaction between cows' manure and sand, palm residues and sand, or the triple interaction between residues and sand, was significantly in the effected on the weight of the masses in the soil of Al-Khairat site. Also the maximum weight of the masses reached 4.49 kg in the comparison treatment (T1), followed by the addition of 5% sand in treatment (T4), it reduced to 1.45 kg, while the minimum weight of the cracked masses was (0) when treatments in which cracks disappeared(T8, T13,T17,T19,T21). The effects were significant in the soil of Al-Khairat soil but lesser degree than that of Al-Kemalia which was in general, greater all the treatments where the highest average weight of the masses was 9.60 kg for the comparison treatment (T1), followed by the 5% addition treatment of sand fraction (T4 treatment) it reached to 8.19 kg where the lowest average weight of the masses (0) in treatments (T13, T19, T21) which the cracks disappeared, so according to what we believe that the reason for this discrepancy in the weights of the cracked masses in the two soil of the study is due to the conditions of their formation and Agricultural exploitation, which affects the redistribution of moisture as a result of the wetting and drying cycles associated with irrigation operations. Likewise, the reason may be due to the increase in the content the expanding clay minerals 2: 1 (smectite) and at the expense of the illite mineral in Al-Kemalia soil, which led to an increase in the volumetric expansion and shrinking, which in turn led to an increase in the plasticity index in the soil of AL- Kemaliya site compared to the soil of the Al- Khayrat site.consistent with the findings of (3,4,25) that soils with higher clay content and containing smectite minerals, had higher volumetric shrinkage than those that contained higher percentages of illite minerals.

Thickness of masses and hard part

The thickness of masses, mean the pieces of soil that are separated from each other by cracks and which intersect with each other. Results of tables 4 and 5 showed that adding sand fraction within treatments used in current study, and interaction treatments between sand and animal and plant wastes all led to reduction in the thickness of the cracked masses, but with different proportions while the triple interaction (sand +cows 'manure + plant residues) and interaction the sand with palm residues were the least of the effect, and in general it was noticed that the increase in addition of sand particles and waste of both types led to a decrease in thickness of the cracked masses in all

treatments, where maximum thickness was (8) cm for the comparison treatment (T1), followed by the treatment (T18), in which the thickness of the masses reached to (6.5) cm. Down to minimum thickness of masses (0) at the treatments (T8, T9, T13, T17,T19, T21), (Fig.2) which then disappeared the cracks.Thickness of the hard part, was decreased with the increase in the levels of addition of residues and sand, as the residues and sand and their interactions had a clear effect on reducing the thickness of the hard part, where the highest thickness of the hard part reached (4.50) cm in comparision treatment (T1), while it reached to (0) when the cracks have disappeared (T8, T9, T13, T17, T19, T21). These results are in agreement with the findings (11) that adding residues reduces thickness of the surface crust of craked masses. while the thickness of the cracked masses in soil of Al- Kemaliya site, showed a clear effect of adding palm residues, cow's manure and sand, or for the triple interaction of the added treatments (palm residues, cows' manure, sand) in reducing the thickness of the cracked masses, while the due interaction was not shown for each cows and palm residues with sand. The highest thickness of the cracked masses was (9) cm in the comparison treatment (T1), while the lowest (0) cm appeared in the treatments (T13, T19, T21) in which cracks disappeared. The reason for decrease in thickness of cracked masses may be due to the reduction of the plasticity index, which is the main goal of stabilizing the expanding soil, as a result of the addition of sand particles and residues, which worked to reduce the clay content, since increasing the clay content leads to a higher plasticity index (20), as coarse particles of sand and residues reduce number of bonds between clay particles, and increase them between sand particles and residues, which leads to a reduction in development of cracks. As for the thickness of hard part of soil of Al- Kamalia site, the cows' manure, palm residues and sand had a clear effect, by reducing thickness of hard part, the interaction between cows' manure and palm residues, as well as the interaction between palm residues and sand, and the triple interaction between waste and sand, had a significant effect by reducing thickness of cracked masses, but the interaction between sand and palm residues was not significant, and reached the highest thickness of hard part (5 cm) in comparison treatment (T1), and the lowest (0) in treatments (T13, T19, T21) (Fig.1) in which cracks disappeared. This may be due to the lower clay content when adding sand mixtures. The greater sand content in mixture reduces the swelling capacity and pressure on one hand, and on other hand the space between sand grains adsorbs much of this swelling. When the sand fraction is coarser, these voids become larger, which leads to a decrease in swelling amplitude. Mixing technique can also provide a better distribution of clay particles in voids created in the mixture, thus reducing the number of bonds between particles of clay and increase typical bonds between sand grains, clay particles, and organic matter, thus reducing size of masses and the disappearance of cracks by increasing levels of addition. These results are consistent with the findings of (5,19) who concluded that adding organic waste and sand to soil leads to increase water retention, reduce crack size and delay their appearance.

Depth and width of the cracks

Results of tables 4 and 5 regarding measurements of depth and width of cracks of Al- Kemaliya site showed that there is a high effect of palm residues and sand in reducing depth of cracks, and Cows' manure and their interaction with palm residues as well as the interaction between Cows' manure, palms and sand had a high effect by reducing depth of the cracks. Highest value of crack depth was (10) cm at the reference treatment (T1), followed by an addition of 2% cows manure + 2% palm residue (T2), reaching (6) cm, and lowest value of crack depth was (0) at treatments of (T13, T19, T21), (Fig. 1) in which the cracks disappeared. As for width of cracks, sand had a clear effect in reducing the width of cracks, followed by the addition of cows manure, and the palm residue and interaction between palm and cows' manure, and interaction between cows' manure, palm residue and sand had a significant effect by reducing width of cracks, and there was no significant effect of interaction between cows' or palm waste with sand by influencing width of cracks, where minimum width of the cracks was (0) at the same treatments in which the cracks disappeared and highest width of the cracks was found in treatment of (T1) and reached 1.3 cm,. These effects are due to the role of residues in binding soil particles and increasing their aggregation, making the cracks narrow and shallow (26).These results are consistent with the findings of (19) when different levels of plant residues were added, ranging from 1 -20% to mixed with clay soil, where the addition reduced width of

cracks as a result of reducing plasticity index, and the effect was less in the levels that increased. About 2% was attributed to the reduction of the clay particles content. Results are also consistent with the findings of (14) that mixing organic fertilizer with crop residues increases the stability of the silty clay soil structure, and reduces the formation of wide cracks due to the increase in the organic matter content and the stability of the aggregates in addition to the microbial activities. As for the depth of cracks in soil of Al-Khairat site, adding sand and interaction with palm residues had a clear effect in reducing the depth of cracks, and the interaction between palm or cows' manure with sand or the interaction between Cows' manure, palms residues and sand had a significant effect by reducing width of cracks, but there is not a significant effect in depth of cracks when adding cow manures or palms residues alone. Maximum depth of cracks was (7) cm when adding 2% palms residues + 4% cows' manure (T23) and minimum crack depth was at (T8, T9, T13, T17, T19,T21, T26)in which the cracks disappeared. As for the width of the cracks, it is noted from results that there is a significant effect of adding sand levels in width of cracks, and that there is a significant effect of interaction between cows' manure and palms residues or palms residues with sand, and there was no significant effect of adding palm residues or cows' manure or the triple interaction with sand in the width of cracks in soil. Maximum width of cracks was (1.25) cm at the two treatments (T6, T27), and lowest width of the cracks was (0) at same treatments mentioned above, at which cracks disappeared. By comparing soil of two sites, it appears that the effect of adding residues and sand in the depth of the cracks in the soil of the Al-Khairat site is higher than that of the soil of the Al-Kemalia site, while the effect on the width of cracks in soil of Al-Kamaliya site was greater than that of soil of Al-Khayrat site. The reason for this discrepancy may be the higher percentage of clay in the Al- Khayrat site than in Al-Kamaliya soil. These results agree with the findings of (19) when they added levels of 0%, 1% 2%, 5%, 10%, 15% and 20% of sawdust for cracked clay soils, which decreased. Width of the cracks ranged from 3mm to 0.1mm and led to a halt in the development of cracks and their transform- ation into a network of small cracks. It appears that width of cracks is proportional to their depth for both soils due to the effect of the type of clay and soil moisture that led to the difference in the plasticity of those soils (21).

Some physical characteristics of the two studied soils in field experiments

Soil Aggregate Stability: The mean weight diameter was used as an indication of the stability of soil aggregations, Results of table 6 regarding soil of Al-Khairat site were shown, that Cows' manure and palm residues and the interaction between them had a clear effect in increasing the mean weight diameter, and the sand had a significant effect by reducing the mean weight diameter and this was reflected in the interaction between each of palms or cows' manure with sand and on the triple interaction between sand, Cows' manure and palm residues, where the effects on the mean weight diameter were significant. Highest mean of weight diameter was (3.74) mm when adding 4% Cows' manure + 4% palm residues (T3) and the lowest mean of weight diameter (0.55) mm when treating addition was 10% sand (T8), this is due to the role of waste in the increasing percentage of organic matter in soil and by their products such as sugars, lignans and glues, which increase the formation of aggregates and increase their stability with water, to formation of complexes with clay minerals, and reduces soil water absorption and reduces the ability of soil particles to swell (7). It is evident in the treatments (T8, T9, T13,T17, T19, T21, T26)(Fig.2) in which the cracks disappeared where the mean weight diameter increased, and these results are consistent with the findings of (15)That increasing the content of organic matter in the soil increases the stability of soil aggregations, as well as the role of sand, which reduced the bulk density of its association with the organic matter resulting from residues, which increased the stability of soil aggregates, improved soil structure, and reduced thickness of hard part. In AL-Kemaliya soil, the results showed that the interaction between palms residues, cows' manure and sand, has taken the same approach affects the mean weight diameter of soil(3.17) mm at the treatment of (T3), and the mean weight diameters in the treatments in which the cracks disappeared were high comparing to the references treatment and reached to 2.23,2.24, 2.37 mm in the treatments of T19, T13, and T21 respectively, The reason for the differences in mean weight diameters in two study soils may be due to the high content of clay fractions in the soil of Al-Khairat site than in the soil of Al-Kemaliya site, as of Al-khairat site, except that the means weight diameter were less and for the same levels of addition, where the lowest mean of weight diameter was(0.23) mm at the

treatment of 10% sand (T7) and the maximum mean of the weight diameter was the mean weight diameter of the soil depends on the nature of added organic matter and the degree and speed of its decomposition by the action of microorganisms Long-term effect on organic matter also depends on the time required for the decomposition of those materials. In addition, increasing the content of both clay particales and organic matter in soil increases its water holding capacity, which provides suitable conditions for increasing microbiological activities. This helps increase both the rate of organic matter dicomposition and soil aggregates stability.(9) stated that the increase in the structure parameters in clay soils represented by the mean weight diameter is due to the increase the soil content of clay particles which has a high specific area and a high cation exchange capacity that enables it to adsorbed humic materials and then increase the stability of the Aggregate to a greater degree than soils with a low content of clay fraction because the clay acts as aggregate agent that binds soil particles, as well as increasing the soil content of organic matter. While organic matter improves soil structure due to its high content of organic carbon, which works to bind primary soil particles together to form more stable micro-aggregates, and these aggregates are linked with each other with residues of fungi and bacteria, which are hydrophobic compounds that reduce the rate of hydration. The bonding process increases to form macro-aggregates, which results in an increase in the stability of soil aggregates. These results are consistent with the findings of (33) that increasing levels of organic wastes led to an increase in the mean weight diameter compared to its non-use.

Table 6. Mean weight diameter, modules rupture and linear expansion coefficient of two study sites

Al-Khairat				Al-Kemaliya			
treatment	Mean weight diameter mm	Modules Rupture kPa	Linear expansion coefficient	treatment	Mean weight diameter mm	Modules Rupture kpa	Linear expansion coefficient
T1	**0.82**	**61.76**	**5.51**	**T1**	**0.52**	**50.90**	**3.47**
T2	**1.87**	**41.45**	**4.28**	**T2**	**1.57**	**31.45**	**2.50**
T3	**3.74**	**31.87**	**2.75**	**T22**	**2.48**	**27.02**	**1.75**
T4	**0.70**	**57.69**	**5.65**	**T11**	**0.35**	**27.34**	**3.75**
T5	**1.75**	**31.87**	**4.52**	**T25**	**1.44**	**30.63**	**2.85**
T6	**3.62**	**23.11**	**2.36**	**T6**	**3.12**	**13.04**	**1.26**
T7	**0.55**	**52.12**	**5.85**	**T7**	**0.23**	**42.09**	**4.15**
T8	**1.60**	**34.09**	**4.70**	**T8**	**1.30**	**24.09**	**2.96**
T9	**3.47**	**13.81**	**2.47**	**T9**	**3.05**	**11.23**	**1.36**
T10	**0.79**	**47.98**	**5.54**	**T10**	**0.48**	**37.94**	**3.53**
T11	**0.65**	**37.43**	**5.71**	**T4**	**0.40**	**47.65**	**3.79**
T12	**0.93**	**59.98**	**5.40**	**T12**	**0.64**	**49.78**	**3.37**
T13	**2.54**	**16.45**	**3.50**	**T13**	**2.24**	**12.45**	**1.94**
T14	**1.86**	**56.18**	**4.30**	**T14**	**1.38**	**36.18**	**2.55**
T15	**2.68**	**26.31**	**3.36**	**T3**	**3.17**	**21.78**	**1.94**
T16	**0.75**	**48.98**	**5.56**	**T16**	**0.44**	**38.95**	**3.55**
T17	**0.64**	**38.87**	**5.73**	**T17**	**0.33**	**28.78**	**3.84**
T18	**0.94**	**59.14**	**5.39**	**T18**	**0.65**	**49.14**	**3.35**
T19	**2.53**	**19.74**	**3.52**	**T19**	**2.23**	**14.71**	**1.96**
T20	**1.88**	**55.23**	**4.26**	**T20**	**1.58**	**45.44**	**2.48**
T21	**2.69**	**25.16**	**3.35**	**T15**	**2.38**	**16.30**	**1.84**
T22	**2.81**	**37.02**	**3.22**	**T23**	**2.47**	**25.20**	**1.77**
T23	**2.80**	**35.19**	**3.24**	**T21**	**2.37**	**15.16**	**1.82**
T24	**1.76**	**39.06**	**4.41**	**T5**	**1.45**	**21.78**	**2.80**
T25	**1.74**	**40.63**	**4.41**	**T24**	**1.46**	**29.04**	**2.63**
T26	**0.60**	**43.21**	**5.81**	**T27**	**0.28**	**34.64**	**3.87**
T27	**0.59**	**44.65**	**5.81**	**T26**	**0.29**	**33.23**	**3.85**
$LSD_{0.05}$	**0.27**	**2.35**	**0.29**	**$LSD_{0.05}$**	**0.25**	**2.26**	**0.37**

Modules Rupture

Results in Table 6 showed the values of the modules rupture for the tow study soils sites after conducting the transactions and field incubation. There were significant effects of cows' manure, palms residues and sand, the interaction between the residues and the interaction between cows' manure and sand in reducing the modules rupture

of the soil, and significant effects occurred in reducing the modules rupture for the interaction between palms residues and sand and the triple interaction of residues and sand, and the lowest modules rupture was 13.81kPa when the addition was treated 4% cows' manure +4% palms residues +10% sand (T9) and highest modules rupture was 61.76 kPa when treating no Addition (T1), and it appears that there is an inverse proportion to values of modules rupture with increasing levels of addition of residues and sand, due to the increase of the linking of soil particles and the formation of Aggregates and increase its stability, which leads to improved soil structure, decreased bulk density and increased porosity, which reduces the modules rupture and reduces the thickness of hard part. As for the soil of AL-Kemaliya site, the addition of sand, palms residues and cows' manure affected the modules rupture of soil and in the same direction insignificant effects, but the decrease in modules rupture rates was higher, with lowest modules rupture being 11.23 kPa from the treatment 4% cows' manure + 4% palms residues + 10% sand (T9) and highest modules rupture 50.90 kPa when no addition treatment (T1). This is due to high percentage of sand and silt and low percentage of clay in that soil compared to Al-Khairat soil, which was reflected in stability of its aggregates, and this was evident from observation that cracks disappeared with a smaller number of addition treatment compared to soil of Al Khairat site, and this was confirmed by (22) that modules rupture increases by increasing content of clay and silt in the soil, and decreases by increasing the sand fraction. These results are consistent with (21) who found that adding four levels of corn cops (0,20,10,30,40 gm.kg^{-1}soil) in cracked clay soil, where they noticed a decrease cracking by increasing the addition and its disappearance with high levels of addition, as well as an increase in the stability of the aggregates and the proportion of organic matter and a decrease in modules rupture values.

Linear expansion coefficient

Results of table 6 indicate that regarding the linear expansion coefficient of study soils, that for soil of Al-Khairat site there are high significant effects of adding levels of palm residues, Cows' manure and sand, as well as for interaction between animal and palm residues in the linear expansion coefficient, and there is also a significant effect of interference between sand and palms residues, sand, cows' manure, and triple interaction between sand, cows' manure, and palms residues. Highest average of the linear expansion coefficient was 5.85when treating the addition of 10% sand (T7), and lowest linear expansion coefficient 2.36 when treating the addition 4% animal waste 4% + plant waste + 5% sand (T6).Soil of Al- Kemaliya site was also taken the same trend in the effects of adding Cows' manure, palms residues and sand levels, on values of linear expansion coefficient of soil, and the highest average of the linear expansion coefficient 4.15 when treating the addition was 10% sand ((T7) and lowest linear expansion coefficient 1.26 when treating the addition 4 % cows' manure 4% + palms residues + 5% sand (T6). It appears that the linear expansion coefficient of all the soil treatments of Al-Kemaliya site was lower than the same levels of the soil treatments of Al- Khairat site, and the reason may be due to the difference of the two soil textures, where the expansion coefficient is for clay soil Al-Khairat are higher than the expansion coefficient of Al- Kemaliya soil, depending on difference in the content of clay fraction, as the addition of residues reduced the linear expansion coefficient, by reducing the effect of minerals responsible for the shirnking and swelling of the soil. Also the decomposition products of organic residues can reduces the swelling ability of the soil and thus reduces value of linear expansion coefficient (28). These results are consistent with the findings of (35) when adding different levels of organic residues to cracked clay soils, which led to a reduction of the linear expansion coefficient and shear modulus of the clay soil, which determined the expansion and shrinking of soil, and this was reflected in the reduction of soil cracking.

REFERENCES

1. Aati, A. S. 2004. Influence of Corn Cobs on Some Soil Properties. Ph.D. Dissertatin. College of Agriculture-University of Baghdad. pp: 62-89

2. Abdul Hamza. 2010. The Effect of Different Organic Residues on Some Soil Properties and Yellow Corn Yield, M.Sc. Thesis, College of Agriculture, University of Baghdad.pp:75-85

3. Albrecht, B. A. and C. H. Benson. 2001. Effect of desiccation on compacted natural clays. ASCE, J. of Geotech. and Geoenvir. Engrg. 127(1),67-75.

4. Al-Jaff.B.O. and S.K. Essa. 2020. Effect of plant coverage on mineralogical changes of mica in Rhizosphere. Iraqi Journal of Agricultural Sciences 51(1):493-499

5. Al-Naser, Y. H. 2018. Effect of phosphor gypsum on formation and development of soil surface crust and wheat crop growth. Tikrit Univ for Agric. Sci J., 18 (3).

6. Al-Nasser, Y. H.,and K. A. Al-Kalid .2020. The behavior and pattern of soil cracks and its management in vertisols .Mesopotamia .J. of Agric. 48 (2): 68-76

7. Al-Qaisi, H. and K. Hamid. 2001. The Effect of Some Humic Substances and Amino Acid Compounds of Various Organic Materials on Soil Construction. M.Sc. Thesis, Faculty of Agriculture - University of Baghdad.pp:78-83

8. Al-Sarraji, Ali J. K. 2006. A Profound Effect of Adding Fuel Oil on Some Physical Properties of Soil Tissues and Maize Growth. M.S. Thesis, Faculty of Agriculture, University of Baghdad.pp:66-72

9. Annabi, M., Y. Le Bissonnais, M. Le Villio-Poitrenaud and S. Houot. 2011. Improvement of soil aggregate stability by repeated applications of organic amendments to a cultivated silty loam soil Agriculture, Ecosystems and Environmen. 144 (1) 382-389

10. Assefa, B. A.,J.J.; Schoenau, J. J., and M. C. J. Grevers. 2004. Effects of four annual applications of manure on black chernozemic soils. Canadian Biosystems Engineering, 46(6), 39-46

11. Baumhardt, R. L.; P. W. Unger and T. H. Dao.2004**.** Seedbed surface geometry effect on soil crusting and seedling emergence. Am.Soc. Agron. J. 69: 1112-1117

12. Bianchi. S.R., M. Miyazawa., E.L. deoliveira., and.M.A. Pavan. 2008. Relationship between the mass of organic matter and carbon in the soil.Brazilian. Archives of Biology and Technology. 51 (2) pp:263-268. ISSN 15516-8913

13. Biassusi M,EA. Pauletto;S. Crestana. Estudo da deformação de um vertissolo por meio da tomografia computadorizada de dupla energia simultânea. Rev Bras Cienc Solo. 1999; 23:1-7. https: //doi.org/ 10.1590/S0100-06831999000100001

14. Borie, F., R. R. and A. Morales. 2008. Arbuscular mycorrhizal fungi and soil aggregation. J. Soil Sc. Plant Nutr. 8 (2): 9-18

15. Bouajila, K. and M.Sanaa.2011**.** Effects of organic amendments on soil physico-chemical andbiological properties. J. Mater. Environ. Sci. 2 (51), 485-490

16. Caravaca, F.,A.Lax and J. Albaladejo .1999. Organic Matter,nutrient countents and cation exchange capacity in fine fractions from semiarid calcareous .Geoderma :161-176

17. Chaudhary, R.S., J. Somasundaram; K.G. Mandal and K.M. Hati. 2018. Enhancing water and phosphorus use efficiency through moisture conservation practice sand optimum phosphoru application in rainfed maize- chickpea system in Vertisols of central India. Agric.Res. https: // doi.org/10.1007/s40003-018-0316-8

18. Dixon, J.B.; S.B. Weed; J.A.kittrick; M.H. Milford;J.L. White. 1977. Minerals insoil environments .Soil.Sci. Soc.AmericaMadison.Wisconsin, USA

19. Dinka, T.M. and R.J. Lascano. 2013. Atechnical Note: Orientation of cracks and-hydrology in a shrink-swell soil, Open Journal of Soil Science, 2, 91-94

20. El -Halim, A. A., andA.A. El -Baroudy, A. A. 2014. Influence addition of fine sawdust on the physical properties of expansive soil in the Middle Nile Delta, Egypt. Journal of soil science and plant nutrition, 14(2), 483-490

21. Jarallah, R. S., and S. K. Essa . 2017. The study of corn cobs and gypsum adding in some physical characters and organic matter of cracking soils from middle of Iraq. AL-Qadisiya Journal for Agriculture Sciences, 7(2), 118-127

22. Lampurlanes, J. and C. Cantero- Martinez, 2003. Soil bulk density and penetration resistance under different tillage and crop management system and their relationship with Barley root grow. Agro.J ., 95;526-536

23. Moraes MT;H. Debiasi , Franchini JC, Silvan VR. 2011. Propriedades físicas do solo sob diferentes níveis de compactação em um latossolo vermelho distroférrico. In: Jornada acadêmica da Embrapa Soja; 2011; Londrina, Brasil. Londrina: Embrapa Soja; 2011. p. 51-5. (Documentos 328).

24. Nichols, K.A., S.F. Wright, M.A. Liebig, and J.L. Pikul Jr. 2004. Functional Significance of glomalin to Soil Fertility Conference Proceedings. Denver, CO, March 2-4, 2004

25. Omidi, G. H.; J. C. Thomas, and K. W Brown. 1996. Effect of desiccation cracking on the hydraulic conductivity of a compacted clay liner. WaterAir and Soil Pollution, 89:91–103

26. Painuli, D.K.;M. Mohanty; N.K. Sinha and A.K Misra. 2017. Crack formation in a swell–shrink soil under various managements. Agric.

Res. 6, 66–72. https: //doi.org10.1007/s40003-016-0241-7.

27. Phanikumar, B. R., Amshu Malini, C.,and R. Karthika. 2012. Swell–consolidation characteristics of artificial sand clay mixes. Geomechanics and Geoengineering, 7(1), 69-74

28. Rama Subbarao GV; D. Siddartha; T. Muralikrishna; K.S. Sailaja and T. Sowmya .2011. Industrial wastes in soil improvement. https://doi.org/10.5402/2011/138149.RedYellow Podzolic soils. Soil Science and Plant Nutrition 59, 683-691

29. Richards, L. A., 1953. Modulus of rupture as index of surface crusting of soil.Soil Sci.Sco.Am.Proc.17, 321.

30. Soil Survey Staff.2006. Keys to soil Taxonomy.7th Edition. USDA, NRCS. Washington, D. C.U.S.D.A. 1954. Diagnosis and Improvement of saline and Alkali soils. Handbook, No. 60, Washington, D.C

31.Soinne.H., R. Keskinen., M.Raty.,S. Kanerva.,T urtola.J.Kaseva.,V. Nuutinen.,A.Simojoki., and T. Sal 2020 . Soil organic carbon and caly content as deciding factors for net nitrogen mineralization and scereal yields in boreal mineral soils.European J. of soil science. Special Issue Article

32. Tawfiq. Salma and Nalbantoglu. Zalihe, 2009, Swell-shrink behavior of expansive clays. Eastern Mediterranean University, Department of Civil Engineering, Gazimagusa, North Cyprus.pp:338-340

33. Yang, w., Z. Li, C. Cai , Z. Guo, J. Chen and J.Wang. 2013. Mechanical propertiesand soil stability affected by fertilizer treatments for an Ultisol in subtropical Chin.Plant and Soil. Volume: 363 (1) P: 157-174

34. Youder, R.E.and J.L.McGuinness.1956.A short method of obtaining mean weight diameter.Soil Sci.83:291-294.37

35. Zong, Y., Chen, D., & Lu, S. 2014. Impact of biochars on swell–shrinkage behavior, mechanical strength, and surface cracking of clayey soil. Journal of Plant Nutrition and Soil Science.