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THE BEHAVIOR AND PATTERN OF SOIL CRACKS AND ITS MANAGEMENTS IN VERTISOLS

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ABSTRACT

Soil cracks are an important physical property of expanded clay soils accompanied by distinctive morphological features such as Galgi and Silkensides as a result of the expansion and contraction processes by moistening and drying the soil which effect on water movement and its flow into the soil body, Three experiments were conducted to study the pattern of soil cracks formation and to show the extent of the effect of adding sand and sheep residues on the cracks forms. Some morphological characteristics resulted from the cracking process such as Number of separate pieces, Cracks length, Cracks width, Thickness of hard part, Area of cracked pieces and Crack pattern were calculated in this study. The morphological description of the cracks showed a clear difference in their forms and the width of the cracks in proportion to the depth of the cracks with their width. The results showed a decrease in the width and length of the cracks with an increase in the addition of sand and sheep residues. Significant differences appeared in values of Crack Intensity Factor (CIF) when adding sheep residues by 6% compared with 6% sand and control treatment. The value of CIF was (2.25%, 2.60% and 3.78%) for sheep residues, sand and control respectively, thus it affected the behavior and pattern of soil cracks.

***Keywords*:** Vertisols, Soil Cracks, CIF, Amendments soil.

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INTRODUCTION

Natural or artificial industrial improver adding is one of the methods that used to improve some of physical and chemical properties of clay soils. Clay represents the important part of the soil texture because it has a chemical effect on soil behavior by absorbing water leading to soil swelling upon moisture and shrinkage if got dried drying (Lakshmikantha, 2009). While Raid and Essa, (2016) showed the persistence of droughts and repeated shrinkage of the soil surface causes enough stresses to form the cracks, and that the biggest decrease in size at drought was 49% in some clayey soils in the Netherlands, Indicate to the largest expansion and contraction of soils in the world.

Maulood, (2015) and Fattah *et al.*, (2018) confirmed that the soil peds boundaries are weak, and these natural peds are separated in the same location during the drought, where cracks form very narrow and these cracks expand during dry conditions. The results of Yesiller, *et al.*, (2000), Majid, (2012) and Dinka and

Lascano (2013) showed that adding potassium alum improves the physical properties and reduces soil cracks, and the hexagonal crack pattern appears on the soil surface in the absence of any other effects. While Muhie, *et al.*, (2011), and Shit, *et al.*, (2015) mentioned that the cracks width of increases linearly with the increase of montmorillonite with continuous drying, the angles of the cracks can be characterized by the appearance of the crack pattern, this appearance relates to the physical processes of creating cracks, which are often in the form of Similar sized pieces vary according to the content of these soils of the expanded clays. If these components do not contain expanded clays, the shape of clay cracks is preserved between the two layers and takes the form of polygonal bodies and wide cracks appear from the top and narrow from the bottom (V shape) (Li *et al.*, 2016). Clay cracks negatively affect crop growth and land productivity as well as to soil erosion and nutrient loss, sometimes the cracks wide enough to break up sheep legs during grazing (Vogel *et al*., 2005 and Li *et al*., 2018). The results of Shah *et al.*, (2017) and Alnaser, (2018) showed that adding amendments to the soil improves the physical properties of the soil, especially the cracks and crusts of soils.

The aim of the study is to investigate the behavior and pattern of soil cracks and its managements in Vertisols.

METHODS & MATERIALS

Silty clay texture samples of Vertisols have been used from Sheikhan region northern of Mosul. The samples air dried, grinded and sieved with a 2 mm sieve to study some physical and chemical of Vertisols characteristics as shown in table (1).

Table (1) Some chemical and physical properties of the study soil

properties	EC dS m^{-1}	pH	Clay	Silt	Sand	Texture	ρb *Mg* m^{-3}
			%				
	0.52	7.7	51.1	41.5	7. 4	Silty Clay	1.35

Three laboratory experiments were conducted on this soil, as follows:

1- First experiment: some water properties of the study soil

Soil samples were prepared with three thickness (5, 10, 20) mm, in dishes had diameter (200) mm and (35) mm in depth. The soil was wetted down to a level less than the field capacity and then slowly dried in a well-ventilated room to avoid cracks. The samples were weighed at regular intervals using 0.05 g of soil each time until notes that no change in moisture content to measure some parameters such as Liquid Limit, Plasticity limit, Plasticity Index and Shrinkage Limit.

2- Second experiment: drying tests

In another experiment, to study the cracks pattern and cracks expansion behavior, Sifted soil samples (4 mm sieve) were mixed with a distilled water, then placed in dishes with a 200 mm diameter to obtain a soil layer with a defined thickness (5, 10, 20 mm) with four replicates. The primary moisture content and primary samples thickness were measured by Vernier caliber, then the plates were covered with

transparent plastic inside the laboratory, then measure final sample thickness form and the moisture content at the beginning of the cracks appearance.
Total crack length was measured, the crack width and the crack intensity factor (CIF = total surface area of cracks overall soil surface area).

3- Third experiment: The effect of sand and sheep residues as improvements on cracks formation.
In order to study the pattern, shapes and the possibility of managing the cracks, Sand and sheep residues have been added to the soil in various percentages to determine their effect on soil cracks. 500 g of sifted soil with 4 mm were placed in metal dishes (20 cm in diameter and 3.5 cm in depth) and mixed with sand and sheep residues in (0, 6, 2)% with 4 replications for each treatment.
The soil was saturated with the capillary property and then left in an open place in laboratory until reaching the field capacity. Soil moisture was daily measured until the cracks begin, and the moisture content continued to be measured, notes of the pattern and shapes of cracks were recorded and photographed with a digital camera of 40 cm height until the soil was drained, then CIF was estimated for all samples, then compared, analyzed and interpretation of all data.

RESULTS AND DISCUSSION

1- First experiment: Table (2) showed a decrease in the volumetric shrinkage of the soil (16.30%), as the low shrinkage limit indicates a high tension of expansion and contraction. It is also noticed increased in soil liquid limit (56.50%), which indicates a high swelling effort for this soil leading to the soil cracking, because the soil with a high liquidity limit swells more than other soils, and the increased of soil clay content caused increasing in the plasticity limit (40.50%), and these results are consistent with the findings of Muhie *et al.*, (2011), Dinka and Lascano (2013) and Shit *et al.*, (2015).

Table (2) Some aqueous properties of the study soil

Properties	%
Liquid Limit (LL)	56.50
Plastic Limit (PL)	40.50
Plasticity Index (PI)	30.00
Shrinkage Limit (SL)	16.30

2- Second experiment: The results of drying test (Table 3) show a decrease in the final soil sample thickness after the decrease in the soil moisture content, which is depends on the thickness of the prototype before drying. When ever the sample thickness was larger, it reduced its final thickness after drying. Cracks also appeared at a different moisture content according to the samples thickness, the less thickness of the soil sample will increases the chance of cracks to appear due to the decrease in soil resistance to the cracks occurrence, cracks appeared in thickness 5 mm at

48.10% of moisture content, while 10 mm thickness was delayed with moisture content 39.70%. These results are consistent with Shit *et al.*, (2015) and Fattah *et al.*, (2018) that mentioned that the soil when exposed to drought the expanded clay minerals lose water from its crystal structure causing shrinkage, thus creating cracks in the soil surface layers.

Table (3): Soil samples drying test

test period	dish Diameter	Primary thickness	final thickness	initial moisture content	Moisture content when cracking occur
day	mm			%	
4	200	5	4.40	54.50	48.10
6	200	10	9.00	54.50	42.20
8	200	20	17.10	54.50	39.70

Table (4) and fig (1) appear differences in the geometric properties of cracks and it is width, as well as overlapping and intersection those cracks, separated pieces are formed due to the occurrence of cracks. Separated pieces are usually in the form of squares or polygons, and the pieces with square shapes are dominant compared to separated pieces with polygons.

The total length of cracks increased at the thickness 5 mm compared with the thickness of 10 and 20 mm, so the number of cracks intersections in 5mm thickness increased, and thus the number of separated pieces increased in comparison with the thickness of 10 and 20 mm, and this was shown in CIF values (11.21, 4.59, 3.92) % for the three samples, respectively, and these results are consistent with Moulood *et al*., (2012), Li *et al*., (2016) and Li *et al*., (2018).

Table (4): Some cracks properties of study soil samples.

dish diameter	Soil thickness	test period	Total length of cracks	Average cracks Width	Number of cracks	Number intersection of cracks	Number of separated pieces	CIF
mm		day	mm		m^{-2}			%
200	5	5	3200	1.1	399	948	314	11.21
200	10	8	412	3.5	82	98	51	4.59
200	20	10	220	5.6	62	68	37	3.92

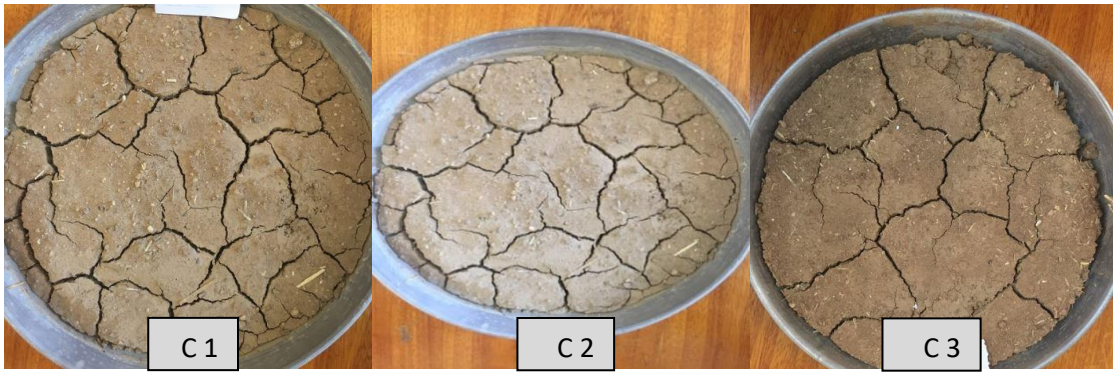
3- Third experiment: adding Sand and sheep residues as amendment in handling soil cracks

Table (5) shows the effect of Sand and sheep residues adding on (CIF) for additives and comparison plates, noting that there was decreases in length and width of the main and secondary cracks with increasing of sand and sheep residues levels (Figure 1), The results showed significant differences in CIF when adding sheep residues by 6% compared with 6% sand and control treatment, the CIF of sheep residues, Sand and control was (2.25%, 2.60% and 3.78%) Respectively (table 5) and these results are consistent with same results as mentioned by Lakshmikantha, 2009 and Shah *et al.*, (2017).

Table (5): The effect of added amendments on crack strength of soil study

Treatments	Additions percentage			Mean
	Control	2%	6%	
	CIF			
Sand	3.78 a	3.37 a	2.60 b	3.25 a
sheep residues	3.78 a	3.11 ab	2.25 c	3.05 b
Additions percentage Mean	3.78 a	3.24 b	2.45 c	

Also, the cracks appearance in the additive parameters has been delayed and compared with the soil without adding, the time of the cracks appearance has reduced with an increase in the percentage of sheep residues. The increase in porosity resulting from the adding of sand and sheep residues increased the regularity of cracks distribution, so untreated soils show an increase in cracks irregularity due to the low presence of pores, these results are consistent with Majid *et al*., (2012), and Raid and Essa, (2016) who pointed out that the presence of large quantities of fine particles such as Smectite and vermiculite in clay soils leads to enhancing crack formation, and when adding treatments with coarse particles to these soils can significantly reduce the amount of shrinkage and thus reduce cracking.



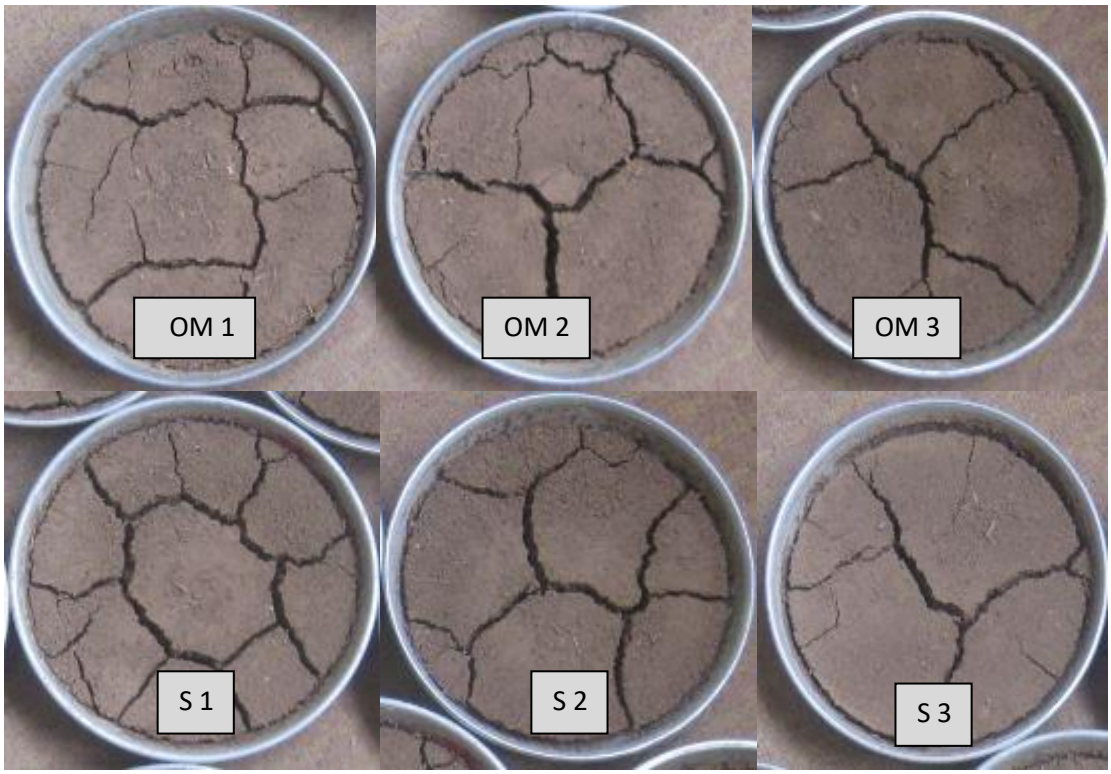


Fig. (1) Relationship of soil cracks with the change of moisture content of three treatments. (C= control, OM= organic matter, S= sand)

The results in the third experiment showed decrease in soil moisture content with the progress of days Figure (2), as this led to drying of the soil and increase in cracks size. The cracks appeared in control treatment after 17 days in 39% of the moisture content but the cracks appeared after 18 days of moisture content at 35% when adding sand, while cracks appeared after 20 days at moisture content 32%, and this shows the positive effect of adding sand and sheep residues in the moisture content of the soil.

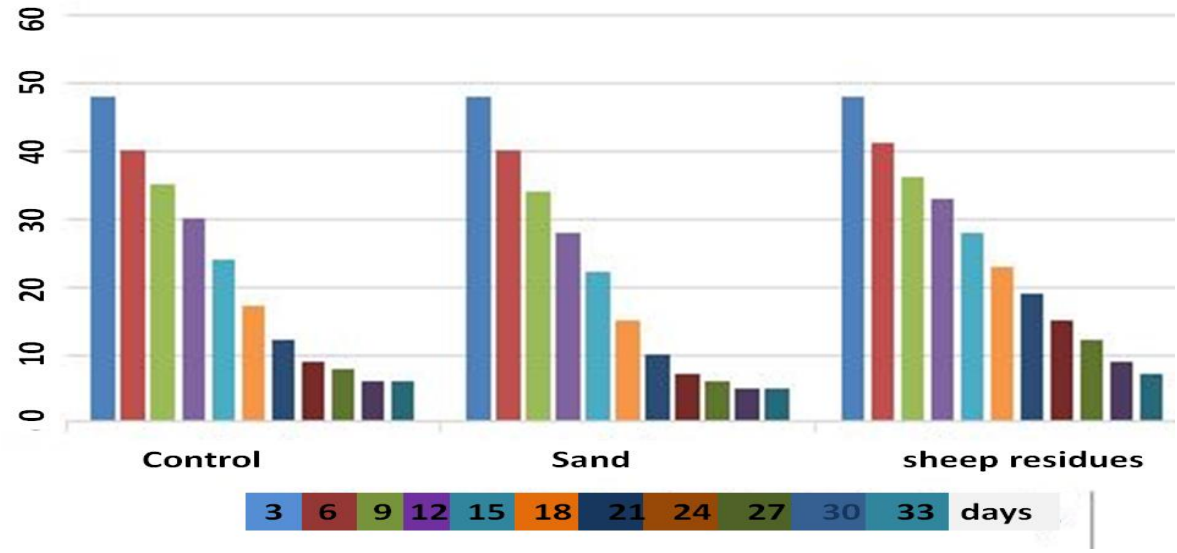


Fig. (2) Relationship of the amendments with the soil moisture content with the days and the appearance of cracks

As well as there was a reduced and delaying the appearance of cracks, which is evident in the values of CIF, These results are consistent with the findings of Dinka and Lascano (2013) and Alnaser, (2018) who found that treatments added to the soil increased moisture preservation, reduced the size of cracks and delayed the time they appear in the soil.

CONCLUSION

1. Volumetric shrinkage limit of the soil was 16.30%, and this indicates the high potential for swelling and shrinkage for the soil.
2. The cracks appear in the middle and extend with orthogonal and straight lines towards the edges to intersect with other cracks so that form a continuous network of cracks in the form of polygonal cells.
3. The crack pattern was more uniform in the soil samples that has 6% added sand and sheep residues.
4. There was a positive relationship between the total length of the cracks and the number of separated pieces compared with the CIF, but it was opposite with crack width.
5. Sand and sheep residues affected of CIF, and the cracks were less dense at the end of the drying stage when adding sheep residues by 6% compared to other treatments.

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سلوك ونمط تشققات الترب وإدارتها في ترب الفيرتسول

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الخلاصة

تشققات التربة خاصية فيزيائية هامة في ترب الفيرتسول والتي تحتوي على نسبة عالية من الاطيان المتمددة وتصاحبها مظاهر مورفولوجية مميزة مثل ظاهرة الكلكاي gilgai والأوجه الصقيلة silken sides لمدرات التربة نتيجة لعمليات التمدد والانكماش عند ترطيب وتجفيف التربة والتي تؤثر على حركة المياه وتدفقها الى داخل جسم التربة ومع ذلك فإن دراسة التشققات واتجاهاتها وتأثيرها على استخدامات الأراضي المختلفة لم يتم توثيقه ومعالجته جيدًا فيما يخص حركة المياه والمغذيات فوق سطح التربة وانتقاله من خلال هذه التشققات. نفذت ثلاث تجارب لدراسة نمط تكوين تشققات الترب وبيان مدى تأثير اضافة الرمل ومخلفات الاغنام في سلوك ونمط التشققات كما تم دراسة بعض الصفات المورفولوجية الناتجة من عملية التشقق مختبريا وشملت الصفات (عدد القطع المنفصلة طول التشقق عرض التشقق سمك الجزء الصلب مساحة القطع المتشققة نمط التشققات). أظهرت نتائج الوصف المورفولوجي للتشققات اختلافاً واضحاً في أشكالها وكذلك عرض التشققات كما بينت النتائج انخفاض في عرض وطول شبكة التشققات مع زيادة اضافة الرمل ومخلفات الاغنام وظهر ذلك واضحا في قيم عامل شدة التشقق CIF وبالتالي اثرت في سلوك ونمط تشققاتها.

الكلمات المفتاحية : Vertisols، تشققات، CIF ، محسنات

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