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Impact of Some Tillage System on Soil Cracks of Northern Gedarif, Sudan*

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Abstract: The study was carried out during three consecutive seasons 2005/06 2006/07and 2007/08 under rain fed condition to investigate the effect of some tillage systems on soil cracks. The study was conducted in the pilot farm of the Faculty of Agricultural Sciences and Environment , University of Gedarif in the Northern area of Gedarif State (Latitude 12° 45′ N, Longitude 35° 15′ E, Elevation 540m above mean sea level). The experimental work laid out on randomize complete block design (RCBD) with three replications of the treatments tillage systems: No tillage or zero tillage (ZT), Offset disc as post harvest tillage (PHT) and Wide Level Disc, which farmers practice, as control (WLD) . Rain gauge reading for total recorded annual rainfall were 368.1mm (2005), 463.6 mm (2006) and 495.2 mm (2007) which was spread over 32, 30 and 32 rainy days during the first , second and third growing seasons, respectively. The results showed that the second season had the best distribution pattern. It recorded 15%, 36%, 26% and 5% for July, August, September and October, respectively compared to 24% ,53% 13% and 2% ; and 29% ,41% , 21% and 1% for first and third seasons in the same months. The maximum measured values for crack were 91 and 81cm for the depth and 8.7 and 8.5 cm for the width recorded during May for the zero tillage and Wide Level Disc treatments respectively. The cracking areas ranged between 0.32 m^2/m^2 to 0.49 m^2/m^2 for ZT and

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0.32 m^2/m^2 to 0.46 m^2/m^2 for WLD, whereas PHT they ranged from 0.28 m^2/m^2 to 0.36 m^2/m^2. For most measurements throughout the three monitoring seasons, the ZT constantly showed significantly higher values of crack parameters over WLD and PHT.

Key words: Soil cracks, Post harvest tillage, Wide Level Disc

INTRODUCTION

Soil cracks, whose formation is associated with natural climate phenomena, play an important role in water and gas transfer. Surface cracks develop in clay soils as they dry and shrink. They may be found naturally in soils with high contents of shrink / swell clay such as Vertisols and soils with Vertic properties Ringroe-svoase *et al.* (1996). Cracks are very common in period of high evapotranspiration demands and may comprise a considerable part of soil surface Yassoglou *et al.* (1994). The volumes of cracks increase the retention of water during heavy rain, causing soil surface pounding and prevent formation of the surface runoff. The internal surface of crack area causes an enlargement of the infiltration area and thus, enables the soil to retain more water for the plants, (Novak ,1999). Shrinkage cracks provide a direct path for water vapor to move from soil pores near the crack wall to the atmosphere. On the other hand, cracks also provide additional extensive surface area for evaporation of soil water, and evaporation from cracks is expected to exceed the evaporation from bare soil, thus increasing water losses. Cracks are important to facilitate penetration of water into the soil profile, root development and exchange of air. Selim and Kirkham (1970) proved, by a laboratory experiment that the presence of an artificial crack caused noticeable decrease in the water content close to the crack wall and caused some decrease in soil water 12 cm from crack wall. Ritichie and Adams (1974) studied evaporation rates, when the soil surface was covered and uncovered and that shrinkage cracks were the dominant factor influencing evaporation from swelling clay soils. In agriculture, soil shrinkage cracking allows rapid transport of water, nutrients and pesticides to the sub-soil where both they become inaccessible to shallow rooting plants and can pollute the local ground water system, (Harris *et al.* 1994 ; Brousurijk *et al.* ,1991). The crack area was generally greater at the end of the growing period of crop due to the lower soil moisture status which was associated with higher bulk density of the soil as reported by Yassoglou *et al.* (1994). He also reported that the crack width initially increased almost linearity with decreasing soil moisture content to a certain level. Flowers and Lal (1999) reported that the ploughing decreased the cracking area and volume. Also, they emphasized that the no- till has caused significantly higher cracking than tillage treatment.

Gedarif region is the most important farming area for the rain-fed crop production in Sudan. The current crop and land management practices are in favor of inefficient use of even with abundant rainfall. Significant water losses through extensive cracks evaporating surfaces as well as from deep percolation and runoff are obvious hydrological phenomena in the central clay plains. Thus, methods to effectively utilize the total available rainfall and the soil in this region are envisaged to have a large potential impact on agricultural production. Therefore, this research was proposed and conducted to study of the hydrological aspects pertaining to improved soil and water management practices to increase efficiently use of the limited available rainwater.

MATERIALS AND METHODS

Cracking Parameters

Influences of tillage systems on soil of cracks pattern were evaluated by measuring the depth, width and surface area of the cracks. Measurements were done at the end of the rainy season up to ploughing for post harvest tillage (PHT) and continued up to mid June for the no tillage (or zero tillage) (ZT) and Wide Level Disc which Farmers practice control (WLD). Three fixed points of each one square meter in size were selected randomly per each plot, for measuring cracking parameters.

Depth and Width of Cracking

Measurements of the depths and widths of the cracks were made by flexible iron-rods graduated to 50 cm and 120 cm length. Depths were measured by inserting the rod down the crack until the bottom floor is reached. While the width measurements were made at perpendicular portion for the cracks walls using measuring rulers. Three readings were taken per point to give nine readings per plots for depth and width.

Area of Surface Cracking

The surface areas of cracks were measured using square meter divided into 5cm*5cm grid mesh. The complete and partially covered cracks by grids were counted.

RESULTS AND DISCUSSION

Table 1. shows that the total rainfall was 368.1mm, 463.6mm and 495.2 mm in the first, second and third seasons respectively .It was distributed successively in 32, 30 and 32 rainy days , July and August were the most rainy months (Table 1.) .

Table 1. Monthly total rainfall and Rainy days for the three seasons.

Month	Rainfall (mm)	Rainy days
Season 2005/06		
June	21.5	2
July	107.7	8
August	151.3	13
September	82.6	8
October	5	1
Total	368.1	32
Season 2006/07		
June	87.3	6
July	67.7	6
August	166.4	10
September	118.2	7
October	24.0	1
Total	463.6	30
Season 2007/08		
June	39.6	4
July	120.5	12
August	261.5	11
September	64.8	3
October	8.8	2
Total	495.2	32

Source: Demonstration farm rain gauge, Faculty of Agricultural Sciences and Environment, University of Gedarif

The results indicated that the values of crack parameter increased as soil moisture content decreased which is closely related to amount of rain water received by the soil (Figs.1.to 6.). Similar results were observed by Stroognijder (1976) who stated that the crack parameters were generally greater at the end of the growing period of crop due to the lower soil moisture status which was associated with higher bulk density of the soil. During the three growing seasons the results showed that the measured values of depths and widths increased gradually at the end of August and reached the maximum values in May of the following year , then started to decrease when rainfall began in June and completely closed or sealed in July depending on the rainfall amount of received . The maximum measured value for depths during May were 75 cm and 70 cm in season 2005 , 91 and 81cm in season 2006 and 90 and 85 cm in season 2007 for the zero tillage and the wide level disc treatments, respectively whereas under post harvest tillage treatment the crack depth was zero (Figs.1. to 3.) .

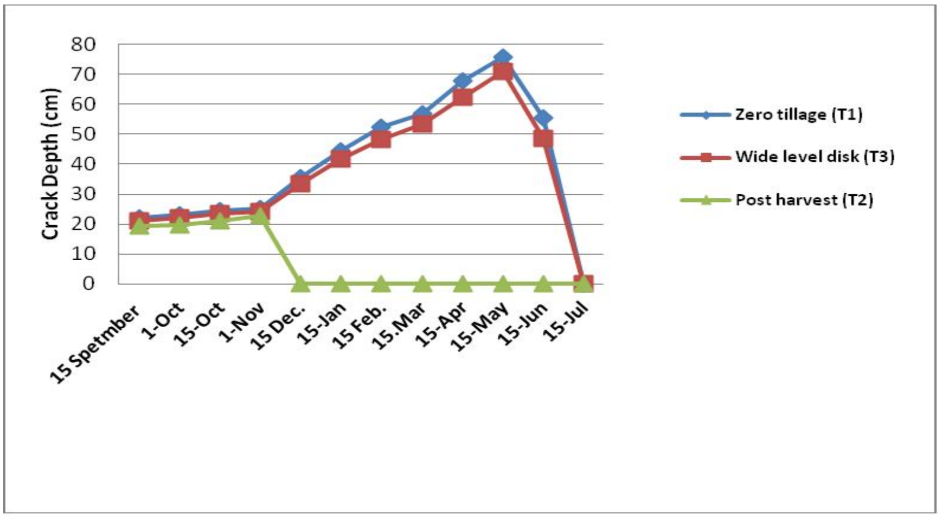

Fig.1 Effect of tillage on soil depth (cm) season 2005.

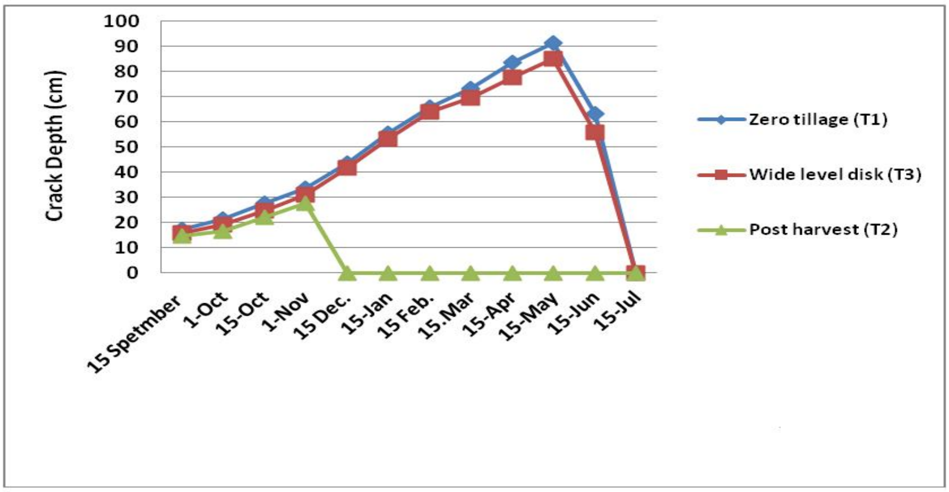

Fig. 2. Effect of tillage on soil cracks depth season 2006.

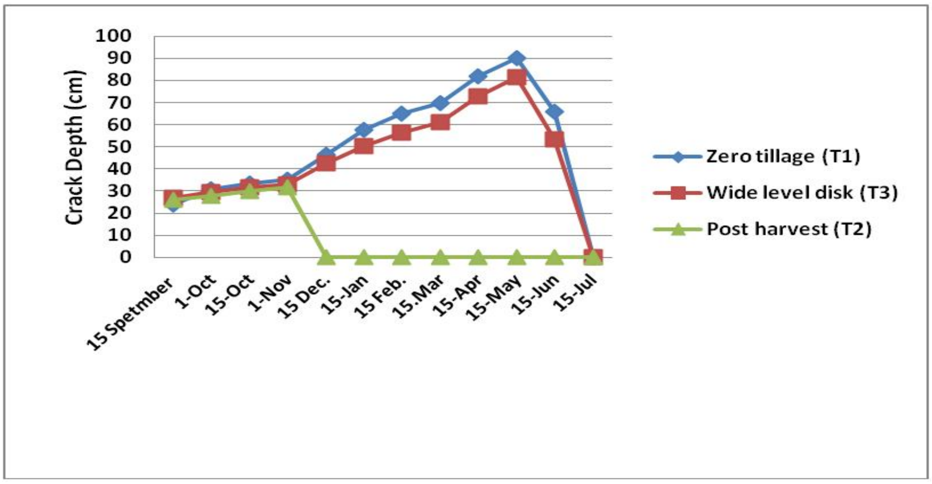

Fig. 3. Effect of tillage on soil cracks depth season 2007.

The same trend appeared as with crack width .The highest measured values for crack width in May were 6 and 5.5 cm in season 2005, 8.7 and 8.5 cm in season 2006 and 6.3 and 5.8 cm in season 2007 for zero tillage and wide level disc treatments, respectively (Figs.4 to 6).

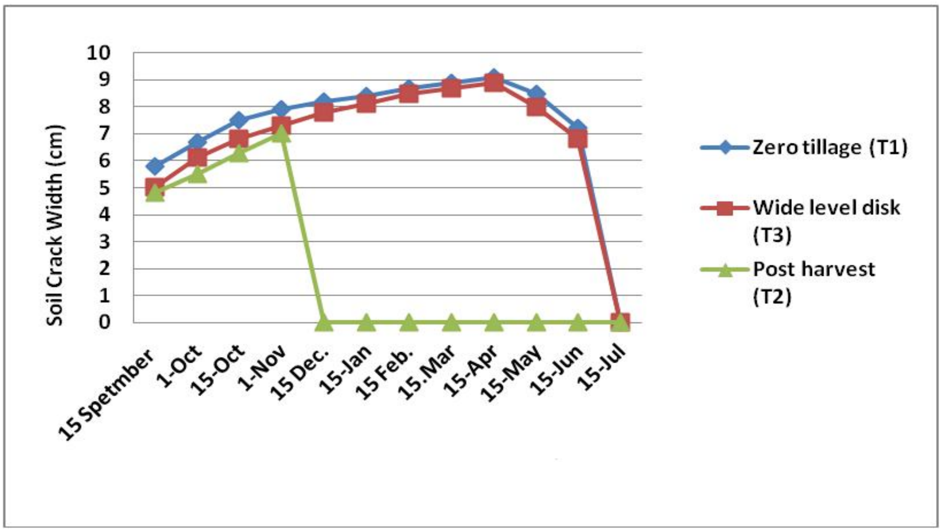

Fig.4 . Effect of tillage on soil cracks width (cm) season 2005.

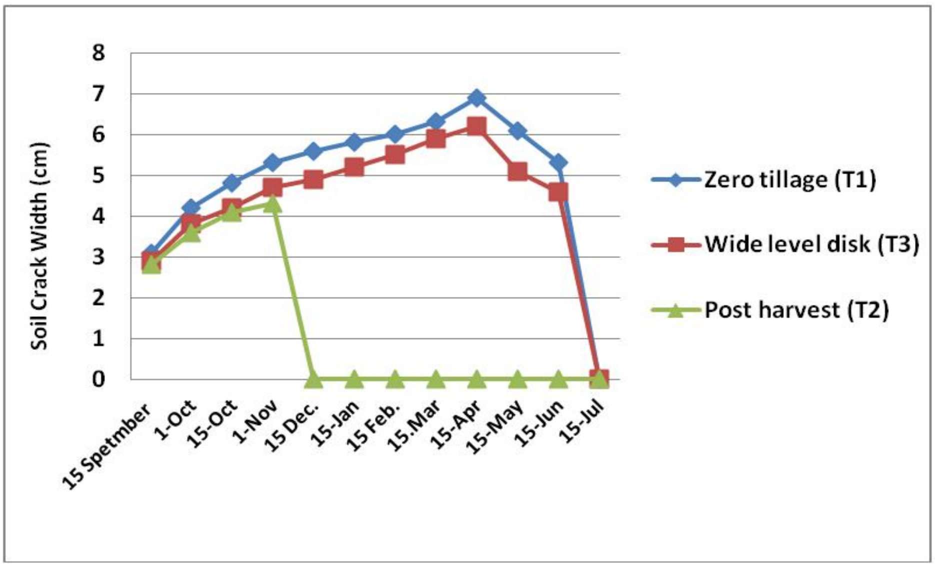

Fig.5 . Effect of tillage on soil cracks width (cm) season 2006.

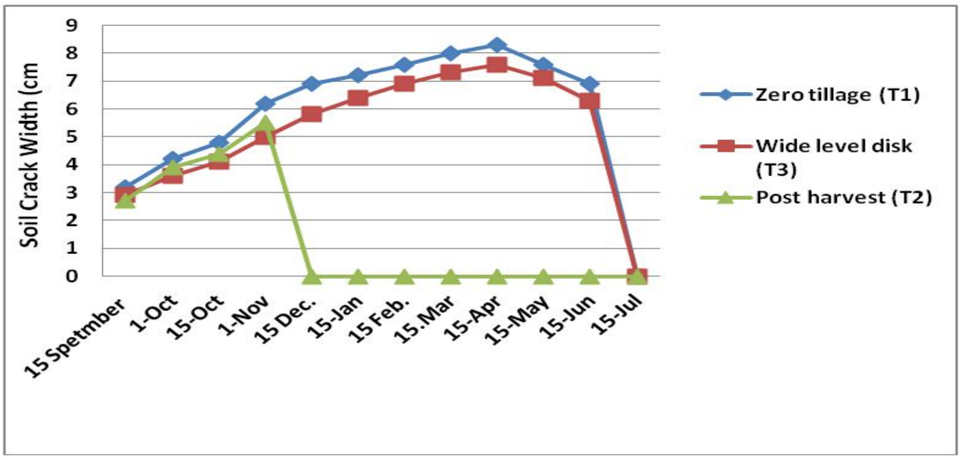

Fig.6 . Effect of tillage on soil cracks width (cm) season 2007.

From these results the highest values for depth and width recorded were attributed to the high temperature recorded in April. The variation in measured values of the depths and widths between years may be associated with the amount of the received rainfall which was reflected in soil moisture content. Similar results were observed by Yassoglou *et al*. (1994). ZT had constantly showed significantly higher values of crack parameters over WLD and PHT for the three growing seasons. Zero tillage recorded higher values for crack depth and width compared with wide level disc and post harvest tillage treatments increased by 18% and 52 % for season 2005/06 , 23% and 83% for season 2006/07 and 88 % and 78% for season 2007/08 . This may be due to the profound effect of these particular tillage systems on soil pulverization and surface and sub-surface modification including reducing cracks depth and width and hence the surface extension of the cracks. The results are in line with those of Saeed *et al*. (2007) findings. Their results indicated that the post harvest offset discing and chisel ploughing was more effective in reducing soil cracks. The effect of introducing soil tillage operation on the area of surface cracking was clearly observed in Fig.7.

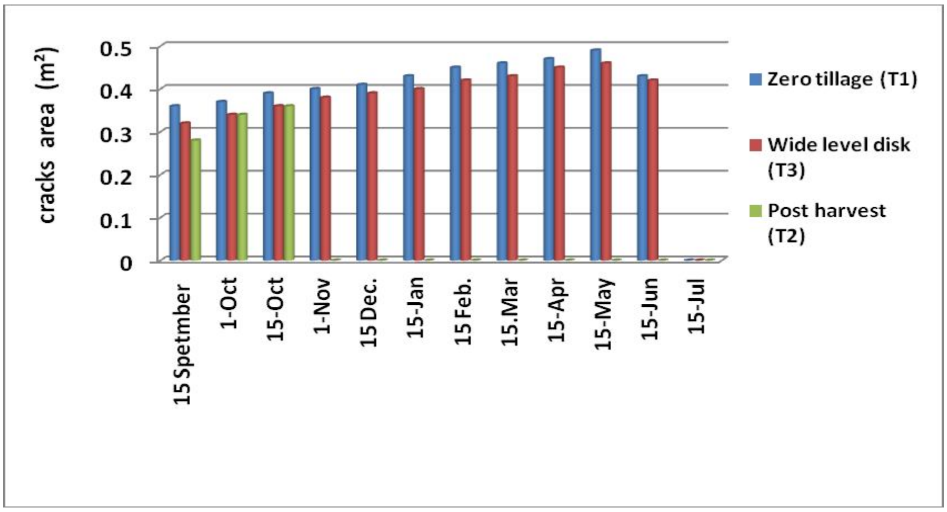

Fig.7. Effect of tillage on soil cracks area season 2005.

The cracking areas were 0.32 m²/ m², 0.28 m²/ m² and 0.32 m²/ m² for ZT, PHT and WLD respectively in mid September when the water started to be depleted by the crop and increased gradually to reach the maximum values of 0.49 m²/m² and 0.46 m²/m² in mid May for ZT and WLD, respectively and then started to seal gradually in mid June to complete sealing in mid July depending on the received amount of rainfall. For PHT treatment the maximum value of cracking area was 0.36 m²/ m² in mid November and the cracks were sealed by soil plowing. Zero tillage resulted in the highest values of cracking area compared to WLD and PHT treatments which may have been due to tillage effect. This agreed with the findings of Flowers and Lal, (1999) who stated that disc ploughing decreased the cracking area and volume .The findings clearly illustrated that the zero tillage required a lot of rain water to fill and seal the crack volume. This led to the loss of much rain water at the beginning of the rainy season and, may thus delays sowing date. However, postharvest tillage ploughing in mid November leads to crack sealing and hence conserve soil moisture of the previous season.

CONCLUSIONS

Zero-Tillage Treatment has constantly showed significantly higher values of crack parameters (depth, width and area) over the Wide Level Disc and

Post Harvest Tillage. Zero-Tillage practice led to loss of water through cracks wall and deep percolations at start of rainy season.

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تأثير بعض نظم الحراثة على على تشققات التربة في منطقة شمال القضارف ، السودان[*]

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مستخلص البحث : أجريت الدراسة خلال ثلاثة مواسم متتالية (2006/05، 06 / 2007 و2008/07) تحت ظروف الامطار ، لدراسة تأثير بعض نظم الحراثة على تشققات التربة في منطقة شمال القضارف. أجريت الدراسة فى المزرعة التجريبية لكلية العلوم الزراعية والبيئية ، جامعة القضارف ، مدينة القضارف ، السودان (خط عرض ′45 °12 شمال وخط طول ′15 °35 شرق ، 540 فوق مستوى سطح البحر) . أستخدم فى التجربة تصميم القطاعات العشوائية الكاملة بثلاث مكررات ؛ لمعاملات ، الحراثة الصفرية ،الحراثة ما بعد الحصاد بأستخدام المحراث المنحرف والحراثة بأستخدام المحراث القرصى العريض كشاهد. اخذت قياسات معدل المطر اليومى والسنوى . كان معدل الامطار السنوى 368.1 ملم (2005) ، 6. 463 ملم (2006) و495.2 ملم (2007) توزعت خلال 32 ، 30 و 32 يوما للمواسم الأول والثاني و الثالث على التوالي. وأظهرت النتائج أن الموسم الثاني كان أفضل من حيث التوزيع فكانت بنسب 15% ، 36% ، 26 % و 5% عن يوليو وأغسطس وسبتمبر وأكتوبر ، على التوالي ، مقارنة بنسب 24% و 53 % ، 13 % و 2 % 29 % ، 41% ، 22 % و 1 % وللمواسم الثالث و الأول لنفس الشهور على التوالى. القيم القصوى المقاسة لعمق والعرض للتشققات كانت 91 سم و 81 سم و 8.7 سم و 8.5 سم سجلت خلال شهر مايو للحراثة الصفرية والحراثة بأستخدام المحراث القرصى العريض على التوالي . تراوحت مساحة التشققات من 0.32 م^2 / م^2 إلى 0.49 م^2 / م^2 للحراثة الصفرية و 0.32 م^2 / م^2 إلى 0.46 م^2 / م^2 الحراثة بأستخدام المحراث القرصى العريض ، بينما تراوحت مساحة الحراثة ما بعد الحصاد بأستخدام المحراث المنحرف من 0.28 م^2 / م^2 إلى 0.36 م^2 / م^2 . أظهرت نتائج القياسات طوال المواسم الثلاثة باستمرار بأن معاملة الحراثة الصفرية تحقق قيم أعلى بكثير من معاملات الحراثة ما بعد الحصاد والحراثة بالمحراث القرصى العريض بالنسبه قياسات التشقق.

كلمات مفتاحية : تشققات التربة ، الحراثة ما بعد الحصاد ، المحراث القرصى العريض

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