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# Effect of Agronomic Practices on the Aggregate Stability and Organic Carbon of soil (Case study: the Northern of Aq Qala)

**H.R. Asgari**
Dept. of Arid Zones Management, Gorgan University of Agricultural Sciences and Natural Resources, Gorgan

**Abstract**

Soil is accounted as a large sink for the atmospheric carbon dioxide. Carbon dioxide emission from soil will increase by operations such as land-use change, biomass and fuel combustion, industrial production as well as tillage. Operations like tillage could accordingly intensify the soil biological activity, which per se leads to more carbon emission to atmosphere. Thus, utilizing the methods of seedbed preparation that cause low soil disturbances (conservation tillage) will prevent carbon emissions from the soil to the atmosphere; that in turn increases the content of soil organic matter; consequently, soil aggregate stability improves, against erosive factors. The research aims to assess the effects of different tillage systems (no-tillage, low tillage and conventional tillage) on the organic accumulation and the aggregate stability of the soil. The appropriate soil management and farming practices could exert a great positive influence upon crop yield. The study area is located in the eastern of Aq Qala, Iran. Three treatments of tillage systems, namely, traditional management, no-tillage and low tillagehave been examined in the study area in three replicates, based on the randomized complete block design (RCB ). In each tillage system, 10 soil samples of about 0.5 kg (wet) weight for each sample (totally 30 soil samples) were taken from two soil depths (0-25 and 25-40 cm) using a 4 cm diameter Edelman auger. Some physicochemical properties of soil such as total soil organic matter, soil texture, bulk density, and mean weight diameter were measured. Tillage systems did not have any positive effects on soil organic matter (SOM) at two different soil depths (0-25 and 25-40 cm). However, the results showed that no-till system significantly ($P>0.05$) increased the SOM content of the total measured soil layer (0-40 cm) in comparison with other tillage systems. There is no significant difference in the effects of soil tillage managements on soil bulk density. Moreover, all these three soil tillage systems caused non-significant change on soil aggregate stability against erosive factors.

***Keywords***: Tillage systems, conservation tillage, physicochemical properties, soil, Aq Qala.

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[*]Corresponding author; hras2010@gmail.com

## 1.Introduction

Iran is located in the world's arid and semiarid belt with low precipitation; therefore, the improper distribution of rainfall and high evaporation are considered as the main characteristics of its climate. Most croplandsare rain-fed, which is strongly influenced by the harshclimatic factors (Khosravani, 1998). The problems of global warming and frequent droughts have caused various management activities to be overshadowed by the issue of carbon sequestration in the soil, because soil plays an important role in the global carbon cycle. The amount of carbon stored in the soil extends up to 5.3%, while for plant and animal biomass, the atmosphere, fossil fuels, and ocean are 1%, 1.7%, 8.9%, 84.9%,and 84.9%, respectively (Lal *et al.*, 1995). On the other hand, due to population growth and the need to feed the human population, agricultural land utilization and heavy traffic of agricultural machinery (mechanization) (Asgari *et al.*, 2014; Ishaq*et al.*, 2001).The dry soils in arid lands during summer period lead to the creation of a large bulk of soil clods after plowing. In order to crush these clods, heavy agricultural machinery is needed; however, their movements to and fro results in powdered soil aggregates. These fine grains will be blown by wind erosion, and removed by water erosion; eventually, leading to unusable lands for future generations (Taki and Assadi, 2009).

Mainly agricultural tillage systems include conventional tillage and conservation tillage. Given all of the advantages of soil conventional tillage compared with the other types of tillage systems, in most cases, the continuous usage may result in adverse outcomes in arid areas. Conventional tillage is defined as a type of soil tillage long practiced in an area to produce a particular product. In addition, in long-term studies, it has been observed that prolonged use of conventional tillage reducessoil organic carbon content, soil structure degradation; this also leads the low rate of water infiltration into the soil and eventually it will lead to increased water and wind erosion (Kettler *et al.*, 2000; Gholami *et al.*, 2014a, b).

Recently, in the different parts of Iran, including Golestan, conservation tillage practices have been replaced for conventional tillage methods. The purpose of conservation tillage is to reduce the tillage intensity and to improve crop residue management (Bull and Sandertto, 1996; Gajri *et al.,* 2002). Any attempt to reduce the severity of tillage practices, lowering tillage depth or loosening the soil without turning the soil layers upside down (upturning) is considered as conservation tillage. In arid and semi-arid areas, the conservation tillage has versatile benefits such as the retaining of soil moisture, the increase of soil temperature in the autumn and its moderation in the summer, soil fertility, producing preterm crops in multicultural systems (Taki and Assadi, 2009; Phllips and Young, 1973). In 1980s, USDA introduced the conservation tillage as the most economical and most effective means of curbing soil erosion (Haghnia and Lakzian, 1995). Many

American farmers have changed tillage systems from conventional tillage to conservation tillage, so that the areal coverage of conventional tillage risesfrom 29 million hectares in 1989 to 40 million hectares in 1994 and the area under cultivation by 2020 will have reached 75% (Lal *et al.*, 1995; 1998).

Another issue is the effect of tillage systems on soil carbon storage. Different soil carbon sequestration in areas where the conventional tillage and no tillage are practiced may be due to differences in plant carbon input and mineralization rates (Sainju *et al.*, 2006). Two ways to increase the amount of soil organic carbon (SOC) arementioned (1) the increase of the amount of carbon input, (2) the reduction of waste and decomposition of soil organic matter by crop residue management via using conservation tillage (no tillage or low tillage), which increases the amount of carbon input and decreases the decomposition rates (Chen *et al.*, 2009). Management practices such as conservation tillage could be a suitable alternative to alleviate the crisis and to increase the amount of organic carbon in the soil along with the improvement of other physiochemical properties (Rolda´n*et al.,* 2009). So that it can be deduced that land management without tillage after years of practicing the conventional tillage, enhances soil organic carbon content across various soils and climates (Bowman *et al.*, 1999). The amount of organic material and water supply in arid and semi-arid climate that were due to continued losses, improves because of the alteration of the cultivation method (Du Preez*et al.*, 2001). In regard to the issues raised, the purpose of the present study is to investigate the effects of different tillage systems (no tillage, low-tillage and conventional tillage) on the accumulation of organic matter and soil erosion potential and soil aggregate stability as the important indicators, in AqQala township of Golestan province in northern Iran.

## 2.Materials and Methods

The Aq Qala areais in the northeastern Golestan province, with dry climate and the problems related to the lack of precipitation. Thus, here crop utilization (via conventional tillage methods) is generally dependent on rain-fed system. In the study area, except low-altitude hills, the rest of the plain is covered by fine-grained materials, which are mostly originated from loess deposits. Having low organic materials, loess soils are sensitive to erosion (Kiani *et al.*, 2007). There is also hot and dry winds and soil texture with a very fine-grains and high percentage of solute which makes the area fragile and susceptible to erosion. According to the harsh climatic conditions in arid and semi-arid areas and the existence of problems such as poor soil, dwindling water resources, limitation of organic matter and vulnerability of soil structure, and the other disadvantages of conventional tillage, it is necessary to pay attention to the protective tillage system as an alternative method for seed planting, and bed preparation. Therefore, the aim of this research is to estimate the amount of organic carbon, soil organic matter accumulation and soil erosion as a result of the different tillage (low tillage and no-tillage, conventional tillage) in an area in the Northeast of the township of Aq Qala.

For sampling, first, the position of the study area was acquired from the Agricultural Jihad organization. The weather data for the study area was obtained from the administration of natural resources and meteorological office of the region. To identify the location of the study sites, field surveys were made from QaraBolaq (54°45' E and 36°59' N), in the east of Aq Qala. Then, under favorable conditions, 30 samples were collected from the depths of 0-25 and 25-40 cm in the treatment plots (no tillage, low tillage and conventional tillage) based on completely randomized block design.

After drying the samples, based on physiochemical tests, soil samples were sieved to perform chemical tests. As samples should be less than 2 mm in diameter, for this purpose, samples were screened througha 2-mm sieve, and then depending on the type of test, different weights were separated. To obtain the amount of soil organic carbon and total percentage of organic matter, which organic carbon is part of it, Walky and Black (1934) method was used. According to previous studies, the most effect from soil erosion is imposed on the surface layers, which is why Aggregate Stability of the samples was measured in the depth of 0-25 cm. To determine the mean weight diameter (MWD) of soil aggregates, the wet sieve method was used. Soil texture was also identified according to the Bouyoucos hydrometer method (1962). In this method, soil texture of samples from each treatment was determined at two depths. Bulk density was measured based on the clod and the paraffin method in grams per cubic centimeter (Black and Hart, 1986). Analysis of variance (one-way ANOVA) was used to compare treatments using SPSS 16 software.

## 3. Results

### The analysis of total organic matter under different tillage systems

The total organic matter of soil under different tillage systems varies in different depths. The results of analysis of variance proved a significant difference in the total organic matter of three treatments at the level of 5%. That is, the total percentage of organic matter among tillage systems at the level of 95% is significantly different. Afterwards, the results of the Duncan's mean comparison showed significant difference between the no tillage system and the two other systems. Results are provided in Table 1.

**Table 1.** Comparison of the average percentage of the total organic matter under different tillage systems using Duncan's at the significance level of 5%.

| Parameters / Treatments | Organic matter at the depth of 0-25 cm (%) | Organic matter at the depth of 25-40 cm (%) | Total organic matter at the two depths (%) |
|---|---|---|---|
| No tillage | 3.78a | 2.47a | 3.13a |
| Low tillage | 2.63a | 3.1a | 2.86b |
| Conventional Tillage | 2.97a | 2.4a | 2.69b |

The average of each column that contains at least one shared letter based on Duncan's doesnot have a significant difference at the level of 5%.

Soil organic matter changes with the soil tillage management and types of tillage systems in which much more crop residue returns to the soil, and it affects soil organic matter in an extended range. The highest amount of total organic matter was observed at the 0-25 cm of no tillage system, and its least amount at the depth of 40-25 cm of the conventional tillage.

**Analysis of organic carbon under different tillage systems**

ANOVA results generally show that for the percentage of organic carbon in the three tillage systems, there is a significant difference at the 5 % level. To find out which treatment is different, Duncan's multiple range testswere used (Table 2). This test represents a significant difference in organic carbon between the no tillage and conventional tillage systems. Results are provided in Table 2.

**Table 2.** Comparison of the average percentage of the total organic carbon under different tillage systems using Duncan's at the level of 5%

| Parameters / Treatments | Total organic carbon at the depth of 0-25 cm (%) | Total organic carbon at the depth of 25-40 cm (%) | Total organic carbonat the two depths(%) |
|---|---|---|---|
| No tillage | 2.2a | 1.44a | 1.82a |
| Low tillage | 1.53a | 1.8a | 1.66b |
| Conventional Tillage | 1.73a | 1.4a | 1.56b |

The average of each column that contains at least one shared letter on the basis of Duncan's does not have a significant difference at the level of 5 %.

In most studies, long term operation of the no tillage system is the prerequisite to benefit from the favorable impact of tillage methods, including increased rates of soil organic carbon. Crop residue on the soil surface over the years under this system will increase the amount of organic material, especially carbon in the soil surface layers. As Figure 2 indicates, the highest percentage of organic carbonoccurs in the no tillage system and the least value corresponds to the conventional tillage. This result is consistent with observations of Hazarika *et al.* (2009) and Shan *et al.* (2010), indicates that most of the organic carbon is observed in the no tillage system. Results of Chen *et al.* (2009), showed that soil surface layers in the no tillage system has the highest level of organic carbon compared with other types of tillage systems. Results are provided in figure 3.

**Bulk density analysis of tillage systems**

Carbon sequestration is one of the most important factors affecting agricultural lands. Carbon sequestration in soil profiles of different tillage systems depends on soil organic carbon content and bulk density of each depth. These two parameters have significant changes at different depths. The results of the three treatments are provided in Table 3.

**Table 3.** Comparison of the average percentage of the total organic carbon under different tillage systems using Duncan's at the level of 5%.

| Parameters / Treatments | Soil bulk density at the depth of 0-25 cm (%) | Soil bulk density at the depth of 25-40 cm (%) | Total soil bulk density at the two depths(%) |
|---|---|---|---|
| No tillage | 1.62a | 1.63a | 1.625a |
| Low tillage | 1.61a | 1.62a | 1.615a |
| Conventional Tillage | 1.62a | 1.61a | 1.615a |

The average of each column that contains at least one shared letter on the basis of Duncan's does not have a significant difference at the level of 5 %.

Depending on soil texture, soil bulk density ranges from 1.1 to 1.8 grams per cubic centimeter. Our results on the bulk density are consistent with Bayat*et al.* (2006), Azad Shahraky *et al.* (2010), in the lack of a significant effect of tillage systems on soil bulk density. Nevertheless, the results of Zakini *et al.* (2010), Heydari (2011) showed discrepancies.

**Analysis of tillage systems on soil erodibility indices**

Tillage systems with a variety of machines, different methods of implementation, the number of operations factors can cause changes in the physical properties of the soil. Soil erodibility depends on the chemical properties and significantly on the physical properties of soil. Tillage system and the type of soil texture affect soil aggregate stability as a physical property. Consequently, we can incorporate tillage systems in rates of soil erosion. Therefore, here, the effect of tillage systems and soil texture on the stability of soil aggregates is investigated.

**ANOVA results of mean weight diameter**

Because of the importance of the stability of soil aggregates on of the erodibility of soil surface, this parameter was evaluated only at the depth of 0-25 cm. The ANOVA results in Table (4) show the mean weight diameter at the depth of 0-25 cm under three tillage systems has no significant differences.

**Table 4.** Comparison of mean weight diameter under different tillage systems using Duncan's at the level of 5%

| Parameters / Treatments | MWD (mm) |
|---|---|
| No tillage | 1.55a |
| Low tillage | 1.6a |
| Conventional Tillage | 1.69a |

The average of each column that contains at least one shared letter on the basis of Duncan's does not have a significant difference at the level of 5%.

The results of this study, showed no significant differences in soil aggregate stability in three tillage systems. According to Table (5), comparison of aggregate stability shows better stability in the conventional system compared with theno and low tillage systems.

Soil aggregate stability is the most important soil physical properties affecting the movement and storage of water, aeration, soil erosion, soil biological activity and the development of effective products (Amezketa*et al.*, 2003). Aggregate stability results of previous studies indicate better conditions in low-tillage systems, especially the no tillage, compared with conventional tillage system. The reason for this is related to high levels of carbon in the no and low tillage systems.

Seta & Karathanasis (1996) showed that soil organic carbon does not have an effective role in soil aggregate stability, but the stability of soil aggregates is the results of the mixed effect of other factors. In addition, Boujila & Gallai (2008) showed that the activity of the calcium carbonate in the soil, changes organic matter effectiveness in shaping soil aggregate stability. With a high percentage of calcium carbonate the role of organic matter in soil stabilization is diminished.

**Analysis of the physical parameters of soil in tillage systems**

In order to determine the physical components of soil between treatments, the percentage of each of the parameters of clay, silt, and sand at a depth of 0-25 cm and 25-40 cm, as well as all the tillage systems were analyzed. The results indicate significant changes between the clay in the no tillage systems with low tillage and conventional tillage at 1 percent. It also indicates the absence of significant changes in the three tillage systems at the level of 5%. Sand percentage between tillage systems at the depth of 0-25 cm and 25-40 cm shows significant differences between. Results of Zangiabadi *et al.* (2005) showed that, with increasing clay content and decreasing the percentage of sand, erosion rate is considerably reduced. In the results of the soil texture analysis in the present study, a significant difference of 99% between the clay contents was observed between low tillage, conventional tillage and no tillage systems. The sand percentage at 95% had significant differences for the no tillage, conventional tillage and low tillage systems, and these differences can be seen in the Figure (1).

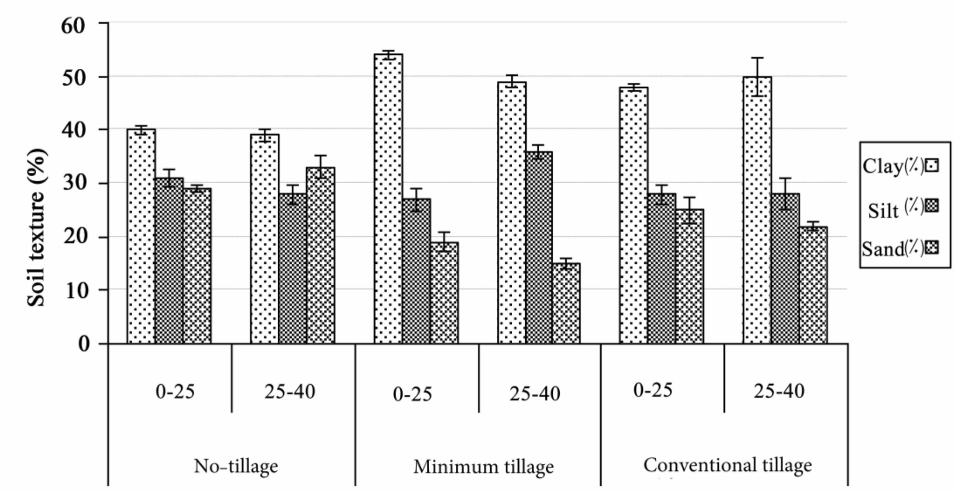


**Figure 1.** Physical parameters at the two depths of different soil tillage systems

Despite high levels of organic carbon in the no tillage system, differences in clay and sand in the soil textures of other tillage systems could be the reason for the decreased stability of soil aggregates. Instead, the conventional tillage with less organic carbon content had better soil aggregate stability.

## 3.Discussion and Conclusion

The aim of this study was to evaluate the effects of different tillage systems on soil organic matter and some indicators of erosion. In the first part of the discussion, the results of the organic matter, confirmed the assumption of greater ability of no tillage system in the accumulation of organic matter. As mentioned, no tillage system had higher levels of carbon at the depth of 0-25 cm, although this difference was not significant. However, in the low tillage system, organic carbon in the layer 25-40 cm layer was less than 0-25 cm. Low levels of organic carbon in the low tillage systems can be caused by mismanagement of the past years in the study area because the land underwent leveling operations about 15 years ago.

During this operation because of the indiscrimination of carbon-rich surface layer before leveling operations, layers poor in organic carbon displaced the surface layer. This leads to structural damage, and loss of soil organic carbon. Negative effects of mismanagement are so high that even after several years of conservation tillage and benefits associated with this system, soil fertility levels has not restored. No-tillage system compared to other tillage methods increased the total level of organic carbon in the soil, at the depth of 0-40 cm, significantly (at 5%).

In the second part of the discussion, the results fit the assumption of stable soil aggregates and reduced soil erosion in the system without soil tillage was rejected. In most studies, high levels of organic carbon in the soil due to no tillage operations have resulted in greater stability. However, a few results argue that organic carbon is not the only cause of high stability, but other factors such as calcium carbonate and texture are involved in this issue. In the reviewed studies, researches about the physical components of soil informed the increase of clay and decrease of sand and silt contents as contributing factors in soil erosion. The results showed no significant differences in terms of the stability of soil aggregates by means of mean weight diameter index between tillage systems. Nevertheless, it seemed stability in conventional tillage was better. The reason for this result is the highest level of interaction between clay and organic carbon in conventional tillage than other tillage systems. However, it should be noted that in the same textures, the no tillage systems are still effective to reduce erosion. The residuals left atop the soil surface under the no tillage system are effective barriers resistant to the direct impact of the raindrops as well as the effects of wind erosion. It also reduces the effect of radiation on the soil surface which helps to conserve soil moisture.

Based on the obtained results and considering the limitations of soil and water resources of the region to gain positive results, both in terms of execution and research, the following suggestions are mad:

- Offering incentives to farmers to replace conventional tillage with no tillage systems by providing subsidized inputs and consultation services
- Localization of the manufacturing chain of conservation tillage machineries
- In poor area of organic carbon, using no tillage methods rather than applying organic fertilizers, to increase soil organic carbon.
- Prior to any research on the effects of tillage systems, try as much as possible to acquire the history of land management.
- In addition to the factors examined in this study the effects of different tillage systems on crop yield and economic issues in the agricultural should be assessed.
- Assessment of the effects of tillage systems on physical and chemical properties for other crops.
- To obtain better results about the effects of tillage systems on soil stability, further research with the same texture and longer courses over four years is needed

- In order to prove the positive effects of tillage system, the impact on the environmental condition and management systems should be evaluated and compared.
- In order to evaluate the extent of tillage system without additional carbon sequestration, the long-term studies should be done in the area.

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