The effect of different cultivation methods on soil microbial respiration and organic C content as two main components for alleviating soil degradation

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Abstract
Conservation tillage systems (CTs) are expanding in different regions of Iran. On the other hand, study on tillage systems effects on chemical and biological properties of soil, which likely affect CO_2 flux rates to the atmosphere and organic C content (OC) is important. The objective of this study was to compare soil respiration (SR) rates and OC among different tillage systems. For this purpose, a four replicated experiment was carried out in Randomize Completely Block Design with seven treatments in a wheat field in Hashemabad Reaserch Center of Gorgan in 2010. The treatments were different cultivation methods including CT by Kombinate, No-tillage by Baldan grain drill, CT by Chizelpacker, CT by Delta model, surface tillage by heavy disk, non-incorporated by Chizel and disk and conventional tillage by moldboard plow and twice disk. SR and OC were measured during spring season in 0-15 cm depth in 3 stages. SR rates at the beginning of the season in different CTs ranged from 0.17-0.26 mg $CO_2.gr^{-1}soil.day^{-1}$. These values at the end of the season ranged from 0.02-0.05. Results showed SR rate was different in different stages. During time, SR rate reduced with decreasing moisture and increasing temperature. There was no difference among cultivation treatments in respect to SR rate. OC values were different among cultivation treatments. The most OC was related to no-tillage followed by CT Kombinate. The lowest OC was related to conventional tillage. Our results indicated that to maintain soil OC and improve soil biological activities, CT is an alternative option to prevent or alleviate soil degradation.
Keywords: Conservation tillage, Soil respiration, Soil degradation.

Introduction
Soil treatment systems influence the physical and chemical properties of soil as well as organisms that live there and thus change the soil itself (Mikanova et al., 2009). Measurements of soil CO_2 flux for different tillage treatments and cropping systemsare important for identifying management practices that may increase this flux and thus affect the global C balance. This flux, also referred to as soil respiration, is a function of microbial decomposition of organic C (Reicosky et al., 1997). However, the influence of soil tillage systems on the total soil organic matter content is detectable experimentally only after a long period of time. In opposite, microbial activity-based indicators of soil quality may respond to disturbances on a shorter period of time than those based on physical or chemical properties. It is widely accepted that soil management alters quantitatively and qualitatively microbial populations, leading to decreases in soil microbial properties that have been associated with tillage. One of the most widespread methods to determine microbial activity has been quantifying soil basal respiration. Soil CO_2 is produced as a result of most of soil microorganisms and its measurement has been proved to be a sensitive measure of soil microbial activity (Santos et al., 2008). Two basic reasons that initiated mentioned changes could be explained by ecological and economic factors. Conventional tillage is on the one side the most expensive, complicated, organisationally slow system and is significantly great energy and labour consumer, while on the other side it is also ecologically unfavourable way of soil tillage. ecological disadvantages of conventional soil tillage system are as follows: increasing of soil compaction induced by frequent machinery traffic over the same area, continuous decreasing of soil organic, greater erosion susceptibility of conventionally tilled soils and finally significant CO_2 emission as a greenhouse gas due to burning of great fossil fuel quantities required for doing that job. On the contrary, non-inversion soil tillage together with harvest residues incorporation, which makes the basic characteristic of conservation tillage system, recovers natural soil fertility being thus counterweight to anthropogenic soil compaction and exposing of soil to erosion (Kasutic et al., 2005). Conservation tillage practices can minimize the rapid breakdown of plant residues, reduce CO_2 emission, and reduce the production of inorganic dissolved nitrogen (nitrate and ammonium)

in soil (Al-kaisi, 2008). Also, lead to improvement of soil properties, increases water infiltration and retention, savings of time, energy and water, and wind erosion control (Madejon et al., 2009; Pisante, 2000). Tillage methods vary widely depending on climate and soil type, crop management objectives, availability of technology, tradition and the personal preference of farmers (Paustian et al, 2000). Soil organic matter is considered the single most important indicator of soil quality. It is important in maintaining soil tilth, aiding the diffusion of air and the retention and infiltration of water and reducing soil erosion controlling. However, many factors that change SOM levels are controlled by management. These include choice of cropping, management of crop residues and methods and intensity of soil tillage (Bessam and Mrabet, 2003). The aims of the study were to determine the effects of different cultivation methods on soil microbial respiration and organic C content as two main components for alleviating soil degradation.

Material and Methods

This experiment was carried out in a wheat field in Hashemabad Reaserch Center of Gorgan in 2010. Seven tillage treatments were arranged in a randomized complete block design with four replications. Cultivation methods, are follows: conservation tillage by Kombinate, no-tillage by Baldan grain drill, conservation tillage by Chizelpacker, conservation tillage by Delta model, surface tillage by heavy disk, non-incorporated by Chizel plow and disk and conventional tillage by moldboard plow and twice disk. Plots size were 25×12 m. Soil texture Was silt clay loam. The following soil analyses were conducted: organic C (Nelson, 1982) and soil respiration (Stotzky, 1965). soil samples was done during spring season of 0-15 cm depth. Soil respiration and Organic C content was measured at stem elongation, pollination and physiological maturity stages.
Statistical analyses for all data were performed using SAS software (Soltani, 2007). Mean comparisons were carried out using the LSD test at the 0.05 significance level.

Results

Analysis of variance showed the effects of different tillage systems on soil respiration rate wasnot significant (Table 1).

Table 1. Analysis of variance on soil respiration (mg $CO_2.gr^{-1}soil.day^{-1}$) and organic C (%) in seven treatments (conservation tillage by Kombinate, no-tillage, conservation tillage by Chizelpacker, conservation tillage by Delta model, surface tillage, non-incorporated by Chizel and conventional tillage) in three stages (stem elongation, pollination and physiological maturity).

		Soil Respiration			Organic C (%)		
		F value			mean of squares		
Source of Variation	Degree of freedom	stem elongation	pollination	physiological maturity	stem elongation	pollination	physiological maturity
Block	3	1.39^{ns}	0.39^{ns}	3.49^{ns}	0.06^{ns}	0.02^{ns}	0.006^{ns}
Cultivation Methods	6	1.20^{ns}	0.48^{ns}	1.48^{ns}	0.64^{**}	0.07^{**}	0.105^{**}
Error	18				0.03	0.01	0.007

** and ns, significant at %1 of probability level and nonsignificant, respectively.

Soil respiration rate was reduced during time. In all cultivation methods, the most and the least soil respiration rate was related to first stage (stem elongation stage) and third stage (physiological maturity), respectively. In the beginning of the season, mean soil respiration in conservation tillage by Kombinate, no-tillage by Baldan grain drill, conservation tillage by Chizelpacker, conservation tillage by Delta model, surface tillage by heavy disk, non-incorporated by Chizel plow and disk and conventional tillage by moldboard plow and twice disk were equivalent to 0.18, 0.26, 0.17, 0.24, 0.18, 0.22 and 0.22 mg $CO_2.gr^{-1}soil.day^{-1}$, respectively. These values at the end of the season were 0.02, 0.03, 0.04, 0.04, 0.05, 0.03 and 0.3 $mgCO_2.gr^{-1}soil.day^{-1}$, respectively (Fig. 1).

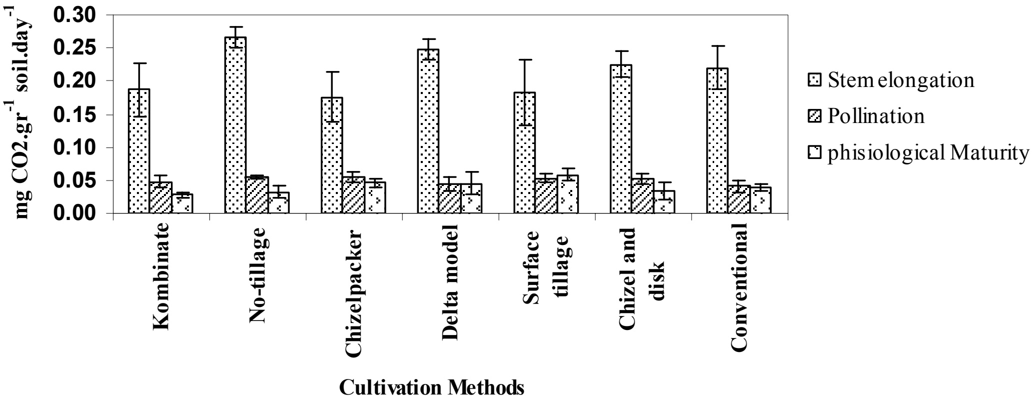

Fig 1. soil respiration (mg CO_2.gr^{-1}soil.day^{-1}) in seven treatment (conservation tillage by Kombinate, no-tillage, conservation tillage by Chizelpacker, conservation tillage by Delta model, surface tillage, non-incorporated by Chizel and disk and conventional tillage) in three stages (stem elongation, pollination and physiological maturity).

Organic C content values in the 0-15 cm soil layer was differented among tillage methods (Table 1). Organic C content was decreased during time in spring. In first stage the most Organic C were related to no-tillage and Conservation tillage by Kombinate. The lowest Organic C was related to conservation tillage by Chizelpacker.

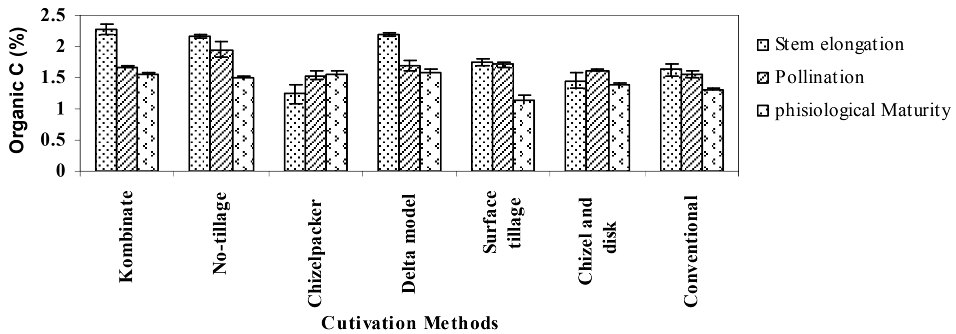

Fig 2. organic C (%) in seven treatment (conservation tillage by Kombinate, no-tillage, conservation tillage by Chizelpacker, conservation tillage by Delta model, surface tillage, non-incorporated by Chizel and disk and conventional tillage) in three stages (stem elongation, pollination and physiological maturity).

Discussion

The relatively hight content of organic C in No-tillage, conservation tillage by Kombinate and conservation tillage by Delta model might be explained by the high amount of plant residues left on the field plots. Also, elimination of soil disturbance under No-tillage system leads to the increase of organic C at the soil surface. In these systems, plant residues can induce soil microorganisms and lead to increase of soil respiration. Less storage of C under conventional tillage can be explained by the high oxidation rates, release of organic compounds in solution. In No-tillage system at least 90% and in conservation tillage by Kombinate and conservation tillage by Delta model at least 30% of the soil surface covered by residue after planting, resulted in more comparable organic C was than other methods. Soil respiration reduced during time. Decrease of the microbial respiration may be caused by the relatively hight rainfalls in the beginning of the spring season, which the soil was quite wet and at the end of the season be resulted from increasing temperature and decreasing rainfall, which the soil was quite dry. rainfalls would provide better conditions for microorganisms activity. Resulting decreased humidity and increased temperature caused reducing trend in the microbial respiration rate. Climatic factores including temperature and humidity can be determined the amount of organic matter and microbial activity in soil. Alzugaray et al. (2008) expressed that the level of respiration depends on humidity and edaphic temperature, which in turn depend on the cultural management of soil that also influence its fauna. Lehocka et al. (2009) reported that the quantity of soil organic C in the whole topsoil varies due to the interacting influences of climate, topography, soil type and crop management history (fertilizer use, tillage, rotation and time). In conservation tillage, soil organic C and microbiological activity are stratified in the soil profile, according to the burial depth of crop residues and manures. The soil respiration is related to the most labile pools of organic matter and it serves as an important reservoir of plant nutrients. Microbial activity increased in conservation compared with conventional tillage. Soil erosion and degradation interrupt it's function. Even, minor disorders by machinery, chemical inputs applications and other affecting factors which influence the soil negatively could fail microorganism functions (Kamkar and MahdaviDamghani, 2008). Plowing can bury plant residues and destruct soil structure and as a result of soil erosion, soil erosion can reduce soil fertility and causes lack of available nutrients reduce soil biological activity. Kamkar and MahdaviDamghani (2008) reported that consequenced by the most important factor in controlling erosion on arable lands is protecting the soil by plant or its residue and the degree of surface roughness. Al-kaisi (2008) in his study on impact of tillage and crop rotation systems on soil carbon sequestration expressed that improper soil and residue management results in increased erosion by water and wind. Soil erosion is a leading cause of soil degradation due to the loss of organic matter, which is the "glue" or binding factor in soil. The most effective way to minimize soil erosion is through the use of conservation tillage practices. The impact of no-tillage practices in improving soil quality in terms of carbon content at the upper part of the soil profile is evident where permanent vegetation has been established in grassy areas. Tillage can cause the loss of significant amounts of carbon (lost as CO_2 bursts) immediately after tillage. The exposure of soil organic carbon to aeration during soil erosion increases CO_2 emissions. In addition, soil erosion can cause carbon to accumulate with soil sediments and be removed from the soil carbon pool. The removal of carbon from the soil will lead to a decline in soil fertility and aggregate stability. Longterm experiments and long term monitoring are necessary methods for achieving the best tillage systems in order to improve agronomical, economical and environmental aspects and maintain a productive and sustainable agriculture.Our results indicated that to maintain soil organic C with reducing tillage and retaining crop residue and improve soil biological activities, in soil management in sustainable agriculture is one of the goals that conservation tillage can be achieved in this important and prevent or alleviate soil degradation.

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