EFFECT OF TILLAGE ON CARBON AND NITROGEN SEQUESTRATION IN SOILS

By

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DEDICATION

To my dear father (Abdaldim),
To my dear mother (Siham),
To my brothers and sisters,
To my sister's daughter (Zaineb),
To my friend (Elwathig),
To sons and daughters of my aunt,
To all whom I love
Ibrahim

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Abstract

Loss of soil organic matter (SOM) has been associated with increased tillage intensity. To investigate the effect of tillage on soil organic carbon (O.C) and total nitrogen (T.N) sequestration and hydraulic conductivity (H.C) two sites were selected for this study, the first site (Elselete North) was conventionally cultivated (sub- soiler, smoothing by disk harrow, leveling and ridging) and was compared with grassland (G.L) (control). The second site (Elgrouf Shambat) was traditionally cultivated (plough drawn by animal) and similarly compared with grassland (G.L) (control). Soil samples were taken from profiles at an interval of 7.5 cm to a depth of 30 cm.

Across all soil depths, content O.C reported in traditional tillage (T.T) were significantly ($P \leq 0.017 - 0.004$) higher than that of conventional tillage (C.T), while tillage showed no significant differences in T.N content.

In the 0 – 7.5cm soil depth, tillage had no effect on T.N and H.C, while O.C determined in T.T (14.82 gkg^{-1}) was significantly ($P \leq 0.017$) higher than that of C.T (9.26 gkg^{-1}). In the 7.5-15 cm depth, H.C in T.T (0.250cm/min) was significantly ($P \leq 0.05$) higher than that of C.T (0.038 cm/min). In this depth (7.5-15cm), O.C in T.T (14.56 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of C.T (8.58 gkg^{-1}).

In the third depth (15-22.5cm), O.C in T.T (15.08 gkg^{-1}) was significantly ($P \leq 0.01$) higher than that of C.T (7.28 gkg^{-1}), and in the same depth T.N in G.L (0.37 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of C.T (0.19 gkg^{-1}).

In the lower soil depth (22.5-30cm), O.C in T.T (14.82 gkg^{-1}) was significantly ($P \leq 0.004$) higher than that of C.T (7.89 gkg^{-1}), and in the same depth O.C in G.L (16.9 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of T.T (14.82 gkg^{-1}), similarly, T.N in the T.T (0.42 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of G.L (0.23 gkg^{-1}). H.C in the G.L (0.068cm/min) was significantly ($P \leq 0.05$) higher than that of C.T (0.016cm/min).

Modeling O.C of C.T and T.T showed that it was best fitted to the exponential model (R^2 = 40%), while T.N was best fitted to the logarithmic model (R^2 = 89%) followed by the liner model (R^2 = 84%).

خلاصة الأطروحة

فقدان المواد العضوية بالتربة دائما يرافق الزيادة في كميات الحراثة. للتحقق من اثر الحراثة على تخزين الكربون العضوي والنيتروجين الكلى بالتربة وكذلك التوصيل الهيدروليكي فقد تم اختيار موقعين لإجراء هذه الدراسة. تمت حراثة الموقع الأول (السليت شمال) عرفيا بواسطة محراث تحت التربة, ثم أجريت عملية تنعيم بواسطة المشط القرصي, تلتها عملية تسوية وتسريب بواسطة الآلة وذلك مقارنًة مع ارض غير محروثة (تحت غطاء نباتي) كشاهد. تمت حراثة الموقع الثاني (الجروف –شمبات) تقليديا بواسطة محراث بلدي مجرور بواسطة الحيوان ومقارنتها أيضا بأرض غير محروثة (تحت غطاء نباتي) كشاهد. أخذت عينات من قطاعات تربية من العمق 30 سم لكل مسافة 7.5 سم على حدة.

لكل الأعماق فقد وضح أن محتوى التربة للكربون العضوي في الحراثة التقليدية كان اكثر معنوية ($P \le 0.017 – 0.004$)ً مما في الحراثة العرفية, بينما لم تظهر الحراثة أي فروقات معنوية بالنسبة لمحتوى التربة للنيتروجين الكلى.

في العمق (صفر-7.5) لم يكن للحراثة أي تأثير على النيتروجين الكلى والكربون العضوي, بينما كان الكربون العضوي المحسوب بالنسبة للحراثة التقليدية (14.82 جم/كجم) اكثر معنوية ($P\le 0.017$) من ذلك المحسوب في الحراثة العرفية (9.26 جم /كجم).

في عمق التربة (7.5-15سم) كانت قيمة التوصيل الهيدروليكي بالنسبة للحراثة التقليدية (0.025 سم/الدقيقة) اكثر معنوية ($P\leq 0.05$) من تلك التي في الحراثة العرفية (.038 سم/الدقيقة), ولذات العمق كان محتوى الكربون العضوي للحراثة التقليدية (14.56جم/كجم) اكثر معنوية($P\leq 0.05$) مما في الحراثة العرفية (8.58جم/كجم).

في العمق الثالث (15-22.5سم) سجل الكربون العضوي للحراثة التقليدية (15.08جم/كجم) قيمة اكثر معنوية ($P\leq 0.01$) مما في الحراثة العرفية (7.28جم/كجم), ولنفس العمق كانت قيمة النيتروجين الكلى في الأرض تحت الغطاء النباتي (0.37جم/كجم) اكثر معنوية ($P\leq 0.05$) مما هي عليه في الأرض تحت الحراثة العرفية (0.19 جم/كجم).

في أدنى عمق (22.5- 30سم) كانت قيمة الكربون العضوي بالنسبة للحراثة التقليدية

التقليدية

(14.82جم/كجم) اكثر معنوية ($P\leq 0.004$) مما في الحراثة العرفية (7.89جم/كجم)، وكانت قيمة الكربون العضوي لذات العمق في الأرض تحت الغطاء النباتي (16.9جم/كجم) اكثر معنوية ($P\leq 0.05$) من تلك التي تمت حراثتها تقليدياً (14.82جم/كجم), وبنفس القدر كانت قيمة النيتروجين الكلى للحراثة التقليدية (0.42جم/كجم) اكثر معنوية ($P\leq 0.05$) من تلك التي وجدت في الأرض تحت الغطاء النباتي (0.23جم/كجم). كانت أيضا قيمة التوصيل الهيدروليكي في ذات العمق للأرض تحت الغطاء النباتي (0.068 سم/الدقيقة) اكثر معنوية ($P\leq 0.05$) من تلك التي وجدت في الحراثة العرفية (0.016 سم/الدقيقة).

اظهر نموذج الكربون العضوي للحراثة التقليدية والعرفية انه كان اكثر ملائمةً للنموذج الأسى R2 = (40%), بينما النيتروجين الكلى كان اكثر ملائمةً للنموذج اللوغريثمى R2 = (89%) متبوعاً بالنموذج الخطى R2 = (84%).

CHAPTER ONE

INTRODUCTION

Soil quality is defined as the capacity of a specific kind of soil to function, within natural or managed eco-system bundaries, to sustain plant and animal productively, maintain or enhance water and air quality and support human health and habitation (Karlen *et al.*, 1997).

Loss of soil organic matter (SOM) has been associated with increased tillage intensity. However, SOM loss due to tillage can be expected to be a function of soil type, climate and cropping practice (Lal *et al.*, 1998). Increased intensity of tillage can increase short–term Co^{2} flux from soils of semi arid (Ellert and Janzen, 1999) and sub humid (Reicosky and lindstrom, 1993) agricultural production systems. The impact of these tillage induced fluxes of Co^{2} on atmosphere Co^{2} concentration or C retention is uncertain. This ultimately add to the gases that contribute to global warming. Contradictory to these findings, Mubark *et al.*, (2004) concluded that, in heavy textured soils, tillage might not be a constant.

A better understanding of soil organic matter is vital for development of effective soil conservation practices. Different management systems imposed different C and N in the stock in the soil profile in the tropical agricultural ecosystem (Manjaiah *et al.*, 2000).

Recent concern for global climate change, however, re emphasizes the importance of conservation tillage and how it can be implemented in many soils to help reduce C losses and hence increase soil C sequestration .While tillage and cultivation generally result in loss of soil C and nitrogen when grasslands or forest levels are changed to arable lands (Mann, 1986).

Conservation tillage has proved to have the potential for converting many soils from source to sinks of atmospheric C (Kern & Jonson, 1993).

In this context, acritism of recent developments in the soil concept has been aimed at more clearly defining the role of soil organic matter towards increasing agricultural productivity and environment quality (Sojka and up church, 1999).

Reicosky, (2000) concluded that large Co^2 loss differences between plowed and No-tilled treatments reflect need for improved soil management and policies favoring conservation tillage to enable carbon sequestration in agricultural production systems.

Globally, (Lal *et al*., 1998) estimated that wide spread adaptation of conservation tillage on some 400 million ha of crop land by year the 2020 may lead to total C sequestration of 1500 to 4900 Mg.

Since Sudan's soils are known for their poor organic content, the area of cultivated organic soil was estimated as area of soil with less than 1% organic matter (NFC and FAO. 2003). However, most agricultural soils in Sudan are fine textured soils that have a greater potential for gains in soil organic carbon as reported in else where arid regions (Mc Conkey *et al*., 2003). The evaluation of changes in SOM and N content due to land use and management is needed to identify adequate strategies to increase agricultural production without soil degradation and without increasing emission of green house gases (Co_2, Co, N_2o, and NH_4). Therefore, the main objectives of this study were to evaluate the effect of different management systems on soil quality measured as some chemical and physical properties. This is to determine the land management systems that increase soil C and N storage.

The specific objectives were to determine the followings:

1. Determination of organic carbon content and total nitrogen storage in the soil profile.
2. Determination of hydraulic conductivity.

It is hypothesized that different farming systems have different potential to store (sequester C and N). These studies of C and N dynamics lead to the understanding of the factors that affect the inputs to and outputs from soils and how these might be manipulated to enhance C sequestration, since loss of soil organic matter (SOM) has been associated with increased tillage.

CHAPTER TWO
LITERATURE REVIEW

2.1 Tillage and sustainability of soil fertility:

Sustainable agriculture was defined as a practice that involves the successful management of resources for agriculture to satisfy human needs, while maintaining or enhancing the quality of the environment and conserving natural resources. (FAO, 1989).

Contents of SOM are one of the more useful indicators of soil quality that improves sustainability of the cropping system (Revees, 1997). This is because it improves the soil physical, chemical and biological conditions (Hudson, 1994)

It has been well documented that the cultivation of soils resulted in structural degradation and decreased soil organic matter (SOM).In this context, Oades (1993) stated that repeated cultivation of soils, combined with limited SOM inputs, well eventually results in major aggregate break down leaving the soil vulnerable to erosion, decomposition and compacting.

Many farming practices such as follows, burning, or removing crop residues, and conventional practices remove organic matter form the soil.(Karlen and Cambarella 1996) suggested that changing management to systems such as reduced and no till practices, residue retention, the use of green manure crops and pasture leys, or the application of organic materials resulted in numerous beneficial effects on soil physical, biological and chemical fertility. However, these processes may take as long as 100 years to reach soils maximum carbon storage (Bruce *et al*., 1998).

2.2 Importance of tillage:

Tillage was earlier defined by Hillel (1969) and Culping (1976) as the mechanical manipulation of the soil aimed at improving soil conditions affecting crop production, whereas, Kraus and Lorenz (1984) made an emphasis on the influence of tillage on the biological and chemical characteristic of soil.

Earlier, Marshal and Holmes (1985) suggested that, tillage is a mechanical soil stirring actions carried on for the preparation of the soil for planting and also the process of Keeping the soil loose and free from weed during the growth of the crops.

Also, it can be defined as the mechanical manipulation of soil for any purpose but in agriculture the term is usually restricted to the changing of soil conditions for crop production (ASAE, 1980).

Lal (1983) defined tillage as physical, chemical or biological soil manipulation to optimize condition for germination seedling establishment and crop growth.

In addition, appropriate tillage practices are those that avoid the degradation of soil properties but maintain crop yield as well as ecosystem stability (Lal, 1981).

Moreover, FAO (1984) defined tillage as the operation of the implements through the soil to prepare seed bed, root bed, control weed, aerate soil and break down of organic matter and minerals to release plant nutrient.

2. 2 .1 Objectives:

Culping (1981) divided the main objectives of tillage as follows:

1. Production of suitable tilth or soil structure.
2. Control of moisture.

3. Burning or cleaning of rubbish and the incorporation of fertilizers into the soil.

Whereas Paul and Metzner (1975) reported the following disadvantage of tillage:

1. The loss of organic matter from most fertile virgin soil.
2. The destruction of plant roots during cultivation.
3. The baring of the soil surface allowing more erosion and soil crusting.
4. The deterioration of soil aggregation.
5. Formation of hard pan by the ploughing of the land at the same depth for many years.

2.3 C Sequestration:

Historical losses of soil organic carbon have been associated with low biomass production level, intensive tillage, in adequate use of fertilizers and organic amendment, removal of crop residue and biomass burning, and lake of soil protection against erosion and other degradative processes (Cole *et al*., 1993; Lal, 1995).

The transfer of atmospheric C to biologically active form in the soil. Sequestration of organic C in previously degraded soils is necessary not only to improve the physical , chemical and biological properties of soils (Follett *et al*., 1987) but also to help mitigate potential greenhouse gas (GHG) effects from rising atmospheric Co_2 level (Lal *et al* , 1998).

Several processes can affect the storage of carbon in soils. This amount of stored in the soil system depends on the rate and magnitude of the process. These processes can be influenced by agriculture management systems and practices (Fenton *et al*., 1999).

In this respect, Reicosky, (2000) concluded that differences in Co_2 losses to the atmosphere between plowed and no–tilled treatments reflect need for improved soil management and policies favoring conservation tillage to enable carbon sequestration in agricultural production systems.

Lal *et al*., (1998) estimated that wide spread adoption of conservation tillage on some 400 million ha of crop land by the year 2020 may lead to total sequestration of 1500 to 4900 Mg.

2.4 Conservation tillage:

2.4.1 Definition:

Conservation tillage is a practice that retains at least 30% cover of crop residues on the soil surface after planting (Lal, 1983). Conservation tillage practices the best opportunity for halting degradation of organic matter and for restoring and improving soil productivity (Parr *et al*., 1990).

The primary reason for the promotion and adoption of conservation tillage in many regions is to control erosion tillage which results not only from relatively aggressive tillage operation such as moldboard and chisel passes, but also from secondary operations which contribute significantly to soil displacement (Muysen and Gover, 2002).

Carter and Sanderson (2001) reported that, conservation tillage significantly increased the content of organic carbon due to absence of excess tillage farming systems.

Conservation agriculture also contributes to wider environmental Benefits (Cited by FAO, 2001). Such as:

a- Improved management of soil and water resources from farm to water shed levels: less flooding, less erosion, less desertification, more constant flow in the rivers, better recharge of ground water resources, improved water quality (less pollution) and reduced siltation effects down stream.

b- Increased carbon sequestration and less carbon release (less fuel used less organic matter degradation).

c- Increased biodiversity through diversification.

2.5 Management and soil tillage:

2.5.1 No–tillage and reduced tillage:

No–till is at least a reduction, and for many the complete elimination of tillage from the farming system and as such is a central principle and practice of conservation agriculture. Also termed zero till or direct drilling, NT is defined as a procedure of planting primary (cash) crops or cover crops directly into the soil without primary or secondary tillage (Des and Geoff, 2003).

A study by Campell *et al*., (1991) had shown that both rotation with legumes and reduced tillage practices can maintain or even decrease the amount and the quantity of organic matter in soil.

No tillage has been proposed as an alternative to conventionalizing cropping systems for reducing soil degradation. It generally, leads to increase of C in the top 5-10 cm of soil profile relative to plowed soil (Al Varez *et al*., 1998). Within the entire plow layer, however, organic C content under no–tillage may be higher (Al varez *et al*., 1998).

Soil organic carbon distribution due to residue management practices, and the effect on total C mass is not well understood, especially in warm regions.

Potter *et al*, (1998) found that, no–tillage management resulted in increased soil organic carbon concentration and mass in the surface 0.07m in comparison to more intensive tillage management e.g. sweep, chisel plough and moldboard plow.

No - till or reduced tillage systems have shown to increase SOC content of the soil layer as a result of various interaction factors, such as increase residue returns, les mixing and soil disturbance, higher soil moisture content, reduce surface soil temperature, proliferation of root growth and biological activity and decreased risk of soil erosion (Lal, 1989; Belvins and Frye, 1993).

Several studies (Unger *et al.*, 1998 ; Parr *et al.*, 1990) reported the success of no tillage system in many part of U. S. A. under no–tillage to increase soil total organic carbon and total nitrogen concentration occurred when compared with conventional tillage.

Another study by (Bayer *et al*,. 2000) showed that no tillage system increase the total organic carbon and nitrogen content in the soil due to the increased amount of retained undisturbed plant residues.

Rates of C accumulation in the soil profile under no–tillage or conservation tillage were reported to vary widely, ranging from below 0 to 1300 $kgha^{-1}$ yr^{-1} (Reciosky *et al.*, 1995).

According to Pin Wang *et al.*, (2000) no tillage improved soil quality and helped to store carbon in soil, thus partially alleviating Co_2 build up in the atmosphere and can reduce the contributor to global warming phenomenon.

Changes in soil organic matter (SOM) pools during adoption of reduced (RT) or zero tillage can influence soil physical properties, nutrient cycling, and Co_2 flux between soil and atmosphere.

Zero tillage management reduces soil exposure and disturbance and therefore, may improve soil aggregation and organic matter sequestration under some environments (Franzlubbers and Arshad., 1996).

There has been a trend towards increased cropping intensity and decreased tillage intensity in the semi - arid region of the Canadian prairies. The impact of these changes on sequestration of atmospheric Co_2 in soil organic carbon (C) is uncertain.

Francis *et al*., (1997) concluded that intensification of cropping practices by elimination of fallow and moving toward continuous cropping is the first step toward increased C sequestration.

In a number of experiments conducted in humid regions , zero tillage increased soil organic C by average of 3Mg ha^{-1} and by as much as 10Mgha^{-1} compared with conventional tillage with mold board plow (Paustian *et al*.,1997). However, differences in soil organic C between conventional and zero tillage systems in semi arid regions are generally small because conventional tillage is less intensive and shallower than in humid regions. (Bauer and Black, 1981, Granalstein *et al*., 1987, Unger, 1991).

In western Canada, Campbell *et al*., (1995) reported that over a 12–year period, a continuous spring wheat system under zero tillage gained about 1.5 mg ha^{-1} more C in the 0-15 cm soil depth than continuous wheat system under conventional tillage (heavy–duty) sweep cultivator. In a spring wheat–fallow system, the gain under zero tillage was only about 0.5 mgha^{-1}.

In another study, Campbell *et al*., (1996) reported that neither tillage nor fallow frequency influenced C sequestration in the top 15cm of a fine sandy loam soil over an ll–year period. They all attributed this to the failure of the tillage or fallow frequency treatments to influence manual crop residue productions in this semi arid climate.

2.5.2 Grassland:

Pasture management is of importance for understanding of agronomic and animal productivity, soil quality, green house gases emissions and environmental quality. Pastures have the potential to serve as a significant sink for carbon (C) sequestrated in soil organic matter.

Alan *et al*., (2002) reported that cattle grazing shunted C and N more directly from forage to the soil, which contributed to greater sequestration of soil organic C and total soil N than with haying or unharvested management.

They also reported that In contrast to result from more arid regions, our results from the humid region of the south eastern U.S.A suggest that well managed cattle grazing systems can improve soil quality and enhance soil C sequestration, while maintain high animal productivity.

In support to this study Franzulebbes *et al*., (2000) found that Grazing of forage crop compared with haying returns much of the manure directly to the land with positive impact on soil organic C and N accumulation.

Angers *et al*., (2000) found that the use of combination of conservation practice involving chisel plowing, forage crops rotation and liquid dairy manure resulted in a C sequestration rate of 222kg Cm^{-2} yr^{-1}. They also stated that moldboard plow soil showed greater C accumulation than chisel plowed soils in the 20– 40 cm layer.

Linden *et al.* (2000) estimated the contribution of the non–harvested corn materials (crown, roots, and root exudates) to the SOC pool under both residue–removal and residue–returns. They found that no - tillage systems retained 24% of the available source carbon in the SOC pool of the top 30 cm of soil. While chisel and moldboard plow retained 14% and 12%, respectively. Hence significant changes in total SOC stored within the top 30 cm of soil occurred only because of the large carbon retention under no–till.

Most of the SOM loss was due to high biological oxidation and absence of C input during the fallow year rather than resulting from erosion. Also, decreasing tillage intensity reduced SOM loss but the effect was as dramatic as elimination summer–fallow. Crop management practices such as N fertilizer increased residue production and improved C and N levels in soils. Soil organic matter can be retained or increased in most semi–arid soil if they are cropped every year, crop residues are returned to soil and erosion kept to minimum. (Rasmussen *et al*., 1998).

2.5.3 Conventional tillage:

These involve the mechanical soil manipulation of an entire field by plowing followed by one or more harrowing, the degree of soil disturbance depends on the type of implement used, the number of passes, soil and intended crop type (Opara - Nadia, 1990).

Agricultural practices, such as tillage intensity and rotation, might contract the declining C sequestration in semiarid soils and thus help alleviate the trend towards increasing concentrations of Co_2 in the atmosphere.

Soil tillage practices are of particular significant to the soil C status because they affect C dynamics directly and in directly. Tillage practices which invert or considerably disturb the soil surface reduce SOC (Lal, 1984; Lal, 1989).

Soil organic C levels following long–term cultivation have been reported to be as low as 30% of pre cultivation levels (Giddens, 1957).

(Tiessen *et al.*, 1992) reported that in a semiarid tropical oxisol in Ararip (NE Brazil) it was observed that 30% of the SOC was lost within six years of adoption of mechanized cultivation.

Soil organic C is sensitive to tillage. The content of SOC in the 0-15 cm layer in the annually tilled by moldboard and chisel plough decreased slightly with years (Clapp *et al.*, 2000).

Tillage practices hade significant negative effect on soil organic carbon. In the top soil layer (0-7.5 cm), organic carbon content was 20% higher in the conventional and no-tillage than in moldboard plows. In the second soil layer (7.5-15) the organic carbon content under conventional plowing was 18% higher than in moldboard plow and 8% higher than no– tillage. Compared with the conventional mold board plow, reducing tillage depth and intensity can result in both reduction of organic matter (Loss by oxidation) and erosion (Doran. 1980).

Influence of different tillage techniques on- top soil (0- 10 cm) organic matter content was studies by Riezebos and Loerts (1998). Their study showed that, the transition from forest to agricultural use had lead to significant decrease of organic matter in the topsoil. Prior to deforestation SOM was 2.09% and 2.42%. Afterwards, it decreased to 1.59% when the soil was cultivated conventionally. Mechanically tilled fields appear to have more rapid decline in organic matter than manually tilled fields (1.59% vs. 1.89%) suggestion more sever soil degradation. A transition from conventional tillage (using a heavy disk plough and harrow) to no-tillage leads initially to a lower organic matter content of 1.45%. After 10 years a transition like this appears to result in benefits in terms of an increase in soil organic matter content.

Wilkins and Albercht *et al*., (2000) conducted an experiment to determine the effect of tillage and fallow on SOC. The result showed that SOC continued to decline in conventional winter wheat/fallow with intensive tillage system, and elimination of tillage or fallow reduced the rate of SOC loss. It was suggested that system based in no–till without a fallow year in the rotation offer the greatest potential for biological sustainability because they maintain or improve soil organic carbon and overall soil quality.

2.5.4 Traditional tillage:

In the humid and sub humid regions of west Africa and in some parts of south America, traditional tillage is practiced mostly by manual labour, using native tools which are generally few and simple, the important tools are being the cutlass and hoe which come in many designs depending on their function .

However, to facilitate seed bed preparation and planting, forests seeding under growth or grass are cleaned with cutlass while trees and shrubs left. Pruned the cut biomass and residues are disposed off by burning in situ. Such type of cleaning is non- exhaustive, leaving both appreciable cover on the soil and the root system which gives the top soil structural stability for one or two year (Aina *et al.*, 1991).

Onjeniy and Dekayode (1999) found that manual heaping and ridging maintained higher values of soil organic carbon, P, K, Ca and Mg and higher cowpea and maize yield compared to ploughing plus harrowing treatments. It is concluded that zero tillage and annual heaping or ridging could substitute for mechanized tillage method on Alfisol in rain forest zones without significant loss in yield of cowpea and maize and soil fertility.

2.6 Factors affecting soil quality:

The soil quality concept has recognized soil organic matter as an important attributes that has a great deal of control on many of the key soil function (Doran and Parkin, 1994).

The indicator of soil quality should give some measure of the capacity of the soil to function with respect to plant and biological productivity, environment quality , human and animal health. They should also be used to assess the changes in soil function with land use or eco system boundaries (Seybold *etal*, 1997).

Soil organic matter dynamics are driven by climate, soil type and land use management. These factors interact to determine the physical, chemical and biological control of SOM. Reducing C loss due to erosion may enhance the storage of soil organic C in tropical areas (Albrecht *et al.*,1992).

Land use and culture practices influence some storage and loss in many ways e.g. in the tropics, soil organic C content under annual crops was approximately 60% of that under natural vegetation with new equilibrium generally reached in 3 to 10 years (Feller and Bear, 1997).

Most researches on soil organic matter are however, conducted in temperate regions of different soil mineralogy and climate compared to the tropics. The rate of increase in soil organic carbon pools is likely to be lower in the tropics than temperate regions, and may range from 50 to 25 kg ha–$^{-1}$years^{-1} in arid and semi- arid tropics and from 300 to 600 kg ha–$^{-1}$years^{-1} in the sub humid and humid – tropics (Lal, 2000).

Loss of soil organic C is indirectly influence by temperature through the direct effect of temperature on decomposition rate.

Soil organic matter (SOM) content is universally recognized as an important indicator of soil quality. Maintaining satisfactory SOM level is important to all the three aspect of soil quality, physical, chemical and biological soil organisms which performs important functions in the soil, including structure improvement, nutrient cycling and organic matter decomposition. In this context, Kladivko (2001) stated that tillage systems affect the soil physical and chemical environment in which soil organism live, thereby, affecting soil organisms. This is because, tillage practice change soil water content, temperature, aeration and the degree of mixing of crop residues within the soil matrix thereby changing the physical environment and the food supply of the organism which affect different groups of organisms in different ways.

Stoiney, (1978) reported that, the chemical properties of the soil will changes as a result of human impact, such as continuous cultivation, mechanical and annual clearing and burning of forest, therefore such soils require considerable addition of input to maintains it's fertility, and hence it's production capacity.

They also found that intensive crop production lead to deterioration of physical properties as well as chemical property of the soil, and eventually the soil become difficult to manage.

As a major attribute of soil quality, organic matter is responsive to agricultural land practices including tillage. A study was initiated by Carter *et al.*, (1998) in eastern Canada to characterize changes in the content of organic C and total N, and organic matter fraction in forested and adjacent cultivated or forage sites. Generally, the cultivated and forage sites had denser soil profiles than the forest sites.

Organic carbon in the light fraction was relatively large (19% in the top–soil of forest soils but it was decreased up to 70%) by cultivation.

2.7 Soil organic matter:

Soil organic matter includes remains of animals and plant, which decompose in the soil due to the action of micro–organism that changes it to humus. The more humus is present, the more the soil is fertile and the darker is its colour (Holm, 1982).

The emmition of carbon dioxide to the atmosphere is related to mineralization and decomposition processes of soil organic matter by micro-organism (Lal, 1999). The emisition from the soil increased by ploughing, mixing crop residues and other biomass into the soil surface and burning of biomass.

Studies in southern Brazil show an increase in organic carbon in the soil under conservation agriculture. The different cover crops showed significant effect on organic carbon level for two depths

(0-5 cm and 5-15 cm). The means of all winter cover crops presented greater values for soil organic carbon than follow at both depths (Calagari and Alexender, 1998).

During the initial until establishment of the cropping system the increase in total organic carbon content was restricted to only the surface layer of the soil (0-2.5cm) (Testa *et al*., 1992). With time, this effect reach deeper soil layer (2.5-7.5 cm).

Castro Filho *et al*., (1998) found a 29 percent increase of soil organic carbon in no tillage compared to conventional tillage in the surface 0-10 cm of the soil irrespective of the cropping system.

Compared to the cropping system fallow-maize, which was taken as a reference, soil carbon content increased by 47 percent in the system maize-lablab (Dolichos Lablab) and by 116 percent in maize-castor (Ricinus Commnuis) cropping system. In system were nitrogen was applied as fertilizer the carbon content increase even more (Testa *et al*., 1992).

FAO (2001) Found that five years after the introduction of intensive cropping systems containing leguminous crops (especially the cropping systems oats + clover-maize and oats + clover-maize + cowpea), soil organic carbon contents were restored, after the loss of 8.3 tons of organic carbon per hectare under pervious cropping systems.

2.7.1 Decomposition of soil organic matter:

Soil organic matter (SOM) plays a major agricultural role through its contribution to nutrient cycling and stabilization of soil structure. In addition to this, Anonymous (1990) reported that more than half of agricultural soil under potato, corn and cereal monoculture has significantly lower amount of organic matter than adjacent soil under perennial forage.

Soil organic matter can be altered by land use, Jenny (1980) gives an example from the area used for corn production. Soil N content declined from 0.22% to 0.13% within 40 years.

Lefroy *et al*., (1993) found that adjacent sites which were either cropped or left uncropped differed by a factor of 2 in total carbon. However, this is not surprising because cultivation tends to breaks macro - aggregates and thereby exposing organic matter to microbial grazing.

The net effect is that conservation tillage can contribute to either an increase in soil organic matter in cultivated soil or maintenance of –carbon soil such as grassland soil (Doran, 1980).

Balesdent *et al*., (1990) reported that the amount of original carbon mineralization under no–tillage was lower than that under conventional tillage because of low content of nitrogen in no–tillage to enhance mineralization of carbon.

2.7.2 Factor affecting soil organic matter decomposition:

There are many factors affect decomposition of soil organic matter, such as:

1. Environmental:

There is a strong interaction between temperature and resistance to degradation. The increase in global temperature has an important impact on decomposition of organic materials particularly, temperate regions. Data by kirschaum (1995) suggest that a 1°C increase in temperature could ultimately lead to a loss of over 10% of soil organic C in regions with annual mean temperature of 5°C. Whereas, the same temperature increase would lead to a loss of only 3% of soil C in region with mean temperature of 30°C. This shows that in temperate regions, the temperature sensitivity of organic matter decomposition increase with temperature.

Similarly, Homann and Grigal (1996) observed that decomposition of below ground organic materials increased with temperature on cool forest slopes but decreased with temperature in warm fields. it could be concluded that climate change plays an important role in the decomposition of organic materials in soil, being more in the low elevation soils in which organic materials was less bound (sandy soil) compare to medium and high elevation soil in which organic material was relatively more bound (silty and clay soils) (Cortez *et al.*, 2000).

2. Soil:

The role of soil texture on decomposition of organic materials incorporated into the soil seemed to be inconsistent.

Generally, the fate of decay of organic materials in soils is thought to be reduced by the presence of clay. Fine soil particles and organic materials interact in soil to form complexes and micro aggregates that render organic substances less susceptible to biodegradation (Skjemstad *et al.*, 1993).

As result of this stabilizing effect, fine texture soils usually contain more organic matter than coarse–textured soils that have received the same input of organic matter. It seems that the degree of physical protection of organic matter varies with the type of organic materials and soil texture.

2.7.3 Environmental impact:

Soil is increasingly becoming a potential carbon sink for lowering atmospheric concentration (Bruce *et al*., 1998; Poulsen *et al*., 1998).

Several authors emphasized the importance of SOM in the C cycle as a major source of Co_2, whereas loss of soil C contribute significant to global Co_2 level and climate change (Post *et al*., 1990; Schnitzer, 1999; kern and Johnson, 1993).

Magnitude of greenhouse gas emissions from degradation of soil organic matter degradation depends on land use, cropping systems and tillage intensity. Soil quality and environment require new knowledge to minimized agricultural environmental impact.

A study was initiated by (Reicosky , 2000) to evaluate the effects of mouldboard plowing on soil properties and long–term Co_2 loss and to verify tillage induced Co_2 loss without the portable chamber. Cumulated Co_2 flux from plowed treatment was 2.4 times higher than no tilled, because plowing created higher soil air permeability resulting in higher gas exchange. Results suggest that less intensive tillage increases soil quality and promotes environmental benefits.

In fact, most of the recent interest in quantifying increases in soil organic C due to conservation cropping systems (Flach. *et al*., 1997) has stemmed from attempt to reduce Co_2 emission to the atmosphere, believed by many to be a major contributor to global warming.

2.7.4 Nutrient release during decomposition:

Soil fertility and nutrient availability are closely connected to the SOM content and its mineralization (Zech *et al*., 1997).

The extent of mineralization determines soil nutrient release and their nutrient availability (Zaman *et al*., 1999).

In addition to losses of organic matter through mineralization, organic matter can be lost through erosion when soil is cultivated. However, it is difficult to quantify the extent of erosion and in only few studies has erosion been recognized (e.g. Davidson and Ackerman, 1993).

Dalal and Mayer (1986, 1987) characterized losses of SOM from various pool of C at six sub tropical sites in Australia. The soils varied in texture, but only one was coarse textured. It has been cultivated for 20 years, and the concentration of soil organic carbon was reduced by 41% relative to native grass land.

Indeed, such prolonged losses were indicated in studies by Dutoit *et al*., (1994) and Dupreez and Dutoit (1995) who found that 5-90 years of land use for cropping of soils in the semi–arid apart of South Africa resulted in a loss of 10-37% of C and N concentration relative to the native grassland.

2.7.5 Effect of soil disturbance on soil quality:

Intensive breakdown of organic elements mainly depends on soil aeration and connected with activity of aerobic bacterium and mushrooms. That's why land tillage system, founding on yearly plowing with mouldbored, makes negative influence keeping organic elements. Thus, mechanical tillage is one of the factors of regulation soil fertility (Kenenbaev and Kireer, 2000).

Management decision that affect tillage intensity and the amount and placement of residues can influence soil C storage thereby, representing available strategy to help mitigate the rise in atmospheric CO_2.

Prior *et al., (*2000) found that selection of fall tillage equipment that maintain surface residue and minimize soil disturbance could help to reduce CO_2 loss. Where such concentration for spring tillage operations would not result in a substantial reduction in CO_2 loss.

2.8 Total nitrogen:

A major source of N to crop is that from mineralization of SOM. Although most soils contain several thousand kilograms of N per hectare, only 1 to 13% of soil organic N is mineralizes and becomes available to plant each year (Keeny, 1982). Mainly, because organic matter accumulation in the topsoil and decreased with depth (Manjaiah . *et al*., 2000).

Wild (1988) stated that when the soil is brought into cultivation, the N content usually decreases. Cultivation however, leads to an increase of soil disturbance that in turn leads to more carbon substrates, becoming available to support greater microbial activity.

Bayer *et al*., (2000) found that under no tillage, an increase of soil total nitrogen concentration occurred when compared with conventional tillage due to increased amount of crop residue retention. Also, tillage enhances decomposition of organic matter and loss of nitrogen.

Different cover crops and tillage system may affect the availability of plant nutrients, especially nitrogen.

The reduction of tillage and the addition of nitrogen by legumes in the cropping system increased the total nitrogen content in the soil. The intensive system consisted in oats and clovers as the cover crops and Maize intercropped afterwards with copea (vignaung uiculate), under zero tillage. After five years, the 0-17.5 cm layer contained 4900kg /ha more total soil nitrogen than the traditional system oats–maize under conventional tillage. After nine years, the system even resulted in a 24% increase in soil N as compared to conventional tillage (Amado *et al.*, 1998).

2.9 Hydraulic conductivity:

Tillage alters the pore structure and hydraulic properties of soils. Likewise, reestablishment of grass on crop land will, over time, produce changes in soil hydraulic properties that can influence the amount of plant available water.

A comparison of soil hydraulic properties on adjacent native grassland, crop land, Conservation Reserve program (CRP) sites by (Schwartz *et al.*, 2000). Showed that mean near–saturated hydraulic conductivities of crop land were not significantly different from grassland, where CRP sites had the lowest ($P \leq 0.05$) near–saturated hydraulic conductivity. Which suggest that, after 10 years, grasses had not fully ameliorated changes in pore structure caused by tillage.

Lower water hydraulic conductivity was found in soils of lower porosity and higher bulk density , and also found to decrease with soil depth (Aina, 1970; Dougles and Mckeys, 1978; Abdur–Rab *et al.*, 1987; Southard and Paul, 1988).

Soil under intensive cultivation has been shown to undergo many changes especially in ities physical and chemical properties, including, reduction in hydraulic conductivity (HC) parallel to increases in Bulk density (Bd) and decrease in prosily (Wood, 1985; Malmer and Grip; 1990; Chauvel, 1991).

Persal and Perkins (1978) and Pikul and Aall amarus (1986) reported that the tillage pan and fragi pan have a lower hydraulic conductivity than over laying layer. They also found that these pan were controlling water flow in the soil. A lower infiltration and decrease in hydraulic conductivity has resulted when the number and size of machines has increased on the field (Malmer and Grip, 1990).

Tillage intensity of the systems considered decreases in fallowing sequence: conventional tillage (CT), use of moldboard ploughing by inversion tillage to 250 mm depth, conservation tillage (RT), use of sweep tine by non inversion tillage to 250mm and no–tillage (NT) where the only soil disturbance is caused by the knife coulters of the direct drill.

In general, if bulk density in the upper layer of NT soils is increased, will result in a decrease in the amount of coarse pore, and lower hydraulic conductivity when compared with CT and RT soils. They concluded that accumulation of organic matter and nutrient near the soil surface under NT and RT are favorable consequences of not inverting the soil and by maintaining a mulch layer on the surface (Tebrugge and Wanger, 2000).

Gehring *et al.*, (2000) found that saturated hydraulic conductivity was significantly higher in no- till for Non–tracked Row middles in both years of measurement when compared with the plow plots. They concluded that No–till has improved the soil by improving saturated flow of water in no–tracked areas even penetration resistance has been elevated in some areas.

Contradictory results were also reported by (Singh. *et al.*, 2000) who found that, under zero–tillage there were increased bulk density, reduced infiltration rate and hydraulic conductivity.

Mc gary *et al*., (2000) reported that traditional tillage had a high density surface crust and significantly larger soil structure units than no tillage. Also there is a high number of earth warms and termites which are major contributors to increase in hydraulic conductivity and infiltration, and also because traditional tillage had the greater volume of pore <1.5 mm. Whereas no tillage had greater volume of the largest pore size measured (1.5-3 mm).

CHAPTER THREE

MATERIALS AND METHODS

This study (soil quality and management) was carried out during the period between March and April (2003) to determine the content of carbon and nitrogen plough layer of the storage in the soil profile under different tillage systems.

The analysis of the experimental soil samples was carried out in the laboratory of the Department of Soil and Environment science, Faculty of Agriculture, University of Khartoum,Shambat.

3.1 Location:

Two types of soils were tested in this experiment which represent two major soil orders in Sudan (Aridisols and Vertisols). The Aridisols samples were collected from the topsoil (0-30cm) Shambat-Gerf and it was classified as clay loam. The Vertisols samples were also collected to a depth of 30cm (Elselete North) and it was classified also as clay loam.

Table. 1 shows some selected chemical and physical characteristics of the study site.

Table (1): Some selected chemical and physical characteristics of the study site (0-30 cm)

Site	TN %	OC %	HC $cmhr^{-1}$	CEC $meq/100g^{-1}$	Particle size distribution (%)				BD tm^{-3}
					Clay	Silt	sand	Texture	
Elselete North*	0.014	0.19	2.01	0.34	38	21	41	Clay loam	1.31
Elgrouf Shambat **	0.06	0.34	3.01	0.28	39	28	33	Clay loam	1.41

Sources: (* Babekir (2000), ** Eltom (1970).

TN: Total nitrogen.

OC: Organic carbon.

HC: Hydraulic conductivity.

CEC: Cation exchange capacity.

BD: Bulk density.

3.1.1 Climate of Khartoum:

Khartoum state lies in the semi-desert region of the country. The climate of the area is arid with a hot dry summer (march-June), low rain (100-300 mm/ year) fall season (June-October) and dry cold winter season (November-February). The mean maximum annual temperature in the area reported ranged between 32.1ºC in January and 41.9ºC in May, while the mean minimum temperature range between 15.7ºC in January and 26.8ºC in June (Obied and Mahmoud,1969). The same authors recorded that the relative humidity values are low and reflect the aridity of the climate during most months of the year (October- June), and they are relatively high during the period between July and September (the period during which rain fall occurs reaching maximum in August).

3.1.2 Northern Selete Scheme:

Site characterization and Profile allocation:

(a) Area No. (1).

(b) Location: The farm is located between Elhajyousif and Elzakiab-East Shambat (about 18 km East Khartoum North).

(c) Vegetation: vegetables as (Abu70) and folder crop.

(d) History of cultural practices: cultivation of the area started in 1975.The tillage operations practiced in the area for Abu70 production were in the following sequence:

1. Disk plowing
2. Disk harrowing
3. Leveling
4. Ridging
5. Canalization

3.1.3 Shambat (Gerf) soil:

(a) Area No. (2).

(b) Location: Immediately adjacent to the River Nile and to the west of the Faculty of Agriculture, University of Khartoum, Shambat.

(c) Vegetation: Seasonal cultivation, under date palm plantation.

(d) Cultivation: The main implement used was wasoge drawn by animal (i.e. traditional tillage).

3.2 Treatments:

Study was carried out in the two different areas with a history of long — term (more than 30 years) of farming system. Therefore, the treatments tested in this study are described below:

- Conventional tillage (C.T) in Elselete project with it's grasslands (G.L) representing the control.
- Traditional tillage (T.T) in Elgrouf area with it's grass lands (G.L) representing the control.

3.3 Soil samples collection and preparation:

Soil samples were collected from profiles. These in each area, three profile were dug areas represent two management systems, mainly the area under tilled soil and the area under native vegetation. In each system, three profiles (3 replications or 3 sites i.e. sites I, II, III) (of 60 cm and 70 cm of length and 80 cm deep) were dugged to represent the study area. Three composite soil samples were taken from each location profile at an interval of 0-7.5, 7.5-15, 15-22.5 and 22.5-30 cm depth. Each composite sample was mixed thoroughly and quartered. One quarter was transferred to the laboratory inside labeled bag for analysis.

The disturbed samples were air- dried, grounded and passed through a 2 mm sieve. The sieved samples were analyzed for organic carbon (O.C), Total nitrogen (T.N) and hydraulic conductivity (H.C).

3.5 Soil analysis:

3.5.1 Chemical:

3.5.1.1 Organic carbon (O.C):

Organic carbon was determined by the rapid dichromate methods described by Nelson and Sommer (1982) using finely (0.5mm) ground soil samples. The C was oxidized with 10 ml of 1N $K_2Cr_2O_7$ added to 1.0 g air- dry soil in a 500 ml wide–mouth conical flask. The flask was gently swirled to disperse the soil in the solution. To hasten oxidation, 20 ml of concentrated H_2SO_4 was added to the mixture, swirled for one minute and the flask was allowed to stand for about 30 minutes. Four hundred ml of distilled H_2o was added to the mixture. Organic C was determined by back titration the excess $K_2Cr_2O_7$ with ferrous-ammonium- sulfate (0.5N) by adding 5 ml of concentrated H_3PO_4 using 3-4 drops orthophenol indicator. A blank determination in the same manner but without soil was determined. Values were multiplied by factor of 1.3, to correct for incomplete oxidation.

3.5.1.2 Total nitrogen (T.N):

Total nitrogen was determined by the salicylic acid-thio sulfate modification of Kjeldhal method to include nitrate and nitrite described by Bremner and Mulvancy (1982). Briefly, 100 mg from a finely ground (0.5 mm) air dry soil was placed in a micro-Kjeldhal digestion flask. To the sample, 5 ml of salicylic acid-Sulfuric acid mixture was added, swirled and left over night. Then after, 0.50g of sodium thiosulfate penta hydrate was added through a funnel and the contents were digested at 150°C until frothing has ceased. To the mixture, about 1g of k_2SO_4 catalyst mixture was added and digestion was continued at 350°C until the solution was clear. The precipated $(NH_4)_2SO_4$ was dissolved in 100 ml distilled water and NH_3 was liberated by distillation with NaOH (40%). Ammonia was trapped into a 2% boric-acid indicator and titrated versus Hcl 0.1. N. Similar to O.C, a blank determination of N was also carried out.

3.5.2 Physical:

3.5.2.1 Hydraulic conductivity (H.C):

Hydraulic conductivity was determined following:

The procedure described by Black (1965). A simple apparatus for the measurement of the conductivity of saturated samples was constructed. It was made to accommodate six samples at a time.

Procedure: Each sample was covered from one end with a circular cloth held in place with a rubber band. The samples, with their cloth covered ends down, where placed in a tray filled with water to a depth just below the top of the samples. They were allowed to soak till saturation. A spatula was used to remove any soil material swelling above the level of the sample holder. An empty cylindrical sample holder was then connected to the top of each sample using durofix adhesive. Apiece of circular bloating paper was then placed on the top of the sample and water was poured slowly into the upper cylinder until it was roughly 2/3 full. After this, the sample was quickly transferred to the apparatus and one of the siphons started to maintain head of water on the sample. Time was allowed for the stabilization of the water level on top of the sample, after which a measuring cylinder was introduced to collect the percolate. The quantity of water (Q) passing through the sample per unit times (t) was measured and the hydraulic conductivity (K) was calculated using the following formula:

$K= (Q/At) (L/H)$.

Where A = cross sectional area of sample.

L = length of sample.

H = hydraulic head difference across sample.

3.6 Statistical analysis:

All statistical analysis was performed using procedure of Statistical Analysis System (SAS, 1985). The modeling tillage of organic carbon and total nitrogen was created through the computer Excel program.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 The effect of tillage on soil chemical properties:

4.1. 1 Content of organic carbon (O.C):

4.1.1.1 Traditional. Vs. Conventional tillage:

The result showed that in all soil depths values of O.C reported in traditional tillage were significantly ($P \leq 0.004$ — 0.05) higher than that of conventional tillage (Fig.4.1).

In the 0-7.5 cm soil depth, O.C. determined in traditional tillage (14.82 gkg^{-1}) was significantly ($P \leq 0.017$) higher than that of conventional tillage (9.26 gkg^{-1}) by 6o%. In the 7.5-15cm soil depth, O.C in the traditional tillage (14.56 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of conventional tillage (8.58 gkg^{-1}) by 69%.

In the 15-22.5cm depth, O.C in the traditional tillage (15.08 gkg^{-1}) was significantly ($P \leq 0.01$) higher than that of conventional tillage (7.28 gkg^{-1}) by107%. In the 22.5-30 cm soil depth, O.C in the traditional tillage (14.82 gkg^{-1}) was significantly ($P \leq 0.004$) higher than that of conventional tillage (7.89 gkg^{-1}) by 90%.

The result of this study clearly showed that intensive manipulation of the soil particles enhances decomposition of soil organic matter by increasing surface area available to micro – organisms. Previous studies also reported similar results (Onjeniy and Dekayode., 1999). They found that, manual heaping and ridging maintained higher values of soil organic carbon, P, k, Ca and Mg higher cowpea and maize yield compared to ploughing plus harrowing.

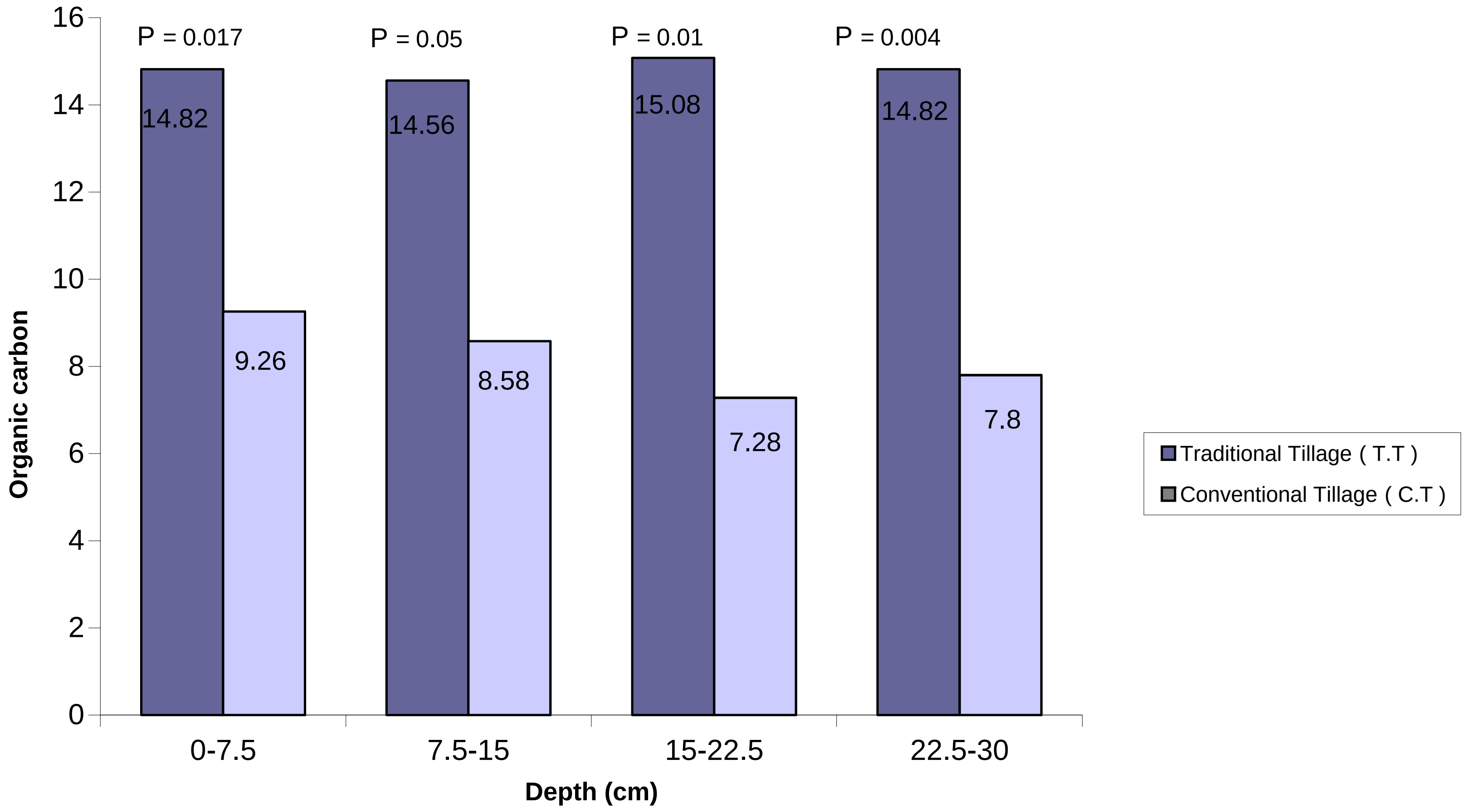

Fig (4.1) Content of Organic carbon (g/kg) in the soil profile (T.T and C.T)

Similarly, Riezobes and Loerts (1998) found that, mechanically tilled soils appear to have more rapid decline in soil organic matter than annually tilled fields (1.59 vs.1.89%) suggesting more sever soil degradation.

Recently, Carter and sanderson., (2001) reported that, reducing tillage e.g. (conservation tillage) significantly increased the content of organic carbon due to absence of excess tillage farming systems.

4.1.1.2 Traditional tillage Vs. Grassland:

With the exception of the 22.5-30 cm soil depth, content of soil O.C determined in traditional tillage and grassland showed no significant differences (Fig. 4.2). Generally, grassland was higher than the traditional tillage. Organic carbon content in grassland in the depths 0-7.5 and 15-22.5 cm (16.12 gkg^{-1} and 15.86 gkg^{-1}) appeared to be slightly higher than the traditional tillage in the same depths (14.82 gkg^{-1} and 15.08 gkg^{-1}) by 8% and 5%, respectively, though statistically not significant.

In the depth 7.5-15 cm the amount of O.C in the grassland soil (16.12 gkg^{-1}) was higher than that in traditional tillage (14.56 gkg^{-1}) by 10%, and it is significantly only at ($P \leq 0.07$).

In the (22.5-30 cm), the result showed that O.C content in the grassland soil (16.9 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of traditional tillage (14.82 gkg^{-1}) by 14%.

This is possibly due to the intensive grass root in this depth. (Albrecht *et al.*, 2000) stated that continuous grassland has greater potential to accumulate SOM as compared to cultivated soils. Because traditional tillage is characterized by reduced soil movement , values of O.C were not much different from grasslands.

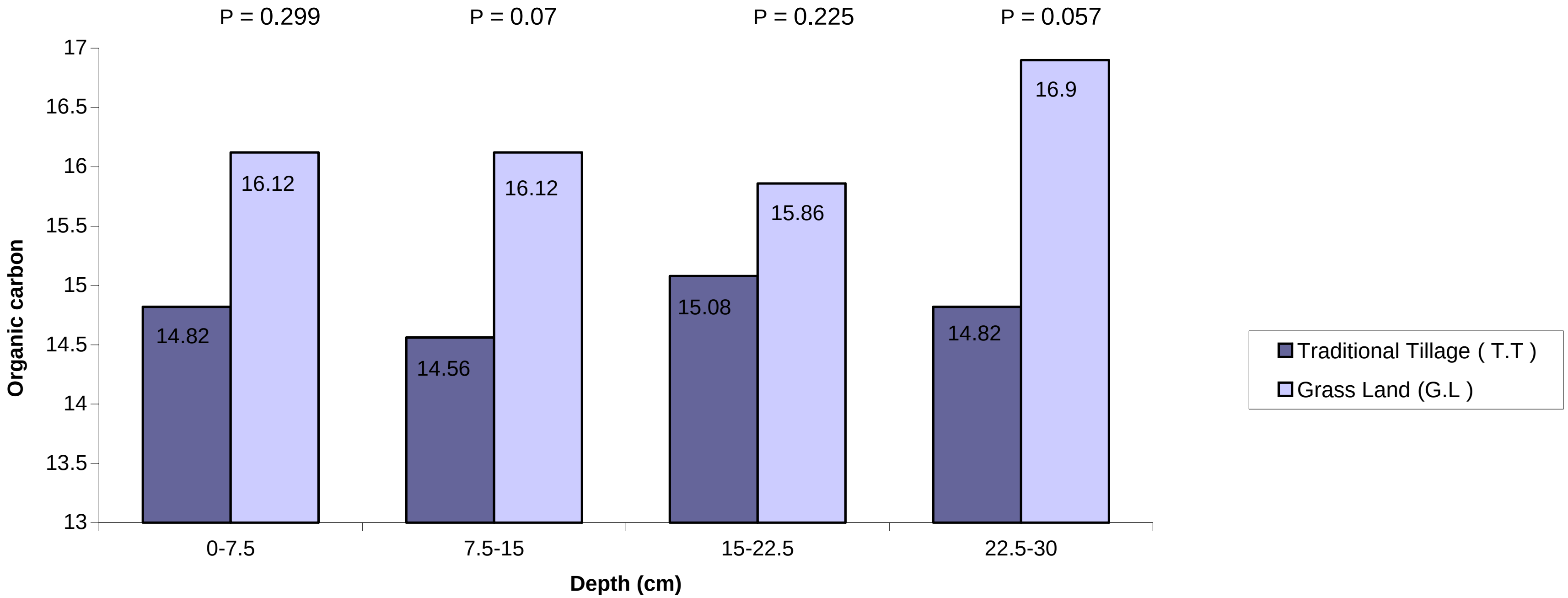

Fig (4.2) Content of Organic carbon (g/kg) in the soil profile (T.T and G.L)

However, work by Bayer *et al*., (2000) recorded that, under traditional tillage a decrease of total organic carbon and total nitrogen was observed compared to no tillage system.

4.1.1.3 Conventional tillage Vs. Grassland:

Almost in all soil depths, organic C was not significantly different between the grassland and conventional tillage (Fig.4.3).

However, the amount of O.C in the 0-7.5 cm soil depth of conventional tillage (9.26 gkg^{-1}) was higher than the grassland soil (6.24 gkg^{-1}) by 48% though not significant. In the 7.5-15 cm soil depth, O.C in the conventional tillage (8.58 gkg^{-1}) was higher than grassland soil (5.98 gkg^{-1}) by 43% though not significant .In the 15-22.5cm soil depth, O.C in the conventional tillage (7.28 gkg^{-1}) was higher than grassland soil (4.42 gkg^{-1}) by 64%, and it is significantly only at ($p \leq 0.09$). In the 22.5-30 cm depth, O.C in the conventional tillage (7.8 gkg^{-1}) was higher than grassland soil (6.24 gkg^{-1}) by 25% though not significant. It appeared that the high clay content at this site (> 50%) acts as a physical protector of SOM from degradation (Vanlauwe *et al*., 1998).

Mubark *et al*., (2004) studying soil quality of heavy textured soils at Elgenaid site concluded that high clay content of the vertisols is positive towards declined of O.M. due to tillage.

Elliot and wildung, (1992) found that, in no tillage farming systems, O.C content was lower than in tilled soil. This clearly indicates that any reduction in O.C content was due to redistribution and mixing in the tilled layer.

Alvarez *et al*., (1998) reported that, nitrogen fertilizer is another management practice that may increase soil organic C content by

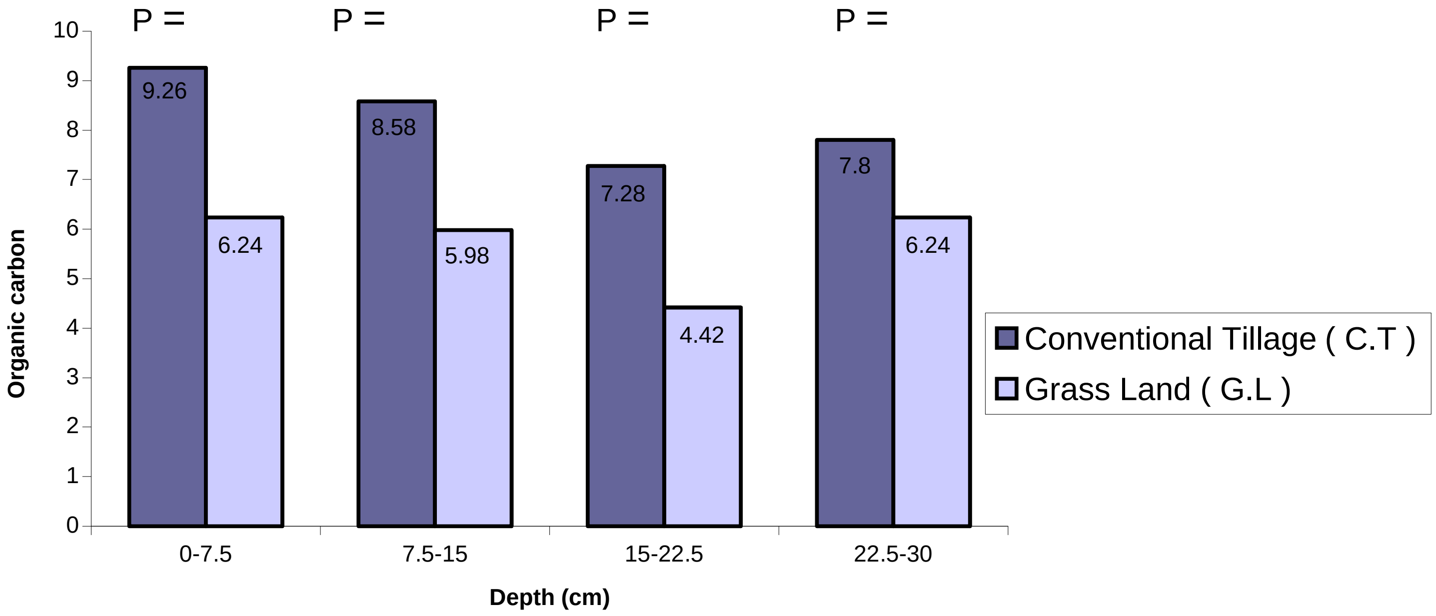

Fig (4.3) Content of Organic carbon (g/kg) in the soil profile (C.T and G.L)

increasing inputs of plant residue to the soil through enhancing biomass production.

An increase in soil organic carbon with increasing cultivation was also reported (Biswat *et al.*, 1977; Jones, 1985; Janzen, 1987).

4.1.2 Total Nitrogen (T.N):

4.1.2.1 Traditional. Vs. Conventional tillage:

Total nitrogen content in the 0-7.5, 7.5-15, 15-22.5 and 22.5-30 cm soil depths of traditional and conventional tillage was illustrated in (Fig.4.4). Generally, N content showed no significant differences between the two systems in all depths, also, generally traditional tillage was higher than conventional tillage

Content of T.N in traditional tillage of the 0-7.5, 7.5-15, 15-22.5 and 22.5-30 cm were 0.33 gkg $^{-1}$, 0.33 gkg $^{-1}$, 0.28 gkg $^{-1}$ and 0.42 gkg^{-1}, respectively. The respective values determined in conventional tillage were 0.28 gkg $^{-1}$, 0.28 gkg $^{-1}$, 0.19 gkg $^{-1}$ and 0.33 gkg $^{-1}$.

The amount of nitrogen is directly related to the amount of organic matter.

Wild (1988) sated that when the soil is brought into cultivation, the N content usually decreases. Cultivation however, leads to an increase of soil disturbance that inturn leads to more carbon substrates, becoming available to support greater microbial activity.
Soil organic matter can be altered by land use, Jenny (1980) gives an example from the area used for corn production. Soil N content declined from 0.22% to 0.13% within 40 years.

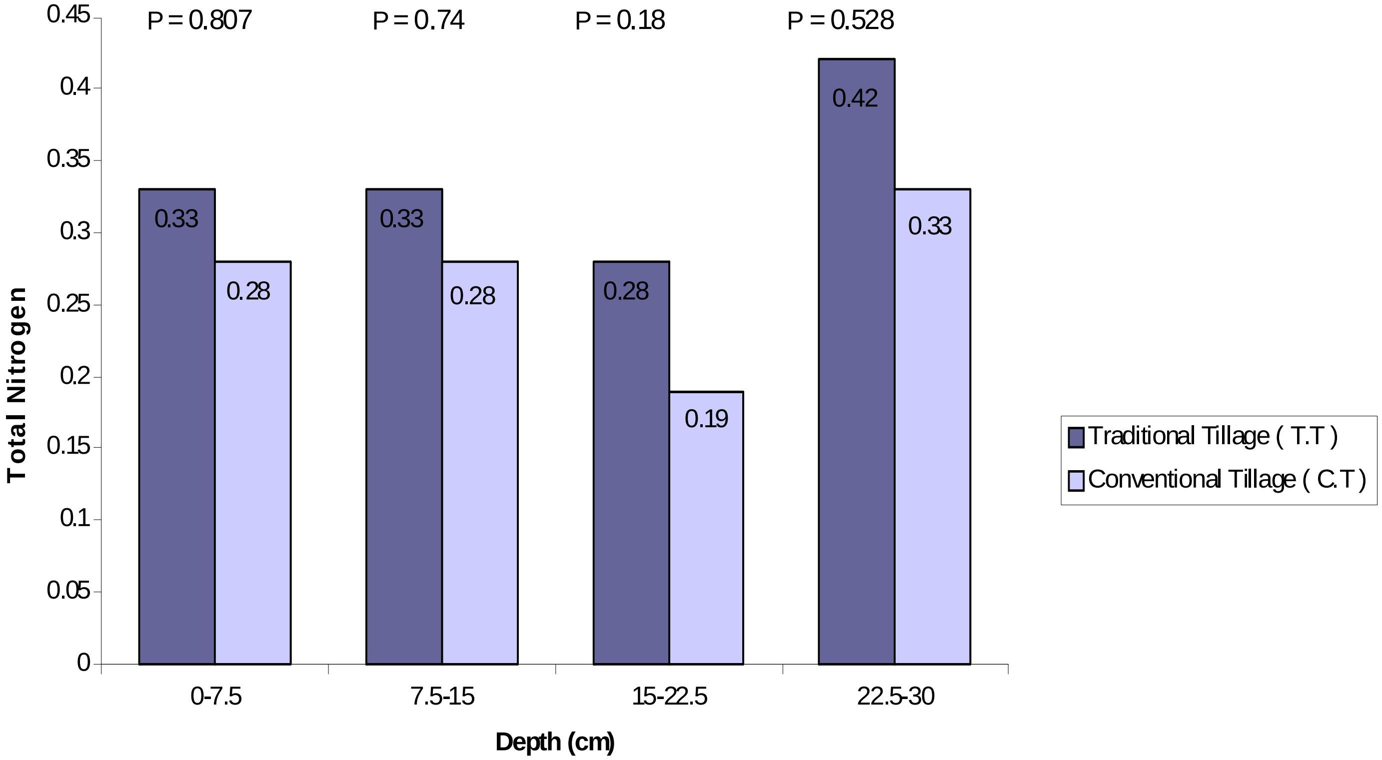

Fig (4.4) Content of Total nitrogen (g/kg) in the soil profile (T.T and C.T)

4.1.2.2 Traditional tillage.Vs. Grassland:

With the exception of the 22.5-30 cm soil depth, T.N content of traditional tillage and grassland showed no significant differences (Fig.4.5).

Total nitrogen content in traditional tillage in the depths, 0-7.5 and 7.5-15cm (0.33 gkg^{-1} and 0.33 gkg^{-1}) were higher than the grassland soil of the same depths (0.28 $gkg^{-1}$and 0.23 gkg^{-1}) by 17% and 43%, respectively, though not significant.

In the depth 15-22.5 cm the amount of T.N in the (G.L) soil (0.42 gkg^{-1}) was higher than that in T.T soil (0.28 gkg^{-1}) by 50% though statistically not significant, and seemed to be due to N mineralization from the dead roots.

In the 22.5-30 cm depths, T.N content under T.T (0.42 gkg^{-1}) was significantly ($p \leq 0.05$) higher than that under (G.L) soil (0.23 gkg^{-1}) by 82%. The increase in the soil nitrogen content is mainly due to annual addition of fertilizer. Ahmed. (2003) found that addition of N fertilizers to cultivated soil had significantly increased T.N content as compared to native vegetation.

Also, Sharma *et al.*, (1980), Bajwa, (1987); and Janzen *et al.*, (1987) found that the soil nitrogen content had increased after addition of nitrogen fertilizer to the soil for long period of cultivation when compared to virgin soils. They also reported that a better level of nitrogen in the soil was found in soil with high organic matter content, or montmorrillonite clay mineral that fixed large amount of applied NH_4^+ - N fertilizers due to the high specific surface area and specific charge.

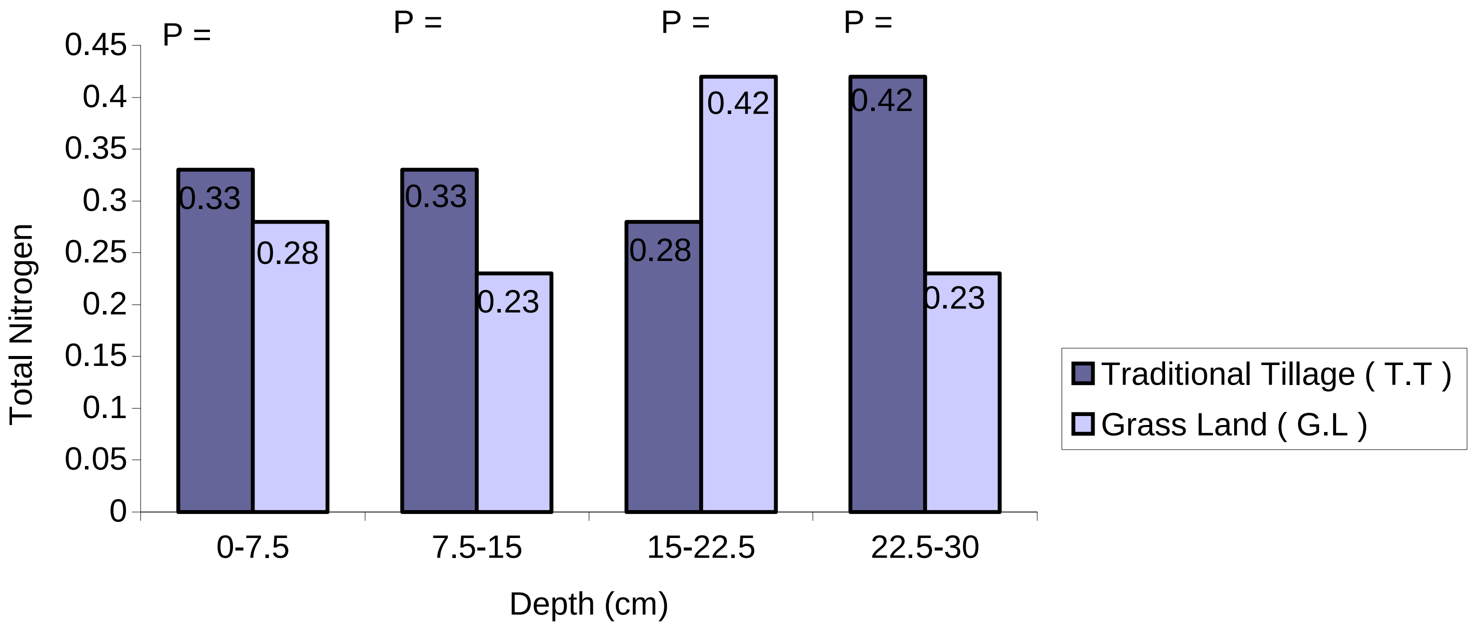

Fig (4.5) Content of Total nitrogen (g/kg) in the soil profile (T.T and G.L)

4.1.2.3 Conventional tillage Vs. Grassland:

With the exception of the 15-22.5cm depths, T.N content of conventional tillage and grassland showed no significant differences (Fig. 4.6). Total nitrogen in grassland in the depths 0.7.5, 7.5-15 and 22.5-30 cm were found to be 0.14 gkg^{-1}, 0.33 gkg^{-1} and 0.37 gkg^{-1}, whereas those under conventional tillage in the same depths were 0.28 gkg^{-1},0.28 gkg^{-1} and 0.33 gkg^{-1}, respectively.

In the 15-22.5 cm-soil depth, T.N content under grassland soil (0.37 gkg^{-1}) was significantly ($P \leq 0.05$) higher than that of conventional tillage (0.19 gkg^{-1}) by 94%.This may point out that in this depth (15-22.5 cm) there was more destruction soil organic matter and enhanced decomposition thereby, resulting in more loss of N. As for the grassland (no soil disturbance) the intense rooting system favor more release of N with less chances of loss due to possibly porosity compared to tilled soil. Bayer *et al*., (2000) found that under no tillage an increase of soil total nitrogen concentration occurred compared with convention tillage due to increased amount of crop residue retention and also tillage enhance decomposing of organic matter and loss of nitrogen.

This reduction in T.N amount in soil under Elselete cultivation may be due to burning of crop residues during harvesting. This confirms the finding of (Raison *et al*., 1985) stating significant N losses from residues, which occur during burning by high temperature volatilization.

A significant decrease in nitrogen levels were observed in the soil after burning of the vegetative parts on the soil surface (Schmidt, 1963, and Nye and Greenland, (1964).

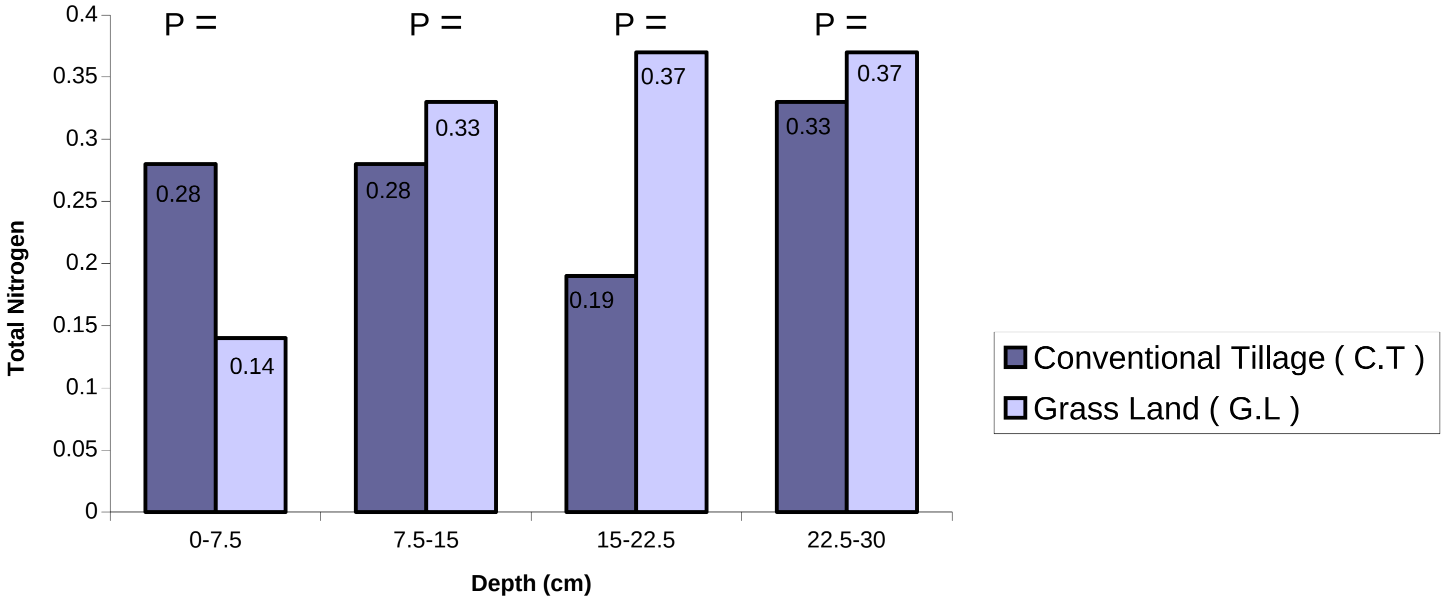

Fig (4.6) Content of Total nitrogen (g/kg) in the soil profile (C.T and G.L)

4.2 The effect of tillage on physical properties:

4.2.1 Hydraulic conductivity (H.C):

4.2.1.1 Traditional .Vs. Conventional tillage:

Hydraulic conductivity of the 0-7.5, 7.5-15, 15-22.5 and 22.5-30 cm soil depth under T.T and C.T was illustrated in (Fig. 4.7).

Generally, in all soil depths, T.T reported higher H.C than C.T. Only, in the sub soil (7.5-15 cm), H.C under T.T (0.250 cm/min) was significantly ($P \leq 0.05$) higher than that under C.T (0.038 cm/min) by five fold. Values of H.C under T.T in the 0-7.5,15-22.5 and 22.5-30 cm soil depth were found to be 0.198 cm/min, 0.420 cm/min and 0.150 cm/min, respectively. Under C.T the values of H.C were 0.174 cm/min, 0.024 cm/min and 0.016 cm/min, respectively.

Because of high variability between replicates, statistical analysis field to show significant differences, through average values were quite different. Higher values reported in T.T compared to C.T, pores continuity in T.T made by active organisms are continuous. Those in C.T were destructed due to intermittent tillage. Therefore, it's expected to increase H.C.

Chang and Lindwall (1989) reported that after 20 years of continuous no-till or plowing, there were no significant differences in bulk density or K_{sat} . Mankin *et al*., (1996) suggested it is rare to find significant differences in K_{sat} because of variability.

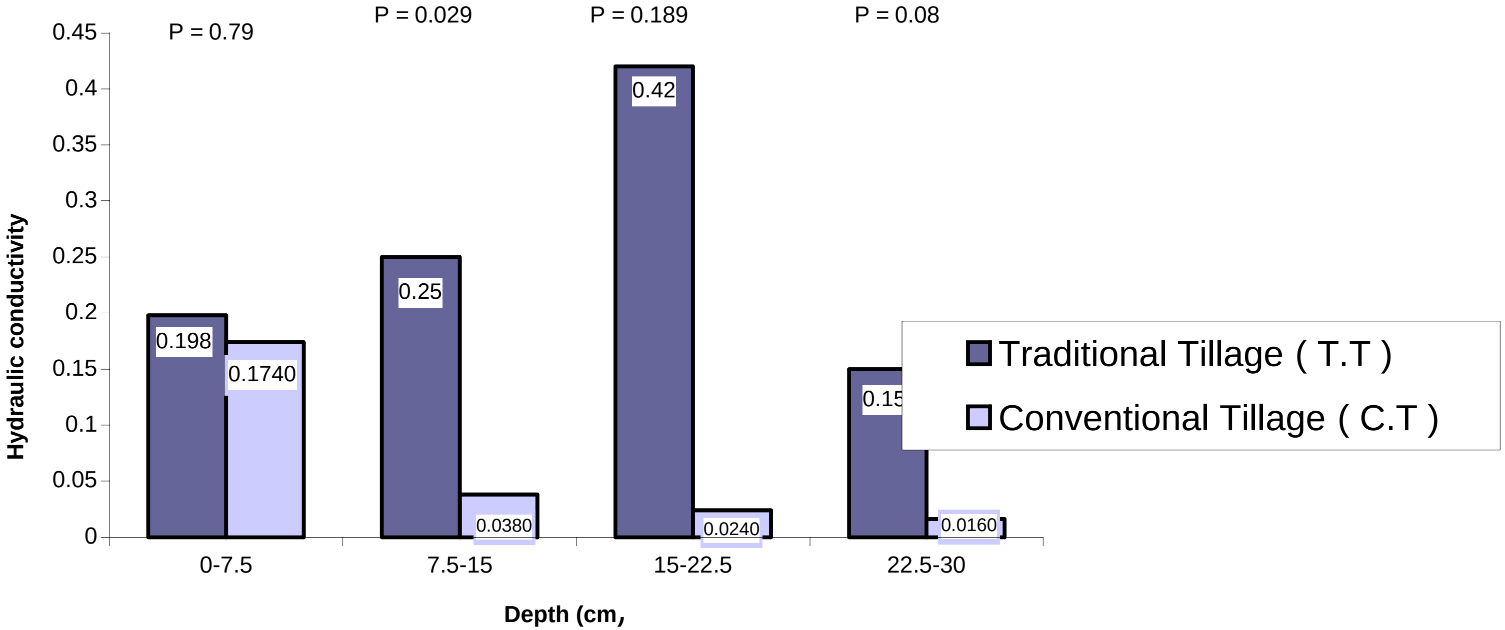

Fig (4.7) Hydraulic conductivity (cm/min) in the soil profile (T.T and C.T)

4.2.1.2 Traditional tillage Vs. Grassland:

Generally, the study showed that Hydraulic conductivity of traditional tillage and grassland showed no significant differences (Fig. 4.8).

Values of Hydraulic conductivity under grassland (G.L) in the 0-7.5, 7.5-15 and 22.5-30 cm soil depth were found to be (0.216 cm/min, 0.372 cm/min and 0.348 cm/min) were slightly higher than that reported in T.T in the same depths (0.198 cm/min, 0.250 cm/min, and 0.150 cm/min), though statistically not significant.

In the depth 15-22.5 cm the H.C in the T.T tillage (0.420 cm/min) was higher than that in grassland (G.L) (0.226 cm/min) by 85%, though not significant. And this may be due to decreases in the amount of coarse pores under G.L.

The inconsistent results of soil hydraulic and other physical properties under tilled and no- till systems may be related to the transitory nature of soil structure after tillage, initial and final soil water content, site history, the time of sampling and the potential for soil disturbance. The ability of soil to absorb and transmit water is affected by structure stability of soil pores and the moisture condition of the soil at the time of measurement. Both of which are usually modified by tillage practices.

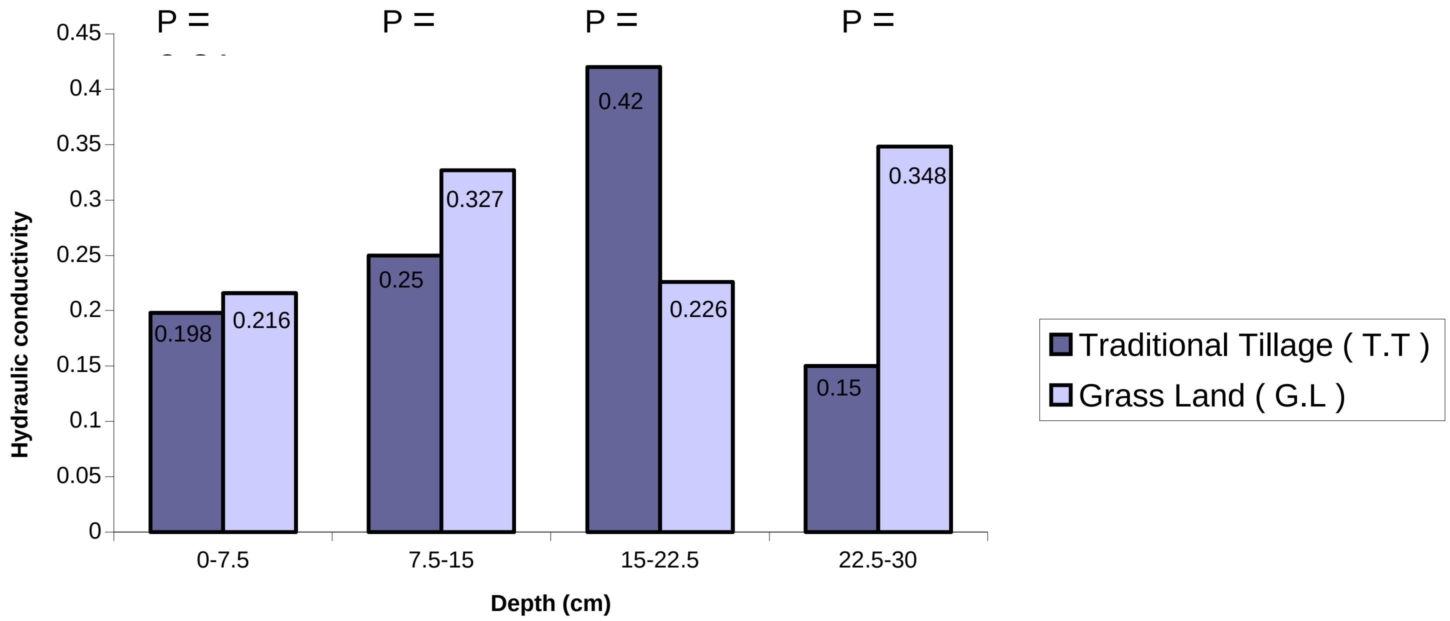

Fig (4.8) Hydraulic conductivity (cm/min) in the soil profile (T.T and G.L)

4.2.1.3 Conventional tillage Vs. Grassland:

With the exception of the 22.5-30 cm soil depth, H.C of conventional tillage (C.T) and grassland (G.L) showed no significant differences (Fig 4.9). Hydraulic conductivity of the depths 7.5-15, and 15-22.5 cm of grassland (G.L) soil were to be (0.128 cm/min and 0.044 cm/min) found higher than that of C.T in the same depths (0.038 cm/min and 0.024 cm/min) by two fold and 83% respectively though statistically not significant.

In the depth 0-7.5 cm the H.C in the C.T (0.174 cm/min) was higher than that of (G.L) soil (0.16 cm/min) by 8% though not significant. In the 22.5-30 cm soil depth, H.C of G.L (0.068 cm/min) was significantly ($p \leq 0.05$) higher than that under C.T (0.016 cm/min) by three fold.

This is probably due to the compaction of soil caused by machines.

Persal and Perkins (1978), and Pikul and All amarus (1986) reported that tillage pan and fragi pan have a lower hydraulic conductivity than over laying layer. They also found that these pan were controlling water flow in the soil. A lower infiltration and decrease in hydraulic conductivity when the number and size of machines has increased on the field (Malmer and Grip, 1990).

Soils behave differently in relation to tillage systems. Benjamin (1993) and Chan and Mead (1989) reported that soil under a no-till system had 30-180% greater saturated hydraulic conductivity than the soil tilled with a moldboard and chisel plow.

A comparison of soil hydraulic properties and a adjacent native grassland, crop land, and conservation reserve programs (CRR) sites by (Schwartz *et al.*, 2000) show that mean near-saturated hydraulic conductively of crop land were not significantly different from grass land, where CRR sites had the lower ($P \leq 0.05$) near saturated hydraulic conductivity.

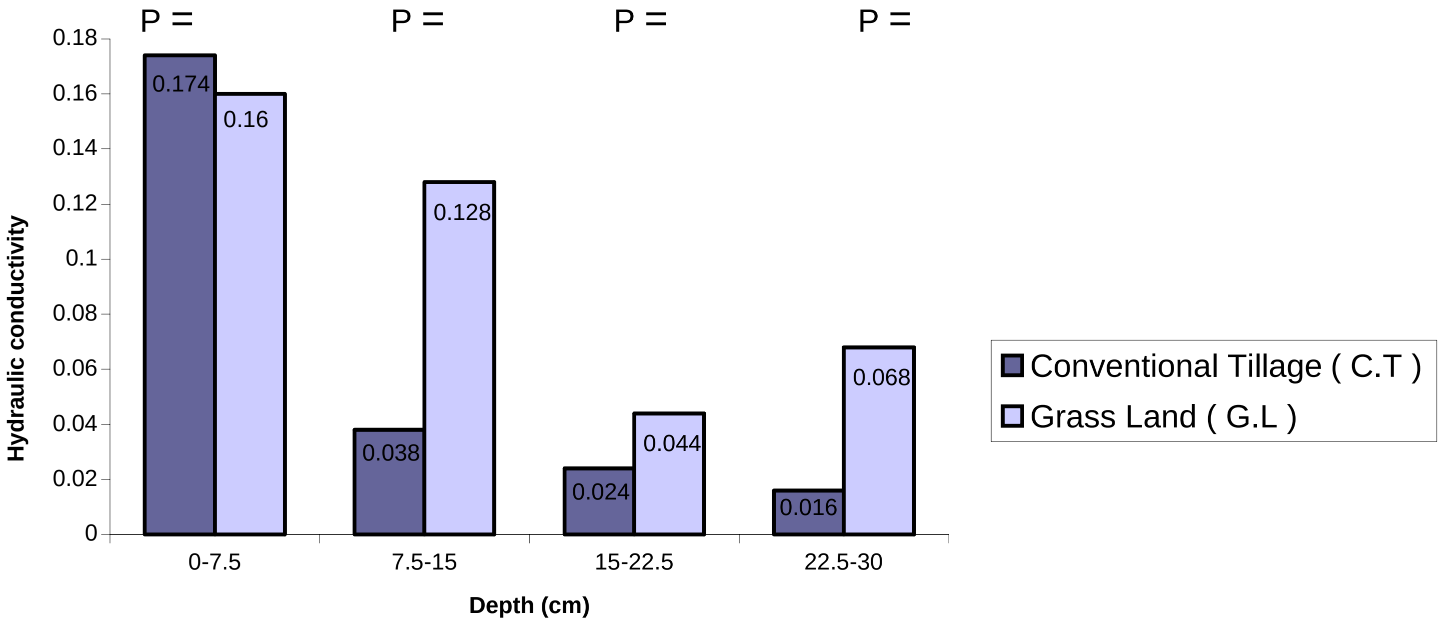

Fig (4.9) Hydraulic conductivity (cm/min) in the soil profile (C.T and G.L)

4.3 Modeling of tillage and organic carbon:

The general equation is:

$Y = a + bx + c$.

Where y represents the conventional tillage and a, b, c were constants and x represent traditional tillage.

The models of tillage and organic carbon from the analysis were discussed below.

(1) $R^2 = 0.37$ (Liner). (2) $R^2 = 0.36$ (Logarithmic).

(3) $R^2 = 0.39$ (Power). (4) $R^2 = 0.40$ (Exponential).

From the equations above it appears that R^2 is greater in equation (4), this presents that in a one unit variation in the dependent variable will lead to (40%) in the independent variable.

4.4 Modeling of tillage and total nitrogen:

The general equation is:

$Y = a + bx + c$.

Where y represents the conventional tillage and a, b, c were constants and x represent traditional tillage.

The models of tillage and total nitrogen from the analysis were discussed below.

(1) $R^2 = 0.84$ (Liner). (2) $R^2 = 0.89$ (Logarithmic).

(3) $R^2 = 0.83$ (Power). (4) $R^2 = 0.78$ (Exponential).

The coefficient of multiple regression is 89% indicating that about 89% of the variations explained by the variables included in the equation (2).

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS:

The following conclusions may be drawn from this study:

1- Organic carbon in all soil depths of traditional tillage was higher than that of conventional tillage. While Organic carbon content in traditional tillage and grassland were similar. However, organic carbon of grassland in the lower soil depth (22.5- 30 cm) was higher than that of traditional tillage. It was also observed that there was no differences between conventional tillage and grassland.

2- Total nitrogen content of traditional tillage and grassland were similar. However, it’s content in traditional tillage in the lower soil depth (22.5- 30 cm) was higher than that of grassland. Total nitrogen content of conventional tillage and grassland were also similar. However, it’s content in grassland in the depth (15- 22.5 cm) was higher than that of conventional tillage.

3- Although hydraulic conductivity of traditional tillage and conventional tillage showed no differences, in the depth (7.5-15 cm) of traditional tillage it was higher than that of conventional tillage. It was also observed that there was no differences between traditional tillage and grassland. In the lower soil depth (22.5- 30 cm) it was higher in grassland compared to conventional tillage.

4- Modeling organic carbon of conventional and traditional tillage showed that it was best fitted to the exponential model ($R^2 = 40\%$), while total nitrogen was best fitted to the logarithmic model ($R^2 = 89\%$) followed by the liner model ($R^2 = 84\%$).

5.2 RECOMMENDATIONS

From the conclusions of this study the following recommendations may be drawn:

1- Elimination of excessive tillage and promotion of conservation tillage such as no-till or reduced tillage is more beneficial to increased soil organic matter.

2- Further research is needed to identify which management systems will cause the most rapid and extensive deterioration to the environment.

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