



## The Contribution of Some Soil and Crop Management Practice on Soil Organic Carbon Reserves: Review

Agegnehu Shibabaw<sup>1</sup> & Melkamu Alemeyehu<sup>1</sup>

1. Bahir Dar University, College of Agriculture and Environmental Science

E-mail-agegnehus@yahoo.com

Telephone: 251-0918705581

alemayehumelkamu@yahoo.com

Telephone: 251-0911406596

### ABSTRACT

Soil organic carbon is the most important attribute and chosen as the most important indicator of soil and environment quality and agricultural sustainability. Maintaining of soil carbon stocks and other nutrient proved as the most important challenge of arable lands. It depends on soil type, surrounding climate and long term land use. Studies of various research reports indicates that agricultural management practice; crop rotation, residue management, reduced tillage, green manuring and organic matter amendment has identified for its contribution to the improvement of soil organic matter stocks and some other nutrients. Implementing of reduced or no tillage operation has underlined in increasing organic carbon stock of the soil through delaying of organic matter decomposition and N mineralization. Long term adoption of legume based crop rotation notably increases soil organic carbon and N contents, helped with natural gift of atmospheric nitrogen fixation. Organic sources of fertilizer are reservoirs of plant nutrients and organic carbon, and hence amendment with adequate and quality manure ultimately enhances the soil nutrients and SOC stocks of the soil. In general, soil and crop management practices allow the soil to sequester more atmospheric carbon in to the soil. The circumstances ultimately contribute to agricultural sustainability, environmental and soil quality and mitigation of climate change at large.

**Key words:** Tillage, residue management, manure and crop rotation

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## 1. Introduction

Soil organic C contents play unquestionably important in sustaining crop production, soil and environmental quality. The level organic carbon content determines the physical, chemical, and biological properties of the soil. Properties of water retention, nutrient cycling, and gas flux, and plant root growth is determined by organic carbon of the soil (Lal, 2004). Organic carbon also acts as a source and sinks for nutrient elements which can form organic moieties (N, P, and S).

Soil organic carbon content in arable lands highly dependent on the existing agricultural practices. Changes in agricultural practice notably influence the rate of carbon stored or released from soils. According to Allmaras (2003) improved practices of crop and soil management such as crop rotations, green manuring, crop residue management, reduced tillage and application of farm yard manure increases soil organic carbon content and other nutrients. Whereas, intensive cultivation, monoculture and frequent tillage operation can reduce soil SOC content and lead to soil deterioration.

Addition of organic fertilizer improves soil quality (Huang and Sun, 2006) and elicits increasing of organic carbon, ions of positive change and other chemical characteristics associated with soil fertility. Subsequent annual application of farmyard manure increased SOC from 1 to 3.4 per cent. According to Huang and Sun (2006) soil carbon sequestration in Chinese crop lands has increased due to extensive applications of balanced fertilization over the past 20 years. Gregorich et al. (2001) has also showed how the use of organic manures and compost enhances the SOC pool than application of the same amount of inorganic fertilizers.

Incorporation of crop residue helps in enhancing the SOC level and some other nutrients. Crop residue cycling are important sources of nutrients (N, P, and K) and organic carbon (OC) to soils. Juo et al. (1996) reviewed a number of studies where additions of stover resulted in greater increases in SOC than without stover. The author also concluded that soil organic C decreased by 75% after 15 years maize cropping with residue removal following forest clearing.

Crop rotation can have a major impact on soil health, due to emerging soil ecological interactions and processes that occur with time. Appropriate rotation increases soil organic carbon stock of the soil and enabling to increase organic matter and nutrients or maintaining them at a proper level. According to Covaleda et al. (2006) significant increases in SOC occurred after 2 years of rotation when combined with high application of cattle manure. The inclusion of cover crops or green manures in the rotation system can also enhance the efficient use of nutrients by plants, mainly owing to the increase in soil microbial population and activity (Watson et al., 2002).

In addition, green manures of leguminous and non-leguminous plants usually incorporated in to the soil soon after flowering to improve soil fertility. Leguminous green manures can fix large quantities of atmospheric N<sub>2</sub>, which non-leguminous crops cannot (Davies and Lennartsson, 2005). They also provide useful amounts of organic matter to the soil. Procházková et al. (2003) in there 32 years of study showed that winter wheat cropping provide higher average yield, soil carbon content with green manuring compared with straw incorporation into the soil.

In general, there are many viable crop and soil management practices which play role in carbon sequestration in agricultural lands. Hence, the objective of the review is to understand some forms of soil and crop management practice which would enhance the soil organic carbon stock and plant nutrients of the soil.

## 2. Soil and Crop Management Practice and Soil organic Carbon Stocks

Research studies on different crops, regardless of the climatic condition indicates that tillage operation, residue retention, manure and crop rotations are frequently verified in improving the soil organic carbon and nutrients content of the soil.

### 2.1 Effects of tillage operation

Reduced tillage is parts of conservation agricultural management options which enhance soil organic carbon of the soil. According to (Vanden et al. 2012) Residues retention improves soil structure, better drainage and water holding capacity, limiting the potential for water logging or drought. In crop lands, reduced tillage is one of the most effective practices for C sequestration. The use of less intensive tillage methods could reduce the SOC loss (Zikeli, 2013) or contribute to sequestration of C from the atmosphere. No-till and minimum tillage have been promoted as practices that will reduce the rate of soil CO<sub>2</sub> flux (loss) to the atmosphere and increase the rate of soil C sequestration as compared to conventional tillage (Blevins, 2007). According to (Chivenge et al., 2007) reduced tillage sequester more SOC of 6.8 mg C/g soil in the sandy soil and 20.4 mg C/g in red clay soil, whereas conventional tillage had the least amount of SOC, with 4.9 mg C/g of soil and 4.2 mg C/g of soil for the red clay and sandy soils, respectively. Duiker and Lal, (1999) has found large increase in total carbon is observed in the following 5–10 years of conservation tillage. Sombrero et al. (2010) has confirmed SOC content was significantly higher with no tillage than conventional tillage. Soil organic carbon has increased by 58% and 11%, respectively at the depth of 0–10 and 10–20 cm after 10 years of management. Huang et.al (2010) showed in his experiment that no- tillage increased the concentration of total SOC by 18.1% compared with conventional tillage under a long-term maize cropping system. Kushwaha et al. (2001) found that the values of SOC and total N were highest in the minimum tillage and residue retained treatment than conventional tillage and residue removed treatment. Changing of tillage from conventional to minimum and zero conditions along with residue retention increased the proportion of macro aggregates over 21–42% over control in soil (Kushwaha et al. 2001).

It is widely believed that soil disturbance by tillage was a primary cause of the historical loss of soil organic carbon (SOC) in arable lands. Substantial SOC sequestration can be accomplished by changing from conventional plowing to less intensive methods known as conservation tillage. Campbell et al. (2005) evaluates tillage effects on soil C storage and CO<sub>2</sub> emission After 3 years of tillage practices and concluded that no-tillage with residue and strip-tillage significantly



increased total soil organic C and mineral fraction C at the 0- 5 and 5- to 10-cm soil depths compared with chisel plow. Lopize C. et al. (2009) examined the effects of various tillage intensities for 5 years and concluded that SOC and N had increased under no-tillage and zero-tillage compared with minimum and conventional tillage in the depth of 0–30 cm. The author also observed most dramatic changes occurred within 0– 5 cm depth. Plots under no-tillage and zero-tillage has 7.0 Mg/ ha<sup>-1</sup> and 6.2 Mg ,ha<sup>-1</sup> more SOC, respectively and 0.5 Mg/ ha<sup>-1</sup> and 0.3 Mg/ ha<sup>-1</sup> more N than under minimum and conventional tillage (Lopize C. et al. 2009). No-tillage and zero tillage plots, however, exhibited strong vertical gradients of SOC and N with concentrations decreasing from 0–5 to 20–30 cm.

Dersch and Bohm (2001) come to the conclusion that minimum tillage can result in supplementary carbon storage. However, the storage of carbon in topsoil results only in a mid-term sequestration. If management practices in the short term are changed, these carbon amounts might be a source of additional CO<sub>2</sub> emissions in the future. Moussadek et al. (2014) has confirmed soil organic matter significantly higher in no-tillage compared to conventional tillage with 10% more in Vertsols and 8% more in Cambisol, but no significant difference was observed in the Luvisol. Average SOC<sub>s</sub> within the 0–30 cm depth was 29.35 and 27.36 Mg ha<sup>-1</sup> under no-tillage and conventional tillage, respectively. Haiqing et.al (2009) did an experiment with the objective to determine how three different tillage practices affected soil organic carbon (SOC) and N content of the soil and found that shallow tillage and no-tillage had 14.2 and 13.7% higher SOC stocks and 14.1 and 3.7% higher total N stocks than conventional tillage in the upper 15 cm. depth, respectively.

Hou R.et.al. (2012) determines the effects of different tillage and residue managements on winter wheat. After six yrs of observation, no-tillage with residue retention sequestered more SOC and total N in the 0- 5cm depth than conventional tillage and residue removed. Elcio et al. (2004) has also prove no tillage systems increased total C by 45%, microbial biomass by 83% at 0–50mm depth over conventional tillage. C and N mineralization increased 74% with no tillage compared to conventional tillage systems for the 0–200 mm depth. After continuous cultivation of seven consecutive years reduced tillage and no-tillage led to change in the physical properties of the surface soil layer (0-5 cm). Conservation tillage systems resulted in a higher water content and lower bulk density in relation to conventional tillage. According to Malecka et al. (2011) reduced tillage and no tillage favored surface accumulation of organic C and total N in the soil, as well as that of available K and Mg. Quintero M. et.al (2013) indicated that reduced tillage in potato-based crop rotations increased the soil C concentration and average C content in the whole profile by 50 and 33%, respectively, as compared to conventional farming practices.

## 2.2 Effect of crop residue

Plant residues decomposition transfers organic matter and nutrients to soil, and plays a decisive role in carbon cycling. Consequently, long-term application of crop residues significantly increased the organic carbon, and total as well as available N, P and K contents of soil. A considerable number of studies, concerning long-term fertility trials, pointed out those soil organic material applications increased the organic carbon stock of the soil and other essential elements. Ogbodo E.N., 2011 has reported that soil organic matter was significantly higher on the soils treated with rice straw and legume residue than untreated control. He has also reported higher levels of the entire soil chemical properties measured were detected on the soil treated with the different crop residue than the soil that was not treated with crop residue. Sommer et al. (2014) have reported the two components of conservation agriculture no-tillage and crop residue a positive impact on soil fertility. This was measurable by higher soil organic matter (SOM) and microbial biomass contents, increased levels of extractable phosphate, higher amounts of larger water-stable soil aggregates, increased soil infiltration capacity and soil water retention. The buildup of SOM and associated carbon (C) sequestration was in the range of 0.29 Mg C/ha/yr.

According to David et al. (2007) significant amounts of nutrients are removed from the soil/plant system when straw is removed. Soil organic C content can increase by managing land use practices in which the rates of organic C input exceed those of organic C mineralization. Yang et al. (2003) indicate that returning above ground crop residues to the soil from year 2002 to 2022 would increase SOC by 26% for the treatment without fertilization addition, 40% for N treatment, compared to the levels in the corresponding treatments in 2002. Barthes et al. (2004) in his 12 years of experimentation, carbon originating from maize in litter-plus-soil (0--40 cm) represented less than 4% carbon and from overall maize residue carbon. In contrast, carbon originating from mucuna in litter represented more than 50% of both total carbon and overall mucuna residue carbon, possibly due to accelerated mineralization of native soil carbon and slow mulch decomposition.

## 2.3 Effect of Farm Yard Manure Addition

Maintenance of soil organic matter is important for the long-term productivity of agro ecosystems. Application of organic wastes rich in organic matter like animal manure, sewage sludge, compost, and other by-products are current environmental and agricultural practice for maintaining soil organic matter, reclaiming degraded soils and supplying plant nutrients. According (Gilley and Risse, 2000) long-term manure applications increase the SOC pool of the soil. Li et al. (2010) has confirmed that long term organic amendments usually enhanced rice yields but the effect depends on the quantity and quality of the organic amendments, and the inherent nutrient and the SOC levels in soil. Ding X et al., (2012) has found that application of graded rates of manure from lower to higher level significantly enhanced total SOC, labile C pools, and recalcitrant C pool as compared with control. The C storage from the top 20cm depth with the rate of 7.5, 15, and 22 t/ha was increased from 3.19% to 12.5%, 14.5%, and 18.2%, respectively, over the unfertilized control.



Bouajila, K. and M. Sanaa (2011) did an experiment on the effects of three concentrations (40, 80 and 120 t/ha) of farm manure and compost made from household wastes and confirmed both organic amendment types increased significantly the organic carbon and nitrogen contents in a dose-dependent manner. Application of 120 t/ha household wastes and manure improved an organic carbon (1.74 % and 1.09 %, respectively) when compared with control (0.69 %). The rest of treatments give intermediate level of soil organic carbon.

Senapati et al. (2010) has confirmed that farm yard manure increased total SOC and slow pool C at 0-0.15 m soil depth by 6.7 t/ha and 1.5 t/ha, respectively, after seven years of rice-wheat cropping cycles. Eleven-year application of organic fertilizers increased the organic C content by an average of 3.3 t/ha C to 4.7 t/ha (Cvetkov M et al. 2009) compared to the organic carbon content in the unfertilized control. Diacono M., Francesco M. (2010) has reviewed, microbial biomass carbon increased by up to 100% using high-rate compost treatments, and enzymatic activity increased by 30% with sludge addition. Long-lasting application of organic amendments increased organic carbon by up to 90% versus unfertilized soil, and up to 100% versus chemical fertilizer treatments. Venecio et al. (2010) has evaluated different organic sources and confirmed the highest value of nitrogen parentage was recorded when adding compost (0.03%), and the lowest value of nitrogen was observed in the untreated control (0.01%). The highest value of phosphorus and potassium were recorded in the compost (3.45ppm, 12.78 mg/100g soil), respectively. Compost increased phosphorus and potassium percentage (97.14%, 39.67%) respectively. Organic carbon was range between (0.44%) in the compost treatment and (0.01%) in the untreated control. The compost treatment gave the highest value of C.E.C 6.71 mg\100g soil); and the lowest value was recorded in the untreated control (4.33 mg\100g soil) (Table 1)

**Table 1 shows the effect of organic fertilizer on soil chemical properties**

Treatments	Depth (cm)	N %	P (ppm)	K (mg/100g soil)	O.C	C.E.C (mg/100gsoil)	pH	ECe (ds/m)
Compost	0 – 20	0.02	3.4	12.34	0.44	6.20	7.14	0.62
	20 – 40	0.03	4.8	13.21	0.34	7.22	7.24	0.93
Cattle	0 – 20	0.01	1.9	10.24	0.24	5.11	7.32	0.84
	20 – 40	0.01	2.5	11.36	0.20	6.03	7.41	1.20
Chicken	0 – 20	0.02	3.1	11.09	0.31	5.24	7.25	0.81
	20 – 40	0.03	3.6	11.75	0.21	6.19	7.40	1.19
Chicken + cattle	0 – 20	0.02	3.2	12.14	0.36	6.05	7.32	0.74
	20 – 40	0.03	3.8	12.86	0.27	7.02	7.72	1.02
Control	0 – 20	0.01	1.4	8.28	0.01	3.94	7.30	1.41
	20 – 40	0.01	1.8	10.02	0.02	4.72	7.17	1.52

Source: Venecio *et al.* (2010)

Zanen1 et al. (2008) has evaluated seven years of amendment and continuous cropping for the effect of organic amendments on soil physical, chemical and biological properties. Changes in soil carbon, nitrogen mineralization has recorded in plants due to different in organic amendments. According to Hepperly et al. (2009) Compost was superior to conventional synthetic fertilizer and raw dairy manure in building soil nutrient levels. Ginting et al. (2003), has found the residual effect of compost and manure after 4 years of application. Residual effects resulted in 20 to 40% higher soil microbial biomass C compared with unfertilized control.

Ghosh S et al. (2010) identified significant increases in nutrient availability with the application of farm yard manure (7.5 t/ha), paddy straw (10 t/ha) and green manure (8 t/ha). Microbial biomass C and mineralizable C were also increased by the addition of organic inputs and continuous cultivation. The unfertilized control has significantly depleted total C content by 39-43% when compared with the addition of organic amendments. There was a significant increase in non-labile C fraction by the amendments when compared with control. There was a net loss of C by 5.6% due to continuous cultivation without any amendment and 26.1%, 17.7% and 6.3% of the C applied through farm yard manure, paddy straw and green manure, respectively.

Upendra M. et al. (2012) study on different organic sources and found that significantly higher cumulative carbon sequestration potential was recorded in improved (4.06 t/ha), followed by enriched (4.01 t/ha) and vermicompost (3.47 t/ha) treatments than farmer's (3.06 t/ha), inorganic (3:2.64 t/ha) and control (1.39 t/ha) treatment. Sandra et al. (2009) also confirmed that poultry manure had the greatest content of C (organic carbon), N (nitrogen), P (phosphorus), K (potassium), Ca (calcium) and lower C: N ratio. The manure treatment significantly increased the soil organic matter contents from 0.46 to 2.8 and 1.1% with poultry and cattle manures, respectively. Upendra M. et al. (2012) also confirmed that organic fertilizer has significantly increased the cation exchange capacity (CEC) from 1.7 to 12.75 to 10 meq/100 g of oil and the bases saturation content from 47 to 80 and to 76% respectively with the poultry and cattle manures.

## 2.4 Effect of Green Manure

Similar to other sources of organic fertilizer, green manure improved the physical, chemical and biological properties of the soil. Soil organic carbon, N content, soil aggregation, reduced soil bulk density and increased infiltration rate of soil. Lalalgre et al. (2012) investigate that legume under sowing and straws added up to 4 times more N, 2.8 times more phosphorus (P) and 2.5 times more potassium (K) returning to the soil. Consequently, red clover, hybrid Lucerne and



white maillot on pure sows produced the highest biomass, amounts of N, P, and K being up to 206, 124 and 144 kg/ha, respectively.

The rate of SOM depletion was reduced with the application of green manure. According to Egodaatta,W. (2014) application of recommended or required amount of green manures, in desired frequencies and appropriate maturity level of the leaves are key factors in maintaining soil quality. Zubair1 et al. (2012) indicates that replenishment of soil organic matter (SOM) was made with green manure and found that soil organic carbon (OC) and nitrogen (N) contents ranging from 0.10 to 1.40% and 0.05 to 0.55% was achieved, respectively. Tejada, M. et al (2007) confirmed that incorporation of 52-day-old Sesbania green manure along with crop residues not only counteracted the adverse effects of crop residues but also improved soil health. Tejada ,M. et al.( 2007) has confirmed that soil enzymatic activities, C, N, P and S, were highest in Trifolium pratense amended soils, followed by Brassica napus treatments.

## 2.5 Effect of crop rotation

Crop rotation has many agronomic, economic and environmental benefits compared to monoculture cropping system. Appropriate crop rotation improves organic matter, soil structure, soil degradation, grain yields and greater farm profitability in the long run. According to Dhu et al. (2005) soil organic C and total N level increased by taking three crops or including green manure in the rotation than taking two crops. Microbial biomass C and dehydrogenises activity was highest in pearl millet- green manure rotation and was lowest in pearl millet-wheat rotation. Ryan et al. (2007) had had concluded rotation of wheat has significantly influenced mean SOM level, the order being fallow (lowest), the rotation wheat, lentil, chickpea and vetch (highest). The N content of the soil increased with adoption legume based crop rotation. According to (Hector J et al., 2000) more diverse rotations of cotton with high-residue-producing crops such as corn, legume and small grains would sequester greater quantities of soil organic C than continuous cotton. Russell et al. (2005) has evaluating four cropping systems which include continuous corn (CC); corn-soybean (CS); corn-corn-oat-alfalfa (CCOA), and corn-oat-alfalfa-alfalfa (COAA) for their soil organic carbon sequestration. Cropping systems that contained alfalfa had the highest SOC stocks, whereas the CC system generally had the lowest SOC stocks. The author also concluded that the quantity of organic C and N can be maximized by in-creasing duration of crop rotation. Mahdi and Al.Kaisi (2000) summarizes the long-term impact of different crop rotations on soil carbon content and concluded higher rate of soil carbon decline under continuous corn compared to corn-oats-clover rotations (Table 2).

**Table 2 soil organic carbon content of the soil in response to crop rotation**

Rotation	Treatment <sup>a</sup>	% Organic C	% Organic Matter	% C change <sup>b</sup>
Corn	None	1.74	2.99	-45.6
	MLP	2.09	3.59	-34.7
Corn-Oats	None	2.14	3.68	-33.1
	MLP	2.44	4.20	-23.6
Corn-Oats-Clover	None	2.28	3.92	-28.7
	MLP	3.35	5.76	+4.0
Sod	None	3.20	5.50	0.0

<sup>a</sup>MLP = Manure-Lime-Phosphorus

<sup>b</sup>% C changes based on sod C value

Mahdi and Al.Kaisi (2000)

Muthoni,j and Jackson (2010) Proper crop rotation might help to conserve soil fertility among small scale potato farmers in Kenya and found that Percent total nitrogen and organic carbon was adequate with crop rotation. According to (Gregorich1 A.G et al.,2000) the quantity of soil C below the plow layer in legume-based rotation was 40% greater than that in monoculture and about the same as that under either continuous grass or forest. Blair and Crocker (2000) examined the effect of different rotations, including legumes and fallows on soil structural stability, unsaturated hydraulic conductivity, and the concentration of different carbon fractions in a long-term rotation trial and found that the inclusion of legume crops in the rotation resulted in an increase in liable carbon concentrations compared with continuous wheat or a long fallow period. AZIZ1 et al. (2011) found that total organic carbon in corn-soya bean- wheat was significantly higher by 14-15% than corn-soybean and corn -corn, respectively (Table 2). The N content significantly increased (5-19%) under all crop rotation over time. Saree et al. 2012 evaluated the changes from upland maize to flooded rice cultivation on soil organic carbon (SOC) and found that, cropping change from maize to flooded rice resulted in an increase in soil bulk density and SOC content when compared to that of maize-rice rotation and continuous maize. The total SOC after two cropping was 16.50, 20.88 and 19.35 ton C ha<sup>-1</sup> in the maize-maize, rice-rice and rice- maize treatments, respectively. Mitchell C.C. and J.A. Entry (2010) conclude that long-term planting of winter legumes with no other source of N applied resulted in higher SOC (9.5 g C/ kg ŷ1) in the plow layer (0±20 cm depth) compared to continuous cotton with no winter cover crops (4.2 g C/ kg ŷ1).



### 3. REFERENCES

1. Allmaras R.R., Schomberg H.H., Douglas, J.R., Dao, T.H. (2000). Soil organic carbon sequestration potential of adopting conservation tillage in US croplands. *Journal of Soil and Water Conservation*, 365–373.
2. Aziz M., Ashraf, T. Mahmood (2011). Crop Rotation Impact On Soil Quality. *Pak. J. Bot.*, 43(2): 949-960, 2011.
3. Barthes B., A. Azontonde, E. Blanchart, C. Girardin, C. Villenave, . Lesaintl (2004). Effect of a legume cover crop (*Mucuna pruriens* var. *utlis*) on soil carbon in an Ultisol under maize cultivation in southern Benin. *Use and Management* .V 20, pp 231-239
4. Blair N., Crocker G.J. (2000). Crop rotation effects on soil carbon and physical fertility of two Australian soils. *Aust. J. Soil Res.*, 38: 71–84.
5. Blevins RL, Frye W.W. (1993). Conservation tillage: an ecological approach to soil management *Adv. Agron.* 51:33-76.
6. Bouajila K., M. Sanaa (2011). Effects of organic amendments on soil physico-chemical and biological properties. *World Congress of Soil Science, Soil Solutions for a Changing World*. PP.154-160
7. Campbell C. A., Vanden Bygaart, A. J., Grant B., Zentner, R. P., Mc Conkey (2007). Quantifying carbon sequestration in a conventionally tilled crop rotation study in southwestern Saskatchewan, *Can. J. Soil Sci.*, 87, 23–38, 2007.
8. Chivenge P., H.K. Murwira, K.E. Giller C, P. Mapfumo D.J. Six (2007). Long-term impact of reduced tillage and residue management on soil carbon stabilization: Implications for conservation agriculture on contrasting soils. *Soil & Tillage Research* 94 (2007) 328–337.
9. Covaleda S., Pajares S., Gallardo J .F. Etchevers JD (2006). Short term changes in C and N distribution in soil particle size fractions induced by agricultural practices in cultivated volcanic soil from Mexico. *Org Geochem* 37:1943 1948
10. Cvetkov M., Anton Tajnšek (2009). Soil organic matter changes according to the application of organic and mineral fertilizers within long-term experiments. *J. Acta agriculture Slovenica*, pp. 311 - 320
11. David D., Tarkalson, Bradford Brown, Hans Kok, and Dave L., Bjorneberg (2007). Irrigated Small-Grain Residue Management Effects on Soil Chemical and Physical Properties and Nutrient Cycling. (*Soil Sci* 2009:174: 303-311)
12. Davies G., Lennartsson M. (2005). *Organic vegetable production. A complete guide*, Henry Doubleday Research Association, the Crowood Press Ltd.
13. Dersch G., and K. Bohm (2001). Effects of agronomic practices on the soil carbon storage potential in arable farming in Austria. *Nutr. Cycl. Agroecosys.* 60, 49–55.
14. Dhull S., Goyal K.K., Kapoor and M.C.Mundra (2005). Crop rotation effects on soil organic matter and soil microbial properties. *Indian J. Agric. Res.*: 39 (2):pp 128 --132
15. Diacono M., Francesco Montemurro (2010). Long-term effects of organic amendments on soil fertility. *Agronomy for Sustainable Development*, Springer Verlag (Germany), 2010, 30 (2), <10.1051/agro/2009040>. <hal-00886539>
16. Diuker S.W., Lal R., (1999). Crop residue and tillage effects on carbon sequestration in a luvisol in central Ohio. *Soil Till. Res.* 52, 73–81.
17. Egodawatta. W (2014). *Gliricidia sepium* green manure application strategies for maintaining the soil organic matter in subsistence Farming in tropical highlands of Sri Lanka. *European International Journal of Applied Science and Technology*. Vol. 1 PP. 17-23
18. Elcio L., Balota A., Arnaldo Colozzi ,Filho A, Diva S. Andrade A, Richard Dick (2004) .Long-term tillage and crop rotation effects on microbial biomass and C and N mineralization in a Brazilian Oxisol. *Soil & Tillage Research* 77 (2004) 137–145
19. Gilley J.E., Risse L.M.( 2000). Runoff and soil loss as affected by the application of manure. *Transactions of the ASAE* 43, 1583– 1588.
20. Ginting D., Kessavalou A., Eghball B., Doran J.W. (2003). Greenhouse gas emissions and soil indicators four years after manure and compost applications, *J. Environ. Qual.* 32, 23–32.
21. Gregorich E.G, C. F. Drury, and J. A. Baldock , Mahdi Al-Kaisi (2000). Changes in soil carbon under long-term maize in monoculture and legume-based rotation Impact of Tillage and Crop Rotation Systems on Soil Carbon Sequestration. *CANADIAN JOURNAL OF SOIL SCIENCE*. 1 Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Central Experimental Farm, Ottawa, Ontario, Canada K1A 0C6
22. Gregory G., Drury C.F., Baldock A., (2001). Changes in soil carbon under long-term maize in monoculture and legume-based rotation. *Canadian Journal of Soil Science* 81, 21– 31.
23. Haiqing Chen, Ruixing Hou, Yuanshi Gong, Hongwen Li., Mingsheng Fan, Yakov Kuzyakov (2009). Effects of 11 years of conservation tillage on soil organic matter fractions in wheat monoculture in Loess Plateau of China. *Soil & Tillage Research* 106 (2009) 85–94



24. Hector J. Causarano , Alan J. Franzluebbers D. Wayne Reeves , Joey N. Shaw , and M. Lee Norfleet (2000). Potential for Soil Carbon Sequestration in Cotton Production Systems of the Southeastern USA. Pp 1-24.
25. Hepperly paul, Don Lotter, Christine Ziegler, Rita Seidel and Carolyn Reider(2009). Compost, Manure and Synthetic Fertilizer Influences Crop Yields, Soil Properties, Nitrate Leaching and Crop Nutrient Content. *Compost Science & Utilization*, (2009), Vol. 17, No. 2, 117-126
26. Hou R. Zhu Ouyang Yunsheng Li (2012). Effects of Tillage and Residue Management on Soil Organic Carbon and Total Nitrogen in the North China Plain. *Soil Science Society of America*, 5585 Guilford Rd., Madison WI 53711 USA *Open Journal of Soil Science*, 2014, 4, 109-125.
27. Huang Shan, Sun Yan N., Rui Wen-Yi, Liu W. and Zhang J., (2010). Long term effect of no-tillage on soil Organic Carbon Fractions in a Continuous Maize Cropping System of Northeast China. *Pedosphere* **20**(3): 285–292, 2010.
28. Huang, Y., and Sun, W. J. (2006). Changes in topsoil organic carbon of croplands in mainland china over the last two decades, *Chinese Sci. Bull.*, 51, 1785–1803.
29. Juo, A.S., Franzluebbers, K., Dabiri, A., Ikhile, B., (1996). Soil properties and crop performance on a kaolinitic Alfisol after 15 years of fallow and continuous cultivation. *Plant Soil* 180, 209–217.
30. Kushwaha C.P., Tripathi S.K., Singh K.P. (2001). Soil organic matter and water-stable aggregates under different tillage and residue conditions in a tropical dry land agro ecosystem. *Appl. Soil Ecol.*, 16: 229–241.
31. Lal R. (2004). Soil carbon sequestration to mitigate climate change, *Geoderma* 123, 1–22.
32. Li Z, Ming Liu, Xiaochen Wu, Fengxiang Han, Taolin Zhang Bi. (2010). Effects of long-term chemical fertilization and organic amendments on dynamics of soil organic C and total N in paddy soil derived from barren land in subtropical China. *Soil & Tillage Research* 106: 268–274.
33. Lopez F., M.T. Pardo (2009). Changes in soil chemical characteristics with different tillage practices in a semi-arid environment. *Soil & Tillage Research* 104 (2009) 278–284
34. Mahdi M., Al. Kaisi and Xinhua Yin (2005). Tillage and Crop Residue Effects on Soil carbon and Carbon Dioxide Emission in Corn–Soybean Rotations. Published in *J. Environ. Qual.* 34:437–445 (2005).
35. Małecka I. , Andrzej Blecharczyk, Zuzanna Sawinska, Tomasz Dobrzeńcki (2011). The effect of various long-term tillage systems on soil properties and spring barley yield. *Turk J Agric For*36 (2012) 217-226.
36. Mitchell, C.C., J.A. Entry (1998). Soil C, N and crop yields in labama's long-term 'Old Rotation' cotton experiment. *Soil & Tillage Research* ,47 (1998) 331-338
37. Moussadek, R. Mrabet, R. Dahan, A. Zouahri, M. El Mourid, and E. Van Ranst (2014). Tillage System Affects Soil Organic Carbon Storage and Quality in Central Morocco. *Hindawi Publishing Corporation Applied and Environmental Soil Science Volume 2014*, Article ID 654796, 8 pages.
38. Muthoni J. Jackson N., Kabira (2010). Effects of crop rotation on soil macronutrient content and pH in potato producing areas in Kenya: *Journal of Soil Science and Environmental Management* Vol. 1(9), pp. 227-233.
39. Ogbodo E.N. (2011). Effect of Crop Residue on Soil Chemical Properties and Rice Yield on an Ultisol at Abakaliki, Southeastern Nigeria. *World Journal of Agricultural Sciences* 7 (1): 13-18, 2011ISSN 1817-3047
40. Prochazkova B., Hruby J., Dovrtil J., Dostál O. (2003). Effects of different organic amendment on winter wheat yields under long-term continuous cropping. *J.Plant Soil Environ.* 49, 433–438.
41. Quintero M, Nicholas B. Comerford (2013). Effects of Conservation Tillage on Total and Aggregated Soil Organic Carbon in the Andes. *Open Journal of Soil Science*, 2013, 3, 361-373
42. Russell E. D. Laird T. B., Parkin and A. P. Mallarino (2005). Impact of Nitrogen Fertilization and Cropping System on Carbon Sequestration in Midwestern Mollisols *Soil Sci. Soil Science Society of America Journal.* Vol. 69 No. 2, p. 413-422
43. Ryan J., S. Masri, Hayriye, Singh, Mustafa Pala, H. C. Harris (2007). Implications of Cereal-Based Crop Rotations, Nitrogen Fertilization, and Stubble Grazing on Soil Organic Matter in a Mediterranean-Type Environment. *Turk J Agric For* 32 (2008) 289-297.
44. Rychcik B., Zawiślak K., Rzeszutek I. (2004). The changes of physico-chemical properties of medium-textured soil under the influence of crop rotation with a different potato share. *V 55: PP 165–172.* (In Polish).
45. Saree S., Pancheewan Ponphang, Ed. Sarobol, Pitayakorn Limtong and Amnat Chidthaisong (2012). Soil Carbon Sequestration Affected by Cropping Changes from Upland Maize to Flooded Rice Cultivation the Joint Graduate School of Energy and Environment, King Mongkut University of Technology Thonburi, Bangkok 10140.
46. Senapati N., Subhadip G., Heiko A., Dinesh K. Benbi B. (2010) Impact of soil amendments on organic carbon pools under a rice-wheat cropping system. *Soil Solutions for a Changing World* .PP 123-126
47. Sombrero A., and Avelino Benito (2010). Carbon accumulation in soil, Ten-year study of conservation tillage and crop rotation in a semi-arid area of Castile-Leon, Spain *Soil. & Tillage Research* 107 (2010) 64–70



48. Sommer R, Colin Piggin, David Feinde, Muhammad Ansar, Lona van Delden, Kayoko Shimonaka, Jihad Abdalla, Osama Douba, George Estefan, Atef Haddad, Rousheen Haj-Abdo, Ali Hajdibo, Pierre Hayek, Yaseen Khalil, Ahmed Khoder, John Ryan (2014). Effects of zero tillage and residue retention on soil quality in the Mediterranean region of northern Syria. *Open Journal of Soil Science*, 2014, 4, 109-125
49. Sommer, R., Rudrappa, L., Purakayastha, T.J., Singh, D., Bhadraray, S., (2006). Long-term manuring and fertilization effects on soil organic carbon pools in a Typic Haplustept of semi-arid sub-tropical India. *Soil Till. Res.* 88, 180–192
50. Subhadip A., Brian W., Subrata K., Ghoshal C., Nimai A, Biswapati Manda, (2010) Management of soil quality and carbon sequestration with long-term application of organic amendments. *Soil Solutions for a Changing*. PP 141-149
51. Talgre, L., E. Lauringson, H. Roostalu, A. Astover, A. Makke (2012). Green manure as a nutrient source for succeeding crops. *Agronomy Research* 8 (Special Issue II), 487–492, 2010
52. Upendra M. Sainju<sup>1</sup>, Andrew W. Lenssen, Thecan Caesar-TonThat<sup>1</sup>, Jalal D. Jabro<sup>1</sup>, Robert T. Lartey, Robert G. Evans<sup>1</sup>, Brett L. Allen (2012). Tillage, Crop Rotation, and Cultural Practice Affects on Dry land Soil Carbon Fractions. *Open Journal of Soil Science*, 2012, 2, 242-255
53. Vanden A.J Bygaart, E. G. Gregorich<sup>1</sup>, and D. A. Angers (2012). Influence of agricultural management on soil organic carbon: A compendium and assessment of Canadian studies. *Canadian Journal of Soil Science*. Canadian Journal Of Soil Science. Pp363-380
54. Venecio U. Ultra J. and Evelyn J. (2010). Influence of long term organic fertilization on the soil microbial community functional structure and enzyme activities in paddy soil. pp 1-12
55. Watson C.A., Atkinson D., Gosling P., Jackson L.R., Rayns F.W. (2002). Managing soil fertility in organic farming systems, *Soil Use Manage.* 18, 239–247.
56. Xueli Ding, Xiaozeng Han, Yao Liang, Yunfa Qiao, Lujun Li, Na Li (2012). Changes in soil organic carbon pools after 10 years of continuous manuring combined with chemical fertilizer in a Mollisol in China. *Soil & Tillage Research*. Key Laboratory of Mollisols Agroecology, Northeast Institute of Geography and Agroecology, Chinese Academy of Sciences, Harbin 150081, PR China.
57. Yang XM, Zhang XP, Fang HJ, Zhu P, Ren J, Wang LC (2003). Long-term effects of fertilization on soil organic carbon changes in continuous corn of northeast China: Roth C model simulations. 16<sup>th</sup> IFOAM Organic World Congress, Modena, Italy, June 16-20.
58. Zanen, M., Bokhorst, J. G. & Koopmans, C.J. (2008). Soil Fertility and Biodiversity effects from Organic Amendments. 16<sup>th</sup> IFOAM Organic World Congress, Modena, Italy, June 16-20, 2008
59. Zikeli S., Sabine Gruber, Claus-Felix Teufel, Karin Hartung and Wilhelm Claupein (2013). Effects of Reduced Tillage on Crop Yield, Plant Available Nutrients and Soil Organic Matter in a 12-Year Long-Term Trial. *Sustainability* 2013, 5, 3876-3894.
60. Zubair M., F. Anwar, M. Ashraf, and S. Chatha (2012). Effect of green and farmyard manure on carbohydrates dynamics of salt-affected soil. *Journal of Soil Science and Plant Nutrition*, 2012, 12 (3) 497-510